GemStone®

System Administration Guide for GemStone/S 64 Bit™

Version 3.6

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PATENTS

GemStone software is or has been covered by U.S. Patent Number 6,256,637 "Transactional virtual machine architecture" (1998-2018), Patent Number 6,360,219 "Object queues with concurrent updating" (1998-2018), Patent Number 6,567,905 "Generational garbage collector with persistent object cache" (2001-2021), and Patent Number 6,681,226 "Selective pessimistic locking for a concurrently updateable database" (2001-2021).

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GemTalk Systems LLC
15220 NW Greenbrier Parkway
Suite 240
Beaverton, OR 97006

Preface

About This Manual

This manual provides information that is useful for configuring and administering a GemStone/S 64 Bit™ installation. This includes configuring GemStone installations, both new systems and systems that have grown or whose requirements have changed; how to keep a GemStone system running smoothly, including recovering from problems and troubleshooting; and information helpful in tuning each of the subsystems that allow GemStone to operate efficiently and seamlessly.

The details of installing GemStone software, and upgrading from earlier versions, is described in detail in the *Installation Guide*, which are platform-specific. Refer to these guides for information on tuning your OS parameters for most efficient use of GemStone.

This manual is intended for users that are at least somewhat familiar with using Smalltalk and the Topaz programming environment to execute GemStone Smalltalk code. It also assumes some familiarity with UNIX.

You should have the GemStone system installed on your host computer, as described in the *GemStone/S 64 Bit Installation Guide* for your platform.

Terminology Conventions

The term "GemStone" is used to refer to the server products GemStone/S 64 Bit and GemStone/S, and the GemStone family of products; the GemStone Smalltalk programming language; and may also be used to refer to the company, now GemTalk Systems, previously GemStone Systems, Inc. and a division of VMware, Inc.

Typographical Conventions

This document uses the following typographical conventions:

- Smalltalk methods, GemStone environment variables, operating system file names and paths, listings, and prompts are shown in `monospace` typeface.
- Responses from GemStone commands are shown in an `underlined` typeface.
- Place holders that are meant to be replaced with real values are shown in *italic* typeface.
- Optional arguments and terms are enclosed in [square brackets].
- Alternative arguments and terms are separated by a vertical bar (|).

Executing the Examples

The GemStone server is not accessed directly; you must login using Topaz, GemBuilder, or another interface in order to execute code. Topaz is GemStone's command-line interface, and the examples in this manual are primarily presented as executable Smalltalk code in Topaz.

Most of these examples may also be executed in GemBuilder or another interface to GemStone; some exceptions are noted in the text. Some details of the display of returned values may be vary depending on the interface used.

Refer to the *Topaz Programming Environment* for more information on Topaz, including establishing a Topaz login and entering and executing commands.

Technical Support

Support Website

gemtalksystems.com

GemTalk's website provides a variety of resources to help you use GemTalk products:

- **Documentation** for the current and for previous released versions of all GemTalk products, in PDF form.
- **Product download** for the current and selected recent versions of GemTalk software.
- **Bugnotes**, identifying performance issues or error conditions that you may encounter when using a GemTalk product.
- **Supplemental Documentation** and **TechTips**, providing information and instructions that are not in the regular documentation.
- **Compatibility matrices**, listing supported platforms for GemTalk product versions.

We recommend checking this site on a regular basis for the latest updates.

Help Requests

GemTalk Technical Support is limited to customers with current support contracts. Requests for technical assistance may be submitted online (including by email), or by telephone. We recommend you use telephone contact only for urgent requests that require immediate evaluation, such as a production system down. The support website is the preferred way to contact Technical Support.

Website: techsupport.gemtalksystems.com

Email: techsupport@gemtalksystems.com

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Please include the following, in addition to a description of the issue:

- The versions of GemStone/S 64 Bit and of all related GemTalk products, and of any other related products, such as client Smalltalk products, and the operating system and version you are using.
- Exact error message received, if any, including log files and statmonitor data if appropriate.

Technical Support is available from 8am to 5pm Pacific Time, Monday through Friday, excluding GemTalk holidays.

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Training and Consulting

GemTalk Professional Services provide consulting to help you succeed with GemStone products. Training for GemStone/S is available at your location, and training courses are offered periodically at our offices in Beaverton, Oregon. Contact GemTalk Professional Services for more details or to obtain consulting services.

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Chapter

1 Administration of the GemStone/S Environment

This chapter provides some basic information about the parts of a GemStone installation, and an overview of the Administration process.

The follow topics are described:

Basic GemStone/S 64 Bit Architecture (page 22)
the components of the GemStone/S 64 Bit server and clients.

Starting GemStone and Logging In (page 23)
the steps of starting a GemStone server and logging in a client

Authentication and Authorization (page 27)
an overview on how GemStone manages authentication and authorization

Transactions and commit records (page 28)
how GemStone manages data between multiple users.

Files and Directories (page 29)
the disk files that the GemStone server requires and creates.

Options for Configuring (page 32)
configuration files, environment variables and other ways to specify configuration parameters.

Avoiding risk of Data loss (page 35)
information on GemStone's features to ensure against loss of critical data

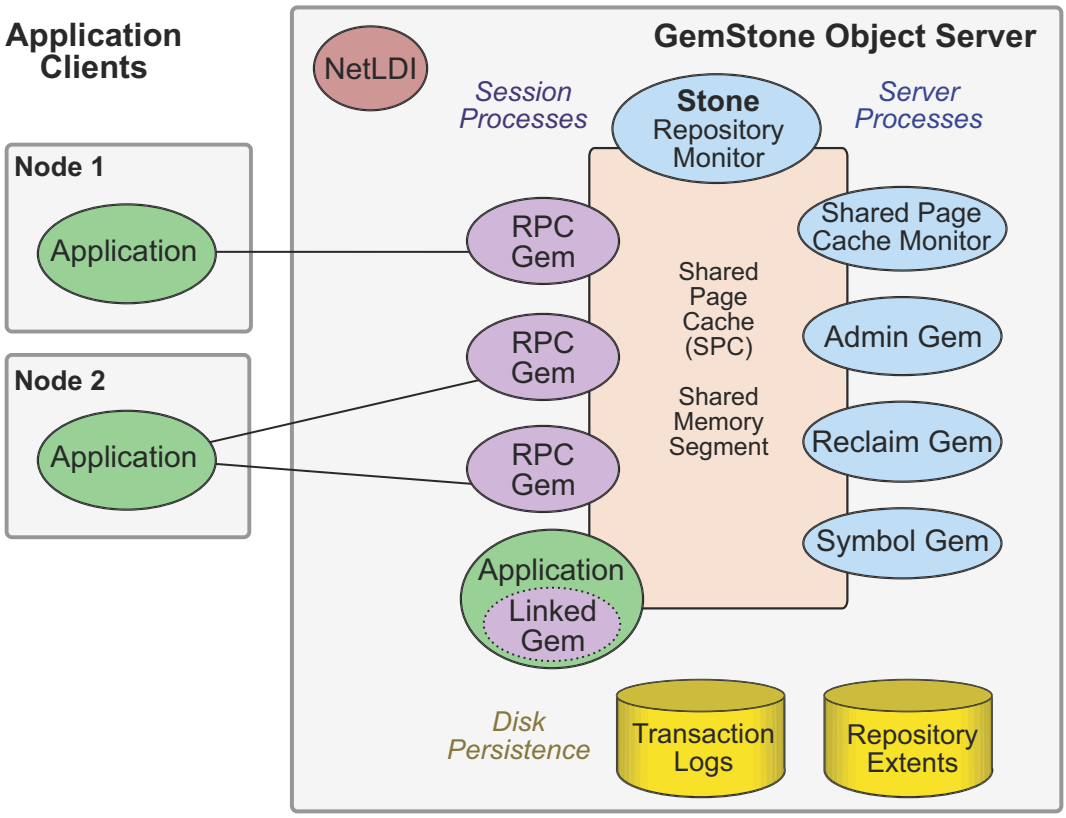
Running a Second Repository (page 36)
instructions on running two repositories on the same machine.

1.1 Basic GemStone/S 64 Bit Architecture

Figure 1.1 shows the basic GemStone/S 64 Bit architecture. The GemStone object server can be thought of as having two parts. The *server processes* consist of the Stone repository monitor and a set of subordinate processes. These processes provide resources to individual Gem *session processes*, which are servers for application clients.

While in this simple configuration, the remote nodes hold only the Application Clients, there are further options to distribute components over multiple nodes, described later in this manual.

Figure 1.1 The GemStone Object Server



Keys parts that define the server configuration include:

Server Processes

- The *Stone repository monitor* process acts as a resource coordinator. It synchronizes critical repository activities and ensures repository consistency.
- The *shared page cache* (SPC) is a shared memory segment that holds the pages on which data and metainformation are stored. Pages are read into *frames* in the cache. Pages are read from the disk extent files into frames, and new pages are allocated and held in frames. A larger cache provides better performance since more frames can hold a larger percent of the repository data in memory. The cache may be sized to be large enough to hold all data in the extents.

- The *shared page cache monitor* process creates and maintains the shared page cache. The monitor balances page allocation among processes, ensuring that a few users or large objects do not monopolize the cache.
- The *Admin Gem* performs administrative garbage collection tasks.
- The *Reclaim Gem* performs reclaim, cleaning up old versions of objects and dead objects, so that the pages can be reused.
- The *Symbol Gem* is responsible for creating all new Symbols, based on session requests that are managed by the Stone.

Disk-based Persistence

- Objects are stored on disk in one or more *extents,* which can be files in the file system, data in raw partitions, or a mixture.
- *Transaction logs* permit recovery of committed data if a system crash occurs, and in *full logging mode* allows transaction logs to be used with GemStone backups for full recovery of committed transactions in case of disk failure.

Session Processes

- *Gem* sessions can be Gem processes in an RPC (Remote Procedure Call) login, or bound with the client application using shared libraries in a linked login.

  The terms "Gem" and "session" are both used to refer to the logged-in Gem, although this may be either a Gem process that is separate from the application process, or a linked application process that also contains the Gem.

Communications process

- The NetLDI (Network Long Distance Information) listens on a configured port for connections, to establish logins and perform other tasks in distributed systems.

1.2 Starting GemStone and Logging In

Stone

A configured GemStone server is started by the **startstone** command, which starts the Stone repository monitor. The Stone in turn starts the shared page cache monitor and other server processes. The extent files are attached, and a transaction log opened for writing.

The Stone is named; by default, *gs64stone*. Only one Stone with a given name can run on a particular node.

You may run more than one Stone on a node, as long as names are different and the extent files and transaction logs are in different locations or have different names.

> Configuring the Stone and other server processes is described in Chapter 2, "Configuring the GemStone Server", starting on page 37.
>
> For details on starting the Stone and other server processes, and troubleshooting issues, see "Starting the GemStone Server" on page 103.

Shared Page Cache

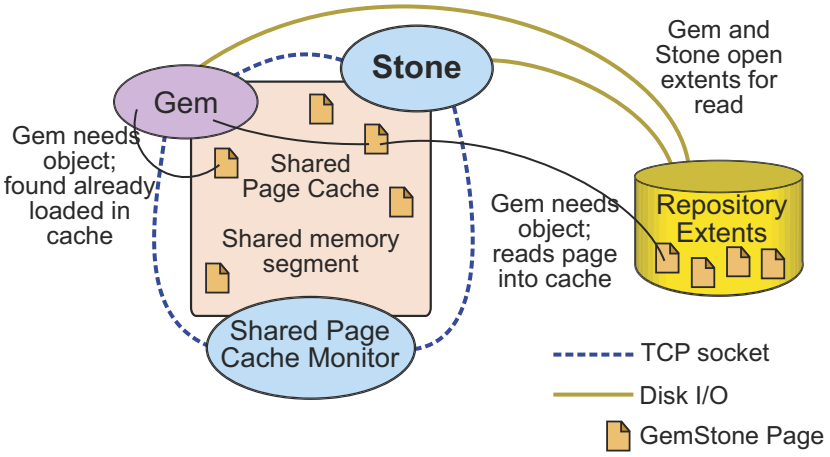
The GemStone shared page cache system has two parts: the shared page cache itself, a shared memory segment; and a monitor process, the shared page cache monitor (`shrpcmonitor`). Figure 1.2 shows the connections between these and other components on a single node.

The shared page cache resides in a segment of the operating system's virtual memory that is available to any authorized process. When the Stone or a Gem session process needs to access an object in the repository, it first checks to see whether the page containing that object is already in the cache. If the page is already present, the process reads the object directly from shared memory. If the page is not present, the process reads the page from the disk into the cache, where all of its objects also become available to other processes.

The shared page cache monitor also has a name, which is derived from the name of the Stone repository monitor and the *Host Identifier*; for instance, `gs64stone~d7e2174792b1f787`.

Each Stone has a single shared page cache on its own node, and may have remote page caches on other nodes in distributed configurations (discussed in detail in Chapter 5). The Stone spawns the shared page cache monitor automatically during startup, and the shared page cache monitor creates the shared memory region and allocates the semaphores for the system. All sessions that log into this Stone connect to this shared page cache and monitor process.

Figure 1.2 Pages in the Shared Page Cache



Shared Cache Size

GemStone performance is almost always improved by making the Shared Page Cache larger, up to a size in which the entire repository can be held in memory.

With a very large cache, it is recommended to run cache warming on startup, so that at least the pages containing the object table (used for lookup) are loaded into the cache. Otherwise, the first access to data will require the pages to be read from disk.

With very large caches on Linux and AIX, you can improve memory use by configuring the cache to use large memory pages; 16MB on AIX, and 2MB and 1GB pages on Linux.

OS memory and Swapping

As described in the Installation Guide, you are likely to need to configure your OS to support a sufficiently large shared memory segment.

Be careful not to make the shared page cache so large that it forces swapping. You should ensure that your system has sufficient RAM to hold the configured shared page cache, with extra space for the other memory requirements.

For details on configuring the shared page cache, see "Shared Page Cache" on page 39.

NetLDI

A NetLDI also must be configured and explicitly started using the **startnetldi** command. While there are some cases, in which there are only linked logins, that do not require a NetLDI, most installations will need to start a NetLDI.

Each NetLDI has a name, but may also be referred to by its listening port number. The default name is *gs64ldi*; by using this name and setting this up in the services database on all your nodes, you can skip the step of specifying the NetLDI.

You may run more than one NetLDI on a node, related to the same GemStone system or an entirely different system, as long as the names and ports are different.

If you are using more than one NetLDI on a particular node, and one of them is running with the default name, use particular care to ensure that all logins contact the correct NetLDI.

Setting up the NetLDI is described in Chapter 4, "NetLDI and Interprocess Access", starting on page 69.
For details on starting the NetLDI see "Starting a NetLDI" on page 109.

Logging in Gem Sessions

Client applications include:

- the topaz command line tool, provided as part of the server
- client Smalltalk applications such, as VisualWorks and VA Smalltalk using GemBuilder for Smalltalk (GBS)
- client Java applications using GemBuilder for Java (GBJ)
- clients using open-source products such as GsDevKit and Rowan for GemStone
- web applications
- other custom GCI application

Client application are configured to load the GCI shared library, provided as a `.dll`, `.dynlib`, or `.so` file, containing the Gem API.

The login commands include, of course, GemStone authorization details. The specification of the Stone and node must be provided, and the location where the Gem process is to be run. The details need to include the name or port of the NetLDI that sets up the login.

The NetLDI uses that information to fork the Gem process, trigger the startup of any other required server processes, and setup the interprocess communications.

Linked vs. RPC

In a linked login, GCI shared libraries are loaded into the client application (linked topaz, GBS, or another), and Gem is part of that client application. Since the Gem is part of the server, this is only possible on platforms that support the GemStone/S 64 Bit server, i.e., not on Windows.

In an RPC login, the Gem is a separate process from the client application. The two processes may be on the same node or on different nodes, and communicate via remote procedure calls.

Gemservers for Large Configurations

Each Gem is an individual process. Depending on your hardware, there is an limit to the number of processes that you can run before degrading performance. For very large configurations, it may be useful to establish a separate node specifically to run Gem sessions, with a high bandwidth connection between the repository server and the Gem server. The Gems on this gemserver have the performance benefit of a remote shared page cache on this node.

> Configuring client Gems is described in Chapter 3, "Configuring Gem Session Processes", starting on page 61.
> For more information on logging in a Gem session, see "Starting a GemStone Session" on page 110.

NRS (Network Resource String)

GemStone's native NRS syntax is used to specify the name and location of each part of the GemStone system. These are widely used in utility commands and in login parameters, to specify the location and name of the Stone and NetLDI, and where the other GemStone processes should run.

> Appendix C, "Network Resource Strings (NRS)" describes NRS strings in detail.

The most commonly used syntax, as in the examples in this manual, has the form:
`!@`*nodeNameOrId*`#netldi:`*netldiNameOrPort*`!`*stoneOrGemService*

- The "`@`*nodeNameOrId*" can be omitted for the local node.
- the "`#netldi:`*netldiNameOrPort*" can be omitted if the NetLDI is running with the default name gs64ldi, and the name and port are configured in the services database.
- *stoneOrGemService* is the name of the running Stone, or `gemnetobject` or another Gem service. If you omit both node and netldi, you do not need the `!` dividers; you can use only *stoneOrGemService*.

1.3 Authentication and Authorization

GemStone provides several levels of security; UNIX user accounts must have permission and may require authentication; login to GemStone requires a GemStone account and authentication; and objects and access to data and important functions is controlled within GemStone using Security Policies and Privileges. In full logging mode, all commits to the repository are recorded in the transaction logs, which can be analyzed to determine the source of changes; and the system can be configured to log all logins.

GemStone UserIds and login

Logins to GemStone are done as GemStone users, which are instances of UserProfile. UserProfiles have names and passwords that are unrelated to UNIX userIds, although GemStone UserProfiles can be created that correspond to the UNIX account names.

Login authentication can be configured to use UNIX or LDAP, in which case either the names must match, or the UserProfile configured with the mapping. UserProfiles can also be configured with single sign-on using Kerberos, by setting up the appropriate mapping within GemStone.

There are several built-in system accounts, including SystemUser, which is similar to a "root" user, used for upgrades; and DataCurator, the administrative user for tasks such as backups and user administration. Other system accounts are used for garbage collection and symbol creation.

When GemStone UserProfile authentication is controlled by GemStone, there are a number of ways to restrict password choice, require password changes, and disable accounts in cases such as too many failed logins. Internally, passwords are stored only in the encrypted form and there is no facility to decrypt them.

A number of important operations, such as code modification and garbage collection, may be restricted to certain users by using privileges. A UserProfile may be granted privileges that allow them to perform these operations.

> Configuring and Administering Users, Groups, and Privileges is described in Chapter 8, "User Accounts and Security".

Authorization to Access Data

Within GemStone, Objects are associated with Security Policies, that allow specific GemStone Users or Groups of users to write, read, or have no access to particular objects. This provides a highly granular way of protecting critical data.

> How to apply Security Policies to your data is described in the *GemStone/S 64 Bit Programming Guide*.

File access and authorization

As a multiuser system, GemStone must allow applications running under different UNIX userIds to create processes that access the repository disk files, while ensuring that the disk files are protected against unauthorized access or modification, both intentional and accidental. This involves managing the permissions for important files and controlling the process owners and groups. Configuring security is described in Chapter 4.

Initial login requests to GemStone connect using SSL (Secure Socket Layer; more specifically, TLS protocol using OpenSSL). For processes on the same machine, communications after the login continue using primarily shared memory. Remote socket connections may be SSL or not, depending on your security requirements.

> Setting up file permissions and authentication is described in Chapter 4.

1.4 Transactions and commit records

GemStone maintains a consistent view for each user, and all changes that are made persistent and visible to other users are done within transactions. Transactions are committed to make changes persistent; sessions abort to discard modifications and update the objects in their view with changes made by other users.

> For more information on transactions and commits, refer to the *GemStone/S 64 Bit Programming Guide*.

Object views

On login, each GemStone user acquires a "view" of the objects in the repository. This view is maintained as long as you are using it, even if the objects have been modified by other users. You may make modifications to the objects in your view, or create new objects, but these changes are transient unless and until you commit, in which case they become persistent and can be viewed by other users.

Making new objects persistent also requires that they be connected to an existing persistent object. Objects that are not reachable by other objects are subject to garbage collection.

If another user has made a conflicting change, your commit may fail, and you can get a report of the conflicts. You may need to discard the changes. This can be avoided by locking objects prior to modifying them; reduced-conflict classes allows certain kinds of conflict to be automatically resolved.

Session transactional state

Each Gem session is either "in transaction", not in transaction, or in "transactionless" state (transactionless is a specialized state designed for idle sessions; most behavior described in this manual is concerned with sessions that are either in or out of transaction.

Sessions that are in transaction may commit changes. Sessions that are not in transaction can view data and modify objects, but these modifications are transient. To make persistent changes, you must begin a transaction, make the changes, and commit successfully.

Both sessions in and not in transaction can abort. An abort discards modifications. When a session commits or aborts, its view is updated to the most recent view, including any changes by other users.

If a session attempts to commit changes that conflict with changes made by another session, the commit will fail.

Commit records

GemStone is designed to accommodate large numbers of users. Each user may have his or her own view of the repository; and each of these views must be maintained as long as they are in use. GemStone maintains these views as Commit Records.

Over time, each of these sessions will commit changes (or abort), at which point the view is no longer required. However, since commit records are sets of changes from a previous view, GemStone must maintain the commit record of the session that has been logged in without commit or abort for the longest time (the oldest commit record) and every intermediate commit record up to the current one.

Commit records are stored in the repository, and a large commit record backlog can use a large amount of repository space. GemStone can signal sessions that are causing a backlog, but applications in multiuser system should be designed to abort or commit and respond to signals to avoid creating backlogs. A long-lasting commit record backlog can fill up all disk space such that the GemStone cannot avoid shutting down.

1.5 Files and Directories

GemStone Installation

The GemStone installation process, as described in the *Installation Guide* for your platform, describes both how to configure your operating system, and the details of installing GemStone.

After installation, you should have a directory containing the executables, shared libraries, extents and other required or useful files. Not all are required, and they do not need to be located in this shared directory structure.

The GemStone installation directory is generally referenced by the environment variable $GEMSTONE. You will usually need to have this environment variable defined, as well as having the $GEMSTONE/bin directory on your machine search path.

GemStone shared libraries

Your GemStone installation includes shared library files as well as executables. Access to these shared library files is required for the GemStone executables. In the standard installation of the GemStone software, these shared libraries are located in the `$GEMSTONE/lib` and `$GEMSTONE/lib32` directories.

For installations that do not include a full server, such as remote nodes that are only running client applications, these libraries may be put in a directory other than this standard. See the *Installation Guide* for more information.

> Separate *GemStone/S 64 Bit Installation Guides* are provided for each supported platform, containing OS configuration, installation, and upgrade information. For Windows clients, see the *GemStone/S 64 Windows Client*.

Lock file directory

In addition to the normal installation directory, GemStone requires access to two directories under `/opt/gemstone/`:

- `/opt/gemstone/locks` is used for the hostId that uniquely identifies this node, and for lock files, which among other things provide the names, PIDs, ports, and other important data for GemStone processes, used in interprocess communication and reported by **gslist**.

  Lock files (*processName*`..LCK`) are normally deleted when the GemStone process exits. To clear out lock files of processes that exited abnormally, use **gslist -c**.

  If there is an unexpected shutdown, the lock files remain in the `/opt/gemstone/locks/` directory. On restart, it is possible for a kernel process to reuse this PID. If the owner is root, GemStone cannot reliably determine the status of the process and thus cannot safely delete the lock file. These lock files must be manually deleted.

  It is recommended that systems be setup so that on boot, the lock files in `/opt/gemstone/locks/*.LCK` are deleted automatically on system restart.

  Do not delete `/opt/gemstone/locks/gemstone.hostid`**.**

- `/opt/gemstone/log` is the default location for NetLDI log files, if **startnetldi** does not explicitly specify a location using the **-l** option.

If `/opt/gemstone/` does not exist, GemStone may use `/usr/gemstone/` instead.

Alternatively, you can use the environment variable GEMSTONE_GLOBAL_DIR to specify a different location. Since the files in this location control visibility of GemStone processes to one another, all GemStone processes that interact must use the same directory.

Host Identifier

`/opt/gemstone/locks` (or an alternate directory, as described above) is also the location for a file named `gemstone.hostid`, which contains the unique host identifier for this host. This file is created by the first GemStone process on that host to require a unique identifier, by reading eight bytes from `/dev/random`. This unique hostId is used instead of host name or IP address for GemStone inter-process communication, avoiding issues with multi-homed hosts and changing IP address.

You can access the host identifier for the machine hosting the gem session using the method `System class >> hostId`.

Extents, Tranlogs, and disk space

GemStone data is preserved on disk in one or more extent files. These extents include the classes and objects that make up GemStone, as well as the classes and objects that make up your application. When GemStone is shutdown, these extents provide the complete set of objects that compose the application.

Each time a session commits changes to the repository, the changes are made on pages in the shared page cache, which are eventually written to disk by the AIO page server. A commit also writes a record in the current transaction log, which is immediately written to disk.

While GemStone is running, it periodically makes a checkpoint, at which point all dirty pages in the shared page cache are written to disk, and the root page, which holds critical global information on the repository, is updated to a new consistent state. GemStone also writes a checkpoint on an orderly shutdown, and before a backup.

Between checkpoints, updates to the repository are recorded in the transaction logs. If GemStone shuts down unexpectedly, it will startup at the point of the most recent checkpoint in the repository. Changes since that checkpoint are restored from the transaction logs.

Disk Usage for Extents and Transaction Logs

On a single disk, multiple processes writing to both extents and transaction logs will encounter contention, since only one physical write to disk media at a time is possible.

For this reason, if you are not using a SAN or a RAID device that avoids single disk contention, using multiple physical disk drives is recommended for better performance.

Using SSD devices will provide the best performance.

Raw Partitions

Each raw disk partition is like a single large sequential file, with one extent or one transaction log per partition.

In general, placing extents on file systems is as fast as using raw partitions, but configuring transaction logs on raw partitions is likely to yield better performance in an update-intensive application.

Process Log Files

Each GemStone process creates or appends to a log file. These log files include process details, startup configuration information, and messages about any errors that occur. The location and file name of most processes is configurable.

When the process exits, by default some processes leave their log files in place for possible later diagnostic use. Other process types delete their log files on a clean exit. A process that exits with a error never deletes its log file.

Note that linked sessions, which do not have an independent Gem process, do not create log files. Log file output is sent to stdout for the client application.

System Clock and GemStone times

The system clock should be set to the correct time. When GemStone opens the repository at startup, it compares the current system time with the recorded checkpoint times as part of a consistency check. A system time earlier than the time at which the last checkpoint was written may be taken as an indication of corrupted data and prevent GemStone from starting.

TimeZones

Internally GemStone uses times in GMT. It is not necessary to adjust GemStone for changes to and from daylight savings time.

GemStone uses an internal TimeZone setting to adjust times for display in local time. This uses the Olson Tz database.

1.6 Options for Configuring

GemStone is a very flexible system, with many options for configuring details. Almost all of these have defaults; for an "average" system, you will only need to set a few basics: the extent files, transaction logs, and the size of the shared cache.

However, few systems are average. Your application may have larger or smaller amounts of data relative to the number of users, or have a higher commit rate, or a commit rate that varies widely over the course of a day; or your system may have particular requirements for reliability, security, or performance; or your system may be distributed over multiple nodes. For example, a nightly batch data archiving process may have very different requirements than a monitoring process that performs frequent small commits.

An application's configuration is set by assigning values in one or more configuration files. These can be modified, or work in concert with, specific environment variables, arguments to the command-line GemStone utilities, and by executing Smalltalk code that adjusts configuration values or behavior at run-time.

This flexibility permits assigning system-wide values that include both fixed and variable configuration settings, while also allowing various components to override these settings when they have specific needs.

Configuration files

GemStone uses configuration files to hold the specifications for most important configuration details. This includes the names and locations of the extent files, the sizes of the various caches, and many parameters designed for tuning. While there are many parameters, only a few of them are required; in most cases the default is sufficient.

On a new Gemstone system, you must determine the basic configuration before starting. The details on how to establish the configuration are described in Chapter 2, "Configuring the GemStone Server" for the server and Chapter 3, "Configuring Gem Session Processes" for Gems.

GemStone distinguishes between the system configuration file, which applies to the Stone and other system processes, and application configuration files, which apply for Gem sessions (linked and RPC). If all GemStone processes are on a single node, the parameters can all be in a single configuration file. Multiple files can be setup, which apply to different tasks or reside on different nodes.

> How configuration files are used, and an alphabetic list of parameters, is provided in Appendix A. Specific parameters are discussed throughout this manual.

Environment variables

There are a number of environment variables that GemStone uses. The most important of these is $GEMSTONE, which is required for adminstration, and indicates the directory in which GemStone is installed.

Other environment variables provide file locations for configuration files themselves, and other information that is needed before a process is able to read the configuration file.

Finally, some logging and debugging settings are provided as environment variables to allow debugging without affecting other sessions in a multiuser system.

> Environment variables are listed in Appendix E. Their use is described in various sections to which they apply.

Utility command arguments

When GemStone is started up, the startup tasks are performed by utility commands, such as **startstone** to start the stone. These command-line tools accept optional arguments, including such things as process names, port numbers, and log file locations.

> Utility commands are listed in Appendix B.

Run-time configurations

Some configuration details are fixed at startup, so making changes requires stopping and restarting the Stone (which stops all other processes except the NetLDI) or Gem (which means logging out). However, other configuration settings can be modified at runtime by executing Smalltalk code.

Example Configurations

As an example of how the scale of application characteristics affect key GemStone configuration settings, the following table provides some examples of "average" configurations.

While these may be useful in planning, the actual values will be based on your particular hardware and application requirements, and most systems will require additional tuning for optimal performance. GemStone can generate performance statistics, both during development and in production systems. These statistics can be displayed and analyzed using the VSD (Visual Statistics Display) utility to understand bottlenecks and determine both changes that are needed, and to study the effect of configuration and application changes.

Table 1.1 Example Configurations

Characteristic or Configuration Option	Sample Server Configuration		
	Small	Medium	Large
Application Characteristics			
Maximum number of user sessions	10	250	1000
Repository size	100 MB	10 GB	500 GB
System Requirements			
Typical number of CPUs	2	4	8+
RAM	4 GB	8 GB	128 GB
Kernel shared memory	2 GB	6 GB	100 GB
Number of disk drives	4	8	12
Configuration Settings			
STN_MAX_SESSIONS	20	280	1200
SHR_PAGE_CACHE_SIZE_KB	75 MB	4 GB	96 GB
Extents			
DBF_EXTENT_NAMES	(1 file)	(4 files)	(10 files)
DBF_EXTENT_SIZES	(unlimited)	(unlimited)	(unlimited)
DBF_ALLOCATION_MODE	SEQUENTIAL	10,10,10,10	10,10,10,...
Transaction Logs			
STN_TRAN_LOG_DIRECTORIES	(1 directory)	(4 directo-ries)	(8 raw partitions)
STN_TRAN_LOG_SIZES	100	500 each	2000 each

GemStone Professional Services can provide expert assistance in establishing your configuration, tuning configurations for performance, and ensuring your configuration can accommodate predicted growth.

> More information about the individual settings is provided in the detailed instructions for establishing your own configuration, in Chapter 2, "Configuring the GemStone Server". For details on the specific configuration parameters, see Appendix A.

1.7 Avoiding risk of Data loss

Protecting data against any risk of loss is a critical part of configuration and application design. Power loss, hardware failure, and disk failures are a risk for any critical system and there are a number of ways to ensure data is protected.

Every unexpected shutdown is different, and the details of how to proceed will depend on the specifics; troubleshooting and recovery is described in more detail in Chapter 6.

GemStone's elements that protect against data loss include:

- Transaction logs allow automatic recovery after a minor failure, such as a power loss.
- Backups, either programmatic or extent copies, allow you to restore to the time of the backup. Transaction logs in full logging mode allow you to restore transactions.
- Disk level mirroring, or RAID storage, for the transaction logs protects against failure of the disks holding transaction logs.
- Hot standbys and warm standbys have secondary systems running in parallel, so they can be made available quickly in case of failure in the primary system.

Recovery vs. Restore

Provided whatever caused the error has been corrected and there is no file damage, a Stone startup following an unexpected shutdown will automatically read the transaction log entries that follow the last checkpoint recorded in the repository, and replay these transactions, recovering the GemStone repository with all committed transactions at the point of shutdown. This is termed "recovery".

If the extent disk files are damaged, you may need to restore from backup. This involves using a previously-made backup, and replaying all transaction logs that were generated since the backup was made. For this to succeed, you must have a complete set of backup files, and each of the transaction logs that were generated since the time that the backup was started.

Developing a Failover Strategy

The particular strategy to use to protect your data, depends on what the tolerance for data loss is, how soon your application must be available again following an unexpected outage, and the resources available to support a strategy.

Making regular backups and using full transaction logging mode provides the minimal amount of reliability.

Assuming that backups are kept on a separate disk, mirroring the transaction logs (using OS-level tools) avoids the risk of a disk failure causing loss of committed transactions.

A warm or hot standby system can allow the fastest failover, by keeping a secondary system running at all times. In this case, only a minimal amount of further restore is needed before the standby is usable.

For more on standbys, see Chapter 13, "Warm and Hot Standbys", starting on page 257

Verifying strategy

Backups are a form of insurance; they are essential, but may never actually be needed.

While it is not part of everyday operations, it is imperative that you periodically verify that your backup files are correct and usable, and that you know how to perform the recovery or failover operations. When and if a disk failure or other problem occurs, that will be too late to discover you have no recent backups or the backup process has been failing and the backups you have are unusable.

The pressure of a production-down application is not an ideal time for creating your failover or recovery process, nor for the first time executing any failover processes.

1.8 Running a Second Repository

You can run more than one repository on a single node—for example, separate production and development repositories. There are several points to keep in mind:

- Each repository requires its own Stone repository monitor process, extent files, transaction logs, and configuration file. Each Stone will start its own shared page cache monitor and a set of other processes, as described on page 22.
- Multiple Stones that are running the same version of GemStone can share a single installation directory, provided that you create separate repository extents, transaction logs, and configuration files.
- You must give each Stone a unique name at startup. That name is used to identify the server and to maintain separate log files. Users will connect to the repository by specifying the Stone's name.
- A single NetLDI typically serves all Stones and Gem session processes on a given node, provided both Stones are running the same version. If you are running two different versions of GemStone, you will need two NetLDIs.

Chapter

2 Configuring the GemStone Server

This chapter tells you how to configure the GemStone server processes, repository, transaction logs, and shared page cache to meet the needs of a specific application. It includes the following topics:

Server Components (page 37)
The basics of GemStone server configuration, and setting up a basic configuration.

Configuring Extents and Transaction Logs (page 41)
Determining the important parameters for your needs, and how to setup your system.

How To Access the Server Configuration at Run Time (page 53)
Adjustments that can be made to your system while GemStone is running.

Tuning Server Performance (page 55)
Tuning the GemStone server for performance.

This chapter describes configuring the GemStone server; for information about configuring session processes for clients, refer to Chapter 3.

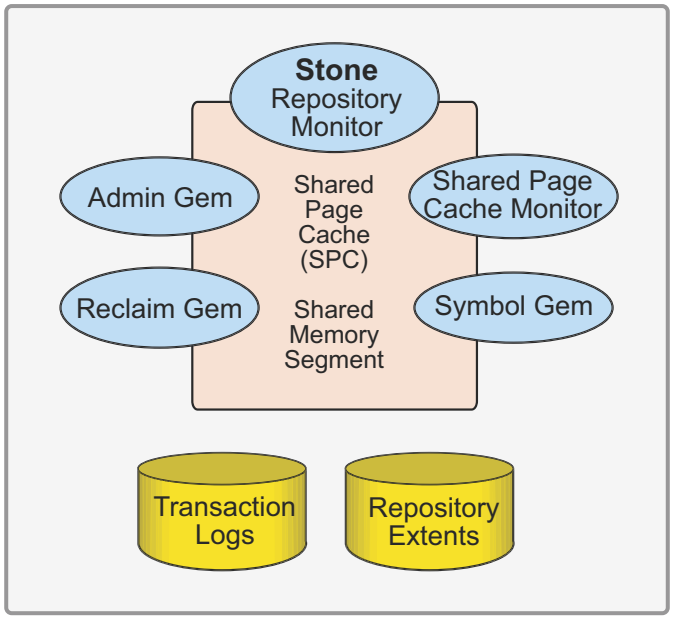
For instructions on starting up the GemStone server, and troubleshooting, see Chapter 6.

2.1 Server Components

The Server is the heart of the GemStone Object Repository. The GemStone server holds the shared classes and objects that compose your data and the shared portion of your application. These classes and objects are written to disk for reliability, and cached in memory for performance. A number of processes work together to keep the GemStone repository running smoothly and support multiple users with different demands and requirements.

The server components are shown in Figure 2.1.

Figure 2.1 The GemStone Server Components



The Server Configuration File

At start-up time, GemStone reads a system-wide configuration file. By default this file is `$GEMSTONE/data/system.conf`, where GEMSTONE is an environment variable that points to the directory in which the GemStone software is installed.

Appendix A, "GemStone Configuration Options", describes the various ways to specify the configuration file to use, and syntax of this file, as well as describing each individual configuration parameter.

There are a large number of configuration options; some are specific to the Stone, some for Gems, some to the shared page cache monitor, and others used by all processes. Most parameters have default values that apply if the parameter is not explicitly set, or if there is a syntax error.

Before you begin

To configure GemStone, it is necessary to know or estimate the following:

- The maximum number of simultaneous sessions that will be logged in to the repository. This may include more than one session per user. You should size your system to accommodate the maximum number of users, plus a few extra for administrative logins.
- The approximate size of your repository, and how much you expect it to grow. For a new system, it may be impossible to come up with a realistic number. The example configurations described in "Example Configurations" on page 33 may give you some idea, but application requirements vary widely.

Number of User Sessions

The maximum number of users is set by the configuration parameter STN_MAX_SESSIONS. This defaults to 40, but on startup, the Stone checks for keyfile limits, and if your licensed limit is less than 40, the maximum number of sessions allowed by the keyfile is applied.

Since the Shared Page Cache (SPC) sets aside individual space for the maximum number of sessions, setting this much larger than you require creates overhead. However, if at some point you do need more sessions than you have configured as the limit, the cache and stone must be restarted with the larger configuration value.

This limit is for user sessions, and does not need to accommodate logins for GemStone server processes (such as the Garbage Collection Gems). However, some operations, including multi-threaded administrative operations, will take their additional sessions from the user session count.

The SHR_PAGE_CACHE_NUM_PROCS is normally derived from STN_MAX_SESSIONS, but may be explicitly set. This limit must accommodate the GemStone system processes as well as the number of user sessions.

Shared Page Cache

The Shared Page Cache (SPC), a shared memory segment that all Server processes attach to, is central to the operation and performance of your repository.

The size of the shared page cache is usually the most significant factor in performance. The first goal in sizing the shared page cache is to make it large enough to hold the application's working set of objects, to avoid the performance overhead of having to read pages from the disk extents. It is particularly important that the pages that make up the object table, which holds pointers to the data pages, can fit in the shared page cache.

Since additional memory is needed for Gem temporary memory, the C heap, and other system loads; in general, the shared page cache should be configured at no more than 75% of the available memory, though the actual limit depends on the absolute amount of memory and the specific use cases.

Recommendations for sizing the shared page cache:

- Configuring the shared page cache as large as possible up to the size of the repository and up to about 75% of system RAM is recommended.
- A shared page cache size of less than 10% of your repository size may not hold the entire object table, and is likely to see performance degradation.
- For maximum performance, the shared page cache can be made large enough to hold the entire repository. After cache warming, sessions should always find the objects in the cache, and never have to perform page reads.
- For large caches, you may also use large memory pages for the shared page cache, if available on your operating system; large memory pages are configurable on Linux and AIX. See the *Installation Guide* for the appropriate platform for details on configuring large memory pages.

Once your application is running, you can refine your estimate of the optimal cache size by monitoring the free space, and use this to tune your configuration. See "Monitoring Performance" on page 139; some relevant statistics are NumberOfFreeFrames, FramesFromFreeList, and FramesFromFindFree.

For example, if you have 20GB of RAM, to set the size of the shared page cache to 15 GB:

```
SHR_PAGE_CACHE_SIZE_KB = 15 GB;
```

Verifying OS support for sufficient Shared Memory

To ensure that your OS has enough memory to handle the desired cache size:

Step 1. Ensure that your OS is configured to allow shared memory segments of the intended size, as described in the *Installation Guide* for your platform.

Step 2. The shared page cache sizing depends in part on the maximum number of sessions that will be logged in simultaneously. Ensure that the STN_MAX_SESSIONS configuration option is set correctly for your application requirements.

Step 3. Use GemStone's **shmem** utility to verify that your OS kernel supports the chosen cache size and number of processes. The command line is

`$GEMSTONE/install/shmem` *existingFile cacheSizeKB numProcs*

where:

- `$GEMSTONE` is the directory where the GemStone software is installed.
- *existingFile* is the name of any writable file, which is used to obtain an id (the file is not altered).
- *cacheSizeKB* is the SHR_PAGE_CACHE_SIZE_KB setting.
- *numProcs* is the value calculated for SHR_PAGE_CACHE_NUM_PROCS. It is computed by STN_MAX_SESSIONS + STN_MAX_GC_RECLAIM_SESSIONS + 1 + SHR_NUM_FREE_FRAME_SERVERS + STN_NUM_LOCAL_AIO_SERVERS + 8.

  For an existing system, you can find the computed value in the Stone log file.

For instance, for a 1.5 GB shared cache and *numProcs* calculated using all default configuration settings:

```
% touch /tmp/shmem
% $GEMSTONE/install/shmem /tmp/shmem 1500000 52
% rm /tmp/shmem
```

If **shmem** is successful in obtaining a shared memory segment of sufficient size, no message is printed. Otherwise, diagnostic output will help you identify the kernel parameter that needs tuning. The total shared memory requested includes cache overhead for cache space and per-session overhead. The actual shared memory segment in this example would be 104865792 bytes (your system might produce slightly different results).

Other shared page caches

Each Stone has a single shared page cache on its own node, and may have remote page caches on other nodes in distributed configurations (discussed in detail in Chapter 5). The configurations for remote shared pages caches may be different than for the Stone's shared page cache.

2.2 Configuring Extents and Transaction Logs

The extents and transaction logs hold the disk-based storage of your GemStone objects. You must configure the location and sizes for these, ensuring that disk I/O does not limit performance.

Encrypted Extents

The extents and transaction logs for your repository may be encrypted, if required by your security needs. Encryption of the extents will automatically created encrypted transaction logs. With encrypted extents, there are additional considerations when starting the stone, performing backup and restore, pageaudit, and similar maintenance operations. Encrypted extents are otherwise transparent, and do not affect user logins, code execution, and other normal operation.

How to setup and manage encrypted extents and transaction logs is described in Chapter 12, "Encrypted Extents and Transaction Logs".

The configuration, sizing, and related information in this section applies to both regular and encrypted extents.

Recommendations About Disk Usage

If you are using a SAN or a disk using some RAID configurations, the following discussion is not entirely applicable, since the distribution to physical media is handled for you and GemStone's configuration may not affect I/O contention. However, if you see I/O performance issues you may need to review your disk configuration.

A file system on an SSD will give the fastest performance for transaction logs, and is easier to manage than raw partitions. The SSD should be an NVMe device or PCIe card or be in a storage array with a high bandwidth connection (rather than connected by SATA), if very high IO rates are needed. File system extents on SSD are also highly performant.

If you are setting up a large repository and you do not have a SAN or RAID disks, it is recommended that you configure your system with three or more separate physical drives for improved performance. Performance bottlenecks can occur in reading or writing to the extents or in updating the transaction logs.

When developing your configuration, bear in mind the following guidelines:

1. Keep extents and transaction logs separate from a drive with operating system swap space.
2. Keep the extents and transaction logs separate from each other. You can place multiple transaction logs on the same disk, since only one log file is active at a time.
3. Transaction logs can be placed on SSD drives or raw partitions for the best performance in update-intensive systems. Using raw partitions requires two or more partitions to allow switching.
4. With applications on disk drives, using multiple extents on multiple physically distinct drives (i.e., not logical partitions), and with weighted allocation mode, improves performance. For details about weighted allocation, see "Allocating Data to Multiple Extents" on page 45.

Raw Partitions

Each raw disk partition is like a single large sequential file, with one extent or one transaction log per partition.

Usually, placing extents on file systems is as fast as using raw partitions. File system extents may perform better, since operating system file buffers may improve I/O.

Placing transaction logs on raw partitions is likely to yield better performance, particularly in an update-intensive application, since such applications primarily are writing sequentially to the active transaction log. Using raw partitions can improve the maximum achievable commit rate by avoiding the extra file system operations necessary to ensure that each log entry is recorded on the disk.

Transaction logs use sequential access exclusively, so the devices can be optimized for that access.

Because each partition holds a single log or extent, if you place transaction logs in raw partitions, you must provide at least two such partitions so that GemStone can preserve one log when switching to the next. The transaction log in each partition must be archived and cleared while the other transaction log is being updated. If your application has a high transaction volume, you are likely to need additional raw partitions for more logs.

For information about using raw partitions, see “How To Set Up a Raw Partition” on page 50.

NFS

Although the Network File System (NFS) can be used to share executables, libraries, and configuration files, they are not recommended, and by default disallowed, for sharing repository extents and tranlogs. This is controlled by the configuration parameter STN_ALLOW_NFS_EXTENTS.

Keyfile limits on repository size

Some GemStone licencing terms place a limit on the maximum size of the repository, which is limited by the keyfile. If the keyfile has this limit, it is important to avoid your repository’s size reaching the limit, since GemStone requires some overhead to reclaim space. If the hard limit of the licence file is reached, you will need to contact GemTalk Technical Support for a temporary keyfile with an increased limit.

With a repository-size-limited keyfile, it is strongly recommended that you do not set a repository size (in which case the limit will be computed as 80% of the licence limit), or if you do, set the limit to 80% of your keyfile limit. If your repository grows such that it reaches this limit, the Stone will shut down due to out of space; however, you will be able to manually set a larger size to restart the Stone and delete objects or collect garbage, to make space available.

Configuring the Repository Extents

Configuring the repository extents involves these primary considerations:

- Providing sufficient disk space
- Minimizing I/O contention
- Providing fault tolerance

Estimating Extent Size

When you estimate the size of the repository, allow 10 to 20% for fragmentation. Also allow at least 0.5 MB of free space for each session that will be logged in simultaneously. In addition, while the application is running, overhead is needed for objects that are created or that have been dereferenced but are not yet removed from the extents. The amount of extent space required for this depends strongly on the particular application and how it is used.

Reclaim operations and sessions with long transactions may also require a potentially much larger amount of extent free space for temporary data. To avoid the risk of out of space conditions, it is recommended to allow a generous amount of free space.

If there is room on the physical disks, and the extents are not at their maximum sizes as specified using DBF_EXTENT_SIZES, then the extents will grow automatically when additional space is needed.

The extent sizes and limits that the system uses are always in multiples of 16MB; using a number that is not a multiple of 16MB results in the next smallest multiple of 16MB being actually used.

If the free space in extents falls below a level set by the STN_FREE_SPACE_THRESHOLD configuration option, the Stone takes a number of steps to avoid shutting down. However, if these steps are not effective, the Stone will shut down. For information, see "Recovering from Disk-Full Conditions" on page 198.

For planning purposes, you should allow additional disk space for making GemStone backups and for making a copy of the repository when upgrading to a new release. Also, you may want to allocate space for retaining the set of transaction logs generated between backups, to allow system recovery.

Choosing the Extent Location

You should consider the following factors when deciding where to place the extents:

- Keep extents on a spindle different from operating system swap space.
- Where possible, keep the extents and transaction logs on separate spindles.

Specify the location of each extent in the configuration file. Two examples:

```
DBF_EXTENT_NAMES = $GEMSTONE/data/extent0.dbf
```

```
DBF_EXTENT_NAMES = /gshost/GemStone3.6/data/dbf1.dbf,
   /gshost/GemStone3.6/data/dbf2.dbf,
   /gshost/GemStone3.6/data/dbf3.dbf;
```

Extent disk configuration

Extents benefit primarily from efficiency of random access (to the 16 KB repository pages). Using RAID devices or other storage that cannot efficiently support random access may reduce overall performance. Disk mirroring may give better results.

Setting a Maximum Size for an Extent

You can specify a maximum size for each extent through the DBF_EXTENT_SIZES configuration option. When the extent reaches that size, GemStone stops allocating space

in it. If no size is specified, which is the default, GemStone continues to allocate space for the extent until the file system or raw partition is full.

For best performance using raw partitions, the maximum size should be 16MB smaller than the size of the partition, so that GemStone can avoid having to handle system errors. For example, for a 2 GB partition, set the size to 1984 MB.

Each size entry is for the corresponding entry in the DBF_EXTENT_NAMES configuration option Use a comma to mark the position of an extent for which you do not want to specify a limit.

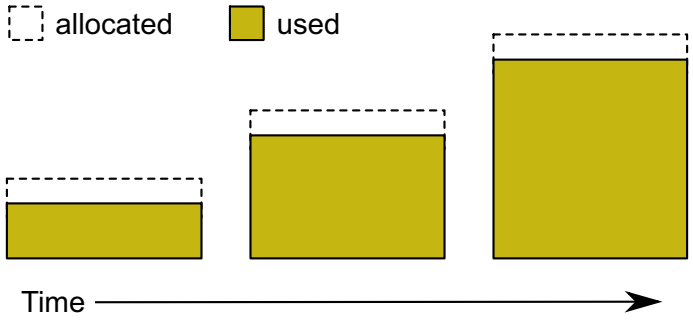
The first example here specifies the size of a single extent, while the second specifies sizes of the first and third extents:

```
DBF_EXTENT_SIZES = 500MB;
DBF_EXTENT_SIZES = 1GB, , 500MB;
```

Pregrowing Extents to a Fixed Size

Allocating disk space requires a system call that introduces run time overhead. Each time an extent is expanded (Figure 2.2), your application must incur this overhead and then initialize the added extent pages.

Figure 2.2 Growing an Extent on Demand



You can increase I/O efficiency while reducing file system fragmentation by instructing GemStone to allocate an extent to a predetermined size (called pregrowing it) at startup.

You can specify a pregrow size for each extent through the DBF_PRE_GROW configuration option. When this is set, the Stone repository monitor allocates the specified amount of disk space when it starts up with an extent that is smaller than the specified size. The extent files can then grow as needed up to the limit of DBF_EXTENT_SIZES, if that is set, or to the limits of disk space.

Pregrowing extents avoids repeated system calls to allocate and initialize additional space incrementally. This technique can be used with any number of extents, and with either raw disk partitions or extents in a file system.

The disadvantages of pregrowing extents are that it takes longer to start up GemStone, and unused disk space allocated to pregrown extents is unavailable for other purposes.

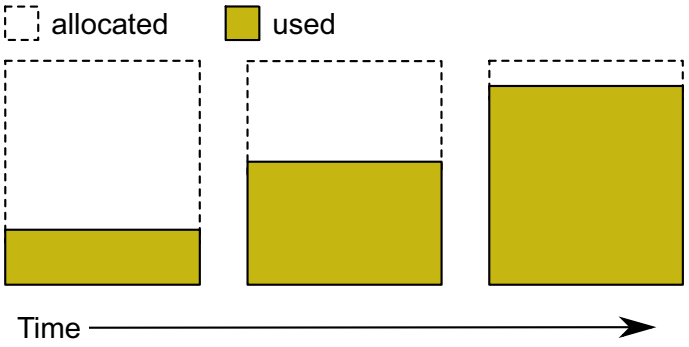
During startup, the Stone starts pregrow page server processes to handle the pregrow.

Pregrowing Extents to the Maximum Size

You may pregrow extents to the maximum sizes specified in DBF_EXTENT_SIZES by setting DBF_PRE_GROW to True, rather than to a list of pregrow sizes.

Pregrowing extents to the maximum size provides a simple way to reserve space on a disk for a GemStone extent. Since extents cannot be expanded beyond the maximum specified size, the system should be configured with sufficiently large extent sizes that the limit will not be reached, to avoid running out of space.

Figure 2.3 Pregrowing an Extent



Two configuration options work together to pregrow extents. DBF_PRE_GROW (page 317) enables the operation, and optionally sets a minimum value to which to size that extent. When DBF_PRE_GROW is set to True, the Stone repository monitor allocates the space specified by DBF_EXTENT_SIZES (page 317) for each extent, when it creates a new extent or starts with an extent that is smaller than the specified size. It may also be set to a list of sizes, which sets the pregrow size individually for each extent to a value that is smaller than DBF_EXTENT_SIZES.

For example, to pregrow extents to the maximum size of 1 GB each:

```
DBF_EXTENT_SIZES = 1GB, 1GB, 1GB;
DBF_PRE_GROW = TRUE;
```

To pregrow extents to 500M, but allow them to later expand to 1 GB if GemStone requires additional space, and that disk space is available:

```
DBF_EXTENT_SIZES = 1GB, 1GB, 1GB;
DBF_PRE_GROW = 500MB, 500MB, 500MB;
```

Allocating Data to Multiple Extents

Larger applications may improve performance by dividing the repository into multiple extents. Assuming the extents are on multiple spindles or the disk controller manages files as if they were, this allows several extents to be active at once.

The setting for the DBF_ALLOCATION_MODE configuration option determines whether GemStone allocates new disk pages to multiple extents by filling each extent sequentially or by balancing the extents using a set of weights you specify. Weighted allocation yields better performance because it distributes disk accesses.

Sequential Allocation

By default, the Stone repository monitor allocates disk resources sequentially by filling one extent to capacity before opening the next extent. (See Figure 2.4 on page 46) For example, if a logical repository consists of three extents named A, B, and C, then all of the disk resources in A will be allocated before any disk resources from B are used, and so forth. Sequential allocation is used when the DBF_ALLOCATION_MODE configuration option is set to SEQUENTIAL.

Weighted Allocation

For weighted allocation, you use DBF_ALLOCATION_MODE to specify the number of extent pages to be allocated from each extent on each allocation request. The allocations are positive integers in the range 5..200, with each element corresponding to an extent of DBF_EXTENT_NAMES. For example:

```
DBF_EXTENT_NAMES = a.dbf, b.dbf, c.dbf;
DBF_ALLOCATION_MODE = 12, 20, 8;
```

You can think of the total weight of a repository as the sum of the weights of its extents. When the Stone allocates space from the repository, each extent contributes an allocation proportional to its weight.

One reason for specifying weighted allocation is to share the I/O load among a repository's extents. For example, you can create three extents with equal weights, as shown in Figure 2.5 on page 47.

Figure 2.4 Sequential Allocation

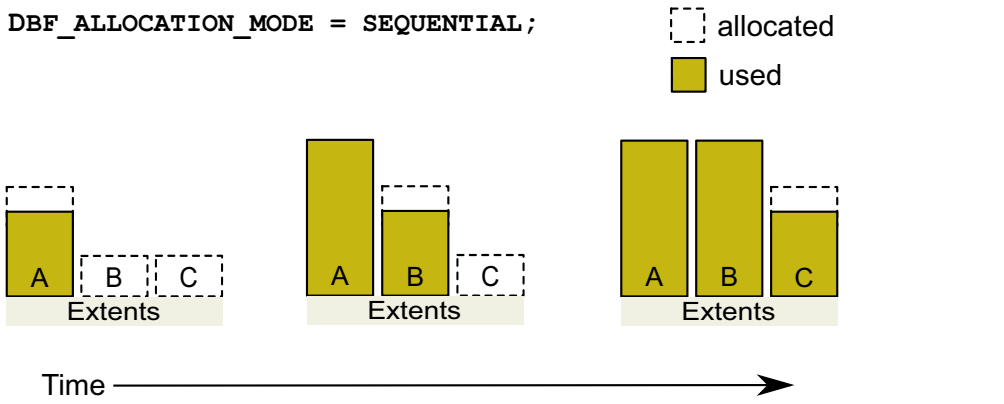
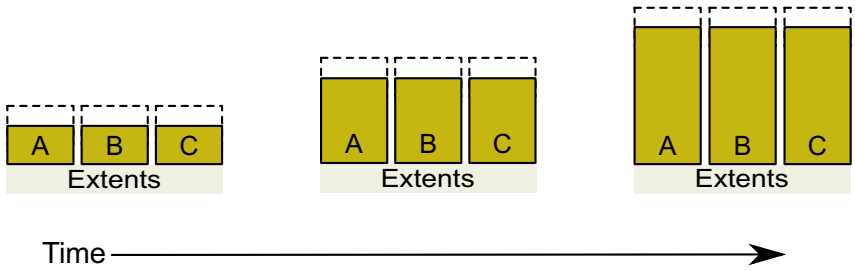


Figure 2.5 Equally Weighted Allocation

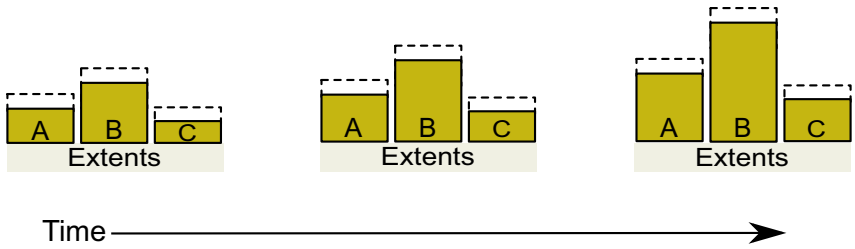
```
DBF_ALLOCATION_MODE = 10, 10, 10;
```



Although equal weights are most common, you can adjust the relative extent weights for other reasons, such as to favor a faster disk drive. For example, suppose we have defined three extents: A, B, and C. If we defined their weights to be 12, 20, and 8 respectively, then for every 40 disk units (pages) allocated, 12 would come from A, 20 from B, and 8 from C. Another way of stating this formula is that because B's weight is 50% of the total repository weight, 50% of all newly-allocated pages are taken from extent B. Figure 2.6 shows the result.

Figure 2.6 Proportionally Weighted Allocation

```
DBF_ALLOCATION_MODE = 12, 20, 8;
```



You can modify the relative extent weights by editing your GemStone configuration file to modify the values for DBF_ALLOCATION_MODE, or to change DBF_ALLOCATION_MODE to SEQUENTIAL; the new allocation scheme take effect the next time you start GemStone. The changes do not affect existing page allocations, only how pages are allocated for ongoing page requirements.

Weighted Allocation for Extents Created at Run Time

Smalltalk methods for creating extents at run time (`Repository>>createExtent:` and `Repository>>createExtent:withMaxSize:`) do not provide a way to specify a weight for the newly-created extent. If your repository uses weighted allocation, the Stone repository monitor assigns the new extent a weight that is the simple average of the repository's existing extents. For instance, if the repository is composed of three extents with weights 6, 10, and 20, the default weight of a newly-created fourth extent would be 12 (36 divided by 3).

Configuring the Transaction Logs

Configuring the transaction logs involves considerations similar to those for extents:

- Providing sufficient disk space
- Minimizing I/O contention
- Providing fault tolerance, through the choice of logging mode

Logging Mode

GemStone provides two modes of transaction logging:

- *Full logging*, the default mode, provides real-time incremental backup of the repository. Deployed applications should use this mode. All transactions are logged regardless of their size, and the resulting logs can used in restoring the repository from a GemStone backup.
- *Partial logging* is intended for use during evaluation or early stages of application development. Partial logging allows a simple operation to run unattended for an extended period and permits automatic recovery from system crashes that do not corrupt the repository. Logs created in this mode cannot be used in restoring the repository from a backup.

In partial logging mode, frequent backups are recommended; any data that is not backed up may be lost if there are disk issues or the repository becomes corrupted.

Full logging is "sticky"; once a repository has started in full logging, changing the logging back to partial logging requires special steps. See "To Change to Partial Logging" on page 210. If you are in partial logging mode, to enable full transaction logging, simply change the configuration setting STN_TRAN_FULL_LOGGING to True and restart the Stone.

After changing from partial to full logging, make a backup as soon as possible. While you may have backups that were made in partial logging mode, these partial-logging-mode backups cannot be used to restore the full-logging-mode transaction logs.

For more information about the logging mode and the administrative differences, see "Logging Modes" on page 203.

Estimating Disk Space for Transaction Logs

How much disk space does your application need for transaction logs? The answer depends on several factors:

- The logging mode that you choose
- Characteristics of your transactions
- How often you archive and remove the logs

If GemStone is in full transaction logging mode (the default), you must allow sufficient space to log all transactions until you next archive the logs.

CAUTION

If the Stone exhausts the transaction log space, users will be unable to commit transactions until space is made available.

GemStone is writing to exactly one log at any given time. The number of transaction logs that should be available for automatic recovery will include this log, of course, and zero or more previous logs. The number of previous logs that is needed depends on the time of the most recent checkpoint, and if there are any long-running transactions.

The method `Repository>>oldestLogFileIdForRecovery` identifies the oldest log file needed for recovery from the most recent checkpoint, if the Stone were to crash. These log files should be left in place to allow automatic recovery.

Log files older than this are needed only if it becomes necessary to restore the repository from a backup. These may be archived, but should be kept at least until the next backup is made.

If GemStone is configured for partial logging, you need only provide enough space to maintain transaction logs since the last repository checkpoint. Ordinarily, two log files are sufficient: the current log and the immediately previous log, although in some cases additional logs are kept. There is no need to retain or archive logs; in partial logging mode, transaction logs can only be used only after an unexpected shutdown, to recover transactions since the last checkpoint.

Choosing the Log Location and Size Limit

The considerations in choosing a location for transaction logs are similar to those for extents:

- Keep transaction logs on a different disk than operating system swap space.
- Where possible, keep the extents and transaction logs on separate disks—doing so reduces I/O contention while increasing fault tolerance.
- Because update-intensive applications primarily are writing to the transaction log, storing raw data in a disk partition (rather than in a file system) may yield better performance.
- Transaction logs on SSDs provide the best performance

WARNING

Because the transaction logs are needed to recover from a system crash, do NOT place them in directories such as /tmp *that are automatically cleared during power-up.*

Transaction logs use sequential access exclusively, so the devices can be optimized for that access.

With raw partitions, or when in partial transaction logging mode, GemStone requires at least two log locations (directories or raw partitions) so it can switch to another when the current one is filled. In full transaction mode, logging to transaction logs on the file system, one directory may be used, in which case all transaction logs are created in that directory.

When you set the log locations in the configuration file, you should also check their size limit.

Although the size of 100 MB provided in the default configuration file is adequate in many situations, update-intensive applications should consider a larger size to limit the

frequency with which logs are switched. Each switch causes a checkpoint to occur, which can impact performance.

NOTE

For best performance using raw partitions, the size setting should be slightly smaller than the size of the partition so GemStone can avoid having to handle system errors. For example, for a 2 GB partition, set it to 1998 MB.

The following example sets up a log in a 2 GB raw partition and a directory of 100 MB logs in the file system. This setup is a workable compromise when the number of raw partitions is limited. The file system logs give the administrator time to archive the primary log when it is full.

```
STN_TRAN_LOG_DIRECTORIES = /dev/rdsk/c4d0s2, /user3/tranlogs;
STN_TRAN_LOG_SIZES = 1998, 100;
```

All of the transaction logs must reside on Stone's node.

How To Set Up a Raw Partition

WARNING

Using raw partitions requires extreme care. Overwriting the wrong partition destroys existing information, which in certain cases can make data on the entire disk inaccessible.

Raw partitions are system-dependent; you will need to work with your system administrator and consult your system documentation to setup or locate a partition of suitable size.

You can mix file system-based files and raw partitions in the same repository, and you can add a raw partition to existing extents or transaction log locations. The partition reference in `/dev` must be readable and writable by anyone using the repository, so you should give the entry in `/dev` the same protection as you would use for the corresponding type of file in the file system.

The first step is to find a partition (raw device) that is available for use. Depending on your operating system, a raw partition may have a name like `/dev/rdsk/c1t3d0s5`, `/dev/rsd2e`, or `/dev/vg03/rlvol1`. A partition is available if all of the following are true:

- It does not contain the root (/) file system (on some systems, the root volume group).
- It is not on a device that contains swap space.
- Either it does not contain a file system or that file system can be left unmounted and its contents can be overwritten.
- It is not already being used for raw data.

When you select a partition, make sure that any file system tables, such as `/etc/vfstab`, do not call for it to be mounted at system boot. Use **chmod** and **chown** to set read-write permissions and ownership of the special device file the same way you would protect a repository file in a file system.

If the partition will contain the primary extent (the first or only one listed in DBF_EXTENT_NAMES), initialize it by using the GemStone **copydbf** utility to copy an existing repository extent to the device. The extent must not be in use when you copy it. If

the partition already contains a GemStone file, first use **removedbf** to mark the partition as being empty.

Partitions for transaction logs do not need to be initialized, nor do secondary extents into which the repository will expand later.

Sample Setup for Extent on Raw Partition

The following example configures GemStone to use the raw partition `/dev/rsd2d` as the repository extent.

Step 1. If the raw partition already contains a GemStone file, mark it as being empty. (The **copydbf** utility will not overwrite an existing repository file.)

```
% removedbf /dev/rsd2d
```

Step 2. Use **copydbf** to install a fresh extent on the raw partition. (If you copy an existing repository, first stop any Stone that is running on it, or suspend checkpoints)

```
% copydbf $GEMSTONE/bin/extent0.dbf /dev/rsd2d
```

Step 3. As root, change the ownership and the permission of the partition special device file in `/dev` to what you ordinarily use for extents in a file system. For instance:

```
# chown gsAdmin /dev/rsd2d
# chmod 600 /dev/rsd2d
```

You should also consider restricting the execute permission for `$GEMSTONE/bin/removedbf` and `$GEMSTONE/bin/removeextent` to further protect your repository. In particular, these executable files should not have the setuid (S) bit set.

Step 4. Edit the Stone's configuration file to show where the extent is located:

```
DBF_EXTENT_NAMES = /dev/rsd2d;
```

Step 5. Use **startstone** to start the Stone repository monitor in the usual manner.

Changing Between Files and Raw Partitions

This section tells you how to change your configuration by moving existing repository extent files to raw partitions or by moving existing extents in raw partitions to files in a file system. You can make similar changes for transaction logs.

Moving an Extent to a Raw Partition

To move an extent from the file system to a raw partition, do this:

Step 1. Define the raw disk partition device. Its size should be at least 16 MB larger than the existing extent file.

Step 2. Stop the Stone repository monitor.

Step 3. Edit the repository's configuration file, substituting the device name of the partition for the file name in DBF_EXTENT_NAMES (page 316).

Set DBF_EXTENT_SIZES for this extent to be 16 MB smaller than the size of the partition.

Step 4. Use **copydbf** to copy the extent file to the raw partition. (If the partition previously contained a GemStone file, first use **removedbf** to mark it as unused.)

Step 5. Restart the Stone.

Moving an Extent to the File System

The procedure to move an extent from a raw partition to the file system is similar:

Step 1. Stop the Stone repository monitor.

Step 2. Edit the repository's configuration file, substituting the file path and name for the name of the partition in DBF_EXTENT_NAMES.

Step 3. Use **copydbf** to copy the extent to a file in a file system, then set the file permissions to the ones you ordinarily use.

Step 4. Restart the Stone.

Moving Transaction Logging to a Raw Partition

To switch from transaction logging in the file system to logging in a raw partition, do this:

Step 1. Define the raw disk partition. If you plan to copy the current transaction log to the partition, its size should be at least 1 to 2 MB larger than current log file.

Step 2. Stop the Stone repository monitor.

Step 3. Edit the repository's configuration file, substituting the device name of the partition for the directory name in STN_TRAN_LOG_DIRECTORIES (page 358). Make sure that STN_TRAN_LOG_SIZES for this location is 1 to 2 MB smaller than the size of the partition.

Step 4. Use **copydbf** to copy the current transaction log file to the raw partition. (If the partition previously contained a GemStone file, first use **removedbf** to mark it as unused.)

You can determine the current log from the last message "Creating a new transaction log" in the Stone's log. If you don't copy the current transaction log, the Stone will open a new one with the next sequential fileId, but it may be opened in another location specified by STN_TRAN_LOG_DIRECTORIES.

Step 5. Restart the Stone.

Moving Transaction Logging to the File System

The procedure to move transaction logging from a raw partition to the file system is similar:

Step 1. Stop the Stone repository monitor.

Step 2. Edit the repository's configuration file, substituting a directory path and name for the name of the partition in STN_TRAN_LOG_DIRECTORIES.

Step 3. Use **copydbf** to copy the current transaction log to a file in the specified directory. The **copydbf** utility will generate a file name like tranlog*nnn*.dbf, where *nnn* is the internal fileId of that log.

Step 4. Restart the Stone.

Server Response to Gem Fatal Errors

The Stone repository monitor is configurable in its response to a fatal error detected by a Gem session process. If configured to do so, the Stone can halt and dump debug information if it receives notification from a Gem that the Gem process died with a fatal error. By stopping both the Gem and the Stone at this point, the possibility of repository corruption is minimized.

In the default mode, the Stone does not halt if a Gem encounters a fatal error. This is usually preferable for deployed production systems.

During application development, it may be helpful to know exactly what the Stone was doing when the Gem went down. It may in some cases be preferred to absolutely minimize the risk of repository corruption, at the risk of system outage. To configure the Stone to halt when a fatal gem error is encountered, change the following in the Stone's configuration file:

```
STN_HALT_ON_FATAL_ERR = TRUE;
```

2.3 How To Access the Server Configuration at Run Time

GemStone provides several methods in class System that let you examine, and in certain cases modify, the configuration parameters at run time from Smalltalk.

To Access Current Settings at Run Time

Class methods in System, in the in category Configuration File Access, let you examine the system's Stone configuration. The following access methods all provide similar server information:

`stoneConfigurationReport`
: Returns a SymbolDictionary whose keys are the names of configuration file parameters, and whose values are the current settings of those parameters in the repository monitor process.

`configurationAt:` *aName*
: Returns the value of the specified configuration parameter, giving preference to the current session process if the parameter applies to a Gem.

`stoneConfigurationAt:` *aName*
: Returns the value of the specified configuration parameter from the Stone process, or returns `nil` if that parameter is not applicable to a Stone.

Here is a partial example of the Stone configuration report:

```
topaz 1> printit
System stoneConfigurationReport asReportString
%
#'StnEpochGcEnabled'    false
#'StnCrBacklogThreshold'        80
#'STN_TRAN_LOG_SIZES'   100
#'StnTranLogDebugLevel' 0
...
```

Keys in mixed capitals and lowercase, such as `StnEpochGcEnabled`, are internal run-time parameters.

To Change Settings at Run Time

The class method `System class>>configurationAt:` *aName* `put:` *aValue* lets you change the value of the internal run-time parameters in Table 2.1, if you have the appropriate privileges.

In the reports described in the preceding section, parameters with names in all uppercase are read-only; for parameters that can be changed at runtime, the name is in mixed case.

CAUTION

Avoid changing configuration parameters unless there is a clear reason for doing so. Incorrect settings can have serious adverse effects on performance. For additional guidance about run-time changes to specific parameters, see Appendix A, "GemStone Configuration Options".

Table 2.1 Server Configuration Parameters Changeable at Run Time

Configuration File Option	Internal Parameter	Required Privilege
SHR_SPIN_LOCK_COUNT	#SpinLockCount	Login as SystemUser
STN_ADMIN_GC_SESSION_ENABLED	#StnAdminGcSessionEnabled	GarbageCollection
STN_CHECKPOINT_INTERVAL	#StnCheckpointInterval	Login as SystemUser
STN_COMMIT_QUEUE_THRESHOLD	#StnCommitQueueThreshold	Login as SystemUser
STN_CR_BACKLOG_THRESHOLD	#StnCrBacklogThreshold	Login as SystemUser
STN_DISABLE_LOGIN_FAILURE_LIMIT	#StnDisableLoginFailureLimit	OtherPassword
STN_DISABLE_LOGIN_FAILURE_TIME_LIMIT	#StnDisableLoginFailureTimeLimit	OtherPassword
STN_DISKFULL_TERMINATION_INTERVAL	#StnDiskFullTerminationInterval	Login as SystemUser
STN_EPOCH_GC_ENABLED	#StnEpochGcEnabled	GarbageCollection
STN_FREE_SPACE_THRESHOLD	#StnFreeSpaceThreshold	Login as SystemUser
STN_GEM_ABORT_TIMEOUT	#StnGemAbortTimeout	Login as SystemUser
STN_GEM_LOSTOT_TIMEOUT	#StnGemLostOtTimeout	Login as SystemUser
STN_GEM_TIMEOUT	#StnGemTimeout	Login as SystemUser
STN_HALT_ON_FATAL_ERR	#StnHaltOnFatalErr	Login as SystemUser
STN_LOG_LOGIN_FAILURE_LIMIT	#StnLogLoginFailureLimit	OtherPassword
STN_LOG_LOGIN_FAILURE_TIME_LIMIT	#StnLogLoginFailureTimeLimit	OtherPassword
STN_LOOP_NO_WORK_THRESHOLD	#StnLoopNoWorkThreshold	Login as SystemUser
STN_MAX_AIO_RATE	#StnMntMaxAioRate	Login as SystemUser
STN_MAX_LOGIN_LOCK_SPIN_COUNT	#StnMaxLoginLockSpinCount	SystemControl
STN_MAX_VOTING_SESSIONS	#StnMaxVotingSessions	Login as SystemUser
STN_NUM_GC_RECLAIM_SESSIONS	#StnNumGcReclaimSessions	GarbageCollection
STN_OBJ_LOCK_TIMEOUT	#StnObjLockTimeout	SystemControl
STN_PAGE_MGR_COMPRESSION_ENABLED	#StnPageMgrCompressionEnabled	Login as SystemUser

Table 2.1 Server Configuration Parameters Changeable at Run Time (Continued)

Configuration File Option	Internal Parameter	Required Privilege
STN_PAGE_MGR_MAX_WAIT_TIME	#StnPageMgrMaxWaitTime	Login as SystemUser
STN_PAGE_MGR_PRINT_TIMEOUT_THRESHOLD	#StnPageMgrPrintTimeoutThresh-old	Login as SystemUser
STN_PAGE_MGR_REMOVE_MAX_PAGES	#StnPageMgrRemoveMaxPages	Login as SystemUser
STN_PAGE_MGR_REMOVE_MIN_PAGES	#StnPageMgrRemoveMinPages	Login as SystemUser
STN_REMOTE_CACHE_PGSVR_TIMEOUT	#StnRemoteCachePgsvrTimeout	SystemControl
STN_REMOTE_CACHE_TIMEOUT	#StnRemoteCacheTimeout	Login as SystemUser
STN_SHR_TARGET_PERCENT_DIRTY	#ShrPcTargetPercentDirty	Login as SystemUser
STN_SIGNAL_ABORT_CR_BACKLOG	#StnSignalAbortCrBacklog	GarbageCollection
STN_SMC_SPIN_LOCK_COUNT	#StnSmcSpinLockCount	SystemControl
STN_SYMBOL_GC_ENABLED	#StnSymbolGcEnabled	GarbageCollection
STN_TRAN_LOG_DEBUG_LEVEL	#StnTranLogDebugLevel	SystemControl
STN_TRAN_LOG_LIMIT	#StnTranLogLimit	Login as SystemUser
STN_TRANQ_TO_RUNQ_THRESHOLD	#StnTranqToRunqThreshold	Login as SystemUser
(none)	#StnLoginsSuspended	SystemControl

The following example first obtains the value of #StnAdminGcSessionEnabled. This value can be changed at run time by a user with GarbageCollection privilege:

```
topaz 1> printit
System configurationAt: #StnAdminGcSessionEnabled
%
true

topaz 1> printit
System configurationAt: #StnAdminGcSessionEnabled put: false
%
false
```

For more information about these methods, see the comments in the image.

2.4 Tuning Server Performance

There are a number of configuration options by which you can tune the GemStone server. These options can help make better use of resources such as memory and I/O.

Tuning the Shared Page Cache

Two configuration options can help you tailor the shared page cache to the needs of your application: SHR_PAGE_CACHE_SIZE_KB and SHR_SPIN_LOCK_COUNT.

You may also want to consider object clustering within Smalltalk as a means of increasing cache efficiency.

Adjusting the Cache Size

As described under “Shared Page Cache” on page 39, increasing the size of the cache, up to the size that will hold the entire repository, will almost always improve performance. Configuring a large cache to use shared memory pages will also provide benefit.

In particular, a cache that is too small may have to preempt frames in order to load or write pages. You can use the statistics for a running application to monitor the load on the cache. In particular, the statistics FreeFrameCount and FramesFromFindFree may be useful, as well as FramesFromFreeList.

Clustering Objects That Are Accessed Together

Appropriate clustering of objects by the application can allow a smaller shared page cache by reducing the number of data pages in use at once. For general information about clustering objects, see the *Programming Guide*.

Controlling Checkpoint Frequency

On each commit, committed changes are immediately written to the transaction logs, but the writing of this data, recorded on "dirty pages," from the shared page cache to the extents may lag behind.

At a checkpoint, all remaining committed changes that have not yet been written to the extents are written out, and the repository is update to a new consistent committed state. If the volume of these waiting committed changes is high, there may be a performance hit as this data is written out. Between checkpoints, new committed changes written to the extents are not yet considered part of the repository's consistent committed state until the next checkpoint.

If checkpoints interferes with other GemStone activity, you may want to adjust their frequency.

- In full transaction logging mode, most checkpoints are determined by the STN_CHECKPOINT_INTERVAL configuration option, which by default is five minutes. A few Smalltalk methods, such as `Repository>>fullBackupTo:`, force a checkpoint at the time they are invoked. A checkpoint also is performed each time the Stone begins a new transaction log.
- In partial logging mode, checkpoints also are triggered by any transaction that is larger than STN_TRAN_LOG_LIMIT (page 358), which sets the size of the largest entry that is to be appended to the transaction log. The default limit is 1 MB of log space. If checkpoints are too frequent in partial logging mode, it may help to raise this limit. Conversely, during bulk loading of data with large transactions, it may be desirable to lower this limit to avoid creating large log files.

A checkpoint also occurs each time the Stone repository monitor is shut down gracefully, as by invoking **stopstone** or `System class>>shutDown`. This checkpoint permits the Stone to restart without having to recover from transaction logs. It also permits extent files to be copied in a consistent state.

While less frequent checkpoints may improve performance in some cases, they may extend the time required to recover after an unexpected shutdown. In addition, since checkpoints are important in the recycling of repository space, less frequent checkpoints can mean more demand on free space (extent space) in the repository.

Tuning Page Server Behavior

The page servers on the Stone's node are threads within the Stone process that write dirty pages from the shared page cache to disk, and add free frames to the free frame list so they are available for use by Gems.

In addition to these threads in the Stone, there are standalone page server processes that support configurations with remote shared page caches. *Remote cache page servers* and *remote Gem page servers* handle the tasks of handling pages between the Stone's node and the remote shared page cache. These page servers will be described in Chapter 5, "Connecting Distributed Systems"

By default, the Stone starts one AIO page server thread per extent up to 4 extents, and the same number of free frame page server threads.

AIO Page Server Threads

You may benefit from increasing the setting for STN_NUM_LOCAL_AIO_SERVERS in some cases, to ensure that the pages are get written to disk and the frames made available again to meet the demand for available free frames in the cache can be met.

- If you have a large number of extents, especially if they are on separate disks.
- If the number of extents is small but the extents are very large and on fast storage (SSD or striped across multiple drives); in this case, it is recommended to have 2 to 4 threads per extent.

Free Frame Page Server Threads

A Gem can get free frames either from the free list, or, if sufficient free frames have not been added to the list, by scanning the shared page cache for a free frame. Scanning has a serious performance impact.

The GEM_FREE_FRAME_LIMIT configuration option determines the point at which the Gem determines to scan for frames.

To offload the work of adding frames back to the free list, the free frame page server threads are dedicated to adding frames back to the free list. By default, the same number of threads as the AIO page server are started; the number of free frame page server threads should not be less than the number of AIO page server threads, to ensure the distribution of free pages and used pages remains balanced over the extents.

In some cases, increasing the number of free frame page servers can improve overall system performance. For example, if Gems are performing many operations requiring writing pages to disk, the AIO page server threads may have to spend all their time writing pages, never getting a chance to add free frames to the free list. Alternatively, if Gems are performing operations that require only reading, the AIO page server threads will see no dirty frames in the cache—the signal that prompts it to take action. In that case, it may sleep for a second, even though free frames are present in the cache and need to be added to the free list.

Process Free Frame Caches

There is a communication overhead involved in getting free frames from the free frame list for scanning. To optimize this, you can configure the Gems and their remote page servers

to add or remove multiple free frames from a free frame cache to the free frame list in a single operation.

When using the free frame cache, the Gem or remote page server removes enough frames from the free list to refill the cache in a single operation. When adding frames to the free list, the process does not add them until the cache is full.

You can control the size of the Gem and remote page server free frame caches by setting the configuration parameters GEM_FREE_FRAME_CACHE_SIZE (page 320) and GEM_PGSVR_FREE_FRAME_CACHE_SIZE (page 323), respectively.

The default behavior depends on the size of the shared page cache; if the shared page cache is 100MB or larger, a page server free frame cache size of 10 is used, so ten free frames are acquired in one operation when the cache is empty. For shared page cache sizes less than 100MB, the Gem or remote page server acquires the frames one at a time.

Running Cache Warming

When the repository is first started up, neither the object table nor any of the objects in the extents are loaded into memory. Initial accesses require reading a number of pages from disk containing the object table, and then reading the data pages that contain the objects.

This cost in a freshly restarted repository can be avoided by warming the cache—loading the object table, and optionally data pages containing the objects, into the cache. This allows the cost of loading pages into the cache to be done at startup time, rather than in the course of end-user application queries.

Cache warming is done using the **startcachewarmer** utility. This utility can be run manually, but since it is most useful immediately after startup, you normally configure your system to run this automatically as part of startup. Cache warming may take some minutes to complete, depending on the number of pages and disk performance; you can execute **startstone** and **waitstone** with arguments so they wait for cache warming to complete.

Configure what is loaded into the cache

The decision on what to load into the cache depends on the size of your shared page cache, relative to the size of your repository.

- If your shared page cache is very large and sufficiently large to hold all objects in the entire repository, you may wish to load all data pages into the cache. This is done using the **-d** argument.
- If your shared page cache is small relative to the repository size, and if the set of data pages that are used is highly variable, you may wish to load only the object table into the shared cache, and allow data pages to be loaded as needed. Ensure that the working set file `/opt/gemstone/locks/<`*stoneName*`><`*hostid*`>workingSet.lz4` does not exist, and do not use either the **-d** or **-D** argument.
- When the entire repository does not fit into the cache, and there is a subset of data that is frequently used, and will predictably be needed after a Stone restart, you can configure the shared page cache monitor to write out a compressed set of pageIds of data pages that are in the cache. The cache warmer looks for this file and automatically loads these data pages. When the **-w** option was specified on cache warming before the previous Stone shutdown, the pages in the shared page cache after restart match what was in the cache on Stone shutdown.

The **-w** <*interval*> enables writing the working set file to disk, at the specified interval, to the file

`/opt/gemstone/locks/<stoneName><hostid>workingSet.lz4`

When the working set file exists, it is automatically used to load pages. Only pages that are valid are loaded, so there is no requirement to keep the file strictly in sync with the repository.

The full set of options for cache warming are described under **startcachewarmer** on page 387.

Configure when warming is run

To perform cache warming automatically every time the repository starts up, use the configuration parameters:

- STN_CACHE_WARMER_ARGS (page 339) to warm the Stone's shared page cache
- GEM_CACHE_WARMER_ARGS (page 318) and GEM_CACHE_WARMER_MID_CACHE_ARGS (page 319) to warm shared page caches that are started by Gems.

These parameters take a string containing the specific arguments to the startcachewarmer utility. Not all arguments make sense in the context of the configuration parameter; for example, you never need to provide the stone name or configuration file paths.

For example, to configure cache warming to write the working set out once a day and on stone shutdown, and to use four sessions to perform the warming, use the following:

```
STN_CACHE_WARMER_ARGS = "-w 1440 -n 4" ;
```

You may manually execute the **startcachewarmer** utility on the command line at any time, but it is most useful immediately after startup of the page cache to be warmed. Cache warming will only load pages until the cache is full.

Chapter

3 Configuring Gem Session Processes

This chapter tells how to configure the GemStone/S 64 Bit session processes for your application. For additional information about running session processes on a node remote from the Stone repository monitor, refer also to Chapter 5.

Overview (page 61)
An overview of Gem sessions.

Configuring Gem Session Processes (page 63)
Configuring the Gem within the GemStone network.

Set the Gem Configuration Options (page 65)
Configuration options for the Gem itself.

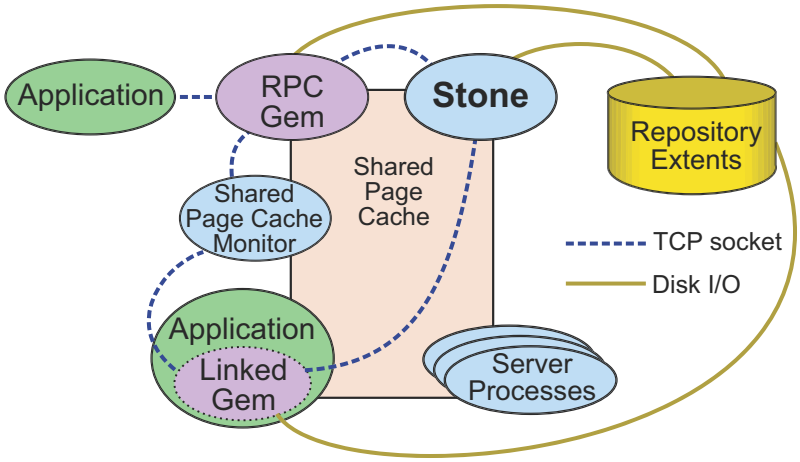
How To Access the Configuration at Run Time (page 66)
Adjustments that can be made to the Gem settings while the Gem is logged in.

3.1 Overview

As shown in Figure 3.1, a GemStone session involves the following components in a client-server relationship:

- The user's client Application
- The Gem, which acts as a server for a particular application. The Gem can be a separate session process, or linked to the client application.
- The Stone repository monitor, and other server processes.
- The shared page cache (shared memory segment), and the shared page cache monitor process.
- The repository extent files

Figure 3.1 GemStone Session Elements



From the point of view of the application, the Gem is the object server; it provides the bulk of the repository capabilities:

- It logs in to the repository with the Stone, and it obtains object locks, free object identifiers, and free pages from the Stone.
- It presents the application with a consistent view of the repository during a transaction, and tracks which objects the application accesses.
- It executes Smalltalk methods within the repository.
- It reads the repository as the application accesses objects, and (with the help of the AIO page server) it updates the repository when the application successfully commits a transaction.

Linked and RPC Applications

The Gem session process can be run as a separate process (the RPC Gem in Figure 3.1) or integrated with the application into a single process, in which case the application is called a *linked* application (the Linked Gem in Figure 3.1).

When the Gem runs as a separate process, it responds to Remote Procedure Calls (RPCs) from the application; this is called an *RPC* application. Applications that use a separate Gem process start that process automatically (from the user's viewpoint) while logging in to the repository.

Either type of application can be used on a single node or across a network.

An application can have only one linked login, since only one Gem can be integrated with the process. Any application may have multiple RPC logins, or one linked and multiple RPC logins.

GemStone provides both linked and RPC versions of topaz for repository administration, and shared client libraries that allow linked and RPC. The linked version allows both linked and RPC logins, but the RPC version allows only RPC logins.

C programmers should always use an RPC version during development and debugging to protect Gem data structures from possible corruption.

Note on terminology

The term "Gem" is used to refer to both the linked and RPC sessions, although only one of these is a separate OS process. Both normally represent a logged in session in GemStone, and from the Stone's point of view, there is little difference.

The term "session" is also sometimes used interchangeably with "Gem". However, multi-threaded operations such as for backup and garbage collection may allow multiple threads within a Gem process to log in individual sessions.

The Session Configuration File

At start-up time, each Gem session process looks for a configuration file, which by default is the same system-wide configuration file used by the repository monitor when it starts. However, there are three important differences:

- Session configuration details are optional. If no configuration file is not found, the session process uses system defaults.
- All session processes read those configuration options that begin with "GEM_" and the few that are used by both Stones and Gems (such as DUMP_OPTIONS and LOG_WARNINGS). Other settings that the Gem needs are obtained from the Stone and are the same for all sessions logged in to that Stone.
- When a Gem is started on a remote node (i.e., a node other than the node on which the Stone and extents are), and there is not already a shared page cache on that node, then the configuration options (SHR_) will determine the configuration of the remote cache.

Different applications and utilities that use the same repository may need different Gem configurations. For example, batch file processes may requires a much larger amount of temporary object memory. Appendix A, "GemStone Configuration Options" describes how to specify an alternate configuration file and how to use supplementary files to adjust the system-wide configuration for a specific session process. These settings may also be passed as arguments to the Gem or to Topaz.

3.2 Configuring Gem Session Processes

In addition to configuring the Gem itself, you must determine where the Gem will be running, and ensure that any other required processes are configured correctly.

Local vs. Remote

The first step in establishing the Gem Session configuration is determining where your Gems will be running.

Local

If you intend the Gem processes or linked applications to run on the same machine as the Stone, this node needs to have sufficient resources above what is needed for the server itself.

Each Gem you plan on running requires memory as described under "Gem Memory Requirements" on page 64.

Remote

When one or more Gems will be remote (that is, running on a different node than the Stone) you will need to set the configuration that will be used on the remote node. Each remote node must be setup to run the required GemStone processes.

On a remote node, the first Gem to login will initiate the startup of the remote shared page cache, and this Gem's configuration will be used to configure the remote shared page cache.

In addition to the memory required for each Gem, as described under "Gem Memory Requirements" on page 64, you must have sufficient resources to run a remote shared page cache, cache monitor process, and other server processes. See "Server Components" on page 37 to review these requirements.

Gem Memory Requirements

The amount of memory required by a Gem session is dependent on how it is configured, as determined by the system requirements. To avoid out-of-memory conditions, Gems must be configured with an adequate temporary object cache. The default of 50MB is suitable for light use; it is likely that particular operations in an application will require more, possibly much more.

With the 50 MB default Gem's temporary object cache, the first Gem session process or linked application on a node ordinarily requires about 80 MB of memory, of which 5 MB is for code that can be shared by other session processes. Each additional session process requires about 65 MB.

If you tune the cache size for Gems, add any increase to the amount given here.

More details are provided in "Configure Temporary Object Space" on page 65, and Chapter 14, "Managing Gem Memory", starting on page 269.

Additional Configuration for Remote Gems

The configuration file used by Gem sessions will also be used, on remote nodes, to configure the associated remote shared page cache monitor.

The Stone always creates a shared page cache monitor and cache on its own node, based on parameters in the Stone's configuration file. This cache is always used by Gems that run on this node.

On other nodes, when the first Gem session process logs in, if there is not already a shared page cache running on that remote node, a remote cache is started. Parameters specified for the first Gem that logs in determine the size of the cache and the number of processes that can attach to it (SHR_PAGE_CACHE_SIZE_KB and SHR_PAGE_CACHE_NUM_PROCS, respectively). These configuration parameter settings usually come from the Gem's configuration file, but may also be specified by Topaz arguments or arguments with the Gem's NRS.

All subsequent sessions that log in from that remote node will use the same cache.

3.3 Set the Gem Configuration Options

There are a number of configuration options for Gem session processes.

Configure Temporary Object Space

Gems use temporary object memory for a number of purposes, described in detail in Chapter 14. The upper limit on this memory is configured by the GEM_TEMPOBJ_CACHE_SIZE configuration option. It is important to provide sufficient temporary object space. If temporary object memory is exhausted, the Gem can encounter an out-of-memory condition and terminate.

The default of 50000 (50 MB) should be adequate for normal user sessions. For sessions that place a high demand on the temporary object cache, modifying large numbers of objects or working with large collections, a large value will be needed.

The configured value must be large enough to accommodate the memory needs of any Gem using that configuration. The amount of temporary object memory required may be different for different application Gems, depending on the specific tasks of the Gem; you may wish to set up special configuration files for application sessions that have a particularly high demand on memory.

The full amount of GEM_TEMPOBJ_CACHE_SIZE is not allocated on Gem login, but it is reserved and will impact memory usage per user.

The configured size of the shared page cache on the Gem's node, plus temporary object memory size should not be greater than the amount of memory available on the machine on which the Gem will be running, allowing for overhead for the operating system and other GemStone requirements.

You will probably need to experiment somewhat before you determine the optimum size of the temporary object space.

Memory management is discussed in greater detail in Chapter 14, "Managing Gem Memory", starting on page 269.

Configure SSL for remote Gem sessions

During the RPC login process, a Secure Socket Layer (SSL) socket is used to establish the login. After that, for gem processes on the same node as their client application, communication reverts to a normal socket connection. For Gem processes that are running on a different node than their client, communication continues to use SSL.

This results in a slightly slower connection, due to the overhead of encrypting and decrypting data. To configure the gem to use normal socket communication for remote connections on secure networks, set the GEM_RPC_USE_SSL configuration option to false and ensure that STN_ANONYMOUS_SSL is false.

Gems that have logged in with X509-Secured GemStone always use SSL.

Native Code

By default, generation of native code for Smalltalk methods is enabled. This is configured using GEM_NATIVE_CODE_ENABLED configuration option. When native code is disabled, execution is interpreted; behavior will be identical but somewhat slower.

Native code generation can be disabled using the runtime parameter #GemNativeCodeEnabled, but it cannot then be re-enabled for that session's lifetime.

If any breakpoints are set in any methods, native code is disabled. Native code is re-enabled when all breakpoints have been removed.

To determine if native code is in use by the currently executing session, execute:

```
GsProcess usingNativeCode
```

Under some configurations on x86, in particular on the Macintosh, the 32-bit offset limit may be exceeded in some cases with a very large temporary object cache. If this occurs, native code is disabled.

Note that the Foreign Function Interface (FFI) feature has additional limitations when native code is disabled. FFI is discussed in the *Programming Guide for GemStone/S 64 Bit*.

3.4 How To Access the Configuration at Run Time

GemStone provides several methods in class System that let you examine, and in certain cases modify, the session configuration parameters at run time.

To Access Current Settings at Run Time

System class methods let you examine the configuration of your current Gem session process. There are three access methods for session processes:

`gemConfigurationReport`
: Returns a SymbolDictionary whose keys are the names of configuration file parameters, and whose values are the current settings of those parameters in the current session's Gem process.

`gemConfigurationAt:` *aName*
: Returns the value of the specified configuration parameter from the current session, or returns `nil` if that parameter is not applicable to a session process.

`configurationAt:` *aName*
: Returns the value of the specified configuration parameter, giving preference to the current session process if the parameter applies to a Gem.

To Change Settings at Run Time

The class method `System class >>configurationAt:` *aName* `put:` *aValue* lets you change the value of the internal run-time parameters in Table 3.1, provided you have the appropriate privileges.

Parameters read from the configuration file at process startup are in all uppercase, and are read-only. Parameters that can be changed at runtime have similar, but not necessarily identical, names that are in mixed case without underscores.

CAUTION

Do not change configuration parameters unless there is a clear reason for doing so. Incorrect settings can have serious adverse effects on GemStone performance.

Table 3.1 Session Configuration Parameters Changeable at Run Time

Configuration File Option	Internal Parameter
GEM_ABORT_MAX_CRS	#GemAbortMaxCrs
(none)	#GemCommitConflictDetails
(none)	#GemCommitStubsForNpObjects
(none)	#GemConvertArrayBuilder
(none)	#GemDropCommittedExportedObjs
(none)	#GemExceptionSignalCapturesStack
GEM_FREE_FRAME_LIMIT	#GemFreeFrameLimit
GEM_FREE_PAGEIDS_CACHE	#GemFreePageIdsCache
GEM_HALT_ON_ERROR	#GemHaltOnError
GEM_KEEP_MIN_SOFTREFS	#GemKeepMinSoftRefs
GEM_KEYRING_DIRS	#GemKeyRingDirs
GEM_NATIVE_CODE_ENABLED	#GemNativeCodeEnabled (can only be disabled at runtime)
GEM_PGSVR_COMPRESS_PAGE_TRANSFERS	#GemPgsvrCompressPageTransfers
GEM_PGSVR_UPDATE_CACHE_ON_READ	#GemPgsvrUpdateCacheOnRead
GEM_READ_AUTH_ERR_STUBS	#GemReadAuthErrStubs
GEM_REPOSITORY_IN_MEMORY	#GemRepositoryInMemory
GEM_SOFTREF_CLEANUP_PERCENT_MEM	#GemSoftRefCleanupPercentMem
GEM_TEMPOBJ_POMGEN_PRUNE_ON_VOTE	#GemPomGenPruneOnVote
GEM_TEMPOBJ_CONSECUTIVE_MARKSWEEP_LIMIT	#GemTempObjConsecutiveMarksweepLimit
GEM_TEMPOBJ_OOMSTATS_CSV	#GemTempObjOomstatsCsv
GEM_TEMPOBJ_POMGEN_SCAVENGE_INTERVAL	#GemTempObjPomgenScavengeInterval

The following example changes the value of the configuration option #GemFreeFrameLimit:

```
topaz 1> printit
System configurationAt: #GemFreeFrameLimit put: 4000
%
4000
```

For more information about the parameters that can be changed at run time, see Appendix A, “GemStone Configuration Options”.

Chapter

4 NetLDI and Interprocess Access

This chapter describes how to setup GemStone users, file permissions, and interprocess connections to ensure users have access while protecting files from unauthorized access. This chapter describes OS-level access security; GemStone login security is described in Chapter 6.

Overview (page 69)
an introduction to the GemStone processes and network objects that facilitate distributed GemStone systems.

The NetLDI (page 71)
explains GemStone's Network Long Distance Information process, and how it works within the system.

NetLDI configuration (page 73)
describes the options for configuring the NetLDI.

File Permissions (page 78)
the permissions for executable and data files work with the NetLDI modes to allow secure access for authorized users.

Linked Gem Sessions (page 81)
managing access for linked sessions that do not use the NetLDI.

4.1 Overview

As a multiuser system, GemStone must allow applications running under different UNIX userIds to log in and perform work, while ensuring that the disk files and other resources are protected against unauthorized access or modification, inadvertent as well as intentional. There are a number of ways to configure process ownership and disk file access depending on your security requirements.

At the simplest level, with a single UNIX user on a single private node, nothing else is needed after installation. Configuring secure file and process access becomes important when you have multiple users, on a shared system, with critical or sensitive data.

In addition to OS-level process and file access, users must also authenticate with GemStone as described in Chapter 6, and object-level permissions provide additional data security as described in the *Programming Guide*. This chapter is concerned with configuring the processes and files that make up a GemStone installation.

The topics that must be considered include:

- How you will configure the NetLDI.

  This may involve both the ownership and file permissions for the NetLDI executable, and the options that are specified when starting up the NetLDI.
- If user logins should also be required to provide the UNIX username and password (in addition to the GemStone UserProfile's name and password).
- The ownership, groups, and permissions for the extent files.
- The ownership and permissions for the other executables, such as the Stone and Page Servers.
- The permissions for the Shared Page Cache.

Administrative user account

Unless you are on a single-user system, or a system with no security concerns, it is recommended to create an administrative UNIX user account to install GemStone and run shared processes. This chapter assumes that you have defined such a user, and in the examples this user is *gsadmin*. The actual administrative userId you create is up to you.

The examples also use *gsgroup* to specify a UNIX group, that includes all UNIX users that will use GemStone.

Login Parameters and Gem process

When logging in to GemStone, client applications provide a number of *login parameters*:

- Stone name, and other details to specify the Stone.
- GemStone username and password
- Host username and password, if a host process needs to be started to support the login
- Gem script name (gemnetobject), and other specifications for the Gem.

Linked logins are the simplest, since a separate Gem process does not need to be started, so for example, the host username and password are not needed. Logins using X509-secured GemStone do not need a Stone name or GemStone username or password, since this information is provided by the certificate files.

For example, for a Topaz RPC login, these parameters may be used:

```
topaz> set gemstone nodeName
topaz> set hostusername hostUserName
topaz> set hostpassword hostPwd
topaz> set gemnetid !#netldi:netldiName!gemnetobject
```

During an RPC login, an initial request goes to the NetLDI with instructions to spawn the Gem process. The host username is used, along with the NetLDI configuration, to determine how to set the owner of the forked Gem process. The owner of the Gem process

is important since the Gem needs to be able to open the extent files, and attach to the shared page cache, operations which should not be available to unauthorized users.

You can avoid specifying the host username and password for each login by configuring the system to run without host authentication (i.e. in guest mode), or by using Kerberos. While in some cases using a `.netrc` may work, the `.netrc` is inherently insecure and is not supported.

Remote logins, in which the Gem is on a different node than the Stone, require additional setup on the remote node; this is described in Chapter 5. X509-secured logins have a number of additional requirements and the specifics of login are described in the *GemStone/S 64 Bit X509-Secured GemStone System Administration Guide*.

4.2 The NetLDI

GemStone NetLDIs (Network Long Distance Information) are responsible for spawning processes and providing information about GemStone processes on a given node. They are a key element connecting a distributed system together, and as such, require care to ensure that their services are available to all authorized users, but secure against unauthorized use.

In a distributed system, each node where the Stone or an RPC Gem runs, including mid-level cache nodes, must have its own NetLDI process running. NetLDIs are also required on to support some remote utilities such as **gslist**.

The NetLDI can also be started with arguments that allow it to be used within an X509-secured GemStone configuration. While some configuration, such port numbers and names, are in common, the details of using a NetLDI within an X509-secured GemStone configuration is not included here; this material is in the *GemStone/S 64 Bit X509-Secured GemStone System Administration Guide*.

You start a NetLDI by invoking the **startnetldi** command (described on page 393). The NetLDI, in turn, starts Gem and other processes on demand.

NetLDI Ports and Names

The NetLDI listens for all requests on a single, fixed TCP/IP port, selected either by querying the OS using `getservbyname()`, a port provided by the **startnetldi -P** argument, or by randomly selecting an available unreserved port.

Client applications can then access the NetLDI either by name (either specifying the name, or relying on the default NetLDI name) or by using the port number directly.

NetLDI access by name

During the installation process, you are instructed on configuring your system to allow NetLDIs to be accessed by name. This involves adding the NetLDI name to the network services database (which can be the `/etc/services` file), and assigning a port number. The default name of the NetLDI process is `gs64ldi`. You may define your own NetLDI name instead, or in addition to `gs64ldi`, and include multiple NetLDI names with different reserved ports.

Your login parameters and command line access can then specify the NetLDI by name, for example:

```
[oboe]$ startnetldi mynetldi
topaz> set gemstone !@oboe#netldi:mynetldi!devstone
```

To access NetLDIs by name, either `gs64ldi` or your own name, the same name and port must be defined on every node, including nodes that do not need to run NetLDI; for example, client applications on Windows. This allows client nodes to reference a NetLDI by name during login.

NetLDI access by port

To avoid the need to update the network services database, you can instead access NetLDIs by port.

If startnetldi uses the **-P** option to specify a port, or uses a number in the port range (1024 to 65535) instead of a name, then this will be used as the listening port, provided it is not already in use. If a port is not specified in the services database, nor by the **-P** option, nor by name, then the NetLDI will select a port at random. This port number can be used in login parameters, but since every time the NetLDI is restarted it will select a new port number and require changing the parameters, this is impractical in most cases. You can determine the NetLDI's port in this case by looking at the results of **gslist -l**.

These examples show several ways you could start the NetLDI, then use the port number in the login parameters. The differences between the startnetldi commands is in what name is assigned, which (if not also added to the services database), does not affect the login parameters.

```
[oboe]$ startnetldi 10382
[oboe]$ startnetldi -P 10382
[oboe]$ startnetldi -P 10382 mynetldi
topaz> set gemstone !@oboe#netldi:10382!devstone
```

Simplified access using GEMSTONE_NRS_ALL

The GEMSTONE_NRS_ALL environment variable provides a convenient way to set a default name or port number to access the NetLDI.

By setting this environment variable across nodes and users, access to the NetLDI from commands such as **startnetldi** and **stopnetldi**, and the parameters for login requests, will automatically use the correct NetLDI.

For example:

```
$ GEMSTONE_NRS_ALL=#netldi:mynetldi
$ export GEMSTONE_NRS_ALL
```

For more information about GEMSTONE_NRS_ALL, see Appendix C, "Network Resource Strings (NRS)".

4.3 NetLDI configuration

When determining the way you will configure the NetLDI, there are two decisions that need to be made: which UNIX userId will own the processes that the NetLDI forks, and what categories of requests require authentication. Each of these has several options, and the answers to the questions can combine in several ways.

There are two usual solutions:

- Authentication, with the NetLDI running as root; so Gem processes are running as the individual UNIX user who logged in.
- No authentication, with Captive Account; so all Gem processes are running as the single administrative UNIX user.

Both of these solutions provide multi-user access and appropriate security. The details of how to set up these solutions are described later, under "Setting up the NetLDI Configuration" on page 76.

The next sections go into more detail on the decisions that need to be made before you can select the right configuration.

Configuration Decisions

NetLDI behavior: who will own spawned processes?

During an RPC login, the client application passes along GemStone login parameters, including the name of the stone, the GemStone userId, and so on. These are sent to the NetLDI to perform the steps of the login.

These login parameters include fields for the host UserId, and the host password. If the host userId is left empty, the UNIX userId of the client application is used.

When the NetLDI receives the request, as part of login it forks a Gem process. The NetLDI configuration determines whether the owner of the Gem process will be the UserId that is provided with the login parameters, or an administrative user.

The owner of the Gem process is important since the Gem needs to be able to open the extent files, and attach to the shared page cache. While it is more intuitive to have Gem processes owned by individual userIds, that requires that each of these individual userIds have write permission to on the extent files, usually by being part of a group that has access.

The NetLDI modes are:

Default mode

In default mode, an ordinary user such as the administrative user, starts and owns the NetLDI process. Regardless of authentication level, all logins must provide the UNIX userId and password of the account that started the NetLDI, since a non-root user cannot fork processes that belong to another user.

This is generally suitable only for single-user systems or systems in which no additional UNIX-level authentication is required, since anyone that can login has sufficient information to access all parts of the GemStone installation.

Root mode

In Root mode, the NetLDI process is owned by the root user. This allows individual spawned processes to be owned by individual userIds; since root user can fork processes that will be owned by any user.

To setup root mode, the owner of the netldid process is changed to root, and the setuid bit is set. The NetLDI can be started by any user with access permission to the executable, and the NetLDI will run with an effective UserId of root.

Either secure or default authentication is required when the NetLDI is running in root mode. Guest authentication mode is disallowed in this mode.

Captive account

In captive account mode, all forked Gem processes are owned by a specific administrative user Id.

To specify captive account, pass the name of the designated account as an argument when starting the NetLDI, using the -a argument.

While technically it is possible to run the NetLDI as root and also startup in captive account, this provides no new capabilities so is not normally done.

Captive account is designed to be used with Guest mode, as described in the next section.

The effect of captive account mode is much like setuid method, but it only affects ownership of processes started by the NetLDI, not linked applications invoked directly by the user.

A disadvantage for some applications is that the Gem session process will perform *all* I/O as that account, not as the account running the application; including file operations and `System class >> performOnServer:`.

Also, captive account mode affects *all* services started by the NetLDI, including any ad hoc processes, which are processes started from the user's home directory. (The NetLDI looks in the user's home directory if it cannot find a service listed in `$GEMSTONE/sys/services.dat`.) If you prefer, you can prohibit such ad hoc services by specifying the **-n** option when starting the NetLDI.

Linked sessions

Linked sessions do not use a separate Gem Session; the Gem is integrated into the client process. The owner of the client application process therefore needs to have the appropriate access.

For consistency with RPC sessions started by the NetLDI, If you are running with captive account, this means using ownership and the setuid bit for the client application executables, to ensure client applications run as the administrative user.

Authentication: which requests need to be authenticated?

The Netldi can be configured to require authentication for all requests, for only process fork requests, or to not require authentication for any requests. Process fork requests include forking new Gems to support login; other kinds of requests includes information, such as Stone name and gslist results.

The authentication modes are:

Secure mode

In secure mode, all accesses, including requests for information such as waitstone and gslist, as well as process forks such as logins, require authentication. In secure mode, authentication is needed before a Gem or Stone can start a page server to access an extent or shared page cache on another node.

This mode is configured by the `-s` argument when starting the NetLDI.

In this mode, PAM (Pluggable Authentication Modules) is used to access user authentication, though the actual means of authentication, such as LDAP, depends on how your system administrators have configured your UNIX installation.

In this mode, all requests to the NetLDI must include *HostUserId* and *HostPassword*.

Fork mode

In fork mode, which is the default, only process forks require authentication. Anyone can make informational requests such as **gslist**. This is the default mode if another authentication mode is not specified.

This mode also requires PAM.

In this mode, GemStone login parameters must include *HostUserId* and *HostPassword*.

Secure or Fork mode plus Kerberos

In either Secure or Fork mode, the authentication can be done using Kerberos to bypass the need to enter the *HostUserId* and *HostPassword*.

For authentication to succeed, there must be a currently valid ticket (TGT) associated with a principle for the UNIX user id that the NetLDI is authenticating as.

Guest mode

In guest mode, no host authentication is required (GemStone login still requires authentication, of course). PAM is not needed. If userIds other than the user that starts the NetLDI will be logging in, this is used in combination with captive account.

This is configured by the `-g` argument when starting the NetLDI. You do not need to include *HostUserId*/*HostPassword*; if the *HostUserId* is included, it will be used when determining ownership of the Gem process.

Table 4.1 shows how guest mode and captive account mode combinations affect NetLDI operation.

Table 4.1 NetLDI Guest and Captive Account Restrictions

startnetldi Options	Host passwords Required	Owner of Spawned Processes	Owner of NetLDI Process	Which Accounts Can Start Processes
(none)	Yes	Owner of the NetLDI	Ordinary user	Only the owner of the NetLDI
			Root	Any user
-k*keytab*	No	Owner of the NetLDI	Ordinary user	Only the owner of the NetLDI
			Root	Any user
-a*aName* (captive account)	Yes	Account *aName* (must start the NetLDI)	Ordinary user (*aName*)	Only *aName*
			Root	Any user
-g (guest mode)	No	Owner of the NetLDI	Ordinary user	Only the owner of the NetLDI
			Root—not allowed	
-a*aName* **-g** (guest mode with captive account)	No	Account *aName* (must start the NetLDI)	Ordinary user (*aName*)	Any user
			Root—not allowed	

Setting up the NetLDI Configuration

As described in the previous sections, there are two common combinations of features that configure the NetLDI for secure multi-user accessibility.

1. Setting up NetLDI as root with Authentication

To run the NetLDI with an effective UserId of root, you can change the ownership of the NetLDI executable, and set the S bit (setuid). This allows any user with execute permissions to start the NetLDI and let that NetLDI run as root.

If you are logged in as root when you run the GemStone installation program, it offers to set the ownership and permissions for the NetLDI. To set them manually, do the following as root:

```
# cd $GEMSTONE/sys
# chown root netldid
# chmod u+s netldid
```

The resulting file permissions and ownership for the NetLDI executable should look similar to this:

```
-r-sr-xr-x 1 root gsgroup 2007036 Mar 7 11:29 netldid
```

In this mode, PAM (Pluggable Authentication Modules) is used to authenticate, and the system should either configure a service with the name `gemstone.netldi`, or ensure that the default PAM authentication will allow logins. The actual means of authentication, such as LDAP, depends on how your system administrators have configured your UNIX installation.

Starting the NetLDI

When you start the NetLDI, you may choose to authenticate all requests by including the **-s** argument to startnetldi, or omit that argument and only authenticate requests for process forks. Using the **-g** for guest mode is not allowed with the NetLDI running as root.

Login parameters

Your application's login interface will generally let you specify a UNIX login name and password for the node on which you will be running an RPC Gem session process. For example, Topaz lets you set these values:

```
topaz> set hostusername HostUserName
topaz> set hostpassword HostPwd
```

GemBuilder for Smalltalk (GBS) provides similar fields in its login dialog, as does GsExternalSession, and other interfaces provide ways to enter this information.

NOTE

Authentication is always done using the "real" user id, not the effective user id as set by the S bit on GemStone executables.

These fields are used to compose instructions in NRS syntax to be sent to the NetLDI. For example, if you set the Topaz login parameters *HostUserName* and *HostPwd*, the application puts them in an NRS like the following:

```
'!@Server#auth:HostUserName@HostPwd!gemnetobject'
```

Although it is less convenient for ordinary use, this can be done manually, by entering the authorization modifier directly using the Topaz *GemNetId* parameter. For example:

```
topaz> set gemnetid !@Server#auth:HostUserName@HostPwd!gemnetobject
```

When NRS is used to login using GsExternalSession, you can compose the NRS programmatically using the kernel class GsNetworkResourceString. See the *Programming Guide* for more on External Sessions, and the classes in the image.

Using Kerberos authentication

The NetLDI can be configured to use Kerberos for authentication for the hostUserId/hostPassword.

To configure Kerberos authentication for NetLDI:

- **startnetldi** must be executed with the **-k** option pointing to the Kerberos keytab file.
- The GemStone login parameters must have an empty `hostPassword` field.
- There must be a currently valid ticket (TGT) associated with a principle for the UNIX user id that the NetLDI is authenticating as.

The **-k** option cannot be used with guest mode; no authentication is done in guest mode.

2. Setting up NetLDI in Guest Mode with Captive Account

To configure guest mode with captive account, do the following

If you do not already have one, create an OS account to own the GemStone distribution tree and serve as the captive account. This will be referred to as *gsadmin*.

1. Make *gsadmin* the owner of the distribution tree
2. Set the setuid bit for any linked GemStone executables that run on the server node.
3. Make the repository extents accessible only by *gsadmin* (mode 600). For instructions, see "How To Set Up a Raw Partition" on page 50.
4. Make sure that *gsadmin* has execute permission for `$GEMSTONE/sys/netldid.`

   The setgid bit should NOT be set on the `netldid` executable ; it should look similar to this:

   ```
   -r-xr-xr-x 1 gsadmin gsadmin 674488 Mar 7 11:29 netldid
   ```

Starting the netldi

Log in as the captive account (such as *gsadmin*).

Start the NetLDI using the arguments for guest mode and captive account. For instance:

```
% startnetldi -g -a gsadmin
```

You may specify other **startnetldi** options.

Login

You do not need to specify the hostUserId and hostPassword parameters.

4.4 File Permissions

The considerations in setting file permissions is the same as in configuring the NetLDI; to protect the repository extents, while ensuring that authorized users can use the repository.

All reads and writes to the extents should be done through GemStone repository executables: the executables that run the Stone, Page Servers, and Gems.

This does not include file copy backups of the GemStone extents, nor restore if that is needed. These are OS level operations that also require protection.

For the tightest security, you can have the extents and executables owned by a single UNIX account, using the setuid bit on the executable files, and making the extents writable only by that account. This way, all processes started from any of the executables are owned by a single user, and only that user can write the extent files.

While most processes that write files such as fileouts and programmatic backups will set the ownership of the resulting file to the client user, this may not be possible for linked sessions in client applications, if the client application does not distinguish between real userId and effective userId.

If this is an issue, rather than using the administrative account, you can make the extents writable by a particular UNIX group and have all users belong to that group. While this

means all Gems are owned by the individual user accounts, there is the risk of inadvertent damage or deletion of the extent files.

Using the Setuid Bit

When all extents and executables are owned and can only be written by a single UNIX account, it provides the strongest security. By setting the setuid bit, the processes started from that executable are owned by the owner you specify for the file.

Table 4.2 shows the recommended file settings. In this table, *gsadmin* and *gsgroup* can be any ordinary UNIX account and group (do NOT use the root account for this purpose). The person who starts the Stone must be logged in as *gsadmin* or have execute permission.

Table 4.2 Recommended File and Executable Permissions for the Server

Resource or Process	Filename	Protection Mode	File Owner	File Group	Process Runs As
Repository extents	(default) `data/extent*.dbf`	`-rw-------`	gsadmin	gsgroup	
Stone	`sys/stoned`	`-r-sr-xr-x`	gsadmin	gsgroup	gsadmin
AIO and Free Frame Page Servers	`sys/pgsvrmain`	`-r-sr-xr-x`	gsadmin	gsgroup	gsadmin
Gem	`sys/gem`	`-r-sr-xr-x`	gsadmin	gsgroup	gsadmin

Ownership and permissions for the `netldid` executable depend on the authentication mode chosen, and are discussed in Chapter 3.

If you are logged in as root when you run the GemStone installation program, it offers to set file protections in the manner described in Table 4.2. To set them manually, do the following as root:

```
# cd $GEMSTONE/sys
# chown gsadmin gem pgsvr pgsvrmain stoned
# chmod u+s gem pgsvr pgsvrmain stoned
# cd $GEMSTONE/data
# chown gsadmin extent0.dbf
# chmod 600 extent0.dbf
```

You must take similar steps to provide access for repository linked clients, which is described under “Linked Gem Sessions” on page 81.

Alternative: Use Group Write Permission

For sites that prefer not to use the setuid bit, the alternative is to make the extents writable by a particular UNIX group and have all users belong to that group. That group must be the primary group of the person who starts the Stone (that is, the one listed in `/etc/passwd`). Do the following, where *gsgroup* is a group of your choice:

```
% cd $GEMSTONE/data
% chmod 660 extent0.dbf
% chgrp gsgroup extent0.dbf
```

Sites that run linked sessions may also prefer to use this protection so that fileouts and other I/O operations that do not read or write the repository will be done using the individual user's id instead of the single *gsadmin* account.

Shared Page Cache

The shared memory and semaphore resources used by GemStone are created and owned by the user account under which the Stone repository monitor is running, and have the same group membership.

Access for the shared page cache is set by the SHR_PAGE_CACHE_PERMISSIONS configuration option; by default, it is read-write for the owner and read for the group (the equivalent of file protection 640). You can inspect the cache ownership and permissions of a running shared page cache using the **ipcs** command.

For a session to connect to the shared cache on login, the OS user account of the linked application or Gem session process must be allowed to by the permissions set by SHR_PAGE_CACHE_PERMISSIONS, by default, either be the same user account as that of the Stone (such as the *gsadmin* account) or a user account that belongs to the same group as the Stone. The same requirement applies to page server processes, which are discussed in Chapter 5, "Connecting Distributed Systems".

If the setuid bit is set on repository executables, the Stone process and shared page cache will belong to the owner you specify for those files (such as *gsadmin*).

File Permissions for Other Files and Directories

GemStone creates log files and other special files in several locations. In a multi-user environment, the protection of these resources must be such that the appropriate file can be created or updated in response to actions by several users.

`/opt/gemstone/locks/`
: All users should be able to read files in the directory `/opt/gemstone/locks/` on each node (or an equivalent location, as discussed on page 30).

`/opt/gemstone/log/`
: Users who will start a NetLDI process that does not explicitly specify a log directory location require read, write and execute access to `/opt/gemstone/log/`.

`system.conf`
: The user who owns the Stone process must have write permission to the configuration file, since the Stone must be able to write as well as read its primary configuration file. Writes are made if an extent is added while the Stone is running, so that subsequent restart will be correct. By default, this file is `$GEMSTONE/data/system.conf`.

$HOME
: GemStone by default creates log files for session processes, such as RPC Gems, in the home directory of the user owning the Gem. This may be the owner of the Gem executable, or the user specified for the NetLDI's captive account.

  An alternate location can be specified using NRS syntax. This NRS can be included in the login parameters, or defined by GEMSTONE_NRS_ALL. See "Controlling log file directory locations" on page 417.

4.5 Linked Gem Sessions

GemStone supports both RPC logins, in which the Gem is a separate process from the client application, and linked logins, in which the Gem is in the client application process.

The above discussions of executable permissions are focused on the issues with RPC logins, which are facilitated by the NetLDI. For linked logins, however, the client application, which could be topaz, client Smalltalk such as VisualWorks or VA/Smalltalk, Pharo, GemBuilder for Java, a GCI Application, or something else, is also involved.

For linked applications *on the server*, we recommend you use the setuid bit on the application's executable file, and have the file owned by an administrative user, *gsadmin*. This works well for linked topaz logins. The `installgs` script offers to set the file ownership and permissions for you. To do it manually, do this (you may need to login or sudo as root):

```
# cd $GEMSTONE/bin
# chmod u+s topaz
# chown gsadmin topaz
```

GemStone's topaz executable performs repository reads and writes as the *effective* user (the account that owns the executable's file), but performs other reads and writes as the *real* user (the one who invoked it).

For linked applications that do not distinguish between real and effective user IDs, you may prefer *not* to use the setuid bit. Linked applications that do not make this distinction are likely to perform *all* I/O as the effective user, or *gsadmin.* In this case, it may be preferable to remove the S bit on that executable and add group write permission to the extents.

Chapter

5 Connecting Distributed Systems

This chapter tells how to set up GemStone/S 64 Bit in a distributed environment:

Overview (page 83)
An introduction to the GemStone processes and network objects that facilitate distributed GemStone systems.

Configuring GemStone on Remote Nodes (page 88)
Examples for setting up typical distributed client-server configurations.

Troubleshooting Remote Logins (page 96)
What to do when there are problems with remote logins.

Note that GemStone also supports distributed configurations in which all connections are initiated from the Stone and secured with X.509 certificates. The architectural details, processes, login parameters, and sequence of operations is entirely different with X509-secured GemStone, and are described in the *GemStone/S 64 Bit X509-Secured GemStone System Administration Guide*

5.1 Overview

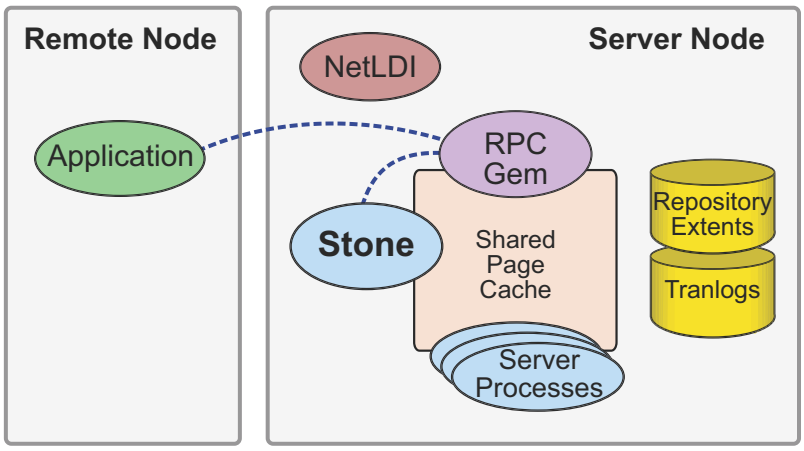
GemStone is designed to be highly efficient and easy to use in a networked environment with many nodes. However, this requires additional steps by the system administrator so that the server processes can be found and accessed, and so server processes can connect to one another. Because processes are running on different nodes, the log files are spread throughout the network, and troubleshooting may become more complicated.

Figure 5.1 and Figure 5.2 show two typical distributed configurations in which an application on a remote node is logged in to a repository and Stone repository monitor running on a server node.

Distributed configuration with Local Gem

In Figure 5.1, an application communicates with a Gem session process on the server node by way of RPC calls. This configuration lets the Gem execute Smalltalk code in the repository without first bringing complex objects across the network. The Gem directly accesses the shared page cache that was started by the Stone repository monitor. This configuration is considered a "Local" Gem, since the Gem is local to the Stone.

Figure 5.1 Gem Session on Server Node

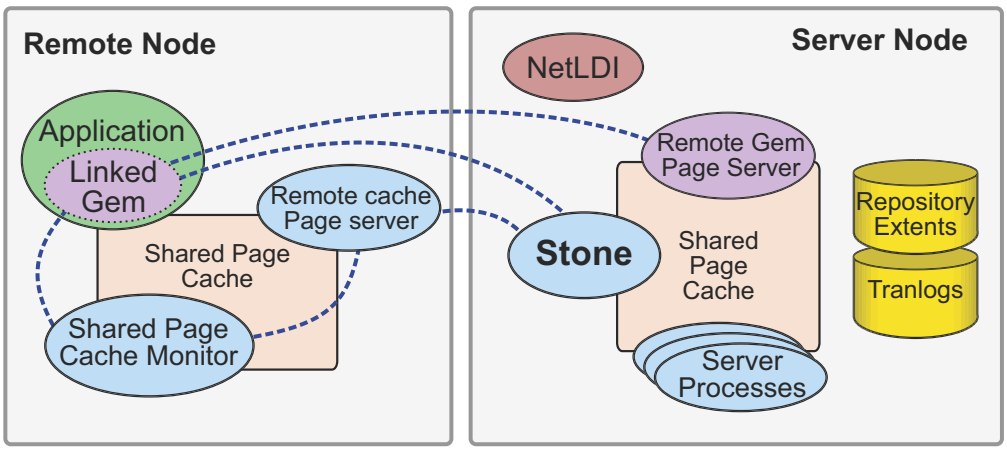


Distributed configuration with Remote Gem

In Figure 5.2, the application and the Gem are linked in a single process that runs on the remote node (i.e, not the Stone's node). This configuration avoids the overhead of RPC calls, but may increase network traffic if large objects must be brought across the network.

When a Gem is on a remote node, it needs a shared page cache on that node. This is started by the first Gem on that node. Page server processes are also needed to handle pages between the two nodes.

Figure 5.2 Gem Session on Remote Node



Network

The nodes in your system can be any combination of GemStone-supported platforms, as long as they have a network connection. Inter-node communication is handled via sockets.

Nodes in which the Stone, or a Gem process, will run must be platforms supported by GemStone/S 64 Bit.

Client-process only nodes such as the remote node in Figure 5.1 can include supported client platforms, such as Windows, as well as server platforms.

GemStone NetLDIs

The NetLDIs are the glue holding a distributed GemStone system together. Each NetLDI spawns other GemStone processes on request, and reports the location of GemStone services on its node to remote processes that must connect to those services.

In a distributed system, each node where a Stone repository monitor or Gem session process runs must have its own NetLDI process running. However, nodes that run only linked applications, or client applications without a Gem on that node, do not require a NetLDI.

The NetLDI listens on a well-known port for requests for RPC logins or other services.

NRS Syntax

GemStone uses Network Resource Strings (NRS) to specify the name and location of each part of the GemStone system. NRS is widely used in utility commands and in login parameters, to specify the location and name of the Stone and NetLDI, and where the other GemStone processes should run.

The most useful parts to know are:

`!@`*node*`#netldi:`*netldi*`!`*stoneOrGemService*

- The "`@`*node*" can be omitted for the local node, and you may use an IP address instead of the name of the node.
- the "`#netldi:`*netldi*" can be omitted if the netldi is running with the default name gs64ldi and that name is recorded in the services database. The netldi can be specified by name or by port number.
- *stoneOrGemService* is the name of the running Stone, or `gemnetobject` or another Gem service. This part is required; if you omit both node and netldi, you do not need the `!` dividers; you can use simply *stoneOrGemService*.

Appendix C, "Network Resource Strings (NRS)" describes NRS in detail.

In particular, you may find it very useful to set the GEMSTONE_NRS_ALL environment variable if you are using a NetLDI name other than the default.

Stone

When logging into to a Stone on the local machine, the stone name is sufficient. If the Stone is on a separate node, you can specify the location of the stone, and the name of the NetLDI on the Stone's node, using NRS.

For example, to connect to a stone named `devstone` on the node `oboe`, with the default-named NetLDI gs64ldi:

```
topaz> set gemstone !@oboe!devstone
```

Connecting to the RPC Gem

When a client requests an RPC login, a Gem session process needs to be spawned to fullfil the login request. To do this, the login parameters include the gem service (in topaz, the gemnetid), usually `gemnetobject`, `gemnetdebug`, or the name of a custom gem script.

For example,

```
topaz> set gemnetid gemnetobject
```

Using gemnetobject alone as here, specifies to run the gem on the same node as the client application.

By specifying an NRS, in the gem service login parameter that includes the node and the NetLDI on which you want the Gem to run, you can instruct GemStone on which processes need to be started and where. This can be the same node as the Stone. It can also be on another node entirely, provided GemStone is installed and a NetLDI is running on that node.

For example, if you intend the gem to run on a machine named lark, with the default-named NetLDI gs64ldi:

```
topaz> set gemnetid !@lark!gemnetobject
```

Note that if the gem service NRS includes a node name and the stone NRS does not include a node name, then the Stone is expected to be on the node in the Gem NRS, not on the client node.

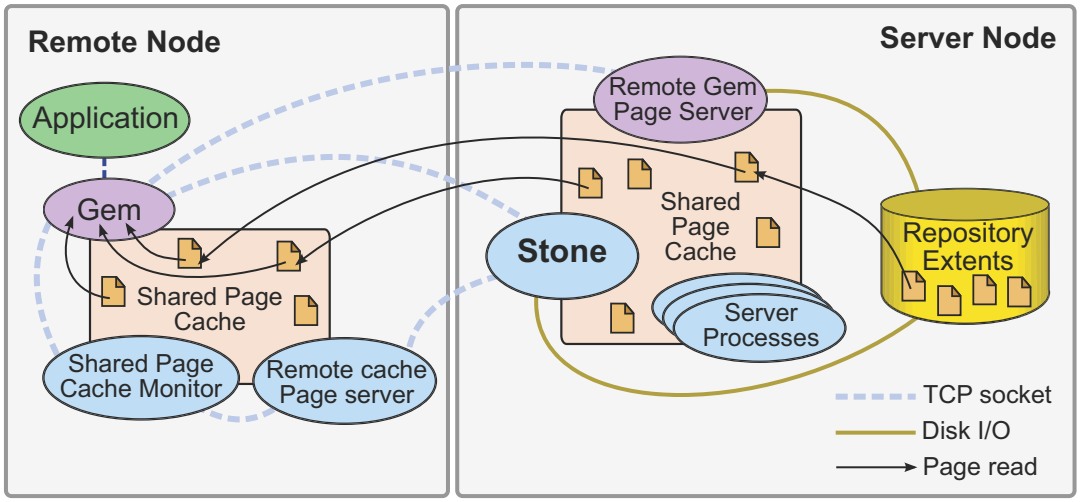
Shared Page Cache

There is always a shared page cache on the Stone's node. Any Gems that are on the Stone's node (local Gems) will use that shared page cache.

When a GemStone login specifies that a Gem should run on a remote node, then a shared page cache and the associated processes, shared page cache monitor and free frame page server, need to be started on that node. Normally, the cache is started up by a NetLDI running on the remote node, although a linked session (but not an RPC session) can also initiate the startup.

When the remote Gem wants to access a page in the repository, it first checks the shared page cache on its own node. If the page is not found, the Gem communicates with the Remote Gem Page Server on the server node, checking in the shared cache on the server node and if necessary, reading the page from the disk.

Figure 5.3 Shared Page Cache with Remote Gem



GemStone Page Servers

Gems on remote nodes require page server processes to support operations between the remote Gem and cache and the Stone:

- When a Gem connects to a repository extent across the network, it requires a Remote Gem Page Server on the Stone's node, associated with the remote node. This is spawned if it is not already running. This page server looks up pages in the Stone's cache and performs extent reads, on behalf of the gem
- On the remote node, a Remote Cache Page Server supports the Stone in managing the remote shared page cache, by starting the cache and removing pages that are being recycled.

Port use in GemStone

GemStone's interprocess and internode communications are established via socket connections. A number of key GemStone processes listen on well known ports for a connection, which initiates the handshakes that establish interprocess socket connections.

Processes that listen on well known ports include the NetLDI, the Stone, and the Shared Page Cache Monitor. These named GemStone processes create a *serviceName*`..LCK` at startup, in the directory `/opt/gemstone/locks` or another location as described on page 30. This file encodes the well-known port that the process is listening on. When the NetLDI (for example) contacts a particular Stone, it first looks up the well-known port for that Stone by locating the lock file for that Stone, then contacts the Stone on that port.

The NetLDI's port is specified on startup in a number of ways, as described on page 71.

The ports used by the Stone and Shared Page Cache Monitor can be specified using STN_WELL_KNOWN_PORT_NUMBER and SHR_WELL_KNOWN_PORT_NUMBER configuration options, respectively. These must be valid port numbers that are not already in use.

Disrupted Communications

Several incidents can disrupt communications between the GemStone server and remote processes in a distributed configuration. This can include network glitches, network overload, crashes or unexpected shut down of a remote process or the entire remote node, or of the network channel itself.

GemStone ordinarily depends on the network protocol *keepalive* option to detect that a remote process no longer exists because of an unexpected event. The keepalive interval is set globally by the operating system, typically at two hours. When that interval expires, the GemStone process tries to obtain a response from its partner. The parameters governing these attempts also are set by the operating system, with up to 10 attempts in 15 minutes being typical. If no response is received, the local GemStone process acts as if its partner was terminated abnormally. The keepalive interval may need to be adjusted.

Firewalls between GemStone processes require that the communications ports be configured to be open.

5.2 Configuring GemStone on Remote Nodes

If you are only running local Gems; in other words, only the client application will run on the remote node, most of the configuration for the Gem is on the server node. However, if you will run Gems or Linked sessions on nodes remote from the Stone, then more configuration is required on the remote node.

Local Gems only

If you are only running Gems on the same node as the Stone, there are only a few steps required on the remote node.

- Install the client shared libraries. This can be done by a complete server installation, or by copying the small number of required library files to the client, and configuring your client search paths appropriately.

  Details on how to do this, and the various options, are in the *GemStone/S 64 Bit Installation Guide* for the client platform.

- If you are using named NetLDIs, you must configure your client system services database to map the same NetLDI name to the same port as defined on the server. If you are using a local services database, edit /etc/services or, on Windows, \WINDOWS\system32\drivers\etc\services to add the appropriate entry.

Remote Gems

Configuring GemStone so that Gem sessions or linked applications can run on the remote node is much the same as configuring the Gem and cache a session process on the server, which is described in Chapter 3, “Configuring Gem Session Processes”.

The remote node will need access to a number of executables and shared libraries within the server installation. You can either repeat the installation from the GemStone distribution media, or mount the directory on the server node that contains $GEMSTONE.

If you repeat the installation on the remote node, we recommend that you also run `$GEMSTONE/install/installgs`. In particular, you should make the same selections

regarding the ownership and group for the GemStone files as you did on the primary server node. You can save disk space later by deleting initial repositories (`$GEMSTONE/data/extent0.dbf` and `$GEMSTONE/bin/*.dbf`) and the complete upgrade (`$GEMSTONE/upgrade`) and seaside (`$GEMSTONE/seaside`) directories.

Some additional details points to keep in mind:

- A remote node (on which a Gem is running) must have its kernel configured for shared memory similarly to how it is configured on the primary server node.
- Only nodes running a Stone need a GemStone key file, not nodes running remote sessions.
- It's best if each node has its own directory for `/opt/gemstone/log` and `/opt/gemstone/locks` (or `/usr/gemstone/log` and `/usr/gemstone/locks`, or other location under $GEMSTONE_GLOBAL_DIR). If these directories are on an NFS-mounted partition, make sure that two nodes are not using the same directories. Each Stone and NetLDI needs a unique lock file. Shared log files may make it impossible to diagnose problems.
- If you are using named NetLDIs, you must configure your client system services database to map the same NetLDI name to the same port as defined on the server. If you are using a local services database, edit /etc/services or, on Windows, \WINDOWS\system32\drivers\etc\services to add the appropriate entry.
- Unless you run the NetLDIs in guest mode with a captive account, users must have an account on, and authorized network access to, all nodes that are part of the GemStone network for the repository they will be using. This includes the nodes on which the Stone Repository monitor and the user's Gem session process reside.

  Unless you run the NetLDIs in guest mode with a captive account, *the user who starts the Stone repository monitor* ordinarily needs an account on *every* node where a Gem session process will run.

Configuration Examples

GemStone supports several configurations in which the application communicates with the Gem session process by using remote procedure calls (RPCs), as well as linked applications. This section presents examples that illustrate the processes and interprocess connections within the following distributed applications:

- RPC Application on a Remote Node with Local Gem (page 90)
- Linked Application on a Remote Node (page 91)
- RPC Application on a Remote Node with Remote Gem (page 92)
- RPC Application, Gem, and Stone on Three Nodes (page 93)
- Distributed System with a Mid-Level Cache (page 94)

Determine if you will run RPC or Linked application

GemStone shared libraries are provided in two variants: linked and RPC. In order to login a linked session, you must be running an application bound to the linked libraries, such as topaz -l. To login an RPC session, you may run an application bound with the RPC libraries or with the linked applications.

A linked application may have only one linked login, but may login RPC sessions in addition to (or instead of) the linked login. RPC sessions applications are not able to login linked sessions.

Set the environment

The instructions assume that you are already set up to run GemStone applications, as described in Chapter 3. In particular, you must have defined the GEMSTONE environment variable and invoked `$GEMSTONE/bin/gemsetup.sh` or its equivalent, so the system search path include `$GEMSTONE/bin`.

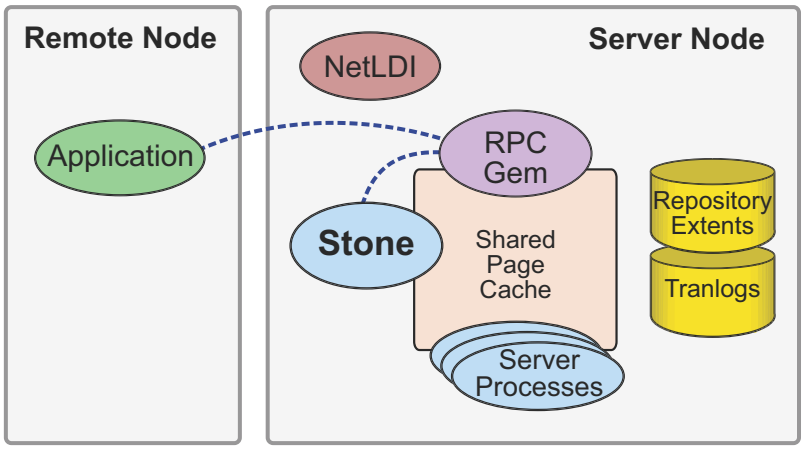
Configure NetLDI and authentication mechanism

For all these examples, you must have a NetLDI running on the Stone's host. In many cases you will also need a NetLDI on the remote node or nodes. These should be configured according to your security requirements, as described under "NetLDI configuration" on page 73.

RPC Application on a Remote Node with Local Gem

If the Gem session process is going to run on the server node (as shown in Figure 5.4), an RPC application uses a NetLDI on that node to start a Gem session process. Unless the NetLDI is running in guest mode with a captive account, the application user must provide authentication to the NetLDI. The login parameters include the specification for the Gem network object (`gemnetobject`). For more information about network objects and how to invoke them, see "Connecting to the RPC Gem" on page 86.

Figure 5.4 RPC Application on a Remote Node with remote Gem



To login an RPC session with the Gem on the Stone's host, set the login parameters as follows:

- Set the Stone's name:

  ```
  topaz> set gemstone stoneName
  ```

  The hostname is optional in this case; by default, it will use the host specified by the NRS in the gem service parameter (gemnetid)

- Set GemStone user name and password:

```
topaz> set username DataCurator
topaz> set password swordfish
```

  You may omit the password; you will be prompted for it on login.

- Set host authentication, if your NetLDI is not running in guest mode:

```
topaz> set hostusername unixUserAccountName
topaz> set hostpassword passwordForUnixUserAccount
```

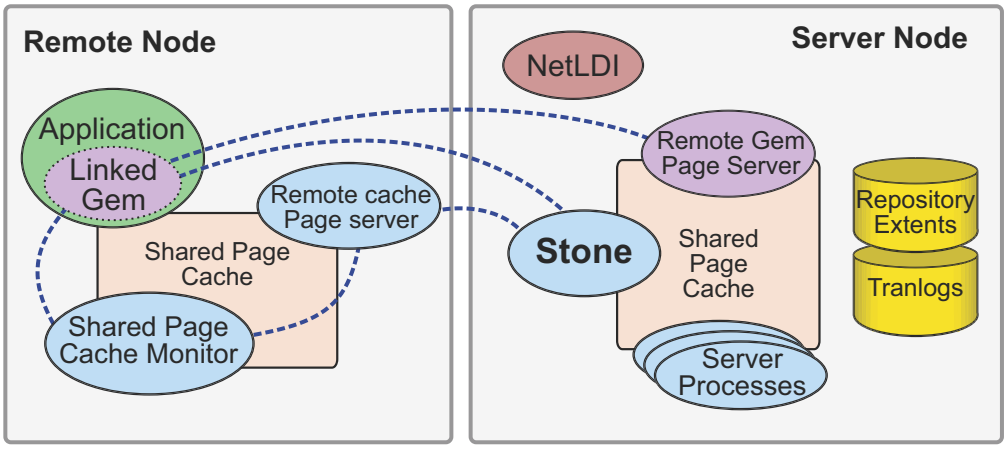
- Set the gem service, specifying the stone's host name, and the name of the NetLDI if necessary. For example, either one of the following:

```
topaz> set gemnetid !@serverhost!gemnetobject
topaz> set gemnetid !@serverhost!netldi:NetLdiName!gemnetobject
```

Linked Application on a Remote Node

Figure 5.5 shows how a linked application on a remote node communicates with a Stone and repository on the primary server node.

Figure 5.5 Connecting a Linked Application to a Remote Server



In this configuration, a remote, subordinate shared page cache is started on the remote node, along with associated server processes. The configuration of this remote cache is set by the first session to log in on this node. After the last session on this node logs out, the cache will shut down.

In addition, this configuration requires a Remote Gem page server on the server node, which reads pages from the repository on behalf of the gem.

Because the shared page cache is readable and writable only by its owner and members of the same group (protection 660), the user running the application may need to belong to that group. See "Shared Page Cache" on page 80.

Set the login parameters as follows:

- Set the Stone's name, one of the following:

```
topaz> set gemstone !@serverhost!stoneName
topaz> set gemstone !@serverhost!netldi:NetLdiName!stoneName
```

- Set GemStone user name and password.

```
topaz> set username DataCurator
topaz> set password swordfish
```

  You may omit the password; you will be prompted for it on login.

- Set host authentication, if your NetLDI is not running in guest mode:

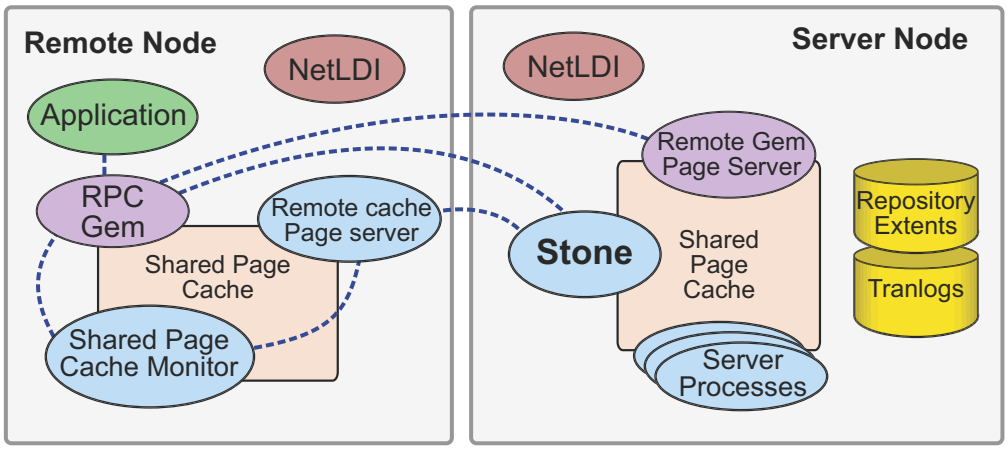
```
topaz> set hostusername unixUserAccountName
topaz> set hostpassword passwordForUnixUserAccount
```

- Do **not** set the gem service; doing so specifies that the login will be RPC, rather than linked.

RPC Application on a Remote Node with Remote Gem

The configuration shown in Figure 5.6 shows the RPC application and its session process running on the same node. This configuration is similar to a linked application, but in this case, a NetLDI is required on the remote node in order to launch the RPC Gem session process.

Figure 5.6 Starting the Session Process on a Remote Node



- Set the Stone's name, one of the following:

```
topaz> set gemstone !@serverhost!stoneName
topaz> set gemstone !@serverhost!netldi:NetLdiName!stoneName
```

  You must specify the Stone's host, since the otherwise it will assume the Stone is on the same node as the Gem, given in the gemnetid's NRS.

- Set GemStone user name and password.

```
topaz> set username DataCurator
topaz> set password swordfish
```

You may omit the password; you will be prompted for it on login.

- Set host authentication, if your NetLDI is not running in guest mode.

```
topaz> set hostusername unixUserAccountName
topaz> set hostpassword passwordForUnixUserAccount
```

- Set the gem service, specifying the stone's host name, and the name of the NetLDI if necessary. For example, one of the following:

```
topaz> set gemnetid !@remotenode!gemnetobject
topaz> set gemnetid !@remotenode!netldi:NetLdiName!gemnetobject
```

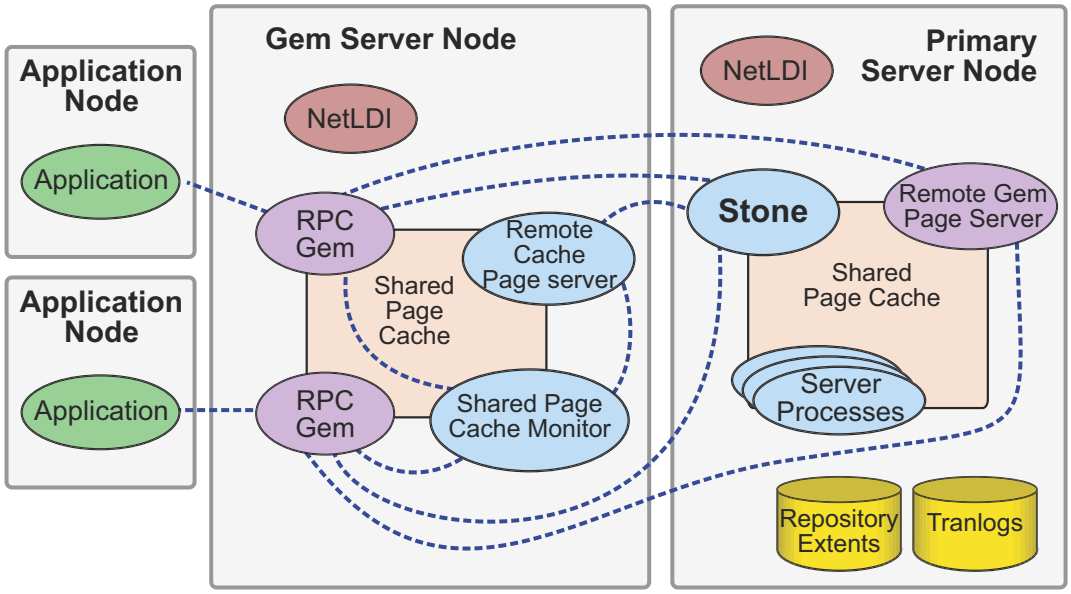
RPC Application, Gem, and Stone on Three Nodes

The RPC application, session process, and Stone can run on three separate nodes. The application runs on its node and connects to a Gem session process on the Gem's node, which is sometimes referred to as the Gem Server. That session process communicates with the repository on the primary server node by way of a page server.

Again we see that a NetLDI must be running on each node where part of GemStone executes (but is not required on the application node, which runs only the RPC application).

The following diagram shows two separate RPC applications connecting to Gems running on the same node, the Gem Server node.

Figure 5.7 RPC Applications using a Gem Server Node



The directions for this configuration are the same as for the previous configuration, "RPC Application on a Remote Node with Remote Gem"; however, the application itself is executing on a third node.

- Set the Stone's name, one of the following:

```
topaz> set gemstone !@serverhost!stoneName
topaz> set gemstone !@serverhost!netldi:NetLdiName!stoneName
```

  You must specify the Stone's host, since the otherwise it will assume the Stone is on the same node as the Gem, given in the gemnetid's NRS.

- Set GemStone user name and password.

```
topaz> set username DataCurator
topaz> set password swordfish
```

  You may omit the password; you will be prompted for it on login.

- Set host authentication, if your NetLDI is not running in guest mode.

```
topaz> set hostusername unixUserAccountName
topaz> set hostpassword passwordForUnixUserAccount
```

- Set the gem service, specifying the stone's host name, and the name of the NetLDI if necessary. For example, one of the following:

```
topaz> set gemnetid !@remotenode!gemnetobject
topaz> set gemnetid !@remotenode!netldi:NetLdiName!gemnetobject
```

Distributed System with a Mid-Level Cache

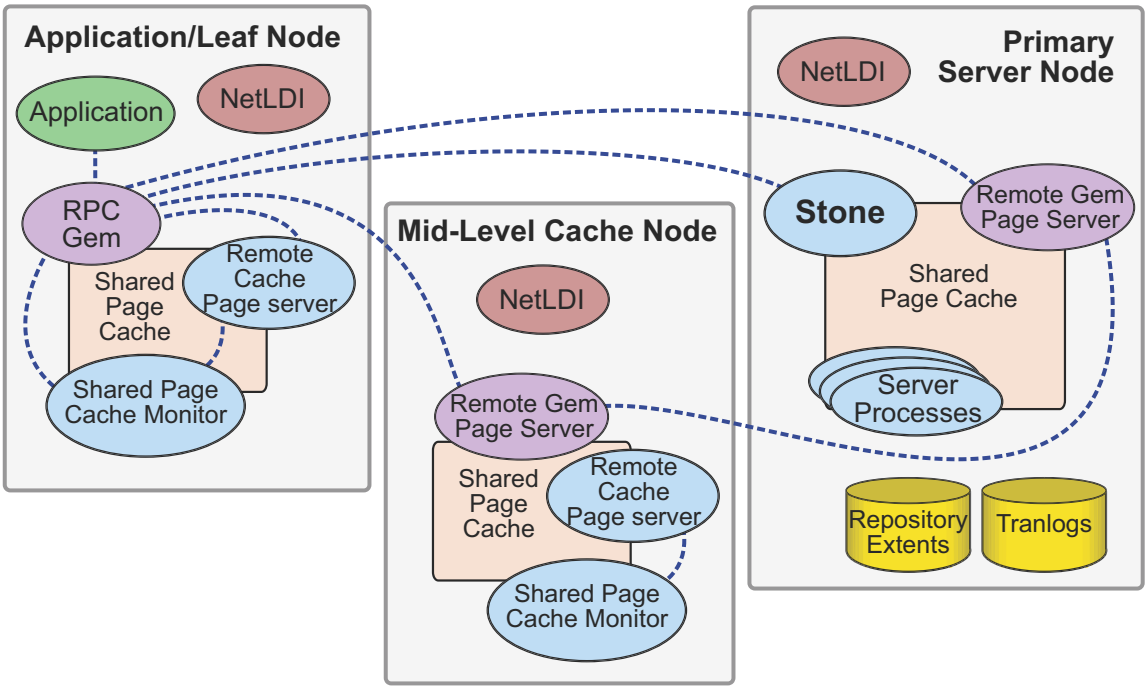
In a distributed system over a Wide Area Network (WAN), with many remote nodes that are topographically distant from the Stone but close to each other, a mid-level cache can improve performance for the remote sessions. In this configuration, the RPC application and the session process may be on the same or different nodes, with the mid-level cache and Stone running on separate nodes. In Figure 3.8, the Gem session process (on the leaf node) connects to a mid-level cache (on the mid-level cache node). The session process communicates with the repository (on the primary server node) by way of a page server.

When the Gem needs a page but can't find it in its local cache, it first looks in the mid-level cache. If the Gem can't find the page in the mid-level cache, it then forwards the request to the page server on the Stone's host.

The Stone's page server aggregates the responses from the page servers on each of the Gem's shared caches, and returns a combined response to the Stone. This reduces the number of round trips from the Stone to distant nodes.

If a mid-level cache is in use, then for each Gem process using the mid-level cache, all the shared caches to which the Gems are attached are subordinate to that mid-level cache.

Figure 5.8 An Application with a Mid-Level Cache



Setting up a configuration with a mid-level cache requires that the session execute code following login to start a mid-level cache on a specified host, or to connect to an existing mid-level cache. Unlike the other remote configurations discussed in this chapter, the configuration is not established entirely by configuration settings and login arguments.

The Gem must be on a node that is remote from the Stone, and the request to connect to a mid-level cache must specify a node that is neither the Stone's nor the Gem's node.

If a Gem is running on the same machine as a mid-level cache, that Gem will use the mid-level cache as its local cache.

Connection Methods

System Class methods in the Shared Cache Management category allow you to connect to a mid-level cache.

`midLevelCacheConnect:` *hostName*

Attempts to connect to a mid-level cache on the specified host, if the cache already exists. The session's Gem process must be on a machine different from the machine running the Stone process.

`midLevelCacheConnect:` *hostName* `cacheSizeKB:` *aSize*
`maxSessions:` *nSess*

If a mid-level cache does not already exist on the specified host, and *aSize* > 0, attempts to start the cache and connect to it. If a cache is already running on the host, this method attempts to connect to the cache and ignores the other arguments.

The size of the mid-level cache is controlled by the method argument *aSize*, rather than by configuration parameters (as with other shared caches).

For example,

```
topaz> set gemstone !@Server!gs64stone
topaz> set username DataCurator
topaz> set gemnetid !@gemNode!gemnetobject
topaz> login
GemStone Password?
<details omitted>
successful login
topaz 1>
topaz 1> printit
  System midLevelCacheConnect: 'midLevelCacheNode'
    cacheSizeKB: 16000 maxSessions: 12
%
true
```

Reporting Methods

To determine what node a session is using as a mid level cache, use `System class >> midLevelCacheAddress`.

System Class methods in the Shared Cache Management category return lists of the shared caches on your system.

`System class >> remoteCachesReport`
: Returns a String that lists all shared caches that the Stone process is managing, not including the cache on the Stone machine.

`System class >> midLevelCachesReport`
: Similar to `remoteCachesReport`, but only includes the mid-level caches.

5.3 Troubleshooting Remote Logins

Logging into GemStone from a remote node requires proper system configuration of the remote node and frequently requires permission for network access from the primary server to the remote node as well as from the remote node to the primary server.

- The UNIX kernel on the remote node should meet shared memory and semaphore requirements similar to those for the server, although smaller sizes may be sufficient.
- Make sure that NetLDIs are running on all nodes that require them (all nodes except remote nodes that do not run RPC Gems), and that the NetLDIs are the same version as your environment, and that the startnetldi that started the NetLDI processes used the appropriate options to specify authentication (guest mode, or Kerberos, for example).

  It can be useful to enable debug mode for each of the NetLDIs, which will report additional details about connection attempts. Restart the NetLDI with the **-d** option, or use the **netldidebug** (page 378).
- Make sure that all named NetLDIs have the same port number in the services database/s for each node, and that all node names are listed in `/etc/hosts`.

- If an RPC application is being started (that is, one with a separate Gem session process), check that the authentication is valid; the user has entered their username and password, if needed, and if Kerberos is used, that their ticket is valid. See "Setting up the NetLDI Configuration" on page 76 for NetLDI authentication.
- Ownership and permissions for `$GEMSTONE/sys/netldid` must be appropriate for the authentication system in use (details can be found under "Setting up the NetLDI Configuration" on page 76
- the directories in `/opt/gemstone` must be writable.
- Ensure that he owner of the Gem process has an account on the node where the Gem will run and needs access to the Gem log location, typically in $HOME; and that the user who started the Stone has an account on the remote node. This user also may require write permission for $HOME, if the remote server process log files are not configured to write to a different location. .
- Check any GEMSTONE environment variables for definitions that point to a previous version: **env | grep GEM**.

How the Login Process starts Session Processes

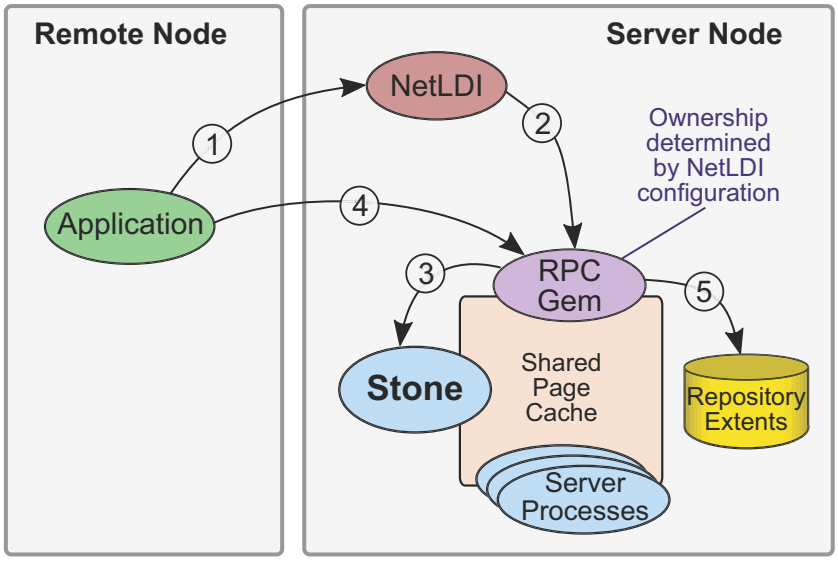
When a remote client applications requests a login, it communicates with the appropriate processes on the server. This process is ordinarily transparent to the user.

The following examples show the sequence of steps that occur during login in order to start the required processes and connect them appropriately.

RPC Application with Gem on Server Node

The simplest configuration for a distributed configuration is a client application running on a remote node, that connects to a RPC Gem session on the server node. The following examples describe the sequence of steps that connect this configuration during login.

Figure 5.9 Connecting an RPC Application with Gem on Server Node



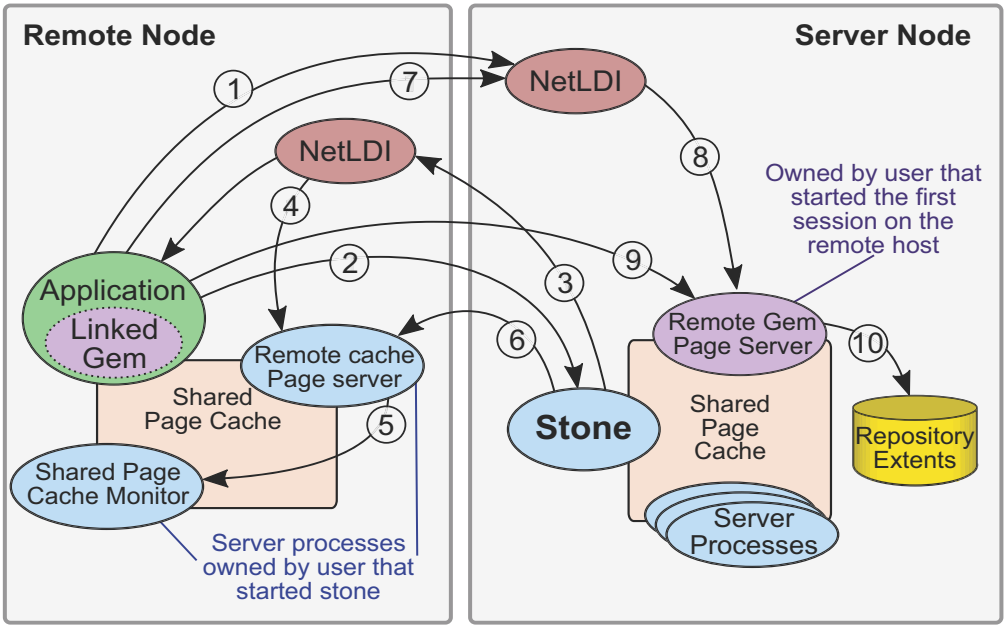
1. The client application contacts the NetLDI on the server node and requests a session.
2. The NetLDI invokes gemnetobject or a similar script to start an RPC Gem.
3. The Gem performs the login to the Stone.
4. The application client connects to the Gem.
5. The Gem attaches extent files.

Linked Application on Remote Node

A remote linked login is more involved, since the remote shared page cache and associated processes are also started up.

In this example, there is a NetLDI running on the remote node. This is not required for a linked login; in the case of a linked login with no NetLDI running, the tasks performed by the NetLDI are handled by the linked gem. .

Figure 5.10 Connecting a Linked Application to a Remote Server



1. The client application contacts the NetLDI on the server node, requesting the Stone's listening port.
2. The client application contacts the Stone on its listening port, requesting login.
3. Stone requests the Remote Cache page server on remote node, if there is not already an SPC on the remote node. If there is a cache already there, continue with step 6.
4. The NetLDI on the remote node launches the Remote Cache page server.
5. The Remote Cache page server launches the Shared Page Cache Monitor, which initializes the shared page cache.
6. Stone connects to the Remote Cache page server.
7. The client application requests a Remote Gem page server, if there is not already a Remote Gem page server for this node. If a Remote Gem page server already present, continue with step 9.
8. The NetLDI on the server node launches the Remote Gem page server.
9. The client application connects to the Remote Gem page server.
10. A newly launched Remote Gem page server attaches the extent files.

If You Still Have Trouble

If you still can't log in to GemStone from an application on a remote node, try logging in on the server node as the same UNIX user account. We suggest that you first try a linked application, such as **topaz -l**, and when that works, move on to an RPC application (such as **topaz** or the equivalent **topaz -r**), still on the server.

Try Linked Topaz on the Server

A linked application on the server offers the least complicated kind of login because the server's shared page cache is already running and no network facilities are used. Any problems are likely to involve access permission for the shared page cache or the repository extents, which can also block attempts to log in from a client node.

- Make sure that the owner of the topaz process (`$GEMSTONE/bin/topaz`) can access the shared page cache. Use the UNIX command **ipcs -m** to display permissions, owner, and group for shared memory; for example:

  ```
  Server% ipcs -m
  IPC status from <running system> as of Thu Aug 27 16:22:27 PDT
  2020
  T     ID     KEY        MODE       OWNER    GROUP
  Shared Memory:
  m    768 0x4c177155 --rw-rw----  gsadmin     pubs
  ```

  Compare the owner and group returned by **ipcs** with the owner of the Topaz process. You can use the **ps** command to determine the owner; for example, **ps -ef | grep topaz**. (The switches may be different on your system.)

  A typical problem arises when root owns the Stone process and the shared page cache because their group ordinarily will be a special one to which Topaz users do not belong. Related problems may occur with a linked GemBuilder session. The third-party Smalltalk may be installed without the S bits and therefore may rely on group access to the shared page cache and repository. For background information, see "File Permissions" on page 78.

  To correct a shared page cache access failure, either change the owner and group of the setuid files or have the Stone started by a user whose primary group is one to which other GemStone users belong. Unlike file permissions, the shared page cache permissions cannot be set directly.

- Make sure the owner of the Topaz process has read-write access to `$GEMSTONE/data/extent0.dbf`.

Try Topaz RPC on the Server

The next step should be to try running Topaz on the server with a separate Gem session process. This configuration relies on the NetLDI to start a Gem session process, and that process, not the application itself, must be able to access the shared page cache and repository extent.

- Make sure that a NetLDI is running on the server by invoking **gslist**. The default name is `gs64ldi`. If you need to start a NetLDI, the command is **startnetldi**.

  GemStone uses the NetLDI to start a Gem session process that does repository I/O in this configuration. For the NetLDI to start processes for anyone other than its owner, it must be owned by root or it must be started in guest mode and captive account mode by someone logged in as the captive account.

  The NetLDI writes a log file with the default name `/opt/gemstone/log/gs64ldi.log`; this may be overridden by the **startnetldi -l** option. Using the **gslist -x** command will provide the location of all log files. The log file contents may help you diagnose problems. (See the following discussion, "Check NetLDI Log Files.")

- Make sure that the owner of the resulting Gem session process (`$GEMSTONE/sys/gem`) can access the shared page cache and `extent0.dbf` through group membership or S bits. The troubleshooting is the same as that given on page 100 for the `topaz` executable.
- The user who starts topaz (or the NetLDI captive account when it is in use) must have write permission for $HOME so that the session process can create a log file there. (For a workaround for situations where write permission is not allowed, see "Controlling log file directory locations" on page 417.)

Check NetLDI Log Files

Troubleshooting on a distributed GemStone system can be complicated. What looks like a hung process may actually be caused by incorrect NRS syntax or by another node on the network going down. The information for analyzing problems may be found in log files on all the nodes used by GemStone.

Where the log file messages include NRS strings, be sure to check their syntax. The problem may be as simple as an incorrect NRS or one that was not expanded by the shell as you intended.

If you can't identify the problem from the standard log messages, try running the NetLDI in debug mode, which puts additional information in the log. The command line is **startnetldi** [*netLdiName*] **-d**. For further details, see **startnetldi** on page 393.

Chapter

6 Running GemStone

This chapter shows you how to perform some common GemStone/S 64 Bit system operations:

Starting the GemStone Server (page 103)
How to startup the GemStone repository, and troubleshooting Stone startup failures.

Starting a NetLDI (page 109)
How to start a NetLDI, and troubleshooting NetLDI startup failures.

Starting a GemStone Session (page 110)
How to login and troubleshooting login failures

Shutting Down Sessions, the Object Server, and NetLDI (page 116)
How to stop sessions and shut down server processes

Logins without a stone running (page 118)
How to login a solo session in the absence of a Stone

Recovering from an Unexpected Shutdown (page 119)
Troubleshooting unexpected shutdowns.

6.1 Starting the GemStone Server

In order to start a Stone repository monitor, the following must be identified through your operating system environment:

- **Where GemStone is installed**

  The GEMSTONE environment variable must point to the directory where GemStone is installed, such as `/users/gemstone`. The directory `$GEMSTONE/bin` should be in your search path for commands.

- **Which configuration parameters to use**

  The repository monitor must find a configuration file. The default is `$GEMSTONE/data/system.conf`. Other files can supplement or replace the default file; for information, see "How GemStone Uses Configuration Files" on page 307.

- **Which repository to use**

  The configuration file must supply the path to one or more repository files (extents) and to the location/s to read and write transaction logs. The default configuration file specifies `$GEMSTONE/data/extent0.dbf` for the extent file, and places transaction logs in `$GEMSTONE/data/`. For further information, see "Choosing the Extent Location" on page 43.

To Start GemStone

Follow these steps to start GemStone following installation or an orderly shutdown. (To recover from an abnormal shutdown, refer to "Recovering from an Unexpected Shutdown" on page 119.)

Step 1. Set the GEMSTONE environment variable to the *full pathname* (starting with a slash) of the directory where GemStone is installed. Ordinarily this directory has a name like `GemStone64Bit3.6.0-x86_64.Linux` (depending on your platform). For example:

```
$ GEMSTONE=/users/GemStone64Bit3.6.0-x86_64.Linux
$ export GEMSTONE
```

If you have been using another version of GemStone, be sure you update or unset previous settings of these environment variables:

- GEMSTONE
- GEMSTONE_SYS_CONF
- GEMSTONE_EXE_CONF
- GEMSTONE_NRS_ALL

Step 2. Set your UNIX path. One way to do this is to use one of the `gemsetup` scripts. There is one version for users of the Bourne and Korn shells and another for users of the C shell. These scripts also set your man page path to include the GemStone man pages. Note that these scripts append to the end of your path or man path; you will need to manually remove references to older versions of GemStone.

(Bourne or Korn shell)

```
$ . $GEMSTONE/bin/gemsetup.sh
```

or (C shell)

```
% source $GEMSTONE/bin/gemsetup.csh
```

Step 3. Start GemStone by using the **startstone** command:

```
% startstone [gemStoneName]
```

where *gemStoneName* is optional and is the name you want the repository monitor to have. The default name is `gs64stone`. If using encrypted extents, the arguments to supply the keys and passphases are required. See **startstone** on page 396 for additional information.

To Troubleshoot Stone Startup Failures

If the Stone repository monitor fails to start in response to a **startstone** command, it's likely that the cause is one of the following. Inspect the Stone log for clues (the default location is `$GEMSTONE/data/gs64stone.log`).

- The GemStone key file is missing or invalid.
- The shared page cache cannot be attached, usually do to OS limits or a previous shutdown did not complete cleanly.
- A problem with the extents: a missing extent, one that is in use by another process, the current user does not have write permission, or the authorization for encrypted extents failed.
- A problem with transaction logs: a log needed for recovery is missing, or the log directory or device does not exist.
- The repository has become corrupted.

Missing or Invalid Key File

The Stone repository monitor must be able to read the GemStone key file. By default, this is `$GEMSTONE/sys/gemstone.key`. The location and filename can be configured by the KEYFILE configuration parameter.

Ordinarily, you create the key file during installation from information provided by GemStone. Be careful to enter the information correctly. GemStone key files are platform-specific, and key files for earlier versions may not work with new major releases.

If you do not have a valid key file, contact GemStone Technical Support as described under "Technical Support" on page 4.

Shared Page Cache Cannot Be Attached

The shared page cache monitor must be able to create and attach to the shared memory segment that will serve as the shared page cache. Several factors may prevent this from happening:

- On some platforms, shared memory is not enabled in the kernel by default, or its default maximum size is too small to accommodate the GemStone configuration. GemStone's default configuration requires a shared memory segment somewhat larger than 75 MB. For specifics about configuring shared memory, refer to the *GemStone/S 64 Bit Installation Guide* for your platform.
- If the size of the shared page cache has been increased, the operating system's limit on shared memory regions may need to be increased accordingly. GemStone includes a utility, `$GEMSTONE/install/shmem`, that will help you check the configuration; this is described on page 40.
- The repository executables (the Stone, Gems, and Page servers) must have permission to read and write the shared page cache. Ways to set up access are described in "How To Set Up a Raw Partition" on page 50. In general, users must belong to the same group as the Stone repository monitor. If the Stone is running as root, it is unlikely that other users will be able to access the shared page cache.

Extent Missing or Access Denied

If the Stone repository monitor cannot access a repository extent file, it logs a message like the following:

```
GemStone is unable to open the file $GEMSTONE/data/extent0.dbf
       reason = File does not exist

    An error occurred opening the repository for exclusive access.
    Stone startup has failed.
```

The reason should provide enough information: the extent file could be missing, the permissions on the file or directory could be set incorrectly, or there may be an error in the configuration file that points to the extents. Correct the problem, then try starting GemStone again.

Extent Open by Another Process

If another process has an extent file open when you attempt to restart GemStone, a message like the following appears in the Stone log (by default, `$GEMSTONE/data/gs64stone.log`):

```
GemStone is unable to open the file $GEMSTONE/data/extent0.dbf
       reason = exclusive open:  File is open by another process.
      , file /gshost/GemStone3.6/data/extent0.dbf,  failed with
      EWOULDBLOCK

    An error occurred opening the repository for exclusive access.
    Stone startup has failed.
```

Close any other Gem sessions (including Topaz sessions) that are accessing the repository you are trying to restart. Use **`ps -ef`** (the options on your system may differ) to identify any `pgsvrmain` processes that are still running, and then use **`kill`** *processid* to terminate them. Try again to start GemStone.

Extent Already Exists

If GemStone attempts to recover from a system crash that occurred just after an extent was created, and GemStone was not able to write a checkpoint when the extent was added, you will find an error message like the following in the Stone log:

```
Repository was not shutdown cleanly, recovery needed.
    fileName
!@::1#netldi:51234#dbf!/gshost/GemStone3.6/data/extent1.dbf
      already exists, delete it and restart recovery.
    Stone startup has failed.
```

Check that an extent was being added to the repository at or shortly before the crash. If necessary, look for a message near the end of the Stone log file.

- If an extent was being added, there is no committed data in the extent file yet. Delete the specified file and do not replace it with anything. Try to start GemStone again. The recovery procedure will recreate the extent file.
- If an extent was NOT being added, it is possible that an existing extent has been corrupted. For instance, `extent0.dbf` of a multiple-extent repository may have

been overwritten. Try to determine the cause and whether the action can be rectified. You may have to restore the repository from a backup.

Other Extent Failures

At startup, the GemStone system performs consistency checks on each extent listed in DBF_EXTENT_NAMES.

All extents must have been shut down cleanly with a repository checkpoint the last time the system was run. This consistency check is the only one for which GemStone attempts automatic recovery.

The following consistency checks, if failed, cause the startup sequence to terminate. These failures imply corruption of the disk or file system, or that the extents were modified at the operating system level (such as by **cp** or **copydbf**) outside of GemStone's control and in a manner that has corrupted the repository.

- Extents must be in proper sequence within DBF_EXTENT_NAMES.
- Extents must be properly sequenced in time.
- The last checkpoint must have occurred earlier than or at the same time as the current system time (in GMT).
- Extents must belong to the correct repository.

Transaction Log Missing

If GemStone cannot find the transaction log file for the period between the last checkpoint and an unexpected shutdown, it puts a message like this in the Stone log:

```
Extent 0 was not cleanly shutdown.
<Repository startup statistics>

Repository startup from checkpoint fileId 2 blockId 16, needs
   recovery

ERROR: cannot find log file(s) to recover repository.
To proceed without tranlogs and lose transactions committed
since the last checkpoint use "-N" switch on your startstone
command.

An error occurred when attempting to start repository recovery.
Waiting for aiowrites to complete

Stone startup has failed.
```

If the log file was archived and removed from the log directory, restore the file.

If the log file is no longer available, you can use **startstone -N** to restart from the most recent checkpoint in the repository. However, any transactions that occurred during the intervening period cannot be recovered.

NOTE

*When you use **startstone** with the **-N** option, any transactions occurring after the last checkpoint are permanently lost.*

Other Startup Failures

- Check `/opt/gemstone/locks` (or equivalent location, as discussed on page 30) and delete old lock files. On Solaris systems, also check `/tmp/gemstone` for *stoneName*`..FIFO`.
- Certain unexpected shutdowns may leave UNIX interprocess communication facilities allocated, which can block attempts to restart the repository monitor. Use the command **ipcs** to identify the shared memory segments and semaphores allocated, then use **ipcrm** to free those resources allocated to a repository monitor that is no longer running. For information about **ipcs** and **ipcrm**, consult your operating system's documentation.
- If it takes more than 5 minutes for your cache to complete initialization, the startup timeout may be expiring. Set the environment variable $GEMSTONE_SPCMON_STARTUP_TIMELIMIT (page 434).
- Check your installation configuration and make sure that all required files and libraries are present and uncorrupted.
- Try to run **pageaudit** on the repository. (See "Repository Page and Object Audit" on page 134.)

If you are still unable to start GemStone or determine the reason that startup is failing, contact your local GemStone administrator or GemStone Technical Support.

If this is an existing GemStone repository and the problems reported on startup attempts indicate that the repository is corrupt, you may need to restore from backups, as described in Chapter 11. See ""How to Restore from Backup" on page 224.

Listing Running Servers

The **gslist** utility lists all Stone repository monitors, shared page cache monitors, and NetLDIs that are running. The **gslist** command by itself checks the locks directory (`/opt/gemstone/locks`, `/usr/gemstone/locks`, or `$GEMSTONE_GLOBAL_DIR/locks`) for entries. The **-v** option causes it to verify that each process is alive and responding. For example:

```
% gslist -v
Status Version Owner     Started      Type   Name
------ ------- --------- ------------ ------ ----
 OK    3.6.0   gsadmin   Aug 24 12:02 cache  gs64stone~1c9fa07f0412665
 OK    3.6.0   gsadmin   Aug 24 12:02 Stone  gs64stone
 OK    3.6.0   gsadmin   Aug 24 10:13 Netldi gs64ldi
```

By default, **gslist** lists servers on the local node. The **-m** *host* option performs the operation on node *host*, which must have a compatible NetLDI running.

6.2 Starting a NetLDI

You will usually need to start a GemStone Network Long Distance Information (NetLDI) server when starting a Stone repository monitor. NetLDI servers are needed to start up Gem processes for RPC logins, and for starting up caches on behalf of Gems that are on other nodes.

If you are running distributed configurations, you will need to perform these steps on each node that requires a NetLDI.

To start a NetLDI server, perform the following steps on the node where the NetLDI is to run:

Step 1. Set the GEMSTONE environment variable to the *full pathname* (starting with a slash) of the directory where GemStone is installed. Ordinarily this directory has a name like `GemStone64Bit3.6.0-x86_64.Linux` (depending on the platform). For example:

```
$ GEMSTONE=/installDir/GemStone64Bit3.6.0-x86_64.Linux
$ export GEMSTONE
```

If you have been using another version of GemStone, be sure you update or unset previous settings of the $GEMSTONE_NRS_ALL environment variable

Step 2. Use one of the `gemsetup` scripts to set your UNIX path. There is one version for users of the Bourne and Korn shells and another for the C shell. These scripts also set your man page path to include the GemStone man pages.

(Bourne or Korn shell)

```
$ . $GEMSTONE/bin/gemsetup.sh
```

or (C shell)

```
% source $GEMSTONE/bin/gemsetup.csh
```

Step 3. Start the NetLDI by using the **startnetldi** command.

- To start the NetLDI for password authentication, make sure that `$GEMSTONE/sys/netldid` is owned by root and has the S bit set. Issue this command (on some operating systems, you may have to issue it as root):

  ```
  % startnetldi
  ```

- To start the NetLDI in guest mode (authentication is not required), make sure that `$GEMSTONE/sys/netldid` does NOT have the S bit set. Log in as the captive account *name*, then issue this command:

  ```
  % startnetldi -g -aname
  ```

See **startnetldi** on page 393 for additional command arguments and further detail. For information about the authentication modes, see under “Configuration Decisions” on page 73.

To Troubleshoot NetLDI Startup Failures

If the NetLDI service fails to start in response to a **startnetldi** command, it’s likely that the cause is one of the following:

- The NetLDI is to run as root but the guest mode option is specified. This combination is not allowed.

- The account starting the NetLDI does not have permission to create or append to its log file.
- The account starting the NetLDI does not have read and execute permission for `$GEMSTONE/sys/netldid`.

Check the NetLDI log for clues. By default, the NetLDI log (*netLdiName*`.log`) is located in `/opt/gemstone/log/`. On some systems, this file may be located in `/usr/gemstone/log/`, and may be overridden using the **startnetldi -l** argument, or by setting `$GEMSTONE_GLOBAL_DIR`.

6.3 Starting a GemStone Session

This section tells how to start a GemStone session and log in to the repository monitor. The instructions apply to all logins from the node on which the Stone repository monitor is running.

- For additional information about the GemStone administrative logins, see Chapter 8, "User Accounts and Security".
- For additional information about logging in from a remote node, see Chapter 5, "Connecting Distributed Systems".

This section begins with a brief discussion of environmental variables, and then presents two examples. The first example starts a linked application and logs in to GemStone. The second example starts an RPC application, which in turn spawns a separate Gem session process that communicates with the GemStone server.

The examples use Topaz as the application because it is part of the standard GemStone Object Server distribution. Other applications may use different steps to accomplish the same purpose. Some users may prefer to make these steps part of an initialization file.

For an explanation of the difference between linked and RPC sessions, see "Linked and RPC Applications" on page 62.

To Define a GemStone Session Environment

In order to start a GemStone session, the following must be defined through your operating system environment:

- Where GemStone executables and libraries are installed.

  All GemStone users must have a GEMSTONE environment variable that points to the GemStone installation directory, such as `/`*installDir*`/GemStone64Bit3.6.0-x86_64.Linux` (depending on your platform). The directory `$GEMSTONE/bin` should be in your search path for commands.

- Which configuration parameters to use.

  While system defaults, or a system-wide configuration file, can be used to configure Gem sessions, you may want to configure individualized environments and configuration files for specific sessions. This may involve setting an environmental variable, such as GEMSTONE_EXE_CONF. For further information, see "How GemStone Uses Configuration Files" on page 307.

To Start a Linked Session

The following steps show how to start a linked application (here, the linked version of Topaz). The steps for setting the GEMSTONE environment variable and the operating system path for a session are the same as those given on page 104 for starting a repository monitor. They are repeated here for convenience.

The procedure assumes that the Stone repository monitor has already been started and has the default name *gs64stone*.

Step 1. Set the GEMSTONE environment variable to the *full pathname* (starting with a slash) of the directory where GemStone is installed. Ordinarily this directory has a name like `GemStone64Bit3.6.0-x86_64.Linux` (depending on your platform). For example:

```
$ GEMSTONE=/installDir/GemStone64Bit3.6.0-x86_64.Linux
$ export GEMSTONE
```

If you have been using another version on GemStone, be sure you update or delete previous settings of these environment variables:

- GEMSTONE
- GEMSTONE_SYS_CONF
- GEMSTONE_EXE_CONF
- GEMSTONE_NRS_ALL

Step 2. Set your UNIX path. One way to do this is to use one of the `gemsetup` scripts. There is one version for users of the Bourne and Korn shells and another for users of the C shell. These scripts also set your man page path to include the GemStone man pages.

(Bourne or Korn shell)

```
$ . $GEMSTONE/bin/gemsetup.sh
```

or (C shell)

```
% source $GEMSTONE/bin/gemsetup.csh
```

Step 3. Start linked Topaz:

```
% topaz -l
```

Step 4. Set the *UserName* login parameter:

```
topaz> set username DataCurator
```

Step 5. Log in to the Gem session. It will query you for the password.

```
topaz> login
GemStone Password?
[Info]: LNK client/gem GCI levels = 36000/36000
--- 08/24/20 15:16:35.199 PDT Login
[Info]: User ID: DataCurator
[Info]: Repository: gs64stone
[Info]: Session ID: 5
[Info]: GCI Client Host: <Linked>
[Info]: Page server PID: -1
[Info]: using libicu version 58.2
[Info]: Gave this process preference for OOM killer: wrote to
/proc/26091/oom_score_adj value 250
[08/24/20 15:16:35.762 PDT]
  gci login: currSession 1  linked session
successful login
topaz 1>
```

At this point, you are logged in to a Gem session process, which is linked with the application. The session process acts as a server to Topaz and as a client to the Stone. Information about Topaz is in the manual *GemStone Topaz Programming Environment*.

When you are ready to end the GemStone session, you can log out of GemStone and exit Topaz in one step by invoking the Topaz **exit** command:

```
topaz 1> exit
```

To Start an RPC Session

The following steps show how to start an RPC application (here, the RPC version of Topaz) on the server node. The procedure assumes that the Stone is running under the default name *gs64stone* and that you are already set up to run a GemStone session as described in Step 1 and Step 2 of the previous example ("To Start a Linked Session").

Sessions that login RPC use SRP (Secure Remote Password) and SSL to authenticate passwords for login. If the Gem is running on the server node, the connection reverts to normal socket communication after login completes.

The following steps demonstrate an RPC login from topaz:

Step 1. Use **gslist** to find out if a NetLDI is already running. The default name for the NetLDI is `gs64ldi`.

```
% gslist
Status Version  Owner      Started    Type  Name
------ -------- --------- ------------ ------ ----
exists 3.6.0    gsadmin   Aug 24 12:02 cache gs64stone~1c9fa07f0412665
exists 3.6.0    gsadmin   Aug 24 12:02 Stone  gs64stone
exists 3.6.0    gsadmin   Aug 24 10:13 Netldi gs64ldi
```

If necessary, start a NetLDI following the instructions under "Starting a NetLDI" on page 109.

Step 2. Start the RPC application (such as Topaz), then set the *UserName*.

```
topaz> set username DataCurator
```

Step 3. Unless the NetLDI is running in guest mode with a captive account, set the application login parameters, such as *HostUserName* and *HostPassword, after you start the application. For example*:

```
topaz> set hostusername yourUnixId
topaz> set hostpassword yourPassword
```

Step 4. Set GemNetId (the name of the Gem service to be started) to `gemnetobject`. This script starts the separate Gem session process for you. For example:

```
topaz> set gemnetid gemnetobject
```

Step 5. Log in to the GemStone session.

```
topaz> login
GemStone Password?
[08/24/20 15:16:35.762 PDT]
  gci login: currSession 1 rpc gem processId 6943 socket 6
successful login
topaz 1>
```

At this point, you are logged in through a separate Gem session process that acts as a server to Topaz RPC and as a client to the Stone repository monitor.

When you are ready to end the GemStone session, you can log out of GemStone and exit Topaz by in one step by invoking the Topaz **exit** command:

```
topaz 1> exit
```

To Troubleshoot Session Login Failures

Several factors may prevent successful login to the repository:

- Your GemStone key file may establish a maximum number of user sessions that can simultaneously be logged in to GemStone. (Note that a single user may have multiple GemStone sessions running simultaneously.) The limit itself is encoded in the keyfile used to start the stone (by default, `$GEMSTONE/sys/gemstone.key`), and reported in the stone log on startup. Look for a line like this:

  ```
  SESSION MAX: The licensed concurrent session max is 10.
  ```

- The STN_MAX_SESSIONS configuration option can restrict the number of logins to fewer than a particular key file allows. An entry in the Stone log file shows the maximum at the time the Stone started. Look for a line like this:

  ```
  SESSION CONFIGURATION: The maximum number of concurrent
     sessions is 40
  ```

- The SHR_PAGE_CACHE_NUM_PROCS configuration option restricts the number of sessions that can attach to a particular shared page cache. This is normally computed based on the setting for STN_MAX_SESSIONS.

  Multi-threaded operations use additional slots for their working threads while they are executing. If you are close to your session limit, these operations may prevent other sessions from logging in.

- The UNIX kernel must provide sufficient semaphores and file descriptors for each logged in session. See your *Installation Guide* for information on UNIX kernel tuning that may be necessary.
- The owner of the Gem or a linked application process must have write access to the extent file and to the shared page cache. Use the UNIX command **ipcs -m** to display permissions, owner, and group for shared memory. For example:

```
server% ipcs -m

------ Shared Memory Segments --------
key         shmid      owner   perms  bytes      nattch  status
0xc8010015  278462466  gsadmin 660    132120576  5
```

  Typical problems occur with linked applications, which may be installed without the S bit and therefore rely on group access to the shared page cache and the repository.
- If the session is using a separate (RPC) gem process, see "Troubleshooting Remote Logins" on page 96.

Identifying and Stopping Logged-in Sessions

Privileges required: SessionAccess.

To identify the sessions currently logged in to GemStone, send the message `System class>>currentSessionReport.` This message returns an array of internal session numbers and the corresponding UserId, executable, and PID. For example:

```
topaz 1> printit
System currentSessionsReport
%
2 SymbolUser symbolgem 32103
3 GcUser admingcgem 32210
4 DataCurator gem 21589 on localhost
5 GcUser reclaimgcgem 32213
```

The session number can be used with other System class methods to stop a particular session. To get the sessionId for the current executing session, use `System class >> session`.

To get the UserProfile for a given session, execute:

```
System userProfileForSession:aSessionId
```

To get the UserProfile for the current session, execute:

```
System myUserProfile
```

The method `System class>>descriptionOfSession:`*aSessionId* returns an array of descriptive information, which can be used to find out details information and status for any session. This method returns an Array; the values in each slot are defined as follows:

1. The UserProfile of the session; nil if the UserProfile is recently created and not visible from this session's transactional view or the session is in login or processing, or has logged out.
2. A SmallInteger, the process ID of the Gem or topaz -l process .

3. The hostname of the machine running the Gem process. Specifically, the peer's hostname as seen by stone, for the gem to stone network connection used for login. (a String, limited to 127 bytes).
4. Primitive number in which the Gem is executing, or 0 if it is not executing in a long primitive.
5. Time of the session's most recent beginTransaction, commitTransaction, or abortTransaction (from System timeGmt).
6. The session state (a SmallInteger).
7. A SmallInteger whose value is -1 if the session is in transactionless mode, 0 if it is not in a transaction and 1 if it is in a transaction.
8. A Boolean whose value is true if the session is currently referencing the oldest commit record, and false if it is not.
9. The session's serial number (a SmallInteger).
10. The session's sessionId (a SmallInteger).
11. A String containing the IP address of host running the GCI process. If the GCI application is remote, the peer address as seen by the gem of the GCI application to gem network connection. If the GCI application is linked (using libgcilnk*.so or gcilnk*.dll) this is the peer's IP address as seen by stone, for the gem to stone network connection used for login.
12. The priority of the session (a SmallInteger).
13. Unique host ID of the host where the session is running (an Integer)
14. Time of the session's most recent request to stone (from System timeGmt)
15. Time the session logged in (from System timeGmt)
16. Number of commits which have occurred since the session obtained its view.
17. Nil or a String describing a system or gc gem.
18. Number of temporary (uncommitted) object IDs allocated to the session.
19. Number of temporary (non-persistent) page IDs allocated to the session.
20. A SmallInteger, 0 session has not voted, 1 session voting in progress, 2 session has voted, or voting not active.
21. A SmallInteger, processId of the remote GCI client process, or -1 if the session has no remote GCI client.
22. The KerberosPrincipal object used for passwordless login to the session, or nil if passwordless login was not used.
23. The sessionId of the hostagent session through which this session is communicating to stone, or -1 if session is not using a hostagent.
24. SmallInteger listening port if this session is a hostagent, or -1.

Refer the image method comment for the most recent details as elements are added at the end of the array.

6.4 Shutting Down Sessions, the Object Server, and NetLDI

Stopping Logged-in Sessions

Privileges required: SessionAccess and SystemControl

There are a number of methods on System class that can be used to stop a specific session, or all sessions:

`stopSession:` *aSessionId*
Stop the specified session; any transactions that the session was in are aborted, and the session is terminated. This method does not stop the GcGems or SymbolGem.

`terminateSession:` *aSessionId* `timeout:` *timeoutSeconds*
Stop the specified session; any transactions that the session was in are aborted, and the session is terminated. Waiting up to *timeoutSeconds* for the session to complete terminating before returning. This method can be used to stop the GcGems. but not the SymbolGem.

`stopUserSessions`
Stops all sessions other than system Gems; does not stop the GcGems nor SymbolGem. Any transactions that any of the sessions were in are aborted.

NOTE

Be aware that it may take as long as a minute for a session to terminate after you send `stopSession:`*.If the Gem is responsive, it usually terminates within milliseconds. However, if a Gem is not active (for example, sleeping or waiting on I/O), the Stone waits one minute for it to respond before forcibly logging it out. You can bypass this timeout by sending* `terminateSession:timeout:`

To verify all user sessions have logged out or been terminated, send the message `currentSessionNames` to System. For example, using Topaz:

```
topaz 1> printit
System currentSessionNames
%
session number: 2    UserId: GcUser
session number: 3    UserId: GcUser
session number: 4    UserId: SymbolUser
session number: 5    UserId: DataCurator
```

The SymbolUser and GcUser sessions are system session and will be shut down cleanly when the stone is shut down. The above example includes session 5, which is the user executing the example code.

Stopping the Stone

After all user sessions have logged out, use the **stopstone** command, which performs an orderly shutdown in which all committed transactions are written to the extent files.

```
% stopstone [StoneName] [gemstoneUserName] [gemstoneUserPassword] [-i]
```

If you do not supply the name of the Stone repository monitor, GemStone username, or password, **stopstone** prompts for this information. The user must have the SystemControl privilege (initially, this privilege is granted to SystemUser and DataCurator).

The **-i** option aborts all current (uncommitted) transactions and terminates all active user sessions. If you do not specify this option and other sessions are logged in, GemStone will not shut down and you will receive a message to that effect.

Stopping the NetLDI

There is a similar command to shut down the NetLDI network service.

```
% stopnetldi [netLdiName]
```

For more information, see the command reference in Appendix B; **stopstone** on page 407 and **stopnetldi** on page 406.

If you are logged in to a GemStone session, you can invoke `System class>>shutDown`, which also requires the SystemControl privilege.

Using OS kill

If you must halt a specific Gem session process or GemStone server processes, be sure to use only **kill** or **kill -term** so that the Gem or other process can perform an orderly shutdown.

kill -usr1 will not kill the process, but will cause a GemStone process to write its C and Smalltalk call stacks to the process log file. For linked logins, which do not have a separate process, the stack is written to the application's stdout.

Do NOT use **kill -9** or another uncatchable signal, which does not result in a clean shutdown, unless it is unavoidable. On some platforms, particular failures in disk I/O can result in a process that does not respond to kill.

If for some reason you do need to send **kill -9** to a shared page cache monitor, use **ipcs** and **ipcrm** to identify and free the shared memory and semaphore resources for that cache. If you send kill -9 to a Stone, use **ipcs** to determine whether **ipcrm** should be invoked.

Handling "Zombie" Sessions

Very rarely, an unexpected error can occur that leaves a Gem in an unresponsive state, where it is not shut down in by a `stopSession:` or similar method. These are often referred to as a "zombie" sessions. The actual cause and symptoms of a zombie session can vary widely. If you encounter issues with a zombie session, check for bugnotes, and contact GemTalk Technical Support for further diagnosis.

A session may be unresponsive for short periods during certain types of execution. This is normal, and not a cause for concern.

- A session that has encountered an error and is waiting for a debugger to attach is not a true zombie, but may require using **kill** to terminate.
- It may be possible to cleanup a zombie session by using **kill -TERM** on the Gem or linked process.
- The method `System stopZombieSession:` *aSessionId* bypasses some safeguards in `stopSession:` and may allow the session to complete logout.

6.5 Logins without a stone running

Read-only GemStone operations can be performed when a Stone is not running, by using a "solo" session. This makes it simple to set up Smalltalk-based scripting without needing to configure or start a Stone. More details on scripting is provided in the *Topaz Users Guide*.

Solo logins require access to an extent file, which can be the read-only empty distribution extent. You may also use an extent containing application code, data, or other modifications, provided the following are true for the repository extent:

- The extent must not part of a multi-extent repository
- The extent file must either have read-only file permissions, or it will be exclusive-locked by the solo session.
- If the extent file is not read-only, the repository using that extent must have been previously cleanly shutdown by the Stone

The configuration parameter GEM_SOLO_EXTENT specifies the extent file to be used by a Solo session. This defaults to the clean, read-only extent within the distribution, `$GEMSTONE/bin/extent0.dbf`.

Methods that require a connection to a Stone are disallowed in a Solo session; this includes a number of methods in System class and Repository. For example, methods such as `markForCollection`, `reclaimAll`, and methods that make and restore backups all require a running Stone. Attempting to execute these methods in a Solo session results in an ImproperOperation Error (#2050).

Solo login from topaz

To login Solo from topaz linked or RPC, execute `set sologin on`, then login.

For example:

```
topaz> set sologin on
topaz> set username DataCurator password swordfish
topaz> login
[08/24/20 15:16:35.762 PDT]
  gci login: currSession 1  rpc gem processId 20617 socket 6
    ReadOnly session
[Info]: Read-Only Repository:
    /gshost/GemStone3.6/bin/extent0.dbf
successful Solo login
topaz 1>
```

The **username** and **password** are required; the setting for **gemstone** is not used. In topaz RPC, you may perform a solo login while also logged into a GemStone Stone, provided the extent file used by the Solo session (by default, `$GEMSTONE/bin/extent0.dbf`) is not in use.

Object creation and memory use

Each Solo RPC or linked Gem also opens a 10MB read-write temporary file, `/tmp/gemRO_`*pid*`_extent1.dbf`, which is deleted on logout or process exit.

Object creation in a Solo session is limited to temporary object memory, but you may create objects as needed up to the limit of memory. To ensure there is sufficient memory, you may:

- Set a larger value for GEM_TEMPOBJ_CACHE_SIZE in the configuration file used by the topaz or Gem session.
- For linked sessions, use -T *cachesize* on the topaz command line.
- For RPC sessions, include -T *cachesize* in the NRS gemnetid login parameter.

Solo sessions other than from topaz

When the GCI flag #GCI_LOGIN_SOLO is used in the login parameters, any GCI application may create a solo login.

6.6 Recovering from an Unexpected Shutdown

GemStone is designed to shut down in response to certain error conditions as a way of minimizing damage to the repository. If GemStone stops unexpectedly, it probably means that one of the following situations has occurred:

- Disk failure
- Shared page cache monitor failure
- Fatal error detected by a Gem
- File system corruption
- Power failure
- Operating system crash

GemStone may also shut down if it runs out of extent or transaction log disk space. These are purposeful shutdowns, but since GemStone cannot perform the final writes to disk, it will require recovery on restart. Handling out of space issues is described under "Recovering from Disk-Full Conditions" on page 198.

When GemStone shuts down unexpectedly, check the message at the end of the Stone log file to begin diagnosing the problem. By default, the Stone log is `$GEMSTONE/data/`*gemStoneName*`.log`, but there are a number of ways that this can be configured. The names and locations of the Stone and other process log files is described under "GemStone Process Logs" on page 124.

Once the problem is identified, your recovery strategy should take into account the interdependence of GemStone system components. For instance, if an extent becomes unavailable, to restart the system and recover you may have to kill the Stone repository monitor if it is still running. The **stopstone** command won't work in this situation, since the orderly shutdown process requires the Stone to clean up the repository before it stops.

Clean Shutdown Message

If you see a shutdown message in the system log file, GemStone has stopped in response to a **stopstone** command or a Smalltalk `System shutdown` method, or in response to a kill -TERM:

```
--- 08/24/20 15:16:35.056 PDT ---
    Starting checkpoint for clean shutdown.
    Waiting for all tranlog writes to complete before shutdown.
    <other shutdown messages>
    Waiting for NetWrite thread to stop
    Waiting for Page Manager thread to stop

--- 08/24/20 15:16:35.961 PDT ---
    Now stopping GemStone.
```

After a clean shutdown, restart GemStone in the usual manner. For instructions, see "Starting the GemStone Server" on page 103 of this chapter.

Disk Failure or File System Corruption

GemStone prints several different disk read error messages to the GemStone log file. For example:

```
Repository Read failure,
fileName = !#dbf!/gshost/GemStone3.6/data/extent0.dbf
PageId = 94
File = /gshost/GemStone3.6/data/extent0.dbf
too few bytes returned from read()
DBF Operation Read; DBF record 94, UNIX codes: errno=34,...
      "A read error occurred when accessing the repository."
```

If you see a message similar to the above, or if your system administrator identifies a disk failure or a corrupted file system, try to copy your extents to another node or back them up immediately. The copies may be bad, but it is worth doing, just in case. If you're lucky, you may be able to copy them back after the underlying problem is solved and start again with the current committed state of your repository.

Otherwise, you may need to restore the repository. For details, see the restore procedures in Chapter 11.

Shared Page Cache Error

If you find a message similar to the following in the GemStone log, the shared page cache (SPC) monitor process (`shrpcmonitor`) died. The SPC monitor log, `$GEMSTONE/data/`*gemStoneName*`_pcmon`*nnnn*`.log`, may indicate the reason.

```
--- 08/24/20 15:16:35.762 PDT ---
    The stone's connection to the local shared cache monitor was
lost.
    Error Text: 'Network partner has disconnected.'
```

The unexpected shutdown of a Gem process may, in rare cases, result in a "stuck spin lock" error that brings down the shared page cache monitor and the Stone. GemStone uses spin locks to coordinate access to critical structures within the cache. In most cases, the monitor can recover if a Gem dies while holding a spin lock, but not all spin locks can be recovered safely. Stuck spin locks may result from a Gem crash, but a typical cause is the use of **kill -**

9 to kill an unwanted Gem process. If you must halt a Gem process, be sure to use only **kill** or **kill -TERM** so that the Gem can perform an orderly shutdown.

Use **`startstone`** to restart GemStone. For instructions, see "Starting the GemStone Server" on page 103.

Fatal Error Detected by a Gem

If a Gem session process detects a fatal error that would cause it to halt and dump a core image, the Stone repository monitor may do the same when it is notified of the event. This response on the part of the Stone is configurable through the STN_HALT_ON_FATAL_ERR configuration option. When that option is set to True and a Gem encounters a fatal error, the Stone prints a message like this in its log file:

```
Fatal Internal Error condition in Gem
   when halt on fatal error was specified in the config file
```

By default, STN_HALT_ON_FATAL_ERR is set to False. That setting causes the Stone to attempt to keep running if a Gem encounters a fatal error; it is the recommended setting for GemStone in a production system. You can set STN_HALT_ON_FATAL_ERR to True during development and testing to provide additional checks for potential risks.

Some Other Shutdown Message

In the event of other shutdown messages in the GemStone log:

1. Consider whether the shutdown might have been caused by a disk failure or a corrupt file system, especially if you see an unexpected message such as `Object not found`. If you suspect one of these conditions, start with a page audit of the repository file (see "Repository Page and Object Audit" on page 134).

   If the page audit fails, refer to "Disk Failure or File System Corruption" on page 120, and consult your operating system administrator.

   If the audit succeeds, continue to the next step.

2. If you don't suspect disk failure or a corrupt file system, try using **startstone** to restart GemStone. For instructions, see "Starting the GemStone Server" on page 103.

3. If the restart fails, you may have to restore the repository. For details, see the restore procedures in Chapter 11.

No Shutdown Message

If the GemStone log doesn't contain a shutdown message, there has probably been a power failure or an operating system crash. In that event, the Stone repository monitor automatically recovers committed transactions the next time it starts. Use **startstone** to restart GemStone, as described under "Starting the GemStone Server" on page 103. See **startstone** on page 396 for more information on this command.

Chapter

7 Monitoring GemStone

A properly configured GemStone repository will run normally with little attention. It is still important to monitor the repository, to catch unexpected problems before they become serious. If you have unexpected problems you will need to examine logs, monitor you system, and perform other analysis. The relevant logs and tools are described in this chapter.

GemStone Process Logs (page 124)
details what logs are created by GemStone/S 64 Bit processes, where they are located, and what configuration is possible.

Repository Page and Object Audit (page 134)
provides instructions on how to perform a page audit and object audit of the repository.

Profiling Repository Contents (page 138)
describes how to analyze the repository contents

Monitoring Performance (page 139)
describes how to monitor the performance of the GemStone server and its clients using GemStone Smalltalk methods.

> **Use caution if keeping a GemStone session running for monitoring purposes**. A GemStone session that is in transaction and does not abort can cause an excessive commit record backlog and undesirable repository growth. See "Disk Space and Commit Record Backlogs" on page 196.

7.1 GemStone Process Logs

All GemStone processes create log files, including startup configuration information, tracking details on certain operations, and details for any errors that were encountered.

For some kinds of processes, these log files are only interesting if an error occurs, and these log files are deleted when the process exits (provided no error occurs). For other kinds of processes, information reported in the log files may provide diagnostic information for problems that occur later to other parts of the system. The log files for these kinds of processes are not deleted when the process exits.

The log file names and directory locations, and the log file deletion polices, are all configurable if you would prefer to set up a customized way to manage your log files. What is important is to know where your log files are and monitor these logs for error conditions, and to know how to find the relevant logs if a problem occurs.

GemStone log contents and names are UTF-8 encoded.

Finding log files

By default, GemStone writes log files to a number of specific locations:

- the Stone and associated server process logs are in the `$GEMSTONE/data` directory. The Stone log file name and location can be configured as described in the next section; the logs for the SymbolGem, Page Manager, and Admin and Reclaim Gems are in the same location as their Stone's log.
- RPC Gem logs, and log files for processes that are running on nodes remote from the Stone are in the `$HOME` directory of the UNIX user. The locations and names can be configured by the NRS used to start the Gem. This is described starting on page 128.
- The NetLDI log is in `/opt/gemstone/log`. The name and can be configured as described on page 128.

If the given GemStone process is running, you can use the **gslist** (page 374) utility to locate its logs. **gslist -x** displays the location of the current log file for Stones, NetLDIs, logsenders, logreceivers, and the shared page cache monitor.

Some process log files are deleted automatically when the process exits cleanly, to avoid an excessive number of unimportant log files. Details on specific processes describe the applicable log file deletion policy. These policies can be overriden per process (in most cases). You can force or disable delete using the environment variables GS_FORCE_CLEAN_LOG_FILE_DELETE and GS_KEEP_ALL_LOGS. Log files for processes that exited with an error are never deleted, and the NetLDI and Stone logs are never automatically deleted.

Stone Log

The log for the Stone repository monitor is always appended to, and is therefore cumulative across runs by default. This log is the first one you should check when a GemStone system problem is suspected. In addition to possible warnings and error messages, the log records the following useful information:

- The GemStone version.
- The configuration files that were read at startup and, if the DUMP_OPTIONS configuration option is set to True, the resulting Stone configuration.

- Each startup and shutdown of the Stone, the reason for the shutdown, and whether recovery from transaction logs was necessary at startup.
- Each expansion of a repository extent and its current size.
- Each opening of a new transaction log.
- Each startup and shutdown of each GcGem session, and the corresponding processId.
- Each #abortErrLostOtRoot sent to a Gem.
- Each suspension and resumption of logins.
- Certain changes to the login security system.
- Each time a backup is started and when the backup is completed.

Log name and location

The Stone log by default is *stonename*`.log`, where *stonename* is the name of the running Stone repository monitor. If a specific name was not specified for startstone, the *stonename* defaults to `gs64stone`.

The Stone log file name and location are determined in the following precedence:

1. A path and filename supplied by **startstone -l** *logFile. logfile* may be a filename, or a relative or absolute path and filename, to which the account starting the Stone has write permission. If *logFile* is a filename only, or not an absolute path, *logFile* is created in the current directory or relative to the current directory.
2. A path and filename specified by the GEMSTONE_LOG environment variable. As with **startstone -l**'s argument, this may be set to a filename or to a relative or absolute path and filename.
3. `$GEMSTONE/data/`*stonename*`.log`.

Log file deletion policy

The Stone log is never deleted; each restart appends to an existing log file of the same name, if one exists.

It is strongly recommended to retain this file over restarts and upgrades; the information in this log file may be useful for problem diagnosis for a significant time. If this file becomes too large, or the log file name or location is changed, we recommend archiving the older Stone logs.

Shared Page Cache Monitor Log

The shared page cache monitor log includes, among other things:

- Its configuration (for remote nodes, this may be different from the configuration on the Stone's node).
- The number of processes that can attach (which can limit the number of logins).
- The UNIX identifiers for the memory region and the semaphore array (these identifiers are helpful in the event you must remove them manually using the **ipcrm** command).

Log name and location

The log for the shared page cache monitor on the Stone's machine is located in the same directory as the Stone's log. This log file has a name of the form

stoneName_PID`pcmon.log`

Check this log if other messages refer to a shared page cache failure.

When a session logs in from another node, a log is created for the shared page cache monitor on the remote node. This log is located by default in the home directory of the account that started the Stone, but this location can be modified by environment variable settings. The default name is of the form

stoneName_PID`pcmon_`*Node*`.log`

where *PID* is the process Id of the monitor process, and *Node* is the name of the remote node.

Log file deletion policy

The shared page cache monitor log is not deleted on exit. A new log is created each time the stone is restarted, and old log files should be manually deleted from time to time.

Admin Gem Log

This log shows the startup value of the Admin Gem parameters that are stored in GcUser's UserGlobals, and any changes to them, and records other Admin Gem functions.

Log name and location

Each time the Stone repository monitor starts an administrative garbage collection session (Admin Gem) process, a new log is created. By default, this log is in the same location as the Stone's log. The location of this log file can be set specifically using the environment variable $GEMSTONE_ADMIN_GC_LOG_DIR.

The log name is formed using the pattern:

stoneName_PID`admingcgem.log`

where *stoneName* is the name of the Stone, and *PID* is the process Id of the Admin Gem process.

Log file deletion policy

By default, the AdminGem log is not deleted on clean exit.

The Admin Gem is started using the script `$GEMSTONE/sys/runadmingem`. You may create a customized version of this script, commenting out the line that sets $GEMSTONE_KEEP_LOG, to allow this log to be automatically deleted.

Reclaim Gem Log

This log shows the startup value of the Reclaim Gem parameters that are stored in GcUser's UserGlobals, and any changes to them, and records other Reclaim Gem functions.

Log name and location

Each time the Stone repository monitor starts a reclaim garbage collection session (Reclaim Gem) process, a new log is created. By default, this log is in the same location as the Stone's log. The location of this log file can be set specifically using the environment variable $GEMSTONE_RECLAIM_GC_LOG_DIR. in the same location as the Stone's log.

The log name is formed using the pattern:

stoneName_PID`reclaimgcgem.log`

where *stoneName* is the name of the stone, and *PID* is the process Id of the Reclaim Gem process.

Log file deletion policy

By default, the Reclaim Gem log is not deleted on clean exit.

The Reclaim Gem is started using the script `$GEMSTONE/sys/runreclaimgem`.You may create a customized version of this script, commenting out the line that sets $GEMSTONE_KEEP_LOG, to allow this log to be automatically deleted.

Page Manager Log

This log is not usually of interest, unless errors occur or tuning is required.

Log name and location

The Page Manager is a thread in the Stone, and is not a separate process, but it writes to a separate log for ease of maintenance. The Page Manager log is located in the same directory as the log for the Stone. This log file has a name of the form:

stoneName_PID`pagemanager.log`

where *stoneName* is the name of the stone, and *PID* is the process Id of the Stone process.

Log file deletion policy

This log is not deleted by default on clean exit. Since it is a thread in the stone, it is not started by a specific script, and will only be deleted on clean exit when $GS_FORCE_CLEAN_LOG_FILE_DELETE is set.

Symbol Gem Log

This log is not usually of interest, unless errors occur or tuning is required.

Log name and location

The Symbol Gem log is located in the same directory as the Stone's log, by default. The location of this log file can be set specifically using the environment variable GEMSTONE_SYMBOL_GEM_LOG_DIR.

The Symbol Gem log file has a name of the form:

stoneName_PID`symbolgem.log`

where *stoneName* is the name of the stone, and *PID* is the process Id of the Symbol Gem process.

Log file deletion policy

This log is deleted by default, if the SymbolGem exits cleanly and no (nonfatal) errors were reported during the lifetime of the SymbolGem, and no Symbol GC operations were performed while the SymbolGem was running. You may create a customized version of this script, uncommenting the line that sets $GEMSTONE_KEEP_LOG, to allow this log to be retained.

NetLDI Log

By default, the NetLDI log contains only configuration information and error messages. The configuration information reflects the environment at the time the NetLDI was started and the effect of any authentication switches specified as part of the startnetldi command.

In some cases it is helpful to log additional information by starting the NetLDI in debug mode (**startnetldi -d**). In this mode, the NetLDI writes a record of each communication to or from all clients to its log. Because the log for NetLDI running in debug mode is much larger, you probably won't want to use this mode routinely.

Log name and location

The NetLDI writes a log file (*netLdiName*`.log`) in `/opt/gemstone/log` (or an equivalent, as described on page 30) on the node on which it runs.

The startnetldi script allows you to specify a log file name and location using the -l option, and optionally the name *netLdiName*. If no log file name is specified using the -l argument, the default is `/opt/gemstone/log/`*netLDIName*`.log`.

Log file deletion policy

The NetLDI log file with the specified or default name is appended to, and is never deleted. You should manually remove outdated messages occasionally.

Gem Logs and logs related to Gem Sessions

The log file written by the Gem includes the Gem's startup configuration details, configuration parameters settings, and login information, as well as the messages generated if an error occurs. This information is important when diagnosing client-related problems.

When the RPC or Linked Gem is not running on the same node as the Stone, the login to GemStone also requires other supporting processes to be spawned. Each of these processes has their own log file.

Linked Gems

Linked logins, in which the Gem is part of the client process, do not write a separate log file to disk. The log file output is sent to stdout of the linked process; for example, the linked topaz console. Topaz command such as **output push** allow this information to be written to disk. See the *Topaz User's Guide* for more information.

RPC Gems on Stone's host

An RPC login spawns a separate Gem session process. When this process is on the same node as the Stone, the RPC Gem can connect directly to the server processes, and does not require further supporting processes to be spawned.

By default, the log file for an RPC Gem is located in the home directory of the account that owns the Gem process, which depends in turn on the NetLDI configuration.

You can change the default location for Gem log files by setting **#dir** or **#log** in the GEMSTONE_NRS_ALL environment variable for the NetLDI itself or for individual clients; see "Controlling log file directory locations" on page 417. Alternatively, when you log in to GemStone, you can specify a different network resource string (NRS) in your login parameters.

Log file deletion policy for RPC Gems

The log file for a Gem log is deleted by default on a clean shutdown. If the Gem terminates with an error, then the log file is not deleted. Since a log is created for each RPC login, you should periodically manually examine log files for errors and delete older logs; especially if you configure you system to keep Gem logs.

To configure RPC Gem log files to be kept on clean shutdown.

- Use the Gem service **gemnetobject_keeplog** instead of gemnetobject to login. **gemnetobject_keeplog** works just like **gemnetobject**, but sets the environment variable $GEMSTONE_KEEP_LOG, and so does not delete the log file.
- You can set the environment variable $GEMSTONE_KEEP_LOG using an argument to **gemnetobject** and the GEM_ENV (page 319) environment variable:

```
set gemnetid 'gemnetobject -C GEM_ENV=GEMSTONE_KEEP_LOG=1'
```

gemnetobject and **gemnetobject_keeplog** are described starting on page 372.

Additional processes for Remote RPC or Linked Gems

For RPC logins where the Gem is not on the same node as the Stone, or for linked logins that are not on the same node as the Stone, the following additional processes are also spawned:

- A page server on the server node (if one does not exist already for the remote node). This allows the session to access a repository extent on the server node.
- A page server on the remote node (if one does not already exist for a previous login), to allow the Stone to start or access a shared page cache on the remote client node. The free frame page servers for the remote cache are threads within this process.
- A shared page cache monitor on the remote node, to manage the remote cache on the client's node.

The default location for the log files of these processes is based on any settings for **#dir** or **#log** that is specified for the Gem, or in the home directory of the account that owns the corresponding process. For the page server on the server node, that account ordinarily is the application user. For the shared page cache monitor and page server on the client node, that account is the one that invoked **startstone**.

The following table shows typical log names for processes related to remote logins, given a Stone named `gs64stone` repository on *node1* with a login from a Gem session process on *node2*.

Typical Name	GemStone Process
`gemnetobject27853`*node2*`.log`	Gem session process on *node2* (serves an RPC session)
`gs64stone_27819cachepgsvr_`*node2*`.log`	Page server on *node2* that the repository monitor uses to create and access its shared page cache on *node2*
`gs64stone_27820pcmon_`*node2*`.log`	Shared page cache monitor on *node2*

Typical Name	GemStone Process
`runpgsvr12397`*node1*`.log`	Page server on *node1* that the Gem session process uses to access the repository extents on *node1*

Further control over log file location and name

The **startnetldi -D** option provides a default log file path for forked processes. NRS includes the **#dir** and **#log** directives, which allow you to specify the log file name and directory location, including pattern substitution, either in Gem login parameters or using GEMSTONE_NRS_ALL.

The options are described under "Controlling log file directory locations" on page 417.

Logsender and logreceiver Logs

The logsender and logreceiver processes are started only if you are setting up a hot standby system.

Log name and location

Each logsender and logreceiver creates a log file in `/opt/gemstone/log` on the node on which it runs.

The log file's name, by default, is `logsender_`*listeningPort*`.log` or `logreceiver_`*listeningPort*`.log`.

This location and name can be overridden by including the option **`-l`***logname* when starting the logsender or logreceiver.

Log file deletion policy

The logsender and logreceiver log files with the specified or default names are appended to, and are never deleted. You should occasionally manually examine these logs and remove outdated messages.

Other Log Files

Other GemStone processes also create log files, which are only of interest if an error occurs; these logs are deleted by default, and you may only ever see them if you use the $GS_KEEP_ALL_LOGS environment variable. Others are specific to particular utilities, and details are described in separate parts of this manual.

- Extent pregrow produces log files named *stonename_pid*`pgsvrPreGrow.log` in the Stone's log file directory.
- **pageaudit** produces a log file for the audit gem, as well as the log file with audit results.
- **statmonitor**, when started from the configuration option, invokes the script runstatmonitor and creates a log file named *stonename_pid*`runstatmonitor_`*type*`.log` in the Stone's log file directory, or for remote caches, in the home directory of the corresponding UNIX process owner.
- cache warmers, from the configuration file option or using **startcachewarmer**, produce log files.

Summary of GemStone Process Log Behaviors

This table provides a summary of the various GemStone process log behaviors.

Table 7.1 GemStone process types and log file details

Process Name	Name and location of log file	Script
Stone	*stonename*`.log`; the default for *stonename* is gs64stone. Override with -l argument to startstone or $GEMSTONE_LOG. Log file is never deleted; the same file is appended to with each restart.	startstone
NetLDI	`/opt/gemstone/`*netldiname*.log; the default for *netldiname* is gs64ldi. Override with -l argument to startnetldi. Log file is never deleted.The same file is appended to with each restart.	startnetldi
Shared Page Cache Monitor	*stonename_pid*`pcmon.log` , in Stone's log file directory. Remote SPC logs are `$HOME/`*stoneName_PID*`pcmon_`*Node*`.log.` Not deleted by default.	shrpcmonitor
Page Manager (Thread in Stone)	*stonename_pid*`pagemanager.log`, in Stone's log file directory. Not deleted by default.	(thread in stone)
Symbol Gem	*stonename_pid*symbolgem.log in Stone's log file directory. Override with $GEMSTONE_SYMBOL_GEM_LOG_DIR Deleted on clean exit by default.	runsymbolgem
Admin Gem	*stonename_pid*admingcgem.log in Stone's log file directory. Override the location with $GEMSTONE_ADMIN_GC_LOG_DIR . Not deleted by default.	runadmingcgem
Reclaim Gem	*stonename_pid*reclaimgcgem.log in Stone's log file directory. Override the location with $GEMSTONE_RECLAIM_GC_LOG_DIR. Not deleted by default.	runreclaimgcgem
RPC Gem	gemnetobject*pidnode*.log in the $HOME directory of the unix user (for gems started using the gemnetobject script). Override with #dir or #log in NRS of login parameters. Deleted by default on clean exit	gemnetobject (alternate scripts are also provided)
page server on remote node	`$HOME/`*stonename_pid*`cachepgsvr_`*node*`.log`. Override with #dir in NRS used for the Gem login.	runcachpgsvr

Table 7.1 GemStone process types and log file details

page server on Stone's node for remote Gems	`$HOME/runpgsvr`*pidnode*`.log`. Override with #dir in NRS use for the Gem login.	runpgsvr
pageaudit	produces both Gem and Stone logs. "Gem" log deleted by default on clean shutdown; delete behavior controlled by environment variables. "Stone" log holds audit results and is never deleted	runpageauditgem
logsender	logsender_*port*.log; override with -l argument to startlogsender. Log file is never deleted. The same file is appended to with each restart.	startlogsender
logreceiver	logreceiver_*port*.log; override with -l argument to startlogreceiver. Log file is never deleted. The same file is appended to with each restart.	startlogreceiver
cachewarmer (from config file)	*stonename*`_cachewarmer.log` in Stone's log file directory. Deleted by default on clean exit.	runcachewarmergem
statmonitor (from config file)	Hold statmonitor startup information; statistics are in a separate file. Deleted by default on clean exit.	runstatmonitor

Managing log files

Since some log files are not deleted by default, and the occasional minor error will leave log files around that would normally be deleted automatically on processes exit, the number of log files will accumulate over time. The Stone and NetLDI log files are reopened used each time the process is restarted, and are cumulative, and so these logs will grow indefinitely. So, some maintenance on GemStone log files is required. Your application's requirements for diagnostics after an incident, as well as your application design, will dictate which log files you need to retain and for how long.

Retaining or deleting all log files

The environment variables GS_KEEP_ALL_LOGS (page 437) and GS_FORCE_CLEAN_LOG_FILE_DELETE (page 437) override the individual defaults and configuration for the processes, to (respectively) force all log files to be retained, or all log files (except Stone and NetLDI) to be deleted on clean exit.

Customizing individual process deletion behavior

Many processes may have their log deletion process configured by setting the GEMSTONE_KEEP_LOG (page 434) environment variable in the service script that starts that process.

Refer to Table 7.1 on page 131 for specific service script names. Scripts that begin with "run", and gemnetobject and its variants, are found in the $GEMSTONE/sys directory. To configure the delete behavior:

1. make a copy of the specific script, providing your own name
2. edit the copy to set or unset GEMSTONE_KEEP_LOG.
3. edit `$GEMSTONE/sys/services.dat` to point the service name to your customized script. For example, if you have created a customized AdminGem script in `$GEMSTONE/scripts/myadmingcgemscript`, edit `services.dat` so the lines look something like this:

```
# runadmingcgem          $GEMSTONE/sys/runadmingcgem
runadmingcgem            $GEMSTONE/scripts/myadmingcgemscript
```

Note that customizations to scripts and services.dat will be lost on upgrade, and you will need to repeat this process after upgrading, to avoid the risk of missing any changes in service or script names and contents.

Localizing timestamps in log files

The timestamps printed in the log headers and in log messages are formatted according to the current system locale. You can override this using the GS_CFTIME environment variable. If this is set in the environment for the process, then the setting is used to control printing in log headers and log messages.

The setting for GS_CFTIME must be a valid `strftime` format string, and must contain fields for:

- Month: %m or %b or %B or %h
- Day: %d
- Hour: %H, or %I and %p, or %I and %P
- Minutes: %M
- Seconds: %S

If the criteria are not met, the default date format based on the system's LOCALE is used, or otherwise the US-centric date format.

Programmatically adding messages to logs

It may be useful for your application to deliberately write messages to the Stone or Gem logs. For example, if you are performing some automated batch processing, it may be useful to know when this started and completed in relation to other system maintenance tasks such as garbage collection.

You can write a message to the stone log using:

```
System addAllToStoneLog: aString
```

To write to the Gem log or console, you may use the following:

```
GsFile gciLogServer: aString
GsFile gciLogClient: aString
```

Logging to the server here will write to the Gem log for an RPC session, or to the topaz console or stdout for a linked session. Logging to the client writes to the topaz console or stdout for both linked and RPC clients.

The correct place to log messages depends on your session configuration and the nature of your client application; in general, it is safer to log to the server. However, the RPC Gem log is deleted by default if the session logs out cleanly, so any messages in it will not be retained. See "Log file deletion policy for RPC Gems" on page 129 for how to configure your login to preserve log files on clean exit. On the other hand, GUI applications may not provide access to stdout, making messages to the client inaccessible.

7.2 Repository Page and Object Audit

This section describes two levels of checks that you can perform on the repository.

- A *page audit* is invoked to ensure page-level consistency, typically after some kind of system failure, such as a read-write error or a cache coherency error. In these cases, a successful page audit indicates that the problem did not affect the committed repository. GemStone must be halted when you perform a page audit.
- An *object audit* checks the consistency of the repository at the object level. An object audit can be performed as part of routine maintenance and is performed while GemStone is running.

Page Audit

Page audits allow you to diagnose problems in the system repository by checking for consistency at the page level. Page audit can be run only on repository extents that are not in use; shut down your Stone, or make an extent copy backup.

Page audit scans the root pages in a repository, the pages used in the bitmap structures referenced by the rootpage, and all other pages (including data pages) to confirm page-level consistency. While data pages are audited, it does not check that the data on data pages is valid. For that, you need to separately run an object audit; see "Object Audit and Repair" on page 135.

To run page audit, use the **pageaudit** utility. This utility starts up an audit gem and a Stone repository monitor in audit mode, to perform the audit.

The options to pageaudit are all optional, and include:

-e *exeConfig* is the executable configuration file.
-z *systemConfig* is the system configuration file.
-l *logfile* is the location and name of the output file. If not specified, then the log is written to a file named *gemStoneName*-pageAudit.log in the standard Stone log file location.
-d specifies to skip audit of data pages.
-f specifies to keep running after an audit error is found, if possible.
-n specifies the number of threads to use; by default, the number of extents plus the number of CPUs. Using a smaller value will cause pageaudit to take more time to complete, but reduces the impact on other processes.
gemStoneName is the name as which the pageaudit repository will run.; if not specified, pageaudit uses `gs64stone-pageAudit`.

The full set of options is described under "pageaudit" on page 379.

When pageaudit completes, it writes a message to stdout:

```
Page Audit of Repository completed successfully - no issues found.
For details, see /gemstone/logs/gs64stone-pageAudit.log
```

The details in the log file include Stone startup and configuration information, and audit steps performed. In addition, it produces statistics on the pages in the repository. For example:

```
PAGE AUDIT STATISTICS
    RepositorySize                112.00 Mbytes       7168 pages
    Data Pages                     41.98 Mbytes       2687 pages
    Object Table Pages              1.20 Mbytes         77 pages
    Dependency Map Pages            0.02 Mbytes          1 pages
    Meta Information Pages          0.33 Mbytes         21 pages
    Commit Record Shadow Pages      0.03 Mbytes          2 pages
    Checkpoint Shadow Pages         0.00 Mbytes          0 pages
    Free Space in Repository       68.38 Mbytes       4376 pages
    OT Internal Pages               0.05 Mbytes          3 pages
    OT Leaf Pages                   1.16 Mbytes         74 pages
    Empty OT leaf pages             0.00 Mbytes          0 pages
    Empty data pages                0.00 Mbytes          0 pages
    Data pages with 25%+ free       6.52 Mbytes        417 pages
    Data pages with 50%+ free       4.56 Mbytes        292 pages
    Free space in data pages        4.77 Mbytes     305.53 pages
```

If the page audit finds problems, the message to the screen ends with a message like this:

```
-------------- PAGE AUDIT RESULTS --------------
**** NumberOfFreePages = 980 does not agree with audit
   results = 988

**** Problems were found in Page Audit.
**** Refer to recovery procedures in System Administrator's Guide.
```

If there are problems in the page audit, you will need to restore the repository file from backups. (See the section “How to Restore from Backup” on page 224.)

Object Audit and Repair

Privileges required: SystemControl.

Object audits check the consistency of the repository at the object level. Starting with Object Table, each object is located and validated.

Object audit is performed using multiple threads (lightweight sessions), and can be configured to perform as quickly as possible using a large amount of system resources, or configured to use fewer resources and take longer to run.

Object audit should be run from linked Topaz, and on the same machine as the Stone.

```
Repository >> objectAudit
```

`objectAudit` is the normal way to perform the audit. You may have other sessions logged in and running simultaneously, but the audit will impact performance. This audit uses two threads and up to 90% of the CPU.

```
Repository >> fastObjectAudit
```

`fastObjectAudit` is like `objectAudit`, but is configured to use most or all system

resources to complete as quickly as possible. This is useful when running an audit on offline systems.

`Repository >> objectAuditWithMaxThreads:` *maxThreads*
`percentCpuActiveLimit:` *aPercent*

This method allows you to specify the exact performance/impact parameters for the audit, if neither `objectAudit` nor `fastObjectAudit` is satisfactory for your requirements.

Performing the Object Audit

To perform an object audit:

Step 1. Log in to GemStone using linked Topaz (**topaz -l**).

Step 2. Send one of the audit messages to the repository. For example:

```
topaz 1> printit
SystemRepository objectAudit
%
```

The audit involves a number of checks and specific error messages. Checks include:

- Object corruption — The object header should contain valid (legal) information about the object's tag size, body size (number of instance variables), and physical size (bytes or OOPs).
- Object reference consistency — No object should contain a reference to a nonexistent object, including references to a nonexistent class.

  When the audit scan reports objects that do not exist, this is handled immediately, to avoid logical corruption of the repository. The objectAudit removes these OOPs from the free list, to avoid the risk of being reused for another new object by another session, and immediately checkpoints. If the checkpoint fails, or if any of the invalid referenced OOPs has already been reused, the stone will shutdown to avoid any commits for new values for these OOPs.
- Identifier consistency — OOPs within the range in use (that is, up to the high-water mark) should be in either the Object Table or the list of free OOPs, and OOPs for objects existing in data pages should be in the Object Table.

If the repository is consistent and no errors are found, the audit will complete with the line:

```
Object Audit: Audit successfully completed; no errors were
detected.
```

Otherwise, the reasons for failure with the specific problems found are reported to standard output

Error Recovery

If an object audit reports errors, these issues should be addressed. You may want to contact GemStone Technical Support for advice.

The following are general approaches to errors from object audit.

Collect and reclaim garbage and retry

If errors are reported during the object audit, you may wish to perform a `markForCollection` and `reclaimAll` and repeat the object audit. This may clear up problems if the object (s) that is (are) corrupt are not referenced from any live objects. Whether this is useful will depend on the particular errors reported.

Restore from backup

The safest approach when you find object audit errors is to restore from backup. GemStone recommends that you make regular backups, run in full transaction logging mode, and archive transaction logs as needed to recover. This would allow you to recover at any time from unexpected problems such as repository corruption.

If you do not have the set of backups and transaction logs that would allow you to restore from a backup and recover later transactions, or if you are in partial transaction logging mode, you can still make and restore a backup. Backups made using fullBackupTo:, when restored, rebuild the internal data structures. Depending on the specific problems found in audit, this may clear up the problem.

Attempt repair

GemStone includes the ability to repair invalid references, but this can only repair detectable corruption. If there are a number of errors reported, whatever caused the objects to disappear or become invalid may easily have also introduced undetectable logical corruption. It is not recommended to repair; you should restore from backup, if at all possible.

However, a single invalid reference may not indicate a widespread problem, and repair may allow important data to be recovered.

To manually repair an individual invalid reference, use the Topaz object specification format *@identifier* to substitute nil or an appropriate reference for an invalid reference.

For example, given an instance of Array with the OOP 51369729, if the element at slot 3 is an object that does not exist, it can be repaired by setting the reference to nil using the following expression:

```
topaz 1> send @51369729 at: 3 put: nil
```

The method `Repository >> repair` will perform an audit and make repairs during the re-scan. The following repairs are done:

- nil is substituted for an invalid object reference.
- Class String is substituted for an invalid class of a byte object, class Array for a pointer object, or class IdentitySet for a nonsequenceable collection object.
- Oops in the Object Table for which the referenced object does not exist are inserted into the list of free Oops.
- Oops for which an object exists but which are also in the list of free Oops are removed from the free list.

The repair audits the repository, keeping track of errors. After the initial audit completes, each error found is repaired. A descriptive message is displayed for each repair.

7.3 Profiling Repository Contents

Some questions, such as "what is using up all the space in my Repository?", can only be answered by examining the types and numbers of objects in your repository. To find out this information, you can use methods on GsObjectInventory.

The methods in GsObjectInventory count all instances of all classes in the repository — or in any collection, or in a hidden set, or in a file of disconnected possible garbage objects — and report the results, ordered by the number of instances or by space consumed.

GsObjectInventory performs a multi-threaded scan of the repository, and thus should only be run in session on the same machine as the Stone. To tune the impact of the scan, additional protocol allows you to perform fast scans or to specify the impact levels. For details, see methods in the image.

The following code will report the number of instances and the space required for all Classes whose total space requirements are more than 50000 bytes.

Example 7.2 Object Inventory byteCountReport

```
topaz 1> run
GsObjectInventory profileRepository byteCountReportDownTo: 50000
%
   *** GsObjectInventory byteCountReport printed at: 16/10/2020
10:54:49 ***
Hidden classes are included in this report.

_____________________________________________________________________
Class                                    Instances          Bytes
_____________________________________________________________________
String                                       32291        8263560
GsNMethod                                    23113        4628608
Array                                        26775        4273072
GsMethodDictionary                            3844        1963336
Symbol                                       20253         909944
CanonStringBucket                             2019         307888
Class                                         1888         294800
IdentityKeyValueDictionary                    1913         260216
SymbolAssociation                             5525         221584
ExecBlock                                     3212         205768
LargeObjectNode                                 16         199072
SymbolDictionary                               991         165584
SymbolSet                                     5081         159200
IdentityCollisionBucket                       1275         136408
_____________________________________________________________________
```

The same profiling with an instance count report is much shorter, since the number of instances, rather than the bytes of space used, limits the results.

Example 7.3 Object Inventory instanceCountReport

```
topaz 1> run
GsObjectInventory profileRepository instanceCountReportDownTo:
10000
%
 *** GsObjectInventory instanceCountReport printed at: 16/10/2020
11:02:01 ***
Hidden classes are included in this report.
_____________________________________________________________________
Class                                        Instances          Bytes
_____________________________________________________________________
String                                           32291        8263560
Array                                            26775        4273072
GsNMethod                                        23113        4628608
Symbol                                           20253         909944
_____________________________________________________________________
```

Both of these reports include instances of hidden classes, classes that are used to implement internal GemStone objects, which are invisible to the image. One such class is LargeObjectNode. Instances of LargeObjectNodes are used to implement the tree structures that underlie large collections. To avoid seeing hidden classes, profile using the method `profileRepositoryAndSkipHiddenClasses`.

For more on GsObjectInventory, see the methods in the image.

7.4 Monitoring Performance

As part of your ongoing responsibilities, you may find it useful to monitor performance of the object server or individual session processes.

GemStone includes graphical tools to allow you to record statistics in file and analyze this data graphically. You can also programmatically access these statistics.

A full list of the statistics that are recorded and are available programmatically can be found in the *VSD User's Guide*.

Statmonitor and VSD

GemStone includes the **statmonitor** utility, which records statistics about GemStone processes to a disk file. You can configure the processes for which statistics are recorded, how frequently the statistics are collected, and other details. See **statmonitor** on page 398 for more information.

Both GemStone-specific and operating system statistics are collected. The operating system statistics include general host information as well as information specific to the individual GemStone processes.

Reliable constant monitoring

We recommend running statmonitor at all times, as it provides a valuable record of many aspects of system behavior. If you encounter certain kinds of problems in your application,

GemTalk Technical Support will request statmonitor data for the period leading up to the problem, to diagnose possible causes.

You can configure statmonitor to start automatically on stone startup using the STN_STATMONITOR_ARGS configuration option (page 356). Similar options allow you to automatically start statmonitor on node that run a remote or mid-level shared page cache.

By using the **-R** or **-r** argument in combination with the **-K** argument to **statmonitor**, you can ensure statmonitor is continuously running while avoiding issues with statmonitor files consuming excessive space. However, ensure that enough files are retained so that when a problem is detected, the relevant statistics files will still be available.

The data generated by statmonitor is normally viewed graphically using VSD (Visual Statistics Display). For details on using VSD, see the *VSD User's Guide*.

Programmatic Access to Cache Statistics

A set of methods on the System class provide a way for you to analyze performance by programmatically examining the statistics that are collected in the shared page cache. This is the same data that is visible using statmonitor and VSD, although statmonitor and VSD can collect additional OS level information. This additional OS level information is also available programmatically; see "Host Statistics" on page 144

A process can only access statistics that are kept in the shared page cache to which it is attached. Sessions that are running on a different node than the Stone use a separate shared cache on that remote node. This means that processes that are on a different node than the Stone, cannot access statistics for the Stone or for other server processes that are attached to the Stone's shared page cache.

Within the shared page cache, GemStone statistics are stored as an array of *process slots*, each of which corresponds to a specific process. Process slot 0 is the shared page cache monitor. On the Stone's shared page cache, process slot 1 is the Stone; on remote caches, slot 1 is the page server for the Stone that started the cache. Subsequent process slots are the page servers, Admin and Reclaim Gems, Symbol Gem, and user Gems. The order of these slots depends on the order in which the processes are started up, and is different on remote caches.

The specific set of statistics is different for each type of process that can attach to the shared page cache. The types of processes are numbered:

1 = Shared page cache monitor
2 = Stone
4 = Page server
8 = Gem (including Topaz, GBS, and other GCI applications).
16 = Statmonitor

Further numbers includes those for shared counters, platform-specific OS system statistics, and so on.

Statistics by name

To obtain the value for a specific statistics for the Stone, the Stone's SPC monitor, or for the current session, use the following methods:

```
System class >> stoneCacheStatisticWithName:
System class >> primaryCacheMonitorCacheStatisticWithName:
System class >> myCacheStatisticWithName:
```

These methods will return the statistics value corresponding to the given name for that process. If the statistics name is not found, it returns nil.

For example, to retrieve the statistics named 'CommitRecordCount' for the Stone:

```
topaz 1> printit
System stoneCacheStatisticWithName: 'CommitRecordCount'.
%
23
```

To retrieve the current session's PageReads:

```
topaz 1> printit
System myCacheStatisticWithName: 'PageReads'.
%
548
```

All statistics for a process

The general way to retrieve statistics is as an array of values. To understand what the value at each index refers to, there are corresponding description methods to return an array of Strings. Matching the index of the statistic name to the index within the values locates the value for that statistic.

Since the statistics are different for the different types of processes, you will need to use corresponding methods to collect the statistics and the descriptions.

For the Stone, the Gem that is running the code, and the Stone's shared page cache monitor, no further information is needed to identify them within the cache, so the following pairs of methods can be used:

```
System cacheStatisticsDescriptionForGem.
System myCacheStatistics.

System cacheStatisticsDescriptionForStone.
System stoneCacheStatistics.

System cacheStatisticsDescriptionForMonitor.
System sharedPageCacheMonitorCacheStatistics.
```

For example, while you would normally use `stoneCacheStatisticForName:`, here is another possible way to get the CommitRecordCount:

```
topaz 1> printit
| index |
index := System cacheStatisticsDescriptionForStone
            indexOf: 'CommitRecordCount'.
System stoneCacheStatistics at: index.
%
23
```

To collect statistics for other Gems, and for page servers, you need to determine the process Id, session Id, or slot of the specific Gem or page server, or the cache name of the Gem. There are a variety of ways you might determine this, but one way is to examine the results of:

```
System cacheStatisticsForAllSlotsShort
```

This method returns the name, process Id, session Id, statistics type, and process slot for each process currently attached to the cache. For example:

```
topaz 1> printit
(System cacheStatisticsForAllSlotsShort) collect:
      [:ea | ea printString]
%
an Array
  #1 anArray( 'ShrPcMonitor', 7722, 4294967295, 1, 0)
  #2 anArray( 'gs64stone', 7721, 0, 2, 1)
  #3 anArray( 'FreeFrmPgsvr2', 7725, 4294967294, 4, 2)
  #4 anArray( 'AioPgsvr3', 7726, 4294967294, 4, 3)
  #5 anArray( 'pagemgrThread', 7729, 1, 8, 4)
  #6 anArray( 'GcAdmin5', 7734, 2, 8, 5)
  #7 anArray( 'SymbolGem6', 7735, 3, 8, 6)
  #8 anArray( 'GcReclaim6_7', 7733, 4, 8, 7)
  #9 anArray( 'Gem26', 2271, 5, 8, 8)
  #10 anArray( 'Gem27', 16924, 6, 8, 9)
```

Of course, a Gem may log out between the time you execute this and the time you collect statistics, so be sure that your code handles that condition gracefully.

The methods you use to get the statistics and the corresponding descriptions will depend on how you have determined the specific process you want information about.

By name:

```
System cacheStatisticsForProcessWithCacheName: aString
```
(You must manually determine the process type)

or

```
System cacheStatsForGemWithName: aString.
System cacheStatisticsDescriptionForGem.
```

By operating system Process Id (PID):

```
System cacheStatisticsProcessId: aPid.
System cacheStatisticsDescriptionAt:
      (System cacheSlotForProcessId: aPid).
```

By process slot:

```
System class >> cacheStatisticsAt: aProcessSlot
System class >> cacheStatisticsDescriptionAt: aProcessSlot
```

By session Id:

The page server for a Gem assumes the same sessionId as its Gem.

```
System gemCacheStatisticsForSessionId: aSessionId.
System cacheStatisticsDescriptionForGem.
```

or

```
System cacheStatsForPageServerWithSessionId: aSessionId
System cacheStatisticsDescriptionForPageServer
```

For example, to find an aggregate value for TimeInFramesFromFindFree of all Gems in the system:

```
topaz 1> printit
| gemPids index time |
gemPids := Array new.
System cacheStatisticsForAllSlotsShort do:
      [:anArray |
   (anArray at: 4) = 8 ifTrue:
            [gemPids add: (anArray at: 2)].
   ].
index := System cacheStatisticsDescriptionForGem indexOf:
            'TimeInFramesFromFindFree'.
time := 0.
gemPids do: [:aPid | | stats |
   stats := System cacheStatisticsProcessId: aPid.
   stats ifNotNil: [time := time + (stats at: index)].
   ].
time
%
```

Setting the name for the Gem in the cache

To make it easier for you to track cache statistics for specific Gems, you can explicitly give each Gem a unique name. The method

`System cacheName:` *aString*

sets the name for the current Gem session in the cache statistics, thus making it much easier to read the statistics in VSD.

When using topaz, the **-u** command line argument will set the cache name for logins from topaz.

Otherwise, set the cache name soon after login. If you are collecting statistics information using statmonitor, information may be logged using the default name for the Gem when the session first logs in, in which case so you may have two separate lines of data for the same session.

Session Statistics

In addition to the system-generated statistics listed below, GemStone provides a facility for defining session statistics — user-defined statistics that can be written and read by each session, to monitor and profile the internal operations specific to your application.

There are 48 session cache statistic slots available, with names of the form SessionStat01...SessionStat47.

You can use the following methods to read and write the session cache statistics:

`System class >> sessionCacheStatAt:` *anIndex*
Returns the value of the statistic at the designated index. *anIndex* must be in the range -2 to 47. Negative indexes are reserved for internal use.

`System class >> sessionCacheStatAt:` *anIndex* `put:` *aValue*
Assigns a value to the statistic at the designated index and returns the new value. *anIndex* must be in the range -2 to 47. Negative indexes are reserved for internal use.

`System class >> sessionCacheStatAt:` *anIndex* `incrementBy:` *anInt*
Increment the statistic at the designated index by *anInt*, and returns the new value. *anIndex* must be in the range -2 to 47. Negative indexes are reserved for internal use.

`System class >> sessionCacheStatAt:` *anIndex* `decrementBy:` *anInt*
Decrement the statistic at the designated index by *anInt*, and returns the new value. *anIndex* must be in the range -2 to 47. Negative indexes are reserved for internal use.

`System class >> sessionCacheStatsForProcessSlot:` *aProcessSlot*
Return an array containing the 48 session statistics for the given process slot, or nil if the process slot is not found or is not in use.

`System class >> sessionCacheStatsForSessionId:` *aSessionId*
Return an array containing the 48 session statistics for the given session id, or nil if the session is not found or is not in use.

Global Session Statistics

In addition to the Gem session statistics, GemStone/S 64 Bit provides global session statistics — user-defined statistics that can be written and read by any Gem on any Gem server. Unlike *session* cache statistics, which are stored in the shared page cache of the machine that the Gem is running on, *global* session statistics are stored in the shared page cache of the Stone. Global session statistics are not transactional. For a given statistic, every session sees the same value, regardless of its transactional view.

There are 48 global cache statistic slots available, with names of the form GlobalStat00...GlobalStat47.

You can use the following methods to read and write the global cache statistics:

`System class >> globalSessionStatAt:` *aProcessSlot*
Returns the value of the statistic at the designated slot (must be in the range 0..47).

`System class >> globalSessionStatAt:` *aProcessSlot* `put:` *aValue*
Assigns a value to the statistic at the designated slot (must be in the range 0..47) and returns the new value. The value must be a SmallInteger in the range of -2147483648 to 2147483647.

`System class >> incrementGlobalSessionStatAt:` *aProcessSlot* `by:` *anInt*
Increments the value of the statistic at the designated slot by *anInt* and returns the new value of the statistic. The value *anInt* must be a SmallInteger in the range of -2147483648 to 2147483647.

Host Statistics

Host Statistics for processes

Process-level statistics require an OS call, which can cause cache statistics to impact performance. These statistics are not part of the information returned by regular cache statistics interface methods. To get this information, use the following methods.

`System class >> hostProcessStatisticsNames`
Returns an array of Strings which are the names of the per-process statistics provided by this host.

`System class >> hostStatisticsForMyProcess`
Returns an array of SmallIntegers which represent the host statistics for this

process. The names of each statistic are returned by the #hostProcessStatisticsNames method.

`System class >> hostStatisticsForProcess:` *processId*
Returns an array of SmallIntegers which represent the host statistics for the process with the given process ID. The names of each statistic are returned by the #hostProcessStatisticsNames

Specific methods are also available to return the host CPU statistics only:

`System class >> hostCpuStatsForProcessId:` *anInt*
Return an Array of two integers as follows:

1 - user mode CPU milliseconds
2 - system mode CPU milliseconds

Both array elements will be -1 if the process slot is out of range or not in use or if this method is not supported for the host architecture.

It is not required that the process with pid *anInt* is attached to the shared page cache or even is a GemStone process. The method will succeed for any process for which the Gem session executing the method has permission to view the target process' CPU usage statistics.

`System class >> hostCpuStatsForProcessSlot:` *anInt*
For the process using the cache process slot *anInt*, return an Array of two integers as follows:

1 - user mode CPU milliseconds used
2 - system mode CPU milliseconds used

Both array elements are set to -1 if the process slot is out of range or not in use, or if this method is not supported for the host architecture.

Host Statistics for OS

While most monitoring is of the object server and session processes, it is also useful to monitor the performance of the operating system that is running GemStone. On host platforms that support it, the following methods return statistics provided by the operating system. This is the same information that is available via statmonitor; see **statmonitor** on page 398.

`System class>> fetchSystemStatNames`
Return an array of Strings with the names of the available OS level statistics. The length is host-dependent. If the host system does not support system statistics, this method returns nil.

`System class >> fetchSystemStats`
Return an array of Numbers corresponding to the names returned by he #fetchSystemStatNames method. The length of the result array is host dependent. While most elements in the result array will be SmallIntegers, the result may also contain other types of Numbers such as SmallDoubles, Floats, LargeIntegers, etc. If the host system does not support system statistics, this method returns nil.

You can also monitor specific CPU usage for the host using the following method:

`System class >> hostCpuUsage`

Returns an Array of 5 SmallIntegers with values between 0 and 100 which have the following meanings:

1 - Percent CPU active (user + system)
2 - Percent CPU idle
3 - Percent CPU user
4 - Percent CPU system (kernel)
5 - Percent CPU I/O wait

On hosts with multiple CPUs, these figure represent the average across all processors. The results of the first call to this method are invalid and should be discarded. Returns nil if the host system does not support collecting CPU statistics.

Chapter

8 User Accounts and Security

This chapter also shows you how to perform some common GemStone user administration tasks:

- How to create and modify user accounts, including privileges, group memberships, symbol resolution, and how to control the user's read-write access to objects through the use of object security policies.
- How to set up login authentication, including GemStone authentication as well as external authentications, such as by UNIX userId, LDAP, or Kerberos.
- Tracking user account logins and logouts

To perform most of these tasks you must have explicit *privilege* to execute a restricted Smalltalk method, and you may also need to be explicitly authorized to modify an affected GsObjectSecurityPolicy. This chapter describes how users can be configured with the appropriate privileges and object security policies. To understand how GsObjectSecurityPolicies can be used to control access to data, see the chapter "Object Security and Authorization" in the *Programming Guide*.

8.1 GemStone Users

This section provides background information about how GemStone stores user accounts, predefined system users, groups of users, and users's name space.

UserProfiles

Each GemStone user is associated with an instance of class UserProfile. This UserProfile object contains information describing objects that the user is allowed to examine or modify, privileges that the user has to perform certain operations, and security information.

Each UserProfile has the following information:

User ID	A unique String that identifies the user to the GemStone system.
Authentication Scheme	How this user is authenticated; #GemStone, #UNIX, #LDAP, #SingleSignOn, or #X509.
Password	The GemStone-specific password (an InvariantString) to use to validate logins for #GemStone authentication. GemStone stores the password in encrypted form in a secure manner.
Default Object Security Policy	Either nil or an instance of GsObjectSecurityPolicy. This determines the default read and write authorizations for objects created by the user.
Privileges	Encoding for a logical collection of symbols that allow the user to perform certain "privileged" system functions.
Groups	In conjunction with object security policies, group membership is used to allow access to restricted objects for specific categories of users.
SymbolList	The list of SymbolDictionaries that is used to resolve references to Classes and other Globals for this user.
Login Hook	Method selector or block of code to execute on login.

These are discussed in more detail under "UserProfile Data" on page 150.

Other information related to the user account is stored in an instance of UserSecurityData; this includes data related to security features. Instances of UserSecurityData are private and protected, but some information, such as lastLoginTime, can be accessed via methods in UserProfile.

AllUsers

Each instance of UserProfile must be in the global collection, AllUsers. AllUsers is the single instance of UserProfileSet. AllUsers acts as the "root" for all objects in the repository; any object in the repository must be reachable from AllUsers, usually via the SymbolLists of the UserProfiles, otherwise it is subject to garbage collection.

Special System Users

When GemStone is first installed, AllUsers has UserProfiles already defined for the following users. These are the special system users. *You must never delete these users.* These users may not have privileges removed, cannot be disabled, must use GemStone authentication, and their accounts are not subject to password or account age limits.

You can determine if an account is a special system user by executing:

```
UserProfile isSpecialUserId: 'theUserId'
```

SystemUser

SystemUser is analogous to `root` in UNIX. SystemUser is not restricted by any privileges, belongs to all predefined groups, and is authorized to read and write all objects regardless

of GsObjectSecurityPolicy protection. These privileges cannot be taken away, so SystemUser can always write to all objects. This account is used only to perform GemStone system upgrades, modify some system configuration settings, and other special-purpose operations that must be highly restricted.

SystemUser can only be configured to use GemStone authentication and cannot be disabled.

The SystemUser account is the owner of the SystemObjectSecurityPolicy, which contains the kernel classes.

WARNING

Logging in to GemStone as SystemUser is like logging in to your workstation as root: an accidental modification to a kernel object can cause a great deal of harm. Use the DataCurator account for system administration functions except those that **require** *SystemUser privileges, such as a repository upgrade.*

DataCurator

The DataCurator account is the account that is normally used for day-to-day administration tasks. Initially, DataCurator is granted all privileges and belongs to all predefined groups, but unlike SystemUser, does not have the ability to read and write all GsObjectSecurityPolicies.

DataCurator can be configured to use GemStone or SingleSignOn authentication, but not LDAP or UNIX, and cannot be disabled.

All GemStone UserProfiles are protected by the DataCuratorObjectSecurityPolicy.

GcUser

The GcUser account is a special account that logs in to the repository automatically to perform garbage collection tasks. The only reason to login as GcUser is to examine or update configuration parameters stored in GcUser's UserGlobals, although this is done more conveniently by executing code.

GcUser can be configured to use GemStone or SingleSignOn authentication, but not LDAP or UNIX, and cannot be disabled.

SymbolUser

The SymbolUser account is a special account that is used to perform symbol creation tasks. Login as SymbolUser is disallowed. Directly accessing the AllSymbols collection, which is in the UserGlobals of the SymbolUser, is possible from another administrative session.

Nameless

The Nameless account is a special account for use only by other GemStone products. Do not use this account or change it unless instructed to do so by GemStone Technical Support.

HostAgentUser

The HostAgentUser account is a special account for use only by X509-Secured GemStone processes. Do not use this account or change except as directed by GemStone Engineering.

UserProfile Data

Each user profile contains important information about the account, which may be explicitly specified during instance creation or rely on default values. This information may also be updated during the course of time for the UserProfile.

The requirements for updating this information vary. In many cases, the requirements are different between updating information for another user and for updating your own information. See the update methods for details.

User ID

Each UserProfile is created with a unique user Id String. Embedded spaces are permitted, and characters in the byte range (up to codePoint 255) are allowed.

UserId may only be changed by SystemUser or by a user with the privilege #ChangeUserId. The userIds of special system users cannot be changed.

Authentication Scheme

When a user wants to log in to the GemStone repository, their login must be authenticated: they must present a password that is matched against stored information for their UserId, to verify that they are authorized to log in. This authentication can be done entirely within GemStone, or GemStone can use UNIX, LDAP, or Kerberos to perform the authentication.

There is another authentication, X509, which requires a different login infrastructure; this is not described in detail here, see the *GemStone/S 64 Bit X509-Secured GemStone System Administration Guide* for more information. Users who are configured with other authentication schemes can both login using traditional login, and login using X509-secured GemStone. Users configured with X509 authentication are restricted to only logging in using X509-secured GemStone

Performing the authentication entirely within GemStone — Gemstone authentication — is the initial default for all users. Other authentication schemes can be configured for individual UserProfiles, though there are restrictions for system accounts. The repository may contain UserProfiles using a mix of authentication schemes.

After the authentication scheme is modified for a user and the change is committed, it will take effect the next time the user logs in. Existing logins are not affected.

In addition to authentication for the GemStone UserProfile, users may need to authenticate the UNIX username, before the NetLDI will start the Gem process for an RPC login. This depends on how the system is configured; see Chapter 4 for details on interprocess security and host authentication.

Changing authentication, or inquiring about authentication, requires #OtherPassword privilege.

Setting up GemStone and other authentication schemes is described in more detail starting on page 169.

Determining an Account's Authentication Scheme

Your repository may contain a mix of authentication schemes, with some users (such as SystemUser) using GemStone authentication, others authenticating using UNIX, LDAP, etc. You can determine what scheme an account is using by sending

`authenticationScheme`. This will return the symbol #GemStone, #UNIX, #LDAP, #SingleSignOn, or #X509. For example,

```
(AllUsers userWithId: 'DataCurator') authenticationScheme.
%
GemStone
```

Password

Passwords for GemStone authentication must be:

- invariant Strings
- not empty
- be different than the User Id
- no longer than 1024 characters
- contain only Characters with codePoints under 256

When each UserProfile is created, the initial password is defined and the account starts off using GemStone authentication. If the UserProfile is modified to use another authentication scheme, the initial password is discarded. For GemStone authentication, the password supplied in the login parameters is verified against this password.

GemStone authentication provides a number of controls on passwords, which apply to changing passwords and constraints on choice of password.

Default Object Security Policy

A users' defaultObjectSecurityPolicy determines the default read and write authorizations for objects created by the user. When you add a new user to the GemStone system, you can either allow the default security policy to be nil, use protocol that creates a new GsObjectSecurityPolicy, or specify an existing GsObjectSecurityPolicy for the user.

For more information on how security policies are used to control read and write authorization for objects in the repository, see the chapter in the *Programming Guide* that discusses security.

A defaultObjectSecurityPolicy of nil means that objects created by that user, by default, have world read and write access; that is, are not restricted from being read or written by all other users. Not requiring authorization checks has the benefit of improved performance, if your application does not require object level security.

When creating a user, you can use methods that specify that a new instance of GsObjectSecurityPolicy should be created and assigned as the default for the new user. Otherwise, you must use an already committed instance of GsObjectSecurityPolicy, either existing or newly created, or nil.

If the defaultObjectSecurityPolicy for a user is not nil, the user MUST have write authorization to this security policy; otherwise, this user will not be able to log in.

To modify your own defaultObjectSecurityPolicy, you must have the #DefaultObjectSecurityPolicy privilege. To modify the defaultObjectSecurityPolicy of another user, you must have this privilege, and write access to the security policy of that UserProfile.

Symbol Lists

As explained in the *Programming Guide*, the GemStone Smalltalk compiler follows a well-defined path in resolving objects named by source code symbols. First, the compiler considers the possibility that a variable name might be either local (a temporary variable or an argument) or defined by the class of the current method definition (an instance variable, a class variable, or a pool variable). If a variable is none of these, the compiler refers to an Array of SymbolDictionaries in the user's UserProfile and current session state. That Array is called the user's *symbol list*. The symbol list tells Smalltalk which of many possible GemStone SymbolDictionaries to search for an object named in a Smalltalk program.

For each user, a persistent instance of class SymbolList is stored in the repository and is referenced from the UserProfile associated with this user as the symbolList instance variable. In addition, a transient copy of that SymbolList is stored in the GsCurrentSession object for the logged-in session.

A session's transient copy can be modified without affecting (or causing concurrency conflicts with) either the persistent symbol list or the transient copies controlling other sessions. Changes to your own UserProfile's persistent symbol list also change the symbol resolution of your current session. However, changes to the persistent symbol list are likely to cause concurrency conflicts with other sessions logged in under the same userId.

For further information about symbol lists, refer to the *Programming Guide*.

New UserProfiles are created with the following SymbolDictionaries, in this order:

UserGlobals	Each UserProfile has its own SymbolDictionary for the user's private symbols.
Globals	The second element in each user's initial symbol list is a "system globals" SymbolDictionary, *Globals*. This dictionary contains all of the GemStone Smalltalk kernel classes (Object, Class, Collection, Integer, and so forth). Although users can read the objects in Globals, ordinarily they cannot modify objects in that Dictionary.
Published	The third and final element in each user's initial symbol list is a SymbolDictionary for application objects that are "published" to all users. Users who are members of the group Publishers can place objects in this dictionary to make them visible to other users. Using the Published dictionary lets you share these objects without having to put them in Globals, which contains the GemStone kernel classes, and without the necessity of adding a special dictionary to each user's symbolList instance variable.

Although all users automatically share access to objects in Globals, sharing application objects between users requires that the objects be in a SymbolList that is visible to both users. There are three primary ways to do this:

- As a member of group Publishers, you can add the objects to the Published dictionary. This dictionary is already in each user's symbol list, so whatever you add becomes visible to users the next time they obtain a fresh transaction view of the repository. You may do this by sending the message `Published at:` *aKey* `put:` *aValue*.

- You can define a special SymbolDictionary, and add that to the user's SymbolList. The procedure is described under "Adding a SymbolDictionary to Someone Else's Symbol List" on page 166.
- The application itself can add the objects to the individual user's symbol list, either to the permanent symbol list in the UserProfile or to a transient symbol list for that session. For information about this approach, refer to the *Programming Guide*.

For more information, refer to the chapter on symbol resolution and object sharing in the *Programming Guide*.

Privileges

When you create a new UserProfile, you determine whether the new user may perform certain "privileged" system functions. For example, stopping another session, or the repository itself, requires a particular privilege to do so. Table 8.1 describes the types of functions that each privilege controls.

Note that privileges are more powerful than security policy authorization. Although the owner of a security policy can always use authorization protocol to restrict read or write access to objects in a policy, an administrator with appropriate privileges, such as DataCurator, can override that protection by sending privileged messages that let you change the authorization scheme.

Attempting to removing privileges from SystemUser has no effect, only SystemUser can remove privileges for other special users.

Table 8.1 GemStone Privileges

Type of Privilege	Privileged Operations
SystemControl	SystemControl is required by methods that start or stop sessions, including operations that invoke the Multi-Threaded Scan (page 300); for methods that suspend or resume logins, send signals to other sessions, and manage checkpoints.
SessionAccess	SessionAccess privilege is required to find out information about sessions other than the current session, or to perform operations on other sessions.
UserPassword	Required to change your own password using `UserProfile>>oldPassword:newPassword:`
DefaultObjectSecurityPolicy	This privilege is required to set a UserProfile's default ObjectSecurityPolicy using `UserProfile>>defaultObjectSecurityPolicy:` or a method that invokes that. For compatibility with previous versions, the DefaultSegment privilege also resolves to this privilege
CodeModification	You must have CodeModification privilege to create or modify instances of GsNMethod, GsMethodDictionary, or Class. See the discussion following this table.

Table 8.1 GemStone Privileges (Continued)

Type of Privilege	Privileged Operations
OtherPassword	You must have OtherPassword privilege to make any changes to a UserProfile other than your own. This includes adding or removing a SymbolDictionary to/from a SymbolList that is not your own. OtherPassword is also needed to find out information about UserProfiles other than the currently logged in session. OtherPassword is required to make any changes to AllUsers, including creating a new user and configuring security requirements.
ObjectSecurityPolicy Creation	Required in order to creating a new GsObjectSecurityPolicy, using `GsObjectSecurityPolicy class>>new`, `newInRepository:` or any methods that invoke these. For compatibility with previous versions, the SegmentCreation privilege also resolves to this privilege.
ObjectSecurityPolicy Protection	You must have ObjectSecurityPolicyProtection to update the authorizations of a GsObjectSecurityPolicy, other than one that is owned by the current session's user. This includes `GsObjectSecurityPolicy>>group:authorization:`, `ownerAuthorization:`, and `worldAuthorization:`. For compatibility with previous versions, the SegmentProtection privilege also resolves to this privilege.
FileControl	FileControl is required for system operations that access external files, including operations related to backup, restore, transaction logs, and extents. This does not affect application access using GsFile.
GarbageCollection	Required to perform any garbage collection operation, to start and stop Admin and Reclaim Gems, and force epoch or reclaim to run. Also required to audit and profile the repository.
NoPerformOnServer	If you have this privilege, you cannot execute `System class>>performOnServer:`, execute code using GsHostProcess, nor access the GsSysLog; except for executables that are white-listed (described on on page 155)
NoUserAction	If you have this privilege, you cannot execute `System class>> loadUserActionLibrary:`, and use of the FFI interface is disallowed.
NoGsFileOnServer	If you have this privilege, you cannot execute any GsFile operation which accesses a file on the server.
NoGsFileOnClient	If you have this privilege, you cannot execute any GsFile operation which accesses a file on the client.
SessionPriority	Required to modify the priority of any session, or to check the priority of a session other than the current session.
CompilePrimitives	Allow user to compile primitive methods, which is otherwise restricted to SystemUser.

Table 8.1 GemStone Privileges (Continued)

Type of Privilege	Privileged Operations
ChangeUserId	Allow user to execute `userId:password:` to rename a user, which is otherwise restricted to SystemUser.

Code Modification Privilege

CodeModification privilege is required to execute any method that modifies Smalltalk code. This privilege is required for all developers writing code.

- You must have #CodeModification privilege to create instances of GsNMethod, or to create or modify instances of GsMethodDictionary or Class. (You cannot modify a GsNMethod once it has been created.)
- You must have #CodeModification privilege to add a Class to, or remove a Class from, a SymbolDictionary or its subclasses.
- You must have #CodeModification privilege to add or remove a SymbolDictionary from your own SymbolList.

You cannot use GemBuilder for C to modify instances of the following classes (or their subclasses): GsNMethod, GsMethodDictionary, Class, SymbolDictionary, SymbolList, UserProfile.

The inverse privileges, NoGsPerformOnServer and related

Some operations, like executing `performOnServer:`, are allowed by default for all users. Since access to operating system functionality and disk files is a security issue, this functionality can be disabled for specific users by assigning an inverse privilege.

For the privileges NoGsPerformOnServer, NoUserAction, NoGsFileOnServer, and NoGsFileOnClient, the user that has that privilege is disallowed from performing the associated operations.

Whitelist for performOnServer:

Accessing OS functions using `performOnServer:` (and the related GsHostProcess functionality) is very useful, and for some applications it may be necessary for users that should not have general OS command access, to be able to execute specific OS commands.

This can be set up via a per-user whitelist. To allow a user with the NoPerformOnServer privilege to execute a specific command, the full path (starting with / and ending with the command name) to the command is put on a whitelist for that specific user. The full path must then be specified on the `performOnServer:` or GsHostProcess method argument; the paths and commands must match exactly for the execution to be permitted.

There are no checks or restrictions on arguments to the commands; only the commands themselves are examined and allowed (or not).

The following methods add one or more commands to the whitelist:

```
UserProfile >> addPerformOnServerCommand: fullPathToCommand
UserProfile >> addPerformOnServerCommands: arrayOfCommands
```

To report the existing whitelist:

```
UserProfile >> performOnServerCommands
```

To remove commands from the whitelist:

```
UserProfile >> removeAllPerformOnServerCommands
UserProfile >> removePerformOnServerCommand: aString
UserProfile >> removePerformOnServerCommands: arrayOfString
```

The requirement to use full paths in the whitelist and in the argument to `performOnServer:` applies to operating system commands such as `ls`. While users without NoPerformOnServer can pass commands such as `'pwd'` and `'ls'` to `performOnServer:`, and rely on the path lookup, users with NoPerformOnServer must configure the whitelist to include the full path, such as `'/bin/pwd'` and `'/bin/ls'`, and pass the same full path to `performOnServer:`.

For example, as DataCurator or another privileged user, update a non-privileged user ReadingUser by executing:

```
(AllUsers userWithId: 'ReadingUser')
   addPrivilege: 'NoPerformOnServer';
   addPerformOnServerCommand: '/usr/bin/git'.
System commitTransaction.
```

Now, as ReadingUser, the following will succeed:

```
System performOnServer: '/usr/bin/git log'
```

But ReadingUser cannot perform other OS commands, such as ls or cp. Each individual executable to be allowed must be specifically entered in the whitelist.

DeletedUserProfile and AllDeletedUsers

Removing a user requires some cleanup to ensure that the references to or from the UserProfile do not allow premature garbage collection of objects that are needed, or prevent garbage collection entirely. There are two kinds of references of concern:

- references from an instance of GsObjectSecurityPolicy to the user, which can prevent the UserProfile from being garbage collected
- references from the UserProfile to the symbol list and to objects that are private to the user that is being deleted, which may need to be retained.
- references from UserProfileGroups

To avoid the risk of problems, removing a user requires using specific protocol that performs cleanup.

These methods update any GsObjectSecurityPolicies to be owned by either the current user or a specified user, and removes the user from each group in AllGroups. To ensure that objects whose only reference is from the deleted user are not prematurely lost, when the instance of UserProfile is deleted a new instance of DeletedUserProfile is created, and added to the globals AllDeletedUsers. This DeletedUserProfile has a reference to the SymbolList of the deleted user, as well as the userId and the date the user was deleted.

An administrator should review the classes and methods in the SymbolLists of the DeletedUserProfile, copy anything valuable elsewhere, and manually remove the DeletedUserProfile from AllDeletedUsers.

8.2 UserProfileGroups

GemStone uses a combination of group memberships and GsObjectSecurityPolicy group permissions to control access to groups of objects by groups of users.

UserProfileGroups are also used to handle KerberosPrincipals that will be shared by multiple UserProfiles for #SingleSignOn authentication.

A UserProfileGroup maps a group name to a set of UserProfiles. For compatibility with past releases, protocol in UserProfile and GsObjectSecurityPolicy may accept arguments of the group name instead of, or in addition to, the UserProfileGroup instance.

AllGroups

AllGroups is a global collection of UserProfileGroups, that includes all groups defined for users and security policies.

Initially, AllGroups contains the following predefined groups:

Table 8.2 GemStone Groups

Group name	Access
System	Members of this group have write access to objects protected by the GcUser's object security policy.
DataCuratorGroup	Members of this groups have write access to objects protected by the **DataCuratorObjectSecurityPolicy**. This is useful if you wish to make a user other than DataCurator to be a system administrator, since many operations that update users require write access to **DataCuratorObjectSecurityPolicy.**
Publishers	Members of this group have write access to objects protected by **PublishedObjectSecurityPolicy**.
Subscribers	Members of this group have read access to objects protected by **PublishedObjectSecurityPolicy**.
SymbolUser	(Reserved for future use).

By default, all new users become members of group Subscribers.

Groups for object authorization

It is common that certain objects must be protected from read or write access by other users in the system (the "world"), while still being accessible to specific individual users. By creating a group, adding authorization for that group to the GsObjectSecurityPolicy that protects these objects, and by making the user a member of the group, you can provide that user with the appropriate access to these objects.

A GsObjectSecurityPolicy can authorize multiple groups and a user can be a member of multiple groups.

Create a group

To create a new group and add it to AllGroups, use:

```
UserProfileGroup class >> newGroupWithName:
```

To lookup an existing group by name, execute one of:

```
UserProfileGroup class >> groupWithName:
UserProfileGroup class >> groupWithName:ifAbsent:
UserProfileGroup class >> groupWithName:otherwise:
```

Delete a group

Deleting a group removes it from all User accounts that are members, as well as from AllGroups.

```
UserProfileGroup class >> deleteGroup:
UserProfileGroup class >> deleteGroupWithName:
UserProfileGroup class >> deleteGroupWithName:ifAbsent:
```

8.3 Creating and Removing Users

Methods that create UserProfiles add the new UserProfile to AllUsers, the global collection or users (a singleton instance of UserProfileSet). UserProfiles that are not in AllUsers cannot log in.

In addition to creating the new UserProfile, you should also ensure that each user's UNIX environment is set up to provide access to GemStone. This is described in the *GemStone/S 64 Bit Installation Guide*.

Removing a user, in addition to removing the UserProfile from AllUsers, requires cleanup to ensure that objects that refer to the deleted user do not inadvertently prevent the deleted user from being garbage collected, and that objects that are referred to only by the deleted users are not inadvertently garbage collected. The methods to remove users perform this cleanup, creating an instance of DeletedUserProfile in the AllDeletedUsers global.

Creating Users

Privileges required: OtherPassword, and write access to the DataCuratorObjectSecurityPolicy. You may also need ObjectSecurityPolicyCreation.

Simple User Creation

At minimum to create a new UserProfile, you must supply the new user's userId and password, each as a String. This creates the new user with no privileges, only the Subscribers group, and with a nil defaultObjectSecurityPolicy.

```
AllUsers addNewUserWithId: 'theUserId'
      password: 'thePassword'.
```

Simple User Creation with GsObjectSecurityPolicy Creation

To create a new user and specify that a new instance of GsObjectSecurityPolicy should be created for the new user, use the following expression:

```
AllUsers addNewUserWithId: 'theUserId'
      password: 'thePassword'
      createNewSecurityPolicy: true
```

User Creation With Privileges, Groups, and ObjectSecurityPolicy

Using the complete form allows you to assign privileges to the new user, add the user to one or more groups, and specify a default ObjectSecurityPolicy. The ObjectSecurityPolicy may be nil.

```
AllUsers addNewUserWithId: 'theUserId'
    password: 'thePassword'
    defaultObjectSecurityPolicy: anObjectSecurityPolicyOrNil
    privileges: anArrayOfPrivSyms
    inGroups: aCollectionOfGroupsOrGroupNames
```

For example:

```
topaz 1> printit
AllUsers addNewUserWithId: 'Mary'
      password: 'herPasswd'
      defaultObjectSecurityPolicy: nil
      privileges: #( UserPassword )
      inGroups: #( 'MarathonRunners' ).
System commitTransaction.
%
```

For additional user creation protocol, see the image. UserProfileSet instance methods and UserProfile class methods both create new UserProfiles and add the new user to AllUsers.

Removing Users

Privileges required: OtherPassword.

In addition to removing the UserProfile from AllUsers, removing a user requires that any GsObjectSecurityPolicies owned by the deleted user are moved to a new user, and the user be removed from all groups. In addition, to ensure that work being done by the user being deleted is not lost, the SymbolLists of the deleted user are moved to a separate location where they can be periodically reviewed and manually dereferenced.

For more details on how this is handled, see “DeletedUserProfile and AllDeletedUsers” on page 156.

Remove User, with ObjectSecurityPolicies Going to the Current User

The following methods remove the user and reassign any GsObjectSecurityPolicies owned by the user to be removed to the UserProfile of the current user (the user executing this code, such as DataCurator).

```
AllUsers removeAndCleanup: aUserProfile.
```

```
AllUsers removeAndCleanupUserWithId: 'aUserId' ifAbsent: aBlock
```

Remove User, with ObjectSecurityPolicies going to another User

The following methods remove the user and reassign any GsObjectSecurityPolicies owned by that user to another specific UserProfile.

```
AllUsers removeAndCleanup: aUserProfile
   migrateSecurityPoliciesTo: anotherUserProfile.
```

```
AllUsers removeAndCleanupUserWithId: 'aUserId'
   migrateSecurityPoliciesToUserWithId: 'anotherUserId'
   ifAnyAbsent: aBlock
```

For example,

```
topaz 1> printit
AllUsers removeAndCleanup: (AllUsers userWithId: 'John')
      migrateSecurityPoliciesTo: (AllUsers userWithId: 'Ann')
System commitTransaction.
```

Users and Group membership

You can specify group memberships when creating users. Alternatively, you can add existing users to a UserProfileGroup, or add existing groups to a UserProfile. The methods to do this ensure that the set of groups that a UserProfile references matches the UserProfile references in the groups.

Adding a user to a group

`UserProfileGroup >> addUser:` *aUserProfile*
Add the given UserProfile to the receiver, and add the receiver to this UserProfile's groups.

`UserProfile >> addGroup:` *'groupNameString'*
Add the UserProfileGroup with the given name to the receiver, and add the receiver to the UserProfileGroup.

`UserProfile >> addToUserProfileGroup:` *aUserProfileGroup*
Add the given UserProfileGroup to the receiver, and add the receiver to the UserProfileGroup.

Removing a user from a group

`UserProfileGroup >> removeUser:` *aUserProfile*
remove the given UserProfile from the receiver, and remove the receiver from this UserProfile's groups.

`UserProfile >> removeGroup:` *'groupNameString'*
Remove the UserProfileGroup with the given name from the receiver, and remove the receiver from the UserProfileGroup.

`UserProfile >> removeFromUserProfileGroup:` *aUserProfileGroup*
Remove the given UserProfileGroup from the receiver, and remove the receiver from the UserProfileGroup.

Querying for Group members

`UserProfileGroup >> users`
Return a set of UserProfiles that belong to the receiver.

`UserProfileGroup >> userIds`
Return a set of UserIds for the UserProfiles that belong to the receiver.

Querying for a User's Groups

`UserProfile >> groups`
Return the set of UserProfileGroups that this user belongs to.

```
UserProfile >> groupNames
```
Return the group names for each UserProfileGroup that this user belongs to.

for example

```
! Create group
UserProfileGroup newGroupWithName: 'Sales'.
System commitTransaction.
! Add users
(UserProfileGroup groupWithName: 'Sales')
      addUser: (AllUsers userWithId: 'DataCurator');
      addUser: (AllUsers userWithId: 'GcUser').
! report the UserIds in that group
(UserProfileGroup groupWithName: 'Sales') userIds
%
anIdentitySet( 'DataCurator', 'GcUser')
```

8.4 Administering Users

List Existing Users

Privileges required: None.

There is no direct method within GemStone Smalltalk to list only the names of existing accounts. The following example shows one way to obtain that information:

```
topaz 1 > run
(AllUsers collect: [:each | each userId ]) asArray.
%
#1 SystemUser
#2 DataCurator
#3 Nameless
#4 SymbolUser
#5 GcUser
#6 HostAgentUser
```

Modifying the UserId

Privileges required: ChangeUserId.

Updating the userId requires resetting the password for that user. The new user ID and password will take effect when you commit the current transaction. The names of special system users cannot be changed.

To modify the user ID of a GemStone user, execute the following expression:

```
(AllUsers userWithId: 'theUserId')
      userId: 'newId'
      password:'newPassword'.
```

An error is raised if *newId* is the userId of an existing UserProfile.

Modifying Password

Accounts that use external authentication (Unix, LDAP, SingleSignOn, and X509) do not manage the password within GemStone. This section applies only to accounts using GemStone authentication.

Users Changing Their Own Password

Privileges required: UserPassword, and the account must be using GemStone authentication.

In many cases, users set their own passwords and may be required to update them periodically. These users must be given the UserPassword privilege to do so, and use the method `UserProfile >> oldPassword:newPassword:` to update their password.

For example:

```
System myUserProfile
      oldPassword: 'oldPasswordString'
      newPassword: 'newPasswordString'.
```

Password choice is constrained by login security that is configured for the repository; see the discussion under "Limiting Choice of Passwords" on page 170.

The new password takes effect when you commit the current transaction.

A different method, requiring other privileges, is used by Administrators to update the password of another user.

Changing Another User's Password

Privileges required: OtherPassword, and the other user must be using GemStone authentication.

To modify the password of any GemStone user, execute the following expression.

```
(AllUsers userWithId: 'theUserId')
      password: 'newPasswordString' .
```

The new password takes effect when you commit the current transaction.

The password set by this method is not subject to the constraints described under "Limiting Choice of Passwords" on page 170, because this method can only be used by a user having the OtherPassword privilege. The password must not be the same as the UserId and must not be longer than 1024 characters.

Each password change of this type is noted in the GemStone security log, which currently is the Stone's log file. The entry includes the userId of the session making the change but not the new password.

Modifying defaultObjectSecurityPolicy

Each security policy maintains access authorization for its owner, the world, and an unlimited number of groups. There are three levels of authorization: none, read (read-only), and write (which includes read permission).

Determining Who Is Authorized to Read or Write in an Object Security Policy

Privileges required: read authorization for the security policy that controls access to this security policy, such as the DataCuratorObjectSecurityPolicy.

You can find out who is authorized to read or write objects in an security policy by sending it the message `asString`. For instance:

```
topaz 1> printit
PublishedObjectSecurityPolicy asString
%
anObjectSecurityPolicy, Number 6 in Repository SystemRepository,
Owner SystemUser write, Group Subscribers read, Group Publishers
write, World none
```

Changing the Authorization of an Object Security Policy

Privileges required: ObjectSecurityPolicyProtection or be the security policy's owner, and write authorization to the DataCuratorObjectSecurityPolicy.

The new authorization will take effect for logins following the commit of the current transaction.

CAUTION

Do not attempt to change the authorization of SystemObjectSecurityPolicy.

To change the authorization for a security policy, execute any (or all) of the following expressions.

theObjectSecurityPolicy `ownerAuthorization:` *#authSym*`.`

theObjectSecurityPolicy `worldAuthorization:` *#authSym*`.`

theObjectSecurityPolicy `group:` *groupOrGroupString*
`authorization:` *#authSym*`.`

NOTE

Exercise caution when changing the authorization for any security policy that a user may be using as his or her default or current security policy — whether or not the user owns the affected policy. If a user attempts to commit a transaction, but has created objects with a policy for which he or she no longer has write authorization, an error will be generated.

For example, to authorize the group Accounting to read (but not write) in user Eli's default security policy, you could execute the following expression:

```
(AllUsers userWithId: 'Eli') defaultObjectSecurityPolicy
      group: 'Accounting'
      authorization: #read.
```

If the group `'Accounting'` does not exist, GemStone will return an error. See under "Create a group" on page 157 for information on creating a new group.

Remove a Group from an Object Security Policy's Authorization List

Privileges required: ObjectSecurityPolicyProtection, and write authorization for the security policy.

To remove a group from a security policy's list of authorized groups, execute an expression similar to the following:

theSecurityPolicy `group:` '*groupOrGroupString*' `authorization: #none`

Change a User's Default Object Security Policy

Privileges required: DefaultObjectSecurityPolicy, and write authorization to the DataCurator ObjectSecurityPolicy.

Changes to another user's default security policy do not take effect until the next login.

To change a user's default security policy, execute the following expression:

```
(AllUsers userWithId: 'theUserId')
      defaultObjectSecurityPolicy: aNewSecurityPolicy
```

NOTE

If you change any user's default security policy (including your own) to a security policy for which that user lacks write authorization, and you subsequently commit the transaction, the affected user will no longer be able to log in to GemStone.

Modifying Privileges

Examining a User's Privileges

No privileges are required for this operation.

GemStone provides messages that allow you to determine which privileged methods a GemStone user may execute, and to change the privileges of any user. Naturally, you need the appropriate privileges to use those methods.

To find out which privileged methods a given user is permitted to execute, send the following message to the desired user's UserProfile:

```
(AllUsers userWithId: 'theUserId') privileges
```

This message returns an Array of Symbols. Table 8.1 on page 153 lists the Smalltalk operations controlled by each privilege.

Adding a Privilege

Privileges required: OtherPassword and write authorization to the ObjectSecurityPolicy of the user's UserProfile.

The new privileges will take effect when you commit the current transaction.

To add to a user's existing privileges, execute the following expression:

```
(AllUsers userWithId: 'theUserId') addPrivilege: aPrivilegeSym.
```

Here's an example that assigns three new privileges to user Bob:

```
topaz 1> printit
(AllUsers userWithId: 'Bob')
      addPrivilege: #SystemControl;
      addPrivilege: #SessionAccess;
      addPrivilege: #UserPassword .
System commitTransaction
%
```

Revoking a Privilege

Privileges required: OtherPassword and write authorization to the security policy of the user's UserProfile.

The privileges will be revoked when you commit the current transaction.

To revoke one (or more) of a user's existing privileges, execute the following expression:
`(AllUsers userWithId: '`*theUserId*`') deletePrivilege:` *aPrivilegeSym*`.`

The following example revokes two of user Jane's privileges:

```
topaz 1> printit
(AllUsers userWithId: 'Jane')
      deletePrivilege: #SystemControl;
      deletePrivilege: #SessionAccess.
System commitTransaction
%
```

Reassigning All Privileges

Privileges required: OtherPassword and write authorization to the security policy of the user's UserProfile.

The new privileges will take effect when you commit the current transaction.

To redefine the full set of a user's privileges, perhaps adding some and revoking others, execute the following expression:
`(AllUsers userWithId:` *theUserId*`) privileges:` *anArrayOfSym*

This expression supersedes any previous privilege assignments. After the change is committed, only those privileges listed in the expression are valid for the user. Any privileges that were previously valid, but are not listed, are revoked.

For example:

```
topaz 1> printit
(AllUsers userWithId: 'Sam') privileges:
      #( UserPassword ) .
System commitTransaction
%
```

Modifying SymbolLists

Adding a SymbolDictionary to Your Own Symbol List

Privileges required: CodeModification.

You can add a dictionary to a symbol list by sending the message `UserProfile>>insertDictionary:` *aSymbolDictionary* `at:` *anIndex*. This change will affect other sessions that are logged in as this user when the other session commits or aborts, unless the other session is using a transient symbol list.

This example inserts dictionary NewDict (which already exists in the Published dictionary) into the user's own symbol list:

```
topaz 1> printit
System myUserProfile
      insertDictionary: NewDict at: 2.
%
```

Inserting the new dictionary at index 2, as in the example, places it between the UserGlobals and the Globals dictionaries in the search order. Because symbol resolution depends on the order of dictionaries in a user's symbol list, the index used in this example may not be appropriate for all situations.

Adding a SymbolDictionary to Someone Else's Symbol List

Privileges required: OtherPassword and write permission to the security policy of the other user's SymbolDictionary.

This example inserts dictionary NewDict (which already exists in the Published dictionary) into user Jerry's symbol list:

```
topaz 1> printit
(AllUsers userWithId: 'Jerry')
      insertDictionary: NewDict at: 7.
System commitTransaction
%
```

Removing a SymbolDictionary from Your Own Symbol List

Privileges required: CodeModification.

You can remove a dictionary from a symbol list by sending the message `UserProfile>>removeDictionary:` *aSymbolDictionary*.

This example removes dictionary `OldDict` from the user's own symbol list:

```
topaz 1> printit
System myUserProfile
      removeDictionary: OldDict.
System commitTransaction
%
```

Removing a SymbolDictionary from Someone Else's Symbol List

Privileges required: OtherPassword and write permission to the security policy of the other user's SymbolDictionary,

This example removes dictionary `OldDict` from user Jerry's symbol list:

```
topaz 1> printit
(AllUsers userWithId: 'Jerry')
      removeDictionary: OldDict.
System commitTransaction
%
```

Disable and Enable User Logins

UserProfiles using GemStone authentication can be disabled in two ways; automatically, by violating password controls such as on the number of failed logins; and explicitly, by sending messages such as `disable`. An account that is disabled in GemStone cannot log in.

UserProfiles using external authentication can also be explicitly disabled in GemStone. However, they may also be unable to login due to violating the password controls enforced by the external authentication. GemStone does not detect, report, or re-enable accounts that are disabled by the external authentication mechanism. If the Unix or LDAP account cannot log in, or if Kerberos does not have a current ticket, logins will fail and you must correct the problems directly in Unix, LDAP, or Kerberos.

Once an account is disabled in GemStone, it must be re-enabled in GemStone before the account can log in again. For accounts using GemStone authentication, a new password must be assigned for that account by an administrator.

Explicitly Disable an Account in GemStone

Privileges required: OtherPassword. Logins cannot be disabled for special system accounts.

Users using any authentication scheme can be disabled using the methods `disable` or `disableWithReason:`. This prevents the user from logging in again, but does not affect currently logged in sessions.

For example:

```
topaz 1> printit
(AllUsers userWithId: 'Sam')
      disableWithReason: 'on Sabbatical'.
System commitTransaction
%
```

Re-enable an Account that is using GemStone authentication

Privileges required: OtherPassword.

To re-enable an account that uses GemStone authentication, an administrative user must login and reset the users's password. An account that becomes disabled, whether explicitly disabled or from security violations, will clear its password.

Users using GemStone authentication can be re-enabled using the methods `password:` or `reenableWithPassword:`.

For example, to reset Sam's password and require him to change his password the first time he logs in:

```
topaz 1> printit
(AllUsers userWithId: 'Sam')
      reenableWithPassword: 'AaBbCc';
      loginsAllowedBeforeExpiration: 1.
System commitTransaction
```

Re-enable an Account that is using external authentication

Accounts using external authentication rely on the security procedures for the external authentication scheme. If the external authentication disables logins, the user will not be able to login using GemStone, but the account in GemStone is not disabled.

Accounts that were explicitly disabled in GemStone can be re-enabled using the method `reenable` . Since the password is managed outside GemStone, you do not need to supply a new password.

```
topaz 1> printit
(AllUsers userWithId: 'Mary') reenable.
System commitTransaction
```

Find Out Which Accounts Have Been Disabled in GemStone

Privileges required: OtherPassword.

The message `AllUsers findDisabledUsers` returns a SortedCollection of UserProfiles that were either disabled explicitly, or that use GemStone authentication and were disabled by a security precaution such as password expiration, login failure, etc. Accounts using external authentication and that have been disabled by the rules for that authentication are not disabled in GemStone, and will not be returned by this method.

For example:

```
topaz 1> level 1
topaz 1> printit
AllUsers findDisabledUsers
  collect: [:aUser | aUser userId ] .
%
an Array
  #1 Sam
  #2 Mary
```

See "Re-enable an Account that is using GemStone authentication" on page 167 for how DataCurator or another user with the OtherPassword privilege can reactivate an account.

Check If an Account Is Disabled

Privileges required: OtherPassword.

You can check if a particular account is disabled in GemStone by sending the message `isDisabled` to the account's UserProfile.

For example:

```
topaz 1> printit
(AllUsers userWithId: 'Sam') isDisabled
%
true
```

Find Out Why an Account Was Disabled

Privileges required: OtherPassword.

You can find out why a particular account was disabled in GemStone by sending the message `reasonForDisabledAccount` to the account's UserProfile.

For example:

```
topaz 1> printit
(AllUsers userWithId: 'Sam') reasonForDisabledAccount
%
LoginsWithSamePassword
```

If the account was disabled using the method **`disableWithReason:`**, this method will return that argument. Otherwise if the account was disabled by login security, it will return one of these Strings: 'PasswordAgeLimit', 'StaleAccount', 'LoginsWithSamePassword', or 'LoginsWithInvalidPassword'.

Disable and Enable Commits by User

Commits can be disabled for particular users to ensure "read only" access to the GemStone repository. These users can still log in and view data for which they have read or write authorization, and can modify objects, but they cannot commit and make any changes permanent.

This restriction is unrelated to authentication, and applies equally to all authentication schemes.

Disable Commits

Privileges required: OtherPassword. Commits cannot be disabled for special system users.

To disable commits for a user, execute the following expression:

```
(AllUsers userWithId: theUserId) disableCommits
```

This expression disables any commits for the given user, beginning with the next login of the user after the session making this change commits. If this user is currently logged in, it does not affect the user's session/s.

For example:

```
topaz 1> printit
(AllUsers userWithId: 'Sam') disableCommits.
System commitTransaction
%
```

Re-enable Commits for a User

Privileges required: OtherPassword.

To enable commits for a user, execute the following expression:

```
(AllUsers userWithId: theUserId) enableCommits
```

This expression enables commits for the given user, beginning with the next login after the session making this change commits.

Check If a User Can Commit

Privileges required: OtherPassword.

To test if commits have been disabled for a user account, execute the following expression:

```
(AllUsers userWithId: theUserId) isReadOnly
```

8.5 Configuring GemStone Authentication

GemStone authentication is the default authentication, using the UserId and password store with the UserProfile of the account. In older versions, this was the only way of authentication within GemStone, and must still always be used by the special system users – especially SystemUser, DataCurator and GcUser.

GemStone authentication always requires a password to be set in the UserProfile. When you enable GemStone authentication, you must provide an initial password.

```
topaz 1> printit
(AllUsers userWithId: 'Mary')
   enableGemStoneAuthenticationWithPassword: 'AaBbCc'.
System commitTransaction.
%
```

Configuring GemStone Login Security

When authentication is done using #GemStone, there are a number of login security features available. You can:

- Constrain the choice of passwords to a certain pattern, ban particular passwords altogether, or ban reuse of a password by the same account

- Require users to change their passwords periodically (password aging)
- Limit the number of logins under a temporary password
- Disable accounts that have not logged in for a specified interval (account aging)
- Limit the number of concurrent sessions by a particular account
- Monitor failed login attempts and, if necessary, disable further login attempts on that account

In all cases, the password must not be the same as the UserId and must not be longer than 1024 characters.

Additional methods let you determine which accounts have been disabled by one of these security features and why a particular account was disabled.

CAUTION

GemStone records certain administrative changes to these security features in the Stone log. You may want to restrict access to that file.

The special system users are never disabled by the security features.

Limiting Choice of Passwords

Privileges required: OtherPassword and write authorization to DataCuratorObjectSecurityPolicy.

You can constrain a user's choice of passwords in terms of pattern (such as the number of characters that repeat). Independently, you can establish a list of words that are disallowed as passwords, and you can keep a user from choosing the same password more than once.

The constraints described here apply only when a user changes his or her own password by using the message `UserProfile>>oldPassword:newPassword:` and only to password changes after the constraint is committed to the repository. That is, the constraints (other than the prohibition of userId as the password) do not apply to changing a users's user's password using the `password:` method (which requires OtherPassword privilege), and they do not invalidate existing passwords.

Table 8.3 lists the messages that you can use to set pattern constraints. You send these messages to the global object AllUsers. For example, to set the minimum password length to six characters, do this:

```
topaz 1> printit
AllUsers minPasswordSize: 6.
System commitTransaction
%
```

The default setting in all cases is 0, which means there is no constraint on the pattern.

Table 8.3 Ways to Constrain the Password Pattern

Message to AllUsers	Comments
`minPasswordSize:` *aPositiveInteger*	Sets the minimum number of characters in a new password; 0 means no constraint.
`maxPasswordSize:` *aPositiveInteger*	Sets the maximum number of characters in a new password; 0 disables the constraint. (The password String itself must not be longer than 1024 characters.)
`maxRepeatingChars:` *aPositiveInteger*	Sets the maximum number of adjacent characters that can have the same value; for example, *1* allows 'aba' but not 'aa'. 0 means no constraint.
`maxConsecutiveChars:` *aPositiveInteger*	Sets the maximum number of adjacent characters that can be an ascending or descending sequence, such as '123' or 'zyx' based on a case-sensitive comparison. 0 means no constraint.
`maxCharsOfSameType:` *aPositiveInteger*	Sets the maximum number of adjacent characters that can be of the same type (alpha, numeric, or special); for example, *3* allows 'abc4de' but not 'abcde'. 0 means no constraint.
`passwordRequiresUppercase:` *aBoolean*	Set the requirement that the password contain at least one uppercase character. false means no constraint.
`passwordRequiresLowercase:` *aBoolean*	Set the requirement that the password contain at least one lowercase character. false means no constraint.
`passwordRequiresSymbol:` *aBoolean*	Set the requirement that the password contain at least one character that is not alphanumeric. false means no constraint.
`passwordRequiresDigit:` *aBoolean*	Set the requirement that the password contain at least one digit. false means no constraint.

Any user can inquire about the current setting of a password pattern constraint by sending its corresponding Accessing message (that is, without the colon or argument shown in Table 8.3).

For example, to query for the current minimum size for a password:

```
topaz 1> printit
AllUsers minPasswordSize
%
6
```

Disallowing Particular Passwords

Privileges required: OtherPassword and write authorization to the DataCuratorObjectSecurityPolicy.

You can create a list of disallowed passwords by adding Strings to the AllUsers instance variable disallowedPasswords set. For instance:

```
(AllUsers disallowedPasswords)
      addAll: #( 'Mother' 'apple_pie' )
```

The default is an empty set.

Additions to this list affect only new passwords requested after the additions are committed; that is, additions do not invalidate existing passwords. If a user attempts to change that account's password to one of the Strings in disallowedPasswords, a SecurityError is signaled.

Any user can examine the current list of globally disallowed passwords by sending the message `AllUsers disallowedPasswords`.

Disallowing Reuse of Passwords

Privileges required: OtherPassword and write authorization to DataCuratorObjectSecurityPolicy.

You can prevent each user from choosing the same password more than once by setting AllUsers disallowUsedPasswords to true. By default, disallowUsedPasswords is false.

When reuse of passwords is disallowed, GemStone maintains a separate encrypted set of old passwords for each user. Each time a user invokes `oldPassword:newPassword:`, the new password is checked against the prior passwords for that account. If the new password matches a prior one, a SecurityError is signaled.

Disallow All Previously Used Passwords

To disallow password reuse, use the method:

```
AllUsers disallowUsedPasswords: aBoolean.
```

Disallow a Specific Number of Previous Passwords

Privileges required: OtherPassword and write authorization to DataCuratorObjectSecurityPolicy.

To disallow a fixed number of previously-used password, but allow earlier passwords, use the following:

```
AllUsers numberOfDisallowedPasswords: anInteger
```

anInteger must be a number between 0 and 65535; 0 means that the user may not reuse any previously-used passwords. The limit on the number of disallowed passwords has no effect if disallowUsedPasswords is false.

For example:

```
AllUsers disallowUsedPasswords: true.
AllUsers numberOfDisallowedPasswords: 10.
```

Clearing a User's Disallowed Old Passwords

Privileges required: OtherPassword.

You can clear the set of old passwords so that they can be reused. As mentioned above, this set is maintained for each user when the AllUsers instance variable disallowUsedPasswords is set to true.

The following example clears the remembered passwords for Mary's account:

```
(AllUsers userWithId: 'Mary')
      clearOldPasswords.
```

Password Aging – Require Periodic Password Changes

You can configure your system so users must change their password periodically. This can be configured at the repository-wide level, or for individual users. Note that if you are not using GemStone login authorization, password aging does not apply.

Privileges required: OtherPassword and write authorization to DataCuratorObjectSecurityPolicy. The special GemStone accounts are not disabled by password aging.

Repository-Wide Password Aging

You can require users to change their password periodically by setting up a password age limit. This can be set for all users in the repository, and can be overridden for specific individual users.

To set a password page limit for all users in the repository, for example to 120 days:

```
AllUsers passwordAgeLimit: 120 * 24 .
```

The passwordAgeLimit is added to the time the password was last changed to determine when the password will expire. A setting of 0 (the default) disables password aging.

Each time this method is invoked, the action is recorded in the Stone's log.

If a user does not change the account's password within the specified interval, the account is disabled, and attempts to log in result in an error.

DataCurator or another user with the OtherPassword privilege can reactivate the disabled account by giving it a new password; see "Re-enable an Account that is using GemStone authentication" on page 167 for details.

Password Age Limits for Individual Users

To override the repository-wide setting for password aging, you can set a password age limit for a specific user. For example, to set the limit for a Mary to 5 days:

```
(AllUsers userWithId: 'Mary')
      passwordAgeLimit: 5 * 24.
```

If repository-wide password aging is enabled, you can also override this for individual users, such as managers or administrators, either by setting the password page limit to 0, or setting the password to never expire. For example, to prevent the password used by batch jobs from expiring, execute:

```
(AllUsers userWithId: 'BatchUser')
      setPasswordNeverExpires: true.
```

Repository-Wide Password Expiration Warning

Privileges required: OtherPassword and write authorization to DataCuratorObjectSecurityPolicy. This does not apply to system users, and has no effect if password aging is not enabled.

You can provide an automatic warning to users repository-wide whose password is about to expire. For example, to warn users who log in within five days of the time their password will expire, do this:

```
AllUsers passwordAgeWarning: 5 * 24.
```

Logins within *numberOfHours* prior to expiration cause a SecurityError to be signaled.

Per-User Password Expiration Warning

You can provide a similar automatic warning to a specific user. For example, to warn Mary within three days of the time her password will expire, do this:

```
(AllUsers userWithId: 'Mary') passwordAgeWarning: 3 * 24.
```

Finding Accounts with Password About to Expire

Privileges required: OtherPassword.

You can find out which accounts have a password within the warning period set by `passwordAgeWarning:`. To do this, send the message `findProfilesWithAgingPassword` to AllUsers. For example:

```
topaz 1> printit
AllUsers findProfilesWithAgingPassword
  collect: [ :u | u userId] .
%
an OrderedCollection
#1 qa1
#2 qa2
#3 qa3
```

Finding Out When a Password Was Changed

Privileges required: OtherPassword.

You can find out the last time the password was changed for a particular userId by sending the message `lastPasswordChange` to that account's UserProfile. This example converts the DateTime returned to a particular pattern based on MM/DD/YY:

```
topaz 1> printit
(AllUsers userWithId: 'qa2') lastPasswordChange US12HrFormat
%
08/24/20 11:28 AM
```

Account Aging – Disable Inactive Accounts

You can configure your system so users must log in periodically, by disabling accounts for which there has been no login for a specified length of time. This can be configured at the repository-wide level, or for individual users.

Privileges required: OtherPassword and write authorization to DataCuratorObjectSecurityPolicy. The special GemStone accounts are not disabled by stale account aging.

Repository-Wide Stale Account Aging

To do this, send the message `staleAccountAgeLimit:` *numberOfHours* to AllUsers. This example disables accounts when they have not logged in for 30 days:

```
AllUsers staleAccountAgeLimit: 30 * 24.
```

Each time this method is invoked, the action is recorded in the Stone log.

A setting of 0 (the default) disables account aging.

DataCurator or another user with the OtherPassword privilege can reactivate the disabled account by giving it a new password; see "Re-enable an Account that is using GemStone authentication" on page 167 for details.

Per-User Stale Account Aging

You can override the repository-wide setting for account aging for a specific user using `UserProfile>>staleAccountAgeLimit:` *numberOfHours*.

For example, for the 'Auditor' account who may log in less frequently, you can set up a 180-day stale account age limit. This will override a repository-wide 30 day setting.

```
(AllUsers userWithId: 'Auditor')
      staleAccountAgeLimit: 180 * 24.
```

Finding Out When an Account Last Logged In

Privileges required: OtherPassword.

If at least one age limit applies to an account, you find out when that account last logged in by sending the message `lastLoginTime` to that account's UserProfile. For example:

```
topaz 1> printit
(AllUsers userWithId: 'Mary') lastLoginTime US12HrFormat
%
08/24/20 01:40 PM
```

The time of the last login is maintained only if loginsAllowedBeforeExpiration is set in that UserProfile or if at least one of these instance variables is set in AllUsers or the specific UserProfile: passwordAgeLimit, passwordAgeWarning, or staleAccountAgeLimit. If none of these features are enabled, the lastLoginTime may be nil, the time of the account creation, or a time representing a login during an earlier period when one of these features was enabled. This is also true if a feature that enables lastLoginTime recording has been enabled on more recently than the last login of the user.

The data curator may explicitly set the time of the last login, using the method `UserProfile >> lastLoginTime:`.

Enabling Account Aging and lastLoginTime

Privileges required: OtherPassword.

The time of the last login is recorded for a UserProfile only if loginsAllowedBeforeExpiration is set in that UserProfile or if at least one of these instance variables is set in AllUsers or the specific UserProfile: `passwordAgeLimit`, `passwordAgeWarning`, or `staleAccountAgeLimit`. This is to avoid the commit during login, which is required to record the lastLoginTime.

Use caution in enabling account aging on existing repositories. Enabling account aging may result in user accounts being disabled, if there happens to be a lastLoginDate recorded in the UserProfile. This may be due to a login date recorded in an earlier period due to

changes in login security in your application, or UserProfiles in an repository progressively upgraded from historical versions of GemStone that routinely set the lastLoginDate.

To avoid this issue, when you enable account aging, you can set the lastLoginTime to the current date, or to nil, for all affected UserProfiles. A nil setting disables account aging checks, allowing the aging period to being with the next login.

```
topaz 1> printit
AllUsers passwordAgeLimit: 120 * 24.
AllUsers do: [:aUserProfile |
      aUserProfile lastLoginTime: DateTime now.
      ].
System commitTransaction.
%
```

Limit Logins Until Password Is Changed

Privileges required: OtherPassword.

When you assign a password to an account, you can make the password temporary by limiting the number of times it can be used. This limitation applies only to a specific account, that is, to the UserProfile that is the receiver of the message. It is intended for use with a new or reactivated account as a means of ensuring that the user changes the password. For example, the following limits the account "Mary" to two more logins under the current password:

```
(AllUsers userWithId: 'Mary')
      loginsAllowedBeforeExpiration: 2.
```

A setting of 0 (the default) disables this feature.

The limit remains in effect until the user changes the password. Once the password is changed, the limit for that account is set to 0. The password will not expire again unless a new limit is set by repeating `loginsAllowedBeforeExpiration:`.

If the limit is exceeded before the password is changed, the system disables the account. DataCurator or another user with the OtherPassword privilege can reactivate the disabled account by giving it a new password; see "Re-enable an Account that is using GemStone authentication" on page 167 for details.

The special user accounts are not disabled by this mechanism.

Limit Concurrent Sessions by a Particular UserId

Privileges required: OtherPassword.

You can limit the number of concurrent sessions logged in under a particular userId. For example, the following limits the userId "qa2" to four concurrent sessions:

```
(AllUsers userWithId: 'qa2')
      activeUserIdLimit: 4.
```

A setting of 0 (the default) disables this feature.

If a user attempts to log in when the maximum number of sessions for that userId are already logged in, the login is denied and a SecurityError is signalled.

Limit Login Failures

Record Login Failures

The Stone repository monitor keeps track of login failures (incorrect passwords) for each account and can write that information to the Stone's log.

By default, messages are logged when the same account fails login attempts 10 or more times within ten minutes. You can change the default limits by setting the STN_LOG_LOGIN_FAILURE_LIMIT (page 348) and STN_LOG_LOGIN_FAILURE_TIME_LIMIT (page 348) configuration options.

The log message gives the following information:

```
---Mon 24 Aug 2020 09:39:40 PDT ---
    GemStone user Mary has failed on 10 attempt(s)
       to log in within 1 minute(s).
    The last attempt was from user account writer1 on hostname
docs.
```

Disabling Further Login Attempts

If login failures continue, the Stone repository monitor can disable the account. By default, the account is disabled when the number of failures exceeds 15 within 15 minutes. You can change the default limits by setting the STN_DISABLE_LOGIN_FAILURE_LIMIT (page 341) and (STN_DISABLE_LOGIN_FAILURE_TIME_LIMIT (page 341) configuration options.

Subsequent attempts to login as that account result in the following error message:

```
Login failed:  the GemStone userId/password combination is
invalid or expired.
```

The special user accounts are not disabled by login failures.

DataCurator or another user with the OtherPassword privilege can reactivate the disabled account by giving it a new password; see "Re-enable an Account that is using GemStone authentication" on page 167 for details.

8.6 Configuring UNIX Authentication

When UNIX account authentication is enabled for a user, they will enter their UNIX account password instead of their GemStone password. Password management for this user then becomes the Unix password management; sending messages to change the GemStone password are not useful, and these accounts are not subject to GemStone's password restriction, aging, and failed login mechanisms.

UNIX authentication uses PAM (pluggable authentication module), and PAM must be configured on the system in order to use UNIX Authentication. Login will look for a module `gemstone.gem`. See the *Installation Guide* for your server platform for details.

The GemStone userId may be the same as the UNIX userId, or they may be different. When you enable UNIX authentication for an account, you may specify the UNIX userId associated with the GemStone UserProfile and this will be used for authentication. Using nil means to use the GemStone userId as the UNIX userId.

```
(AllUsers userWithId: GemStoneUserId)
   enableUnixAuthenticationWithAlias: UNIXUserIdOrNil
```

for example, if Mary's UNIX userId is **msmith**, you can use the first form if her GemStone userId is **Mary**. If her GemStone userId is also **msmith** you leave the argument nil.

```
(AllUsers userWithId: 'Mary')
      enableUnixAuthenticationWithAlias: 'msmith'.

(AllUsers userWithId: 'msmith')
      enableUnixAuthenticationWithAlias: nil.
```

To verify that the UNIX userId exists, execute:

```
System unixUserIdExists: UNIXUserId
```

8.7 Configuring LDAP Authentication

An LDAP (Lightweight Directory Access Protocol) server consolidates and centralizes user authentication, and can be used to authenticate logins to the GemStone server. UNIX authentication, which uses PAM, may ultimately use LDAP if PAM is configured to use LDAP. When you configure GemStone to use LDAP authentication, it goes to LDAP directly, rather than using PAM.

To use LDAP for GemStone authentication, you must have an LDAP server available. When a UserProfile has been configured for LDAP authentication, on login, GemStone performs an LDAP bind to authenticate the userId.

In most cases, the LDAP bind requires a Distinguished Name (DN), which is the unique identifier for an entry. The DN includes both the userId and domain information, e.g. 'uid=msmith,ou=employees,dc=somecompany,dc=com'. GemStone composes the DN based on the arguments provided when you configure LDAP authentication.

To configure a user to use LDAP for authentication, use the following method:

```
(AllUsers userWithId: GemStoneUserId)
      enableLDAPAuthenticationWithAlias: LDAPUserIdOrNil
      baseDn: baseDn
      filterDn: filterDn
```

UserId or Alias

As with UNIX authentication, if the LDAP userId is the same as the GemStone Id, you may pass in nil for the argument *UNIXUserIdOrNil*; otherwise, pass in the LDAP userId. The user will use their GemStone userId and the password for their LDAP account to log in.

Fully Qualified DN

You can configure the LDAP authentication for a particular user with the specific DN, with '%s' replacing the userId, for the `baseDn:` argument. In this case you should pass in nil for the `filterDn:` argument, which will disable the query.

For example, to configure authentication to use a specific fully qualified DN:

```
topaz 1> printit
(AllUsers userWithId: 'Mary')
      enableLDAPAuthenticationWithAlias: 'msmith'
      baseDn: 'uid=%s,ou=employees,dc=somecompany,dc=com'
      filterDn: nil.
System commitTransaction.
%
```

Search for DN

You can also configure authentication to include the base domain information in the `baseDn:` argument, and include a filter in the `filterDn:` argument. The filter must contain '%s' in the position for the userId. GemStone will perform a query to get the full DN given the base and filter information.

The base and filter information is provided at the time the authentication is configured, not at login time, so a search option is particularly useful if the LDAP structure is likely to be modified.

To configure authentication to do a search for the given user:

```
topaz 1> printit
(AllUsers userWithId: 'Mary')
      enableLDAPAuthenticationWithAlias: 'msmith'
      baseDn: 'dc=somecompany,dc=com'
      filterDn: '(uid=%s)'.
System commitTransaction.
%
```

LDAP authentication without anonymous binds

By default, GemStone login authentication requires that the LDAP server allow anonymous binds. For installations that disallow anonymous binds, you may configure instances of LdapDirectoryServer with the information required for authenticated binds.

AllLdapDirectoryServers is a global collection of instance of LdapDirectoryServer. Each instance of LdapDirectoryServer contains authentication information for an particular LDAP server.

During login, If there are existing instances of LdapDirectoryServer in AllLdapDirectoryServers, then these are used, in order; normally this would include a primary LDAP server and an alternate. If and only if the bind to the first LDAP server fails, the second is tried, and so on. If no binds are successful, then the login will fail.

If AllLdapDirectoryServers is empty, then login will use anonymous bind.

To create an LdapDirectoryServer, and add it to the global list, use the following method:

```
LdapDirectoryServer class >> newWithUri: uri bindDN: aBindDn
      password: password
```

If LDAP authentication is setup, using

```
enableLDAPAuthenticationWithAlias: aString baseDn: baseDn
      filterDn: filterDn
```

then either anonymous or authenticated binds are performed to authenticate the user password.

For example, to set up a user to use LDAP authentication, and setup a single LDAP server to authenticate binds, the following code would be executed.

```
aUserProfile
      enableLDAPAuthenticationWithAlias: nil
      baseDn: 'ou=Users,dc=gemtalksystems,dc=com'
      filterDn: '(uid=%s)' .

LdapDirectoryServer
      newWithUri: 'ldaps://ldap.gemtalksystems.com'
      bindDN: 'uid=bindUser,ou=Users,dc=gemtalksystems,dc=com'
      password: 'swordfish' .
```

Users are individually configured to use LDAP authentication, but LDAP directories are configured for the repository as a whole, so this step is only done once. All users use the same bind authentication, though they use their own individual passwords to perform the actual account authentication.

Note that the instances of LdapDirectoryServer store the encrypted bind password. This is not the actual user password to login to GemStone; this bind password allows you to perform the user password authentication.

To determine if a particular LdapDirectoryServer exists, use the following method, which returns either the LdapDirectoryServer or nil if it is not found:

```
LdapDirectoryServer >>findServerWithUri: aUriString
```

to remove an LdapDirectoryServer, use the method:

```
LdapDirectoryServer >> removeServerWithUri: aUriString
```

Validating passwords

Once logged in, you can perform an validation call to the LDAP server that passes in the LDAP authentication as well as the user authentication, using this method:

```
System class >> validatePasswordUsingLdapServers:baseDn:
      filterDn:userId:password:bindDn:bindPassword:
```

The additional bind arguments should be nil if authenticating in explicit mode, or with anonymous bind. For example:

Explicit mode

```
System validatePasswordUsingLdapServers:
            (Array with: 'ldaps://myldap.mydomain.com')
      baseDn: 'uid=%s,ou=Users,dc=mycompany,dc=com'
      filterDn: nil
      userId: 'MyUserId' password: 'swordfish'
      bindDn: nil bindPassword: nil
```

Search mode with anonymous bind

```
System validatePasswordUsingLdapServers:
            (Array with: 'ldaps://myldap.mydomain.com')
      baseDn: 'ou=Users,dc=mycompany,dc=com'
      filterDn: '(uid=%s)'
      userId: 'MyUserId' password: 'swordfish'
      bindDn: nil bindPassword: nil
```

Search mode with authenticated bind

```
System validatePasswordUsingLdapServers:
            (Array with: 'ldaps://myldap.mydomain.com')
      baseDn: 'ou=Users,dc=mycompany,dc=com'
      filterDn: '(uid=%s)'
      userId: 'MyUserId' password: 'swordfish'
      bindDn: 'LdapBindUser' bindPassword: 'LdapBindPassword'
```

For further details, see the method comments in the image.

8.8 Configure SingleSignOn Authentication

If your system is setup with Kerberos, you can configure GemStone authentication to use SingleSignOn, which checks for a current Kerberos ticket and avoids the requirement that a user should provide a password on login. Using SingleSignOn (SSO), the "User Password" field in the login parameters is left empty.

When Kerberos is not running or has no current ticket, the user cannot login. For this reason, SystemUser may not be setup to use SSO. SystemUser always requires GemStone authentication.

Kerberos concepts

For details on how to install or configure Kerberos at your site, consult your System Administrators. GemStone uses Kerberos v5 Release 1.15 with AES encryption.

Note that on Windows, Kerberos is built in as part of SSPI, and SingleSignOn can only be used on Windows clients that are part of a Windows Domain, either Samba or an MS Windows server.

Kerberos uses the term "realm" for a domain within an installation/organization. Realms are generally the DNS domain in upper case; for example, at GemTalk the realm would be GEMTALKSYSTEMS.COM.

The term "principal" is used for any unique identity, including UNIX user ids, hosts, and services.

User principles are identified as name@REALM, e.g.

```
maryb@BIGCORPORATION.COM
```

When a user authenticates using Kerberos (e.g by UNIX login or by using kinit), the user enters their password, and Kerberos provides a ticket—more specifically, a **ticket granting ticket (TGT)**. This is cached on the user's host, and is used to create specific tickets for requested services at the time they are requested. The TGT is usually put under `/tmp`, and is valid for a limited period, by default usually 10 hours.

In addition to Kerberos user principals, you will need to create a Kerberos **service principal** for GemStone. The service principal is of the form `Service/fully.qualified.domain.name@REALM`. The name of the service principal for authentication in GemStone is GEMSTONE64. So, for example, a service principal might be

```
GEMSTONE64/nodename.bigcorporation.com@BIGCORPORATION.COM
```

You will need to create a **keytab file** with the GEMSTONE64 service principals for each individual host node. This keytab file will be used for authorization; any user who has

authenticated via Kerberos and has access to the keytab file, and has their GemStone user account setup for SingleSignOn, will be able to do a passwordless login to GemStone.

KerberosPrincipal and AllKerberosPrincipals

Instances of the class KerberosPrincipal define the association between the name of a Kerberos principal and GemStone login information. An instance of KerberosPrincipal has the following information:

`name`	(Symbol) the name for the kerberos principal; must be unique.
`loginUserProfile`	a UserProfile, or nil for a shared KerberosPrincipal.
`loginUserProfileGroups`	an IdentitySet of UserProfileGroups, to support a shared KerberosPrincipal, or nil.
`loginAsAnyoneEnabled`	a Boolean; true if any UserProfile can use this KerberosPrincipal.

There are a number of ways that a repository can be configured to allow one or more UserProfiles to login using one or more KerberosPrincipals.

- There may be a one-to-one relationship between a UserProfile and a KerberosPrincipal, with each referencing the other. In this case `loginUserProfileGroups` and `loginAsAnyoneEnabled` are usually nil.
- One or more UserProfile/s may reference a KerberosPrincipal with `loginUserProfileGroups` configured as a set of UserProfileGroups. The KerberosPrincipal has a nil loginUserProfile and `loginAsAnyoneEnabled` set to false. Any user that is a member of any of these groups can use this KerberosPrincipal to log in.
- One or more UserProfile/s may reference a KerberosPrincipal that has a nil `loginUserProfile`, and with `loginAsAnyoneEnabled` set to true. This allows any user to configure SingleSignOn using that KerberosPrincipal.

KerberosPrincipals are created using class protocol in KerberosPrincipal, and are automatically added to the global collection AllKerberosPrincipals. You can look up a KerberosPrincipal by name. The AllKerberosPrincipals global should not be accessed directly.

Setting up Kerberos Authentication in GemStone

There are several steps to setting up SingleSignOn for a user account. You must:

- Create the KerberosPrincipal specific to that user
- Use that KerberosPrincipal as an argument to enable #SingleSignOn authentication
- Configure the environment for the user that will login with the keytab file location.

1. Create an instance of KerberosPrincipal for the User

A UserProfile who will use SSO is associated with a specific instance of KerberosPrincipal. For example, to create a Kerberos user principle for the GemStone user named Mary, use an expression such as this:

```
KerberosPrincipal
      newPrincipalWithName: 'maryb@BIGCORPORATION.COM'
      loginUserProfile: (AllUsers userWithId: 'Mary').
```

This creates the KerberosPrincipal and adds it to AllKerberosPrincipals.

2. Enable SingleSignOn for that UserProfile using the new KerberosPrincipal

Use the Kerberos Principle when enabling SingleSignOn, using `UserProfile >> enableSingleSignOnAuthenticationWithPrincipal:`.

3. Configure the gem's environment to set the keytab file location

The Gem configuration parameter GEM_KERBEROS_KEYTAB_FILE must be set in order to specify the location of the keytab file.

For example, enter this in the configuration file that will be used by Gem sessions. This may be the default `$GEMSTONE/data/system.conf`, or another configuration file, as described in "How GemStone Uses Configuration Files" on page 307.

```
GEM_KERBEROS_KEYTAB_FILE =
'/export/localnew/common/kerberos/gemtalk.keytab';
```

4. Verify login without password

Verify authentication; make sure the user account for maryb is authenticated using Kerberos, enter the GemStone user name (Mary) in the login parameters, and leave the password empty.

Example 8.1 Setting up SingleSignOn for a single account

```
| prin user |
user := AllUsers userWithId: 'Mary'.
prin := KerberosPrincipal
      newPrincipalWithName: 'maryb@GEMTALKSYSTEMS.COM'
      loginUserProfile: user.
user enableSingleSignOnAuthenticationWithPrincipal: prin.
System commitTransaction.
```

Using Groups to authenticate with Kerberos

A KerberosPrincipal often will correspond to a specific GemStone UserProfile. However, you may use groups to configure your system so multiple GemStone UserProfiles can login using the same KerberosPrincipal.

To do this, create a KerberosPrincipal with a nil `loginUserProfile`. Create a new group and make the users part of the group, and add the group to the KerberosPrincipal. You can then use this KerberosPrincipal to enable SingleSignOn for all the users in the group

For example, the following code uses jsmith's principal to login as both 'john' and 'mary'.

Example 8.2 Setting up SingleSignOn using Groups

```
| prin user1 user2 group |
user1 := AllUsers userWithId: 'john'.
user2 := AllUsers userWithId: 'mary'.
group := UserProfileGroup
      newGroupWithName: 'KerberosAdminLogin'.
user1 addGroup: group groupName.
user2 addGroup: group groupName.
prin := KerberosPrincipal newPrincipalWithName:
      'jsmith@GEMTALKSYSTEMS.COM' loginUserProfile: nil.
prin addGroup: group.
group users do: [:aUserProfile | aUserProfile
      enableSingleSignOnAuthenticationWithPrincipal: prin].
System commitTransaction.
```

KerberosPrincipal available to all users

You can configure all users on your system to share the KerberosPrincipal by using

aKerberosPrincipal `loginAsAnyoneEnabled: true`

This is equivalent to creating a group that includes all users and using this for the KerberosPrincipal's group.

Then, any user (except SystemUser) can set their authentication to #SingleSignOn using the principal *aKerberosPrincipal*.

Example 8.3 Sharing a KerberosPrincipal

```
| prin user1 user2 |
user1 := AllUsers userWithId: 'Mary'.
user2 := AllUsers userWithId: 'John'.
prin := KerberosPrincipal newPrincipalWithName:
      'jsmith@GEMTALKSYSTEMS.COM' loginUserProfile: nil.
prin loginAsAnyoneEnabled: true.
user1 enableSingleSignOnAuthenticationWithPrincipal: prin.
user2 enableSingleSignOnAuthenticationWithPrincipal: prin.
System commitTransaction.
```

8.9 Tracking User Logins

GemStone provides to options related to user logins: logging of each user login and logout, and a hook that allows you to execute specific code when a specific user logs in.

These features apply for all authentication schemes.

Login logging

It is sometimes useful to keep a log recording when each session logs in and out. You can configure your system to record login/logout events for each session in the repository. Other related operations, such as Stone startup and shutdown, are also recorded.

Tracking login/logout events is disabled by default. It is enabled by setting the STN_LOGIN_LOG_ENABLED configuration option to True in the configuration file used by the Stone, prior to Stone startup.

Once this is enabled for the repository, by default, all sessions that login to the stone will have logins and logouts logged.

Specific UserProfiles can be configured to not log events on login and logout; this can help avoid having the log cluttered with system logins. For example, you may not want to track when the GcUser logs in and out. This is done with the method `UserProfile >> disableLoginLogging`. After this is executed, the particular UserProfile will not have logins or logouts recorded in the log file.

Logins and logouts are recorded to a text file named *stoneName*`_login.log`, in the same directory as the Stone log. Each log entry is on an individual line, with the following fields:

```
TimestampString TimeStampSeconds EventKind UserName SessionId
ProcessId RealUserID EffectiveUserID HostName GemIPAddress
ClientIPAddress NumCommits LoginUserId KerberosPrincipal
```

For example:

```
"04/28/20 10:49:13.404 PDT" 1488307753 STARTUP Stone 0 2045 631 631
localhost 127.0.0.1 0.0.0.0 0 631 ''
"04/28/20 10:51:04.111 PDT" 1488307864 LOGIN DataCurator 5 2641 631
631 localhost 127.0.0.1 127.0.0.1 0 631 ''
"04/28/20 10:51:05.792 PDT" 1488307865 SHUTDOWN Stone 0 2045 631 631
localhost 127.0.0.1 0.0.0.0 0 631 ''
```

Login Hook

The loginHook is an optional feature that allows you to specify code to be executed each time a specific UserProfile logs in.

The argument to the method `UserProfile >> loginHook:` specifies either a symbol, which must be a unary selector of an instance method that was added to UserProfile, or a zero-argument block. When the UserProfile logs in, if the `loginHook:` is not nil, then the method associated with the selector, or the block, is executed.

For example:

```
topaz 1> printit
(AllUsers userWithId: 'Mary')
      loginHook: [MyApplicationLogger logLogin: 'Mary']
System commitTransaction.
%
```

Debugging

The loginHook code will be executed each time that user logs in. If there are errors in the loginHook code, the login does not complete and the user will not be able to log in.

Logging in as another user with OtherPassword privilege may be required, to reset the loginHook code and allow the user to login.

SystemUser can enable to configuration parameter STN_ALLOW_NO_SESSION_INIT using the runtime parameter #StnAllowNoSessionInit. When this is set, the login reports the error but will complete, which may allow you to debug the loginHook code.

Chapter

9 Managing Repository Space

The *repository* is the logical unit that represents the universe of shared objects that are stored within a GemStone/S 64 Bit system. The logical repository maps to one or more physical *extent* files in the file system, or to data on one or more raw disk partitions.

This chapter explains how the repository grows, and tells you how to perform a number of administrative tasks related to the repository and extents.

The Repository and Extents (page 188)
describes the relationship between the repository and the extents, and why the repository grows.

Adding and Removing Extents (page 189)
provides instructions on adding and removing extents from the repository.

Reallocating Existing Objects Among Extents (page 192)
describes how to change the way objects are distributed over the extents.

Shrinking the Repository (page 194)
provides instructions for reducing the size of the repository extents.

Checking Page Fragmentation (page 196)
describes page fragmentation and how to address it.

Disk Space and Commit Record Backlogs (page 196)
avoiding running out of space due to an idle session creating a commit record backlog.

Recovering from Disk-Full Conditions (page 198)
describes the actions taken by the Stone to prevent running out of space, what to do to avoid this condition, and how to recover.

9.1 The Repository and Extents

Within GemStone Smalltalk, the repository – the logical unit holding the universe of shared GemStone objects – is the single instance of Class Repository, with the name `SystemRepository`. The logical repository is represented on disk by one or more physical *extent* files in the file system or on raw disk partitions. This is described under "Extents, Tranlogs, and disk space" on page 30.

Whenever GemStone performs a *checkpoint,* it makes sure that transactions committed before the checkpoint have been written to the repository extents. The maximum time between checkpoints is set by the STN_CHECKPOINT_INTERVAL configuration option; the default is five minutes, but various factors may cause a checkpoint to occur sooner. The checkpoint limits the amount of time that is needed to recover from a system crash by guaranteeing that the data for the transaction is written to the extent and not just to the transaction log. For information, see "Controlling Checkpoint Frequency" on page 56.

Repository Growth

Repository extents not only have to hold the data in your database, they also need to hold the changes all the users make, and coordinate the views of each user so the user has a consistent view of the data. All these activities require space in the extents.

The repository begins in the compact form of `$GEMSTONE/data/extent0.dbf`. As repository activity progresses, the extent file expands as more space is needed, in increments of 16 MB. Not only does your new application data require space, but space is required for internal structures that organize and manage the objects. Also, sessions, and their transactional views of the repository, require space.

Garbage objects—objects that are no longer referenced, or the older versions of objects—also use space in the repository until they are garbage collected. To manage the size of the extents, you need to regularly perform garbage collection on your GemStone repository. The frequency can vary from monthly to daily, depending on the amount of activity in the repository. Without garbage collection, the repository will continue to grow and be filled with wasted space. See Chapter 15, "Managing Repository Growth", for a discussion of garbage collection in GemStone.

How To Check Free Space

Use the methods `Repository>>fileSize` and `Repository>>freeSpace` to obtain reports about the logical repository as a whole.

The result of the message `fileSize` is the total size of the repository in bytes, including all extent files. If the repository consists of a single extent file, it is ordinarily the same result as you would obtain by using the operating system commands to find file size. For example:

```
topaz 1> printit
SystemRepository fileSize
%
153092096
```

The result of `freeSpace` tells how much space (in bytes) is available for allocation within the repository at its current size. Free space is equal to the sum (for all extents in the

repository) of the number of free pages in each extent multiplied by the page size. This space does not include fragments on partially filled data pages.

```
topaz 1> printit
SystemRepository freeSpace
%
26411008
```

Depending on the configuration options selected and the available disk space, the Stone repository monitor may be able to create additional free space by enlarging the repository.

If your configuration has more than one extent, use `Repository>>fileSizeReport` to generate statistics about each individual extent and also totals for the entire repository. (The heading "Extent #1" identifies the primary extent regardless of its file name, which by default is `extent0.dbf`.)

Example 9.1 Checking free space using fileSizeReport

```
topaz 1> run
SystemRepository fileSizeReport
%
Extent #1
  Filename = /users/extents/extent0.dbf
  File size =       256 MB
  Space available =  34 MB
-----------
Extent #2
  Filename = /users/extents/extent1.dbf
  File size =        64 MB
  Space available =   9 MB
------
Totals
  Repository size = 320 MB
  Free Space =       43 MB
```

The amount of free space in the repository can also be determined from the cache statistic FreePages. To obtain the free space, multiply FreePages by the page size, 16384.

9.2 Adding and Removing Extents

GemStone provides two ways to add extents:

- When the stone is not running, you can add new extents at startup by editing the Stone's GemStone configuration file, by adding extent names and sizes to the DBF_EXTENT_NAMES (page 316), DBF_EXTENT_SIZES (page 317), and (if not sequential)) DBF_ALLOCATION_MODE (page 316) configuration options.

  Append the new values at the end of the existing entries, just before the semicolon (;) delimiter. The new extent/s will be created the next time the Stone starts up.

- You can add extents while the Stone is running by invoking the Smalltalk methods described in this section. These methods are especially useful in avoiding or resolving low disk space conditions, since the change takes effect immediately.

To Add an Extent While the Stone is Running

To prevent the repository from becoming full, you can dynamically add another extent to the Stone configuration. This section describes the Smalltalk methods that allow you to do this.

For general information about multiple extents, see "Configuring the Repository Extents" on page 42.

Possible Effects on Other Sessions

When a new extent is dynamically added to the logical repository through Smalltalk, sessions that are currently logged in must have access to the new extent. The possibility exists that an online session may terminate because it cannot open a new extent, for example, if file permissions do not allow access.

CAUTION

The operating system creates the new extents with the ownership and permissions of the Stone repository monitor process. If these permissions are not the same as for other extents, you should use operating system commands to modify them as soon as possible. Such changes can be made without stopping the Stone.

A session's view of which files make up the logical repository is updated whenever one of the following events occurs:

- Users commit or abort the session.
- The Stone repository monitor hands out disk resources to the session.

An explicit **commit** or **abort** may succeed but then cause the session to be terminated because of the inability to mount new extents immediately after the **commit** or **abort** operation.

Repository>>createExtent:

Privileges required: FileControl.

The Smalltalk method `createExtent:`*extentFilename* creates a new repository extent with the given extent file name (specified as a String). The new extent has no maximum size. The extent must be located on the machine running the Stone process; NFS-mounted disks are only allowed if your stone is configured to allow NFS mounted disks; see STN_ALLOW_NFS_EXTENTS (page 338). For example:

```
topaz 1> run
SystemRepository createExtent: '$GEMSTONE/data/extent2.dbf'
%
```

You can execute this method when other users are logged in.

The Stone creates the new extent file, and it also appends the augmented extent list to your configuration file:

```
#  DBF_EXTENT_NAMES written by Stone (user gsadmin) on 8/12/20
12:56:18 PDT
DBF_EXTENT_NAMES = "$GEMSTONE/data/extent0.dbf",
"$GEMSTONE/data/extent1.dbf",
"!@::1#dbf!/gshost/GemStone3.6/data/extent2.dbf";
```

If the given file already exists, the method returns an error and the specified extent is not added to the repository.

Creating an extent with this method bypasses any setting you may have specified for the DBF_PRE_GROW configuration option at system startup. Because extents created with this method have no maximum size and do not have an entry in a list setting for DBF_PRE_GROW, they cannot be pre-grown. If the repository is using weighted allocation, the new extent will be given a weight equal to the average weight of all other extents. (weighted allocation is discussed on page 46.)

If this method is run from a session on a host remote from the Stone, *extentFilename* must include a Network Resource String (NRS) specifying the Stone host. The syntax is shown above in the excerpt from the augmented configuration file. For information about NRS syntax, see Appendix C.

Repository>>createExtent:withMaxSize:

Privileges required: FileControl.

The Smalltalk method `createExtent:`*extentFilename* `withMaxSize:`*aSmallInteger* creates a new repository extent with the specified *extentFilename* and sets the maximum size of that extent to the specified size. You can execute this method when other users are logged in.

The size must be a non-zero positive integer representing the maximum physical size of the file in MB.

If the specified extent file already exists, this method returns an error and the extent is not added to the logical repository.

If DBF_PRE_GROW is set to True, this method will cause the newly created extent to be pre-grown to the given size. If the pre-grow operation fails, then this method will return an error and the new extent will not be added to the logical repository.

To Remove an Extent

The only way to remove an extent file is by first performing a Smalltalk full backup and restore to move the contents of that extent to other extents.

Privileges required: FileControl.

Reducing the number of existing extents requires special steps to ensure data integrity. If you must remove an extent file, follow this procedure:

Step 1. Back up your repository using the Smalltalk full backup procedure described under “How To Make a Smalltalk Full Backup” on page 219.

You cannot use an online or offline extent backup to remove or shrink extents (obviously).

Step 2. Shut down the Stone repository monitor.

Step 3. Modify the DBF_EXTENT_NAMES configuration option to show the new extent structure.

Step 4. Restore the repository from your Smalltalk full backup. Follow the GemStone restore procedure described under "Restoring from a Full Backup" on page 228.

9.3 Reallocating Existing Objects Among Extents

If you want to reallocate existing objects among two or more extents, the procedure depends in part on whether you are also changing the number of extents. Because changes to the DBF_ALLOCATION_MODE configuration option directly affect only the subsequent allocation of pages for new or modified objects, additional steps are necessary.

To Reallocate Objects Among a Different Number of Extents

If you are increasing or decreasing the number of extents and want to change allocation of existing objects as part of that operation, perform a Smalltalk full backup, then restore the backup after setting appropriate weights for DBF_ALLOCATION_MODE.

For example, suppose your existing repository contains 800 MB and you want to divide them about equally between the existing extent and a new one. To populate each extent with about 400 MB, follow this procedure:

Step 1. Back up your repository, using the Smalltalk full backup procedure described under "How To Make a Smalltalk Full Backup" on page 219. You cannot use an online or offline extent backup to redistribute objects (obviously).

Step 2. Shut down the Stone repository monitor.

Step 3. Modify the DBF_EXTENT_NAMES configuration parameter to show the new extent structure.

```
DBF_EXTENT_NAMES = $GEMSTONE/data/extent0.dbf,
$GEMSTONE/data/extent1.dbf;
```

Step 4. Edit DBF_ALLOCATION_MODE to reflect the intended distribution of pages (see "Allocating Data to Multiple Extents" on page 45). For example:

```
DBF_ALLOCATION_MODE = 10, 10;
```

Step 5. Restore the repository from your Smalltalk full backup, using the procedure described under "Restoring from a Full Backup" on page 228.

If objects in the repository were explicitly clustered using instances of ClusterBucket that explicitly specified the first extent, those objects may tend to migrate back to that extent over time. You can prevent such migration by placing size limits on the existing extent, or by explicitly reclustering those objects in the new extent using a ClusterBucket that specifies either an extentId of nil or the extentId of the new extent. For information about clustering, refer to the *Programming Guide*.

To Reallocate Objects Among the Same Number of Extents

Changes to DBF_ALLOCATION_MODE directly affect only the subsequent allocation of pages for new or modified objects. When you restore into a repository with the same number of extents, the distribution of the original repository will be used in the restored repository, regardless of the DBF_ALLOCATION_MODE.

To change the allocation of existing objects, you can either restore into a repository with a different number of extents (as discussed in the previous section) or you can specify a temporary maximum size on the extent files during the restore, to force objects to be distributed as you want them.

For example, suppose your existing repository has three extents, and that you are running in sequential allocation mode. The first extent has 600 MB, while the second and third extents are 4 MB each (the minimum size). You now want to redistribute the objects so they are spread evenly over all three extents. You cannot simply change the DBF_ALLOCATION_MODE, and restore a backup into three extents; existing objects would be distributed according to the original allocation mode, that is, entirely in the first extent. Only new objects created after the restore would be created evenly over the three extents.

To populate the three extents evenly, you can follow this procedure:

Step 1. Back up your repository, using the Smalltalk full backup procedure described under "How To Make a Smalltalk Full Backup" on page 219.

Step 2. Shut down the Stone repository monitor.

Step 3. Edit the DBF_EXTENT_SIZES configuration option to limit the size of the first extent temporarily to 200 MB. For example:

```
DBF_EXTENT_SIZES = 200MB, , ;
```

Step 4. Edit the DBF_ALLOCATION_MODE configuration option to reflect the intended distribution of pages (see "Allocating Data to Multiple Extents" on page 45). This setting determines the distribution of new or modified objects. For example:

```
DBF_ALLOCATION_MODE = 10, 10, 10;
```

Step 5. Restore the repository from your Smalltalk full backup, using the procedure described under "Restoring from a Full Backup" on page 228.

Step 6. If you want the first extent to grow beyond the temporary limit you set in Step 3, stop the Stone after you restore the repository. Edit the configuration file again, either specifying a higher limit or no limit. For example:

```
DBF_EXTENT_SIZES = , ,  ;
```

If objects in the repository were explicitly clustered using instances of ClusterBucket that explicitly specified the first extent, those objects may tend to migrate back to that extent over time. You can prevent such migration by maintaining the size limit set in Step 3, or by explicitly reclustering those objects in the new extent using a ClusterBucket that specifies either an extentId of nil or the extentId of the new extent. For information, refer to the *Programming Guide*.

9.4 Shrinking the Repository

Privileges required: SystemControl, GarbageCollection, and FileControl.

To shrink the repository to its minimum size, make a Smalltalk full backup. Then take the repository offline and restore the backup into a copy of the GemStone distribution repository. Use the following procedure, which compacts the repository into the minimum set of consecutive pages.

Step 1. Mark your repository for garbage collection, and wait for GemStone to complete the garbage collection and reclaim the space.

For details on how to run `markForCollection` and `reclaimAll`, see Chapter 15, "Managing Repository Growth", starting on page 277.

Details on the `markForCollection` method are under "MarkForCollection" on page 286. Details on reclaim and reclaimAll are under "Reclaim" on page 294.

Step 2. Make a Smalltalk full backup of your repository by sending it the message `fullBackupTo:` or `fullBackupTo:MBytes:`.

For example:

```
topaz 1> run
SystemRepository fullBackupTo: '/users/backups/August_20'.
%
```

This example writes the backup to a single disk file. If you need to write multiple files, see "The fullBackupTo: Methods" on page 220.

Step 3. Take the repository offline:

```
topaz 1> run
System shutDown
%
```

Step 4. Remove the existing repository extents. Obtain a copy of the distribution repository as the first (primary) extent by using the **copydbf** command. For example, assuming that all of your GemStone extents are in `$GEMSTONE/data`:

```
% cd $GEMSTONE/data
% rm extentNames
% copydbf $GEMSTONE/bin/extent0.dbf primaryExtentName
```

Use **`chmod`** to set the extent permission to what you ordinarily use for your repository.

Step 5. To put the repository back online, issue the **startstone** command:

```
% startstone -R gemStoneName
```

If you do not specify *gemStoneName*, **startstone** defaults to `gs64stone`.

Step 6. Log in to linked Topaz again.

NOTE

To perform the remaining parts of this procedure, you must be the only user logged in to GemStone. Logins will be disabled when you start the next step.

Step 7. Restore the repository by using the method `Repository>>restoreFromBackup:`*fileOrDevice*, using the same file or device as in Step 2. Because it is being restored into a copy of the initial repository, the restored

repository will be compressed to the minimum space. This example restores the backup from a single disk file:

```
topaz 1> printit
SystemRepository restoreFromBackup: '/users/backups/August_20'
%
```

If you need to restore multiple files, use the method `Repository>>restoreFromBackups:`*fileOrDeviceArray* instead:

```
topaz 1> printit
SystemRepository restoreFromBackups:
#( '/users/backups/August_20.1'
   '/users/backups/August_20.2' )
%
```

(For more information, see "Restoring from a Full Backup" on page 228.)

GemStone reads the backup(s) and rebuilds the repository in a "shadow" object space that is invisible to users at this time. If the restore succeeds, GemStone commits the restore and returns a summary in the form of a nonfatal error message like the following:

```
Restore from full backup completed with 616227 objects
restored.
```

Each restore operation, on completion, terminates its GemStone session. You will need to log in again before performing the next restore operation.

Step 8. Between the time the full backup was started (Step 2) and the time the repository was shut down (Step 3), there may have been transactions on your repository. To ensure that no work is lost, restore from transaction logs and commit the restore. For example:

```
topaz 1> printit
SystemRepository restoreFromCurrentLogs
%
Restore from transaction log(s) succeeded.
```

Step 9. Commit the restore.

```
topaz> login
<details omitted>
successful login

topaz 1> printit
SystemRepository commitRestore
%
Restore from transaction log(s) succeeded. commitRestore
succeeded
```

9.5 Checking Page Fragmentation

Space within the repository is managed in pages having a fixed size of 16 KB. It is possible for these pages to become *fragmented*—that is, only partially filled with objects. GemStone automatically schedules reclaim of pages with greater than 10% free space as part of its garbage collection activity.

You can inquire about the amount of fragmentation in the repository by executing the following expression.

```
SystemRepository pagesWithPercentFree:aPercentage
```

Typical values of *aPercentage* range from 10 to 25. This method returns an array containing the following statistics:

- The total number of data pages processed
- The sum (in bytes) of free space in all pages
- The page size in bytes; always 16384.
- The number of data pages having at least the specified percentage of free space
- The number of data pages having at least the specified percentage of free space, that contain only a single object
- The total number of pages in the repository that contain only a single object
- The number of pages that should be in the scavengablePages but are not.

`pagesWithPercentFree:` executes using the multi-threaded scan. See "Multi-Threaded Scan" on page 300 for details.

9.6 Disk Space and Commit Record Backlogs

Sessions only update their view of the repository when they commit or abort. The repository must keep a copy of each session's view so long as the session is using it, even if other sessions frequently commit changes and create new views (commit records). Storing the original view and all the intermediate views uses up space in the repository, and can result in the repository running out of space. To avoid this problem, all sessions in a busy system should commit or abort regularly.

For a session that is not in a transaction, if the number of commit records exceeds the value of STN_CR_BACKLOG_THRESHOLD, the Stone repository monitor signals the session to abort by signaling `TransactionBacklog` (also called "sigAbort"). If the session does not abort, the Stone repository monitor terminates it.

Sessions that are in transaction are not subject to losing their view forcibly. Sessions in transaction enable receipt of the signal `TransactionBacklog`, and handle it appropriately, but it is optional. It is important that sessions do not stay in transaction for long periods in busy systems; this can result in the Stone running out of space and shutting down (see "Repository full" on page 198). However, sessions that run in automatic transaction mode are *always* in transaction; as soon as they commit or abort, they begin a new transaction. (For a discussion of automatic and manual transaction modes, see the "Transactions and Concurrency Control" chapter of the *Programming Guide*.)

To avoid running out of disk space, we recommend that you use *manual transaction mode* whenever possible. To enter manual transaction mode:

```
topaz> printit
System transactionMode: #manualBegin
%
```

At the point that this session needs to commit a change, begin a transaction manually, then make the changes:

```
topaz> printit
System beginTransaction .
AllUsers addNewUserWithId: #Jane password: 'gemstone' .
System commitTransaction
%
```

After you commit (or abort) the transaction, your session will return to waiting outside of a transaction.

Handling signals indicating a commit record backlog

Even in manual transaction mode, it is possible to cause a commit record backlog, depending on how your system is configured. Sessions should ensure that they commit or abort regularly, or set up sigAbort handlers to abort when requested by the Stone. A sigAbort handler may be as simple as this:

Example 9.2 sigAbort handler

```
Exception
   installStaticException:
   [ :exception :GSdictionary :errID :array |
      System abortTransaction.
      System enableSignaledAbortError).
```

Note that a session that is entirely idle does not become aware of the signal to abort, and may timeout and be terminated by the stone in spite of the handler. If your application may have idle sessions, we recommend setting up a timer that causes regular aborts when the session is otherwise idle.

Sessions that are in transaction, and therefore immune from the sigAbort mechanism, may also be signaled when there is a commit record backlog. When the number of commit records exceeds the value of STN_CR_BACKLOG_THRESHOLD, and the session holding the oldest commit record is in transaction, the Stone repository monitor signals the session by sending `TransactionBacklog`. The session then has the opportunity to perform a continueTransaction to update its view of unmodified objects. It may also commit or abort. Unlike sigAbort, the session can choose to ignore this message and will not receive further signals from the stone.

Example 9.3 finishTransaction handler

```
Exception
   installStaticException:
   [ :exception :GSdictionary :errID :array |
      System continueTransaction.
      System enableSignaledFinishTransactionError).
```

For more information on these signals, see the *Programming Guide for GemStone/S 64 Bit*.

9.7 Recovering from Disk-Full Conditions

The Stone repository monitor has two critical needs for disk space. It must be able to:

- Append to the transaction log as sessions commit changes.
- Expand the repository as necessary to allocate free pages to current sessions or to sessions logging in.

Whenever the Stone cannot log transactions or cannot find sufficient free space in the repository, it issues an error message to any session logged in as DataCurator or SystemUser. If users report that GemStone appears to be hung or that they get a disk-full error while logging in, you should check one of these administrative logins for such a message. The message is also written to the Stone's log file.

The following topics explain the Stone's actions in greater detail and describe steps you can take to provide sufficient space.

For details on how tranlog full conditions are handled, see "Recovering from Disk-Full Conditions" on page 198.

Repository full

The Stone takes a number of actions to prevent the repository from becoming completely full. If the free space remaining in the repository falls below the level set by the STN_FREE_SPACE_THRESHOLD configuration option and the Stone cannot allocate more space in any extent, it takes the following actions to prevent a system crash:

1. It becomes more aggressive about disposing of commit records so that garbage collection can proceed. (If the Stone is very busy, a backlog of commit records can accumulate.)
2. It starts a checkpoint if there isn't one in progress and reduces the checkpoint interval to three minutes until the condition clears. (This checkpoint may free pages that have been reclaimed.)
3. It writes a message to the Stone log to indicate the condition.
4. It prevents new logins except for DataCurator and SystemUser accounts. It issues a disk-full error to other sessions attempting to log in.
5. It signals the Exception RepositoryError to any sessions logged in (or logging in) as DataCurator or SystemUser so that they know disk space is becoming critical.

6. It signals Gem session processes to return all except five free pages per extent. It responds to requests for additional pages by allocating only five pages at a time.
7. If the free space available drops below 400 KB (50 pages), the Stone stops responding to page requests from sessions that are not logged in as DataCurator or SystemUser. This action prevents users from acquiring all of the available space, which would cause the system to crash. Gem session processes appear to "hang" while they are waiting for pages. The unhonored page requests are granted when the free space goes back above the threshold.
8. If the previous steps do not solve the problem within the time specified by the STN_DISKFULL_TERMINATION_INTERVAL configuration option, then the Stone begins to terminate sessions holding on to the oldest commit record *even if the session is in a transaction*. This action applies to any user session, including logins as SystemUser and DataCurator. Allowing the Stone to dispose of the commit record allows additional garbage collection.

   NOTE

   You can configure the Stone to never terminate sessions by setting STN_DISKFULL_TERMINATION_INTERVAL *to 0; however, doing so increases the risk of GemStone shutting down because of a lack of free space in the repository.*

9. When the condition clears, another message is written to the Stone log and operation returns to normal.

If you see a message like the following while logged in as DataCurator or SystemUser or in the Stone log, disk space is becoming critical:

```
The repository is currently running below the freeSpaceThreshold.
```

When the system must dynamically expand the repository, it checks one extent at a time, in the order dictated by the allocation strategy, to see if that extent can be expanded to create more space. When no extents can be extended and the free space is below STN_FREE_SPACE_THRESHOLD, the Stone takes the actions described above.

Failure to expand an extent has two possible causes: either the disk containing the extent is full, or the extent has reached its maximum size as set by the DBF_EXTENT_SIZES configuration option.

There are a number of things you can do to create more space in an existing extent, or you can create a new extent. Each of these actions may create sufficient additional space for immediate needs:

- Warn the current users about the problem, and have them log out until enough space is made available.
- Remove any non-essential files to create enough space for expanding the repository.
- Create a new extent through Smalltalk with `Repository>>createExtent:` or a related method. If the Stone has stopped, you can create a new extent by editing the parameters in the configuration file before restarting it. See "Adding and Removing Extents" on page 189.

Keyfile limits reached

Some GemStone licencing terms place a limit on the maximum size of a repository, which is limited by the keyfile. When a repository with a keyfile limit on repository size reaches that size limit, the Stone will shut down due to out of space. However, with a licence limit, is not possible to simply add extents or disk space to allow GemStone to restart. You must contact GemTalk Technical Support for a temporary keyfile with an increased limit, so you can restart GemStone and take whatever steps are necessary to make space available.

If the keyfile has a size limit, it is important to avoid your repository's size reaching the licence limit. It is strongly recommended that you do not set a repository size (in which case the limit will be computed as 80% of the licence limit), or if you do, set the limit to 80% of your keyfile limit.

Recovering from Out of disk space with keyfile repository size limit

If you have a keyfile with a repository size limit, but your repository size is limited to less than the keyfile limit, the following steps will recover and restore your repository to the previous state.

Step 1. Edit the configuration file used by the Stone to set the DBF_EXTENT_SIZES to the license limit.

Step 2. Restart the Stone. Perform a `markForCollection` and `reclaimAll`.

Step 3. Ensure your repository size has returned to the appropriate range. If your shutdown was due to a commit record backlog or excessive dead or shadow objects, the restart and garbage collection may be sufficient. Otherwise, archive and delete unnecessary objects.

To ensure that you can continue to run with a repository size limit that is 80% of your keyfile limit, you will need to make the extents smaller.

Step 4. Make a programmatic full backup of your repository.

Step 5. Shut down the Stone.

Step 6. Edit the configuration file used by the Stone to remove the setting for DBF_EXTENT_SIZES, or to set it to 80% of the license limit.

Step 7. Start the Stone on a clean, empty extent, and restore the fullBackup you made in Step 4.

These steps are summary; for more details on garbage collection, see Chapter 15, and for making and restoring backups, see Chapter 11.

Chapter

10 Managing Transaction Logs

Transaction logs hold records of changes to the repository, which allow you to recover any changes made between backups. This chapter describes how to manage these transaction logs.

Overview (page 201)
explains transaction logs, how to configure them, and how to use them when restoring from backup.

How To Manage Full Logging (page 207)
describes transaction log management when transaction logs are configured for full logging.

How To Manage Partial Logging (page 210)
describes transaction log management when transaction logs are configured for partial logging.

How To Recover from Tranlog-Full Conditions (page 211)
describes how the system responds when there is no disk space for transaction logs, and what to do in these circumstances.

10.1 Overview

A transaction log contains the information necessary to redo transactions to the repository that have been committed by GemStone sessions since the last checkpoint or orderly shutdown. This log is used to recover from crashes such as those caused by a power failure, an operating system failure, or the killing of GemStone monitor processes.

If you need to restore the repository from a backup, transaction logs written in full-logging mode can be used to recreate all transactions committed since the most recent backup was written.

The transaction log is implemented as a sequence of files having names of the form `tranlog1.dbf` ... `tranlogNNN.dbf`. The numeric `fileId` starts at 1 when the Stone starts with a copy of the initial repository extent (`$GEMSTONE/bin/extent0.dbf`). If the

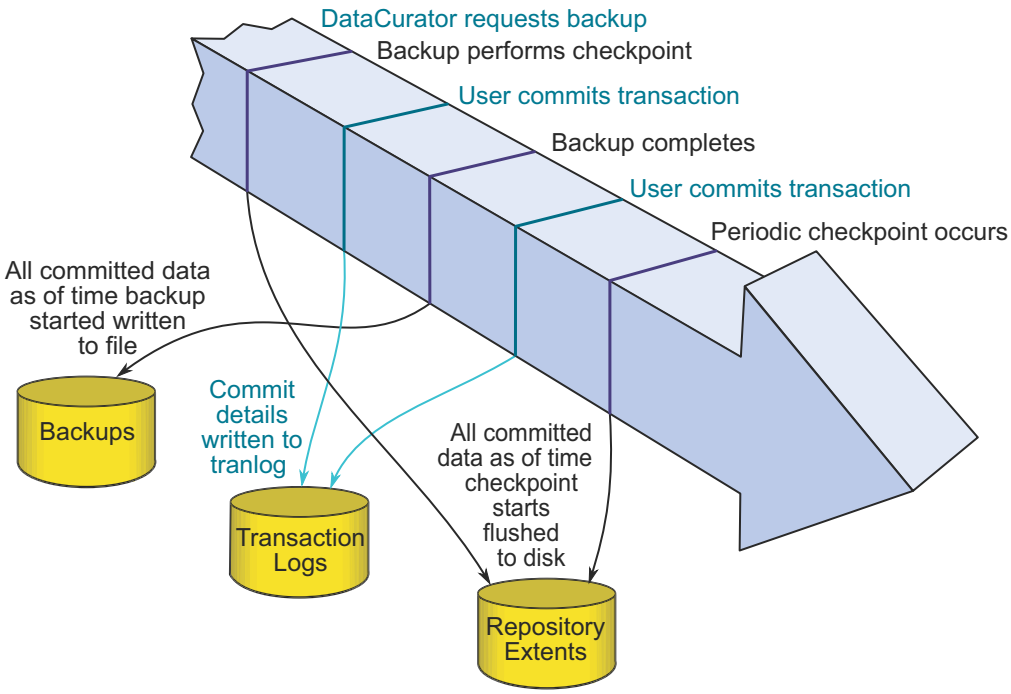
Stone starts on an existing repository without any logs present, the `fileId` will be one greater than when the repository was last shut down cleanly.

The filename prefix, by default "tranlog", can be controlled by setting the STN_TRAN_LOG_PREFIX configuration option.

The transaction logs are written to a list of directories or raw partitions specified by the STN_TRAN_LOG_DIRECTORIES configuration option, which is treated as a circular list. Each log is limited to the size set for that directory or raw partition by the STN_TRAN_LOG_SIZES configuration parameter. When one log is full, logging switches to the next directory or raw partition. (What happens when logs have been created in all directories is discussed in Table 10.1 on page 203) Collectively, the transaction log files logically form an extremely large sequential file with a maximum size of 4×10^6 GB.

As users commit changes to the repository, GemStone writes the changes to a transaction log. Periodically, the stone repository monitor performs a checkpoint, at which point all committed changes are guaranteed to be written to the extents. During the periods between checkpoints, the transaction logs hold the record of the changes, so they are available if an unexpected shutdown occurs.

Figure 10.1 Normal Operation



Use ordinary UNIX utilities to backup the transaction logs in the file system. To backup a transaction log that is on a raw disk partition, use **copydbf** to copy it to a file system. You'll also need to use **removedbf** to clear the partition for reuse.

Tranlogs with Encrypted Extents

Transaction logs written by a Stone that is using encrypted extents are written in encrypted form, using the same keypair as the extents. When the Stone is started, if recovery is needed, it will be able to read the transaction logs for recovery, since they were encrypted using the same key as was used to start the Stone. However, extra care must be taken when changing the encryption key for the Stone.

If the encryption key of the extents have changed, on startup after a clean shutdown, the Stone will start a new transaction log that is automatically encrypted with the new key. In this case, you must keep the older keypairs, or modify the older tranlogs to use the new encryption key, if you want to be able to restore these older tranlogs into an older backup.

Logging Modes

GemStone provides two modes of transaction logging, selected by setting the STN_TRAN_FULL_LOGGING configuration option:

- To provide real-time incremental backup of the repository, set STN_TRAN_FULL_LOGGING to True. All transactions are logged regardless of their size. This mode is strongly recommended for deployed GemStone systems.
- To allow a simple operation without critical data to run unattended for an extended period, set STN_TRAN_FULL_LOGGING to False. This mode, known as *partial* logging, provides automatic recovery from system crashes that do not corrupt the repository, such as fatal errors or loss of power. However, if you do experience extent corruption and need to restore from backup, you cannot recover any changes made after the backup was taken.

Table 10.1 compares full and partial transaction logging.

Table 10.1 Comparison of Full and Partial Transaction Logging

Characteristic	Full Logging STN_TRAN_FULL_LOGGING =TRUE	Partial Logging STN_TRAN_FULL_LOGGING =FALSE
Type of transaction logged	All transactions	Only those transactions smaller than STN_TRAN_LOG_LIMIT; successful commits of larger transactions cause an immediate checkpoint
Recovery from system crash (extents are OK)	Yes, automatic recovery during restart using checkpoint and log	Yes, automatic recovery during restart using checkpoint and log
Replay of transactions since last backup (as after media failure)	Yes—can carry forward GemStone backup by recreating subsequently committed transactions	No—cannot replay transactions since the backup

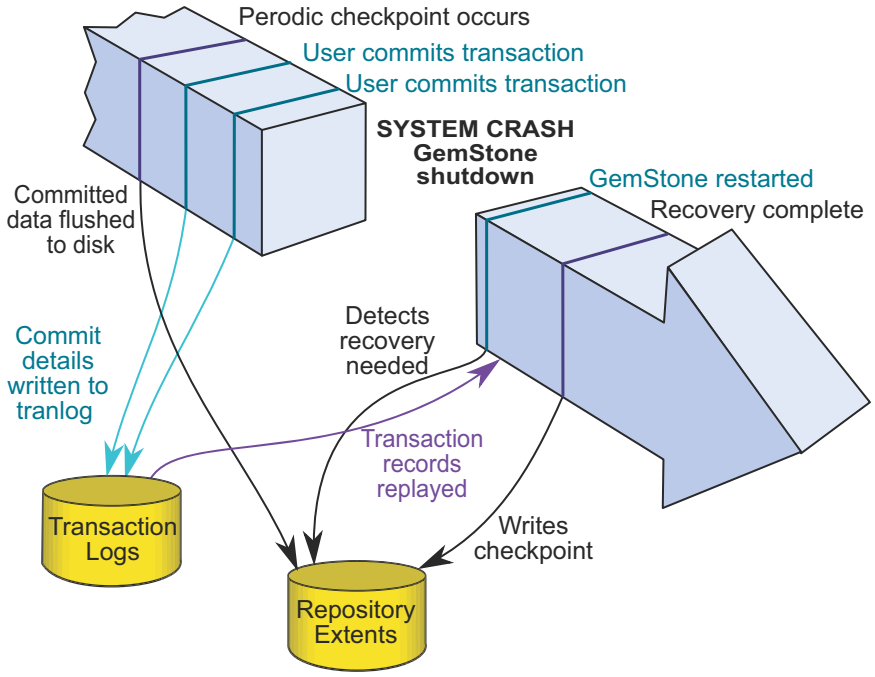
Table 10.1 Comparison of Full and Partial Transaction Logging

Characteristic	Full Logging STN_TRAN_FULL_LOGGING =TRUE	Partial Logging STN_TRAN_FULL_LOGGING =FALSE
Action when current log is full	Logging moves to the next directory or to the head of the list. If a file system directory, the Stone opens a new log file, and retains existing transaction logs. If a raw partition, a new log can be opened only if the previous one has been removed. There is no limit on the number of file system logs in the directory, but the number of raw partition logs is limited to the number of partitions listed in STN_TRAN_LOG_DIRECTORIES.	Logging moves to the next directory or to the head of the list. The Stone removes the existing transaction log before opening a new one. The maximum number of logs on line at one time depends on the number of directories or raw partitions in the list.
Action when log space becomes full	The Stone pauses execution if it cannot find space in any of the specified directories or raw partitions.	The Stone deletes log files from the circular list of directories and keeps running.
Administrative task	Monitor log space; archive log files and delete them as necessary	None

In the event of a system crash, GemStone can recover by automatically replaying transactions recorded in the transaction log, from the latest checkpoint before the crash to the end of the log at the moment of the crash (Figure 10.2). This allows you to restart from where you were at the time of the crash.

No special administrative action is required to perform this recovery. Every time the system does a normal startup, it checks to see if there are transactions that need to be recovered. Thus, if the extents and transaction logs are good, the system will automatically recover from a crash.

Figure 10.2 System Crash



Restoring Transactions to a Restored Backup

An important use of transaction logs is to restore transactions that were committed between the last full backup and a system failure. If you experience system failure and your current extents are no longer usable, you can still recover all data, provided that the repository already is in full transaction logging mode and that the backup was made in that mode.

For details on restoring transactions to a backup, see “How to Restore Transaction Logs” on page 237.

How the Logs Are Used

You can only use transaction logs to restore your system from backup if you are in full logging mode.

After creating a backup, you need to retain all the transaction logs that are created during and after the backup. To determine the oldest transaction log that will be required, use the `copydbf` utility to query the backup file. For example:

Example 10.1 Determining the oldest tranlog needed for restore

For a programmatic full backup

```
unix> copydbf -i backup.dat
File type: backup  fileId: 0 in a backup set with 1 files
   File size: 25952256 bytes (24 MB), 198 records
   ByteOrder: Intel (LSB first)  compatibilityLevel: 860
   The file was created at: 08/26/20 18:16:35 PDT
   Full backup started from checkpoint at: 08/26/20 18:16:35 PDT
   Oldest tranlog needed for restore is fileId 4 ( tranlog4.dbf )
   Backup was created by GemStone Version: 3.6.0, Tue Aug 25
14:14:38 2020 15f18029e261daf4
   Backup Attributes:
         Compression: NONE
          Encryption: NONE
      Signature Hash: NONE
     Encryption Keys: 0
```

For an extent copy backup

```
unix> copydbf -i extent0.dbf
Source file: /gshost/GemStone3.6/data/extent0.dbf
   File type: extent  fileId: 0 in a repository with 1 files
   File size: 83886080 bytes (80 MB), 5120 records
   ByteOrder: Intel (LSB first)  compatibilityLevel: 844
   Last checkpoint written at: 2020-08-26-12:01:59.591.
   Oldest tranlog needed for recovery/restore is fileId 4 (
tranlog4.dbf ).
   Extent was shutdown cleanly; no recovery needed.
   GemStone Version: 3.6.0, Tue Aug 25 14:14:38 2020
15f18029e261daf4
   Encryption: NONE
```

For this example, tranlog4.dbf and later must be available. If any of these transaction logs are deleted or lost, you will not be able to recover completely. These transaction logs may be archived elsewhere, as long as they can be readily be made available if you do need to restore from backup. If the tranlogs are encrypted as when using encrypted extents, and the Stone's encryption key changes, you must also keep the old encryption keys for the tranlogs, or update the encryption key in the old tranlogs.

If you do need to restore your system, first restore from backup using the using the appropriate procedure, then replay transactions committed since the backup by reading the transaction logs in the order in which they were created.

For detailed procedures on restoring from backup and replaying transaction logs, see the instructions in Chapter 11, "Making and Restoring Backups", starting on page 213

NOTE

Restoring a repository from backup resets it - both the GemStone kernel and your application classes and data - to the state it was in at the time the backup was created. Anything that was done after that can be recovered only by replaying transaction logs in order, or by restoring a more recent backup.

10.2 How To Manage Full Logging

When the system is operating with the STN_TRAN_FULL_LOGGING configuration option set to True, you (as system administrator) should monitor the available log space. If the log space defined by STN_TRAN_LOG_DIRECTORIES becomes full, users will be unable to commit transactions to the repository until space is made available.

For transaction logs in file system directories, "full" means that there is no free space in the file systems containing those directories.

For transaction logs in raw partitions, "full" means that all partitions listed already contain a GemStone transaction log or other repository file. After archiving an existing log, you must invoke **removedbf** (page 384) before that partition can be reused.

There are two recovery situations to consider in managing transaction logs under full logging:

- Recovery from a system crash requires logs for all transactions committed since the last *checkpoint*. Because of the way GemStone logs changes involving large objects, parts of these transactions may be in earlier logs. The method `Repository>>oldestLogFileIdForRecovery` returns the fileId of the oldest log that would be needed if a crash were to occur at that point. All logs needed for crash recovery should be kept online.
- Recovery from damaged extents, such as a media failure, requires all transaction logs since the last *backup*, and earlier logs may be needed if lengthy transactions were in progress at the time the backup started. Log files not needed for crash recovery may be archived offline, although restoring them will take longer.

To Archive Logs

Ordinary UNIX tools, such as **tar** and **cp**, can be used to move log files to other locations or to archival media. We recommend that you archive and free one complete log directory at a time, in the order listed in the STN_TRAN_LOG_DIRECTORIES configuration option.

Two special commands are provided for working with raw disk partitions:

- The **copydbf** command copies a repository file (extent, transaction log, or full backup) to or from a raw disk partition.
- The **removedbf** command writes over a raw partition so that GemStone will no longer think it contains a repository file.

To determine the current size of a transaction log that is in a raw partition, use the method `Repository>>currentTranlogSizeMB`. This method returns the log size (in MB) as an Integer.

To determine the oldest transaction log that would be needed to recover from the most recent checkpoint, use the method `Repository>>oldestLogFileIdForRecovery`. This method returns the internal fileId, which is part of the filename for transaction logs in the file system. If a session was in a lengthy transaction at the time of a system crash, the oldest log needed during recovery may be one that was written before the last checkpoint occurred.

You can obtain similar information by applying **copydbf -i** to an extent, as shown in the examples on page 206.

For an example script showing how to archive transaction logs out of raw partitions, see `$GEMSTONE/examples/archivelog.sh`. You will need to edit the script to conform to your own partition names and archive location, and then test it.

To Add a Log at Run Time

Privileges required: FileControl.

You can add a directory or a raw partition for transaction logs to the existing list without shutting down the Stone repository monitor. When you do this, the repository monitor also records the change in its configuration file so that the addition becomes permanent. Send the following message:

`SystemRepository addTransactionLog:` *deviceOrDirectory* `size:` *aSize*

For example:

```
topaz 1> printit
SystemRepository addTransactionLog: '/users/tlogs2' size: 100
%
```

The argument *aSize* sets the maximum log size (in MB) for *deviceOrDirectory*. It will be added to the list in STN_TRAN_LOG_SIZES (page 358).

You can use the method `System class>>stoneConfigurationAt:` to examine the contents of STN_TRAN_LOG_DIRECTORIES at run time. For information, see "How To Access the Server Configuration at Run Time" on page 53. The Repository methods in Table 10.2 return other information that is helpful in managing transaction logs.

Table 10.2 Repository Methods for Information About Transaction Logs

Method	Description
`currentLogDirectoryId`	Returns a positive SmallInteger, which is the one-based offset of the current log file into the list of log directory names.
`currentLogFile`	Returns a String containing the name of the transaction log file to which records currently are being appended.
`currentTranlogSizeMB`	Returns an Integer that is the size (in MB) of the currently active transaction log.
`allTranlogDirectories`	Returns an Array of Strings corresponding to the STN_TRAN_LOG_DIRECTORIES configuration.
`allTranlogSizes`	Returns an Array of SmallIntegers corresponding to the STN_TRAN_LOG_SIZES configuration.
`logOriginTime`	Returns the log origin time of the receiver, the time when a new sequence of log files was started. For details, see the method comment in the image.

Table 10.2 Repository Methods for Information About Transaction Logs

Method	Description
`oldestLogFileIdForRecovery`	Returns a positive SmallInteger, which is the internal fileId of the oldest transaction log needed to recover from the most recent checkpoint, if the Stone were to crash as of now.
`restoreStatusOldestFileId`	Returns a SmallInteger, which is the internal fileId of the oldest transaction log needed for the next restore from log operation.

To Force a New Transaction Log

Privileges required: FileControl.

You can force closure of the current log and opening of a new log at almost any time by using the method `Repository>>startNewLog`. The method performs the following sequential actions:

1. Starts a checkpoint.
2. Waits until the checkpoint completes.
3. Starts the new log.
4. Returns a SmallInteger, which is the `fileId` of the new log.

In the following example, the new transaction log file would be `tranlog9.dbf`.

```
topaz 1> printit
SystemRepository startNewLog
%
9
```

If a checkpoint is already in progress when you execute `startNewLog`, the method will fail and return –1 instead. If you're using this method in an application, therefore, you need to accommodate the possibility of such a failure with code such as:

```
| id  |
id := SystemRepository startNewLog.
[ id < 0 ] whileTrue: [
  System sleep: 1.
  id := SystemRepository startNewLog ].
```

To Initiate a Checkpoint

Privileges required: SystemControl.

System class provides two methods that you can use to start checkpoints manually. These methods do not commit, abort, or otherwise modify the current transaction.

`startCheckpointSync`

Starts a new checkpoint and returns when the new checkpoint has completed. If a checkpoint is already in progress, this method waits until the current checkpoint completes, then starts a new checkpoint. Returns true if a new checkpoint was successfully completed, returns false if a new checkpoint could not be started because transaction logs are full or checkpoints are suspended.

`startCheckpointAsync`

Starts a new checkpoint if a checkpoint is not already in progress and returns immediately, without waiting for the checkpoint to finish. Returns true if a checkpoint is in progress or was started; returns false if a checkpoint could not be started because transaction logs are full or checkpoints are suspended.

To Change to Partial Logging

Once the full transaction logging has been started on a repository, the STN_TRAN_FULL_LOGGING state of True persists regardless of later changes to the configuration file.

To terminate full logging, the procedure is:

Step 1. Make a Smalltalk full backup (not an extent snapshot), following the instructions under "How To Make a Smalltalk Full Backup" on page 219.

Step 2. Edit the configuration file to set the STN_TRAN_FULL_LOGGING option to False.

Step 3. Stop the Stone repository monitor, and restore the backup following the instructions under "Restoring from a Full Backup" on page 228. Be sure to restore into a copy of the empty distribution extent (`$GEMSTONE/bin/extent0.dbf`).

Step 4. Restart GemStone.

10.3 How To Manage Partial Logging

Partial logging provides ease of administration along with some protection against loss of data from system crashes. The Stone repository monitor treats the log directories as a circular list. If the file in the current directory reaches the limit set by STN_TRAN_LOG_SIZES, the Stone switches to the next directory in the list that does not contain a transaction log. In the process of creating log *n*, the Stone attempts to find and delete log (*n* – size_of_STN_TRAN_LOG_DIRECTORIES); for example, if the new log will be `tranlog7.dbf` and there are three elements in STN_TRAN_LOG_DIRECTORIES, the Stone searches all three in attempting to delete `tranlog4.dbf`.

If there is only one directory specified in by the STN_TRAN_LOG_DIRECTORIES, then the stone deletes the log file in this directory before starting a new log. This means that badly-timed crashes may not be recoverable. You should ensure that there are two directories specified and that there is sufficient disk space for at least two log files, so that one can be preserved when the next is opened.

To Change to Full Logging

To change a repository from partial to full logging, simply change the STN_TRAN_FULL_LOGGING (page 357) setting to True and restart the Stone repository monitor.

Be sure to make a new GemStone full backup in full-logging mode so that you will be able to restore from the transaction logs if necessary. Transaction logs cannot be restored to backups that were made in partial-logging mode.

10.4 How To Recover from Tranlog-Full Conditions

Transaction Log Space Full

If the space for transaction logs becomes full, the Stone stops processing commits or other requests that initiate a write to the transaction log. Sessions performing these operations are blocked until the condition is resolved and may appear to the user to be hung. The Stone writes a message like the following in its log:

```
The tranlog directories are full and the stone process is waiting
for an operator to make more space available by either cleaning up
the existing files (copying them to archive media and deleting
them) or by adding a new tranlog directory.
```

Also, the Exception `RepositoryError` is signaled in any sessions that have enabled receipt of this error by sending `System enableSignalTranlogsFull`, and setting up a handler for this error.

Once enabled, you can disable receipt of this error by sending `System disableSignalTranlogsFull`, and determine the current status by `System signalTranlogsFullStatus`.

If the transaction log space is full, you have the following options:

- You can free space by taking some existing log files offline. Archive them using operating system utilities and then remove them. GemStone can reuse that slot in the circular list of log directories. (To archive and remove a log file from a raw partition, use **copydbf** and then **removedbf**.)
- You can increase the available log space by adding a raw partition or a directory on another disk drive to this list specified for the configuration option STN_TRAN_LOG_DIRECTORIES. Add its maximum file size to STN_TRAN_LOG_SIZES. For information on how to make these changes while GemStone is running, see "To Add a Log at Run Time" on page 208.

When transaction log space becomes available, waiting sessions can complete operations that were blocked.

Chapter

11 Making and Restoring Backups

This chapter describes how to make backups of your GemStone/S 64 Bit repository and how to use the backups and transaction logs to restore the repository.

Overview (page 213)
explains the importance of backups.

Types of Backups (page 215)
describes the different types of backups, and how to choose a backup strategy.

How To Make an Extent Snapshot Backup (page 217) and **How To Make a Smalltalk Full Backup** (page 219)
describe the processes for making backups.

How to Restore from Backup (page 224) and **How to Restore Transaction Logs** (page 237)
describe how to restore a backup and any subsequent transaction logs, to reproduce a complete repository state.

How to Make and Restore a Secure Backup (page 231)
describes the process of making a digitally signed and optionally encrypted backup.

Special Cases and Errors in Restore (page 239)
provides additional information for special cases of restore.

11.1 Overview

To safeguard your repository, you should create a backup of your GemStone repository periodically, and store the backup in a safe place. Backups provide security in case of problem with power, operating system, disks, or other system corruption, and if used in combination with transaction logs, preserve all committed data against loss.

Making a backup of the GemStone repository captures the state of the system at a particular moment in time, and restoring that backup can return your system to the state it was in at the time the backup started. A GemStone backup is a backup of not only your application data, but also your application code and GemStone kernel code, and of user profiles and passwords and so on - everything in the repository. Because the backup

includes kernel code, backups can only be restored into the same version of GemStone as that in which the backup was created; otherwise the kernel classes and methods may not be appropriate for that version.

Between these periodic backups, transaction logs capture all committed changes that occur in the repository (provided the repository is in full logging mode). By preserving the backup and a set of transaction logs, you have the ability to recreate the system up to the last committed change in the transaction logs.

In partial tranlog mode, the transaction logs cannot be applied after restoring a backup. In this case, the transaction logs are useful when recovering from transient problems such as unexpected shutdown, but restoring a backup can only restore the system to the state it was in at the time of the backup. Later transaction logs in partial logging mode cannot be applied to recover work done after the time of the backup.

You should establish a regular backup process and schedule that fits your application requirements, and a system of managing and archiving the backup files and transaction logs that will allow you to recover smoothly after any problems.

In addition to regular backups, to ensure protection from disk failure, we recommend that you either use mirrored disks or operating system mirroring. For more information, see "Developing a Failover Strategy" on page 35.

Warm and Hot Standbys

GemStone's backup and restore mechanisms can be used to set up a secondary server, running in parallel with the primary server and ready to take over as quickly as possible in case of any failure of the primary system.

To do this, a backup of the primary server is restored into a separate location. This backup stays running in restore mode, and as transactions are generated on the primary server, they are restored into the standby system. In case of failure of the primary system, the standby can be quickly ready to use and in a state identical to the failed system.

For details on how to set up a warm or hot standby system, see Chapter 13, "Warm and Hot Standbys", starting on page 257.

Version Compatibility

It is not always possible to restore backups made by a previous version of GemStone into a new version. Since kernel classes and methods are also included in the full backup, restoring an older version will result in GemStone Smalltalk code that is not correct for the GemStone version.

If you archive backups of your GemStone repository over multiple upgrades of your GemStone installation, you should also archive the GemStone executables for each version.

While not supported, in cases where it is possible to restore the backup from an older version into a more recent version, you should follow the upgrade instructions in the *Installation Guide* to run `upgradeImage`, to ensure kernel code is updated.

11.2 Types of Backups

GemStone supports several types of backup:

- Offline extent snapshot backups
- Online extent snapshot backups
- Smalltalk full backups (programmatic backups)
- Smalltalk secure full backups

Extent snapshot backups consist of operating system copies of the extent files.

When the repository is offline, and was cleanly shut down, the extent files can be copied using regular OS copy functions with no further considerations.

To make extent file copies of a repository that is in use (online), checkpoints must be suspended for the duration of the extent copy. The extents are updated during checkpoints, so if a checkpoint occurs during extent file copy, it is likely the backup files will be corrupted and unusable.

Smalltalk full and secure backups are made by executing backup methods in GemStone code. These can only be created when the system is running. Executing the backup methods will cause all live objects in the repository as of the time the backup method execution began to be written out to one or more operating system files. Dead objects, and internal structures such as the object table, are not written out, so these files typically are somewhat smaller than the repository extent size (excluding free space in extents).

Determining which type of backup to make depends on the size of your repository and the uptime requirements.

- **Offline extent backups** are the most simple, since nothing is needed beyond clean shutdown and file copy. However, since these must be taken when the repository is shut down, they are not suitable for systems that must be available 24x7.
- **Online extent snapshots** require the most effort to setup, since checkpoints must be suspended for the entire duration of the file copy. Since file copy is limited only by throughput of the physical disks, for large repositories that are in heavy use 24x7, online extent backups should have the least impact on availability and performance compared to other backups. They may also be faster to restore than full backups.
- **Full backups** are convenient to run in highly-available systems that are not shut down regularly. However, backup execution places load on the system, and should be avoided during periods of heavy system use. Restore from full backup will also take longer than offline or online extent backups.

  Backups made using fullBackup methods have other uses; restoring these backup files can be used to change the number of extents, redistribute objects among extents, or reduce the size of extent files, and with the availability of transaction logs, can be restored to allow full or partial recovery from some kinds of corruption. Full backups can be written directly in compressed form, for the most efficient storage of the resulting backups.
- **Secure backups** include both digitally signed backups, and backups that are encrypted as well as signed. Different methods are used to create and restore these backups, but otherwise they are similar to full backups.

Secure backups are useful when you want to verify that a backup has not been modified, to archive backups to a non-secure location, and to distribute backups privately to multiple destinations without having to share private keys.

Full vs. Partial Transaction logging

As described under "Logging Modes" on page 203, your repository may be run in partial transaction logging mode, or in full transaction logging mode.

In partial transaction logging mode, you cannot make online extent backups, since checkpoints cannot be suspended while you are this mode.

While in partially logging mode, you can make Smalltalk full backups, or offline extent copy backups, you cannot restore transaction logs into these backups. If you need to restore from backup, any work done after the start of the backup is permanently lost. For repositories with valuable data, we strongly recommend that you run in full logging mode to avoid data loss in case of extent corruption.

Verify Backup Process

Creating a backup and archiving transaction logs is only useful if you can restore them successfully in case of a system failure. To make sure that your procedures for archiving and restoring backups is complete and correct, it is good practice to periodically perform the restore operation into a non-production system, replay tranlogs, and audit the restored repository. Instructions for auditing can be found Audit information are under "Repository Page and Object Audit" on page 134.

Performing this exercise ensures that if you do have an emergency situation, you will have the required files available and be familiar with the process of restore, and avoid the risk of losing data.

Backups with Encrypted Extents

Making a backup in a repository configured with secure extents is no different than making a backup with ordinary extents. From a repository configured with encrypted extents, you may make:

- Online or offline extent snapshot backups, which remain encrypted with the same keys as the working system extents.
- Ordinary programmatic backups, which are not encrypted. An ordinary backup from a repository using encrypted extents is **not** automatically encrypted.
- Secure programmatic backups, which are signed and may either be encrypted or not encrypted. Encryption keys are provided as argument to the secure backup methods, so the backup may be encrypted using the same keypair as the working system's extents, or an entirely different keypair.

While restoring a programmatic fullbackup or a extent snapshot back into a repository with extent encryption is not substantially different from restoring into a repository with regular unencrypted extents, if the encryption keypairs that are used to encrypt the extents has changed, this will impact restoring transaction logs.

11.3 How To Make an Extent Snapshot Backup

Extent snapshot backups are file system copies of the repository extents. These copies can be made when the repository is not running (offline); or when the repository is running (online), provided you suspend checkpoints for the duration of the extent file copy.

WARNING

File system copies of the extents of a running GemStone repository that are taken during a period that includes a checkpoint will have inconsistent state, and not be usable for restore.

Offline Extent Snapshot Backup (Repository is shutdown)

When the repository is shut down, you can safely perform a file system backup of the extents files. During the shutdown process, a checkpoint is performed in which all committed transactions are written to the extents. A copy of the extents after an orderly shutdown constitutes a complete operating system backup of the repository without requiring any transaction logs.

If GemStone was not shut down cleanly, file system copies of the extents are usable, but they will not include any transactions committed since the last completed checkpoint before the shutdown. In order to recover later work, you will also need one or more transaction logs. This applies for both partial logging and full logging.

copydbf -i will report if the extents were cleanly shutdown and the oldest tranlog required for recovery if the extents were not cleanly shutdown.

Online Extent Snapshot Backup (Repository is running)

When the repository is running, you must suspend checkpoints before starting the extent file copy, and resume checkpoints when the file copy is complete.

You should not attempt to take online extent snapshot backups when the repository is in partial logging mode (STN_TRAN_FULL_LOGGING = FALSE), since checkpoints cannot be suspended in partial logging mode.

Extent copies that are made while the repository is running, by definition, represent a repository that has not been cleanly shutdown. On startup, the stone will normally automatically recover the current and subsequent transaction logs. This constrains the location of transaction logs during a restore.

Three steps are involved in an online extent backup

1. Suspend checkpoints.

   Checkpoints are not permitted while the extent file are being copied for the online backup. There must not be a checkpoint in progress when the first extent file copy starts, and no checkpoints are allowed to begin until the last extent file copy has completed. All other database operations (including commits, aborts, and the creation of new tranlogs) are permitted during the online extent snapshot backup.

   To suspend checkpoints for a specified number of minutes, call `System class >> suspendCheckpointsForMinutes:`. If this method is called while a checkpoint is already in progress, it will block until the current checkpoint completes. On some systems under heavy load, checkpoints may take some time to complete; the period in which checkpoints are suspended does not begin until the previous checkpoint is complete.

If one session attempts to suspend checkpoints and is blocked while the current checkpoint completes, and then a second session attempts to suspend checkpoints, the second session fails and the method returns false.

If the system is shut down while checkpoints are suspended, checkpoints will be re-enabled and a final checkpoint will be written during the clean shutdown process. Any extent snapshot backups in progress during system shutdown must be discarded.

To query the current status of checkpoints, call `System class >> checkpointStatus`. This method returns an Array object containing a Boolean that indicates whether checkpoints are suspended, and an Integer giving the number of seconds remaining in the suspension.

Example 11.1 Suspending Checkpoints

```
topaz 1> printit
System checkpointStatus
%
an Array
  #1 false
  #2 0

topaz 1> printit
System suspendCheckpointsForMinutes: 15
%
true

topaz 1> printit
System checkpointStatus
%
an Array
  #1 true
  #2 900
```

We recommend using a value of *minutes* that is much larger than any possible anticipated time, taking into consideration the amount of time backups may take in the future, after further repository growth. If checkpoints resume before the extent/s copy is complete, the snapshot will not be usable.

While it is preferable to have checkpoints suspended for as short a time as possible, it is safer for the backup script to manually resume checkpoints after the file copies are completed, rather than relying on tuning the time out period.

2. Copy the repository extents.

   Once checkpoints are suspended, the session requesting the suspension can log out from GemStone and start the extent copy, using operating system commands or **copydbf**.

3. Resume checkpoints.

   Once the extent copy has completed, a session should log in to GemStone and request the Stone to resume checkpoints (`System class >> resumeCheckpoints`). The result of this method is false if checkpoints were not previously suspended before

executing `System class >> suspendCheckpointsForMinutes:` (as in Step 1), and true if they were previously suspended.

```
topaz 1> printit
System resumeCheckpoints
%
true
```

From this result, you can determine if the online extent backup was completed while checkpoints were still suspended. If the backup was completed in time, no further action is required and the backup is complete. If the backup did not complete before checkpoints were resumed, then the backup must be discarded and another online extent backup must be taken.

CAUTION

Make sure your backup code checks this result, since a false return value means that your backup is not usable.

An Example Script

The GemStone installation directory includes an example script `$GEMSTONE/examples/admin/onlinebackup.sh`. You can customize this script for your own system.

This script does not include code to make file system copies of the extents; you must add the necessary code to perform this task. This script provides a default checkpoint suspension of 15 minutes, which may or may not be sufficient time.

NOTE

The example script `onlinebackup.sh` *is unsupported. It is provided here for your convenience, and is subject to change in future releases.*

Be sure to review and test your script adequately to ensure the integrity of your backups.

11.4 How To Make a Smalltalk Full Backup

You can create a backup of the objects in your repository by performing Smalltalk full backups, using methods provided as part of the GemStone kernel. Smalltalk full backups are required if you want to reduce the number of extents in the repository or redistribute objects within the repository. During a Smalltalk full backup, dynamic internal data structures are not copied and will be rebuilt, which can, at least temporarily, improve the performance of such routine maintenance tasks as garbage collection.

In a Smalltalk full backup, the methods `Repository>>fullBackupTo:` or `fullBackupTo:MBytes:` save the most recently committed version of the repository in a way that is consistent from a transaction viewpoint. These methods force a checkpoint of the repository at the time the method is executed and then creates a backup from that checkpoint, copying all objects in the repository and arranging them in a compact form in one or more files.

You can make Smalltalk full backups while the repository is in use. Other sessions can continue to commit transactions, but those transactions are not included in the backup. Full backups require the GcLock, and so full backups cannot be made while other operations that hold the GcLock are running.

A Smalltalk full backup includes these three steps:

1. The Gem performing the backup scans the object table, building a list of objects to back up. This step runs in a transaction and can therefore cause a temporary commit record backlog in systems with high transaction rates. This step normally completes fairly quickly.
2. The Gem performing the backup next writes all shadow objects to the backup file. This step also runs in a transaction; furthermore, backing up shadow objects requires more disk I/O than backing up live objects, so the rate of objects backed up per second is slower in this step than in the next.

   (For definitions of shadow and live objects, see "Basic Concepts" on page 277.)
3. In the final step, all remaining live objects are written to the backup file. This step is performed outside a transaction; if the Stone signals the session to abort, it will do so. This step takes the longest of the three.

The fullBackupTo: Methods

`Repository>>fullBackupTo:` *fileNameOrArrayOfNames*
`Repository>>fullBackupTo:` *arrayOfFilenames* `MBytes:`*mByteLimit*

In these methods, *fileNameOrArrayOfNames* or *arrayOfFilenames* specifies one or more files where the backup is to be created. You must specify the name of the files, not a directory name. You may include a relative or absolute path in addition to the file name.

If you use a relative path, the path is relative to the working directory of the Gem process or linked session. Note that this is different for linked and RPC sessions; for linked topaz sessions, this is the directory from which topaz was started, and for RPC Gems, this may be the users's home directory, or as specified by the configuration, as described on page 417. You can determine the working directory by invoking `GsFile class >> serverCurrentDirectory`.

You can create backups on a remote node if the drive is NFS-mounted, or by using a network resource string (NRS) to specify the node name as part of the file name, and ensuring a NetLDI is running on the remote node. These are likely to take longer than local mounts due to I/O limitations. Backups cannot be made to a raw partition.

mByteLimit is either a single integer, or an array of integers with the same number of elements as *arrayOfFilenames*. This argument limits the maximum size of each file, except the last. If *mByteLimit* is one integer, each backup file will use that value; if it is an array of integers, each file will be limited by the matching entry. A value of 0 means the file sizes are unlimited.

In order to avoid running out of space for the backup, the last file is not limited, regardless of the size limit specified. If the number and size limit of *arrayOfFilenames* is too small to hold the entire backup, after each of the earlier files reaches its *mByteLimit*, the last file may grow significantly larger to contain the remainder of the backup.

WARNING

If there is not sufficient space to write the entire backup, the backup returns an error and deletes the incomplete backup files. Make sure you have sufficient disk space and the appropriate value for mByteLimit.

If you do not want to limit the size of the backup file, specify a *mByteLimit* of 0.

For example:

```
topaz 1> printit
"Create a full backup of the Repository"
SystemRepository
    fullBackupTo: {
      '/users/backups/August_20.1' .
      '/users/backups/August_20.2' .
      '/users/backups/August_20.3'
      }
    MBytes: 0.
%
true
```

This writes the backup into three files, named **`August_20-1`**, **`August_20-2`**, and **`August_20-3`**. Messages are written to the stone log indicating when the backup started and when it completed.

During the backup, after the initial period in transaction, the session is put into manual transaction mode so the backup won't interfere with ongoing garbage collection. When the backup completes, the session is left outside of a transaction. If you want to make changes to the repository after a backup, send `System beginTransaction` or `System transactionMode: #autoBegin`.

Backup fails to run or encounters an error

If the backup file already exists, a path cannot be found, or if any of the file names are empty strings, the method returns an error.

If another session is already performing a repository scan operations, the system may not be able to acquire a GcLock. The backup will wait for up to 5 minutes for a lock to become available, otherwise it will fail and return an error. You can determine the session holding the GcLock by using:

```
System sessionIdHoldingGcLock
```

This method will return 0 if no session is holding the GcLock.

Backup (and restore) require at least one extra session be available, beyond the session that is starting the backup, and uses more sessions to write backups in system with multiple extents and to multiple backup files. If the number of users logged in is equal to the STN_MAX_SESSIONS setting, the backup will fail with an error.

If backup encounters an error, then any backup files that were created are automatically deleted.

Compressed Backups

It is possible to write and read full backup files in compressed mode. GemStone supports both gzip and lz4 compression for backups.

Writing to, and reading from, a compressed file can be performed only to a local file system file or to a file system that is NFS-mounted.

Backup files written in compressed mode are automatically appended with the suffix `.gz` or `.lz4`, according to the selected compression.

All restore methods automatically detect whether a file is compressed or not and read the file accordingly. Even a backup originally created in uncompressed mode, then later compressed externally, is readable by `restoreFromBackup:`.

The following class methods in Repository are provided to create compressed full backups:

`fullBackupGzCompressedTo:` *filename*
`fullBackupLz4CompressedTo:` *filename*

These methods back up the receiver to a single backup file, which is written compressed in gzip or lz4 format.

`fullBackupGzCompressedTo:` *arrayOfFilenames* `MBytes:` *mByteLimit*
`fullBackupLz4CompressedTo:` *arrayOfFilenames* `MBytes:` *mByteLimit*

These methods are similar to `fullBackupTo:MBytes:` except that the output file is written compressed in gzip or lz4 format.

Performance Optimization

The fullBackup operation must read all data in the repository extents, compose backup records, and write these to disk. Performance depends on, among other factors:

- the amount of data in the repository
- the number of extents and the read performance of the media holding the extents
- the number of backup files and write performance of the media holding backup files

The fullBackup code starts two threads per extent file in the repository, and one thread per backup file, to support parallel reading/processing and writing, respectively. These threads require sufficient number of CPUs, and disk media that can be read/written in parallel, for full benefit.

Given these variables, the backup performance and optimization strategies will be quite different between individual installations.

The following suggestions are generally true:

- SSDs or SANs for the extents and/or for the backup file destination provides much better performance. If repository extents or backup files are on disk drives, ensuring that there are multiple extents and multiple backup files on distinct spindles will reduce I/O contention.
- Increasing the number of backup files allows more parallel writes, up until the point that CPUs are saturated or the limit of the read operations. However, keep in mind the operational impact of managing a very large number of backup files, since any individual file that is lost makes the backup unusable.
- If the shared page cache is large so that the entire repository can fit into memory, and the cache is entirely warm, there will be no need to read pages from the extents.

Impact on other sessions

While much of the time taken by backup may be in disk I/O, there is processing that must be done by the backup session and other GemStone processes. For larger repositories with optimized I/O, this processing may have a significant impact on other sessions that are running during this period. Backups are often scheduled for "off hours", where using more

system resources for faster performance is desirable. The default settings for backup support this optimization.

For applications that schedule backups while the repository is in use, you may want to control backup performance to avoid this impact.

By default, the backup sets the maximum number of session threads (which read from the extents) to 2 times the number of extents in the repository (this is addition to the per-file threads that write the backup). Session threads may be deactivated and system impact reduced using the methods described in "Tuning Multi-Threaded Scan" on page 300; this allows you to reduce the impact of the backup on any other work being done in the application.

Also note that these session threads require a user login in your system. If there are not sufficient session slots available – if the number of users logged in is close to the STN_MAX_SESSIONS setting – then the backup or restore will use fewer sessions and performance will be slower. In this case, a message is printed to stdout (the topaz -l terminal) and to the stone log.

Restore is always done with maximum performance.

Increasing session threads

The default number of session threads (which read data from extents) is 2 times the number of extents. This generally provides the best performance for "average" configurations. This can be increased, before the backup is started, by executing

```
SessionTemps current at: #GsOverrideNumThreads put: numThreads
```

where *numThreads* can be any value between 1 and (4 * numberOfCPUs). This limit avoids oversaturating the number of CPUs and negating the benefit of the multi-threading.

This larger number of session threads can be modified (reduced and then increased back to this limit) during the run using the Multi-threaded Scan Tuning methods.

Backups and Garbage Collection

It is more efficient to run a Smalltalk full backup when there are few pages that need to be reclaimed (for a discussion on garbage collection and reclaim, see "Basic Concepts" on page 277).

If possible, check the statistic PagesNeedReclaimSize, and if it is high, check that one or more Reclaim Gem sessions is running and/or increase the number of Reclaim Gems, and wait for reclaim to complete; or use `reclaimAll`, before performing the backup. For details on configuring Reclaim Gems, see "Admin and Reclaim Gems" on page 283.

Monitoring and Verification

statmonitor and cache statistics

Using statmonitor and VSD, you can see cache statistics related to backup, both to monitor progress of the backup and to identify what may be limiting performance.

During the main part of a full backup, the cache statistic ProgressCount for the session performing the backup indicates the number of objects written to the backup file thus far. If you know the total number of objects in the repository, you can use this statistic to determine how far the backup has progressed.

The TimeWaitingForIO statistic for the backup process will show if your backup is I/O bound.

Verifying a Backup is Readable

To verify that a backup file is readable, use the GemStone utility **copydbf**. You can conserve disk space and reduce disk activity by specifying `/dev/null` as the destination. For instance:

```
% copydbf /users/backup/August_20-1 /dev/null
```

Checking Backup Start and Completion

The time a backup is started, and the time that it completes successfully, are written to the stone log. For multi-file backups, only the first filename is listed.

```
--- 8/20/20 13:51:19 PDT ---
     Full backup of the repository has been started.
         Host: ip6-localhost        ProcessId: 2930
         User: DataCurator          SessionId: 5
--- 8/20/20 13:53:32 PDT ---
     Full backup successfully completed by sessionId 5 to file:
bkup.dat
```

Details about the backup

You can get more information about the resulting backup fils using **copydbf -i**. See **copydbf** on page 366 for more details.

11.5 How to Restore from Backup

There are several circumstances under which you will want to restore from backup.

If you have disk errors or file corruption, or if you encounter object corruption in your repository, you will need to restore from backup and replay transaction logs to recover all work up to the time of the corruption.

Restoring from backup is also used to set up and refresh warm or hot standby systems, and to set up test environments that match production systems.

To make the repository smaller, or to redistribute objects among a different number of extents, or to change your system to use partial logging mode, you must restore from full backup. Restore from full backup may also improve space use and performance by recreating internal structures.

Note that if your intention is to redistribute objects over a different number of extents, if the number of extents during restore is the same as the number of extents when the backup was started, this takes precedence over the DBF_ALLOCATION_MODE configuration setting during restore. If the number of extents differs, then the DBF_ALLOCATION_MODE setting at the time of the restore controls the distribution of objects across extents.

The ability to restore from backup to recover from file or object corruption is critical to the reliability of your GemStone system. You should ensure that you regularly take backups, and from time to time, verify that the processes that you use to make the backups result in complete and usable backup files.

To secure work that is done between backups, it is recommended to be in full transaction log mode. In this mode, the transaction logs record all commits in your repository and the transaction logs are not automatically deleted, so they can be replayed into a restored backup if they are needed.

There are two phases of restoring from backup:

Phase 1 - restore the backup. The process will vary depending on if you are restoring from an extent snapshot backup or from a full backup.

- To restore from extent snapshot backups, see "Restoring from an Extent Snapshot Backup" on page 225.
- For restore from a fullbackup, see "Restoring from a Full Backup" on page 228

Phase 2 - restore transaction logs. This phase is only possible in full transaction logging mode. If you are not in full transaction logging mode, any work done after the backup was made will be lost in the restored repository.

- "How to Restore Transaction Logs" on page 237

After the backup has been restored, the repository reflects its state at the time of the backup. All the objects are intact and ordinarily are clustered in a way similar to their organization in the original repository. This clustering reflects both explicit clustering of objects by the application and default clustering into the generic cluster bucket.

Restore Status

Before, during, and after restore from backup and from transaction logs, you can use the message `restoreStatus` to determine where you are in the process. This status is an attribute of the repository, not of the session, and persists across login sessions and stopping and restarting the Stone.

Not in restore mode

```
topaz 1> printit
SystemRepository restoreStatus
%
Restore is not active
```

During restore from transaction logs

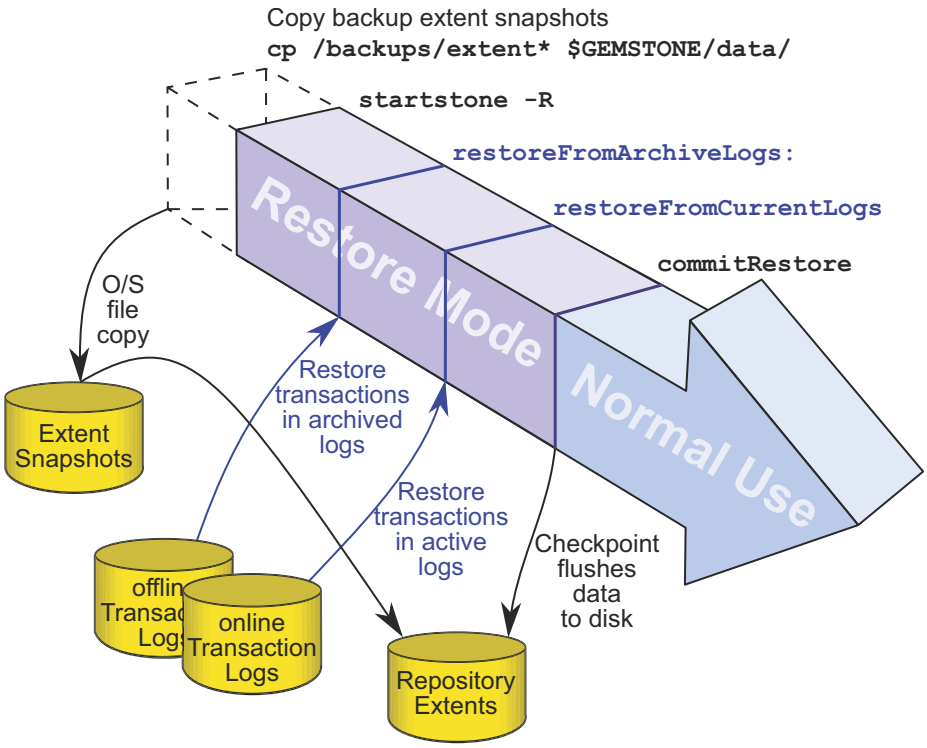
```
topaz 1> printit
SystemRepository restoreStatus
%
Restoring from transaction log files, restored to 03/20/15
12:21:41 PDT, nextFileId = 1, record = 409 oldest fileId = 1
```

Restoring from an Extent Snapshot Backup

This section describes how to restore extent snapshot backups; that is, backups made using utilities such as **cp** or **copydbf** to make a file copy of the extents.

In order to recover, this extent snapshot backup must have been made while the repository monitor was shut down (offline), or if the repository is online, checkpoints must have been suspended for the entire time the copy was being made.

Figure 11.1 System Timeline: Restoring from a Extent Snapshot Backup



To restore your working repository from a extent copy backup, use the following procedure:

Step 1. If GemStone is still running, tell all users to log out and use **stopstone** to stop the repository monitor.

Step 2. If you are restoring the repository because of a suspected GemStone failure, preserve a copy of the extents in case Technical Support wants to examine them.

Step 3. Delete all **extent** files specified by DBF_EXTENT_NAMES in your configuration file.

Do NOT delete any transaction log files —leave them online in their current locations.

The full set of transaction log files, starting with the oldest transaction log required for recovery, should be available, in either the tranlog directories or an archive log directory. You can determine the oldest transaction log required by using copydbf -i on the first secure backup extent file.

Step 4. Copy the operating system backup copies of the extent files to the locations specified by the DBF_EXTENT_NAMES configuration option.

Step 5. Ensure that there is space to create a new transaction log file. At least one of the directories specified by STN_TRAN_LOG_DIRECTORIES must have space available or one of the raw partitions must be empty. You may need to add entries to the lists under STN_TRAN_LOG_DIRECTORIES and STN_TRAN_LOG_SIZES in your configuration file.

Step 6. Start up the stone.

- If the repository was in full logging mode, and you have both online and offline transaction logs to restore, or you wish to control which logs are restored, then invoke **startstone** using the **-R** and **-N** flags. This starts the stone without restoring any transaction logs, and leaves the repository in restore mode.

  You can now restore transaction logs. Continue with "How to Restore Transaction Logs" on page 237.

- If the repository was in full logging mode, and if you have all the transaction logs required for restore in the current transaction log directories (those listed under STN_TRAN_LOG_DIRECTORIES), and you wish to restore all of them, then you can allow automatic recovery to restore all transactions. Startup the stone as usual (that is, not using the **-R** or **-N** flags). All available transaction logs are automatically recovered, and the equivalent of `commitRestore` is automatically done. The completely restored repository is left in normal (that is, not restore) mode.

  The restore process is now complete.

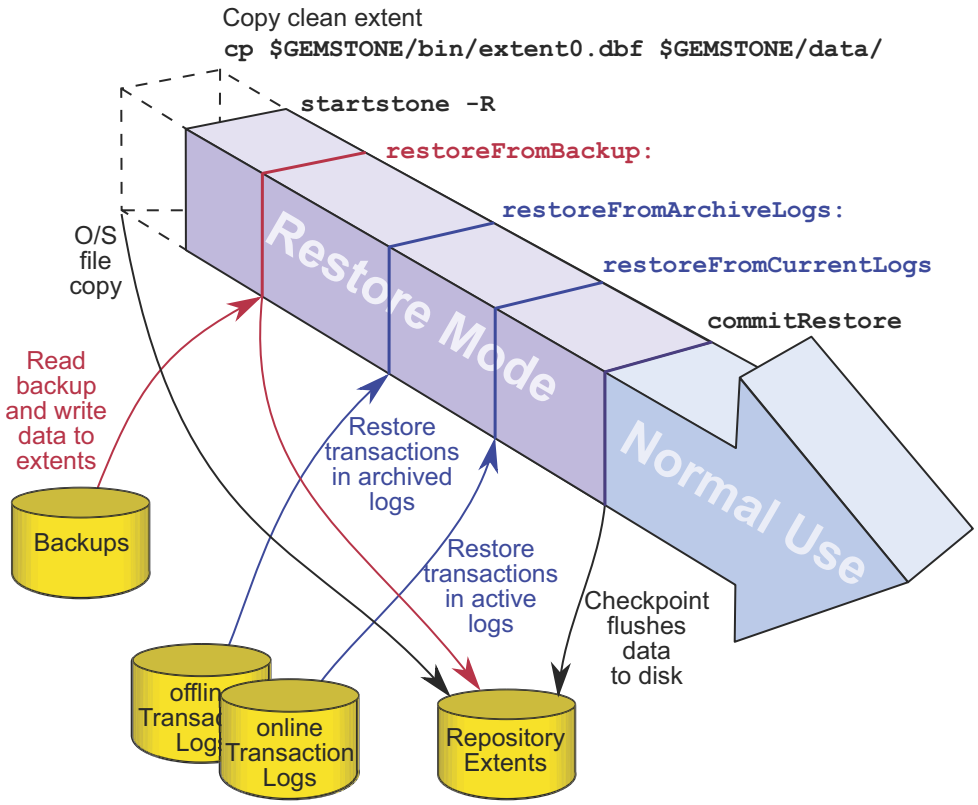
- If your repository was in partial logging mode, you will only be able to recover transactions if the extent snapshot backup was made within the timeframe of the most recent transaction log. Start your stone normally, and the transaction log that was being written to at the time of the backup will be automatically recovered. Any transactions that occurred after this transaction log are permanently lost.

  The restore process is now complete.

Restoring from a Full Backup

A GemStone full backup writes the contents of the repository into backup files. When restoring from a full backup, you start with a clean, empty extent, and restore the objects from the backup file into your repository.

Figure 11.2 System Timeline: Restoring from a Smalltalk Full Backup



You will need a file copy (*not* a GemStone backup) of a good repository. We recommend that you use a copy of the `extent0.dbf` that was shipped in `$GEMSTONE/bin`.

Although any extent file that is a complete, uncorrupted repository will work, do not use your repository extent files if this can be avoided. Restoring from a full backup into existing repository extents effectively loads the restored objects in addition to the previously existing objects, and then removes the old objects; this takes much longer and results in a much larger repository size.

First, depending on your reasons for restoring, you may wish to move the existing extents to an archive location, in case they are needed to diagnose a problem. The existing extents must all be removed from the configured location.

Make sure that you have all backup files are complete. If the backup consists of multiple files, the complete set must be available.

The user restoring the backup must be the only user logged in to the server. The method that starts the restoration will suspend other logins.

NOTE

We recommend that you log in as DataCurator or SystemUser to restore the

backup. If you start the restore as another user and that UserProfile disappears as a result of the restore, Topaz will see a fatal error.

To restore your working repository from a Smalltalk full backup, use the following procedure.

Steps in restoring a full backup

Step 1. If GemStone is still running, tell all users to log out and use **stopstone** to stop the system.

Step 2. If you are restoring the repository because of a suspected GemStone failure, preserve a copy of the extents in case GemStone Technical Support wants to examine them.

Step 3. Delete all **extent** files specified in DBF_EXTENT_NAMES in your configuration file.

Do NOT delete the transaction log files up to the time of the crash—leave them online in their current locations.

The full set of transaction log files, starting with the oldest transaction log required for recovery, should be available, in either the tranlog directories or an archive log directory. You can determine the oldest transaction log required by using copydbf -i on the first secure backup extent file.

Step 4. Copy the clean, empty extent to the location of your primary extent, which is the extent listed first in DBF_EXTENT_NAMES.

Make sure there are no other extent files in that location. Do not copy any other extent files to the extent location. If you have more than one extent, the Stone repository monitor will create the new extents at startup.

Use **chmod** to give the clean extent copy the same permissions you ordinarily assign to your repository files.

For example:

```
% copydbf $GEMSTONE/bin/extent0.dbf $GEMSTONE/data/extent0.dbf
% chmod 600 $GEMSTONE/data/extent0.dbf
```

Step 5. Ensure that there is space to create another transaction log file. At least one of the directories specified by STN_TRAN_LOG_DIRECTORIES must have space available or one of the raw partitions must be empty. You may need to add entries to STN_TRAN_LOG_DIRECTORIES and STN_TRAN_LOG_SIZES in your configuration file.

Step 6. Configure the extents for pre-grow

For better performance, your extent files should be pre-grown during startup, rather than growing incrementally during restore. This is done by setting configuration parameters in configuration file the Stone uses on startup. See “Pregrowing Extents to a Fixed Size” on page 44.

Step 7. Use **startstone -R** to restart the Stone.

The -R option starts the stone in restore mode and avoids creating an orphan transaction log.

Step 8. Log in to GemStone as DataCurator or SystemUser using linked Topaz (**topaz -l**). Remember that the password will be the original one supplied when you installed GemStone, not necessarily the one you have been using.

To perform the following steps, you must be the only user logged in to GemStone. Once you start the next step, other logins will be suspended.

Step 9. Restore the most recent full backup to the new repository by sending the message `restoreFromBackup:` or `restoreFromBackups:`. These methods automatically detect whether a backup is compressed or not and reads it accordingly.

```
topaz 1> printit
SystemRepository restoreFromBackup: 'backup.gz'
%
```

To restore from a multi-file backup, you must specify all the files in the backup, in the order the backups were created.

```
topaz 1> printit
SystemRepository restoreFromBackups:
  #( '/users/backups/August_20.1'
     '/users/backups/August_20.2'
     '/users/backups/August_20.3')
%
```

When restore from backup is complete, the session logs out.

```
[Info]: Logging out at 8/20/20 13:51:19 PDT
The restore from backup completed, with 97655 objects restored.
 Ready for restore from transaction log(s).
```

If partial logging was in effect (STN_TRAN_FULL_LOGGING = false) at the time the backup was made, the final status line reads:

```
Restore complete. (Backup made while in partial logging mode.)
```

This status means that transaction logs cannot be restored. The repository is ready for ordinary use, and logins have been enabled.

If corrupted objects are detected during the restore, the restore will report error 4152, BKUP_ERR_RESTORE_FAILURE. You may continue with the restore, invoking the method `commitRestoreWithLostData` rather than `commitRestore`; however, your resulting repository may contain missing or corrupt objects.

If other fatal errors occur during backup, the system returns to the state it was in before restore. Determine the cause of the error and correct it, and redo the restore.

Step 10. If full logging was in effect (STN_TRAN_FULL_LOGGING = true), the status line indicates the next step:

```
Ready for restore from transaction log(s).
```

Exit the linked topaz environment, and restart topaz, before logging in again to restore transaction logs. This ensures that your restarted topaz environment will load the version of the ICU library that is compatible with the newly restored repository. ICU library versions are discussed in the *Programming Guide*, page 86.

Continue with “How to Restore Transaction Logs” on page 237.

Controlling Reclaim Activity When Restore Completes

During restore, pages that contain free space are by default not added to the scavengeable pages at the end of the restore. This avoids a load on the reclaim gems immediately after the commitRestore. In the normal course of operations as repository objects are operated on, pages with free space will tend to be reclaimed over time.

This can be controlled, so that pages with a specific percentage of free space are made scavengeable, so they will be reclaimed after the commitRestore. This will result in the largest amount of free space after this initial reclaim, at the expense of heavy reclaim load on the repository shortly after startup. Since reclaim requires pages, you should use some caution to avoid running out of free space before the newly reclaimed pages become available.

To explicitly specify the page free space percentage required to add pages tot he scavengeable pages list, use the method `Repository >> restoreFromBackups:` *arrayOfFileNames* `scavengePagesWithPercentFree:` *aPercent.*

A *aPercent* value of 100 means no pages are added (the default), while 0 means pages with any free space at all are added.

For example,

```
topaz 1> printit
SystemRepository restoreFromBackups:
  #( '/users/backups/August_20.1'
     '/users/backups/August_20.2'
     '/users/backups/August_20.3')
scavengePagesWithPercentFree: 90
%
```

11.6 How to Make and Restore a Secure Backup

Secure backups are similar to full backups, but include some important security features:

- They are digitally signed, ensuring the identity of the originator and that the backup file has not been modified. All backups created using the secure backup API are digitally signed.
- They may be encrypted, requiring a private key to restore. Encryption is optional, using AES-CTR with key sizes of 128, 192, or 256.

Secure backups require RSA keypairs, both for signing and for encryption (if used); DSA can be used for signing, but not for encryption. For any secure backup, a signing keypair is needed; encrypted backups require additional separate keypair/s. The signing key may or may not require a passphrase, although a passphrase is recommended for security. The example keys included in the distribution require passphrases.

For an encrypted secure backup, you may use one or up to eight public keys, as well specifying the other details of the encryption. Restoring this backup later will require a private key that corresponds to any one of these public keys. This allows you to create a backup that can be restored by multiple other entities, without these entities having to share a single private key.

Secure backups, like fullBackups, can also be written to one or multiple files and may be uncompressed, compressed using zlib or compressed using lz4.

While secure and fullBackups are similar programmatic backups, the API methods are different. You cannot use the secure restore methods to restore a standard full backup, nor vice versa.

Creating a secure backup

Secure backups are created using the Repository method `secureFullBackupTo:...`, which allows you to specify filename or names, encryption type, and other details of the backup.

Making a secure backup requires more information to be passed in than an ordinary fullBackup, but otherwise the process is similar. "How To Make a Smalltalk Full Backup" on page 219 describes the general process of making a full backup, including error conditions (other than certificate errors) and monitoring backups.

The method to create a secure backup is:

```
Repository >> secureFullBackupTo: arrayOfFileNames
    MBytes: mByteLimit
    compressKind: compressionKind
    bufSize: bufSize
    encryptKind: encryctionKind
    publicKeyCerts: anArrayOrString
    signatureHashKind: hashKind
    signingKey: signingKeyFn
    signingKeyPassphraseFile: pathAndFileForPassphrase
```

A similar method that accepts a passphrase string rather than a filename is also available.

The following information must be provided:

arrayOfFileNames - a String containing a filename for the backup, or an array of strings for a multi-file backup. The extension '.sdbf' will be appended.

mByteLimit specifies the sizes of the backup files, as described under "How To Make a Smalltalk Full Backup" on page 219. 0 means unlimited. Note that the last file of the backup is always unlimited size, to avoid inadvertent backup failures.

compressionKind - may be 0, 1, or 2. 0 indicates no compression, 1 specifies zlib/gzip compression, and 2 specifies lz4 compression.

bufSize - specifies the number of records to fit in a buffer. This would normally be 8 for uncompressed backups, 1 with gzip compression, and 16 with lz4 compression.

encryptionKind - may be 0, 1, 2, or 3. 0 indicates no encryption, and 1, 2, and 3 specify AES-CTR-128, AES-CTR-192, and AES-CTR-256, respectively.

anArrayOfString - an array of names of public certificate files, or nil if the backup will not be encrypted (if *encryptionKind* is 0). Up to 8 may be included. At least one of the private keys corresponding to these public keys will be needed in order to restore this backup.

hashKind - may be 1, 2, or 3, specifying SHA256, SHA384, or SHA512, respectively.

signingKeyFn - the name of the signing private key certificate file.

pathAndFileForPassphrase - the path and file containing the passphrase for the signing key certificate.

Setting the certificate directories

Before using the secure backup API to make or restore secure backups, you must set the keyfile directories (keyring), using the Gem configuration option GEM_KEYRING_DIRS. This can be set either in the configuration file used by the Gem process, or set at runtime. The directories specified in GEM_KEYRING_DIRS are used to confirm there are matching public and private keyfiles for keys used by the secure backup operations.

The code examples below can be executed using the example certificates, by executing the following expression. Since this is a Gem runtime parameter, you will need to execute it each time after login.

```
System gemConfigurationAt: #GemKeyRingDirs
   put: {'$GEMSTONE/examples/openssl/certs' .
         '$GEMSTONE/examples/openssl/private' }.
```

Create an unencrypted secure backup

The following example code creates a secure backup in a single file, uncompressed and not encrypted, using the example key and passphrase in the GemStone distribution.

Example 11.2 Creating an unencrypted backup

```
SystemRepository
   secureFullBackupTo: '$GEMSTONE/data/backupSig'
   MBytes: 0
   compressKind: 0
   bufSize: 8
   encryptKind: 0
   publicKeyCerts: nil
   signatureHashKind: 1
   signingKey: 'backup_sign_2_clientkey.pem'
   signingKeyPassphraseFile: '$GEMSTONE/examples/openssl/private/b
      ackup_sign_2_client_passwd.txt'
```

Create an encrypted backup

The code in Example 11.3 creates an encrypted, compressed backup to three files:

Example 11.3 Creating an encrypted backup

```
SystemRepository
   secureFullBackupTo: '$GEMSTONE/data/backupEncr'
   MBytes: 0
   compressKind: 2
   bufSize: 16
   encryptKind: 2
   publicKeyCerts: { 'backup_encrypt_1_clientcert.pem' .
      'backup_encrypt_2_clientcert.pem'}
   signatureHashKind: 1
   signingKey: 'backup_sign_2_clientkey.pem'
   signingKeyPassphraseFile:
      '$GEMSTONE/examples/openssl/private/backup_sign_2_client_pas
      swd.txt'
```

Restoring a secure backup

Restoring a secure backup is similar to restoring a fullBackup—the only difference is that a specialized method is used to pass in the additional required information. For a overview of the restore process, see the illustration on page 228.

For an encrypted secure backup, you must also specify one of the private keys corresponding to the public keys used in the encryption.

To restore a secure backup, following the steps under “Steps in restoring a full backup” on page 229, through step 7.

In Step 9, you will use one of the secure backup restore methods:

```
Repository >> restoreFromSecureBackup: aFileName
   privateDecryptionKey: aKey passphrase: aPassphrase

Repository >> restoreFromSecureBackup: anArrayOfFilenames
   privateDecryptionKey: aKey passphraseFile: aPassphrase

Repository >> restoreFromSecureBackups: anArrayOfFilenames
   privateDecryptionKey: aKey passphrase: aPassphrase

Repository >> restoreFromSecureBackups: anArrayOfFilenames
   scavengePagesWithPercentFree: aPercent
   privateDecryptionKey: aKey passphraseFile: aPassphrase
```

There are several other variants available; see the image for other methods.

These methods require that you have set the keyfile directories using the Gem configuration option GEM_KEYRING_DIRS. This can be set either in the configuration file used by the Gem process, or set at runtime. The directories specified in

GEM_KEYRING_DIRS are searched for the public key corresponding to the private signing key, and a private key that corresponds to a public encryption key.

Restore an unencrypted backup

The following example restores a single file secure backup that was signed, but not encrypted. `#GemKeyRingDirs` must include a directory containing the public key for the signing certificate, which is used to verify the backup. This public key can be extracted from the backup using the **copydbf -V** command, so anyone can restore this backup; it is secured against modification, but not private.

Example 11.4 Restore an unencrypted secure backup

```
SystemRepository
   restoreFromSecureBackup: '$GEMSTONE/data/backupSig.sdbf'
   privateDecryptionKey: nil
   passphrase: nil.
```

Restore an encrypted backup

The code in Example 11.5 restores a encrypted backup. The private key `backup_encrypt_1_clientkey.pem` and passphrase used for decryption corresponds to the public key `backup_encrypt_1_clientcert.pem` which was used to make the backup. The private key is required in order to be able to restore the encrypted backup.

While **copydbf -W** will extract the public keys from the backup, these are not sufficient for restore.

GemStone automatically detects the encryption type and compression type.

Example 11.5 Restore an encrypted backup

```
SystemRepository
   restoreFromSecureBackup: '$GEMSTONE/data/backupEncr.sdbf'
   privateDecryptionKey: 'backup_encrypt_1_clientkey.pem'
   passphraseFile:'$GEMSTONE/examples/openssl/private/backup_encry
      pt_1_client_passwd.txt'
```

After restoring the secure backup, you can continue with restoring transaction logs or performing the `commitRestore`, as described in "How to Restore Transaction Logs" on page 237.

Verifying the digital signature

Secure backups are always digitally signed using a private key. You can use **copydbf** or the GemStone utility **verify_backup_with_openssl** to verify the signature, specifying (respectively) a directory containing the public key corresponding to that private key, or the public key itself. This ensures that the backup was creating using the same private key as the distributer provided directly to you.

To verify a digitally signed backup:

`copydbf -V` *backupFile* `-K` *certificateDirectory* [-K *certificateDirectory*]
: Use copydbf to verify the backup file *backupFile*, with the certificates located in the directory *certificateDirectory*.

`verify_backup_with_openssl` *backupFile publicKeyPathAndFile*
: Use openSSL to verify the backup file *backupFile*, with the public certificate *publicKeyPathAndFile*. The public key can be omitted, in which case it performs verification using the public key extracted from the private key, which does not provide useful verification.

The following examples verify the digital signature in the signed but not encrypted backup from Example 11.2:

Example 11.6 Verify digital signature

```
% copydbf -V backup1.sdbf -K $GEMSTONE/examples/openssl/certs/
Source file: backup1.sdbf
   File type: secure backup  fileId: 0 in a backup set with 1
files
   File size: 37879808 bytes (36 MB), 289 records
   ByteOrder: Intel (LSB first)  compatibilityLevel: 860
   The file was created at: 8/20/20 13:51:19 PDT
[Info]: Starting verification of secure backup...SUCCESS

% verify_backup_with_openssl backup1.sdbf
   $GEMSTONE/examples/openssl/certs/backup_sign_2_clientcert.pem
[Info]: Using certificate file
   /lark1/GS/examples/openssl/certs/backup_sign_2_clientcert.pem
[Info]: Digest kind is SHA-256
[Info]: Invoking openssl to perform the digital signature
   verification:

Verified OK
```

Since the backups contain the private key, and a public key can be extracted from a private key, you can also verify the signature based on the information in the backup file; however, this does not ensure that the backup was signed by the distributer. This can be done either by omitting the public key argument to **verify_backup_with_openssl**, or extracting the public key from the backup using **copydbf -X** and passing that into **copydbf -V**.

Do not rely on the results of this kind of validation to ensure that the backup file is signed by the distributer!

11.7 How to Restore Transaction Logs

The second phase of restoring the repository is to roll forward from the state at the starting point of the last backup to the state of the last committed transaction. This action repeats the transactions in the order in which they were committed.

You can do this only if the STN_TRAN_FULL_LOGGING configuration option was set to True at the time the backup was made. You cannot restore transaction logs that are not part of a sequence of tranlogs that includes the backup. Since restore breaks this sequence, the transactions being restored cannot span a more recent restore.

Compressed Tranlogs

Note that while backup files can be written in either uncompressed or compressed format, transaction logs are always written in uncompressed format. Transaction logs may be compressed, using **copydbf**, gzip, or lz4, before archiving them. These compressed tranlogs can be restored directly, without having to manually uncompress them, although there will be performance impact.

Restoring Encrypted Transaction Logs

When using encrypted extent files, the Stone will write transaction logs that are encrypted with the same key that was used to encrypt the extents. Restoring these transaction logs operates the same as with ordinary extents and transaction logs.

However, if you change the encryption key of the Stone's extents, it will start a new transaction log, which will be encrypted by the new key. Additional steps are required to provide the key for the older transaction logs to the Stone, or update the key on the transaction logs, before the older transaction logs can be restored.

These issues are described in Chapter 12, "Encrypted Extents and Transaction Logs"; see "Restoring transaction logs" on page 251.

Process for Restoring Transaction Logs

When restoring transaction logs, GemStone should be running and in restore mode, following a restore from either an extent snapshot backup started with -R, or from a full backup. The following steps describe the most common case of restoring the transaction logs.

CAUTION

Ordinarily, you will restore transactions from all log files written since the backup. If for some reason you plan to omit one or more log files, refer to the section "Special Cases and Errors in Restore" on page 239.

Step 1. Log in to GemStone as DataCurator or SystemUser using linked Topaz (**topaz -l**).

Step 2. Determine which transaction logs are needed for restore and their locations. The method `restoreStatus` identifies the earliest transaction log that is needed. In this example it is `tranlog6.dbf`:

```
topaz 1> printit
SystemRepository restoreStatus
%
Restoring from Transaction Log files,
  restored to 05/02/20 13:26:31 PST
  next fileId = 6, record = 9.
```

Compare the `fileId` in the message with the names of the transaction log files in the directories specified in STN_TRAN_LOG_DIRECTORIES. For transaction logs in the file system, `fileId` forms the numeric portion of the file name, `tranlog`*NN*`.dbf`. For transaction logs in raw partitions, use **copydbf -i** *fileName* to display the fileId.

Transaction log files that are located in a directory specified in STN_TRAN_LOG_DIRECTORIES are "current". If some required transaction logs have been moved to another location, they are "archive" logs, and are restored using a different method.

Step 3. Restore archive transaction logs, if any.

If any of the tranlogs to be restored are not in one of the current tranlog directories, collect the names of directories containing all these archive logs, and restore using `Repository>>restoreFromArchiveLogs:` or related methods.

You will have to login prior to running this step.

```
topaz 1> printit
SystemRepository restoreFromArchiveLogs:
  #( 'GS-archive' )
%
```

See the method comments in the image for details. A directory location can include an NRS for a remote node, but a NetLDI must be running on that node.

If you encounter a failure because of a truncated or corrupted transaction log, refer to "Errors While Restoring Transaction Logs" on page 244.

Step 4. Before continuing to restore tranlogs, you must log in again. Restore operations terminate the session when complete.)

Step 5. Restore transactions from the current log files by executing the method `Repository>>restoreFromCurrentLogs`. All the remaining log files must be in directories or raw partitions specified in STN_TRAN_LOG_DIRECTORIES.

```
topaz 1> printit
SystemRepository restoreFromCurrentLogs
%
Restore from transaction log(s) succeeded.
```

Continue with the next step, Finalize by commitRestore.

Finalize by commitRestore

Once the backup is restored and transaction logs are restored, there is a final commitRestore that completes the restore and returns the repository to normal mode.

If your backup was from a repository that is in partial logging mode, or with transaction logs configured to write to /dev/null, you do not need to do an explicit commitRestore; the commit Restore occurs automatically.

If restoration from the transaction logs was successful, you may send the message `commitRestore` to tell the system that you are finished restoring. After this, no further logs can be restored, and normal user commits will be allowed.

You will have to login again prior to running this step.

```
topaz 1> printit
SystemRepository commitRestore
%
Restore from transaction log(s) succeeded. commitRestore
succeeded
```

Make a new GemStone backup as soon as operational circumstances permit.

commitRestore without restoreFromCurrentLogs

If you send `commitRestore` prior to `restoreFromCurrentLogs`, a warning is issued because all previously committed transactions may not have been restored. However, this usage provides a way to recover as much as is available when a log file has been corrupted or lost.

After restoring a backup with corrupted objects

When a full backup file is readable, but contains corrupted or missing objects, the restore continues, but report error 4152/BKUP_ERR_RESTORE_FAILURE when all valid objects are restored. If this occurs, automatic commitRestore is disabled. You must explicitly execute `commitRestoreWithLostData`.

11.8 Special Cases and Errors in Restore

If the backup files and all transaction logs needed to restore up to the current time are available, restore is straightforward. However, in some cases transaction logs may be missing or corrupt, or you may wish to restore to an earlier point in time. This section describes these special cases and problems that you may encounter.

Missing or Corrupted Objects in Full Backup

If a file that is part of a full backup has corruption which does not make it unreadable, but prevents certain objects from being restored, you should locate a non-corrupt set of backup files to restore. However, if no alternative backup files are available, you can continue to attempt the restore. If the missing or corrupted objects were unreferenced, it may be possible to recover completely.

When restore encounters corrupted records it will skip the replay and continue to perform the restore, but on completion, it signals error BKUP_ERR_RESTORE_FAILURE/4152. If you do not have an uncorrupted backup, you may continue with restoring transaction logs. To complete the restore, you must invoke `RepositorycommitRestoreWithLostData >> commitRestoreWithLostData` rather than `RepositorycommitRestoreWithLostData >> commitRestore`.

After the `commitRestoreWithLostData` you should perform an object audit to determine the extent of the problems. It may be helpful to perform `markForCollection` and `reclaimAll` before the object audit. If object audit still reports issues, you should repair these. Contact GemTalk Technical Support for further recommendations.

Restoring Logs up to a Specific Log

To restore transaction logs, stopping at a specific log, execute `Repository>>restoreToEndOfLog:`*fileId*. This restores all transaction logs up to and including the specified transaction log. All tranlogs from the next tranlog required through the specified tranlog must be available. For example:

```
topaz 1> printit
SystemRepository restoreStatus
%
Restoring from Transaction Log files,
  restored to 05/02/20 13:51:19 PDT
  next fileId = 7, record = 0 oldest fileId = 7
topaz 1> printit
SystemRepository restoreToEndOfLog: 15
%
[Info]: Logging out at 05/24/20 14:37:07 PDT
Restore from transaction log(s) succeeded.
```

If the transaction logs to be restored are in a archive location, use the similar methods `restoreFromArchiveLogs:toEndOfLog:` or `restoreFromArchiveLogs:toEndOfLog:withPrefix:`.

```
topaz 1> printit
SystemRepository restoreStatus
%
Restoring from Transaction Log files, restored to 05/02/20
13:51:19 PDT, next fileId = 7, record = 0 oldest fileId = 7
topaz 1> printit
SystemRepository
      restorefromArchiveLogs: #(GS-archive)
      toEndOfLog: 15
%
[Info]: Logging out at 05/24/20 14:37:07 PDT
Restore from transaction log(s) succeeded.
```

Restoring Logs to a Point in Time

Ordinarily, the methods to restore one or more transaction logs restores each individual transaction within the log file. However, you can specify an earlier stopping point and restore only part of a transaction log, by sending one of the following messages:

```
restoreToPointInTime: aDateTime
restoreFromArchiveLogs: arrayOfDirSpec toPointInTime: aDateTime
restoreFromArchiveLogs: arrayOfDirSpec toPointInTime: aDateTime
   withPrefix: tranlogPrefix
```

Restoration will stop at the first repository checkpoint that originally occurred at or after *aDateTime*. This may be several minutes after *aDateTime*, depending on the checkpoint frequency in the transaction log.

To display the time a transaction log was started and the time of each checkpoint recorded in it, use **copydbf -I** *fileName*. By default, the interval between checkpoints is five minutes. For example:

```
% copydbf -I tranlog2.dbf

Source file: tranlog2.dbf
  File type: tranlog  fileId: 2
  ByteOrder: Intel (LSB first)  compatibilityLevel: 940
  The file was created at: 05/25/20 14:55:59 PDT.
  The previous file last recordId is  69.
  Scanning file to find last checkpoint...
   Checkpoint 1 started at: 05/25/20 14:55:59 PDT.
     oldest transaction references fileId -1 ( this file ).
   Checkpoint 2 started at: 05/25/20 14:57:23 PDT.
     oldest transaction references fileId -1 ( this file ).
   File size is 2.2 MBytes (4350 records).
```

The method to use to restore to a point in time depends on if the logs are archive (not in a directory on STN_TRAN_LOG_DIRECTORIES), OR ONLINE (IN A DIRECTORY USED FOR CURRENT TRANSACTION LOGS).

If the point in time that you wish to restore to occurs in an current/online transaction log, first restore any archives logs using `restoreFromArchiveLogs:`.

Then, restore all current logs up to a specified time. The following example restores the repository to the first checkpoint that would have included a commit on May 22, 2020 at 2:56:00 p.m.:

```
topaz 1> printit
SystemRepository restoreToPointInTime:
      (DateTime fromString: '22/05/2020 14:56:00').
%
```

To restore to a point in time that is in an archived tranlog, use the method `restoreFromArchiveLogs:toPointInTime:` or `restoreFromArchiveLogs:toPointInTime: withPrefix:`. This second method allows you to also specify alternate file prefixes, if you rename files as part of the archive process.

The following sequence restores the repository to the first checkpoint that would have included a commit on May 22, 2020 at 2:56:00 p.m.:

```
topaz 1> printit
SystemRepository restoreFromArchiveLogs:
            #( 'GS-archive' )
      toPointInTime:
            (DateTime fromString: '22/05/2020 14:56:00').
%
```

You can continue restoring past *aDateTime* by issuing further restore messages.

Precautions When Restoring a Subset of Transaction Logs

When you determine the need restore an incomplete set of transaction logs, be aware of the likely consequences:

- Obviously, the omitted transactions will be lost. Presumably that is unavoidable or intentional.
- Less obviously, it may be impossible to reverse your action later and restore the omitted logs. Operations after the first `commitRestore` create a time fork in the repository, and attempting to reverse the course later results in inconsistent data and object audit errors. For a detailed example illustrating this, see the following discussion on Fork-in-Time Scenario.

If there is any chance that you may want to restore from the full set of transaction logs later, you should archive everything before restoring the subset. Archive the repository backup and all transaction logs required for complete restore, to a separate location. The transaction logs should not be on any directory listed in STN_TRAN_LOG_DIRECTORIES.

Later, if you wish to perform a second restore, you can repeat the entire restore process, including restoring any omitted transaction logs. However, you will only be able to restore to the point in which the final transaction log of the archived set was completed. Any new work done in the partially restored system constitutes a "Fork-in-Time", so the transaction logs written after the partially restored system's commitRestore cannot be restored to this second restored system. That work will be lost.

Fork-in-Time Scenario

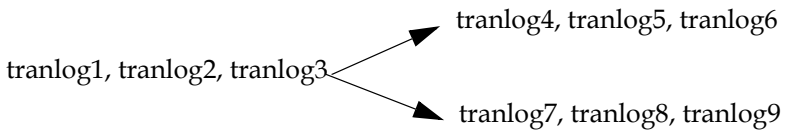
In some cases, you may encounter problems with restoring from your most recent backup file and must restore from an earlier backup. This scenario presents a risk of transaction logs that are out of sequence due to a "fork-in-time." Consider the following sequence of repository events:

1. Generate backup1.
2. Generate transaction logs tranlog1, tranlog2, tranlog3.
3. Generate backup2.
4. Generate transaction logs tranlog4, tranlog5, tranlog6.
5. Restore backup2.
6. commitRestore (without replaying transaction logs tranlog4, tranlog5, tranlog6).

   The repository is now at same state as Step 3.

7. Generate transaction logs tranlog7, tranlog8, tranlog9.
8. Restore backup1.
9. Replay transaction logs tranlog1 through tranlog9.

In terms of the repository lifecycle, this scenario has two timelines, with a fork-in-time at the end of tranlog3:



If, at step 5, we also restored the transaction logs (tranlog4, tranlog5, tranlog6), the resulting sequence could be replayed without problems. The problem is caused when the continuity of the transaction log chain is broken.

After restoring backup1 in step 8, it would be possible to safely replay transaction logs tranlog1 through tranlog6 without problems, but any changes made in (tranlog7, tranlog8, tranlog9) would be lost.

During step 9, the replay of (tranlog7, tranlog8, tranlog9) is likely to produce problems. If any object changes made in (tranlog4, tranlog5, tranlog6) are logically inconsistent with those made in (tranlog7, tranlog8, tranlog9), possible errors are wide-ranging, including UTL_ASSERT/UTL_GUARANTEE errors or errors of the form:

```
recovery/restore: invalid operation XXXXXXXXXX
Transaction expected to abort.
non-empty invalidObjs in recover.c:commitTran
```

In the worst case, errors may not be written to the Stone log during transaction log replay, but the final repository may be corrupted in obscure ways. If the corruption is structural, it may be detected by an object audit (described on page 135). Otherwise, the corruption may go undetected unless picked up by application code.

If you are presented with a situation wherein you are forced to restore from an earlier backup, keep in mind the following:

1. Be aware of the fork-in-time phenomenon and avoid restore/replay operations that would create a fork.
2. When restoring into an ongoing transaction log sequence, only restore a backup file generated earlier within that same sequence, and then replay *all* transaction logs in that sequence generated since that backup.
3. If for some reason you cannot follow guideline 2, realize that you cannot restore from an earlier backup and replay transaction logs beyond the point of the initially restored backup.

Errors While Restoring Transaction Logs

Missing Transaction Log File

If a transaction log file in the sequence is missing, the tranlog restore stops at that point, and reports an error if it detects the existence of later transaction logs.

For example, if you have `tranlog1.dbf` through `tranlog10.dbf`, but `tranlog4.dbf` is missing, `restoreFromCurrentLogs` stops after restoring from `tranlog3.dbf`.

```
topaz 1> printit
SystemRepository restoreFromCurrentLogs.
%
[Info]: Logging out at 8/20/20 13:51:19 PDT
ERROR 4049 , Restore from transaction log failed,
    EndOfAllLogs reached after fileid 3 before last log for
recovery 10 found.
```

The tranlog after the one reported in the error is the one that is missing. You can also execute the method `restoreStatus` to identify the next log file explicitly. Locate the missing file or files, and then continue the restore process.

Truncated or Corrupt Transaction Log File

If a transaction log is truncated or corrupt, it may not be noticed until the next transaction log is restored. This may occur, for example, if you have an undetected disk full condition when copying a transaction log.

The truncated log may restore successfully, but when the next log is restored, the gap is detected and the error is reported.

In the following example, `tranlog6.dbf` is truncated, and `restoreFromCurrentLogs` reports an error.

```
topaz 1> printit
SystemRepository restoreFromCurrentLogs
%
[Info]: Logging out at 05/24/20 14:37:07 PDT
ERROR 4049 , Restore from transaction log failed
    Log with fileId 6 is truncated or corrupt, or log 7 is
corrupt.
```

Logging in again and checking the restore status confirms that `tranlog6.dbf` is incomplete:

```
topaz 1> printit
SystemRepository restoreStatus
%
Restoring from Transaction Log files, restored to 05/02/20
13:51:19 PDT, next fileId = 6, record = 4409 oldest fileId = 6
```

After locating a complete, uncorrupted copy of `tranlog6.dbf`, it is copied into the appropriate directory and the restore is done again:

```
topaz 1> printit
SystemRepository restoreFromCurrentLogs
%
[Info]: Logging out at 05/24/20 14:37:07 PDT
Restore from transaction log(s) succeeded.
```

You can verify that this and any later transaction logs were restored by logging in again and checking the restore status:

```
topaz 1> printit
SystemRepository restoreStatus
%
Restoring from Transaction Log files, restored to 05/02/20
13:51:19 PDT, next fileId = 11, record = 4409 oldest fileId =
11
```

Since in this case all available transaction logs are now successfully restored, login again and commit the restored repository:

```
topaz 1> printit
SystemRepository commitRestore
%
Restore from transaction log(s) succeeded., commitRestore
succeeded
```

If you cannot find an undamaged copy of the transaction log, you cannot restore any further logs. Executing `commitRestore` will commit as much as has been restored. However, if there is any chance of a finding a good copy, see the discussion,"Precautions When Restoring a Subset of Transaction Logs".

Recovering from File System Problems

We recommend disk or operating system mirroring for applications that cannot tolerate the risk of data loss. In particular, recent transaction logs should be mirrored, or at minimum copied to an archive location on a frequent basis. In the case of a disk failure or a corrupt file system, if any of the transaction logs created since the last backup are corrupt or unusable, this recent work may be permanently lost.

In the case of disk failure or a corrupt file system, the file system must be repaired or restored. The most reliable strategy is to restore GemStone from backup, restoring copies of all transaction logs for which you have uncorrupted copies.

However, if you have important work that may be lost, you may want to attempt recovery of the existing repository. If each of these steps completes successfully, your repository is uncorrupted and you can resume normal operations.

Step 1. Perform page audit

Execute pageaudit per the instructions under "Page Audit" on page 134, to verify page-level integrity of the repository.

Step 2. Restart GemStone

Step 3. Perform object audit

Execute objectAudit per the instructions under "Object Audit and Repair" on page 135 to verify objects in the repository. This may take some time.

Some types of objectAudit failures indicate corruption in internal GemStone structures, which are rebuilt during restore of a full backup. If objectAudit reports errors, it may be worthwhile to attempt to make a fullBackup of the repository. If this succeeds, restoring it may provide a uncorrupted repository.

Chapter

12 Encrypted Extents and Transaction Logs

This chapter describes using encrypted extent files and tranlogs, how to manage these files, and some considerations when using encrypted extents and transaction logs with backup and restore.

Overview (page 247)
Explains GemStone's use of secured extents, transaction logs.

Encrypted Extents (page 248)
Describes how to setup encrypted extents and tranlogs.

Encrypted Extents with Backup and Restore (page 250)
Provides information on handling encrypted extent files and tranlogs in various kinds of restore and backup scenarios.

Modifying Encrypted Files (page 254)
Describes how to encrypt, decrypt, and change keys for encrypted extents, transaction logs, and backup files.

12.1 Overview

GemStone provides user and object level security to protect your application data from unauthorized access via applications or Smalltalk code execution. These objects also have persistent state on disk, which, depending on the specifics of your repository, may be vulnerable. The repository extents and backup files contain all repository objects, and the tranlogs record recent changes. The objects on disk are stored for efficiency of access and the contents is likely to include readable data. These disk files are normally protected by disk permissions from unauthorized access.

For applications with high security requirements, the default protections may not be sufficient. The extents, transaction logs and backup files can be configured to be written in encrypted form.

Encryption of extents, transaction logs, and backups (as well as signing of backup files), is done using OpenSSL libraries. OpenSSL is a robust, widely used toolkit for the Transport

Layer Security (TLS) and Secure Sockets Layer (SSL) protocols, and contains support for general-purpose cryptography. The GemStone distribution includes OpenSSL executables and libraries. For many OpenSSL functions, you may use your own OpenSSL installation if you prefer.

A full explanation of SSL key algorithms and the choice of which to use, and the details of generating keys, is outside the scope of this document, and SSL and security algorithms are under active development. You should review your application security requirements with the latest security recommendations and ensure that your security is sufficiently strong. Using encryption or signing with GemStone example keys from the distribution, for example, does **not** provide any security. You are responsible for integrating your own security procedures with the tools that GemStone provides, and verifying that your system has the appropriate security precautions for your requirements.

> For applications that are not limited to internal, secure networks, security is a critical. The usage in these examples is NOT sufficient to provide complete security.

When using encrypted extents, transaction logs backups you must put processes in place to avoid the dbf files being so secure that you yourself cannot read them.

- Ensure that you encrypt all files that are part of an extent, backup, or tranlog sequence with the same key.
- Retain older keys if you may need to use an older backups or tranlogs; or, update the keys of archived backups and tranlogs before discarding a key.
- Prior to encryption any dbf file, make a copy and verify that the encrypted dbfs are usable, before deleting the unencrypted version.

12.2 Encrypted Extents

With encrypted extent files, the on-disk extents are encrypted at all times. Transaction logs written by a Stone using encrypted extents are always written in encrypted form, using the same keypair as the Stone.

To use encrypted extents, you must manually encrypt the repository extent files prior to starting the Stone, using a public key or X.509 certificate. The **startstone** command takes additional arguments, specifying the private key. If the repository has more than one extent, all extents must be encrypted using the same key. Only one keypair can be associated with encrypted extents.

The encryption step is done using a public key; to start the stone on these extents, the private key corresponding to the public key (and the passphrase for the private key, if configured) are required. Encryption is done using AES-XTS symmetric encryption with a key length of 128 or 256 bits.

In an encrypted extent, all data in the extent is encrypted, except for a small number of records with metadata information. This unencrypted information also allows **copydbf -i** to report information without needing the key.

Once the Stone has started, the private key is not needed again until the next time the Stone is restarted. Pages from the extents are decrypted before reading into the cache, and

encrypted on write back to disk. Since the Stone may need restart at any time if an unexpected outage occurs, the private key must be keep readily available.

Internal handling for other sessions

The Stone uses the private key argument provided by **startstone** to decrypt the session key stored in each of the extents. Each extent has its own unique session key. This is stored in private stone memory, and so is not accessible to other sessions on the shared page cache. Processes that read or write to the extents need access to this key.

For gems, which may be on remote hosts over unsecured networks, a random key is generated and used to encrypt the keys, which are provided in shared memory for local gems, or over an encrypted SSL socket for remote gems.

The first gem to attach to a remote shared page cache stores the keys in the encrypted extent key table in the remote cache, under spin lock control.

Transaction Logs

Transaction logs written by a Stone using encrypted extents are written in encrypted form, using the same keypair as the extents. When the Stone is started, if recovery is needed (that is, on unclean shutdown), it will be able to recover from transaction logs since they were encrypted using the same key as was used to start the Stone.

If the encryption key of the extents have changed, on startup after a clean shutdown, the Stone will start a new transaction log that is automatically encrypted with the new keys. In this case, you must take care to keep the older keypairs, or update the encryption keys for the older tranlogs, if you want to be able to restore these older tranlogs into an older backup.

Note that the encryption key/s of a secure backup are entirely distinct from the encryption keys of the transaction logs. For restore, the tranlog encryption key will need to match the encryption key used to start the stone (or the Stone may be provided with the list of older transaction log keys). Once the secure backup is restored, the encryption key that was used to encrypt the backup is no longer relevant.

Restart and Recovery

If the stone unexpectedly shuts down, the private key is needed to restart the stone. Automatic recovery from transaction logs requires that all required transaction logs for recovery be encrypted using the same key as the stone. If necessary, the transaction logs may have their keys updated using **updatesecuredbf**.

Programmatic Backups

Making a programmatic backup of a repository running with encrypted extents does **not** automatically create an encrypted backup.

Independently of extent encryption:

- the standard methods `Repository >> fullBackupTo:...` make unencrypted backups.
- the secure backup methods `Repository >> secureFullBackupTo:...` make encrypted or unencrypted/signed backups, using the key/s provided to that method.

Extent Copy Backup

An extent copy backup of a repository with encrypted extents is, of course, encrypted.

Ensure that the private key remains available in order to decrypt or restore. If the certs and keys need to be updated, you can use **updatesecuredbf** on the extent copy backups, but you will need to use the **-O** option, since the extents were not cleanly shutdown.

Example Setting up Encrypted Extents

The following example shows the steps to encrypt a two-extent repository with a key from the GemStone distribution. Note that this does not provide security; you must generate your own private key meeting your own security requirements.

Step 1. Stop the Stone cleanly. While it is possible to encrypt an extent that is not cleanly shutdown, you would also need to encrypt the tranlogs needed for recovery.

```
unix> stopstone stoneName administrativeUser password
```

Step 2. Make encrypted copies of your extents using copydbf.

```
unix> copydbf $GEMSTONE/data/extent0.dbf
   $GEMSTONE/data/secextent0.sdbf -e server_1_servercert.pem
   -s 256 -K $GEMSTONE/examples/openssl/certs

unix> copydbf $GEMSTONE/data/extent1.dbf
   $GEMSTONE/data/secextent1.sdbf -e server_1_servercert.pem
   -s 256 -K $GEMSTONE/examples/openssl/certs
```

Step 3. Edit the configuration file used by the Stone to specify the new extent names.

```
DBF_EXTENT_NAMES = $GEMSTONE/data/secextent0.sdbf,
   $GEMSTONE/data/secextent1.sdbf;
```

Step 4. Execute startstone using the private key.

```
unix> startstone -D server_1_serverkey.pem
   -J $GEMSTONE/allcerts/server_1_server_passwd.txt
   -K $GEMSTONE/examples/openssl/certs
   -K $GEMSTONE/examples/openssl/private gs64stone
```

On startup, the Stone will immediately start a new transaction log that is encrypted with the key `server_1_servercert.pem`.

Using the stone, and stopping the stone, now proceed as with any GemStone installation.

12.3 Encrypted Extents with Backup and Restore

How to make and restore the various kinds of backups, including encrypted backups, is described in the *System Administration Guide*, Chapter 11. Making a backup in a repository configured with secure extents is no different than making a backup with ordinary extents, and restoring a backup is much the same.

However, if the encryption key for the Stone changes during the course of operation, some transaction logs may be written with different encryption keys. You must either update the

transaction logs's encryption, or provide the older keys to the Stone, before these transaction logs can be replayed.

Restoring Backups

When restoring a programmatic fullbackup to a system that is using encrypted extents, you will need to start with a clean, **encrypted** extent (in order to continue using encrypted extents). This requires an additional step to use **copydbf** to encrypt a clean, empty extent.

Alternately, you can restore into an unencrypted extent, and then shut down the restored stone, encrypt the extent files, and restart.

All **startstone** invocations will require the appropriate key for the encrypted extents of the Stone you are restoring, regardless of any encryption in the fullbackup.

The restore process is similar to the processes described in Chapter 11, under:

- **Restoring from an Extent Snapshot Backup** (page 225)
- **Restoring from a Full Backup** (page 228)
- **Restoring a secure backup** (page 234)

Restoring transaction logs

No changes in encryption keys

When using encrypted extents, the transaction logs are also encrypted with the same keypair as the Stone. As long as all required transaction logs for restore are encrypted with the same keypair as the newly restored Stone (or not encrypted), then restoring transaction logs into a Stone with encrypted extents follows the same process as restoring into a Stone with regular (non-encrypted) extents.

Changes in encryption keys

When using encrypted extents, over time you may change the keypair used to encrypt the extents (using **updatesecuredbf** or **copydbf** twice to decrypt and re-encrypt). When the stone is restarted with the new key, it will create a new transaction log that is encrypted using the new keypair. Since the full series of transaction logs will be encrypted with multiple keys, special handling is required to allow all the transaction logs to be restored.

There are several options:

- Use **updatesecuredbf** to update the encryption key for every transaction log so it is using the current Stone's encryption key. Any tranlogs that do not have the Stone's encryption key cannot be read, and restore will stop there.
- Use the method `Repository >> setTranlogPrivateKeysForRestore:` to provide the stone with the private key for all of the transaction logs that you will be restoring. Any transaction logs using keys that are not provided to the stone cannot be read, and restore will stop there.
- Always make backups immediately after changing the encryption key, and set up your systems for backup and restore, such that you will never need to restore older encrypted repositories. For example, you may decrypt the older backups and transaction logs and archive these as insecure files using your own secure storage mechanisms.

Update transaction log keys

The following examples updates a tranlog that was previously encrypted with `server_1_servercert.pem` to the new key, `server_3_servercert.pem`. Both keys must be provided so the tranlog can be read using the old key, and re-encrypted with the new key.

```
unix> updatesecuredbf tranlog1.sdbf -e server_3_servercert.pem
   -D server_1_serverkey.pem
   -J $GEMSTONE/examples/openssl/certs/server_1_server_passwd.txt
   -K $GEMSTONE/examples/openssl/certs
   -K $GEMSTONE/examples/openssl/private
```

Providing private keys to the Stone in Smalltalk code

Rather than updating all the keys for existing transaction logs, you may pass into the stone all the private keys for all the transaction logs that you will be restoring, using the method `Repository >> setTranlogPrivateKeysForRestore:` and creating instance of GsTlsPrivateKey.

`Repository >> setTranlogPrivateKeysForRestore:` *arrayOfGsTlsPrivateKey*
Specifies a list of instances of GsTlsPrivateKey representing private keys, that will be used to read encrypted tranlogs during a restoreFromArchiveLogs operation. The private key used to start the stone does not need to be included.

During a restoreFromArchiveLogs operation, the stone searches *arrayOfGsTlsPrivateKey* for a match to the public key stored in the encrypted tranlog. An error is raised if no match is found, and the restore operation fails.

`GsTlsPrivateKey class >> newFromPemFile:` *pemFilename*
Create an instance of GsTlsPrivateKey for the private key in the given filename. This key must not require a passphrase.

`GsTlsPrivateKey class >> newFromPemFile:` *pemFilename*
`withPassphraseFile:` *passPhraseFilename*
Create an instance of GsTlsPrivateKey for the private key in the given filename. The key in this file is assumed to require a passphrase, which is in the given passphrase file.

There are other instance creation methods on GsTlsPrivateKey; refer to the image for other options.

Once GsTlsPrivateKeys are provided to the Stone, this list of keys is saved in the Stone, so you may execute this expression multiple times with new arguments, without losing key information.

Example 12.1 Setting tranlog keys for restore

```
topaz 1> run
SystemRepository setTranlogPrivateKeysForRestore: {
(GsTlsPrivateKey newFromPemFile:
     '$GEMSTONE/examples/openssl/private/server_1_serverkey.pem'
   withPassphraseFile:
     '$GEMSTONE/examples/openssl/private/server_1_server_passwd.txt')
 .
(GsTlsPrivateKey newFromPemFile:
     '$GEMSTONE/examples/openssl/private/server_2_serverkey.pem'
   withPassphraseFile:
     '$GEMSTONE/examples/openssl/private/server_2_server_passwd.txt')
   }
%
```

After this is executed, the Stone can restore transaction logs encrypted with `server_1_servercert.pem` or `server_2_servercert.pem`, as well any tranlogs created with the current Stone's encryption key `server_3_servercert.pem`.

Page Audit

To run **pageaudit** on a system with encrypted extents, you must include the same private key information as when starting a stone.

For example, when the extent files for a repository are encrypted using the key `server_2_servercert.pem`, then the following invocation will allow pageaudit to execute:

```
unix> pageaudit -D server_2_serverkey.pem
    -J $GEMSTONE/examples/openssl/private/server_2_server_passwd.txt
    -K $GEMSTONE/examples/openssl/private
```

Hot Standby

You may use encrypted extents within a warm or hot standby system. The logsender and logreceiver do not require any special configuration; they pass along the records without decrypting them.

The slave stone must be started with the same encryption key as the master stone, so that the process restoring the tranlogs is able to decrypt them. If the encryption key on the master is changed, you should also update the encryption key on the slave's extents.

Alternatively, if the encryption key on the master system has changed, you can provide the new key to the slave system using `setTranlogPrivateKeysForRestore:`. However, this is not retained over shutdown/restart of the slave system, since it is in restore mode. After a restart of the slave system you will need to execute `setTranlogPrivateKeysForRestore:` again.

12.4 Modifying Encrypted Files

The utilities **copydbf** and **updatesecuredbf** allow you to perform a number of operations on encrypted extents, transaction logs, and backup files.

copydbf allows:

- copy the file without changing encryption state
- encrypt an extent or transaction log file (backups cannot be encrypted using copydbf)
- decrypt an extent, transaction log, or backup to a regular file

updatesecuredbf allows:

- change the encryption key of an extent or transaction log, or one of the encryption keys of an encrypted backup, to a different key.

Note that it is possible to create secure backups that are signed, but not encrypted. The signing key for these backups cannot be changed, and these backups cannot be converted into encrypted nor into regular files.

Creating extent or transaction log files that are both encrypted and compressed is not supported. Manually compressing an encrypted dbf file is unlikely to provide much improvement on disk space use, since the encryption makes the bytes appear random and thus not compressible.

Examples

Keys are not needed to make a copy of an encrypted dbf. **copydbf** on an encrypted file, without using decryption keys, results in a file that is encrypted with the same key as the source file.

To encrypt an extent

This example encrypts the distribution extent into `secextent0.sdbf`.

```
unix> copydbf $GEMSTONE/bin/extent0.dbf
   $GEMSTONE/data/secextent0.sdbf -e server_2_servercert.pem
   -s 256 -K $GEMSTONE/examples/openssl/certs
```

If you have multiple extents, you must encrypt **all** extents with the same key, to be able to start a Stone.

The same process can be used to encrypt an extent snapshot backup. Unencrypted programmatic fullbackups cannot be encrypted using **copydbf**.

You may also encrypt an unencrypted transaction log, although normally encrypted transaction logs are created by a Stone using encrypted extents.

To start a stone on an encrypted extent

When the Stone's configuration file specified extent files that are encrypted using the key `server_2_servercert.pem`, then the following invocation will start the stone on those extents.

```
unix> startstone -D server_2_serverkey.pem
   -J $GEMSTONE/examples/openssl/private/server_2_server_passwd.txt
   -K $GEMSTONE/examples/openssl/private gs64stone
```

To decrypt an extent or extent snapshot backup

This example decrypts `secextent0.sdbf`, which was encrypted with `server_2_servercert.pem`, into `decrypextent0.dbf`.

```
unix> copydbf secextent0.sdbf decrypextent0.dbf
   -D server_2_serverkey.pem
   -J $GEMSTONE/examples/openssl/private/server_2_server_passwd.txt
   -K $GEMSTONE/examples/openssl/certs
   -K $GEMSTONE/examples/openssl/private
```

If you have multiple extents, you must decrypt **all** extents to be able to start a Stone.

To decrypt an extent or extent snapshot backup

This example decrypts `sectranlog1.sdbf` into `decryptranlog1.dbf`.

```
unix> copydbf sectranlog1.sdbf decryptranlog1.dbf
   -D server_2_serverkey.pem
   -J $GEMSTONE/examples/openssl/private/server_2_server_passwd.txt
   -K $GEMSTONE/examples/openssl/certs
   -K $GEMSTONE/examples/openssl/private
```

Decrypted transaction logs can be restored without special handling, including in a series with other transaction logs that are encrypted.

To change the key of an encrypted extent or extent snapshot backup

This example updates the original key `server_2...` to `server_3...` The modification is done to `secextent0.dbf` in place; we recommend making a copy before using **updatesecuredbf**.

The stone using this extent must have been shut down cleanly.

```
unix> updatesecuredbf secextent0.sdbf
   -e server_3_servercert.pem -D server_2_serverkey.pem
   -J $GEMSTONE/examples/openssl/private/server_2_server_passwd.txt
   -K $GEMSTONE/examples/openssl/certs
   -K $GEMSTONE/examples/openssl/private
```

If you have multiple extents, you must update the keys for **all** extents to the same key to be able to start a Stone.

To change the key of an encrypted transaction log

This example updates the original key `server_2...` to `server_3...` The modification is done to `sectranlog1.dbf` in place; we recommend making a copy before using **updatesecuredbf**.

```
unix> updatesecuredbf sectranlog1.sdbf
   -e server_3_servercert.pem -D server_2_serverkey.pem
   -J $GEMSTONE/examples/openssl/private/server_2_server_passwd.txt
   -K $GEMSTONE/examples/openssl/certs
   -K $GEMSTONE/examples/openssl/private
```

Transaction logs are normally part of a series that are retained to allow restore. Before a transaction log can be restored, it must either be using the same key as the extents for the

Stone into which it is being restored, or the keys must be supplied using `setTranlogPrivateKeysForRestore:`.

To change the encryption key of an encrypted fullbackup

Encrypted programmatic fullBackups are always signed; you will need to supply the signing key (and passphrase, if required), as well as the previous and new encryption keys.

Encrypted backups may be encrypted with up to 8 different public keys, and the private key corresponding to any of these public keys can be used to decrypt. An invocation updatesecuredbf changes a single one of these public key encryptions, leaving the others unchanged.

```
unix> updatesecuredbf encryptedBackup1.sdbf
   -e backup_encrypt_2_clientcert.pem
   -J $GEMSTONE/examples/openssl/private/backup_encrypt_1_clientce
   rt_passwd.txt -D backup_encrypt_1_clientcert.pem
   -S backup_sign_3_clientkey.pem
   -T $GEMSTONE/allcerts/backup_sign_3_client_passwd.txt
   -K $GEMSTONE/examples/openssl/certs
   -K $GEMSTONE/examples/openssl/private
```

For a multi-file fullbackup, you must update they keys for **all** backup files to allow them to be used for restore.

To decrypt a fullbackup

This example decrypts `encryptedBackup1.sdbf` into `Backup.dbf`, using the private encryption key `backup_encrypt_2_clientkey.pem`.

```
unix> copydbf encryptedBackup1.sdbf Backup.dbf
   -D backup_encrypt_2_clientkey.pem
   -J $GEMSTONE/examples/openssl/private/backup_encrypt_2_client_p
   asswd.txt -K $GEMSTONE/examples/openssl/certs
   -K $GEMSTONE/examples/openssl/private
```

For a multi-file fullbackup, you should decrypt **all** backup files to allow them to be used for restore.

Chapter

13 Warm and Hot Standbys

For high-availability production systems, it is a serious problem if the repository has an unexpected error and has to be shut down, or possibly require restore from backup. While such problems are rare, critical systems must be prepared.

For such systems, a second GemStone system can be kept running in parallel, so it can be brought into use with minimal downtime. GemStone provides several options for standby systems.

Warm Standby (page 258)
describes a standby system in which entire transaction logs may be manually transmitted and restored into the standby system.

Hot Standby (page 260)
describes how to setup processes to automatically transmit transaction log records as they are generated, and automatically restore the records into the standby

13.1 Overview

Customers with critical, high-availability systems may want to keep a duplicate of a production GemStone server running almost in parallel as a standby system. This duplicate continually runs in restore mode, restoring transactions from the production server. If anything goes wrong with the primary production server, the standby can be brought into use very quickly.

The production system is referred to here as the primary or master system. The standby system is also referred to as the slave system.

Following a failover, these roles change; the standby system becomes the master and users log in to perform work. Often the system that was previously the master, after correcting the problem that caused failover, is updated to become the new standby.

To operate a standby, the primary system must be running in full logging mode, as described under “Logging Mode” on page 48.

This chapter discuss how to set up the standby server and the process for restoring logs, which differ between warm and hot standbys. For general information about restoring

backups and transaction logs, see "How to Restore from Backup" on page 224. This discussion assumes you are familiar with that procedure.

13.2 Warm Standby

With a warm standby, transaction logs from the primary system are manually copied to the standby system as each log is completed. The standby runs in restore mode, and restores each log as it is closed.

When failover is needed. the final transaction log from the primary is copied over and restored, and the standby system performs a commitRestore and is then available for use as the new primary server.

An important point to remember is that the transaction logs copied from the production server, called the *archive logs* here, must be kept separate from transaction logs created by the duplicate server. You can do that by using different log directories or different file name prefixes.

Setup and run the warm standby

Step 1. Install the duplicate server. It is best to do a complete GemStone installation on a second node.

Step 2. Decide on a naming convention or location that you will use on the duplicate server to keep the archive logs separate from those being created by the duplicate server itself. For instance, if both Stones use the default prefix of *tranlog*, you might copy `tranlog123.dbf` on the production server to `$GEMSTONE/data/prodtranlog123.dbf` on the duplicate server.

Step 3. Make an extent copy backup, or a full backup of the primary system. You'll have to do this at least once, when you start this system; however, regular backups will simplify matters when you need to synchronize the primary and the standby systems.

Step 4. Copy the extent backups, or restore the full backup, into the duplicate server. If you use extent copies, use the -R option to start the Stone, which causes the Stone to enter restore mode. For instance, **startstone -R**.

Step 5. As each transaction log completes on the primary system, move the log to a file system accessible to the warm standby GemStone installation. Avoid moving these logs into the transaction log directory that the warm standby uses for its own transaction logs.

Wait several seconds after the new log is created before copying the old log, to ensure the completion of any asynchronous writes.

You can limit each transaction log to a tolerable amount of information either by limiting transaction log size or by starting a new log at regular time intervals:

- *Size-based:* Limit the transaction log size, as described under "Choosing the Log Location and Size Limit" on page 49. When a transaction log grows to the specified limit, GemStone starts a new transaction log.
- *Time-based:* On your primary system, run a script at regular intervals that terminates the current transaction log and starts a new one, using the method `System class >> startNewLog`.

Step 6. On the warm standby, restore the transaction logs as they are available.

Since the transaction logs for the primary are not in the STN_TRAN_LOG_DIRECTORIES of the standby, you will restore from an archive log directory for these tranlogs. You can restore from an archive log directory using one of the following methods:

```
Repository>>restoreFromArchiveLogs:
Repository>>restoreFromArchiveLogs:tranlogPrefix:
Repository>>restoreFromArchiveLogs:toEndOfLog:
Repository>>restoreFromArchiveLogs:toEndOfLog:tranlogPrefix:
```

The `tranlogPrefix:` argument allows you to use a different setting for STN_TRAN_LOG_PREFIX on the production and standby systems.

Since restoring transaction logs terminates the session, you will need to login for each restore. For example:

```
topaz> login
<details omitted>
successful login
topaz 1> printit
System restoreFromArchiveLogs: {'GS-archive'}.
%
```

Step 7. Repeat Step 5 and Step 6 as necessary.

You may find it necessary to shut down the standby from time to time. Ensure that you shut down the stone using stopstone. This does not affect the restore status.

Note that if the standby is not shut down cleanly (i.e. an unexpected shutdown), the restarted system has the status of its last checkpoint. You may need to restore tranlogs again that were previously restored.

Activate the warm standby in case of failure in the primary

Step 1. If the primary system fails, replay its latest transaction log on the standby system.

Step 2. On the standby server, send the message `Repository>>commitRestore` to terminate the restore process and enable logins.

Step 3. Client applications will have to reconnect to the standby system, which now becomes the primary system. Applications may have to perform their own failure recovery code as necessary, as well.

NOTE

Design your application and configuration so that, after a failure occurs and the standby is activated, client applications can reconnect to the new primary correctly.

Step 4. Correct the problem on the failed system and restart it.

Depending on how much time has elapsed since the standby system became the primary system, either make a full backup of the new primary system and restore it on the system that failed, or replay the new primary system's transaction logs on the system that failed. Maintain that system in restore mode as the new standby.

13.3 Hot Standby

A Hot Standby provides faster failover since it can always remain synchronized with the primary server. If failover is needed, all that is required is to stop tranlog transmittal and restore, perform the final commitRestore, and the repository is ready for use.

As with the warm standby, a backup of the primary (or master) repository is installed on a standby (or slave) system. Then, special processes run to transmit the transaction log records as they are generated on the primary system. Individual transaction records, rather than entire transaction logs, are transmitted in compressed form between the systems. The standby system runs in a special mode where it will continuously restore the transaction log records. As a result, the standby system can keep closely synchronized with the primary.

Precautions regarding tranlog sequences

Since the hotstandby process relies on a logical sequence of tranlogs, some care must be taken to avoid situations such as described under "Fork-in-Time Scenario" on page 242.

For example, if you restore from backup on the primary, you must make a new backup of the primary, and restore this into the hot standby. Likewise, you cannot restore a backup into both the primary and the standby, since this creates a fork in the logical sequence of tranlogs, regardless of the tranlog numbering. While in some cases the automated process that transmit and restore the transaction log records will detect this, hotstandby systems should be managed with care to avoid any risk of issues.

Encrypted Extents and Transaction logs

On a hotstandby system with encrypted extents, the transaction logs are automatically encrypted. As long as the slave system uses the same key as the master, and the encryption keys do not change, there is no special handling required, other than the arguments provided to **startstone** to start the master and slave systems.

However, if the encryption key is changed on the master, the slave stone will not be able to restore any subsequent transaction logs without additional steps. This is described under "Handling encrypted extents the master Stone" on page 267; also, ensure you have carefully read Chapter 12 on handling encryption keys.

Hot standby processes

logsender

The **logsender** process runs on the master system. It determines when new transaction records are available on the primary system, and sends these records in compressed form to the standby slave system.

The logsender process is started using the **startlogsender** utility command. When starting the logsender, you must specify:

- The address and port to listen on for connections from a logreceiver on a slave system.
- The name of the master stone, or the list of all directories or raw partitions containing transaction logs generated by the master system, to provide the complete set of

transaction logs containing data to be transmitted. It is strongly recommended to provide the Stone name.

There are other optional arguments. See **startlogsender** on page 391 for more specific information on the arguments for this command.

A logsender continues to run when the associated master stone is shut down, and will check every few seconds for the master stone to be restarted, so it can reconnect. Since it is continuously listening for connection requests from a logreceiver, the connection with the logreceiver can also be automatically reestablished after a disconnect, provided the logreceiver is running.

The logsender must be stopped explicitly using the **stoplogsender** utility command. See **stoplogsender** on page 405 for more details.

logreceiver

The **logreceiver** process runs on the standby slave system. It receives transaction logs from the master system and writes them to a location where the slave stone can restore them.

The logreceiver process is started using the **startlogreceiver** utility command. When starting the logreceiver, you must specify:

- The address and port that the logsender on the master system is listening on.
- One or more directories to write incoming transaction logs from the master system. It is not recommended to use raw partitions.
- The name of the slave stone. While technically optional, without this the logreceiver cannot notify the slave stone that new data has arrived.

There are other optional arguments. See **startlogreceiver** on page 389 for more specific information on the arguments for this command.

A logreceiver continues to run when the associated slave stone is shut down, and will check every few seconds for the slave stone to be restarted, so it can reconnect. If the connection to the logsender is lost, the logreceiver will attempt to reconnect.

The logreceiver must be stopped explicitly using the stoplogreceiver utility command. See **stoplogreceiver** on page 404 for more details on this command.

Continuous Restore Mode

A slave system in a hot standby runs in continuous restore mode. In this mode, it can restore individual transaction records as they become available.

To enter continuous restore mode, execute:

```
SystemRepository continuousRestoreFromArchiveLogs:
    anArrayOfRestoreDirectories
```

To exit continuous restore mode, execute:

```
SystemRepository stopContinuousRestore
```

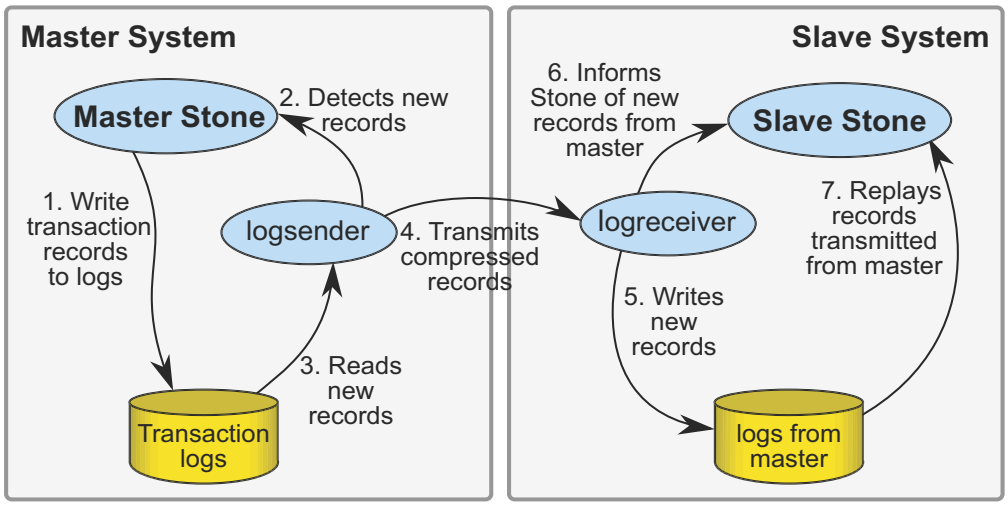
You must be in restore mode before you can enter continuous restore mode, and executing `stopContinuousRestore` leaves the stone still in restore mode.

You may not execute the `commitRestore`, which exits from restore mode, without first exiting continuous restore mode.

Transaction Record Transmittal

The process that transaction records follow from the master to the slave is described in this section.

Figure 13.1 High-level sequence of operations and processes in a hot standby



As transactions are committed on the master stone, transaction log records are written to the transaction logs. The logsender process is logged into the master stone and is aware when new transaction records are generated. The logsender also has an established connection with the logreceiver process. The logsender transmits the transaction log records in compressed form to the logreceiver.

The logreceiver accepts the transaction log records and writes them to the slave system's directories for restore logs. The logreceiver is logged into the slave stone, and makes the slave stone aware that new transaction records are available for restore.

The slave stone is running in continuous restore mode, and restores the transaction records.

When a logsender or logreceiver is logged into a stone, or while a stone is in continuous restore mode, the stone cannot restore a full backup or restore tranlogs (using other restore methods), nor can it perform a commitRestore.

Multiple standby repositories

A given master stone may have multiple slave stones. Each slave system will have a separate logreceiver process running. The logsender on the master system can transmit data to up to 5 logreceiver processes.

To setup and run the hot standby

Step 1. Install the slave server. It is best to do a complete GemStone installation on a second node.

Step 2. Decide on a directory location that you will use on the slave server to keep for the logs transmitted from the master. This should be a separate directory or directories from the tranlog directories of the slave stone.

Step 3. Restore a backup of the master system into the slave. There are several options:

- ❒ Make a programmatic full backup of the primary system. This must be a backup from the primary system; **you cannot restore a programmatic backup into both the primary and standby**, since `commitRestore` creates a fork-in-time (see page 242).

  On the slave system, start the stone on a clean extent using `startstone -R`, and restore the full backup. Do not explicitly restore any transaction logs, nor `commitRestore`.

- ❒ Make an extent copy backup, either while the master stone is shutdown, or with checkpoints suspended. You can restore an extent copy backup into both the master and slave; the current transaction log from the time of the extent copy backup must be online and available. This includes an extent copy from a repository that was shutdown cleanly; the transaction log that was current at the time of a clean Stone shutdown will be needed, since no recovery can be done on the slave.

  Copy the extent copy backup files to the slave system, and start the stone using `startstone -N -R`, so that the slave system is in restore mode.

You'll have to do this at least once, when you start this system, and after each restore from backup or upgrade on the primary system. Regular backups will simplify matters when you need to synchronize the primary and the standby systems.

Step 4. Start the logsender process on the master system using the **startlogsender** utility.

Before starting the logsender, you will need to determine the set of directories that contain transaction logs on the master system. This will include all the entries in the master stone's STN_TRAN_LOG_DIRECTORIES. If the master stone's transaction logs are copied to another directory as part of an archive process, these archive directories may also need to be specified.

You will also need to select an port number that is unused on the master and slave systems for the logsender to listen on.

For example:

```
startlogsender -P 57222 -A masterListeningAddress -s masterStone
```

Step 5. Start the logreceiver process on the slave system using the **startlogreceiver** utility.

You will use the same port as the logsender, and the directory or directories you determined in Step 2

```
startlogreceiver -P 57222 -A masterNode
   -T /gemstone/masterTransLogs -s slaveStone
```

Step 6. Put the slave stone into continuous restore mode. To do this, log into the slave system and execute `Repository >> continuousRestoreFromArchiveLogs:`, passing in the list of directories you determined in Step 2 After entering continuous restore mode, this method will exit and you can log out.

```
topaz 1> run
SystemRepository continuousRestoreFromArchiveLogs:
   {/gemstone/masterTransLogs}
```

Activate the hot standby when master system is not usable

In case of a failure in the master system, perform the following steps:

Step 1. Confirm that all tranlog records have been transmitted to the slave system, and that the slave system has restored all transaction log records.

If the master system is operational, `Repository >> failOverStatus` on the master will provide both the current tranlog record and the failover (slave) stone's restored tranlog record.

If the master system is not available, check the results of `Repository >> restoreStatus` on the slave system, and compare this to the results of **copydbf -i** on the final tranlog on the master system.

Step 2. If the master system is operational, stop the logsender process on the master system using the **stoplogsender** utility command.

```
stoplogsender -P 57222
```

Step 3. On the slave system, stop the logreceiver process using the **stoplogreceiver** utility command.

```
stoplogreceiver -P 57222
```

Step 4. On the slave system, execute `SystemRepository stopContinuousRestore` to exit continuous restore mode, then `SystemRepository commitRestore` to terminate the restore process and enable logins. The slave system is now ready for use as the new master.

Step 5. If you have changes in the configuration parameters for the slave system, you should reset these to the values that you want for the master, in the configuration file/s used by the former-slave system. Depending on the specific parameters, you may need to restart the former-slave system for these changes to take effect.

You will also need to enable any automated processes that you normally run on the master, such as monitoring, on the former-slave system.

Step 6. Client applications will have to reconnect to the former-slave system, which now becomes the primary system. Applications may have to perform their own failure recovery code as necessary, as well.

Step 7. Correct the problem on the failed former-master system, and restart this as the new slave system, following steps 3-6 under "Setup and run the warm standby" on page 258.

Note that in this failover process, you need to make a fresh backup of the new master system, and restore this into the new slave (the former master), as the first step in setting back up the hot standby.

Failovers with immediate role reversal

Planned failovers, or failovers when the master system is operational and can be immediately put into use as a slave system, can simplify the effort of setting up the new slave system, by using `failOverToSlave` on the master. This informs the master that the roles are reversing.

This is the full set of step required to perform a failure with role reversal:

Step 1. Confirm that all tranlog records have been transmitted to the slave system, and that the slave system has restored all transaction log records.

On the master system, execute

```
SystemRepository failOverStatus
```

and verify that the master and slave are on the same log and record.

Step 2. On the master system, execute:

```
SystemRepository failOverToSlave
```

which will suspend commits, and perform a checkpoint, and enter restore from logs mode. Commits are disallowed. Do not shut down the master stone.

Step 3. Stop the logsender process on the master system using the **stoplogsender** utility command.

```
stoplogsender -P 57222
```

Step 4. On the slave system, stop the logreceiver process using the **stoplogreceiver** utility command.

```
stoplogreceiver -P 57222
```

Step 5. On the slave system, execute `SystemRepository stopContinuousRestore` to exit continuous restore mode, then `SystemRepository commitRestore` to terminate the restore process and enable logins. The slave system is now ready for use as the new master.

Step 6. If you have changes in the configuration parameters for the slave system, you should reset these to the values that you want for the master, in the configuration file or files used by the former-slave system. Depending on the specific parameters, you may need to restart the former-slave system for these changes to take effect.

You will also need to enable any automated processes that you normally run on the master, such as monitoring, on the former-slave system.

Step 7. Client applications will have to reconnect to the former-slave system, which now becomes the primary system.

Step 8. Start the logsender process on the former slave, new master system using the **startlogsender** utility.

```
startlogsender -P 57222 -A masterListeningAddress -s masterStone
```

Step 9. Start the logreceiver process on the former master, new slave system using the **startlogreceiver** utility. You will need to have transaction log directories available for the logreceiver to put the transaction logs transmitted from the master.

```
startlogreceiver -P 57222 -A masterNode -T tranlogDirectories
    -s slaveStone
```

Step 10. Put the former master, now slave stone into continuous restore mode. To do this, log in and execute `Repository >> continuousRestoreFromArchiveLogs:`, passing in the list of directories.

After entering continuous restore mode, this method will exit and you can log out. The hot standby is now operational in the reverse direction.

Connecting using SSL Mode

Generally, both master and slave nodes of a hot standby would be within your secure network, and benefit from the ease and performance of regular socket connections.

However, you may also configure the logsender-logreceiver connection to use SSL, if the network between your master and slave system is not secure.

When you run the hotstandby in SSL mode, you will need SSL credentials for both the logsender and logreceiver in order for them to connect.

SSL standard TLS v1.2 is used.

The SSL-specific arguments are optional, and include:

-C *fileName*	certificate in PEM format that will be sent to the peer upon request.
-J *fileName*	certificate authority (CA) file in PEM format to use for peer certificate verification.
-K *fileName*	private key in PEM format for the certificate (-C option).
-Q *string*	private key passphrase. Required if the -K option is used and theprivate key is encrypted.
-S	enable SSL mode. Must be specified to use any other SSL options and must also be specified when starting the peer process.
-V	Disable verification of the peer's certificate.

For example, to setup a logsender/logreceiver with certificate verification fully enabled, using the example certificates provided with the GemStone/S 64 Bit distribution:

```
startlogsender -A santiam.gemtalksystems.com -P 57222 -s masterStone
   -T $GEMSTONE/data
   -S -J $GEMSTONE/examples/openssl/certs/cacert.pem
   -C $GEMSTONE/examples/openssl/certs/server_1_servercert.pem
   -K $GEMSTONE/examples/openssl/private/server_1_serverkey.pem
   -Q ax3vd1PI6tkQEaW9EliXW2Lbzm9qgOA1bcsDudngRAkdpA8ffwcVnA==

startlogreceiver -A santiam.gemtalksystems.com -P 57222 -s slaveStone
   -T $GEMSTONE/masterTranlogs
   -S -J $GEMSTONE/examples/openssl/certs/cacert.pem
   -C $GEMSTONE/examples/openssl/certs/client_1_clientcert.pem
   -K $GEMSTONE/examples/openssl/private/client_1_clientkey.pem
   -Q rFjqh4Q71Bh+6mAH8U1tFJFvZUzZkUIyLY+7A7mU0bT450c9voEvWA==
```

Self signed certificates

By default, self-signed certificates will be rejected, because the certificate cannot be verified by a known certificate authority. To use self-signed certificates, the signer must be added to the CA list in the CA file (-J flag), or certificate verification must be disabled with the -V flag. Using -V effectively tells OpenSSL to ignore certificate errors. In this mode, communications between the logsender and receiver are encrypted, but the identities of the logsender and/or logreceiver have not been verified.

Handling encrypted extents the master Stone

GemStone supports encryption of the on-disk extents, and when the repository extents are encrypted, the transaction logs are automatically encrypted with the same key. The logsender/logreceiver can transmit the records from the master system to the slave system without decryption, but the slave Stone must be able to decrypt the transaction log records.

Master and Slave have the same encryption

Normally, the master and slave Stones would both use encrypted extents with the same encryption key. Both master and slave Stones are started with that key, and the slave can read the encrypted transaction logs produced by the master without further effort.

If you need to change the encryption key for the master system, this can be modified by using **updatesecuredbf** when the Stone is not running. When the master Stone is then started up with a new key, it will start a new tranlog that is encrypted with a new key. This will present problems for the slave system.

The recommended solution is to also update the encryption key for the slave Stone's extents to match the key on the master Stone's extents. This can be either by shutting down the slave Stone and restoring an extent copy backup into the slave, or by shutting down the slave Stone and executing **updatesecuredbf** on the slave's Stone's extents.

Slave encryption independent of Master

It is not required that the slave Stone use the same encryption keys as the master, or even that the Slave extents be encrypted at all. However, the slave Stone must be able to read the encrypted tranlogs provided by an encrypted master Stone.

You can pass the encryption keys that the master is using to the slave, using `SystemRepository setTranlogPrivateKeysForRestore:`, and providing an instance of GsTlsPrivateKey for the master extent encryption key. Note that since information is not retained while in restore mode, you will need to execute this again if you shutdown and restart the slave system.

For example:

```
topaz 1> run
SystemRepository setTranlogPrivateKeysForRestore: {
   GsTlsPrivateKey newFromPemFile:
      '$GEMSTONE/examples/openssl/private/server_2_serverkey.pem'
    withPassphraseFile:
      '$GEMSTONE/examples/openssl/private/server_2_server_passwd.txt'
   }.
%
```

Added transaction logs to the master

If you anticipate the need to add transaction log directories or raw partitions to the master stone, use the **-s** *stoneName* argument rather than **-T** *tranlogDir* with **startlogsender**. The logsender will automatically pick up configured tranlogs for the Stone when **-s** is used. This includes transaction logs added dynamically using `Repository >> addTransactionLog:size:`.

13.4 Tuning a Warm or Hot Standby

The key consideration in tuning your standby system is keeping the standby as up-to-date as possible, so it will be ready if needed. This differs from the tuning priorities on your production system, which must balance user commit activity against background maintenance operations.

As your standby replays transactions, it duplicates the work that was performed on the primary system. Large operations that take considerable time on the production system will also require time on the standby.

Tuning Reclaim

When transactions from the production system are replayed, and create a large amount of reclaim work to be done, the time that this reclaim takes can be a significant bottleneck.

The parameters that are used to tune reclaim in your primary system may be set to values that ensure that reclaim does not delay user commits, which does not provide optional reclaim performance for the standby.

To tune reclaim on your standby, set the ReclaimGem configuration parameters to standby-specific values using the runtime interface.

For example, if you have set the parameter `#sleepTimeBetweenReclaimMs` to a nonzero value in your production system, to ensure that ReclaimGem activity does not block user sessions, you can reset this to zero in the standby system:

```
System setReclaimConfig: #sleepTimeBetweenReclaimMs toValue: 0
```

This will need to be executed again if you stop and restart your standby system, since it is not a persistent change; recall that you cannot commit persistent changes to a repository in restore mode.

For a full set of Reclaim Gem configuration parameters, see “Tuning Reclaim” on page 295.

Chapter

14 Managing Gem Memory

Executing your application code will naturally require access to previously committed objects in the repository. These objects are faulted into the Gem session's memory to be examined or updated. When new objects are created, they must reside in memory while they are being modified.

GemStone automatically garbage-collects temporary objects that are no longer referenced, and clears out the space used by persistent, committed objects, when memory is needed. However, the memory available for any session is finite. If you need to create large temporaries or modify many objects within a transaction, you may need to tune your application to increase the available memory, or to use memory more efficiently.

This chapter discusses the following topics:

Memory Organization (page 269)
How a GemStone session's memory is organized.

Configuring Temporary Memory Usage (page 270)
How to configure temporary object memory, and debug out-of-memory problems.

14.1 Memory Organization

Each Gem session has a temporary object memory that is private to the Gem process and its corresponding session. This local object memory is divided into the following regions:

- `new` — Young temporary objects; includes two subspaces named `eden` and `survivor`
- `old` — Older temporary objects
- `pom` — Unmodified faulted-in objects, divided into ten subspaces
- `perm` — Faulted-in or created Classes and Metaclasses
- `code` — Instances of GsNMethod being executed, or recently executed
- `mE` — oopMap entries that map objId to in-memory objects for committed objects

Temporary objects are created in the `new` area of local object memory. When the `new` area fills up, a scavenge occurs which throws away unreferenced objects in `new`. After an object has survived a number of scavenges, it is copied to the `old` area. After the `old` area has grown by some amount or is almost full, a mark/sweep takes place, finding all live objects and then compacting the `new`, `old`, `perm`, and `code` areas as needed to remove dead objects.

Committed objects referenced by the session are copied from the shared page cache into the `pom`, `perm`, or `code` areas at the point they are first referenced by interpreter execution or a GCI call. (This is called a "copy-on-read" design.)

If a committed object in the `pom` area has been modified, it is copied to the `old` area if a scavenge occurs before the change is committed. Objects that are sent to the GCI client, such as GBS, are also moved to the `old` area, whether or not they are modified.

When the `pom` area becomes full, the contents of its oldest subspace (that is, the oldest 10%) are discarded, and that subspace is reused to continue faulting-in committed objects. Before the oldest subspace is recycled, any objects in the subspace that have been modified, or that are currently referenced from the interpreter stack, are copied to the `old` area.

At transaction commit, any committed objects that have been modified, and any new objects transitively reachable from those modified objects, are copied to new data pages in the shared cache. A transaction conflict check is then performed. If the commit succeeds, the in-memory state of all new objects copied to the shared cache is changed to "committed". The newly committed objects are now eligible to be removed from temporary memory by a mark/sweep or scavenge if they are no longer directly referenced from temporary objects.

14.2 Configuring Temporary Memory Usage

You may encounter an OutOfMemory error if you create too large a graph of live temporary objects at any time, or if you try to modify too many committed objects in a single transaction. OutOfMemory is a fatal error that terminates the session.

Very large numbers of Classes can also fill up temporary object memory. Any class that is referenced by message send or iteration is loaded into the `perm` area, and its method dictionaries, classHistory, and so on are loaded into the `old` area.

Persistent objects that are in the export set for a GCI client, such as GemBuilder for Smalltalk, are also moved to the `old` area. This includes objects that are replicated but not modified.

If you find that your application is running out of temporary memory, you can use several GemStone environment variables to help you identify which parts of your application are triggering garbage collection. Once you've done that, you can set GemStone configuration options to provide the needed memory.

Configuration Options

The values for these options are set when the gem or topaz -l process is initialized. You cannot change these values without restarting the VM. For more about these options, see the descriptions that begin on page 328.

GEM_TEMPOBJ_CACHE_SIZE
: The maximum size (in KB) of temporary object memory. (This limit also applies to linked Topaz sessions and linked GemBuilder applications.) When you only change this setting, and the other GEM_TEMPOBJ... configuration options use default values, then all of the various spaces remain in proportion to each other.

The following should normally be left at the default, so the system can calculate the appropriate values based on the setting for GEM_TEMPOBJ_CACHE_SIZE.

GEM_TEMPOBJ_MESPACE_SIZE
: The maximum size (in KB) of the mE (Map Entries) space within temporary object memory.

GEM_TEMPOBJ_OOPMAP_SIZE
: The size of the hash table (that is, the number of 8-byte entries) in the objId-to-object map within temporary object memory.

GEM_TEMPOBJ_PERMGEN_SIZE
: The maximum size (in KB) of the PERM generation area in temporary object memory. The PERM generation areas holds faulted in or creates instances of Classes and Metaclasses.

GEM_TEMPOBJ_POMGEN_SIZE
: The maximum size (in KB) of the POM generation area in temporary object memory. The POM generation area holds unmodified copies of committed objects that have been faulted into a Gem, and is divided into ten subspaces.

Methods for Computing Temporary Object Space

To find out how much space is left in the `old` area of temporary memory, the following methods in class System (category Performance Monitoring) are provided:

`System _tempObjSpaceUsed`
: Returns the approximate number of bytes of temporary object memory being used to store objects.

`System _tempObjSpaceMax`
: Returns the approximate maximum number of bytes of temporary object memory that are usable for storing objects.

`System _tempObjSpacePercentUsed`
: Returns the approximate percentage of temporary object memory that is in use to store temporary objects. This is equivalent to the expression:

```
(System _tempObjSpaceUsed * 100) //
  System _tempObjSpaceMax.
```

Note that it is possible for the result to be slightly greater than 100%. Such a result indicates that temporary memory is almost completely full.

Sample Configurations

This section presents several sample configurations:

- Small configuration
- Larger old area, smaller pom
- Smaller old area, larger pom

These examples assume that you have already set the GS_DEBUG_VMGC... environment variables (see page 271) to produce the resulting printouts. The examples shown are for Solaris and may vary on other platforms.

Default Configuration

A value of 75000 for GEM_TEMPOBJ_CACHE_SIZE (that is, 75 MB) produces a limit of about 35 MB of temporary plus modified-committed objects (`old`), space for a working set of about 40 MB of unmodified committed objects (`pom`), and a maximum memory footprint on the order of 160 MB.

The following example shows the printout for this configuration:

```
(vmGc spaceSizes: eden init 2048K max 9344K , survivor init
448K max 1600K,
vmGc    old max 37440K, code max 10048K, perm max 5056K, pom 10
* 4224K = 42240K,
vmGc    remSet 1156K, meSpace max 51544K oopMapSize 262144  max
footprint 160M)
```

Larger old, Smaller pom

The following settings configure the application for a 20 MB working set of unmodified committed objects (smaller than the default), and a maximum of 100 MB of temporary plus modified objects (larger than the default).

```
GEM_TEMPOBJ_CACHE_SIZE = 100 MB;
GEM_TEMPOBJ_POMGEN_SIZE = 20 MB;
```

The following example shows the printout for this configuration:

```
(vmGc spaceSizes: eden init 2048K max 19200K , survivor init
384K max 3200K,
vmGc    old max 76800K, code max 20480K, perm max 10240K, pom
10 * 2048K = 20480K,
vmGc    remSet 1732K, meSpace max 73764K oopMapSize 262144  max
footprint 229M)
```

Smaller old, Larger pom

The following settings configure an application with a large working set of committed objects and smaller temporary object space.

```
GEM_TEMPOBJ_CACHE_SIZE = 50000;
GEM_TEMPOBJ_POMGEN_SIZE = 100000;
```

The following example shows the printout for this configuration:

```
(vmGc spaceSizes: eden init 2048K max 9344K , survivor init
448K max 1600K,
vmGc    old max 37440K, code max 10048K, perm max 5056K, pom 10
* 10048K = 100480K,
vmGc    remSet 1732K, meSpace max 79512K oopMapSize 524288  max
footprint 247M)
```

Debugging out-of-memory errors

When any of the following environment variables are set to a positive non-zero value, they have the effect described here for each Gem or linkable Topaz (topaz -l) process that you subsequently start. For all of these environment variables, the printout goes to the "output push" file of a linkable Topaz (topaz -l) session, for use in testing your application. If that file is not defined, the printouts go to standard output of the session's Gem or topaz -l process.

The Gem service script gemnetdebug is designed to be used instead of gemnetobject, for debugging memory issues. Memory environment variables are documented in this script (`$GEMSTONE/sys/gemnetdebug`). When using this script, most of these environment variables remain commented out; you must uncomment them in order for them to have effect.

The contents of `gemnetdebug` are subject to change. For the most current information about these and other variables, examine the contents of `gemnetdebug`.

GS_DEBUG_COMPILE_TRACE
: Trace method compiles. The following are valid values:
  0 - no tracing
  1 - one line (class,selector) of each method compiled
  2 - in addition to above, bytecode disassembly
  3 - in addition to above, native code assembly listing

GS_DEBUG_VMGC_MKSW_MEMORY_USED_SOFT_BREAK
: At the end of each mark/sweep, if the percent of memory used is greater than the threshold specified by this variable, a SoftBreak (error 6003) is generated, and the threshold is raised by 5 percent. We suggest a setting of 75%.

GS_DEBUG_VMGC_MKSW_PRINT_C_STACK
: The mark/sweep count at which to begin printing the C stack at each mark/sweep. This variable is very expensive, consuming two seconds plus the cost of fork() for each printout.

GS_DEBUG_VMGC_MKSW_PRINT_STACK
: The mark/sweep count at which to begin printing the Smalltalk stack at each mark/sweep.

GS_DEBUG_VMGC_PRINT_MKSW
: The mark/sweep count at which to begin printing mark/sweeps.

GS_DEBUG_VMGC_PRINT_MKSW_MEMORY
: The mark/sweep count at which to begin printing detailed memory usage (20 lines) for each mark/sweep.

GS_DEBUG_VMGC_PRINT_MKSW_MEMORY_USED
: Specifies when Smalltalk stack printing starts as the application approaches

OutOfMemory conditions. At the end of each mark/sweep, if the percent of memory used is greater than the threshold specified by this variable, the mark/sweep is printed, the Smalltalk stack is printed, and the threshold is raised by 5 percent. In a situation producing an OutOfMemory error, you should get several Smalltalk stacks printed in the Gem log file before the session dies.

GS_DEBUG_VMGC_PRINT_SCAV
: The scavenge count at which to begin printing scavenges. Once this takes effect, all mark/sweeps will also be printed. Be aware that printing scavenges can produce large quantities of output.

GS_DEBUG_VMGC_SCAV_PRINT_C_STACK
: The scavenge count at which to begin printing the C stack at each scavenge. This variable is very expensive, consuming 2 seconds plus the cost of fork() for each printout.

GS_DEBUG_VMGC_SCAV_PRINT_STACK
: The scavenge count at which to begin printing the Smalltalk stack at each scavenge. Be aware that this print activity can produce large quantities of output.

GS_DEBUG_VMGC_VERBOSE_OUTOFMEM
: Automatically call the primitive for `System class>>_vmPrintInstanceCounts:0` when an OutOfMemory error occurs, and also print the Smalltalk stack. (For details about this method, see the comments in the image.) This applies to each Gem or linkable Topaz (topaz -l) process that you subsequently start.

GS_DEBUG_VMGC_VERIFY_LOGOUT
: Verify object memory at logout, for use when memory corruption or GC bugs are suspected.

GS_DEBUG_VMGC_VERIFY_MKSW
: The mark/sweep count at which to begin verifying object memory before and after each mark/sweep.

GS_DEBUG_VMGC_VERIFY_SCAV
: The scavenge count at which to begin verifying object memory before and after each scavenge. Once this takes effect, GS_DEBUG_VMGC_VERIFY_MKSW will also be in effect. Be aware that this activity uses significant amounts of CPU time.

GS_DEBUG_VM_PRINT_TRANS
: Print transaction boundaries (begin/commit/abort) in the log file.

Recording Out of Memory Information to CSV file

The Out of memory and almost out of memory information that is written to a Gem log can also be directed to write to a disk log file in (CSV) comma separated format, which can be loaded into spreadsheet applications for analysis.

To configure your system to write such a CSV file, set the configuration option GEM_TEMPOBJ_OOMSTATS_CSV to TRUE.

If a Gem or linked topaz process encounters an almost out of memory or out of memory condition, a file will be created or appended to with the name `gemnetobject`*pid*`.csv` or `topaz`*pid*`.csv`.

The config parameter GEM_TEMPOBJ_OOMSTATS_CSV and the environment variable GS_DEBUG_VMGC_VERBOSE_OUTOFMEM operate independently.

Signal on low memory condition

When a session runs low on temporary object memory, there are actions it can take to avoid running out of memory altogether. By enabling handling for the signal `AlmostOutOfMemory`, an application can take appropriate action before memory is entirely full. This signal is asynchronous, so may be received at any time memory use is greater than the threshold the end of an in-memory markSweep. However, if the session is executing a user action, or is in index maintenance, the error is deferred and generated when execution returns.

When performing index operations, such as creating indexes for large collections, the IndexManager can be configured to use this facility to automatically commit when memory is low. Committing objects allows them to be removed from memory, since they can be re-loaded as needed from the persistent object. See the *Programming Guide* for details on IndexManager autoCommit, and for more information on handling `AlmostOutOfMemory`.

Chapter

15 Managing Repository Growth

In the course of everyday operations, your GemStone/S 64 Bit repository will grow. Some of this growth will be the result of new data in your repository, but some will represent unreferenced or outdated objects. These objects, no longer needed, must be removed to prevent the repository from growing arbitrarily large. The process of removing unwanted objects to reclaim their storage is referred to as *garbage collection*.

This chapter describes GemStone's garbage collection mechanisms and explains how and when to use them.

This chapter discusses the following topics:

Basic Concepts (page 277)
The main concepts underlying garbage collection.

Garbage Collection Operations
This include **MarkForCollection** (page 286), **Epoch Garbage Collection** (page 288), and **Reclaim** (page 294).

Running Admin and Reclaim Gems (page 297)
How to configure, start, and stop the Admin Gem and the Reclaim Gem.

Further Tuning Garbage Collection (page 300)
Tuning multi-threaded scan operations, and other special issues affecting Garbage Collection.

15.1 Basic Concepts

Smalltalk execution can produce a number of objects needed only for the moment. In addition, normal business operations can cause previously committed objects to become obsolete. To make the best use of system resources, it is desirable to reclaim the resources these objects use as soon as possible.

Different Types of Garbage

Garbage collection mechanisms vary according to *where* garbage collection occurs — temporary (scratch) memory or permanent object space — and *how* it occurs — automatically, or in response to an administrator's action.

Each Gem session has its own private memory intended for scratch space, known as *local object memory*. The Gem session uses local object memory for a variety of temporary objects, which can be garbage-collected individually. This type of garbage collection is handled automatically by the session and is (for the most part) not configurable, although memory can be configured for specific gem requirements. These issues are covered in Chapter 14, "Managing Gem Memory", starting on page 269.

Permanent objects are organized in units of 16 KB called *pages*. Pages exist in the shared page cache and on disk in the extents. When first created, each page is associated with a specific transaction; after its transaction has completed, GemStone does not write to that page again until all its storage can be reclaimed.

Objects on pages are not garbage-collected individually. Instead, the presence of a shadow object or dead object triggers reclaim of the page on which the object resides. Live objects on this page are copied to another page.

The Process of Garbage Collection

Removing unwanted objects is a two-phase process:

1. Identify — *mark* – superfluous objects.
2. *Reclaim* the resources they consume.

Together, *marking* and *reclaiming* unwanted objects is *collecting garbage*.

Complications ensue because each Gem in a transaction is guaranteed a consistent view of the repository: all visible objects are guaranteed to remain in the same state as when the transaction began. If another Gem commits a change to a mutually visible object, both states of the object must somehow coexist until the older transaction commits or aborts, refreshing its view. Therefore, resources can be reclaimed only after all transactions concurrent with marking have committed or aborted.

Older views of committed, modified objects are called *shadow objects*.

Garbage collection reclaims three kinds of resources:

- The storage occupied by dead objects
- The storage occupied by shadow objects
- Object identifiers (OOPs) for dead objects

Live objects

GemStone considers an object *live* if it can be reached by traversing a path from AllUsers, the root object of the GemStone repository. By definition, AllUsers contains a reference to each user's UserProfile. Each UserProfile contains a reference to the symbol list for a given user, and those symbol dictionaries in these lists in turn point to classes and instances created by that user's applications. Thus, AllUsers is the root node of a tree whose branches and leaves encompass all the objects that the repository requires at a given time to function as expected.

Transitive closure

Traversing such a path from a root object to all its branches and leaves is called *transitive closure.*

Dead objects

An object is *dead* if it cannot be reached from the AllUsers root object. Other dead objects may refer to it, but no live object does. Without living references, the object is visible only to the system, and is a candidate for reclaim of both its storage and its OOP.

Shadow objects

A *shadow object* is a committed object with an outdated value. A committed object becomes shadowed when it is modified during a transaction. Unlike a dead object, a shadow object is still referenced in the repository because the old and new values share a single object identifier.The shadow object must be maintained as long as it is visible to other transactions on the system; then the system can reclaim only its storage, not its OOP (which is still in use identifying the committed object with its current value).

Commit records

Views of the repository are based on *commit records,* structures written when a transaction is committed. Commit records detail every object modified *(the write set),* as well as the new values of modified objects. The Stone maintains these commit records; when a Gem begins a transaction or refreshes its view of the repository, its view is based on the most recent commit record available.

Each session's view is based on exactly one commit record at a time, but any number of sessions' views can be based on the same commit record.

NOTE

The repository must retain each commit record and the shadow objects to which it refers as long as that commit record defines the transaction view of any session.

Commit record backlog

The list of commit records that the Stone maintains in order to support multiple repository views is the *commit record backlog.*

Shadow or Dead?

The following example illustrates the difference between dead and shadow objects. In Figure 15.1, a user creates a SymbolAssociation in the SymbolDictionary Published. The SymbolAssociation is an object (oop 27111425) that refers to two other objects, its instance variables key (#City, oop 20945153), and value ('Beaverton', oop 27110657).

The Topaz command "display oops" causes Topaz to display within brackets ([ ]) the identifier, size, and class of each object. This display is helpful in examining the initial SymbolAssociation and the changes that occur.

Figure 15.1 An Association Is Created and Committed

```
topaz 1> display oops
topaz 1> printit
Published at: #City put: 'Beaverton'.
Published associationAt: #City
%
[27111425 sz:2 cls: 111617 SymbolAssociation] a SymbolAssociation
  key                   [20945153 sz:4 cls: 110849 Symbol] City
  value                 [27110657 sz:9 cls: 74753 String]
```

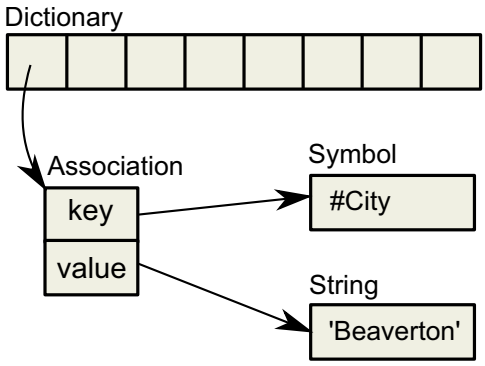


Figure 15.2 shows a second Topaz session that logs in at this point. Notice that the Topaz prompt identifies the session by displaying a digit. Because Session 1 committed the SymbolAssociation to the repository, Session 2 can see the SymbolAssociation.

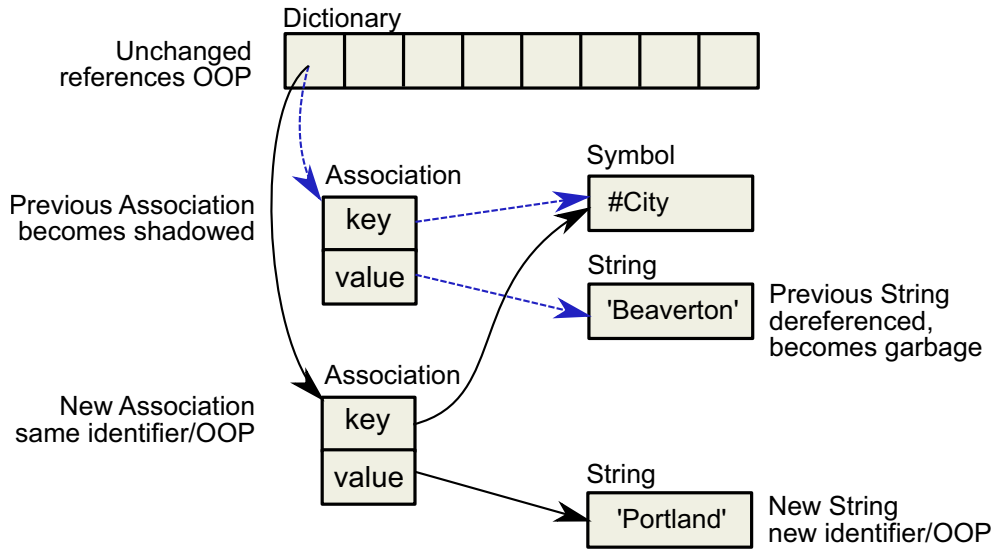
Figure 15.2 A Second Session Can See the Association

```
topaz 2> display oops
topaz 2> printit
Published associationAt: #City.
%
[27111425 sz:2 cls: 111617 SymbolAssociation] a SymbolAssociation
  key                   [20945153 sz:4 cls: 110849 Symbol] City
  value                 [27110657 sz:9 cls: 74753 String] Beaverton
```

Now Session 1 changes the *value* instance variable, creating a new SymbolAssociation (Figure 15.3). Notice in the oops display that the new SymbolAssociation object has the same identifier (27111425) as the previous Association.

Figure 15.3 The Value Is Replaced, Changing the Association

```
topaz 1> printit
City := 'Portland'.
Published associationAt: #City.
%
[27111425 sz:2 cls: 111617 SymbolAssociation] a SymbolAssociation
  key                   [20945153 sz:4 cls: 110849 Symbol] City
  value                 [27109121 sz:8 cls: 74753 String] Portland
topaz 1> commit
Successful commit
```



- The SymbolAssociation is now *shadowed*. Because the shadow SymbolAssociation was part of the committed repository and is still visible to other transactions (such as that of Session 2), it cannot be overwritten. Instead, the new SymbolAssociation is written to another page, one allocated for the current transaction.
- The previous value (oop 27110657) is no longer referenced in the repository. For now, this object is considered *possibly dead;* we cannot be sure it is dead because, although the object has been dereferenced by a committed transaction, other, concurrent transactions might have created a reference to it.

Even though Session 1 committed the change, Session 2 continues to see the original SymbolAssociation and its value (Figure 15.4). Session 2 (and any other concurrent sessions) will not see the new SymbolAssociation and value until it either commits or aborts the transaction that was ongoing when Session 1 committed the change.

Figure 15.4 Session 2 Sees Change After Renewing Transaction View of Repository

```
topaz 2> printit
Published associationAt: #City.
%
[27111425 sz:2 cls: 111617 SymbolAssociation] a SymbolAssociation
  key                  [20945153 sz:4 cls: 110849 Symbol] City
  value                [27110657 sz:9 cls: 74753 String] Beaverton

topaz 2> abort
topaz 2> printit
Published associationAt: #City.
%
[27111425 sz:2 cls: 111617 SymbolAssociation] a SymbolAssociation
  key                  [20945153 sz:4 cls: 110849 Symbol] City
  value                [27109121 sz:8 cls: 74753 String] Portland
```

Only when all sessions with concurrent transactions have committed or aborted can the shadow object be garbage collected.

What Happens to Garbage?

This section describes the steps involved in garbage collection. Specific garbage collection mechanisms will follow these steps, although the details will vary when using different garbage collection mechanisms.

The basic garbage collection process encompasses nine steps:

1. Find all the live objects in the system by traversing references, starting at the system root AllUsers. This step is called *mark/sweep.*

2. The Gem that performed mark/sweep now has a list of all live objects. It also knows the universe of all possible objects: objects whose OOPs range from zero to the highest OOP in the system. It can now compute the *set of possible dead objects* as follows:

   a. Subtract the live objects from the universe of possible objects.

   b. Subtract all the unassigned (free) OOPs in that range.

   This step is called the *object table sweep* because the Gem uses the object table to determine the universe of possible objects and the unassigned OOPs.

3. The Gem performing this work now has a list of *possibly dead* objects. We can't be sure they're dead because, during the time that the mark/sweep and object table sweep were occurring, other concurrent transactions might have created references to some of them.

   The Gem sends the Stone the *possible dead set* and returns.

4. Now, in a step called *voting,* each Gem logged into the system must search its private memory to see if it has created any references to objects in the possible dead set. When it next commits or aborts, it votes on every object in the possible dead set. Objects referenced by a Gem are removed from the possible dead set.

   Gems do not vote until they complete their current transaction. If a Gem is sleeping or otherwise engaged in a long transaction, the vote cannot be finalized and garbage collection pauses at this point. Commit records accumulate, garbage accumulates, and

a variety of problems can ensue. Repository scan operations such as listInstances cannot be executed until voting is complete.

5. Because all the previous steps take time, it's possible that some Gems were on the system when the mark/sweep began, created a reference to an object now in the possible dead set, and then logged out. They cannot vote on the possible dead set, but objects they've modified are in the write sets of their commit records. The *Admin Gem,* a process dedicated to administrative garbage collection tasks, scans all these write sets (the *write set union),* and votes on their behalf. This is called the *write set union sweep.*
6. After all voting is complete, the resulting set now holds nothing but unreferenced objects. The Stone now promotes the objects from possibly dead to dead.
7. the *Reclaim Gem* reclaims pages: it copies live objects on the page onto a new page, thereby compacting live objects in page space. The page now contains only recycleable objects and perhaps free space.
8. The Reclaim Gem commits. The reclaimed OOPs are returned to their free pool.
9. The Reclaim Gem's commit record is disposed of. The reclaimed pages are returned to their free pool.

Admin and Reclaim Gems

It is useful to understand the distinction between the Admin Gem and the Reclaim Gem:

- The Admin Gem finalizes the vote on possibly dead objects (Step 5 on page 283), and performs the write set union sweep. The Admin Gem also performs Epoch Garbage Collection (page 288), if enabled.
- The Reclaim Gem is dedicated to the task of reclaiming shadowed pages and dead objects repository-wide, along with their OOPs.

  The Reclaim Gem includes a master session and multiple reclaim sessions, each being a thread within the Reclaim Gem process. This allows reclaim to occur in parallel.

By default, the Admin Gem and the Reclaim Gem with one reclaim session are configured to run, and are started automatically when the Stone is started. By default, epoch is disabled.

- We recommend that you leave the Admin Gem running at all times, although it is required only following a `markForCollection` or `markGcCandidatesFromFile:`, or after a epoch garbage collection operation. (Subsequent sections of this chapter describe these operations in detail.) If the Admin Gem is not running following one of these operations, the garbage collection process cannot complete, and garbage can build up in your system.
- We recommend that you have the Reclaim Gem running at all times, to reclaim shadow objects.

Admin and Reclaim Gem configuration parameters

Both the Admin and Reclaim Gems are run from the GcUser account, a special account that logs in to the repository to perform garbage collection tasks. This account is used to set configuration values for the GcGems.

The configuration parameters that apply to either the Admin or Reclaim Gems can either be set persistently, or at runtime. These values are stored in the UserGlobals of the GcUser

user profile account. While you can login as GcUser to make persistent updates, it is not necessary to do this.

To set parameters persistently, a user with GarbageCollection privilege, such as DataCurator, can execute System class methods `setPersistentReclaimConfig:toValue:` or `setPersistentAdminConfig:toValue:`. For example, to set `#reclaimMinPages` to 90:

```
topaz> set user DataCurator password thePassword
login
...
topaz 1> run
System setPersistentReclaimConfig: #reclaimMinPages toValue: 90
%
```

This has the effect of both setting the value in the current environment and setting the persistent value. These methods perform a commit, and will error if there are uncommitted changes in the image, and will error if the value is out of range or invalid.

GcGem configuration parameters can also be set transiently, so they do not persist if the Admin or Reclaim GcGem is restarted, using the System class methods `setReclaimConfig:toValue:` or `setAdminConfig:toValue:`. These methods also require GarbageCollection privilege.

GemStone's Garbage Collection Mechanisms

GemStone provides the following mechanisms that together mark and reclaim garbage, thereby helping you to control repository growth.

Marking

Repository-wide marking — To prevent the repository from growing large enough to cause problems on a regular basis, you can run `Repository >> markForCollection`. This method combines a full sweep of all objects in the repository and the marking of each possible dead object in a single operation.

Epoch garbage collection — If enabled, the Admin Gem periodically examines all transactions written since a specific, recent time (the beginning of this *epoch*) for objects that were created and then dereferenced during that period. However, epoch garbage collection cannot reclaim objects that are created in one epoch but dereferenced in another. In spite of its name, epoch garbage collection only marks; it does not reclaim. You can configure various aspects to maximize its usefulness. Epoch garbage collection is disabled by default. For details about epoch garbage collection, see "Epoch Garbage Collection" on page 288.

Reclaiming

Reclaim — Once you've run `markForCollection` or epoch garbage collection, the Reclaim Gem will reclaim pages that contain either dead or shadow objects. When there are a high number of objects needing to be reclaimed, you may increase the number of sessions under the Reclaim Gem. For details about reclaiming pages, see "Reclaim" on page 294.

GcLock

Garbage collection processes such as mark/sweep, and some other repository-wide scan operations, cannot safely be run concurrently. To prevent this, there is a shared internal lock called the GcLock. Operations that cannot run concurrently get the GcLock, which prevents another one from starting up.

In addition to garbage collection, the GcLock is also held by the Admin Gem for Epoch GC and for the write-set union sweep. some repository-wide operations such as GsObjectInventory (see page 138) also hold the GcLock while they are running.

If another task that requires the GcLock is in progress at the time you try to do `markForCollection` or `findDisconnectedObjects...`, they will not execute, but report an error similar to that shown below.

```
-- Request for MFC gclock by session 10 denied, reason: vote state
is voting, sessionId not voted 2
ERROR 2501 , a Error occurred (error 2501), Request for gcLock
timed out.
'Request for MFC gclock by session 10 denied, reason: vote state
is voting, sessionId not voted 2' (Error)
```

The cause of the conflict may be:

- Another operation that requires the GcLock is in progress in another session; this includes epoch and MFC, and also operations such as GsObjectInventory.
- A previous epoch or MFC completed the mark phase, but voting on possible dead objects has not completed.

  For voting to complete, the Admin Gem must be running. Also, any long-running session that neither aborts nor commits will prevent the vote from completing.

Symbol Garbage Collection

Symbols in GemStone are a special case of Object, since they must always have a unique OOP across all sessions. To ensure this, symbol creation is managed by the SymbolUser, who creates all new Symbols. Symbols are stored in the AllSymbols dictionary, and are not removed, to avoid any risk of creating duplicate symbols.

However, there are cases where a large number of unimportant symbols are created, perhaps inadvertently. To reclaim this space and to manage the size of AllSymbols, you can configure GemStone to collect unreferenced symbols in a multi-step process that ensures that symbols in use are not collected.

By default, Symbol garbage collection is not enabled. It can be enabled using the configuration parameter, STN_SYMBOL_GC_ENABLED, or by the runtime equivalent, #StnSymbolGcEnabled. If enabled, symbol garbage collection is performed automatically in the background and requires no management.

When enabled, unused symbols are located and put in a possibleDeadSymbols collection as part of a markForCollection,. These symbols are hidden, to remove references from AllSymbols but retain the OOPs until the voting, union, and finalization is done. Any lookups on the hidden symbol will return the existing hidden symbol and restore it to the AllSymbols dictionary.

Once voting and write-set union sweep are done, the symbols that are otherwise unreferenced are removed from the possibleDeadSymbols, so they will be collected by the next markForCollection.

15.2 MarkForCollection

The method `Repository>>markForCollection` sweeps the entire repository and marks as live all objects that can be reached through a transitive closure on the symbol lists in AllUsers, as described on page 278. The remaining objects become the list of possible dead objects.

`markForCollection` only provides a set of possible dead objects for voting and eventual reclaiming as described under "What Happens to Garbage?" on page 282. It does not reclaim the space or OOPs itself; the Reclaim Gem does that, as described under "Reclaim" on page 294.

To mark unreferenced GemStone objects for collection, log in to GemStone as a user with GarbageCollection privilege (normally DataCurator), and execute `SystemRepository markForCollection`.

Running `markForCollection`, and the subsequent reclaim tasks, places demands on system resources. On production systems. consider scheduling MFC for off hours and otherwise reducing the impact, as described in the following sections.

`markForCollection` aborts the current transaction and runs the mark/sweep operation inside a transaction, but monitors the commit record backlog so it can abort as necessary to prevent the backlog from growing. When `markForCollection` completes, the session reenters a transaction, if it was in one when this method was invoked.

When `markForCollection` completes successfully, the Gem that started it displays a message such as the one below:

```
Warning: a Warning occurred (notification 2515), markForCollection
found 110917 live objects, 3496 dead objects(occupying approx
314640 bytes)
```

If another garbage collection task is in progress at the time you try to do `markForCollection`, this method will retry for a fixed period, reporting status. If the other operation does not complete within the timeout period, it reports an error indicating it could not get the GcLock. See "GcLock" on page 285 for more details.

By default, the `markForCollection` method waits for up to a minute for the other operation to complete. To have the `markForCollection` wait for a longer period, use `markForCollectionWait:` *waitTimeSeconds*.

To avoid `markForCollection` having to wait:

- Make sure that other sessions are committing or aborting, which allows voting on possible dead to complete.
- Make sure that the Admin Gem is running, to complete processing of dead objects once the vote is completed.

Impact on Other Sessions

The `markForCollection` operation uses multi-threaded scan. For more details on this, see "Multi-Threaded Scan" on page 300.

By default, markForCollection limits is use of cpu resources if the cpu load on the system reaches 90%. It starts the operation with two threads and a page buffer size of 128. If the cpu limit is reached, the code automatically causes threads to sleep until the load is less than 90%. Depending upon the I/O required, the system may never reach this limit.

To enable `markForCollection` to complete as quickly as possible, you can use:

```
SystemRepository fastMarkForCollection
```

This uses higher settings (95% of CPU, and a number of threads based on the current hardware) to use as many system resources as possible. The performance of anything else running on the same system may be heavily degraded.

For maximum control, use the method

```
SystemRepository markForCollectionWithMaxThreads: threadsCt
      waitForLock: seconds
      pageBufSize: pageBufSize
      percentCpuActiveLimit: percentLimit
```

This allows you to specify the precise limits.

Starting markForCollection with these limits provides a specification for the trade-off you wish to make between speed to complete and the impact on other sessions. The desired trade-off may vary over time; for example, if your markForCollection extends over both business hours and non-business hours, you may accept greater impact during these periods of light load. The Multi-threaded scan parameters can be changed at runtime, as described under "Tuning Multi-Threaded Scan" on page 300.

After the `markForCollection` has completed, there may be additional impact on other sessions, since it is likely that dead objects that require reclaim were identified. After the remaining Garbage Collection steps have completed, the Reclaim Gem Sessions may become busy reclaiming the dead objects.

Scheduling markForCollection

To invoke `markForCollection` using the **cron** facility, create a three-line script file similar to the Topaz example on page 284 by entering everything except the prompt. Use this script as standard input to **topaz**, and redirect the standard output to another file:

```
topaz < scriptName > logName
```

Make sure that $GEMSTONE and any other required environment variables are defined during the **`cron`** job. Either create a `.topazini` file for a user who has GarbageCollection privilege, or insert those login settings at the beginning of the script.

Topaz has a number of scripting options; see the *Topaz Users Guide*. For information about using **cron**, refer to your operating system documentation.

15.3 Epoch Garbage Collection

Epoch garbage collection operates on a finite set of recent transactions: the *epoch*. Using the write set that the Stone maintains for each transaction, the Admin Gem examines every object created during the epoch. If an object is unreferenced by the end of the epoch, it is marked as garbage and added to the list of possible dead objects.

Epoch collection is efficient because:

- It's faster and easier to perform a transitive closure on a few recent transactions than on the entire repository.
- Most objects die young, especially in applications characterized by numerous small transactions updating a few previously committed objects. An epoch of the right length can collect most garbage automatically.

Although epoch collection identifies a lot of dead objects, it cannot replace `markForCollection` because it will never detect objects created in one epoch and dereferenced in another.

By default, epoch garbage collection is disabled. You can enable it in either of two ways:

- Before you start the Stone, set STN_EPOCH_GC_ENABLED (PAGE 342) to TRUE.
- Execute the method `System class>>enableEpochGc`. You may also manually disable epoch garbage collection using `System class>>disableEpochGc`. Using these methods updates the system configuration file.

After your installation has been operating for a while, and you've had the chance to collect operational statistics, consider this: epochs of the wrong length can be notably inefficient. The section "Determining the Epoch Length" on page 289 includes an in-depth discussion of the performance trade-offs of short or long epochs

Running Epoch Garbage Collection

When epoch garbage collection is enabled, it will run automatically according to the GcUser configuration parameters #epochGcTimeLimit and #epochGcTransLimit.

You can force an epoch garbage collection to begin using `System class >> forceEpochGc`. `forceEpochGc` will return false, and not start an epoch garbage collection, if any of the following are true:

- Checkpoints are suspended.
- Another garbage collection operation is in progress.
- Unfinalized possible dead objects exist (that is, `System voteState` returns a non-zero value).
- The system is in restore mode.
- The Admin Gem is not running.
- Epoch garbage collection is disabled (that is, STN_EPOCH_GC_ENABLED = FALSE).
- The system is performing a reclaimAll.
- A previous `forceEpochGc` operation was performed and the epoch has not yet started or completed.

Tuning Epoch

Epoch Configuration Parameters

The following configuration parameters are available to control the performance of epoch garbage collection. You can get the current descriptions from the image by executing

```
System adminGemConfigs
```

which returns a report of all supported Admin Gem configuration parameters. For details on modifying values, see page 283.

`#epochGcTimeLimit`	The maximum frequency of epoch garbage collection (in seconds). Default: one hour (3600 seconds). This value should be at least 1800 (30 minutes), since the aging of objects faulted into Gem memory uses 5 minute aging for each of 10 subspaces of the POM generation.
`#epochGcTransLimit`	The minimum number of transactions required to trigger epoch garbage collection. Default: 5000.
`#epochGcPercentCpuActiveLimit`	Limit active epoch threads when system percentCpuActive is above this limit. Default: 90.
`#epochGcPageBufferSize`	Size in pages of buffer used for epoch GC (must be power of 2). Default: 64.
`#epochGcMaxThreads`	The MaxThreads used for next epochGc.

Epoch garbage collection uses the multi-threaded scan (see "Multi-Threaded Scan" on page 300) and can be tuned to complete more quickly with more system performance and resources impact, or take longer and use fewer system resources. The parameters `#epochGcPercentCpuActiveLimit`, `#epochGcPageBufferSize`, and `#epochGcMaxThreads` are used to tune epoch garbage collection's multi-threaded scan impact.

Determining the Epoch Length

Epoch garbage collection's ability to identify unreferenced objects depends on the relationship between three variables:

- The rate of production *R* of short-lived objects.
- The lifetime *L* of these objects.
- The epoch length *E*.

The only variable under your direct control is epoch length. Although you cannot specify it explicitly, the following configuration parameters jointly control the length of an epoch:

- `#epochGcTimeLimit`
- `#epochGcTransLimit`

Epoch garbage collection occurs when:

```
(the time since last epoch > epochGcTimeLimit ) AND
      (transactions since last epoch > epochGcTransLimit)
```

The following discussion assumes that the epoch is determined by the minimum time interval (`#epochGcTimeLimit`) because other threshold is always met.

Figure 15.5 shows the effect of the epoch on the number of items marked. If L = E, for example, five minutes, every object's lifetime spans epochs (top part of graph), and none are collected.

When the epoch is longer than an average object's lifetime, however, some objects live and die within the same epoch, and can be marked. The lower part of Figure 15.5 shows an example where $E = 3L$ and objects are created at a uniform rate. Objects created during the first two-thirds of the interval die before its end and are marked. Only those created during the final third survive to the next epoch.

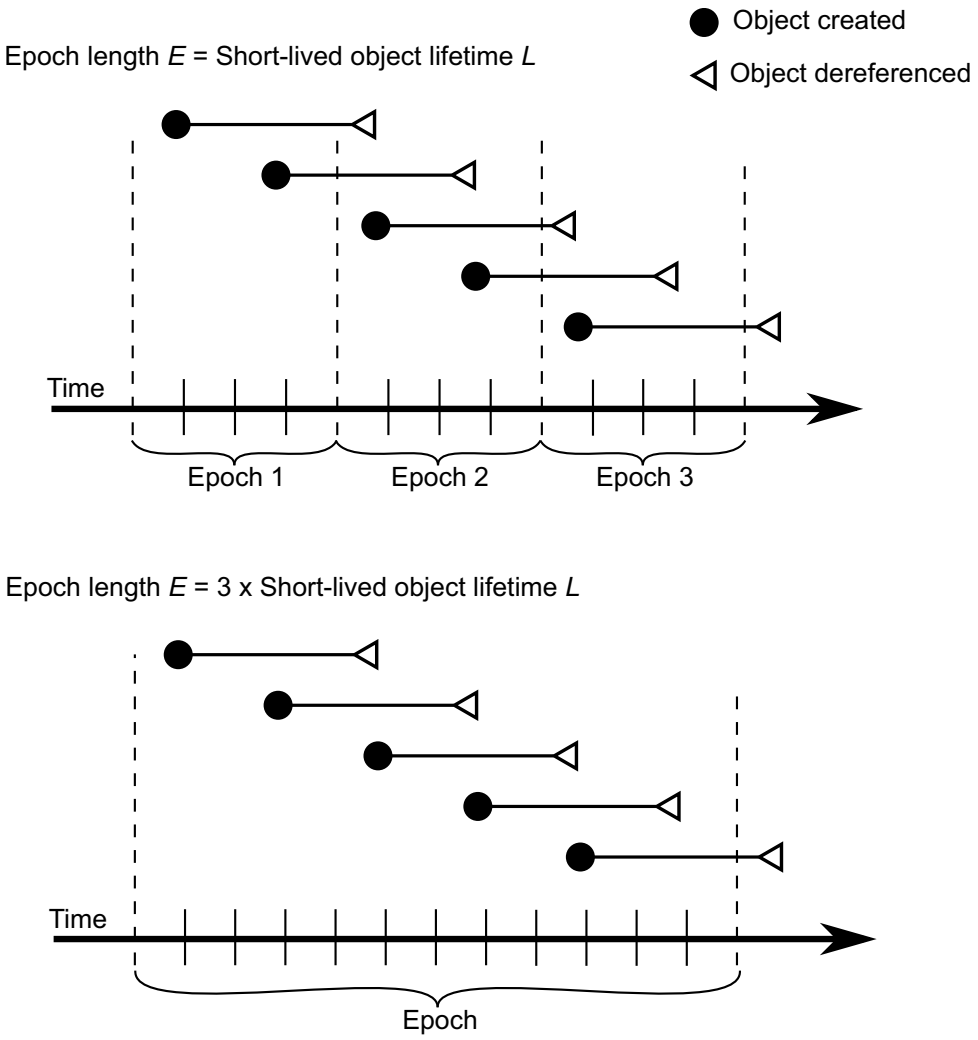
The results shown in Figure 15.5 can be expressed as:

Objects Missed by EpochGC $=R \times L$
Objects Recovered by EpochGC$=R(E - L)$

For example, assume R = 1000 objects per minute, L = 5 minutes, and E = 15 minutes. Then, for each epoch:

Objects Missed = 1000 x 5 = 5000
Objects Recovered = 1000 (15 – 5) = 10000

Figure 15.5 Effect of Collection Interval on Epoch Garbage Collection



Therefore:

- Set `#epochGcTimeLimit` *E* > lifetime *L* of short-lived objects.

Figure 15.6 graphs the effect of the epoch. When *E* = *L*, epoch garbage collection is in effect disabled; all objects survive into the next epoch; the number of unmarked yet dead objects in the repository grows at the creation rate. These dead objects remain unidentified until you run `markForCollection`.

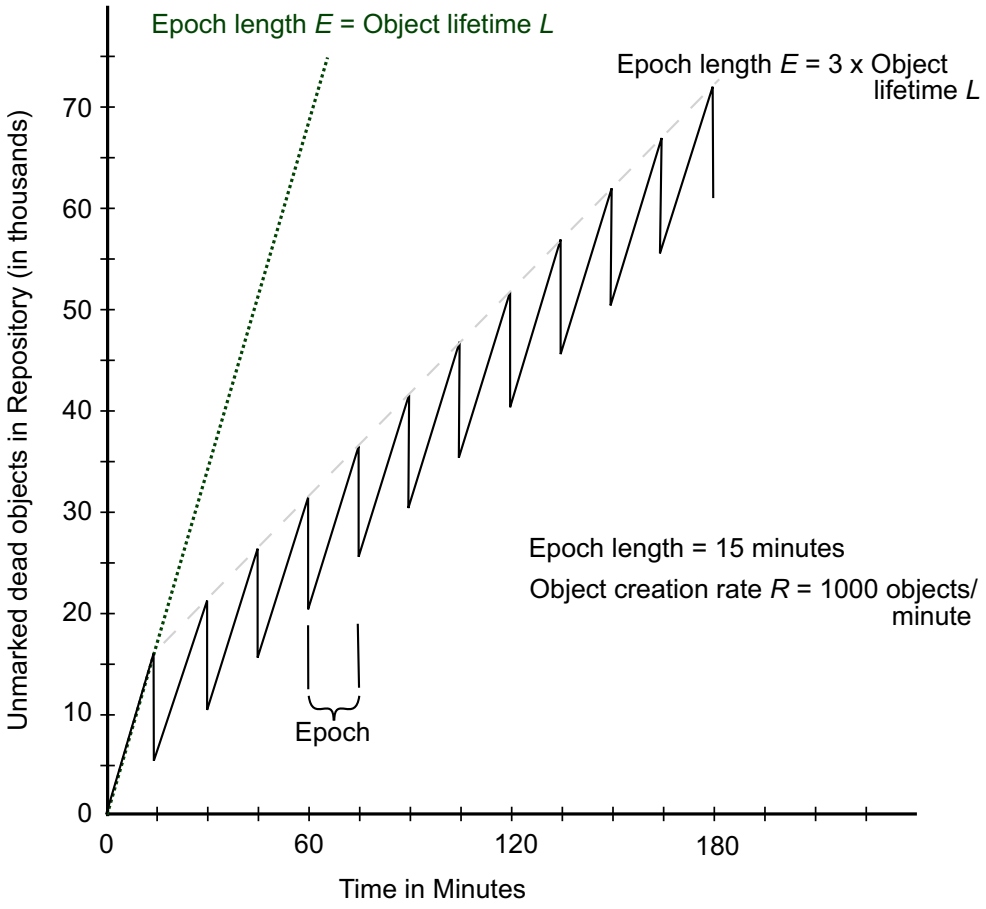
When the epoch is extended so that *E* = 3*L*, each epoch garbage collection marks those objects both created and dereferenced during that interval. This ratio causes the sawtooth pattern in the graph. If the creation rate is uniform, two-thirds of the dead objects are marked *((E-L)/E)*, and one-third are missed *(L/E)*. Consequently, the repository grows at one-third the rate of the case *E* = *L*.

This configuration trades short bursts of epoch garbage collection activity for:

- moderate growth in the repository, and

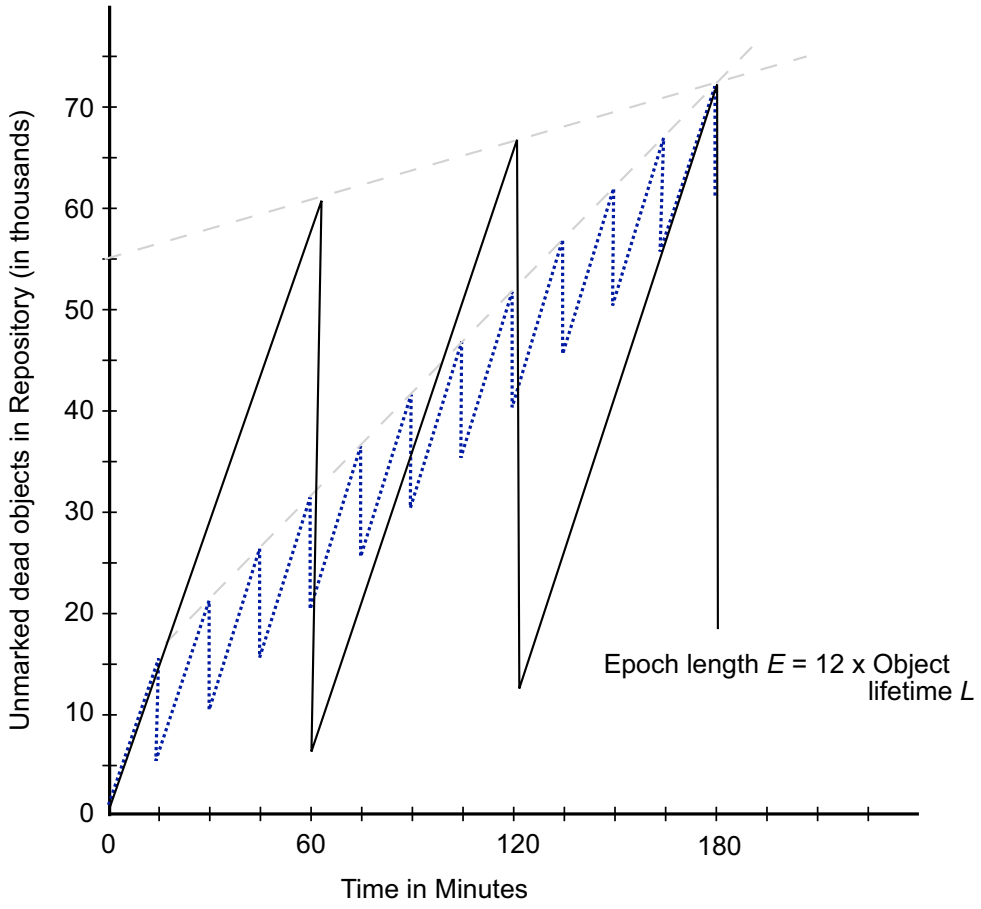
- the need to run `markForCollection` often enough to mark dead objects that survive between epochs.

Figure 15.6 Repository Growth with Short Epoch



Suppose we extend the epoch to $E = 12L$. The result is shown in Figure 15.7, superimposed on part of the previous figure.

Figure 15.7 Effect of Longer Epoch on Repository Growth



Although the longer epoch allows many more dead objects to accumulate, the growth rate of the repository is substantially less—25% of the previous case.

This configuration trades a slower growth rate for:

- a need for greater headroom on the disk, and
- longer bursts of epoch garbage collection activity.

Certain cases have needed an epoch as long as several hours, or even a day.

Cache Statistics

Several cache statistics include information about the epoch garbage collection process. These are visible by using statmonitor data viewed in VSD (the visual statistics display tool). You may also access methods in System to get the values programmatically; see "Programmatic Access to Cache Statistics" on page 140 for more information.

The following statistics may be useful in monitoring epoch:

EpochGcCount	The number of times that the epoch garbage collection process was run by the Admin Gem since the Admin Gem was started. For a system in steady state, look for uniform periods between runs or a uniform run rate.
EpochNewObjs	The number of new objects that were created during the last epoch.
EpochPossibleDeadObjs	The number of possible dead objects found by the last epoch garbage collection.
EpochScannedObjs	The number of objects scanned by the last epoch garbage collection.

15.4 Reclaim

The Reclaim Gem is responsible for reclaiming both dead and shadowed objects (see "Shadow or Dead?" on page 279 for the difference between these types of garbage).

Shadowed objects are created naturally as your application modifies existing objects, so it is a good idea to always have the Reclaim Gem running to avoid shadowed objects accumulating. Some operations, such as migration, create a very large number of shadowed objects that need to be reclaimed.

After a mark/sweep operation — markForCollection or epoch — completes, there will be a number of dead objects that need to be reclaimed.

Although it is objects that are dead or shadowed, reclaim is done in pages. Pages that contain dead or shadowed objects may also contain some live objects; these live objects are copied to fresh pages, and the resulting page may then be reclaimed.

Reclaim is performed multi-threaded. Each thread within the Reclaim Gem is similar to a session, but runs within the Reclaim Gem process.

When the Reclaim Gem is running, its sessions examine pages marked reclaimable because they contain either dead or shadow objects, and reclaim fragments of space left by transactions that did not fill an entire page. This occurs in the background, with no specific action required.

Although it is recommended to allow the background processes to perform the reclaim, you can explicitly invoke it by executing `SystemRepository reclaimAll`.

Note that immediately after a mark/sweep, objects are not yet eligible for reclaim. All sessions must vote, and the Admin Gem must complete the write set union sweep, before objects can be reclaimed. The method `Repository>>reclaimAllWait:` *timeoutSeconds* allows the reclaim all to be started immediately and wait for these tasks to complete.

Reclaimed space does not appear as free space in the repository until other sessions have committed or aborted all transactions concurrent with the reclaim transaction, and the Stone has disposed the commit record. Make sure there is some extra space in your repository extents to hold the dead and shadowed objects that are in the process of being reclaimed, until that space becomes available again.

Tuning Reclaim

Reclaim Configuration Parameters

The following configuration parameters are available to control the reclaim task. You can get the current descriptions from the image by executing

```
System reclaimGemConfigs
```

which returns a report of all supported Reclaim Gem configuration parameters. For details on modifying values, see page 283.

`#deadObjsReclaimedCommit-Threshold`	The maximum number of dead objects to reclaim in a single transaction, including dead objects reclaimed when reclaiming shadow pages. The default is 20000.
`#deferReclaimCacheDirtyThresh-old`	If the primary shared page cache (the shared cache on the stone's machine) is more than this percentage dirty, then Reclaim Gems will wait until the cache is less than 5% below this threshold before resuming reclaims. The default is 75%.
`#maxTransactionDuration`	The maximum length (in seconds) of a GcGem transaction. The transaction will be committed once this time is exceeded. Must be ≥ 1; the default is 300, maximum is SmallInteger maximumValue.
`#objsMovedPerCommitThresh-old`	The approximate maximum number of live objects to move in a reclaim transaction. Must be ≥ 100; the default is 20000, maximum is SmallInteger maximumValue.
`#reclaimDeadEnabled`	A Boolean indicating whether or not to reclaim dead objects; the default is true.
`#reclaimMinFreeSpaceMb`	Minimum repository free space which must be available in order for reclaims to proceed. Reclaims will be temporarily suspended if the repository free space drops below this threshold. The default value of 0 specifies a limit computed as the current size of the repository divided by 1000, with a minimum value of 5MB. Default and minimum 0, maximum 65536.
`#reclaimMinPages`	The minimum number of pages to process in a single reclaim operation (reclaiming does not start until this threshold is reached). Must be ≥ 1; the default is 30 pages, maximum is SmallInteger maximumValue.

`#sleepTimeBetweenReclaimMs`	The minimum amount of time in milliseconds that the process will sleep between reclaims, even when work is scheduled. The default is 0 milliseconds, maximum 3600000.
`#sleepTimeWithCrBacklogMs`	Amount of time (in milliseconds) to sleep after a commit when the commit record backlog is larger than 1.25 * the current setting for STN_CR_BACKLOG_THRESHOLD. For each 25 percent above the threshold the sleep time is increased so that the ReclaimGem does fewer commits the higher the number of commit records is about the threshold. Must been between 0 and 300000; the default is 0.

Reclaim Commit Frequency

A Reclaim Gem session will commit reclaim changes as soon as any one of the following conditions is met:

- Number of live objects moved exceeds `#objsMovedPerCommitThreshold`.
- Duration of the transaction exceeds `#maxTransactionDuration`.
- Number of dead objects reclaimed exceeds `#deadObjsReclaimedCommitThreshold`.

Controlling the impact of reclaim

Reclaim, particularly with a larger number of sessions configured for the Reclaim Gem, can perform quickly but place a large load on your system. If you are likely to be doing reclaim during periods where users will also need to use the system, you may wish to slow down reclaim. This can be done in a number of ways:

- Reduce the number of reclaim sessions using `System class >> changeNumberOfReclaimGemSessions:` with a argument of 1 or 0.
- Set `#sleepTimeBetweenReclaimMs` to ensure that reclaim Gem sessions pause between reclaim operations.
- Set `#sleepTimeWithCrBacklogMs` so that in case your system encounters a commit record backlog, the impact of reclaim is automatically reduced.

Speeding up reclaim

You can also setup your system to run reclaim with the maximum impact during off-hours. If you have a large amount of reclaim to perform, this allows the reclaim to finish more quickly. You can increase the number of Reclaim session to the maximum using:

```
System class >> startMaxReclaimGemSessions
```

This will start the number of sessions specified by STN_MAX_GC_RECLAIM_SESSIONS.

Avoiding disk space issues

Reclaim requires pages from the repository in order to copy non-dead objects. There are further steps that the stone must complete, before the space on the reclaimed pages is available again. So initially, reclaim will cause the amount of free space in the repository to drop.

Depending on overhead required by your system and the largest amount of reclaim that needs to be done at any time, you may want to configure a larger `#reclaimMinFreeSpaceMb`. This will ensure that reclaim pauses before your repository becomes dangerously low in free space.

Cache Statistics

Several cache statistics provide information about reclaim. These are visible by using statmonitor data viewed in VSD (the visual statistics display tool). You may also access methods in System to get the values programmatically; see "Programmatic Access to Cache Statistics" on page 140 for more information.

The following Stone statistics may be useful in monitoring reclaim:

DeadNotReclaimedObjs	The number of objects known to be dead but not yet reclaimed.
DeadObjsReclaimedCount	The total number of dead objects reclaimed since the Stone repository monitor process was last started.
GcVoteState	Indicates the current phase of garbage collection: Gems voting, voting complete, Possible Dead Write-Set Union Sweep (PDWSUS) in progress, or PDWSUS complete.
PagesNeedReclaimSize	The amount of work waiting for the reclaim task.
PossibleDeadObjs	The number of objects marked as dereferenced but not yet declared to be dead.
ReclaimCount	The number of times the reclaim process has been run.
ReclaimedPagesCount	The number of scavenged pages.

15.5 Running Admin and Reclaim Gems

Admin Gem Privileges required: GarbageCollection

The initial configuration for the Admin and Reclaim Gems are provided in the system configuration file for the stone; by default, `$GEMSTONE/data/system.conf`. These settings determine what is started automatically when the stone starts up. During runtime, you can start and stop the Admin Gem and change the number of Reclaim sessions that are running.

Configuring Admin Gem

The Admin Gem is enabled or disabled by the setting for the STN_ADMIN_GC_SESSION_ENABLED configuration option. By default, this is enabled, and normally you should leave this enabled. You can stop and restart the Admin Gem at runtime as needed.

Configuring Reclaim Gem

The number of Reclaim sessions is set by the STN_NUM_GC_RECLAIM_SESSIONS configuration option. By default, this is one, and you should normally keep at least one Reclaim session running. Most systems will benefit from increasing the number of Reclaim sessions. In general, we recommend running one Reclaim session for between 5 and 10 extents. You may need to experiment to find the correct balance for your system. The number of Reclaim sessions can be changed at runtime as needed.

To ensure that Reclaim sessions do not impact the number of user sessions, a separate configuration setting, STN_MAX_GC_RECLAIM_SESSIONS, configures the maximum number of Reclaim sessions you will be running.

By default, this is set to the number of extents on your system. This parameter cannot be changed without restarting the stone. The upper limit for the number for the number of Reclaim sessions that can be run under any configuration is 255.

While the number of Reclaim sessions should normally be less than or equal to STN_MAX_GC_RECLAIM_SESSIONS, it is possible to start a larger number of Reclaim sessions. However, this will reduce the number of user sessions that can login to this Stone. If your system does not have excess unused user sessions, you should be careful to configure STN_MAX_GC_RECLAIM_SESSIONS high enough that you will never want to run a larger number of Reclaim sessions.

Starting GcGems

You can ensure all configured GcGems are running using:

`System startAllGcGems`
: If the Admin Gem is not running, start it. If the Reclaim Gem is not running, start it with the configured number of Reclaim sessions. Return true if the Admin Gem and at least one Reclaim sessions are started.

or by executing both:

`System startAdminGem`
: If the Admin Gem is not running, start it. Return true if the Admin Gem is running, false if the Admin Gem could not be started.

`System startReclaimGem`
: If the Reclaim Gem is not running, start it with the configured number of Reclaim sessions. Return the number of Reclaim sessions that will be running. If the Reclaim Gem is already running, has no effect and returns the number of Reclaim sessions already running.

It may take a little time for the GcGems to complete login. The above methods do not block; they initiate the startup and return immediately. To wait a given period of time for the GcGems to start up:

`System waitForAllGcGemsToStartForUpToSeconds:` *anInt*
If the Admin Gem is not running, start it. If the Reclaim Gem is not running, start it with the configured number of Reclaim sessions. If all the GcGems have not started up within that time, return false. However, this does not necessarily mean that any GcGems have failed to start; on a slow system with a short timeout, this method may return false, even though all GcGems eventually start correctly.

To confirm that the GcGems are running,:

`System hasMissingGcGems`
Returns false if either the Admin Gem or the Reclaim Gem is not running.

To determine the number of Reclaim sessions that are currently running:

`System reclaimGcSessionCount`
Returns the total number of Reclaim sessions that are running.

Stopping GcGems

To ensure that the Admin Gem and all Reclaim sessions are stopped:

```
System stopAllGcGems
```

or you may execute both:

```
System stopAdminGem.
System stopReclaimGem.
```

Adjusting the number of Reclaim sessions

You can adjust the number of Reclaim sessions that are running during the course of operation of your application. When there is a large amount of reclaim and little other load on your system, running a large number of Reclaim sessions will allow the reclaim work to complete more quickly. During normal operation, reducing the number of Reclaim sessions avoids using too many system resources and impacting users.

To set the number of Reclaim sessions that are running:

`System changeNumberOfReclaimGemSessions:` *targetReclaimSessionCount*
Start the ReclaimGem, if it is not running, with *targetReclaimSessionCount* Reclaim sessions.

targetReclaimSessionCount should be a number less than or equal to the value for STN_MAX_GC_RECLAIM_SESSIONS. Using a larger argument does not error, but may have consequences for user logins; see the discussion on page 298.

Return the new target number of Reclaim sessions; Reclaim sessions will be started or stopped to reach this number. This method does not block, so it may take a little time before the correct number of Reclaim sessions is actually running.

Using this method only changes the currently running number of Reclaim sessions, but does not affect the configured number. After stopping the ReclaimGem, on restart the regular configured number of sessions will be started.

To change the default number of Reclaim sessions that will be started by default when the ReclaimGem starts up:

```
System configurationAt: #StnNumGcReclaimSessions
      put: targetReclaimSessionCount.
```

This does not effect the number of Reclaim sessions that are currently running, if any. Changes to the runtime parameter do not persist if the Stone is restarted. For a permanent change, you should edit the configuration parameters in the configuration file used by the stone: STN_NUM_GC_RECLAIM_SESSIONS, and if necessary, STN_MAX_GC_RECLAIM_SESSIONS.

15.6 Further Tuning Garbage Collection

Multi-Threaded Scan

For large systems, it can take a considerable amount of time to scan the entire repository, as is required by a mark/sweep operation (or other operations such as `listInstances`). To allow these scans to complete faster, operations that scan the entire repository use multiple threads running in parallel. There is a trade-off between how fast the operation completes and how much of the system resources it uses. Obviously, the faster the scan completes, the less of anything else can be done on that system during that period.

The trade-off can be configured per operation and can be changed as the operation proceeds. You can choose to run it to complete as quickly as possible but use all the system resources, or with minimal impact on the rest of your application, but taking much longer to complete. You can switch between these approaches as often as you need to.

Tuning Multi-Threaded Scan

Each session has two variables that control the impact of the multi-threaded operation it is running:

- MtThreadsLimit—The upper limit on the number of threads can be activated.
- MtPercentCpuActiveLimit—The total CPU load level at which the scan starts to deactivate threads.

Repository scan operations determine their impact in several ways:

- By default, scan operations use 2 threads.
- You may explicitly override the default number of threads by executing

  ```
  Repository >> setDefaultNumThreads:
  ```

  which sets the default until this session logs out; or by using

  ```
  Repository >> setDefaultNumThreads:during:
  ```

  which accepts a block; the default number of threads is set only while the block is executing.

  The thread limits are defined in the class Repository, although the scan method itself may be implemented in Class, Object, or GsObjectInventory, or elsewhere.
- Most repository scan operations, including `markForCollection`, `listInstances:`, etc., have variants that use a larger number of threads based on the number of CPUs and the number of configured sessions. These method selectors start with ''fast", e.g. `fastMarkForCollection`, and increase the maximum CPU load as well. `fast*` repository scan methods are not affected by setting the default number of threads.

- Most repository scan operations, including `markForCollection`, `listInstances:`, etc., have variants that accept, as an argument, the number of threads to use. These method selectors end in the keyword such as ''threads:" or WithMaxThreads:", e.g. `markForCollectionWithMaxThreads:`. Methods that allow you to specify the number of threads are not affected by setting the default number of threads.

While the initial number of threads is set before the scan operation starts, you can also update them while the scan is running. This enables you, for example, to reduce impact during working hours, while allowing more resources to be used during off hours.

Since the scan is running, you need to update these variables from a second session, using the sessionId of the session that is running the scan.

One way to determine the session Id of the session that is running a scan operation is by checking the session holding the GcLock.

To access the upper limit on the number of threads:

```
System mtThreadsLimit: aSessionId
```

To update the upper limit on the number of threads:

```
System mtThreadsLimit: aSessionId setValue: anInt
```

To access the CPU load limit:

```
System mtPercentCpuActiveLimit: aSessionId
```

To update the CPU load limit:

```
System mtPercentCpuActiveLimit: aSessionId setValue: anInt
```

Both of these variables are used in tuning, but they have somewhat different uses. The primary way you will tune the impact on your system is by setting MtPercentCpuActiveLimit. The operations then controls its impact by activating or deactivating threads, up to a limit of MtThreadsLimit. The operation will proceed, using more or less resources at any particular time depending on what else is executing on your system. Note that the CPU load includes non-GemStone process running on this same machine, so if a machine is heavily used by non-GemStone processes, the operation may make little progress even if the GemStone repository itself is idle.

MtThreadsLimit acts as a ceiling on the impact as well. Since this limit is of more relevance within GemStone, on heavily loaded machines you may want to pay more attention to this limit to control the impact within the repository. This limit is also useful when you want to pause the scan. Setting the MtThreadsLimit to 0 means that the scan cannot perform work, but does not stop executing, it waits until a non-zero limit is set.

Cache Statistics

The following cache statistics are important for tuning multi-threaded scans. These are visible by using statmonitor data viewed in VSD (the visual statistics display tool); see *VSD User's Guide*. You may also access methods in System to get the values programmatically; see "Programmatic Access to Cache Statistics" on page 140 for more information.

MtThreadsLimit	The upper limit on the number of threads that can be running at any one time.
MtPercentCpuActiveLimit	The upper limit on percent of CPU that can be active before threads are deactivated.

percentCpuActive	The current percentage of CPU that is active.
MtActiveThreads	The current number of active threads

Memory Impact

Multi-threaded operations may require considerable C Heap memory. This memory requirement is **not** part of temporary object cache memory. You can configure your GEM_TEMPOBJ_CACHE_SIZE according to other application Gem requirements, or even configure the sessions performing repository scan operations with a very small temporary object cache size.

The amount of memory space that is needed depends primarily upon the current oopHighWater value, the number of threads, and the page buffer size. markForCollection uses a pageBufferSize of 128, epoch and writeSetUnionSweep use a size of 64, and it is an explicit argument to FDC.

The overhead associated with the oopHighWater value can be computed as:

```
(stnOopHighWater + 10M) / 2
```

The memory cost per thread is:

```
50K + (180K * pageBufSize)
```

For example, a system with an oopHighWater mark of 500M running eight threads with a page buffer size of 128 would require a minimum of about 440 MB of free memory.

Identifying Sessions Holding Up Voting

Voting is the 4th phase of garbage collection, described in Step 4 on page 282. During this phase, each logged-in gem must vote on possibly dead objects. Sessions perform this vote on the next abort or commit that they execute, or on logout. If there are idle sessions that do not commit or abort, voting will not be able to complete.

You can determine the status of voting using VSD to examine cache statistics in your system. See the Gem statistic VoteOnDeadCount.

You may find these sessions using:

```
System class >> notVotedSessionNames
```

The method `System class >> descriptionOfSession:` can help in tracking down such sessions. The array returned by this method includes the not voted status, as element 20. For details, see the comment in the image.

Repository scan operations, such as listInstances:, are not allowed while Voting is in progress.

Tuning Write Set Union Sweep

The write set union sweep is the 5th phase of garbage collection, described in Step 5 on page 283. It is performed by the Admin Gem.

The write set union sweep is performed using the Multi-Threaded Scan (page 300), and can be tuned using the following GcGem parameters:

`#sweepWsUnionPercentCpuActiveLimit`	Limit active wsUnion threads when system percentCpuActive is above this limit. Default: 90.
`#sweepWsUnionPageBufferSize`	Size (in pages) of buffer used for wsUnion sweep. Must be a power of 2. Default: 64. Minimum: 8. Maximum: 1024.
`#sweepWsUnionMaxThreads`	The maximum threads used for next wsUnion sweep. By default, use one thread.

Identifying Sessions Holding Up Page Reclaim

Reclaiming pages can proceed only up to those pages currently providing some session's transaction view of the repository—that is, only up to the oldest commit record. When other sessions are logged in, reclaim stops at that point until all sessions using that commit record either commit or abort their transaction.

It can be helpful to identify which sessions are holding on to the oldest commit record.

You can determine the status of voting using VSD to examine cache statistics in your system. See the Stone statistics OldestCrSession and OldestCrSessionNotInTrans.

The method `System class>>sessionsReferencingOldestCr` returns an array of session IDs, which can be mapped to GemStone logins through various System class methods, including `currentSessionsReport` and `descriptionOfSession:`*aSessionId*. For example:

```
topaz 1> exec System sessionsReferencingOldestCr %
an Array
  #1 5

topaz 1> exec System currentSessionsReport %
2 SymbolUser symbolgem 27555
3 GcUser reclaimgcgem 27550
4 GcUser admingcgem 27552
5 DataCurator gem 27906 on localhost
```

The method `currentSessionsReport` prints out information in human-readable form; to `descriptionOfSession:` returns this information, and many other details, in an array. For details, see the comment in the image.

Finding References to Objects that prevent garbage collection

Objects that have references from a live object anywhere within the GemStone repository are "live", and not garbage collected. If you believe you have de-referenced an object, but it does not get garbage collected, you can perform a find references operation to track down references that you were not aware of.

Note that repository wide scan may take considerable time and/or use noticeable system resources. See "Multi-Threaded Scan" on page 300 for how these can be tuned.

Using GsBitmaps

These methods return instances of GsBitmap, which do not require temporary object memory and so can return unlimited number of objects. To analyze the results, for small result sets you can send `GsBitmap >> asArray` to convert the results to an Array. Otherwise, retrieve only a specified number of results using `removeCount:` (which removes elements from the bitmap) or `peekCount:` (which does not remove them).

Finding all references

To find references to a particular object, use one of the following messages:

`SystemRepository allReferences:` *anObject*

`SystemRepository fastAllReferences:` *anObject*

These methods return a GsBitmap of all persistent objects in the repository that reference *anObject*. These methods performs the search using the Multi-Threaded Scan (page 300). `allReferences:` uses moderate resources; `fastAllReferences:` uses as much of the system resouces as it can, to complete more quickly.

You can find all references to all instances of a particular class using:

`SystemRepository allReferencesToInstancesOfClasses:` *aClass*

These methods all accept one argument, or an array of arguments. If an Array is passed in, the result will be an Array of Arrays mapping argument element to GsBitmaps; the order may not be preserved. See the method comments in the image for more details.

Full reference path

To find a complete reference path to a particular object, you can use methods on the GsSingleRefPathFinder. This allows you to determine the complete reference path from a root object to the argument.

NOTE

This method runs in transaction, and may take a considerable time to run. Avoid using it in production systems.

To perform the scan, you create an instance of the GsSingleRefPathFinder for the object or objects, run the scan, and collect/view the results.

Steps to find a reference path:

Step 1. Create an instance with default settings:

```
inst := GsSingleRefPathFinder newForSearchObjects:
      (Array with: mySearchObject).
```

Step 2. Run the scan

```
inst runScan.
```

Step 3. Build the result

```
resultObjs := inst buildResultObjects.
```

`buildResultObjects` returns a collection of instance of GsSingleRefPathResult, which is a subclass of Array. Each element in the GsSingleRefPathResult represents an element in the reference path; it also has instance variables for the searchOop and status.

Step 4. 4) For display, collect the results as strings:

```
resultObjs collect: [:e | e resultString].
```

Steps 2-4 can be done using the GsSingleRefPathFinder method `scanAndReport`. For example:

```
(GsSingleRefPathFinder newForSearchObjects: { mySearchObject })
      scanAndReport
```

These methods locate the first path from a root object to the argument object that is found, but there may be multiple paths.

Note that you cannot find references to a Class or Metaclass using these methods.

Once you have found the references to the unwanted object, set those references to `nil`. This allows the object to be removed during normal garbage collection.

Example 15.1 Finding reference path

```
| inst |
inst := GsSingleRefPathFinder newForSearchObjects:
      { PlusInfinity }.
inst runScan.
(inst buildResultObjects)
   collect: [:e | e resultString]
%
 anArray( 'Reference path for search oop 21393665 (Float)
   1   207361 (SymbolDictionary)
   2   1126401 (IdentityCollisionBucket)
   3   1790721 (SymbolAssociation)
   4   21393665 (Float)
')
```

In this example, PlusInfinity is a Float (#4). It is referred to in a SymbolDictionary (#1), using internal implementation objects (an IdentityCollisionBucket and a SymbolAssociation) that actually have the references.

GsSingleRefPathFinder provides a number of instance variables to parameterize the search:

- maxThreads
- lockWaitTime
- pageBufferSize
- percentCpuLimit
- maxLimitSetDescendantObjs
- maxLimitSetDescendantLevels
- printToLog

Defaults are provided, or you may send messages, for example to perform a less aggressive scan.

Finding large objects that are using excessive space

Repositories usually contain some large objects, such as collections of business objects, but there may also be inadvertent large objects, such as collections that were intended to be

temporary or log strings. If you have large objects that are no longer needed, you can free space by explicitly removing these references.

Identify Larger Objects in the Repository

The following methods returns all objects that are over a specified size:

```
Repository >> allObjectsLargerThan: aSize
Repository >> fastAllObjectsLargerThan: aSize
```

These methods return a GsBitmap of all objects in the repository larger than *aSize*; objects for which you do not have read authorization are not included.

This method performs the repository wide search using the Multi-Threaded Scan (page 300). `allObjectsLargerThan:` uses moderate resources; `fastAllObjectsLargerThan:` uses as much of the system resouces as it can, to complete more quickly.

Finding named objects that are large

Named objects are Global variables; objects that have a reference by a Symbol name in some user's SymbolDictionary. While there are some legitimate uses of Globals for environment-wide information, generally using global variables (other than for classes) is not good software engineering practice.

A common pattern is to use a global to keep some objects persistent, such as an expression:

```
UserGlobals at: #tempCollection put: IdentityBag new
```

If this collection and its contents is not deleted, it may continue to use space and may not be easily noticed. Using SessionTemps is preferred to avoid this problem.

The following expression causes GemStone to look through the symbol list for each user in AllUsers and gather information on any named objects larger than the SmallInteger *aSize*. Since it is looking for named references, it does not need to do a repository scan.

```
topaz 1> printit
AllUsers findObjectsLargerThan: aSize limit: aSmallInt
%
```

This method locates large collections or strings referenced by name; it will not locate collections stored within the class variables of classes, or in instances of classes. It returns an Array of up to *aSmallInt* elements, each of the form `{` *aUserId* `.` *aKey* `.` *anObject* `}`, where *anObject* is an object larger than *aSize* defined in the symbol list of *aUserId*, and *aKey* is the Symbol associated with that object.

Chapter

A GemStone Configuration Options

This appendix describes the GemStone/S 64 Bit configuration settings that control many facets of the GemStone system. It covers:

How GemStone Uses Configuration Files (page 307)
describes system-wide and executable-dependent configuration files, how the system locates configuration files, and how to setup customized configuration files

Configuration File Syntax (page 314)
lists syntax used within configuration files.

Configuration Options (page 316)
describes of all options that can be used within configuration files

Runtime-only Configuration Options (page 359)
lists configurations options that do not have settings for a configuration file, but have runtime settings that can be used in a running system.

A.1 How GemStone Uses Configuration Files

A GemStone/S 64 Bit configuration file is a file containing information that, when read at startup time, can control the configuration, behavior, and functionality of the system at run time. Some of these configuration settings can be modified dynamically by sending messages in GemStone Smalltalk.

The Stone, Gem, and linked applications (collectively, the repository executables) are able to read two different types of configuration files: system-wide configuration files and executable-dependent configuration files.

- **System-wide configuration files** allow the GemStone system administrator to set options pertaining to all GemStone executables on a system- or network-wide basis. This file is required for a Stone to start.

  System-wide configuration files are found in a default location, passed by the **-z** argument, or located by a GEMSTONE_SYS_CONF environment variable.

- **Executable-dependent configuration files** can be used by individual users to control their own running copy of the GemStone system. Options contained in executable-dependent configuration files override the options specified in a system-wide configuration file.

  Executable-dependent configuration files are found by name, passed by the **-e** argument, or located by a GEMSTONE_EXE_CONF environment variable.

These environment variables can be set in the usual way. For example:

```
$ GEMSTONE_EXE_CONF=$HOME/myFile.conf
$ export GEMSTONE_EXE_CONF
```

Both GEMSTONE_SYS_CONF and GEMSTONE_EXE_CONF can be defined to point to either a file or a directory.

At startup time, GemStone repository executables attempt to find and read both a system-wide and an executable-dependent configuration file, searching for these files in the following manner.

System Configuration File

GemStone repository executables begin by attempting to find a system-wide configuration file.

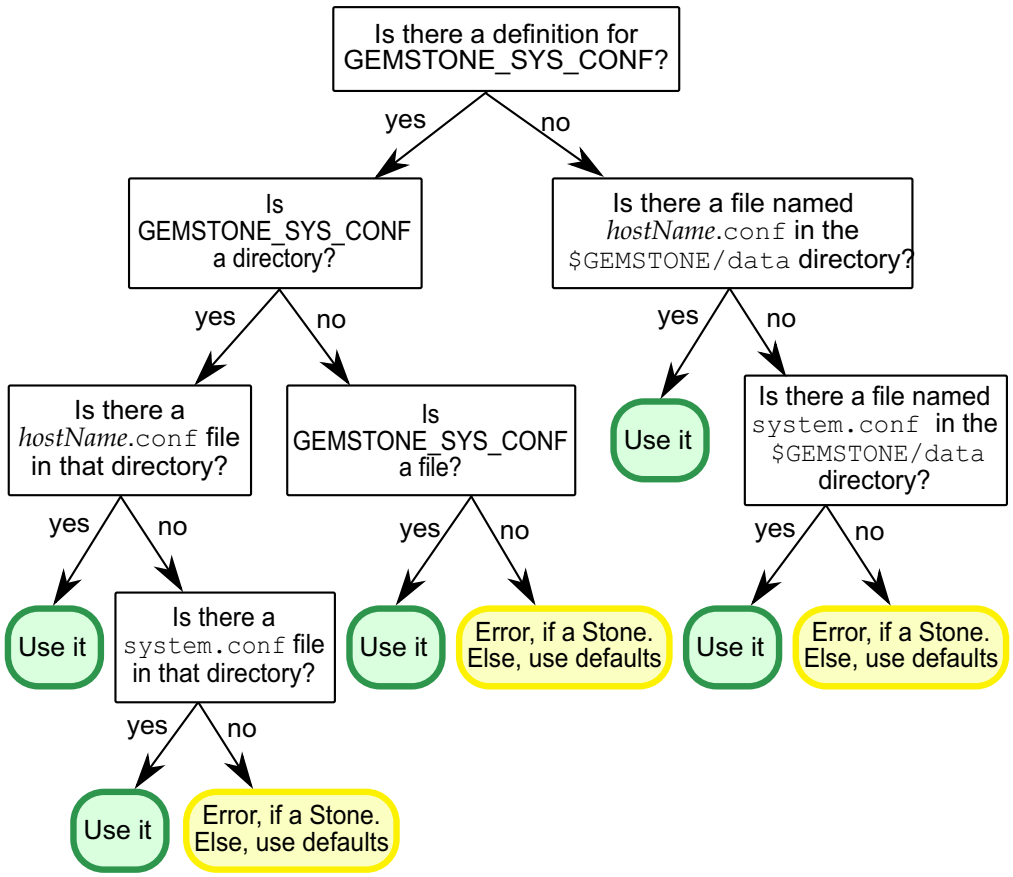
1. As shown in Figure A.1, GemStone first checks to see if there is an environment variable defined for GEMSTONE_SYS_CONF.
2. If GEMSTONE_SYS_CONF is *not* defined, GemStone looks for a file named *hostName*`.conf` in `$GEMSTONE/data` and uses that file. *hostName* must match the results of executing the `hostname` command on the machine on which the executables are running.
3. If no such file exists, it looks for a file named `system.conf` in `$GEMSTONE/data` and uses that.
4. If neither of those files exist, the system defaults are used, unless the executable is Stone, in which case an error is generated.
5. If GEMSTONE_SYS_CONF *is* defined, GemStone checks to see if it points to a directory.
6. If GEMSTONE_SYS_CONF points to a directory, GemStone looks for a file named *hostName*`.conf` in that directory. If it finds such a file, it uses it. *hostName* must match the results of executing the `hostname` command on the machine on which the executables are running. If no *hostName*`.conf` is found, it looks in that directory for a file named `system.conf` and uses that. If neither of those files exist, the system defaults are used, unless the executable is Stone, in which case an error is generated.

   If the GEMSTONE_SYS_CONF environment variable points to a file instead of a directory, GemStone just uses that file.

Within each file, if an option is listed more than once, then the value it is given the last time it is specified is used as its true value at executable run time.

This rule also applies between the two types of configuration files. If the same option is given a value in both the system and executable configuration files, the value in the executable configuration file overrides the system configuration file's value.

Figure A.1 Search Path for a System Configuration File

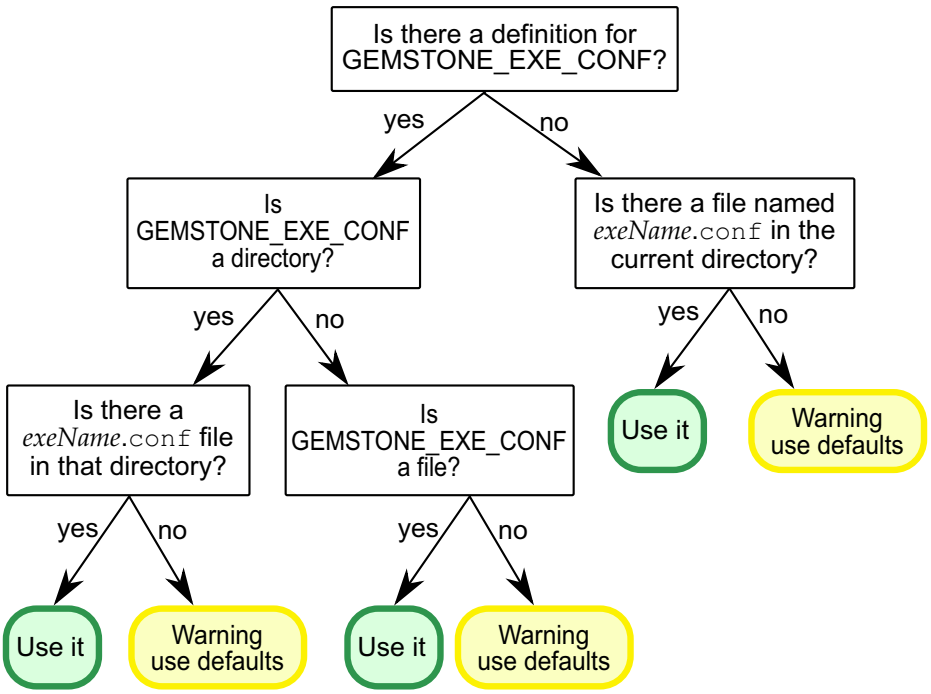


Executable Configuration File

Ordinarily, GemStone repository executables next try to find an executable-dependent configuration file. (The exception is a Stone repository monitor that failed to find its system-wide configuration file—it exits with an error.)

1. As shown in Figure A.2, GemStone begins by checking to see if there is an environment variable defined for GEMSTONE_EXE_CONF.
2. If GEMSTONE_EXE_CONF is not defined, GemStone tries to find a file called *exeName*.conf in the current working directory. (For information about the naming conventions, see "Naming Executable Configuration Files" on page 311.)
3. If it succeeds at finding such a file, it uses that file. If such a file does not exist, it generates a warning and relies solely on the system configuration file for configuration parameters.

Figure A.2 Search Path for an Executable Configuration File



If GEMSTONE_EXE_CONF *is* defined, GemStone first looks to see if it points to a directory.

- If GEMSTONE_EXE_CONF points to a directory, GemStone looks for a file named *exeName*.conf in that directory. If such a file exists, it uses it; if not, a warning is generated and GemStone relies on the system configuration file for configuration parameters.
- If GEMSTONE_EXE_CONF points to a file, rather than to a directory, GemStone simply uses that file.
- If GEMSTONE_EXE_CONF points to a directory or file that doesn't exist, a warning is generated and GemStone defaults to using the system configuration file for configuration parameters.

Creating or Using a System Configuration File

If you are satisfied with the standard options and the defaults, the simplest thing to do is to just use the configuration file provided in `$GEMSTONE/data/system.conf`. You can either copy this file and set the GEMSTONE_SYS_CONF environment variable to point to your new file, or you can do nothing and let GemStone use `$GEMSTONE/data/system.conf` itself.

Creating an Executable Configuration File

There are two ways to create a configuration file for a specific executable:

- You can copy the entire system-wide configuration file to a new file, name it appropriately, and change selected parameters.

- You can create a new file, give it an appropriate name, and include only those parameters that you want to differ from the default.

To make sure that GemStone is able to find and use your executable configuration file, you can set the GEMSTONE_EXE_CONF environment variable to point to your file. GEMSTONE_EXE_CONF can be either a file name or a directory name. If you set the environment variable to a directory name, be sure to name the configuration file *exeName*.conf so GemStone can find it at start up. (Information about the naming conventions for configuration files is just ahead.)

If you don't set the GEMSTONE_EXE_CONF environment variable, GemStone looks for a file named *exeName*.conf in the current working directory at startup. If it doesn't find one, it uses the configuration parameters set in the system configuration file, or it uses the system defaults.

NOTE

Make sure your executable-dependent file is both readable and writable by the Stone process, which will update options by writing to it if you make certain configuration changes at run time.

Nesting Configuration Files

Configuration files can include other configuration files using the option INCLUDE. This may be a more intuitive way to manage multiple configuration settings that are shared and unshared among individual clients.

The INCLUDE configuration parameter can be set to the name of a single file, which will be read, along with the configuration file itself, when a process starts. Unlike other parameters, more than one INCLUDE may be included in a configuration file, and each included file is read, not just the last one. Nesting may be up to 100 levels.

When a duplicate parameter definition is found, the last one is used. Location of the INCLUDE directive determines the last value; if the INCLUDE directive is at the end of the file, values in the nested configuration file override the current file values.

For example:

```
INCLUDE=config2.conf;
INCLUDE="$GEMSTONE/data/config3.conf";
```

Naming Executable Configuration Files

The default name of an executable configuration file generally is determined from the name of the executable itself.

Application Gems

Stand-alone (RPC) Gems look for a file named `gem.conf` in the current working directory unless GEMSTONE_EXE_CONF is defined. The working directory by default is the user's home directory, unless otherwise specificed by the NRS or a customized `gemnetobject` script.

The file `$GEMSTONE/sys/gemnetobject` is a script that a NetLDI invokes to start a GemStone session process. This script can be edited to define the name of the Gem to execute, the directory where the Gem resides, and the GEMSTONE_SYS_CONF and GEMSTONE_EXE_CONF environment variables.

The NetLDI that is specified by the login parameters will lookup tries to map the requested object to the path of an executable by looking for an entry in `$GEMSTONE/sys/services.dat`. That file contains an entry for the standard Gem session process:

```
gemnetobject              $GEMSTONE/sys/gemnetobject
```

For example, when you enter "gemnetobject" as a session login parameter (such as for gemnetid in Topaz), the NetLDI uses the `services.dat` file to map the request to the script `$GEMSTONE/sys/gemnetobject`. Similarly, an object name can be entered while setting up a GemBuilder session (as Name of Gem Service) or other application. Application programmers provide the name as a parameter to `GciSetNet()`.

If the NetLDI does not find the requested object in `services.dat`, it searches for an executable with that name in the user's $HOME directory. If you have a private Gem executable, place the executable in $HOME and then enter its name in place of *gemnetobject* during a GemStone login. Because of the search order, the private name must not be the same as that of an object in `services.dat`. The name must be the name of a file in $HOME, not a pathname.

System Gems

It is sometimes useful to change the parameters in a configuration file specific to a system Gem, such as the Admin or Reclaim Gem. This allows customized configuration settings that remain in effect if the system is stopped and restarted.

To do so:

Step 1. Create a text file with the configuration settings you want.

Step 2. Save your changes with an appropriate filename (for example, `admingcgem.conf`, `reclaimgcgem.conf`, etc., depending on which system Gem the new configuration file is for). Place the file in GemStone's `sys` directory.

Step 3. Make a copy of the appropriate script/s.

`runadmingcgem`	Starts the Admin Gem.
`runcachewarmergem`	Starts the cache warmer Gems.
`runreclaimgcgem`	Starts the Reclaim Gem.
`runsymbolgem`	Starts the SymbolGem.

These scripts are located in $GEMSTONE/`sys/`. Name the copy appropriately; for example, $GEMSTONE/`sys/my`**`runreclaimgcgem`**

Step 4. Edit `myrunreclaimgcgem` to specify the customized configuration file.

For example, to use a Reclaim Gem configuration file named `$GEMSTONE/sys/reclaimgcgem.conf`, locate the lines:

```
exeConfig=""
```

and change to:

```
exeConfig="$GEMSTONE/sys/reclaimgcgem.conf"
```

Step 5. Edit the file `$GEMSTONE/sys/services.dat`. Comment out the existing line:

```
runreclaimgcgem           $GEMSTONE/sys/runreclaimgcgem
```

and add an entry specifying the new script to be executed for the `runreclaimgcgem` service.

```
#runreclaimgcgem          $GEMSTONE/sys/runreclaimgcgem
runreclaimgcgem           $GEMSTONE/sys/myrunreclaimgcgem
```

Stone

Stone looks for a file named *stoneName*`.conf` in the current working directory.

Linked Topaz

The linked version of Topaz looks for the configuration file `gem.conf` in the current working directory, so, by default, Gem and Topaz can share the same options.

Linked GemBuilder for Smalltalk (GBS)

Linked GBS logins by default look for a file named `gbs.conf` in the current working directory.

Linkable GemBuilder for C Applications

Linkable GemBuilder for C applications look for a file named `gci.conf` in the current working directory unless the application has provided a different name by calling GciInitAppName().

Determining which Configuration Files are in use by a Gem or Stone

The Gem log file or topaz linked output will report the names of the system and executable configuration files that were read to determine the configuration for a given session.

You may also execute

```
System gemConfigurationFileNames
System stoneConfigurationFileNames
```

Which will return a file path and name, or an empty string if the expected file did not exist.

Alternate ways to specify configuration parameter values

Usually, configuration parameter values are specified in configuration files. These are found according the rules described earlier using the environment variables, default locations, or by values passed to the -e and -z arguments for GemStone utilities that accept these arguments (such as Stone and Topaz).

Configuration parameter values may also be passed in to Gem and Linked sessions using the -C argument. This is accepted by the Gem NRS and by topaz. The argument string must follow the configuration file syntax rules, and must be quoted, double quoted, and escaped as necessary.

For example, to set a configuration parameter for a RPC Gem, in Topaz:

```
set gemnetid 'gemnetobject -C GEM_TEMPOBJ_OOMSTATS_CSV=TRUE'
```

To set a configuration parameter in linked Topaz:

```
topaz -l -C GEM_TEMPOBJ_OOMSTATS_CSV=TRUE
```

Naming Conventions for Configuration Options

The prefix "GEM_" indicates that the option is processed directly by Gems. Unless indicated otherwise by the phrase "used by all executables," most other options are processed only by the Stone, which passes the information to executables as needed through network connections. Exceptions are the shared page cache configuration options ("SHR_"). The first Gem session process on a node remote from the Stone and extents reads these options, which determine the configuration of the shared page cache on that node.

All executables (that is, the Stone and Gems) understand the standard options used in the file `$GEMSTONE/data/system.conf` as shipped. The GemStone executables generate a warning message whenever they encounter an option that is not in the standard list.

NOTE:

If the DUMP_OPTIONS *option is set to true, then once the system-wide and executable-dependent configuration files have been processed, the values of all the options understood by the executable are displayed. You can access the configuration parameters from Smalltalk by using the methods described starting on page 53.*

A.2 Configuration File Syntax

The following section describes the rules of grammar to be used in editing configuration files.

White space
Leading white space and white space before and after the equal and semicolon termination symbol are ignored.

New lines
New lines within a statement are allowed only after an equal sign or after a comma within a list of values.

Comments
The comment symbol for GemStone configuration files is the pound sign (#). Any text following the pound sign in a line is ignored.

Lists
Lists are separated by commas; list elements can be empty, for example:

```
DBF_EXTENT_SIZES = 2GB, , 2GB;
```

Within lists of values, leading and trailing white space is ignored.

Strings
Strings may be encased in single or double quotes, or if no spaces or escape are included, the quotes can be omitted. An empty string is acceptable, and may be expressed using quotes (""), or by no value at all (for instance, OPTION = ;).

Case-sensitivity
String option values are case-sensitive; boolean option names are *not* case-sensitive.

Maximum Sizes
The maximum length of a string option is 1024 characters. There is no limit on the number of elements within a list.

Use of Environment Variables In Options

Options that are either file names or directories may have environment variables as the first part of their value or the entire value.

Errors in Configuration Files

At startup, each GemStone executable reads the configuration files. If any error is detected, information about the error is written to the standard output. This information indicates the file and line containing the error and the error's severity.

If the CONFIG_WARNINGS_FATAL configuration option (page 316) is set to true, then any errors in the configuration file/s read by the process will cause the process to terminate. This avoids inadvertently getting default configuration values. When CONFIG_WARNINGS_FATAL is false, some invalid settings will still result in execution

Two kinds of errors can be generated by the processing of configuration files: syntax errors and option value errors.

Syntax Errors

Syntax errors are generated whenever a grammatical error is detected in the configuration file. All syntax errors are warnings; they do not cause execution to terminate unless CONFIG_WARNINGS_FATAL is true. These errors include:

- End-of-line or end-of-file detected before expected
- Invalid starting character for an option name or invalid character within an option name
- Equals or semicolon sign expected
- Invalid 3-digit escape sequence
- Invalid escape character
- Terminating quote missing in a quoted string

Option Value Errors

Option value errors are generated when the value assigned to an option has no meaning or is of the wrong type. For example, an option value error is generated when an option defined to need a boolean for its value has been set to an integer.

Option value errors vary in severity. Some options, such as not specifying the list of files that make up a logical repository, will necessarily terminate execution. Other option value errors, such as a invalid cache size, might only generate warnings, unless CONFIG_WARNINGS_FATAL is true. When a warning is issued and CONFIG_WARNINGS_FATAL is false, the executable ignores the given value and use the option's default value.

A.3 Configuration Options

The system configuration file contains the following standard configuration options. In this discussion, *default* refers to the value that results when an option is not explicitly set by a statement in the configuration file. *Initial setting* refers to an explicit setting in the initial `system.conf` file that differs from the default.

Some configuration options have an internal runtime parameter that can be changed while GemStone is running. Where such a parameter exists, its name is given as part of the entry. For more information, see "To Change Settings at Run Time" on page 54.

The `$GEMSTONE/bin` directory contains a write-protected file named `initial.config` that is an exact replicate of `$GEMSTONE/data/system.conf` as it was originally shipped. After modifying `system.conf`, you can always recover its original condition.

CONFIG_WARNINGS_FATAL

If CONFIG_WARNINGS_FATAL is set to TRUE, then any warnings about invalid or out of range entries in a configuration file are treated as a fatal errors, terminating the Gem or Stone process that is reading the configuration file. The last occurrence of this parameter in any configuration file (in the case of multiple settings within a file, or settings in nested configuration files), will control the value used. If the last occurrence is TRUE, then any warnings from preceding configuration parameter will be treated as fatal.

Default: FALSE

DBF_ALLOCATION_MODE

DBF_ALLOCATION_MODE describes the space allocation heuristic to be used when filling repository extents.

Permissible values are either Sequential or a series of allocation weights, separated by commas. Under sequential allocation, each extent has its full resources used before the next extent's resources are used. Under weighted allocation, those extents with a larger weight will have proportionally more of their disk resources allocated than those with smaller weights. Each weight applies to the corresponding extent in the series of extents specified in DBF_EXTENT_NAMES, and the number of elements must match. Extent allocation weights must be integers in the range 5..200 (inclusive).

Default: Sequential

DBF_EXTENT_NAMES

DBF_EXTENT_NAMES list of all repository extents, in order, primary extent first, separated by commas. Taken together, all of the listed file resources make up the logical repository. This option is required, and must contain at least one entry, the name of the primary extent. The maximum number of extents is 255.

An extent name can be a file name or the device name for a raw disk partition. The name can have an environment variable as its first component.

You may add an extent at runtime using `Repository >> createExtent:` and related methods; this is described under "To Add an Extent While the Stone is Running" on page 190. Executing these methods automatically updates the Stone's configuration file.

Default: EMPTY. The system will not run unless you define an extent list.
Initial setting: `$GEMSTONE/data/extent0.dbf`

DBF_EXTENT_SIZES

DBF_EXTENT_SIZES sets the maximum sizes of all repository extents, in order, primary extent first, separated by commas. Each size applies to the corresponding extent in the series of extents specified in DBF_EXTENT_NAMES.

A size entry may be empty, which indicates that the corresponding extent has no fixed maximum size. This setting allows the extent to grow until it fills the disk containing it.

The actual maximum size of an extent will always be a multiple of 16 MB. If an extent size specified by DBF_EXTENT_SIZES is not a multiple of 16 MB, then the actual maximum size will be the next lowest multiple of 16 MB. For example, an extent created with a maximum size of 260 MB, this extent really has a maximum size of only 256 MB.

When an extent is on a raw partition, for optimal performance the corresponding setting in DBF_EXTENT_SIZES should be 16MB smaller than the size of the partition. For example, set it to about 1984 MB for a 2 GB partition.

You can modify the size of an existing extent under these conditions:

- If the original maximum size was unlimited, the new maximum size must be larger than the current physical size of the extent.
- If the original maximum size was limited, the new maximum size must be larger than the original maximum size.

The Stone repository monitor is the only executable allowed to change DBF_EXTENT_SIZES. At GemStone system startup, the maximum size of each extent is written to the system log.

If no units are specified, the value is in MB (1 Megabyte = 1048576 bytes). You may also specify units as KB, MB, or GB.

Default Units: MB
Min: 16 MB
Max: 33554432 MB (subject to disk, operating system and platform limits)
Default: EMPTY (no maximum sizes)

DBF_PRE_GROW

If DBF_PRE_GROW is set to TRUE and there are extents for which a size is specified in DBF_EXTENT_SIZES, then on repository startup, each extent with a size in DBF_EXTENT_SIZES larger than the current size will be pregrown to the specified size. If the grow fails, the extent is reset to its original size and startup fails.

If DBF_PRE_GROW is set to TRUE and a new extent is added programmatically with a size specified, it will be pregrown to that size. If the extent cannot be grown to the maximum size because of disk capacity problems, then extent creation will fail.

The default value for DBF_PRE_GROW is FALSE. This setting indicates that extents will grow only when new space is needed. An extent without a maximum size is never pregrown.

The value of DBF_PRE_GROW may also be a list of integer sizes, which may include blanks for specific extents that will not be pregrown. Extents with an integer size specified in DBF_PRE_GROW will be pregrown to this size if needed. Extents without an entry in DBF_PRE_GROW will not be pregrown.

It is an error if the value for an extent's DBF_PRE_GROW size is larger than the corresponding DBF_EXTENT_SIZES size; if one but not both are empty, it is not an error and the extent will not be pregrown.

Elements of DBF_PRE_GROW may be blank to specify pregrow sizes for some but not all extents, such as:

```
DBF_PRE_GROW = 1000, , 1000;
```

If no units are specified, the value is in MB (1 Megabyte = 1048576 bytes). You may also specify units as KB, MB, or GB.

Default Units: MB
Min: 1 MB
Max: 33554432 MB (limited by DBF_EXTENT_SIZES values)
Default: FALSE

DBF_SCRATCH_DIR

DBF_SCRATCH_DIR specifies a scratch directory that the Stone process can use to create "scratch" repositories for use during **pageaudit**. The file name is appended to the directory name *without* an intervening delimiter, so a trailing delimiter is necessary here.

Default: `$GEMSTONE/data/`

DUMP_OPTIONS

If DUMP_OPTIONS is set to true, dumps a summary of all configuration options as part of the process log file headers.

Default: true

GEM_ABORT_MAX_CRS

When a Gem is not in a transaction and aborts, GEM_ABORT_MAX_CRS specifies the maximum number of commit records to analyze to compute the writeSetUnion since the last time this session aborted. If the number of commit records would exceed this limit, the abort is treated similar to a LostOt and all in-memory copies of committed objects are marked invalid and will be re-read as needed during subsequent execution.

A session remote from stone will use one third of the configured value; and system gems (HostAgent, SymbolGem, AdminGem, ReclaimGem) configure themselves with values in the range 10 .. 3000 .

A value of 0 (zero) means no limit on number of commit records to analyze.

Runtime parameter: **#GemAbortMaxCrs**
Min: 0
Max: 2147483647
Default: 100000

GEM_CACHE_WARMER_ARGS

Configures cache warming on a regular remote cache; does not apply to X509-secured remote caches. If it is an empty string (the default), no cache warming is done when the remote gem starts a remote shared page cache. If it is set to a string containing spaces, a default cache warmer is started.

Otherwise, the value should contain valid startcachewarmer options and values that will be used to invoke the cache warmer on the remote cache.

The arguments used here will use to fork the startcachewarmer utility and have the same meanings. Not all startcachewarmer arguments are valid: only: `-d -D -l -L -n -w`. For the meanings and details for these arguments, see "startcachewarmer" on page 387.

This option is only used by remote gems that create a remote shared page cache. It is ignored by all other gems.

For example, to start a cache warmer with 5 threads and write the working set on cache shutdown:

GEM_CACHE_WARMER_ARGS = "-n 5 -w 0";

Default: "" (cache warmer will not be started)

GEM_CACHE_WARMER_MID_CACHE_ARGS

Configures cache warming on a regular mid-level cache; does not apply to X509-secured mid-level caches. If it is an empty string (the default), no cache warming is done when the remote gem starts a mid-level shared page cache. If it is set to a string containing spaces, a default cache warmer is started.

Otherwise, the value should contain valid startcachewarmer options and values that will be used to invoke the cache warmer on the mid-level cache.

The arguments used here are passed to the **startcachewarmer** utility and have the same meanings. Not all **startcachewarmer** arguments are valid: only: `-d -D -l -L -n -w`. For the meanings and details for these arguments, see "startcachewarmer" on page 387.

For example, to start a mid-level cache warmer with 5 threads and write the working set on cache shutdown:

GEM_CACHE_WARMER_MID_CACHE_ARGS = "-n 5 -w 0";

Default: "" (cache warmer is not started)

GEM_ENV

Specifies one or more String values to be added to the gem process environment during GciInit. Values must be of the form name=value and are passed to putenv() during GciInit.

For example, to specify that gem logs should not be deleted even on a clean exit, you may modify the configuration file used by the Gem to include:

```
GEM_ENV=GEMSTONE_KEEP_LOG=1;
```

which is the equivalent of passing this directly to the gem during login:

```
set gemnetid 'gemnetobject -C GEM_ENV=GEMSTONE_KEEP_LOG=1'
```

Default: '' (empty string)

GEM_COMPRESS_TRANLOG_RECORDS

If true, sessions will compress tranlog data records using lz4 compression before sending them to stone .

Default: true

GEM_FREE_FRAME_CACHE_SIZE

GEM_FREE_FRAME_CACHE_SIZE specifies the size of the Gem's free frame cache. When using the free frame cache, the Gem removes enough frames from the free frame list to refill the cache in a single operation. When adding frames to the free list, the Gem does not add them until the cache is full.

A value of 0 disables the free frame cache (the Gem acquires frames one at a time). A value of –1 means use the default value: 0 for caches less than 100 MB and 10 for caches of 100 MB or greater.

Cache Statistic: **FreeFrameCacheSize** (Gem)
Units: frames
Min: –1
Max: 63
Default: –1 (see above discussion)

GEM_FREE_FRAME_LIMIT

When the number of free frames in the shared page cache is less than GEM_FREE_FRAME_LIMIT, the Gem session process scans the cache for a free frame rather than using one from the free frame list. This action is desirable for performance reasons so the remaining frames in the list are available for use by the Stone repository monitor.

If the value of GEM_FREE_FRAME_LIMIT is –1, the free frame limit is set to one of the following default values:

- For primary shared page cache that is 800 MB or smaller: 10% of the number of frames in the cache
- For primary shared page cache greater than 800 MB: 5000 frames
- For a remote shared page cache: 0

Runtime parameter: **#GemFreeFrameLimit**
Cache Statistic: **FreeFrameLimit** (Gem)
Min: 1
Max: 65536
Default: –1 (see above discussion)

GEM_FREE_PAGEIDS_CACHE

GEM_FREE_PAGEIDS_CACHE specifies the maximum number of free pageIds to be cached in Gem. Larger values reduce number of calls to Stone, at a cost of needing more free space within the extents.

Runtime parameter: **#GemFreePageIdsCache**
Min: 40
Max: 3500
Default: 200

GEM_HALT_ON_ERROR

GEM_HALT_ON_ERROR causes a Gem to halt and write full stack dumps to its log file, if an error with the specified GemStone error number occurs. A value or 0 or less means "never halt". A value of -2 causes printing of details of error 2101, Object does not exist (but does not halt).

This can be overriden during login by argument to GciLoginEx().

Runtime parameter: **#GemHaltOnError**
Default: -1

GEM_KEEP_MIN_SOFTREFS

GEM_KEEP_MIN_SOFTREFS determines the minimum number of most recently used SoftReferences that will not be cleared by VM markSweep if *startingMemUsed* — the percentage of temporary object memory in use at the beginning of a VM mark/sweep — is greater than GEM_SOFTREF_CLEANUP_PERCENT_MEM but less than 80%.

In most cases, the default (0) is appropriate and should not be changed.

Runtime parameter: **#GemKeepMinSoftRefs**
Min: 0
Max: 10000000
Default: 0

GEM_KERBEROS_KEYTAB_FILE

Path to the Kerberos key table file. The keytab file only is required when passwordless logins to GemStone are in use. The file contains pairs of Kerberos principals and encrypted keys. For GemStone passwordless logins, the Kerberos service is the service for a GemStone repository.

See "Configure SingleSignOn Authentication" on page 181 for how to setup passwordless login and use GEM_KERBEROS_KEYTAB_FILE.

Default: NONE

GEM_KEYRING_DIRS

A list of directories which contain keys and certificates used for secure backup and restore.

Runtime equivalent: #GemKeyRingDirs
Default: NONE

GEM_LISTEN_FOR_DEBUG

If true, the gem or topaz -l process will open a listening socket, listening on localhost only for a topaz -r process to connect using the topaz DEBUGGEM command (GciDebugConnectToGem, GciDebugStartDebugService). The listening socket will show up in gslist with the name gem<pid>debug. When the socket is opened, the process will print to the gem log or stdout of the topaz -l the DEBUGGEM command required to debug it; that command includes a random integer token.

For more information on debugging from another session, see the *Topaz User's Guide*.

Runtime equivalent: `System class >> listenForDebugConnection`
Default: false

GEM_MAX_SMALLTALK_STACK_DEPTH

GEM_MAX_SMALLTALK_STACK_DEPTH determines the size of the GemStone Smalltalk execution stack space that is allocated when the Gem logs in. The unit is the approximate number of method activations in the stack. This setting causes heap memory allocation of approximately 64 bytes per activation. Exceeding the stack depth results in generation of the error RT_ERR_STACK_LIMIT.

Min: 100
Max: 30000 for native code on Intel CPU, 1000000 otherwise
Default: 1000

GEM_NATIVE_CODE_ENABLED

GEM_NATIVE_CODE_ENABLED enables or disables generation of native code. This is set to an integer 0, 1, or 2. For compatibility with configuration files from earlier versions, it may be also set to TRUE or FALSE.

Breakpoints in methods disable native code. Also, a session with a very large GEM_TEMPOBJ_CACHE_SIZE, on the Mac, may disable native code for internal reasons.

The runtime parameter #GemNativeCodeEnabled can be used to disable native code, and can be used to control whether subsequent GsProcesses start execution using interpreted or native code. Enabling generation of native code for methods as they are loaded for execution can only be controlled by the value of GEM_NATIVE_CODE_ENABLED in the configuration files at process startup.

- 0 or FALSE disables native code generation
- 1 enables native code generation
- 2 or TRUE enables native code generation, with inlining of some SmallInteger math primitives.

Runtime parameter: **#GemNativeCodeEnabled**
Minimum: 0
Maximum: 2
Default: 2

GEM_PGSVR_COMPRESS_PAGE_TRANSFERS

If GEM_PGSVR_COMPRESS_PAGE_TRANSFERS is true, use LZ4_compress() from the LZ4 compression library to compress page transfers between the Stone and Gem or mid-cache page server.

For the first Gem to login on a remote machine, that Gem's configuration file value of GEM_PGSVR_COMPRESS_PAGE_TRANSFERS is propagated to the page manager, and is used to configure the page manager's communication to the page manager's pgsvr on the new remote cache.

When a Gem triggers creation of a mid-level cache via the method `midLevelCacheConnect:cacheSizeKB:maxSessions:`, that Gem's current runtime value of GEM_PGSVR_COMPRESS_PAGE_TRANSFERS is propagated to the page manager, and is used to configure the page manager's communication to the page manager's pgsvr on the new mid-level cache.

Runtime parameter: **#GemPgsvrCompressPageTransfers**
Default: TRUE

GEM_PGSVR_FREE_FRAME_CACHE_SIZE

GEM_PGSVR_FREE_FRAME_CACHE_SIZE specifies the size of the free frame cache used by the Gem's remote page server. This configuration option has no effect for Gems that are local to the repository extents (which have a page server).

When using the free frame cache, the page server removes enough frames from the free frame list to refill the cache in a single operation. When adding frames to the free list, the page server does not add them until the cache is full.

A value of 0 disables the free frame cache (the page server acquires frames one at a time). A value of –1 means use the default value: 0 for caches less than 100 MB and 10 for caches of 100 MB or greater.

Cache Statistic: **FreeFrameCacheSize** (Page Server)
Units: frames
Min: –1
Max: 63
Default: –1 (see above discussion)

GEM_PGSVR_FREE_FRAME_LIMIT

GEM_PGSVR_FREE_FRAME_LIMIT determines the free frame limit used by the Gem's remote page server. It has no effect for Gems local to the repository extents (which do not have a page server). For a description of free frames, see the configuration option GEM_FREE_FRAME_LIMIT (page 320).

If the value of GEM_PGSVR_FREE_FRAME_LIMIT is –1, the free frame limit is set to one of the following default values:

- For primary shared page cache that is 800 MB or smaller: 10% of the number of frames in the cache
- For primary shared page cache greater than 800 MB: 5000 frames

To tune the free frame limit of a page server at runtime, use the method `System class>>changeCacheSlotFreeFrameLimit:` *aSlot* `to:` *aValue.*

Cache Statistic: **FreeFrameLimit** (Page Server)
Min: –1
Max: 65536
Default: –1 (see above discussion)

GEM_PGSVR_UPDATE_CACHE_ON_READ

GEM_PGSVR_UPDATE_CACHE_ON_READ determines the read behavior of the Gem's remote page server when pages are read from disk. If this option is true, pages read from disk are also added to the shared page cache on the page server's host. If this option is false, pages read are not added to the page server's shared cache.

This option has no effect for Gems that are local to the repository extents, which do not have page servers, nor on mid-level caches.

Runtime parameter: **#GemPgsvrUpdateCacheOnRead**
Default: TRUE

GEM_PGSVR_USE_SSL

GEM_PGSVR_USE SSL controls whether a remote gem uses a secure socket layer (SSL) connection to converse with its page server(s), both the page server on the stone's host and the page server on the mid-level cache, if any.

This option has no effect local gems (i.e., gems running on the same host the stone process), nor on solo sessions, nor on X509-secured sessions.

Secure sockets are slightly slower than insecure sockets due to the overhead of encrypting and decrypting data.

When enabling this option, check that GEM_PGSVR_COMPRESS_PAGE_TRANSFERS is also enabled (as it is by default). SSL encodes no more than 16 KB into a single packet and some messages sent between the gem and page server may exceed this limit, causing SSL to send multiple encrypted packets to convey a single message.

Default: FALSE

GEM_READ_AUTH_ERR_STUBS

GEM_READ_AUTH_ERR_STUBS configures the behavior when a read authorization denied occurs on object fault. When FALSE (the default), a SecurityError is signalled. When set to TRUE, an in-memory instance of UnauthorizedObjectStub is constructed.

Runtime equivalent: **#GemReadAuthErrStubs**
Default: FALSE

GemRemoteCommit

Used only in X509-secured GemStone.

GemRemoteCommit determines if a gem on a remote gem will execute the critical region of commit in the session's thread in the pgsvr or hostagent on stone host.

Default is true if gem is remote and gem host has same byte order as stone host and the gem is an X509 session. Can only be enabled if gem and stone host have same byte order and the gem is an X509 session.

Runtime name: #GemRemoteCommit
Default: TRUE for remote X509 Gems on a host with the same byte order as Stone host, FALSE otherwise.

GEM_REPOSITORY_IN_MEMORY

GEM_REPOSITORY_IN_MEMORY sets the performance behavior of the gem for certain operations that scan the entire repository.

When the shared page cache size (SHR_PAGE_CACHE_SIZE_KB) is sized to match the total repository extent size, then the entire repository is in memory. This achieves the best possible performance since pages do not need to be read into the cache.

If GEM_REPOSITORY_IN_MEMORY is set to TRUE, the gem assumes most or all of the data pages in the repository have been previously loaded into the shared page cache. If set to FALSE, the gem assumes many of the data pages are not in the cache, and must be read from disk.

Setting GEM_REPOSITORY_IN_MEMORY to true for repositories in which the entire database is in memory will have improved performance for repository scan operations such

as `findReferencePathToObject:` (and related methods). This setting affects performance only. All operations affected by this setting will succeed and produce the same results with either setting.

Runtime parameter: **#GemRepositoryInMemory**
Default: FALSE

GEM_RPCGCI_TIMEOUT

GEM_RPCGCI_TIMEOUT specifies the time in minutes after which lack of an Rpc command will cause a Gem to terminate. Negative timeouts are not allowed. Resolution of timeouts is one-half the specified timeout interval.

Min: 0
Default: 0 (Gem waits forever)

GEM_RPC_KEEPALIVE_INTERVAL

GEM_RPC_KEEPALIVE_INTERVAL is the interval in seconds for the RPC GCI client to send a packet to the gem to ensure the network connection is kept alive.

With the traditional GCI interface (gci.hf), this controls how often keep-alive packets are sent during the GciPollForSignal() calls. The application needs to be calling GciPollForSignal at regular intervals at least as often as the configured value.

In the thread safe GCI (gcits.hf), the gem will send an interrupt byte periodically, and the application must be calling GciTsWaitForEvent at least as often as this config value.

Min: 0
Max: 7200
Default: 0 (disabled)

GEM_RPC_USE_SSL

GEM_RPC_USE_SSL controls whether a remote RPC gem uses a secure socket layer (SSL) connection to converse with its RPC client. RPC sessions always establish a secure connection during the login sequence. This parameter controls whether the gem and its remote RPC client continue using the SSL connection. Otherwise, a standard TCP/IP socket connection is used.

This option has no effect for linked gems and local RPC gems (i.e., a gem running on the same host its client). Local gems always revert to a standard TCP/IP socket after login.

Secure sockets are slightly slower than insecure sockets due to the overhead of encrypting and decrypting data.

Default: TRUE

GEM_SOLO_EXTENT

GEM_SOLO_EXTENT only applies to a session that is logging in solo, that is, a login that does not use a running Stone. A solo session is produced by having the GCI_LOGIN_SOLO bit set in the loginFlags argument to GciLoginEx(), or by using SET SOLOLOGIN ON in topaz prior to LOGIN.

The extent must be a repository that has only one extent. If not read-only on the filesystem, the extents must come from a clean shutdown of the Stone, and will be opened with an exclusive file lock and be usable by only one Solo session at a time.

For more on using solo sessions, see the *Topaz User's Guide*, or the section on External Sessions in the *Programming Guide*.

Default: $GEMSTONE/bin/extent0.dbf

GEM_STATMONITOR_ARGS

GEM_STATMONITOR_ARGS provides a way to automatically start one or more statmonitor processes when a remote cache is started. The value of this parameter is a list of double-quoted strings, each of which is composed of a list of statmonitor arguments. Each argument string will correspond to starting one statmonitor process with the given arguments. This allows you to start, for example, both daily and monthly startmonitor monitoring processes on the same remote cache.

The argument strings must be at least 2 but not more than 1023 characters long, and consist of legal statmonitor arguments. The name of the stone should not be included, and it is not legal to use the **-X** argument. Statmonitor arguments are described on page 398, and can also be obtained by invoking **statmonitor -h**.

The list of argument string elements are separated by commas and can contain no more than 64 elements.

For example, the following will start one statmonitor with a 5 second sample interval and another with a 60-second sample interval, with a date and timestamp included in the output file name:

```
GEM_STATMONITOR_ARGS =
   "-i5 -u5 -F'statmon5s_%%S_%%P_%d-%m-%y-%H:%M:%S'",
   "-i60 -u5 -F'statmon60s_%%S_%%P_%d-%m-%y-%H:%M:%S'";
```

To start statmonitor automatically on the Stone's node, see STN_STATMONITOR_ARGS (page 356); for mid-level caches, see GEM_STATMONITOR_MID_CACHE_ARGS (page 326).

Default: "" (statmonitor will not be started)

GEM_STATMONITOR_MID_CACHE_ARGS

GEM_STATMONITOR_MID_CACHE_ARGS provides a way to automatically start one or more statmonitor processes when a mid-level cache is started. The value of this parameter is a list of double-quoted strings, each of which is composed of a list of statmonitor arguments. Each argument string will correspond to starting one statmonitor process with the given arguments. This allows you to start, for example, both daily and monthly statmonitor monitoring processes on the same mid-level cache.

The argument strings must be at least 2 but not more than 1023 characters long, and consist of legal statmonitor arguments. The name of the stone should not be included, and it is not legal to use the **-X** argument. Statmonitor arguments are described on page 398, and can also be obtained by invoking **statmonitor -h**.

The list of argument string elements are separated by commas and can contain no more than 64 elements.

For example, the following will start one statmonitor with a 5 second sample interval and another with a 60-second sample interval, with a date and timestamp included in the output file name:

```
GEM_STATMONITOR_MID_CACHE_ARGS =
   "-i5 -u5 -F'statmon5s_%%S_%%P_%d-%m-%y-%H:%M:%S'",
   "-i60 -u5 -F'statmon60s_%%S_%%P_%d-%m-%y-%H:%M:%S'";
```

To start statmonitor automatically on the Stone's node, see STN_STATMONITOR_ARGS (page 356); for remote caches, see GEM_STATMONITOR_ARGS (page 326).

Default: "" (statmonitor will not be started)

GEM_SOFTREF_CLEANUP_PERCENT_MEM

GEM_SOFTREF_CLEANUP_PERCENT_MEM controls the cleanup of SoftReferences.

If *startingMemUsed* — the percentage of temporary object memory in-use at the beginning of a VM mark/sweep — is less than the value of this option, no SoftReferences will be cleared.

If *startingMemUsed* is greater than the value of this option and less than 80%, the VM mark/sweep will attempt to clear an internally determined number of least recently used SoftReferences. Under rare circumstances, you might choose to specify a minimum number (GEM_KEEP_MIN_SOFTREFS) that will not be cleared.

If *startingMemUsed* is greater than 80%, VM mark/sweep will attempt to clear all SoftReferences.

Also see the statistics **NumSoftRefsCleared**, **NumLiveSoftRefs**, and **NumNonNilSoftRefs**.

Runtime parameter: **#GemSoftRefCleanupPercentMem**
Min: 10
Max: 80
Default: 50

GEM_TEMPOBJ_AGGRESSIVE_STUBBING

GEM_TEMPOBJ_AGGRESSIVE_STUBBING controls stubbing in in-memory garbage collection. If instance variable X in object A references object B, and X contains a memory pointer to B, then the reference is *stubbed* by storing into instance variable X the objectId of object B.

When this option is TRUE (the default), references from temporary objects to in-memory copies of committed objects are stubbed whenever possible, during both scavenge and mark/sweep. Also, references from not-dirty in-memory copies of committed objects to other committed objects are stubbed whenever possible. This reduces the number of committed objects forced to stay in-memory, but can slow down garbage collection and subsequent execution.

When this option is FALSE, references from temporary objects to in-memory copies of committed objects are never stubbed. References from not-dirty in-memory copies of committed objects to other committed objects are stubbed after the number of objects flushed during commits reaches a threshold, or if almost OutOfMemory. Performance may be faster, but there is a greater risk of OutOfMemory errors.

Stubbing is always disabled when a commit attempt is in progress, regardless of the setting of this parameter. Certain objects private to the object manager are always immune from

stubbing, and so are references stored into Session State by using `System class >> _sessionStateAt:put:`.

Also see the statistics **NumRefsStubbedMarkSweep** and **NumRefsStubbedScavenge**.

Default: TRUE

GEM_TEMPOBJ_CACHE_SIZE

GEM_TEMPOBJ_CACHE_SIZE sets the maximum size of the Gem's temporary object memory. This limit also applies to memory in linked Topaz sessions and linked GemBuilder applications. This value is set when the VM is initialized and cannot be changed without restarting the VM. When you only change this setting, and the other GEM_TEMPOBJ* configuration options use default values, then all of the various spaces remain in proportion to each other.

This setting defines the maximum memory size. The initial memory allocated will be smaller, and as the actual space required for objects grows, the VM requests and allocates virtual memory as needed. As the limit is approached, in-memory garbage collection becomes more aggressive; if the limit is reached, the Gem will exit.

If no units are specified, the value is in KB. You may also specify units as KB, MB, or GB.

Statistic: **GemTempObjCacheSizeKb** (Gem)
Default Units: KB
Min: 2 MB
Max: 62 GB
Default: 50 MB

SeeChapter 14, "Managing Gem Memory", starting on page 269, for a detailed discussion of temporary object memory.

GEM_TEMPOBJ_CONSECUTIVE_MARKSWEEP_LIMIT

GEM_TEMPOBJ_CONSECUTIVE_MARKSWEEP_LIMIT controls in-memory garbage collection. If there are more consecutive in-memory mark sweeps than this value, without any intervening successful in-memory scavenges, then an OutOfMemory error will occur.

Runtime equivalent: **GemTempObjConsecutiveMarksweepLimit** (Gem)
Default: 50
Min: 20
Max: 5000

GEM_TEMPOBJ_MESPACE_SIZE

GEM_TEMPOBJ_MESPACE_SIZE sets the maximum size of the Map Entries space within the Gem's temporary object memory. This value is set when the VM is initialized and cannot be changed without starting the VM.

One Map Entry is required for each faulted-in committed object, or for any temporary object that might become committed, referenced from an IdentityBag, or exported to the GCI. One Map Entry occupies approximately 24 bytes.

If a Map Entry is needed and the Map Entries Space is full, an OutOfMemory occurs, terminating the session.

Unless you are trying to minimize the memory footprint on HP-UX or AIX, you should always leave GEM_TEMPOBJ_MESPACE_SIZE at its default value (0) so that the system

can calculate the size of the Map Entries space based on other memory sizes Otherwise, you are at risk of premature OutOfMemory errors.

If no units are specified, the value is in KB. You may also specify units as KB, MB, or GB.

Default units: KB
Min: 1 MB
Max: 2 GB
Default: 0

GEM_TEMPOBJ_OOMSTATS_CSV

GEM_TEMPOBJ_OOMSTATS_CSV configures the production of a CSV file on an OutOfMemory error. If TRUE, then when an Error 4067/OutOfMemory occurs, the detailed statistics of instances of classes in temporary memory are written to a `gemnetobject`*pid*`.csv` file in CSV format. For a topaz -l process, CSV data is written to a `topaz`*pid*`.csv` file in the current directory.

The config parameter GEM_TEMPOBJ_OOMSTATS_CSV and the environment variable GS_DEBUG_VMGC_VERBOSE_OUTOFMEM operate independently. The environment variable GS_DEBUG_VMGC_VERBOSE_OUTOFMEM controls writing statistics in standard text to the gem log or stdout.

Runtime parameter: **#GemTempObjOomstatsCsv**
Default: FALSE

GEM_TEMPOBJ_OOPMAP_SIZE

GEM_TEMPOBJ_OOPMAP_SIZE sets the size of the hash table (that is, the number of 8-byte entries) in the objId-to-object map within the Gem's temporary object memory. This value is set when the VM is initialized and cannot be changed without starting the VM.

The value specified is rounded up to the next higher power of 2.

This option should normally be left at its default value (0) so that the system can calculate the size of the map based on other memory sizes.

Min: 16384
Max: 524288000
Default: 0

GEM_TEMPOBJ_PERMGEN_SIZE

GEM_TEMPOBJ_PERMGEN_SIZE sets the size of the Perm generation of temporary object memory. If the configuration value is zero, the Perm generation is sized at 10% of CFG_GEM_TEMPOBJ_CACHE_SIZE up to a maximum of 30MB.

If no units are specified, the value is in KB. You may also specify units as KB, MB, or GB.

Default units: KB
Min: 200 KB
Max: 100 MB
Default: 0

GEM_TEMPOBJ_POMGEN_PRUNE_ON_VOTE

GEM_TEMPOBJ_POMGEN_PRUNE_ON_VOTE sets the percent of POM generation area to be thrown away when voting on possible dead objects.

If the value is 0, no subspaces of POM generation are cleared; if the value is 100, all subspaces are cleared. For values greater than 0 and less than 100, the number of spaces that are in use and older than 5 minutes is computed, and the specified parameter is the percentage, rounded down, of these subspaces that are discarded.

Runtime parameter: **#GemPomGenPruneOnVote**
Default: 50
Min: 0
Max: 100

GEM_TEMPOBJ_POMGEN_SCAVENGE_INTERVAL

GEM_TEMPOBJ_POMGEN_SCAVENGE_INTERVAL is the interval in seconds in which the oldest POM generation subspace will be discarded. Lower values may reduce Gem memory usage but may also cause objects to be re-read. Larger values may result in higher Gem memory usage and may reduce disk I/O. Setting this value to zero disables scheduled POM generation scavenges. In this case, POM generation will only be scavenged when all subspaces become full.

Runtime parameter: **#GemTempObjPomgenScavengeInterval**
Units: seconds
Min: 0
Max: 86400
Default: 1800

GEM_TEMPOBJ_POMGEN_SIZE

GEM_TEMPOBJ_POMGEN_SIZE sets the maximum size of the POM generation area in the Gem's temporary object memory. This value is set when the VM is initialized and cannot be changed without starting the VM.

The POM generation area holds unmodified copies of committed objects that have been faulted into a Gem, and is divided into ten subspaces.

This option should normally be left at its default value (0) so that the POM generation area is allocated to the default, which is approximately 80% of GEM_TEMPOBJ_CACHE_SIZE, for smaller cache sizes (under 200MB); the proportion decreases as the cache size becomes larger.

If no units are specified, the value is in KB. You may also specify units as KB, MB, or GB.

Default units: KB
Min: 1 MB
Max: 2 GB
Default: 0

GEM_TEMPOBJ_SCOPES_SIZE

GEM_TEMPOBJ_SCOPES_SIZE is the size of the scopes stack in Gem temporary object garbage collection. This value is set when the VM is initialized and cannot be changed without starting the VM.

The scopes stack consumes (8 bytes * GEM_TEMPOBJ_SCOPES_SIZE) of C heap memory.

The primary user-visible effect of this setting is maximum depth of nested expressions that can be compiled by the method compiler. The default setting is sufficient for expression nesting of about 200, such as in depth of nested parenthesized expressions.

Min: 1000
Max: 10000000
Default: 2000

GEM_TEMPOBJ_START_ADDR

GEM_TEMPOBJ_START_ADDR applies for AIX only. If the default mmap of temporary object memory fails, this value is used to define the starting address at which to attempt to mmap temporary object memory using MAP_FIXED at fixed addresses and munmap to simulate MAP_NORESERVE.

A config file value of zero results in an internal default of 0xA00000000000000 for AIX 7, and 0x700000000000000 for AIX 6. A non-default value must be coded as an exact address and may be affected by use of mmap by other shared libraries.

Default: 0

INCLUDE

INCLUDE specifies the name of a file to be included in this config file when parsing include files. The value must be a single string, which is a path to a file, and may include environment variables which will be expanded. INCLUDE directives may be nested up to 100 deep.

Unlike other configuration parameters, the INCLUDE parameter may be present more than once in a configuration file, and each file specified by an INCLUDE, not just the last one, is read. When other configuration parameters settings are found in more than one file, however, the last one read is the value that is used.

For example:

```
INCLUDE=config2.conf;   # will look in current directory
INCLUDE="$GEMSTONE/data/config3.conf";
```

KEYFILE

KEYFILE sets the location of GemStone licensing keyfile.

Default: `$GEMSTONE/sys/gemstone.key`

LOG_WARNINGS

If LOG_WARNINGS is set to true, warnings are printed for invalid configuration options.

Default: true

NETLDI_HostAgentUser_cert

Used only in X509-secured GemStone, in a configuration file supplied as the **-E** argument to **startnetldi** on a remote node. See the *X509-Secured GemStone Adminstration Guide* for more information.

Required for a X509-Secured remote cache or when cache-warming an X509-secured remote or mid-level cache (NETLDI_WARMER_ARGS is non-empty).

A String, the path to a HostAgentUser certificate .pem file.

Default: none

NETLDI_HostAgentUser_key

Used only in X509-secured GemStone, in a configuration file supplied as the **-E** argument to **startnetldi** on a remote node. See the *X509-Secured GemStone Adminstration Guide* for more information.

Required for a X509-Secured remote cache or when cache-warming an X509-secured remote or mid-level cache (NETLDI_WARMER_ARGS is non-empty).

A String, the path to a HostAgentUser private key .pem file.

Default: none

NETLDI_PORT_RANGE

Used only in X509-secured GemStone, in a configuration file supplied as the **-E** argument to **startnetldi** on a remote node. See the *X509-Secured GemStone Adminstration Guide* for more information.

A list of two integers specifying the minimum and maximum of the port range to be used for listening sockets in forked gem processes for X509 sessions.

The two elements must be in the port range 1..65535, and the second element must be greater than the first. The pair of values 10000,65535 will be interpreted as use random ports. On Linux, the ephemeral port range is in /proc/sys/net/ipv4/ip_local_port_range.

Default: not set; use random ports in the range used for ephemeral ports.

NETLDI_START_MIDCACHE

Used only in X509-secured GemStone, in a configuration file supplied as the **-E** argument to **startnetldi** on a remote node. See the *X509-Secured GemStone Adminstration Guide* for more information.

NETLDI_START_MIDCACHE specifies that this NetLDI should start an X509-secured mid-level on this node. The NetLDI starts the shared cache on this mode in response to a start request from a **starthostagent**, and when this configuration parameter is set to true, it will start a HostAgent process on localhost. That HostAgent will login to the HostAgent on the stone's host, to make this newly started cache a mid-level cache.

If true, NETLDI_HostAgentUser_cert and NETLDI_HostAgentUser_key must be specified in this config file.

Default: FALSE

NETLDI_WARMER_ARGS

Used only in X509-secured GemStone, in a configuration file supplied as the **-E** argument to **startnetldi** on a remote node. See the *X509-Secured GemStone Adminstration Guide* for more information.

NETLDI_WARMER_ARGS may be set to a string specifying how an X509 mid-level or leaf cache should be warmed.If string is empty, no warming of the newly started cache is performed. If not empty, the argument string may contain the following options:

-d include data pages. If not included, only warm object table pages.

-M *midCacheHostName*
Include this argument if you wish to warm the newly started cache from an already running mid level cache.

When starting a mid-level cache, if -M specifies a host on which a mid-level cache is running (that is associated with the same Stone), the new cache will be warmed with the pages from the other mid-level cache.

When starting a leaf cache, if -M specifies a host on which a mid-level cache is running (that is associated with the same Stone), and *midCacheHostName* does not resolve to localhost, the new cache will be warmed with the pages from a leaf cache of the other mid-level cache, if present.

When starting either cache, if no -M argument is provided or if *midCacheHostName* is not found, then pages will be pulled from the stone cache to warm the new cache. Pages pulled from the Stone are based on the current view as of the login of the warmer session.

-n *int*
the integer number of threads. These must be in the range 1..20 for warming a mid-level cache and in the range 1..2 for warming a leaf cache. If warming by pulling pages from the Stone (no or unresolved **-M** argument), **-n** is limited to the value for SHR_PUSH_TO_MIDCACHES_THREADS.

Default: "" (no warming is done)

SHR_NUM_FREE_FRAME_SERVERS

SHR_NUM_FREE_FRAME_SERVERS specifies the number of free frame page server threads that will be started in the Stone, when the shared page cache is created. A value of -1 means the default value should be used. On the primary shared page cache (the cache to which the stone attaches), the default value is equal to the value used for the STN_NUM_LOCAL_AIO_SERVERS parameter. On a remote shared page cache, the default is 1.

Min: -1
Max: 255
Default: -1

SHR_PAGE_CACHE_LARGE_MEMORY_PAGE_POLICY

SHR_PAGE_CACHE_LARGE_MEMORY_PAGE_POLICY specifies whether large memory pages will be used when creating the shared page cache. Enabling large memory pages can result in significant performance gains when large shared page caches are used. The improvement is due to a reduction in translation lookaside buffer (TLB) cache misses. The

TLB is an internal structure used by the operating system to manage memory address translation.

Large memory page support is an operating system and hardware dependent feature. Currently, GemStone supports large memory pages on AIX and Linux only. This configuration option is silently ignored on all other platforms.

Three policies are available on supported operating systems:

0 - Disabled: No large memory page support.

1 - Advisory: Large memory pages are requested when the shared page cache is created. If the operating system denies the request, a warning is printed in the SPC monitor log file and the cache is started without large memory pages. **It is strongly discouraged to use this setting on AIX.**

2 - Mandatory: Large memory pages are requested when the shared page cache is created. If the operating system denies the request, an error is printed in the SPC monitor log file and the shared page cache fails to start.

Both Linux and AIX require operating system kernel changes in order to enable large memory pages. Refer to the *Installation Guide* for your platform for more information.

Default: 0
Minimum: 0
Maximum: 2

SHR_PAGE_CACHE_LARGE_MEMORY_PAGE_SIZE_MB

On Linux only, specifies the large memory page size, in megabytes, that will be used when creating the shared page cache. A value of 0 means use the default large page size for the host. This option is only supported on Linux, and any setting is ignored on other platforms.

This setting is ignored if SHR_PAGE_CACHE_LARGE_MEMORY_PAGE_POLICY is 0.

Valid large page sizes on Linux are 2 MB and 1024 MB; not all systems will support both large memory page sizes. Normally the default large page size on Linux is 2 MB, but that default can be changed by the system administrator.

Default: 2
Minimum: 0
Maximum: 1024

SHR_PAGE_CACHE_LOCKED

SHR_PAGE_CACHE_LOCKED specifies whether the shared page cache should be locked in memory. On systems that permit a portion of memory to be dedicated to GemStone, this option may provide higher performance.

On Solaris 10, GemStone uses Intimate Shared Memory for the shared page cache, making setting this variable unnecessary.

Other specific operating systems may restrict this action to processes running as root or may require special privileges (such as on Linux, either the capability CAP_IPC_LOCK or an RLIMIT_MEMLOCK resource limit greater than the size of the shared page cache). For further information, check the shared page cache monitor log for error messages and consult your operating system documentation.

Default: false

SHR_PAGE_CACHE_NUM_PROCS

SHR_PAGE_CACHE_NUM_PROCS sets the maximum number of processes allowed to attach to the shared page cache. This parameter is used to allocate space in the shared page cache for session information and cache statistics. This cache space is in addition to extent page space allocated by SHR_PAGE_CACHE_SIZE_KB.

The value for SHR_PAGE_CACHE_NUM_PROCS must accommodate the GcGems and various background GemStone processes, as well as user Gem and Topaz session processes. If the value is too small, sessions might be unable to login because they can't attach to the cache. If the value is too large, space in the cache may be wasted.

It is recommended to leave this at the default value, and adjust STN_MAX_SESSIONS for your application requirements. When the default setting of –1 is specified, the value of this parameter is calculated as:

STN_MAX_SESSIONS
+ 8 (for system logins)
+ STN_MAX_GC_RECLAIM_SESSIONS + 1
+ SHR_NUM_FREE_FRAME_SERVERS
+ STN_NUM_LOCAL_AIO_SERVERS

Cache Statistic: (SPC Monitor) SlotsTotalCount
Min: 15, or the number extents + 3, whichever is larger
Max: determined by STN_MAX_SESSIONS or file descriptor limits
Default: –1

SHR_PAGE_CACHE_NUM_SHARED_COUNTERS

SHR_PAGE_CACHE_NUM_SHARED_COUNTRERS specifies the number of shared counters available in the shared page cache. On most platforms, each counter consumes 128 bytes of shared memory. On AIX, each counter consumes 256 bytes of shared memory. Shared memory used for shared counters is in addition to the shared memory size specified in SHR_PAGE_CACHE_SIZE_KB.

Cache Statistic: **NumSharedCounters** (SPC Monitor)
Min: 0
Max: 500000
Default: 1900

SHR_PAGE_CACHE_PERMISSIONS

SHR_PAGE_CACHE_PERMISSIONS specifies the UNIX permission settings of the shared page cache, expressed as an octal number. The first two digits are constant and must always be 06. The 0 indicates an octal constant and 6 indicates the UNIX user which created the cache has read/write permissions.

The last two digits specifies the group and other permissions respectively. Each of the last two digits must be one of the following:

6 - read/write
4 - read only
0 - no access

By default, the shared page cache is created with group read/write permission but no access for other users.

Default: 0660

SHR_PAGE_CACHE_SIZE_KB

SHR_PAGE_CACHE_SIZE_KB sets the base size of the shared page cache. Additional shared memory is used for overhead, so the actual size of the memory segment will be larger. Specific details of the final cache size and overhead are reported in the shared page cache monitor log file. For more on the shared page cache size, see "Shared Page Cache" on page 39.

If no units are specified, the value is in KB. You may also specify units as KB, MB, or GB. Values in KB are rounded up to the next MB increment.

Default Units: KB
Min: 16000 KB
Max: Limited by system memory and kernel configurations
Default: 75000 KB

Systems on Linux and AIX may configure large memory pages, which improve performance with very large caches.

For information about platform-specific configurations that impact the size of the shared page cache, as well as large pages, refer to Chapter 1 of the *GemStone/S 64 Bit Installation Guide* for your platform.

SHR_PUSH_TO_MIDCACHES_THREADS

Used only in X509-secured GemStone. See the *X509-Secured GemStone Adminstration Guide* for more information.

In a configuration file for the Stone, SHR_PUSH_TO_MIDCACHES_THREADS sets the total number of page pusher threads across all hostagent processes on the Stone host that can be used to push pages to mid caches. On the Stone host, if set to a number larger than zero, then newly committed pages will be pushed to any X509-secured mid-level cache by the hostagents running on the Stone host.

In a configuration file for a remote X509 mid-level cache node, supplied as the **-E** argument to **startnetldi**, SHR_PUSH_TO_MIDCACHES_THREADS specifies the maximum number of warmer threads that can be configured in NETLDI_WARMER_ARGS to warm another mid-level cache from this mid cache.

Default: 0,
Maximum: 20

SHR_SPIN_LOCK_COUNT

SHR_SPIN_LOCK_COUNT specifies the number of tries to get a spin lock before the process sleeps on a semaphore. Semaphores involve a relatively time-consuming call to the operating system. Spin locks involve busy-wait loops. Efficient locking may require a combination of these methods.

A value of 5000 is recommended, unless running with a single processor. In single-processor architectures, this value should be 1 since there is no value in spinning (the lock won't change until the process holding the lock gets scheduled).

We recommend that you leave this option set to the default value of –1, which causes GemStone to use a value of either 1 or 5000, based upon the number of CPUs detected.

The runtime parameter can be changed only by SystemUser.

Runtime parameter: **#SpinLockCount**
Default: –1 (use either 1 or 5000, based on the number of CPUs detected)

SHR_TARGET_FREE_FRAME_COUNT

SHR_TARGET_FREE_FRAME_COUNT specifies the target number of free frames to keep in the shared cache at all times. The free frame page server threads in the Stone, or the cache page server for a remote shared page cache, will attempt to keep the number of free frames in the cache equal to or greater than this value.

If the value of the parameter is –1, the target free frame count is set to a percentage of the total frames in the shared cache. For the main shared cache (the cache to which the stone attaches), the default is 1/8 the frames in the cache. For remote caches, the default is 1/100 the frames in the cache.

For best performance, keep this setting greater than GEM_FREE_FRAME_LIMIT.

If the value of SHR_TARGET_FREE_FRAME_COUNT is –1, the target number of free frames is set to one of the following default values:

- For primary shared page cache that is 800 MB or smaller: 12.5% of the number of frames in the cache
- For primary shared page cache greater than 800 MB: 7000 frames
- For a remote shared page cache: 1% of the number of frames, or 2000 frames, whichever is smaller

Min: –1
Max: 65535
Default: –1 (see above discussion)

SHR_WELL_KNOWN_PORT_NUMBER

SHR_WELL_KNOWN_PORT_NUMBER specifies the port number that the shared page cache monitor will use as its well-known port. The well-known port is used by all Gems and page servers on this host to connect to the cache monitor.

If the specified port is in use by another process, the monitor process will not start and exits with an error. A value of zero indicates that the port number will be selected by the system.

Min: 0
Max: 65535
Default: 0

STN_ADMIN_GC_SESSION_ENABLED

STN_ADMIN_GC_SESSION_ENABLED determines whether the Admin Gem is started when the Stone is started. (The Admin Gem performs administrative garbage collection functions such as write set union sweeps; the Reclaim Gem performs dead object and page reclaim.)

Runtime parameter: **#StnAdminGcSessionEnabled**
Default: true

STN_ALLOCATE_HIGH_OOPS

STN_ALLOCATE_HIGH_OOPS instructs the Stone to skip the first 16 million object identifiers and begins to allocate object identifiers (GCI OopTypes) for non-special objects at 16r100000001.

This option is designed for testing conversion of GCI applications and user actions. Do not set this option in a production environment.

Default: FALSE

STN_ALLOW_NFS_EXTENTS

STN_ALLOW_NFS_EXTENTS allows the Stone to start up using extents and tranlogs which are on NFS-mounted filesystems. This is less reliable and less performant than locally mounted filesystems, or filesystems on storage arrays which appear as local mounts. This variable cannot be changed at runtime.

Default: FALSE

STN_ALLOW_NO_SESSION_INIT

STN_ALLOW_NO_SESSION_INIT enables bypass, and allows debugging, of `GsCurrentSession>>initialize` and any functions specified by UserProfile's loginHook, which are normally always executed on login.

If false, GciLogin ignores the flag GCI_CLIENT_DOES_SESSION_INIT. All sessions perform `GsCurrentSession>>initialize`, and errors are fatal to the session logging in.

If true, GciLogin uses the setting for the flag GCI_CLIENT_DOES_SESSION_INIT. `GsCurrentSession>>initialize` is executed unless this flag is set or topaz executes the SET SESSIONINIT OFF command. If `GsCurrentSession>>initialize` is executed, errors in execution are reported, but are not fatal errors.

See also the topaz command **set sessioninit off** in the *Topaz Programming Guide*.

Runtime parameter: #StnAllowNoSessionInit (may only be set by SystemUser)
Default: FALSE

STN_ANONYMOUS_SSL

If STN_ANONYMOUS_SSL is set to true, the network connections between the Stone and other processes, and between the shrpcmonitor and other processes, are encrypted with Anonymous SSL. In this case, GEM_PGSVR_USE_SSL and GEM_RPC_USE_SSL are ignored and the GCI to Gem and Gem to Pgsvr connections will always use SSL.

STN_ANONYMOUS_SSL does **not** affect any connections established using X509 certificates; those connections always use SSL. These connections are described in the *X509-Secured GemStone Adminstration Guide*.

Default: FALSE

STN_CACHE_WARMER

Legacy; replaced by STN_CACHE_WARMER_ARGS. Specifies the type of cache warming to perform on startup.

The STN_CACHE_WARMER has the following possible values:

0 - Disabled; with STN_CACHE_WARMER_ARGS, specify ""
1 - Warm only object table pages; with STN_CACHE_WARMER_ARGS to " ".
2 - Warm object table and data pages; with STN_CACHE_WARMER_ARGS, include the flag "-d".

STN_CACHE_WARMER_ARGS

This configuration option can be used to have the stone automatically start a cache warmer process on its cache. The options that can be specified here are:

-d read data pages into the cache.
-D read data pages into the UNIX file system buffers
-l stop cache warming if the free frame count falls below <cacheFullLimit>.
-n the number of warmer threads to use
-w enable saving and restoring a workingSet of data pages

The complete description of the options and default values can be obtained by invoking the command: $GEMSTONE/bin/startcachewarmer -h

The other options if specified are ignored by the cache warmer when starting from this configuration. The **-s** *stoneName* argument is automatically provided, so it is not required.

If this configuration option is specified with a non empty string, it overrides any settings for STN_CACHE_WARMER and STN_CACHE_WARMER_SESSIONS

Example: Start a cachewarmer to load only the object table into the cache using 4 warmer threads.

STN_CACHE_WARMER_ARGS = "-n 4"

Default: "" (cachewarmer is not started)

STN_CACHE_WARMER_SESSIONS

Legacy; replaced by STN_CACHE_WARMER_ARGS. Specifies the number of worker sessions (threads) to use to perform cache warming on startup. A value of 0 means to compute the default based on (numberOfCPUs + numberOfExtents).

Equivalent to using **-n** *numSessions* in the STN_CACHE_WARMER_ARGS.

STN_CACHE_WARMER_WAIT_MODE

Determines if and when startstone waits until cache warming has finished. The following values are allowed:

0 - disabled. startstone does not wait until cache warming has finished.
1 - startstone waits until cache warming has finished but only if stone is starting after a clean shutdown, or without tranlogs (i.e., startstone with -N option). Otherwise startstone does not wait for cache warming to finish. This is the default setting.
2 - startstone always waits until cache warming has finished.

Has no effect and is ignored if cache warming is not enabled.

Minimum: 0
Maximum: 2
Default: 1

STN_CHECKPOINT_INTERVAL

STN_CHECKPOINT_INTERVAL sets the maximum interval between checkpoints. Checkpoints may be written more often, depending on other factors. The unit is seconds.

This can be changed at runtime only by SystemUser.

Runtime parameter: **#StnCheckpointInterval**
Units: seconds
Min: 5
Max: 1800
Default: 300

STN_COMMIT_QUEUE_THRESHOLD

STN_COMMIT_QUEUE_THRESHOLD determines whether the Stone defers the disposal of commit records, based on the number of sessions in the commit queue and the run queue. If the size of either of these queues exceeds this threshold, the Stone defers commit record disposal until all queues have sizes less than or equal to the value.

This setting is ignored if the commit record backlog exceeds the value of STN_CR_BACKLOG_THRESHOLD.

Runtime parameter: **#StnCommitQueueThreshold**
Default: -1 (never defer commit record disposal)
Min: -1
Max: 1024

STN_COMMIT_RECORD_BM_CACHING

When true, enables caching at the commit point of page allocation information needed when disposing a commit record. This option can reduce I/Os during commit record dispose when the commit record backlog is high, or when there is a lot of page preemption occurring in the shared cache.

When enabled, the maximum commit rate is slightly lower and commit latency is slightly higher because more work is done in the commit critical region in stone.

Default: true

STN_COMMIT_RECORD_QUEUE_SIZE

STN_COMMIT_RECORD_QUEUE_SIZE determines the size of the Stone's internal commit record cache. The Stone will keep copies of up to this many commit records in heap memory. Stone is able to dispose commit records more quickly when a copy of the commit record is found in this cache.

When the default value of -1 is specified, Stone sets this value to be twice the value of the STN_SIGNAL_ABORT_CR_BACKLOG option.

Units: Commit Record Pages
Default: -1
Min: 16
Max: 2000000

STN_COMMIT_TOKEN_TIMEOUT

STN_COMMIT_TOKEN_TIMEOUT sets the maximum interval (in seconds) that a session may possess the commit token. If the session possesses the token for longer than this period, the session will be logged off the system and an error message written to the Stone log. If the value is non zero, GcGems of all types will have a timeout of twice the configured value.

Default: 0 (Stone waits forever)
Min: 0
Max: 86400

STN_COMMITS_ASYNC

If STN_COMMITS_ASYNC is set to TRUE, it causes the stone to acknowledge each commit or persistent shared counter update to the requesting session without waiting for the tranlog writes for that commit to complete.

Default: FALSE

STN_CR_BACKLOG_THRESHOLD

STN_CR_BACKLOG_THRESHOLD sets the size of the commit record backlog above which the Stone aggressively disposes of commit records. This setting overrides the deferral of commit record disposal provided by the STN_COMMIT_QUEUE_THRESHOLD parameter.

The default setting of -1 causes the Stone to use a setting equal to (2 * STN_MAX_SESSIONS). A setting of 0 disables this threshold.

Runtime parameter: **#StnCrBacklogThreshold**
Default: -1
Min: -1
Max: 500000

STN_DISABLE_LOGIN_FAILURE_LIMIT

STN_DISABLE_LOGIN_FAILURE_LIMIT is the number of failed login attempts, within the time limit set by STN_DISABLE_LOGIN_FAILURE_TIME_LIMIT, that result in the user account being disabled. When an account exceeds these limits, the user account is disabled (the system changes the password on the account to one that is invalid) and a record of the event is written to the Stone log file. The user account can only be restored by another user with OtherPassword privileges.

Changes to the runtime parameter requires the OtherPassword privilege.

Runtime parameter: **#StnDisableLoginFailureLimit**
Units: login attempts
Default: 15
Min: 0
Max: 65536

STN_DISABLE_LOGIN_FAILURE_TIME_LIMIT

STN_DISABLE_LOGIN_FAILURE_TIME_LIMIT is the period of time in which if STN_DISABLE_LOGIN_FAILURE_LIMIT number of failed login attempts are made, the user account will be disabled (the system changes the password on the account to one that

is invalid) and a record of the event is written to the Stone log file. The user account can only be restored by another user with OtherPassword privileges.

Changes to the runtime parameter requires the OtherPassword privilege.

Runtime parameter: **#StnDisableLoginFailureTimeLimit**
Units: Minutes
Default: 15
Min: 1
Max: 1440 (24 hours)

STN_DISKFULL_TERMINATION_INTERVAL

STN_DISKFULL_TERMINATION_INTERVAL specifies how soon (in minutes) the Stone should start terminating sessions holding on to the oldest commit record when the repository free space is below the value set for STN_FREE_SPACE_THRESHOLD. Such sessions are sent the fatal diskfull error.

The runtime parameter can be changed only by SystemUser.

Runtime parameter: **#StnDiskFullTerminationInterval**
Units: Minutes
Min: 0 (no sessions are terminated)
Max: 1440 (24 hours)
Default: 3

STN_EPOCH_GC_ENABLED

STN_EPOCH_GC_ENABLED determines if epoch garbage collection can be run on the system. Leave this value set to FALSE unless you plan to run epoch garbage collection on the system. Setting this to TRUE adds a small amount of overhead to commit processing.

Runtime parameter: **#StnEpochGcEnabled**
Default: FALSE

STN_EXTENT_IO_FLAGS

STN_EXTENT_IO_FLAGS specifies what (if any) special I/O flags will be used to open the database extents. Two kinds of special I/O are supported: direct I/O and concurrent I/O.

Direct I/O tells the operating system avoid caching extent data in the file system cache. Enabling direct I/O tells the operating system to treats the database extents as if they were on raw partitions. Direct I/O may greatly improve database performance in some cases. Concurrent I/O is only available to extents running on the Enhanced JFS file system (aka JFS2) on AIX. Setting this flag has no effect on other operating systems.

STN_EXTENT_IO_FLAGS has the following possible values:

0 - no special I/O flags. This is the default.
1 - enable Direct I/O on all extents on file systems.
2 - enable concurrent I/O (AIX only)

If the requested I/O mode is not available, the stone will fail to start and an error message will be printed in the stone log. If this happens, change this option back to zero and restart the stone.

STN_EXTENT_IO_FLAGS has no effect on extents which reside on raw partitions.

Once the stone starts, all processes which open the database extents (gems and page servers) will open the extents using the same I/O flags. This behavior is required by some operating systems.

Default: 0
Min: 0
Max: 2 (AIX only), 1 (All Others)

STN_FREE_FRAME_CACHE_SIZE

STN_FREE_FRAME_CACHE_SIZE specifies the size of the Stone's free frame cache. When using the free frame cache, the Stone removes enough frames from the free frame list to refill the cache in a single operation.

Units: frames
Default: 1 (disables the free frame cache; Stone acquires frames one at a time)
Min: 1
Max: 1% of the frames in the cache

STN_FREE_SPACE_THRESHOLD

STN_FREE_SPACE_THRESHOLD sets the minimum amount of free space to be available in the repository. If the Stone cannot maintain this level by growing an extent, it begins to take action to prevent the shutdown of the system. If the amount of free space remains below this level for more than the number of minutes specified by STN_DISKFULL_TERMINATION_INTERVAL, the stone will start terminating sessions. For more information, see "Repository full" on page 198.

The default value of 0 specifies a varying STN_FREE_SPACE_THRESHOLD that is computed when needed as the current size of the repository divided by 1000, with a minimum value of 5 MB.

If no units are specified, the value is in MB. You may also specify units as KB, MB, or GB.

The runtime parameter can be changed only by SystemUser.

Runtime parameter: **#StnFreeSpaceThreshold**
Default units: MB
Default: 0 (system computes based on repository size)
Min: 0
Max: 65536 MB

STN_GEM_ABORT_TIMEOUT

STN_GEM_ABORT_TIMEOUT sets the time that the Stone will wait for a Gem running outside of a transaction to abort (in order to release a commit record), after Stone has signaled that Gem to do so. If the time expires before the Gem aborts, the Stone sends the Gem the error ABORT_ERR_LOST_OTROOT, and then either stop the Gem or force it to completely reinitialize its object caches, depending on the value of the related configuration parameter STN_GEM_LOSTOT_TIMEOUT.

The time can be configured in minutes or seconds, e.g. 60seconds or 1minutes. The default, if a number with no units is used, is to interpret the value as minutes.

For compatibility with previous releases, the configuration parameter read in configuration files remains STN_GEM_ABORT_TIMEOUT. In the results of sending

`System >> stoneConfigurationReport`, the name is STN_GEM_ABORT_TIMEOUT_SECONDS.

Negative timeouts are not allowed. Resolution of timeouts is one half the specified time-out interval.

The runtime parameter can be changed only by SystemUser.

Runtime parameter: **#StnGemAbortTimeoutSeconds**
Default: 60seconds
Min: 5seconds
Max: 86400seconds

STN_GEM_INITIAL_TRANSACTION_MODE

The setting for STN_GEM_INITIAL_TRANSACTION_MODE controls the transaction mode of a session immediately after login, equivalent to sending `System transactionMode:`.

The runtime parameter can be changed only by SystemUser.

Runtime equivalent: **#StnGemInitialTransactionMode**
Legal values: autoBegin, manualBegin, transactionless
Default: autoBegin

STN_GEM_LOSTOT_TIMEOUT

STN_GEM_LOSTOT_TIMEOUT sets the time in seconds that the Stone will wait after signaling the Exception `RepositoryViewLost`, before retracting the Gem's commit record and forcibly stopping the session.

If set to zero, no signal is sent; the stone immediately stops the session.

The runtime parameter can be changed only by SystemUser.

Runtime parameter: **#StnGemLostOtTimeout**
Default: 60
Min: 0
Max: 5000000

STN_GEM_PGSVR_CONNECT_TIMEOUT

The time in seconds that a remote gem will wait for a connection to a pgsvr on stone's machine to complete.

Runtime equivalent: #StnGemPgsvrConnectTimeout (may only be set by SystemUser)
Default: 20
Min: 5
Max: 3600

STN_GEM_PRIVATE_PGSVR_ENABLED

A Boolean, TRUE means a remote gem will start a private pgsvr process if the attempt to connect to a multi-threaded pgsvr on stone's machine fails.

Runtime equivalent: #StnGemPrivatePgsvrEnabled (may only be set by SystemUser)
Default: FALSE

STN_GEM_TIMEOUT

STN_GEM_TIMEOUT sets the time in minutes after which lack of interaction with the Gem causes the Stone to terminate the session. Negative timeouts are not allowed. Resolution of timeouts is one half the specified time-out interval. If non-zero, this timeout is also the maximum time allowed for a Gem to complete processing of its login to the Stone. If this timeout is 0, the maximum time for login processing is set to five minutes.

The runtime parameter can be changed only by SystemUser.

Runtime parameter: **#StnGemTimeout**
Min: 0
Default: 0 (Stone waits forever)

STN_GROUP_COMMITS

A value greater than 1, specifies maximum number of commits to group into a tranlog write. Grouping is performed only if another session is waiting to commit while stone is processing a session's commit.

Default: 10
Min: 1
Max: 20

STN_HALT_ON_FATAL_ERR

If STN_HALT_ON_FATAL_ERR is set to true, the Stone will halt and dump core if it receives notification from a Gem that the Gem died with a fatal error that would cause Gem to dump core. By stopping the Stone at this point, the possibility of repository corruption is minimized. true is the recommended setting for systems during development.

If STN_HALT_ON_FATAL_ERR is set to false, the Stone will attempt to keep running if a Gem encounters a fatal error. false is the recommended setting for systems in production use.

This parameter also accepts integer values 0 (equivalent to false), 1 (equivalent to true, and 2. With a setting of 2, the stone will continue running after release to run via gdb.

The runtime parameter can be changed only by SystemUser.

Runtime parameter: **#StnHaltOnFatalErr**
Default: false

STN_LISTENING_ADDRESSES

STN_LISTENING_ADDRESSES is a list of 0 to 10 addresses upon which stone should listen for login connections. If list is empty, the default address "::" is used, which means listen on any active network interfaces, plus the loopback ("::1") interface.

Each element of the list may be a name or a numeric IPv6 address. Each named address must resolve via getaddrinfo() to at least one address legal to listen on, i.e. resolve to the loopback or wildcard address, or to an address assigned to a network interface on this machine. Each numeric address must be an address legal to listen on.

Numeric IPv6 addresses may be any form recognized by inet_pton(AF_INET6, address, etc.) or by inet_pton(AF_INET, address, etc.) on the host operating system. Per RFC 2373 this includes these forms:

- IPv4 dotted-decimal format, d.d.d.d
- IPv6 hex format x:x:x:x:x:x:x:x where x is a 16 bit hexadecimal number
- IPv4-mapped IPv6 ::FFFF:d.d.d.d where d is an 8 bit decimal number

IPv6 format may contain at most one :: which is a contiguous group of zeros. The loopback address 0:0:0:0:0:0:0:1 can be written as ::1. The wildcard address 0:0:0:0:0:0:0:0 can be written as ::.

If the list contains the wildcard address ::, the other elements of the list are ignored.

If the list does not contain ::, then the loopback addresses ::1 and 127.0.0.1 are always listened on, even if not explicitly in the list, to support logins from system gems.

See public documents RFC 4291 and RFC 4038 for more information on IPV6 addressing.

Default: An empty list, "::"

STN_LOGIN_LOG_DIR

STN_LOGIN_LOG_DIR specifies a directory where the login log is located when the STN_LOGIN_LOG_ENABLED option is set to TRUE. If STN_LOGIN_LOG_ENABLED is false, this option is ignored. If STN_LOGIN_LOG_DIR is not specified and STN_LOGIN_LOG_ENABLED is set to TRUE, then the login log will be placed in the same directory as the stone log. It is a fatal error if the directory specified is not writable by the stone process.

Default: Stone log's directory
Min: 0 entries
Max: 1 entry

STN_LOGIN_LOG_ENABLED

STN_LOGIN_LOG_ENABLED enables the logging of all session login and logout events to s separate log file owned by the stone. The file will be named *stoneName*_login_*timestamp*.log and will be placed in the same directory as the stone log, unless a directory is specified using STN_LOGIN_LOG_DIR.

When this feature is enabled, logins and logouts are recorded for all sessions by default. Logging may by disabled for a UserProfile by sending the #disableLoginLogging message to a UserProfile instance and committing the transaction.

The login log file is a text file that contains one line per event. Fields within a line are separated by spaces; the Timestamp String is quoted. The fields logged in each line are:

- Timestamp String - time in human-readable form
- Timestamp Seconds - seconds from the epoch (January 1, 1970, 00:00 UTC)
- Event Kind - one of STARTUP, SHUTDOWN, LOGIN, LOGIN_FAIL, LOGOUT, or COMMIT_RESTORE.
- UserName - the UserProfile's userId, or "Stone" for the stone process.
- SessionId
- ProcessId
- Real UNIX user ID - numeric value
- Effective UNIX user ID - numeric value.

- Host Name - node name where the gem process is running.
- Gem IP Address - IP Address of the gem.
- Client IP Address - IP Address of the gem's client.
- NumCommits - number of commits performed by the session.
- Login UNIX user ID - numeric value
- KerberosPrincipal - the name of the principal used for passwordless login, or ''.

STARTUP and SHUTDOWN records are written to indicate when the stone was started and stopped and do not indicate a session login or logout.

Login failures are written for non-exempt sessions that fail a login attempt, usually due to specifying a bad password.

Default: FALSE

STN_LOGIN_LOG_HALT_ON_ERROR

STN_LOGIN_LOG_HALT_ON_ERROR specifies the behavior of the stone if a write to the login log file fails. If this option is set to TRUE, the Stone will shutdown if the login log file cannot be written, due to lack of disk space or any other error. If this option is set to FALSE, the Stone does not halt but a warning message is printed to the Stone log.

Default: FALSE

STN_LOGIN_LOG_MAX_SIZE

STN_LOGIN_LOG_MAX_SIZE specifies the maximum size of the login log file in megabytes. Once the login log file reaches this size, it will be closed and a new login log file will be created. 0 means no file size limitation and the file size is not monitored by GemStone.

If no units are specified, the value is in KB. You may also specify units as KB, MB, or GB.

Default Units: MB
Default: 0 (no size limit)
Min: 0
Max: 1024 MB

STN_LOG_IO_FLAGS

STN_LOG_IO_FLAGS specifies if special I/O flags will be used to open the database transaction logs.

This configuration is only applicable for Solaris and Linux, and has no effect for tranlogs on raw partitions.

Direct I/O tells the operating system avoid caching extent data in the file system cache. Enabling direct I/O tells the operating system to treats the database tranlogs as if they were on raw partitions. Direct I/O may greatly improve database performance in some cases.

On Solaris, direct I/O requires a UFS file system; using STN_LOG_IO_FLAGS = 1 is not supported on ZFS file system.

STN_LOG_IO_FLAGS has the following possible values:

0 - no special I/O flags. This is the default.
1 - enable Direct I/O on all file system tranlogs.

Min: 0
Max: 1 (Solaris and Linux), 0 (Others)
Default: 0

STN_LOG_LOGIN_FAILURE_LIMIT

If a user has greater than or equal to the STN_LOG_LOGIN_FAILURE_LIMIT number of login failures within the time in minutes specified by STN_LOG_LOGIN_FAILURE_TIME_LIMIT, a message is written to the Stone log file.

Changes to the runtime parameters require the OtherPassword privilege.

Runtime parameter: **#StnLogLoginFailureLimit**
Units: login attempts
Min: 0
Max: 65536
Default: 10

STN_LOG_LOGIN_FAILURE_TIME_LIMIT

If a user has greater than or equal to the STN_LOG_LOGIN_FAILURE_LIMIT number of login failures within the time in minutes specified by STN_LOG_LOGIN_FAILURE_TIME_LIMIT, a message is written to the Stone log file.

Changes to the runtime parameters require the OtherPassword privilege.

Runtime parameter: **#StnLogLoginFailureTimeLimit**
Units: Minutes
Min: 1
Max: 1440 (24 hours)
Default: 10

STN_LOOP_NO_WORK_THRESHOLD

STN_LOOP_NO_WORK_THRESHOLD indicates the maximum number of times the stone will continue executing its main service loop when there is no work to do. If the stone loops more than this number of times and finds no work, the stone will sleep for up to one second. The stone will immediately wake up when there is any work to be done.

Setting this value to zero disables this feature. Setting this value to a non-zero setting, in addition to causing the above behavior, will also cause the stone to not sleep whenever any of the following conditions are true and the no work threshold has not been exceeded:

- a session holds the commit token
- one or more sessions are waiting in the commit queue
- one or more sessions are waiting in the run queue.

Setting this parameter to a non-zero value will always cause the stone to consume more CPU.

Runtime parameter: **#StnLoopNoWorkThreshold**
Default: 0
Min: 0
Max: 536870911

STN_MAX_AIO_RATE

STN_MAX_AIO_RATE specifies the maximum I/O rate that each AIO page server thread is allowed when performing asynchronous writes. Since the I/O rate specified is applied to each thread, the total maximum I/O rate on the disk system is this value multiplied by STN_NUM_LOCAL_AIO_SERVERS.

The maximum I/O rate applies for both dirty page and checkpoint writes.

Runtime parameter: **#StnMntMaxAioRate**
Min: 20
Max: 1000000
Default: 3000

STN_MAX_AIO_REQUESTS

STN_MAX_SESSIONS specifies the maximum number of asynchronous write requests the stone can have pending. If more than this number of asynchronous writes are requested, the stone will wait (sleep) until one or more of the pending requests have completed. Asynchronous write requests are only used to write to the current tranlog.

Min: (2 * STN_NUM_AIO_WRITE_THREADS)
Max: 4096
Default: the lower of SHR_PAGE_CACHE_NUM_PROCS and 128

STN_MAX_GC_RECLAIM_SESSIONS

The maximum number of page reclaim garbage collector threads allocated for the the ReclaimGem. This value is used in determining the number of process slots configured in the shared cache and set aside for use by the ReclaimGem, to avoid using user session slots. It is possible to use more threads at runtime, if there are user session slots that are not allocated.

When the default 0 is specified, the actual value used depends on the number of extents defined in DBF_EXTENT_NAMES configuration.

- If repository size at stone startup is > 100GB and the host has at least 20 cores, the actual value is 10, or number of extents, whichever is greater.
- If repository size at stone startup is > 10GB and the host has at least 8 cores, actual value is 4, or the number of extents, whichever is greater.

Default: 0
Minimum: 0
Maximum: 256

STN_MAX_LOGIN_LOCK_SPIN_COUNT

Maximum number of times a session will attempt to write lock its user security data object at login time before raising a fatal error and failing the login. The session will sleep for 100 milliseconds between retries.

Enabling certain UserProfile security features (password aging, etc) causes each session to update its user security data object at login time and commit. A write lock must be acquired on this object to guarantee the commit succeeds.

Each UserProfile has a unique user security data object. Lock retries may be required when 2 sessions attempt to login with the same user ID at nearly the same instant. Simultaneous logins that user different user IDs never require lock retries.

Repositories that do not enable UserProfile security features are not affected by this parameter because the write-lock and commit described above are not required at login time.

Runtime parameter: **#StnMaxLoginLockSpinCount**
Default: 100
Minimum: 1
Maximum: 36000

STN_MAX_REMOTE_CACHES

STN_MAX_REMOTE_CACHES specifies the maximum number of remote shared page caches that the system may have.

Min: 0
Max: 10000
Default: 255

STN_MAX_SESSIONS

STN_MAX_SESSIONS limits the number of simultaneous sessions (number of Gem logins to Stone). The actual value used by Stone is the value of this parameter or the number of sessions specified by the software license key file, whichever is less. Using a value that is larger than needed will result in wasted space in the cache.

The number of logins may also be limited by changes in SHR_PAGE_CACHE_NUM_PROCS, or by the setting for the maximum number of file descriptors per process (imposed by the operating system kernel).

Recommended: 40 or more, depending on your requirements
Min: 1
Max: 32767
Default: 40

STN_MAX_VOTING_SESSIONS

STN_MAX_VOTING_SESSIONS specifies the maximum number of sessions that can simultaneously vote on possible dead objects, at the end of a markForCollection or epoch garbage collection. To help prevent the voting on possible dead objects from causing large increases in response time of the system, set this to a value substantially lower than STN_MAX_SESSIONS.

Runtime parameter: **#StnMaxVotingSessions**
Min: 1
Max: 1000000
Default: 100

STN_NUM_AIO_WRITE_THREADS

STN_NUM_AIO_WRITE_THREADS specifies the number of native threads the Stone will start to perform writes to the tranlog. In commit-intensive systems, this should be increased, generally to 8 or 16.

Cache Statistic: **StnAioNumWriteThreads** (Stone)
Min: 4
Max: 256
Default: 4

STN_NUM_GC_RECLAIM_SESSIONS

STN_NUM_GC_RECLAIM_SESSIONS specifies the number of page reclaim garbage collector sessions (Reclaim Gem sessions) that will be started when the Stone starts. This value must be less than or equal to STN_MAX_GC_RECLAIM_SESSION.

If the value of both the STN_MAX_GC_RECLAIM_SESSIONS and STN_NUM_GC_RECLAIM_SESSIONS are at default, and STN_MAX_GC_RECLAIM_SESSIONS is greater than the number of extents (due to automatic increase), then then the value of this configuration is set to one half of the STN_MAX_GC_RECLAIM_SESSIONS value.

A value of zero disables the Reclaim Gem.

Runtime parameter: **#StnNumGcReclaimSessions**
Default: 1
Min: 0
Max: 256

STN_NUM_LOCAL_AIO_SERVERS

STN_NUM_LOCAL_AIO_SERVERS is the number of threads to be started in the Stone to write dirty pages from the shared page cache to the repository extents on disk.

For systems with many extents, provided that disk drive hardware allows concurrent updates, adding additional threads may improve overall system performance.

Normally not more than one thread per extent is recommended; however, when using a small number of extents on fast storage (SSD or striped across multiple drives) and a large cache, 2 to 4 threads per extent is recommended.

With the default setting of -1, the value is automatically computed:

- if the repository is larger than 100GB and the host has at least 20 cores, the greater of 5 or the number of extents.
- If the repository size is greater than 10GB, and the host has at least 8 cores, the greater of 2 or the number of extents.
- otherwise, a value of 1 is used

Min: -1
Max: 256
Default -1

STN_OBJ_LOCK_TIMEOUT

STN_OBJ_LOCK_TIMEOUT specifies the time in seconds that a session is allowed to wait to obtain one of the special single object write locks. For more information, see `System >> waitForApplicationWriteLock:queue:autoRelease:`.

Runtime parameter: **#StnObjLockTimeout**
Min: 0
Max: 86400
Default: 0 (stone waits forever)

STN_PAGE_MGR_COMPRESSION_ENABLED

STN_PAGE_MGR_COMPRESSION_ENABLED determines if the page manager thread in Stone will compress the list of pages that it sends to remote shared page caches for removal. If TRUE, all lists of pages larger than 50 will be compressed before transmission using the > LZ4_compress() function from the LZ4 compression library.

The same compressed list is used to send to all remote shared page caches; i.e., the compression operation is performed no more than once for each list of pages to be sent.

This option has no effect on systems that do not use remote shared page caches.

Runtime parameter: **#StnPageMgrCompressionEnabled**
Cache Statistic: **PageMgrCompressionEnabled** (Stone)
Default: TRUE

STN_PAGE_MGR_MAX_WAIT_TIME

Maximum time the Stone will defer servicing the page manager thread because the Stone is busy with other tasks. Normally the Stone services the page manager thread whenever it has idle time and no session is performing a commit. If the time the page manager thread has been waiting for service exceeds this value, the stone will service the page manager unconditionally and increment the cache statistic PageManagerStarvedCount.

Runtime parameter: **#StnPageMgrMaxWaitTime**
Units: Milliseconds
Default: 200
Min: 1
Max: 1000

STN_PAGE_MGR_PRINT_TIMEOUT_THRESHOLD

STN_PAGE_MGR_PRINT_TIMEOUT_THRESHOLD is the threshold in real seconds used by the page manager thread in Stone to determine if a slow response from a remote shared page cache should be printed to the page manager log file. If a remote cache takes longer than this number of seconds to respond to the page manager, the page manager will print a message to the log file. If a remote cache takes less than this number of seconds to respond, no message is printed.

Note that this value controls the writing of log messages only. The connection to the remote cache will not be terminated by page manager unless STN_REMOTE_CACHE_PGSVR_TIMEOUT is exceeded.

Runtime parameter: **#StnPageMgrPrintTimeoutThreshold**
Cache Statistic: **PageMgrPrintTimeoutThreshold** (Stone)
Min: 0

Max: 3600
Default: 5

STN_PAGE_MGR_REMOVE_MAX_PAGES

STN_PAGE_MGR_REMOVE_MAX_PAGES sets the maximum batch size for the Page Manager thread in Stone. This is the maximum number of pages in a single request to the stone. Must be greater than or equal to STN_PAGE_MGR_REMOVE_MIN_PAGES

Runtime parameter: **#StnPageMgrRemoveMaxPages**
Cache Statistic: **PageMgrRemoveMaxPages** (Stone)
Min: 1
Max: 16384
Default: 16384

STN_PAGE_MGR_REMOVE_MIN_PAGES

STN_PAGE_MGR_REMOVE_MIN_PAGES sets the minimum batch size for the Page Manager gem. When the number of pages waiting to be processed by the Page Manager is greater than this value, then the Page Manager will request the pages from the stone and process them. Otherwise the Page Manager will wait until this threshold is exceeded before requesting pages from the stone. Must be less than or equal to STN_PAGE_MGR_REMOVE_MAX_PAGES

Runtime parameter: **#StnPageMgrRemoveMinPages**
Cache Statistic: **PageMgrRemoveMinPages** (Stone)
Min: 0
Max: 1792
Default: 40

STN_PGSVR_PORT_RANGE

A list of two integers specifying the minimum and maximum port range to be used for listening sockets in pgsvr processes on the stone machine. Such pgsvr processes will listen on the first available port from this range, using the address that was used by the remote gem when it contacted the netldi to start the pgsvr, i.e. one of the addresses from the -A argument to that netldi's startnetldi command.

Both elements on the list must be between 1 and 65535, and the second element must be greater than the first.

Default: empty (random ports above 10000 will be used)

STN_RC_LOOKAHEAD_LIMIT

Maximum number of entries in the Rc transaction queue in stone that will be analyzed after a session that was on the queue commits.

Runtime equivalent: **#StnRcLookaheadLimit**
Min: 1
Max: 100
Default: 5

STN_REMOTE_CACHE_PGSVR_TIMEOUT

STN_REMOTE_CACHE_PGSVR_TIMEOUT specifies the maximum time in seconds that the page manager session will wait for a response from a page server on a remote shared page cache. If no response is received within the timeout period, all Gems attached to that cache are logged off and a message is written to the Stone and page manager logs. Negative timeouts are not allowed. A timeout value of zero causes the page manager to wait forever.

Runtime parameter: **#StnRemoteCachePgsvrTimeout**
Cache Statistic: **PageMgrRemoteCachePgsvrTimeout** (Stone)
Min: 0
Max: 3600
Default: 15

STN_REMOTE_CACHE_STARTUP_TIMEOUT

STN_REMOTE_CACHE_STARTUP_TIMEOUT is the time in seconds allowed for startup of a remote shared cache. This is time from when first Gem on the remote machine connects to the Stone process until the remote cache completes its connection to the pagemanager thread in the Stone. Within this interval the first Gem forks the remote cache and that cache has to create its shared memory.

The configured value may be overridden for large caches. If cache is 32GB or larger, the actual minimum timeout will be 120 seconds, scaling up to 5 minutes for a 300GB cache. For caches less than 32GB, very small configured values may also be overriden.

The computed timeout value is passed as an argument to the shared page cache monitor, which applies the timeout.

Runtime equivalent: #StnRemoteCacheStartupTimeout
Default: 60
Min: 10
Max: 1800

STN_REMOTE_CACHE_TIMEOUT

STN_REMOTE_CACHE_TIMEOUT sets the time in minutes after the last active process on a remote node logs out before the Stone shuts down the shared page cache on that node.

A value of 0 causes the Stone to shut down the remote cache as soon as possible.

The runtime parameter can be changed only by SystemUser.

Runtime parameter: **#StnRemoteCacheTimeout**
Min: 0
Max: 5000000
Default: 5

STN_SHR_TARGET_PERCENT_DIRTY

STN_SHR_TARGET_PERCENT_DIRTY specifies the maximum percentage of the Stone's shared page cache that can contain dirty pages without AIO page server threads increasing their IO rates.

Runtime parameter: **#StnShrPcTargetPercentDirty**
Min: 1

Max: 90
Default: 20

STN_SIGNAL_ABORT_AGGRESSIVE

If the number of outstanding commit records exceeds STN_SIGNAL_ABORT_CR_BACKLOG, then STN_SIGNAL_ABORT_AGGRESSIVE is the maximum number of sessions which will receive SignalAbort when those sessions reference a commit record beyond STN_SIGNAL_ABORT_CR_BACKLOG and newer than the oldest commit record.

Changing the runtime parameter requires GarbageCollection privilege.

Runtime equivalent: #StnSignalAbortAggressive
Default: 0
Min: 0
Max: 500

STN_SIGNAL_ABORT_CR_BACKLOG

STN_SIGNAL_ABORT_CR_BACKLOG sets the number of old transactions (commit records) above which the Stone will start to generate SignalAbort messages to Gems. The Gem receives these as a TransactionBacklog exception.

If the Gem is not in transaction, this is received if the Gem has enabled receipt of sigAborts by invoking `System >> enableSignaledAbortError`. If the Gem that is out of transaction does not respond within the time allowed by STN_GEM_ABORT_TIMEOUT, the Gem will receive a ABORT_ERR_LOST_OT_ROOT.

If the Gem is in transaction, it will receive finishTransaction if it has invoked System >> enableSignaledFinishTransactionError. No further signals are sent to a Gem that is in transaction, whether or not it responds to the signal.

You may need to tune this option according to your application's commit rate and repository free space.

Changing the runtime parameter requires GarbageCollection privilege.

Runtime parameter: **#StnSignalAbortCrBacklog**
Default: 20
Min: 2
Max: 65536

STN_SMC_SPIN_LOCK_COUNT

STN_SMC_SPIN_LOCK_COUNT specifies the number of times a process (gem or page server) that is waiting for a response from the stone will check a variable in shared memory before sleeping on a semaphore. Higher values can lead to higher throughput on performance-intensive systems, at the expense of higher CPU consumption.

Setting this value to 0 disables this feature, which causes the client process to always wait on the semaphore without checking the variable in shared memory.

Runtime equivalent: **#StnSmcSpinLockCount**
Cache Statistic: **StnSmcSpinLockCount** (Stone)
Min: 0
Max: 10000000
Default: 5000

STN_STATMONITOR_ARGS

STN_STATMONITOR_ARGS provides a way to automatically start one or more statmonitor processes when the stone is started. The value of this parameter is a list of double-quoted strings, each of which is composed of a list of statmonitor arguments. Each argument string will correspond to starting one statmonitor process with the given arguments. This allows you to start, for example, both daily and monthly statmonitor monitoring processes on the same stone, provided they log to different files.

The argument strings must be at least 2 but not more than 1023 characters long, and consist of legal statmonitor arguments. The name of the stone should not be included, and it is not legal to use the **-X** argument. Statmonitor arguments are described on page 398, and can also be obtained by invoking **statmonitor -h**.

The list of argument string elements are separated by commas and can contain no more than 64 elements.

For example, the following will start one statmonitor with a 5 second sample interval and another with a 60-second sample interval, with a date and timestamp included in the output file name:

```
STN_STATMONITOR_ARGS =
   "-i5 -u5 -F'statmon5s_%%S_%%P_%d-%m-%y-%H:%M:%S'",
   "-i60 -u5 -F'statmon60s_%%S_%%P_%d-%m-%y-%H:%M:%S'";
```

To start statmonitor automatically on remote caches, see GEM_STATMONITOR_ARGS (page 326) and GEM_STATMONITOR_MID_CACHE_ARGS (page 326).

Default: "" (statmonitor will not be started)

STN_STONE_CACHE_STARTUP_TIMEOUT

STN_STONE_CACHE_STARTUP_TIMEOUT specifies the time in seconds allowed for the startup of the shared cache on the Stone's machine. This is time from when the Stone forks the page cache monitor process until it is able to complete its connection to that process.

The configured value may be overridden for large caches. If cache is 32GB or larger, the actual minimum timeout will be 120 seconds, scaling up to 5 minutes for a 300GB cache. For caches less than 32GB, very small configured values may also be overriden.

The computed timeout value is passed as an argument to the shared page cache monitor, which applies the timeout.

Min: 10
Max: 1800
Default: 60

STN_SYMBOL_GC_ENABLED

STN_SYMBOL_GC_ENABLED determines if symbol garbage collection is allowed to run on the system. Setting this value to true enables symbol garbage collection.

Updating the runtime parameter requires the GarbageCollection privilege.

Runtime parameter: **#StnSymbolGcEnabled**
Default: FALSE

STN_SYMBOL_GEM_TEMPOBJ_CACHE_SIZE

STN_SYMBOL_GEM_TEMPOBJ_CACHE_SIZE specifies the temporary object memory size of the Symbol Gem. The Stone's runtime parameter #StnSymbolGemTocSize is initialized from STN_SYMBOL_GEM_TEMPOBJ_CACHE_SIZE at stone startup. If the Symbol Gem dies (other than from an explicit execution of `System stopSymbolGem`), and is automatically restarted, then the setting for #StnSymbolGemTocSize setting will be doubled.

This doubling only occurs for the first restart since either Stone startup or an runtime change to #StnSymbolGemTocSize.

While the default is normally 20MB, if repository conversion is detected at stone startup (startstone -C) the default is 200MB.

Runtime equivalent: **#StnSymbolGemTocSize**
Min: 10000KB
Max: 10GB
Default: 20MB

STN_TRAN_FULL_LOGGING

If STN_TRAN_FULL_LOGGING is set to true, all transactions are logged, and log files are not deleted by the system. This is full transaction logging mode. In this mode, the transaction logs are providing real-time incremental backup of the repository. If no disk space is available for logs, Gem session processes may appear to "hang" until space becomes available.

If STN_TRAN_FULL_LOGGING is set to false, only transactions smaller than STN_TRAN_LOG_LIMIT are logged; larger transactions cause a checkpoint, which updates the extent files. This is partial transaction logging mode. Log files are deleted by the system when the circular list of log directories wraps around. This setting allows a simple installation to run unattended for extended periods of time, but it does **not** provide real-time backup.

Once you have started the Stone on a repository with STN_TRAN_FULL_LOGGING = true, then the true state will persist in the repository; any subsequent changes to this parameter in the configuration file are ignored. To change the repository back to partial logging, you must do a Smalltalk full backup and then restore the backup into a copy of `$GEMSTONE/bin/extent0.dbf`.

For further information, see "Logging Modes" on page 203.

Default: NONE. The system will not run unless you specify the logging type.

STN_TRAN_LOG_DEBUG_LEVEL

This option is only for GemStone internal use. Customers should not change the default setting unless directed to do so by GemStone Technical Support.

Runtime parameter: **#StnTranLogDebugLevel**
Default: 0

STN_TRAN_LOG_DIRECTORIES

STN_TRAN_LOG_DIRECTORIES lists the directories or raw disk partitions to be used for transaction logging. This list defines the maximum number of log files that will be online at once. Each entry must be a directory or a raw disk partition. Directories may appear multiple times in the list. A given raw disk partition may appear only once. If raw partitions are used or if STN_TRAN_FULL_LOGGING is false, at least two entries should be included.

STN_TRAN_LOG_DIRECTORIES may be set to `/dev/null` in development systems; this means that no tranlog records at all are written. If the repository shuts down unexpectedly, committed work done since the last checkpoint is irretrievably lost.

You may add a tranlog directory at runtime using `Repository >> addTransactionLog:size:`; this is described under "To Add a Log at Run Time" on page 208. Executing this method will automatically update the Stone's configuration file.

Min: 1 entry
Max: 100
Default: Empty (the system will not run without at least one entry)
Initial setting: `$GEMSTONE/data/`

STN_TRAN_LOG_LIMIT

STN_TRAN_LOG_LIMIT sets the maximum transaction log entry size limit in KB. Successful commits of transactions consuming more than this amount of log file space when STN_TRAN_FULL_LOGGING is set to false will cause a checkpoint. This option has no effect when STN_TRAN_FULL_LOGGING is set to true.

If no units are specified, the value is in KB. You may also specify units as KB, MB, or GB.

The runtime parameter can be changed only by SystemUser.

Default units: KB
Runtime parameter: **#StnTranLogLimit**
Min: 25 KB
Max: 1000 KB
Default: 1000 KB

STN_TRAN_LOG_PREFIX

STN_TRAN_LOG_PREFIX sets file name prefixes for transaction log files. A sequence number and "`.dbf`" is added to the prefix; for example, "`tranlog`" produces "`tranlog0.dbf, tranlog1.dbf, ...`". You can set this configuration option to permit multiple repository monitors to share a log directory without conflict.

Default: `tranlog`

STN_TRAN_LOG_SIZES

STN_TRAN_LOG_SIZES sets the maximum sizes of all transaction log files, in order and separated by commas. Each size applies to a corresponding log file specified in STN_TRAN_LOG_DIRECTORIES, and the number of entries must match.

If no units are specified, the value is in MB. You may specify units as KB, MB, or GB.

Default units: MB
Min: 10 MB

Max: 16384 MB
Default: Empty (the system will not run unless sizes are specified)
Initial setting: 100 MB

STN_TRANQ_TO_RUNQ_THRESHOLD

The number of sessions in the commit queue (waiting for the commit token) that are allowed to simultaneously process unions (read old commit records) while waiting for the commit token.

For example, if this parameter is set to 2, then sessions commitQueue[1], and commitQueue[2] (if they exist) will process unions. The first session in the commit queue , commitQueue[0], will never process unions since it will receive the token when the current commit completes.

Cache Statistic: (Stone) StnTranQToRunQThreshold
Runtime equivalent: #StnTranqToRunqThreshold (may only be set by SystemUser)
Default: 2
Min: 1
Max: 20

STN_WELL_KNOWN_PORT_NUMBER

STN_WELL_KNOWN_PORT_NUMBER is the port number that the Stone will use as its well-known port. The well-known port is used by all Gems while establishing their initial connection to the Stone during the login sequence.

If the specified port is in use by another process, the Stone will not start and exits with an error.

A value of zero indicates the port number will be selected by the system.

Min: 1
Max: 65535
Default: 0

A.4 Runtime-only Configuration Options

The parameters described in this section are similar to the configuration options above, but can only be read or modified at runtime.

The process for modifying is similar to that for the runtime parameter equivalents for the configuration options listed in the configuration files.

The runtime parameters are read using the method `System class>>configurationAt:`, and updating using `System class>>configurationAt:put:`.

DelayAutoServiceSigAbort

Runtime-only configuration option, applicable only in a remote session (`System class >> clientIsRemote` returns true). This setting affects operation of the GemAutoServiceSigAbort configuration option.

DelayAutoServiceSigAbort can be used to set an internal delay counter to a specified value, the delivery of the error 3007 will be delayed for the specified number of GCI calls received by the gem; this is to facilitate testing.

Default: zero
minimum: 0
maximum: 16r7FFFFFFF.

GemAutoServiceSigAbort

Runtime-only config option, applicable only in a remote session (`System class >> clientIsRemote` returns true). When the session's transaction mode is manualBegin or transactionless the gem process will automatically service any sigAbort received when there is no GCI traversal in progress and the gem is waiting for the next GCI command. After auto servicing of one or more sigAbort, the next GCI command will signal a TransactionBacklog with error number 3007.

After auto servicing of a sigAbort, the "GciAlteredObjs" portion of the traversal result of the next GciStoreTravDoTravRefs will include the result of writeSetUnion of commits by other sessions since last GciStoreTravDoTravRefs intersected with the PureExportSet.

Default: false

GemCommitConflictDetails

If this configuration parameter is true, `System class >> conflictsReport` and `System class >> transactionConflicts` return details about which session(s) caused commit conflicts. Must be enabled before the conflicting commit takes place. This is intended for debugging, since it may have performance impacts in some configurations.

Default: false

GemCommitStubsForNpObjects

If this configuration parameter is true, an invariant String will be committed in place of an instance of a class which has the instancesNonPersistent option, instead of signalling TransactionError 2407.

Default: false

GemConvertArrayBuilder

If true, allows old style Array Builder syntax #[a, b] to be parsed correctly. The compiler converts this syntax to the new form { a . b }, and updates method source as well as compiled code.

Default: false

GemConfigFileNames

The names of the system and executable configuration files for the Gem, an Array:

```
{ systemConfigFileName . exeConfigFileName }
```

This is a read-only value.

GemDebuggerActive

This controls debugging of exceptions signaled from within user actions. When false (the default), a UserAction error that is handled by an `on:do:` block will not halt for

ERR_EXC_RETURN_DISALLOWED (2758). When true, the handler block will halt with ERR_EXC_RETURN_DISALLOWED, and the stack will include the complete stack including frames from the user action, to allow debugging of the error in the UserAction.

Default: false

GemDropCommittedExportedObjs

If this configuration parameter is true, clean, committed objects may be dropped from RAM. This reduces demand on memory in the Gem, but there is the small cost of an additional bitmap lookup when the object is faulted, to detect if this object is in the Pure Export Set.

Default: false

GemExceptionSignalCapturesStack

If this configuration parameter is true, invocations of `AbstractException>>_signalWith:` fill in the gsStack instance variable of the receiver, allowing subsequent calls to `Exception >> stackReport`.

Default: false

GemFailSafeNscEnumerate

Runtime-only configuration parameter for the Gem, which enables fail-safe enumeration logic in primitives for IdentityBag. This parameter should only be enabled after getting a corrupt object error (error 2261) during an enumeration.

LogOriginTime

`#LogOriginTime` is the time the current sequence of Stone logs was started. It is the same value returned by `Repository>>logOriginTime`. For information about when a new sequence is started, see the method comment for `Repository>>commitRestore` in the image.

This should not be modified.

StnReverseDns

Runtime-only configuration parameter for the Stone. If false, the IP addresses of other nodes are reported in the Stone log as IP addresses only. If true, the Stone uses reverse DNS lookup to get the node's name, and reports both IP address and node name.

Default: true if stone started with -H, false otherwise

SessionInBackup

`#SessionInBackup` is the GemStone session number of the session performing a full backup, or –1 if a backup is not in progress.

This should not be modified by the user.

StnConfigFileNames

The names of the system and executable configuration files for the Stone, an Array:

```
{ systemConfigFileName . exeConfigFileName }.
```

This is a read-only value.

StnCurrentTranLogDirId

`#StnCurrentTranLogDirId` is the one-based offset of the current transaction log into the list of log directory names, STN_TRAN_LOG_DIRECTORIES. It is the same value returned by `Repository>>currentLogDirectoryId`.

This should not be modified.

StnCurrentTranLogNames

`#StnCurrentTranLogNames` is an Array containing up to two Strings: the name of the transaction log to which records currently are being appended, and the name of the current replicated log. These are the same values returned by `Repository>>currentLogFile` and `currentLogReplicate`, respectively.

StnLogFileName

The stone log file path and name.

This is a read-only value.

StnLogGemErrors

`#StnLogGemErrors` is intended for internal debugging use. When it is set to 1, the Stone logs error messages it sends to Gems.

StnLoginsSuspended

`#StnLoginsSuspended` ordinarily has the values 0 (false) and 1 (true) as set by `System class>>suspendLogins` and `resumeLogins`.

Changing this parameter requires the SystemControl privilege.

StnMaxReposSize

`#StnMaxReposSize` is the maximum size of the repository for your GemStone license, as set by the GemStone keyfile. The value of this parameter is 0 when not limited by the keyfile.

This should not be modified.

StnMaxSessions

`#StnMaxSessions` is the maximum allowed number of sessions for your GemStone license, as set by the GemStone keyfile. It is not related to the STN_MAX_SESSIONS configuration option. The value of this parameter is 0 when not limited by the keyfile.

This should not be modified.

StnStandbyRole

`#StnStandbyRole` reflects the role of this stone in a hot standby system. It should not be modified.

StnSunsetDate

`#StnSunsetDate` is the sunset date for your GemStone license, as set by the GemStone keyfile. The value of this parameter is 0 when not limited by the keyfile.

This should not be modified.

StnTranLogOriginTime

`#StnTranLogOriginTime` is the time when the current transaction log was started.

This should not be modified.

Chapter

B GemStone Utility Commands

GemStone provides the following utility commands in the `$GEMSTONE/bin` directory.

- **copydbf** (page 366) – copy an extent, transaction log or backup.
- **gemnetobject** (page 372) – script that starts a Gem during RPC login.
- **gslist** (page 374) – list running GemStone server processes.
- **largememorypages** (page 377) – calculate large memory page requirements.
- **netldidebug** (page 378) – turn debugging on or off for a NetLDI process.
- **pageaudit** (page 379) – offline audit of repository pages.
- **printlogs** (page 381) – print contents of a transaction log.
- **pstack** (page 383) – get C-level and Smalltalk stack traces.
- **removedbf** (page 384) – delete an extent, transaction log or backup.
- **searchlogs** (page 385) – search for OOPs within a transaction log.
- **startcachewarmer** (page 387) – start cache warmers.
- **startlogreceiver** (page 389) – start logreceiver for hot standby system.
- **startlogsender** (page 391) – start logsender for hot standby system.
- **startnetldi** (page 393) – start a NetLDI.
- **startstone** (page 396) – start a Stone.
- **statmonitor** (page 398) – start statmonitor to record statistics.
- **stoplogreceiver** (page 404) – stop logreceiver for hot standby system.
- **stoplogsender** (page 405) – stop logsender for hot standby system.
- **stopnetldi** (page 406) – shut down a NetLDI.
- **stopstone** (page 407) – shut down a Stone.
- **topaz** (page 408) – command line scripting tool for GemStone.
- **updatesecuredbf** (page 410) – update key in an encrypted dbf file.
- **verify_backup_with_openssl** (page 412) – verify signature of signed backup
- **vsd** (page 413) – graphic tool to analyze GemStone statistics files.
- **waitstone** (page 414) – verify status of a Stone.

copydbf

copydbf *sourceFile destFileOrDir* [**-C** | **-z** | **-Z** | **-u**] [**-E**] [**-f** *filePrefix*] [**-s** *Mbytes*] [**-l** | **-m** | **-P**] [**-F**]
Copy an extent, transaction log or backup file, converting per the arguments.

copydbf *sourceFile* **(-a** | **stdout)** [**-C** | **-z** | **-Z** | **-u**] [**-l** | **-m** | **-P**]
Copy an extent, transaction log or backup file to stdout.

copydbf *sourceFile* **-i** | **-I**
Report information on an extent, transaction log or backup file to stdout.

copydbf **-h** | **-v**
Report information on the copydbf utility to stdout.

copydbf -V *sourceFile* [**-K** *keyRingDirs*]
Verify a digitally signed backup.

copydbf *sourceFile destFile* **-e** *encryptionCert* **-s** *keyLength* **-K** *dir* [**-K** *dir*+]
Encrypt an extent or transaction log.

copydbf *sourceFile destFile* -D *privKey* **-K** *dir* [**-K** *dir*+] [**-j** *passPhrase* | **-J** *pfFile*] [**-O**]
Decrypt an encrypted extent, transaction log or backup file.

copydbf *sourceFile* **-W** *encrCertFN* | **-X** *signCertFN* | **-Y** *sigFN*
Extract the encryption certificate from an encrypted extent, transaction log or backup file.

sourceFile	The source file or raw partition (containing an extent, a transaction log, or a backup file created by `fullBackupTo:`).
destFileOrDir	The destination file, directory, or raw partition. If *destFileOrDir* is a file system directory (the trailing / is optional), the resulting filename will have the same name as *sourceFile*, with the appropriate extension added if necessary. Use of `/dev/null` as the destination is supported only for files as a means of verifying that the file is readable.
-a	Write output to stdout, rather than to a disk file.
-C	Write the entire output file compressed, in gzip format (identical to the **-z** option). The output must be a non-encrypted filesystem file that is not already gzipped. If the filename does not end in `.gz`, a `.gz` is automatically appended.
-d	Dry run; reports the output as if the copydbf operation was performed, but does not actually make a copy.
-D *privateKey*	Decrypt: Use *privateKey* to decrypt into the destination. Applies for extents, transaction logs and backups. Requires **-K**, and if the private key has a passphrase, also **-j** or **-J**.
-e *encryptionCert*	Encrypt: Use *encryptionCert* to encrypt into the destination. Applies for extents or transaction log, not for backups (which require a digital signature). Requires **-s** and **-K**.

-E	Ignore disk read errors. If the disk read error occurs while reading an extent root page, the copy will fail. Otherwise, pages of the source file that cannot be read will be replaced with an invalid-page-kind page in the destination file. The destination file may not be usable. This option only applies to extents, not to transaction logs or backup files.
-f *fileName*	If *destFileOrDir* is a file system directory, then *fileName* is the destination file name, with the appropriate extension added. If *destFileOrDir* is a filename or anything other than a file system directory, this option has no effect.
-F	(flush) Use fsync(2) to flush all data to disk before exit.
-h	Print usage and exit.
-i	Information only. When this option is present without *destFileOrDir*, information about *sourceNRS* is printed without performing a file copy. Does not require keys to report information on encrypted files.
-I	Full information only. The same information is printed as for **-i**. In addition, if the file is a transaction log, all checkpoint times found are listed rather than only the last one. Does not require keys to report information on encrypted files.
-j *Passphrase*	Use the given passphrase to read the private key specified by **-D**.
-J *pfFile*	Use the passphrase contained in file *pfFile* to read the private key specified by **-D**. *pfFile* must be the full path and filename.
-K *keyRingDirs*	List of colon-separated directories which contain keys and certificates. This is required for all operations on encrypted or signed dbf files.
-l	Least-significant-byte ordering for the *destFileOrDir*. This byte ordering is the native byte ordering for Intel processors. May not be used when copying encrypted dbf files.
-m	Most-significant-byte ordering for the *destFileOrDir*. This byte ordering is the native byte ordering for AIX and Solaris SPARC processors. May not be used when copying encrypted dbf files.
-O	(encrypted extents only) Override the requirement that an extent must have been cleanly shutown. Use with caution.
-P	Preserve byte ordering. This option creates the destination file using the byte ordering found in the source file. The default is to write the file using the host's native byte ordering.
-s *keyLength*	When encrypting an extent or tranlogs, specifies the encryption key length in bits. Legal values are 128 and 256; 128 specifies AES-XTR-128, 256 specifies AES-XTR-256. Requires **-e** and **-K**.
stdout	equivalent to **-a**, write the output to stdout.

-u	Uncompress the resulting copy; only valid on gzipped or lz4-zipped source files.
-v	Print version and exit.
-V	Verify the digital signature of a secure backup. This requires the -K command line option, which must contain a public cert corresponding to one of the private keys used to sign the backup.
-W *encrCertFN*	Extract the public encryption cert from the encrypted extent, transaction log, or backup. Creates a new file with the given name containing the encryption certificate; for encrypted backups, more than one certificate file may be created. Cannot be used with other write options on a single command line.
-X *signCertFN*	Extract the public signing cert from a secure backup. Creates a new file with the name *signCertFN* containing the signing certificate from the secure backup. Cannot be used with other write options on a single command line.
-Y *sigFN*	Extract the digital signature from a secure backup. Creates a new file with the name *sigFN* containing the digital signature from the secure backup to file. Cannot be used with other write options on a single command line.
-z	Write the output file compressed, in gzip format; the same as the -C option. The output must be a non-encrypted filesystem file that is not already gzipped. If the filename does not end in `.gz`, a `.gz` is automatically appended.
-Z	Write the output file compressed, in LZ4 format. The output must be a non-encrypted filesystem file that is not already LZ4-zipped. If the filename does not end in `.lz4`, a `.lz4` is automatically appended.

copydbf reads GemStone extent files, transaction logs, and backups, and either reports the details, or writes a copy of the file with or without performing state changes such as compression/ decompression, encryption/unencryption, and byte order changes. Finally, you can use **copydbf** to extract the public key from an encrypted file.

For a copy that does not involve raw partitions and does not make state changes, GemStone repository files can be copied using the ordinary `cp` command, as well as using **copydbf**.

To make copies of extent files or transaction logs, the user executing **copydbf** must have read permission to the file. If you attempt to copy extent files that are in use, and if checkpoints are not suspended, the resulting repository may be corrupt and unusable. See "How To Make an Extent Snapshot Backup" on page 217 for more information.

copydbf reports information about the file that is being copied.

For example, the following makes a copy of a clean GemStone extent into the data directory:

```
unix> copydbf $GEMSTONE/bin/extent0.dbf $GEMSTONE/data
Source file: /gshost/GemStone3.6/bin/extent0.dbf
   File type: extent  fileId: 0 in a repository with 1 files
   File size: 50331648 bytes (48 MB), 3072 records
   ByteOrder: Intel (LSB first)  compatibilityLevel: 844
   Last checkpoint written at: 2020-08-25-14:45:55.867.
   Extent was shutdown cleanly; no recovery needed.
   GemStone Version: 3.6.0, Tue Aug 25 14:14:38 2020 15f18029e261d
Destination file: /gshost/GemStone3.6/data/extent0.dbf
```

Compression of copydbf output

copydbf preserves the compression state of the original. The output of copydbf can be compressed during the copy using gzip (**-C** or **-z**) or LZ4 (**-Z**) compression . Restore from backup, transaction log restore, and **copydbf** can read all compression types.

Compresssed backups, transaction logs and extents can be uncompressed using **-u**.

copydbf will append the correct extension (`.gz.`, `.lz4`, `.dbf`, or `.sdbf`) to the destination filename, if the copydbf target filename does not already end in that extension.

Encrypted files cannot be compressed or uncompressed using **copydbf**.

Byte Order

GemStone executables write .dbf files in the native byte ordering for the platform they are executing on. When moving between operating systems with different byte orderings, such as between AIX/RS6000 and Linux/x8664, it is strongly recommneded to use **copydbf** to update the byte order. Files with non-native byte order can be used, but are inefficient. See the -l and -m arguments.

You cannot change the byte order for encrypted dbf files.

Using copydbf to access information on a file

To obtain the same source file information (but not the size) without making a copy, use the second form of the command: **copydbf -i** *sourceFile*. In this usage, you do not specify a destination.

The following **copydbf -i** example displays information for an extent, and indicates the oldest transaction log that would be needed to recover from a system crash:

```
unix> copydbf -i $GEMSTONE/bin/extent0.dbf
Source file: /users/GemStone/bin/extent0.dbf
File type: extent  fileId: 0 in a repository with 1 files
   File size: 50331648 bytes (48 MB), 3072 records
   ByteOrder: Intel (LSB first)  compatibilityLevel: 844
   Last checkpoint written at: 2020-08-25-14:45:55.867.
   Extent was shutdown cleanly; no recovery needed.
   GemStone Version: 3.6.0, Tue Aug 25 14:14:38 2020 15f18029e261d
   Encryption: NONE
```

The next example displays information for a backup, and indicates the oldest transaction log that would be needed to restore subsequent transactions.

```
unix> copydbf -i backup.dat
Source file: /gshost/GemStone3.6/backup.dbf
File type: backup  fileId: 0 in a backup set with 1 files
   File size: 49152000 bytes (46 MB), 375 records
   ByteOrder: Intel (LSB first)  compatibilityLevel: 860
   The file was created at: 08/18/2020 16:00:30 PDT
   Full backup started from checkpoint at: 08/18/2020 16:00:29 PDT.
   Oldest tranlog needed for restore is fileId 3 ( tranlog3.dbf ).
   Backup was created by GemStone Version: 3.6.0, Mon Aug 17
12:48:07 2020 578cbcb16e15383f.
   Backup Attributes:
         Compression: NONE
          Encryption: NONE
      Signature Hash: NONE
     Encryption Keys: 0
```

For a listing of all checkpoints recorded in a transaction log, use **copydbf -I** *sourceFile*. This information is helpful in restoring a GemStone backup to a particular point in time. For example:

```
unix> copydbf -I tranlog5.sdbf
Source file: /gshost/GemStone3.6/tranlogs/tranlog5.sdbf
   File type: secure tranlog  fileId: 5
   File size: 14336 bytes (14 KB), 28 records
   ByteOrder: Intel (LSB first)  compatibilityLevel: 950
   The file was created at: 08/26/2020 13:17:53 PDT
   The previous file last recordId is  8
   Encryption: AES_256_XTS
   Scanning tranlog to find last checkpoint...
   Checkpoint 1 started at: 08/26/2020 13:17:52 PDT.
     oldest transaction references fileId -1 ( this file ).
   Checkpoint 2 started at: 08/26/2020 13:17:52 PDT.
     oldest transaction references fileId -1 ( this file ).
   Checkpoint 3 started at: 08/26/2020 13:17:52 PDT.
     oldest transaction references fileId -1 ( this file ).
   Checkpoint 4 started at: 08/26/2020 13:18:57 PDT.
     oldest transaction references fileId -1 ( this file ).
   Checkpoint 5 started at: 08/26/2020 13:19:06 PDT.
     oldest transaction references fileId -1 ( this file ).
   Checkpoint 6 started at: 08/26/2020 13:24:07 PDT.
     oldest transaction references fileId -1 ( this file ).
   Checkpoint 7 started at: 08/26/2020 15:48:09 PDT.
     oldest transaction references fileId -1 ( this file ).
   Checkpoint 8 started at: 08/26/2020 16:44:47 PDT.
     oldest transaction references fileId -1 ( this file ).
   Checkpoint 9 started at: 08/26/2020 16:45:35 PDT.
     oldest transaction references fileId -1 ( this file ).
```

copydbf with raw partitions

To moved extent files or transaction logs onto or off of raw partitions, you should use copydbf. copydbf of backup files to raw partitions is not supported.

The following example copies a fresh repository extent to an existing raw disk partition. If the raw partition already contains a repository file or backup, use **removedbf** first to mark it as being empty.

```
unix> copydbf $GEMSTONE/bin/extent0.dbf /dev/rsd3h
```

Copying a transaction log from a raw partition to a file system directory generates a file name having the same form as if that transaction log had originated in a file system. If the internal fileId is 43, this example would name the destination file `/dsk1/tranlogs/tranlog43.dbf:`

```
unix> copydbf /dev/rsd3h /dsk1/tranlogs/
```

copydbf with encrypted backups, extents, and transaction logs

copydbf can copy encrypted files without special arguments; the contents are copied without decryption. The -e, -s, -k, -D, -j, -J, and -O flags apply to encrypting and decrypting dbf files. Note that you cannot encrypt a backup file using **copydbf**, although you can decrypt an encrypted backup.

copydbf for encrypted dbf files does not allow encryption, or changes to byte order.

To change the encryption key for a .dbf file, without a separate decrypt and re-encryption, you an use **updatesecuredbf** (page 410), which changes the encryption key in place.

You can extract the public key of an encrypted .dbf using the -W argument. With a secure backup, which is also signed, you can also verify the signature and extract the signature and signing key using copydbf with the -V, -X or -Y arguments.

See Chapter 12, “Encrypted Extents and Transaction Logs” for details on using **copydbf** to manage encrypted extents and transaction logs.

gemnetobject

The **gemnetobject** script is not invoked on the command line. It, and related scripts such as **gemnetdebug**, are used to set the environment and invoke the Gem process during an RPC login.

Some of the arguments to **gemnetobject** are passed in by the NetLDI process, but other arguments can be included with the gemnetobject specification during login. This allows specification of the Gem environment for a specific login without requiring the definition of a configuration file.

gemnetobject -h

gemnetobject TCP *socketFD* [**-T** *tocSizeKB*] [**-N** *nativeCodeArg*] [**-e** *exeConfPath*] [**-C** *configParamsString*] [**-U** *ignoredArg*] *otherApplicationArgs*

socketFD	File descriptor of client socket inherited from fork. Provided automatically by NetLDI.
-e *exeConfPath*	Passes in a configuration file; the settings in the specified configuration file override environment settings.
-C *configParamsString*	The argument is a string containing configuration value settings. Multiple configuration parameter settings are accepted, and must be separated by ';' (with no additional spaces).
-h	print help text.
-N *nativeCodeArg*	Arguments are 0, 1, or 2. A setting overrides other settings for GEM_NATIVE_CODE_ENABLED.
-T *tocSizeKB*	a setting overrides other settings for GEM_TEMPOBJ_CACHE_SIZE.
-U *ignoredArg*	Argument to be passed to and ignored by the Gem.
otherApplicationArgs	Other application-specific arguments may be included, which are passed to the Gem without interpretation.

The user-supplied arguments **-e**, **-C**, **-N**, and **-T** may be specified in any order. If any individual argument is included twice, only the last specification is used.

Any other arguments or tokens can be included at the end or within the string passed to **gemnetobject**.

All arguments, including *ignoredArg* and *otherApplicationArgs*, are passed to the Gem and available to the application via `System class >> commandLineArguments`.

The Gem configuration parameters to be used by the Gem are determined in the following precedence order.

- values in -T or -N argument
- values in -C argument
- values in the executable config file.
- values in the system config file.

The system configuration file is the first one found when searching:

- path from $GEMSTONE_SYS_CONF environment variable
- $GEMSTONE/data/system.conf

The executable configuration file is the first one found when searching:

- path from **-e** argument
- path from $GEMSTONE_EXE_CONF environment variable
- a file named 'gem.conf' in current directory of the gem process (the current directory is set from a #dir directive, or from a NetLDI -D argument; see page 417)

The higher precedence setting is used and lower precedence settings are ignored. If there are multiple settings for a specific parameter at the same level, that is in the same executable or system configuration file, or within the **-C** argument, the last one that is found applies and earlier settings for that parameter within the file or string are ignored.

The following variants of **gemnetobject** are included in the distribution. Any of these can be used in place of **gemnetobject**.

gemnetdebug—sets debugging environment variables that are particularly useful for debugging memory issues

gemnetobject_noop—starts a non-optimized Gem executable

gemnetobject_slow—starts a slow Gem executable with assertion checks

gemnetobject_keeplog—starts an ordinary Gem executable, configured to not delete the gem log on clean shutdown.

Examples

gemnetobject is used in topaz, GemBuilder for Smalltalk, and GemBuilder for C applications in the login parameters for gemnetid. The following examples are in topaz.

Note that single quotes may be needed when the gemnetid arguments include spaces.

```
topaz> set gemnetid 'gemnetobject -T 500MB -e devStone.conf'
```

This example passes in a temporary object cache size and a configuration file named devStone.conf with other configuration parameter settings.

```
topaz> set gemnetid '!#netldi:54321!gemnetobject
   -C GEM_RPCGCI_TIMEOUT=5;GEM_ABORT_MAX_CRS=2; -N 1 devStone'
```

This example specifies NetLDI port (54321) to fork the Gem. It includes two configuration parameter settings and modifies the Native Code setting. The token devStone is ignored, but visible in ps output and can be used by code that fetches the command line arguments.

Error checking

Note that minimal argument error checking is done and unrecognized tokens or invalid argument values are ignored during login. Check the gem log to ensure that intended values are used.

For example, an extra space as in the following, results in the second configuration value silently being ignored:

```
'gemnetobject -C GEM_RPCGCI_TIMEOUT=5; GEM_ABORT_MAX_CRS=2;'
```

gslist

gslist [**-c**] [**-l | -p | -x**] [**-H**] [**-m** *host*]+ [[**-n**] *name*]+ [**-N** *netldiName*] [**-q**]
[**-s** *key* | **-S** *key*] [**-t** *secs*] [**-u** *user*] [**-v**] [**-U** *certFile* **-R** *key*File **-J** *caCertFile*]+

gslist -h | -V

-c	Removes locks left by servers that have been killed.
-h	Print usage and exit.
-H	Include HostAgent processes in the output. By default, **gslist** does not report HostAgent processes. HostAgents are support processes for X509-Secured GemStone.
-j	Print extra long listing in JSON format to stdout. The listing always implictly behaves as if **-q** and **-x** were specified.
-J *caCertFile*	To list processes started with X509-Secured GemStone. Specify an X509 CA certificate file. **-R** and **-U** must also be specified.
-l	Prints a long listing (includes pid and port).
-m *host*	Only list servers on machine *host*; default is '.' which represents the local host. If not the local host, the machine *host* must be running a compatible version of NetLDI, and the -N argument is required if it is not running with the default name in the environment of gslist.
-n *name*	Only list the server *name.*
-N *netldiName*	When **-m** is used, **-N** specifies name of netldi to contact on remote host. Default is name specified in GEMSTONE_NRS_ALL environment variable, otherwise name is 'gs64ldi'.
-p	Prints only the pid (process id), or 0 if the server does not exist.
-q	(Quiet.) Don't print any extra information; intended for use when the output will be processed by some other program.
-R *key*File	To list processes started with X509-Secured GemStone. Specify an X509 private host key file. **-J** and **-U** must also be specified.
-s *key*	Sort results by the given sort key. Legal key values: **name** sort by process name (default). **owner** sort by process owner. **time** sort by process start time. **type** sort by process type. **version** sort by process version.
-S *key*	Same as **-s** except results are sorted in reverse order.
-t *secs*	Wait *secs* seconds for server to respond (only with **-v**); default is 2 seconds.
-u *user*	Only list servers started by *user.*

-U *certFile*	To list processes started with X509-Secured GemStone. Specify an X509 public host certificate file. **-J** and **-U** must also be specified.
-v	Verify the status of each server.
-V	Print the version information and exit.
-x	Prints an exhaustive listing, with each item on a separate line.

The **gslist** command prints information about GemStone servers. The default listing prints the following server attributes in columns:

Status	One of the following: **contRestore** Continous restore for hot standby (**-v** only) **exe deleted** server process running from a deleted or overwritten executable **exists** server process exists but is not verified **frozen** server is not responding (**-v** only) **full** server can't accept any more clients (**-v** only) **killed** server process does not exist **OK** server is accepting clients (**-v** only) **restoreBkup** server is in restore from backup (**-v** only) **restoreLogs** server is in restore from logs mode (**-v** only) **recovery** Restart after unclean shutdown in progress (**-v** only) **startup** server process is not yet accepting clients (**-v** only) **stutdown** server process is in shutdown (**-v** only)
Version	GemStone version of the server.
Owner	The account name of the user who created the server.
Started	The date and time that the server was started.
Type	One of the following: Netldi, Stone, cache (shared page cache monitor), logsender, logreceiver, or hostagent.
Name	The server's name.

When you include the **-l** or **-x** option, the following additional columns are printed:

Pid	The process id of the server's main process.
Port	The port number of the server's listening socket.

The **-x** option prints the preceding attributes on separate lines, and adds lines for the following as appropriate:

options	Options used when the server was started.
logfile	Full path of server's log file, if it exists.
sysconf	The GemStone system configuration file. See "System Configuration File" on page 308.

execonf	The GemStone executable configuration file. See "Executable Configuration File" on page 309.
GEMSTONE	Root of the product tree used by the server.

If many servers are reported as **frozen** to **gslist -v**, try increasing `-t` *secs*.

By default, status is returned for all servers on the current host. To specify a particular server, use the -n switch, or just include the server name on the command line (since the -n is optional). To specify multiple server names, include the **-n** *name* option for each server.

Remote queries

The **-m** option allows you to list servers on a remote host. To specify more than one remote host, include the **-m** *host* option multiple times, one for each host. Names on remote hosts are prefixed by `host:`, where *host* is the name of the remote machine.

To list servers on a remote host, **gslist** must be able to contact a NetLDI running on the remote machine.

- The remote NetLDI must be a GemStone version that is compatible with the version of **gslist**. This limitation applies to the remote NetLDI, but not to the Stone and other server processes on the remote host, for which **gslist** fetches information.
- The remote NetLDI must be named with the default name, or the **-N** argument should be included to specify the name. The default name here is the default for the environment in which **gslist** is running. This is either "gs64ldi", or a name specified by $GEMSTONE_NRS_ALL.

Date and Time format

The date and time that the process started is normally printed in a format specific to gslist and fitting into the table display. To get a parse-able but potentially less readable format, you may use the environment variable GS_GSLIST_TIME_FORMAT to specify a UNIX-style date format string.

Json output

gslist -j provides the **gslist -x** contents, but in json format. This can be easily processed as needed for system administration. For example:

```
(JsonParser new parse: (System performOnServer: 'gslist -j')
```

This creates a structure of Dictionaries and Arrays in GemStone Smalltalk containing all information about all GemStone services. Note that all keys and values in the output are capitalized. This includes gslist status values (such as 'Exists'), and command line arguments.

Exit status

The exit status has the following values:

0	Operation was successful.
1	No servers were found.
2	A stale lock was removed (in response to **-c** switch).
3, 4	An error occurred.

largememorypages

largememorypages [-e *exeConfig* **] [-z** *systemConfig* **] [-M** *sharedCacheKB* **]**
[-P *maxProcesses* **] [-C** *maxSharedCounters* **] [-p** *largeMemoryPageSize* **]**

largememorypages -h

-C *maxSharedCounters*	Overrides the setting for SHR_PAGE_CACHE_NUM_SHARED_COUNTERS in a configuration file.
-e *exeConfig*	The GemStone executable configuration file. See "Executable Configuration File" on page 309.
-h	Print usage and exit.
-M *sharedCacheKB*	The shared cache size. The default unit is MB, but KB or GB can also be used. Overrides the setting for SHR_PAGE_CACHE_SIZE in a configuration file.
-p *largeMemoryPageSize*	Used on Linux only. The intended large memory page size, legal values must resolve to 2MB or 1024MB. The default is 2MB. The default unit is MB, but KB or GB can also be used. This overrides a setting for SHR_PAGE_CACHE_LARGE_MEMORY_PAGE_SIZE_MB in a configuration file.
-P *maxProcesses*	Overrides the setting for SHR_PAGE_CACHE_NUM_PROCS in a configuration file.
-z *systemConfig*	The GemStone system configuration file. See "System Configuration File" on page 308.

largememorypages computes the number of large or huge memory pages that will be required for a given shared page cache size and other system requirements.

Large or huge memory pages are available for use with GemStone on Linux and AIX.

- On Linux, GemStone supports 2MB and 1024 MB pages.
- On AIX, 16GB large memory pages are supported.

Large pages are not supported on other platforms.

Using the **largememorypages** utility is described in the Installation Guide for Linux and for AIX. For example:

```
unix> largememorypages  -M 20GB -C 1900 -P 200
Cache config is 1310720 pages = 20480 MB,  total is 21384 MB,
overhead 4% of configured size
Large page size requested is: 2 MB.
Large page overhead: 1.12 MB
For 1310720 pages, 200 processes and 1900 shared counters,
   10 pusherThreads
  required cache size is 22422749184 bytes.
Number of 2 MB large pages required: 10692
```

netldidebug

netldidebug [**-h**] *netldiNameOrPort actionToTake*

-h	Display a usage line and exits
netldiNameOrPort	The name or port of the NetLDI.
actionToTake	The action to take, which must one of the keywords **`enabledebug`**, **`extradebug`**, or **`disabledebug`**. ▸ **`enabledebug`** turns on ordinary debugging (the equivalent of using startnetldi -d) ▸ **`extradebug`** enables ordinary debug mode and also prints extra debugging for NRS handling ▸ **`disabledebug`** turns off debugging.

The netldidebug command allows you to modify the debug state of a running NetLDI (that is, the state resulting from omitting or including -d with startnetldi), without the need to shut down and restart the NetLDI.

pageaudit

pageaudit [*gemStoneName*] [**-e** *exeConfig*] [**-z** *systemConfig*] [**-f**] [**-d**] [**-l** *logfile*]

pageaudit [*gemStoneName*] [**-e** *exeConfig*] [**-z** *systemConfig*] [**-f**] [**-d**] [**-l** *logFile*]
[**-D** *privateKey* **-K** *dir* [**-K** *dir*+] [**-j** *passPhrase* | **-J** *passphraseFile*]

pageaudit -h | **-v**

gemStoneName	Name of the GemStone repository monitor; the default is `gs64stone-audit`. Network resource syntax is not permitted.
-d	Disable audit of data pages. Only audit Object Table pages, bitmaps, and other non-data pages.
-D *privateKey*	For encrypted extents, specifies the private key file corresponding to the public key used to encrypt the extents. The file must be in PEM format. Requires **-K**, and if the private key has a passphrase, also **-j** or **-J**.
-e *exeConfig*	The GemStone executable configuration file. See "Executable Configuration File" on page 309.
-f	Keeps running beyond the first error, if possible
-h	Print usage and exit.
-j *Passphrase*	For encrypted extents, use the given passphrase to read the private key specified by **-D**.
-J *passphraseFile*	For encrypted extents, use the passphrase contained in file *passphraseFile* to read the private key specified by **-D**. *passphraseFile* must be the full path and filename.
-K *keyRingDirs*	For encrypted extents, specifies one or more colon-separated directories which contain keys and certificates. May be included more than once.
-l *logfilename*	Write output to the file with the given name. The file is created if it does not exist. If there is an existing file with this name, the pageaudit output is appended to the end of this file.
-n *numSessions*	Run with the specified number of sessions. The default is numExtents + numCpus.
-v	Print version and exit.
-z *systemConfig*	The GemStone system configuration file. See "System Configuration File" on page 308.

Audit the pages in a GemStone repository, which must not be in use. **pageaudit** opens the repository specified by the relevant configuration files. The arguments **-e** *exeConfig*, and **-z** *systemConfig* determine which configuration files **pageaudit** reads.

pageaudit by default runs aggressively, using a large number of threads (based on the number of CPUs and extents for this system), in order to complete as quickly as possible; the **-n** option can be used to specify fewer threads, and reduce the impact on your system.

By default, all pages in the repository are verified; this includes data pages as well as Object Table, bitmap, and other pages containing internal information. Audit of data pages can be disabled using the **-d** option.

An error is returned if another Stone is running as *gemStoneName* or has opened the same repository.

When you include the **-f** switch, **pageaudit** prints all errors possible. Without **-f**, the default is to stop after the first error is found.

This utility can take a long time to run, so it is best to run it as a background job.

For additional information about **pageaudit** and a description of its output, see "Page Audit" on page 134.

printlogs

printlogs [-h] [*arguments, see below*] [*filters, see below*] **all** | *tlog1...tlogN*

Arguments

full	More detailed logs are produced. This may produce a VERY large amount of output.
all	Print out contents of all tranlogs in this directory.
keyring *privKeyPath*	the path to the directory containing the private key cert or file.
nostrings	Suppress the printing of String data in the output. Useful for security when sharing tranlog output.
nouserinfo	Suppress the printout of user information.
privkey *keyFileName*	filename of the private key or cert.
privkeypf *keyPassphrase*	Passphrase for the private key, if the key requires it.
privkeypffn *fileContainingPassphrase*	Full path to a file containing the passphrase for the private key, if the key requires it.
tlog1...tlogN	The specific tranlog or tranlogs to print. These must be a contiguous sequence in order. This or **all** is required.
-h	Print usage and exit.

Search filter criteria:

user *username*	Only print records for the specified GS UserProfile name.
host *hostname*	Only print records for the specified gem/topaz process host.
client *X.X.X.X*	Only print records for the specified client IP Address.
euid *integer*	Only print records for Gems with the specified effective UNIX user ID.
ruid *integer*	Only print records for Gems with the specified real UNIX user ID.
luid *integer*	Only print records for Gems with the specified login UNIX user ID.
euidstr *string*	Only print records for Gems with the specified effective UNIX user name.
ruidstr *string*	Only print records for Gems with the specified real UNIX user name.
luidstr *string*	Only print records for Gems with the specified login UNIX user name.

gempid *integer*	Only print records for Gems with the specified process ID.
sessionid *integer*	Only print records for Gems with the specified session ID.

printlogs prints out the contents of transaction logs in human-readable form. This may produce a very large amount of output; without filters, the output will be at least as large as the original and may be multiple times larger depending on the options used.

Tranlogs to be printed are by default named tranlogNNN.dbf. This can be overridden by setting the environment variable $GS_TRANLOG_PREFIX to the tranlog prefix.

When using multiple filters, records that match any of the filters are printed. Each filter key can be used only once.

A maximum of 256 transaction logs can be analyzed at once.

For details on using printlogs for tranlog analysis, see: http://downloads.gemtalksystems.com/docs/Other/SDoc-TranlogAnalysis-3.5/SDoc-TranlogAnalysis-3.5.htm.

Examples

To print out the entire contents of all tranlogs in the current working directory:

```
printlogs all
```

To print out all entries in a selected number of tranlogs:

```
printlogs tranlog5.dbf tranlog6.dbf tranlog7.dbf
```

To print out all tranlog entries for the user DataCurator in any tranlog:

```
printlogs user DataCurator all
```

To print out detailed information for all entries in tranlog5.dbf for the user DataCurator:

```
printlogs full user DataCurator tranlog5.dbf
```

pstack

pstack [-**b** | **-c** | **-C** | **-h**] *processPid*

processPid	The PID of a running GemStone process.
-b	Print brief C and Smalltalk stacks.
-C	Print brief C stack, omit Smalltalk stack.
-c	Print brief and full C stack, omit Smalltalk stack.
-h	Print usage and exit.

The **pstack** command attaches a debugger to the process with the given pid, outputs the C and Smalltalk stacks of that process to stderr, and detaches. The Smalltalk stack is printed to the Gem log or topaz linked session console.

Execution of the running process briefly pauses while the debugger is attaching, but the process will subsequently continue running normally.

pstack is similar to functions provided with some OS platforms.

By default, the stack summary is printed with one line per frame for each thread, followed by the complete stack details. The **-b** and **-C** options allow you to specify brief format stacks.

By default, both C stack and (if there is a Smalltalk context) Smalltalk stacks are printed. The **-c** and **-C** options allow you to omit the Smalltalk stack.

removedbf

removedbf *dbfNRS* [**-h**]

dbfNRS	The GemStone repository filename or the device for the repository to be removed.
-h	Print usage and exit.

This command removes (erases) a GemStone repository file. It is provided primarily for erasing an extent or transaction log from a raw partition, but it also works on files in local or NFS-mounted file systems. It does not work for disks on remote file systems.

If you specify a file in the file system, this command is equivalent to the **rm** command. If you specify a raw disk partition, GemStone metadata in the partition is overwritten so that GemStone will no longer think there is a repository file on the partition.

For example, to remove an extent on the raw partition /dev/rsd3h:

```
removedbf /dev/rsd3h
```

This command does not disconnect an extent from the logical repository. To alter the configuration by disconnecting an existing extent, see "To Remove an Extent" on page 191.

searchlogs

searchlogs [-h] [*arguments, see below*] [*filters, see below*] *oop1...oop2*

Arguments

keyring *privKeyPath*	the path to the directory containing the private key cert or file.
nostrings	Suppress the printing of String data in the output. Useful for security when sharing tranlog output.
privkey *keyFileName*	filename of the private key or cert.
privkeypf *keyPassphrase*	Passphrase for the private key, if the key requires it.
privkeypffn *fileContaiingPassphrase*	Full path to a file containing the passphrase for the private key, if the key requires it.
oop1...oopN	The specific OOPs to search for. Required.
-h	Print usage and exit.

Seach Filters:

user *username*	Only print records for the specified GS UserProfile name.
host *hostname*	Only print records for the specified gem/topaz process host.
client *X.X.X.X*	Only print records for the specified client IP Address.
euid *integer*	Only print records for Gems with the specified effective UNIX user ID.
ruid *integer*	Only print records for Gems with the specified real UNIX user ID.
luid *integer*	Only print records for Gems with the specified login UNIX user ID.
euidstr *string*	Only print records for Gems with the specified effective UNIX user name.
ruidstr *string*	Only print records for Gems with the specified real UNIX user name.
luidstr *string*	Only print records for Gems with the specified login UNIX user name.
gempid *integer*	Only print records for Gems with the specified process ID.
sessionid *integer*	Only print records for Gems with the specified session ID.

Searchlogs searches all tranlogs in the current directory for selected oops, filtering results by user, host, and other criteria. Filters are optional.

Tranlogs to be searched are by default named tranlogNNN.dbf. This can be overridden by setting the environment variable $GS_TRANLOG_PREFIX to the tranlog prefix.

When using multiple filters, records that match any of the filters are printed. Each filter key can be used only once.

A maximum of 256 transaction logs can be analyzed at once.

For details on using searchlogs for tranlog analysis, see http://downloads.gemtalksystems.com/docs/Other/SDoc-TranlogAnalysis-3.5/SDoc-TranlogAnalysis-3.5.htm.

Examples

To print out all entries involving OOP 1234 and OOP 5678:

```
searchlogs 1234 5678
```

To print out all entries involving OOP 1234 performed by DataCurator:

```
searchlogs user DataCurator 1234
```

startcachewarmer

startcachewarmer [**-d** | **-D**] [**-h**] [**-l** *limit*] [**-L** *path*] [**-n** *numSessions*] [**-s** *stoneName*] [**-w** *writeInterval*] [**-W**] [**-C** *midCacheSizeKb*] [**-e** *gemConfigPath*] [**-H** *stoneHost*] [**-M** *midCacheHost*] [**-N** *midCacheMaxProcs*]

-C *midCacheSizeKb*	The size of the mid-level cache in KB (default 75000). Only used if the **-M** option is specified and the mid-level cache does not exist.
-d	Reads data pages into the cache (default: only object table pages are read).
-D	Reads data pages into the UNIX file buffer cache and not the shared page cache.
-e *gemConfigPath*	path to a gem config file, by default gem.conf in the current directory. Used to specify a shared cache configuration, if the warmer starts a remote or mid-level cache.
-h	Print usage and exit.
-H *stoneHost*	The host name or IP address where the stone is running. This option should only be used when warming a remote cache.
-l *cacheFullLimit*	Stops cache warming if the number of free frames in the cache falls below the specified *cacheFullLimit*. If *cacheFullLimit* is -1 (the default), have the system compute the actual limit based on the size of the shared cache. If *cacheFullLimit* is 0, force cache warming to continue even if the shared cache is full.
-L *path*	Path to a writable log file directory (default: current directory)
-M *midCacheHost*	The host name or IP address where the mid-level cache is running or will be created. The **-H** option must also be specified with this option (default: no mid-level cache is used)
-n *numSessions*	Number of worker sessions to start. The default is the number of CPUs + number of Extents, plus 1 additional master session. The cachewarmer will exit if not enough sessions are available.
-N *midCacheMaxProcs*	The maximum number of processes that can use the mid-level cache (default: 50). Only used if the **-M** option is also specified and mid-level cache does not exist.
-s *stoneName*	Name of the running Stone (default: `gs64stone`).

-W	Wait for cache warming Gems to exit before exiting this script. By default, this script spawns Gems in the background and exits immediately.
-w *writeInterval*	Instruct the shared page cache monitor to write the ids of all data pages in the shared cache to the working set file, at the given interval in minutes. A value of 0 means write the file only when the stone is shutdown or killed. The working set is written to `/opt/gemstone/locks/`*stoneName*`~`*hostid*`.workingSet.lz4`

The **startcachewarmer** command warms up the shared page cache on startup, by preloading object table pages and optionally data pages into the cache. This allows the overhead of initial page loading to occur in a controlled way on system startup, rather than more gradually as the repository is in use.

The object table and dependency map pages are always loaded; data pages are loaded based on the **-d** flag or the presence of the working set file.

- If the working set file `/opt/gemstone/locks/`*stoneName*`~`*hostid*`.workingSet.lz4` exists, the valid data pages in this file are loaded.
- If the working set file does not exist, then behavior depends on the use of the **-d** and **-D** options:
  - ❒ If the **-d** option is specified, all data pages in page order are loaded.
  - ❒ With the **-D** option, data pages are loaded into the OS file buffer but not into the shared page cache.

  The **-d** and **-D** flags are mutually exclusive, if both are specified, then the later one is used.

Cache warming writes messages to stone log when it starts and with status when it completes. When the **-W** option is specified, it will also write the results to the console. If an error occurs during cache warming, details are preserved in a file named *stonename*`_cachewarmer.log` in the directory from which this utility was executed.

If a remote shared page cache is to be warmed (i.e., the **-H** option is used), then the remote cache will be created if it does not already exist. The configuration used to start the remote cache are controlled by the **-e** argument, a gem.conf in the current directory, or the GEMSTONE_EXE_CONF environment variable.

If a mid-level cache host name or IP address is specified (via **-M**), the mid-level cache will be created if it does not already exist. The **-C** and **-N** options will be used to specify the size and number of processes that can attach the mid-cache respectively. If the mid-cache already exists, the **-C** and **-N** options are ignored.

For greater efficiency, you can set the configuration file parameters STN_CACHE_WARMER_ARGS, GEM_CACHE_WARMER_ARGS, AND GEM_CACHE_WARMER_MID_CACHE_ARGS to invoke cache warming automatically on startup.

startlogreceiver

startlogreceiver -P *listeningPort* **-A** *listeningAddress* **-T** *tranlogDir*+ [**-l** *logFile*] [**-s** *stoneName*] [**-p** *alternatePort*] [**-d** | **-D**] [**-t** *timeoutSeconds*] [**-f** *flushIntervalSecs*] [**-C** *certFileName*] [**-J** *certAuthFileName*] [**-K** *keyFileName*] [**-Q** *passphrasestring*] [**-S**] [**-V**]

startlogreceiver -h | -v

-A *listeningAddress*	Address that will be used to attempt connection to a logsender.
-d	Print debug tracing of tranlog read and write operations to log file. The log file will be much larger.
-D	Like **-d**, but also prints commands sent between the logsender and log receiver to the log file. The log file will be much larger.
-f *flushIntervalSecs*	Interval in seconds at which the logreceiver flushes the tranlog file. 0 means flush as often as possible (this may be very slow). -1 disables flushing (file is flushed only when closed). The default is 10.
-l *logFileOrDir*	The path and filename or directory for the logged output of the logreceiver process. The default is `/opt/gemstone/log/logreceiver_`*listeningPort*`.log`.
-h	Print usage and exit.
-P *listeningPort*	Port or named service that will be used to attempt connection to a logsender.
-p *alternatePort*	The logreceiver listens on localhost on this port for stoplogreceiver commands. If logsender and logreceiver are run on same machine, then -p must be used to specify a port different than *listeningPort* specified with the -P argument.
-s *stoneName*	The name of the slave stone. *stoneName* is required for the logreceiver to be able to notify a stone in continuous restore mode that new log records have arrived. Without *stoneName*, logreceiver will just write tranlogs to the file system.
-T *tranlogDir*	Directory(s) where logreceiver writes files received from the logsender, and `continuousRestoreFromArchiveLogs:` will read from. At least one is required, up to 20 -T may be specified.
-t *timeoutSeconds*	How long the logreceiver will wait for logsender to reply to commands. The default is 60; the legal range is 5 to 1000000.
-v	Print version and exit.

Additional arguments for SSL:

-C *certFileName*	Certificate in PEM format that will be sent to the peer upon request.
-J *certAuthFileName*	Certificate authority (CA) file in PEM format to use for peer certificate verification.

-K *keyFileName*	Private key in PEM format for the certificate (associated with the -C certificate).
-Q *passphrasestring*	Private key passphrase. Required if the -K option is used and the private key is encrypted.
-S	Enable SSL mode. Must be specified to use any other SSL options and must also be specified when starting the peer process.
-V	Disable verification of the peer's certificate.

This utility starts up a logreceiver process. As part of a hot standby setup, the logreceiver process runs on the slave system to receive transaction log records, as they are generated, from a logsender process that is running on a master system.

The received transaction log records are written to files in a specified directory on the slave system. The slave system can run `continuousRestoreFromArchiveLogs:` to restore these transaction log records.

The logreceiver writes logging output to a file with the path and name or in the directory specified by the -l argument. If this file is a directory, the file name is `logreceiver_`*listeningPort*`.log`. If no -l argument is used, it writes to `/opt/gemstone/log/logreceiver_`*listeningPort*`.log`. If a file with the specified name exists, it is appended to. It is not deleted on process exit.

The logreceiver process will continue running until explicitly stopped using the **stoplogreceiver** command. If connection to the stone or the logsender process is lost, it will attempt to reconnect.

gslist will report running logreceiver processes.

To start the logsender using SSL to establish a secure connection between logsender and log receiver, both startlogsender and startlogreceiver can be provided with SSL credentials. When SSL arguments are provided, startlogreceiver will start the logreceiver in secure mode, requiring an SSL connection with the logsender. This is described under "Connecting using SSL Mode" on page 266

startlogsender

startlogsender -P *listening* port **-A** *listeningAddress*+ (**-T** *tranlogDir*+ | **-s** *stoneName*)
[**-l** *logFile*] [**-d**] [**-g**] [**-t** *numberOfThreads*] [**-C** *certFileName*] [**-J** *certAuthFileName*]
[**-K** *keyFileName*] [**-Q** *passphrasestring*] [**-S**] [**-V**]

startlogsender -h | -v

-A *listeningAddress*	The address (es) on which the logsender will listen for connections from logreceivers. At least one is required, up to 4 may be specified.
-d	Print debug tracing of tranlog read and write operations to log file. The log file will be much larger.
-g *tranlogPrefix*	The base used to compose tranlog filenames, by default `tranlog`. Only used if there is no **-s** argument, and only needed if the Stone's setting for STN_TRAN_LOG_PREFIX is not at the default.
-l *logFileOrDir*	The path and filename or directory for the logged output of the logsender process. The default is `/opt/gemstone/log/logsender_`*listeningPort*`.log`.
-h	Print usage and exit.
-P *listeningPort*	The port or named service on which on which the logsender will listen for connections from logreceivers.
-s *stoneName*	The name of the master stone. logsender will transmit records from the transaction logs in the tranlog directories configured for the Stone named *stoneName*. Either **-s** or **-T** may be used, but the use of both together is disallowed. When **-s** is used, transaction logs that are added to the master stone are automatically used by the logsender.
-t *numberOfThreads*	The number of threads that netldi will use. The default is 10, min 1, max 500. If **-S** specified, or netldi running as root, only uses one thread.
-T *tranlogDir*	Directory(s) where the master stone's transaction logs are located. Normally the same as stone's STN_TRAN_LOG_DIRECTORIES but may also include archive directories. logsender will examine these directories for new files to send. Disllowed if **-s** is used, if **-s** is not used then at least one is required and up to 20 **-T** may be specified.
-v	Print version and exit.

Additional arguments for SSL:

-C *certFileName*	Certificate in PEM format that will be sent to the peer upon request.
-J *certAuthFileName*	Certificate authority (CA) file in PEM format to use for peer certificate verification.
-K *keyFileName*	Private key in PEM format for the certificate (-C option).

-Q *passphrasestring*	Private key passphrase. Required if the -K option is used and the private key is encrypted.
-S	Enable SSL mode. Must be specified to use any other SSL options and must also be specified when starting the peer process.
-V	Disable verification of the peer's certificate.

This utility starts up a logsender process. As part of a hot standby setup, the logsender process runs on the master system to transmit transaction log records, as they are generated, to a logreceiver process that is running on a slave system. See "Hot Standby" on page 260 for complete information on setting up a hotstandby system.

The logsender writes logging output to a file with the path and name or in the directory specified by the **-l** argument. If this file is a directory, the file name is `logsender_`*listeningPort*`.log`. If no **-l** argument is used, it writes to `/opt/gemstone/log/logsender_`*listeningPort*`.log`. If a file with the specified name exists, it is appended to. It is not deleted on process exit.

The logsender process will continue running until explicitly stopped using the **stoplogsender** command. If connection to the stone is lost, it will attempt to reconnect.

gslist will report running logsender processes.

To start the logsender using SSL to establish a secure connection between logsender and log receiver, both startlogsender and startlogreceiver can be provided with SSL credentials. When SSL arguments are provided, startlogsender will start the logsender in secure mode, requiring an SSL connection with the logreceiver. This is described under "Connecting using SSL Mode" on page 266.

startnetldi

startnetldi [*netLdiName*] [**-g** | [**-s**] [**-k** *keytab*]] [**-a** *name*] [**-A** *addresses*]+ [**-b**] [**-d**] [-H] [**-X** *nrs*] [**-D** *directoryPath*] [**-l** *logFile*] [**-n**] [**-P** *portNumber*] [**-r**] **[-t** *numThreads]*

startnetldi [*x509NetLdiName*] [**-b**] [**-d**] [**-E** *configFileName*] [**-l** *logFile*] [**-n**] [**-X** *nrs*] [-H] [**-P** *portNumber*] [**-r**] **-D** *directoryPath* **-S -J** *certAuthFileName* **-R** *keyFileName* **-U** *certFileName* **-L** *crlFileName*

startnetldi -h | **-v**

netLdiName
The name or port number of the GemStone network server.
If *netLdiName* is a numeric value equal to or less than 65535, it is interpreted as a port number. If the given port is in use, it will result in an error. Other values are interpreted as the netldi name. If the **-P** argument is omitted, this name is looked up in the network services database to determine the port number. Network resource syntax is not permitted.
If this argument is omitted, *netLdiName* defaults to:
- a `netldi:` specification in GEMSTONE_NRS_ALL, if present
- a `netldi:` specification in the **-X** argument, if present
- `gs64ldi`

-a *name*
Captive account; all child processes created by the NetLDI will belong to the account named *name*. By default, child processes belong to the client's account.

-A *addresses*
Address to listen on. Up to 10 arguments are accepted. If no **-A** arguments are provided, listening is on the default wildcard address ::. If this default wildcard address is included, then other -A arguments are ignored. If the **-A** entry arguments do not include :: or ::1, then ::1 is also listened on.

-b
Maximum client connection backlog (default: 64).

-d
Debug mode; inserts more extensive messages in the log file. You can modify the debug mode during runtime using **netldidebug** on page 378.

-D *directoryPath*
Specifies a directory that will be used to compose log file paths for process log files. It is the default log path if the NRS does not include a #dir directive. This directory must exist and be writable, and the $GEMSTONE_NRS_ALL in the startnetldi's environment must not include a #dir directive.
If the NRS includes the %D pattern in the #dir or #log, when spawning a child process, the %D in the NRS is replaced with *directoryPath* before forking. Path separator is appended if necessary.

-g
Guest mode; no accesses are authenticated. This option is not allowed if the NetLDI's effective user id is the root account. Not compatible with **-k**.

-h	Print usage and exit.
-H	Do reverse DNS lookup on IP addresses of hostnames, and print both name and IP address in the log.
-k	Enable Kerberos and set the keytab file name; logins with empty host password will authenticate using Kerberos. Not compatible with **-g**.
-l *logFile*	The logged output of the NetLDI; the default is `/opt/gemstone/log/`*NetLdiName*`.log`
-n	Do not allow any *ad hoc* processes to be created (ad hoc processes are ones not listed in `$GEMSTONE/sys/services.dat`).
-N	Use numeric IP addresses for printing peer info in logs. This is the default.
-P *portNumber*	The well-known port number that NetLDI will listen on.
-r	If there is a running NetLDI (version 3.3 or above) with this name, and that NetLDI has different version than specified in the current environment, stop the running NetLDI and restart it.
-s	Secure; require authentication for **all** NetLDI accesses.
-t *numThreads*	Start the NetLDI with *numThreads* threads. For an X509-Secured NetLDI, or if the NetLDI will be running as root, only uses one thread. Default 10, min 1, max 500.
-v	Print version and exit

Additional arguments for use only when starting a X509-Secured NetLDI:

-E *configFileName*	For use when starting a X509-Secured NetLDI on a remote node (not the Stone's node). Provides specifications for starting the remote cache. The actual cache startup is initiated by starthostagent on the Stone's node. See the *GemStone/S 64 Bit X509-Secured GemStone System Administration Guide*.
-J *certAuthFileName*	Specifies a certificate authority certificate (CA) in PEM format to use. Requires **-S**.
-L *crlFileName*	Specifies a certificate revocation list (CRL) file in PEM format.
-R *keyFileName*	Specifies host private key in PEM format to use. Requires **-S**.
-S	Start a X509-Secured NetLDI. Certificates must also be provided using **-U**, **-R**, and **-J**, and **-E** is required for remote caches. The NetLDI will do mutual authentication for all connections.
-U *certFileName*	Specifies a host X509 certificate in PEM format to use. Requires **-S**.
-X *nrs*	Specifies an NRS containing one or more of #log:, #dir:, and #netldi:, which take precedence over an GEMSTONE_NRS_ALL setting in the environment of the startnetldi.

This command starts a GemStone network server with the specified *netLdiName* and *timeout* (given in seconds). The server spawns GemStone processes in response to login requests from remote applications and requests for remote repository access from Stone repository monitor processes. If your machine is slow or heavily loaded, and RPC logins time out before completing, specify a larger timeout value.

Legal characters in a NetLDI name are A-Z, a-z, 0-9, and the characters period, underscore, and dash (. _ -). NetLDI names with other characters are disallowed. NetLDI names should not start with period or dash, and should include at least one letter or digit. Also, NetLDI names must not match an existing system service, such as `ldap`, `syslog`, etc.

The NetLDI listens for requests, including RPC login requests, on a specified or configured port and optionally on a specific address. During the RPC login process, it uses a separate set of ports to establish communication between the Gem and its client. If you are running over a firewall, you can specify the port using the **-P** option, and configure your firewall to permit access via this port.

The locations and names of log files for process started by the NetLDI are defined by NRS directives in the login parameters or by settings in the GEMSTONE_NRS_ALL. Using the **-D** *logfile* argument to startnetldi sets a default log file path. For more on managing log file paths, see "Controlling log file directory locations" on page 417.

NetLDI can be configured to authenticate starting processes, or all accesses. It may configure to authenticate the UNIX userId (including by using Kerberos) or to run in guest mode, which does not authenticate. These options work in conjunction with permissions for the extent files to provide security while also ensuring the appropriate access to GemStone for authorized users. How to configure the NetLDI is described in Chapter 4, "NetLDI and Interprocess Access", starting on page 69.

To use startnetldi within an X509-Secured GemStone configuration, see the *GemStone/S 64 Bit X509-Secured GemStone System Administration Guide*.

For assistance with startup failures, refer to "To Troubleshoot NetLDI Startup Failures" on page 109.

Return values

The **startnetldi** utility returns one of the following codes to the command line:

- 0 (success) Successful start
- 1 (informational) The specified NetLDI is already running
- 2 (warning) The sspecified NetLDI is already running, but the exectuables have been deleted or overwritten
- 3 or above (error) an error occurred and *gemStoneName* was not started.

netldid

`$GEMSTONE/sys/netldid` is the executable that is invoked by startnetldi. While **startnetldi** blocks until startup is complete, then returns control to the command line, executing **netldid** directly does not return. This can allow you to run the NetLDI as a background process.

The options described for **startnetldi** are also available for **netldid**, with the exception of **-r**.

startstone

startstone [*gemStoneName*] [**-l** *logFile*] [**-e** *exeConfig*] [**-z** *systemConfig*] [**-R**] **[-N] [-H]**

startstone [*gemStoneName*] [**-l** *logFile*] [**-e** *exeConfig*] [**-z** *systemConfig*] [**-R**] **[-N] [-H]**
-D *privateKey* **-K** *dir* [**-K** *dir*+] [**-j** *passPhrase* | **-J** *passphraseFile*]

startstone -h | **-v**

gemStoneName	Name of the GemStone repository monitor, default is `gs64stone`. Network resource syntax is not permitted.
-D *privateKey*	For encrypted extents, specifies the private key file corresponding to the public key used to encrypt the extents. The file must be in PEM format. Requires **-K**, and if the private key has a passphrase, also **-j** or **-J**.
-e *exeConfig*	The GemStone executable configuration file. See "Executable Configuration File" on page 309.
-h	Print usage and exit.
-H	Do reverse DNS lookup on IP addresses of hostnames, and print both name and IP address in the log.
-j *Passphrase*	For encrypted extents, use the given passphrase to read the private key specified by **-D**.
-J *passphraseFile*	For encrypted extents, use the passphrase contained in file *passphraseFile* to read the private key specified by **-D**. *passphraseFile* must be the full path and filename.
-K *keyRingDirs*	For encrypted extents, specifies one or more colon-separated directories which contain keys and certificates. May be included more than once.
-l *logFile*	The location (or filename) for the logged output of the stone; the default is (1) the setting of the `$GEMSTONE_LOG` environment variable, if defined; (2) `$GEMSTONE/data/`*gemStoneName*`.log`
-N	Do not replay transaction logs as part of startup. Unless used with the **-R** option, and transaction logs are replayed manually, work may be lost.
-R	Start up from the most recent checkpoint and go into restore mode. Used when restoring from backup, to allow transaction logs to be restored. With this option, the stone does not create or write to a transaction log on startup.
-v	Print version and exit
-z *systemConfig*	The GemStone system configuration file. See "System Configuration File" on page 308.

This command opens the GemStone repository specified by the configuration files. For details on how **startstone** determines which the configuration file/s to use, see "How GemStone Uses Configuration Files" on page 307.)

Legal characters in a Stone name are A-Z, a-z, 0-9, and the characters period, underscore, and dash (. _ -). Stone names with other characters are disallowed. Stone names should not start with period or dash, and should include at least one letter or digit. Also, Stone names must not match an existing system service, such as `ldap`, `syslog`, etc.

The **-N** option is intended for use when the repository needs recovery, but the transaction logs specified in the configuration file cannot be found or have become corrupted. The **-N** forces the repository to start up anyway, even though transactions committed since the last checkpoint will be lost.A new transaction log will be initialized as part of the startup.

The **-R** option is used when restoring from backup. This starts up the repository at the point of the most recent checkpoint in the extents, and puts the repository into restore mode. You can then invoke Topaz to restore from transaction logs and commit the restored state.

If the extents against which Stone is being started require recovery, or if you are restoring from online extent backups, then you must specify the **-N** option along with the **-R** option; otherwise, an error will result and the repository monitor will not start.

For startup failures, refer to "To Troubleshoot Stone Startup Failures" on page 105.

If you are using encrypted extent files, you must also specify the private key corresponding to the public key used to encrypt the extents, with **-D**, and the directory or directories containing public and private keys, with **-K**. If the private key has a pass phrase, you must also provide this with the **-j** or **-J** arguments. If the repository was uncleanly shutdown, the associated encrypted transaction logs must be encrypted with the same key as the repository extents, for the automatic recovery to succeed. However, if you are restoring tranlogs from backup, you may specify alternate private keys. See Chapter 12 for more details on using encrypted extents and tranlogs.

stoned

`$GEMSTONE/sys/stoned` is the executable that is invoked by **startstone**. While **startstone** blocks until startup is complete, then returns control to the command line, executing **stoned** directly does not return. This can allow you to run the Stone as a background process.

The options described for **startstone** are also available for **stoned**.

Return values

The **startstone** utility returns one of the following codes to the command line:

- 0 (success) Successful start
- 1 (informational) The stone named *gemStoneName* is already running
- 2 (warning) The stone *gemStoneName* is already running, but the exectuables have been deleted or overwritten
- 3 or above (error) an error occurred and *gemStoneName* was not started.

statmonitor

statmonitor *stoneName* [*options, see below*]

stoneName	Required; the name of the Stone to monitor.
-a	Collect all available system statistics except per-core CPU statistics.
-A	Collect all available system statistics.
-B *count*	Number of persistent shared counters to sample. Maximum is 1536, default is 0.
-C	Collect system statistics for each individual CPU.
-d *directory*	Directory where output files are written. Cannot be used with the **-f** or **-F** options; to specify a directory with those options, include it in the filename or pattern.
-D	Collect system statistics for all disks and partitions.
-f *fileName*	The output file name. If not specified, the output filename is statmon*N*.out, where *N* is the process ID. If the file already exists, statmonitor will append -*N* to the filename, and the correct extension will be appended if not already present. To send output to stdout instead of a file, specify **-f stdout**. May not be used with the **-d** option.
-F *pattern*	Pattern used to generate the file name. Values in the pattern starting with a single '%' character have the meaning described in the strftime(3) function call. Additionally, the following patterns which start with double '%' characters are also accepted: %%C - name of the shared page cache %%H - name of the host %%i - sample interval in seconds %%I - sample interval in milliseconds %%P - process ID of statmonitor %%S - name of the stone May not be used with the **-d** option. %%C and %%S cannot be used when statmonitor is started with the **-X** argument. If the file already exists, statmonitor will append -*N* to the filename, and the correct extension will be appended if not already present.
-h	With no argument, print usage and exit.
-h *hours*	The number of hours (default: forever).
-i *interval*	The interval in seconds (default: 20). Select either **-i** or **-I**.
-I *intervalMs*	The interval in milliseconds (default 20000; minimum 10). Select either **-i** or **-I**.
-J	Sample the Stone, shared cache monitor, and page manager only.

-k *listOfTimes*	List of times at which statmonitor should be restarted. The restart is performed at the next sample interval after the specified time has passed. ▸ Either the **-r** or **-R** command must also be specified. ▸ **-t** and **-h** are disallowed ▸ List must start and end with a single quote. ▸ times include hours and minutes, colon separated. ▸ hours are in 24-hour format. ▸ Multiple times are comma separated. ▸ Duplicates should not be included.
-K *numOldFilesLimit*	Tells statmonitor to automatically delete old output files as new ones are created. *numOldFilesLimit* specifies how many old files to keep (excluding the current file). Files are deleted in order of age, oldest files first. Requires either -r or -R.
-n *numAppStats*	The number of application statistics (default: 0).
-N	Collect system statistics for all network interfaces.
-p *sessionId*	A GemStone sessionId to monitor. You may specify multiple sessions. (Default: monitor all sessions.)
-P	Sample the Stone, shared cache monitor and AIO page server threads only.
-q	Quiet mode. Only print messages if an error occurs.
-Q *pid1,pid2,...*	Record statistics for a list of process IDs.
-r	Restart a new output file when the current one completes. Each file will be given a unique name. This option may only be used with the **-h**, **-t** or **-k** switches, which control when a restart is done.
-R	Same as **-r** except the output file name is regenerated for each restart if the **-F** option is used.
-S	Sample only the Stone and shared cache monitor.
-t *times*	The maximum number of samples to collect before starting a new output file (default is forever). Select either **-h** or **-t**.
-T	Do not collect statistics for all NetLDI processes.
-u *seconds*	The maximum number of seconds to wait before flushing the cached information to the output file (default: 60). If 0 then the flush will be done every interval.
-U*uid1,uid2,...*	Record statistics for all processes owned by one or more UNIX user IDs.
-v	Print version and exit
-W	Collect system statistics for system memory pages (Solaris only).

-X	Run in host-only mode. Sample host system statistics only and do not attach to a shared page cache. May be combined with other flags EXCEPT: **-B**, **-n**, **-p**, **-P**, **-S**, or **-Y**. There are some limitations in log file name patterns in this mode; see **-F**.
-Y	Disable collection of all system statistics, including per-process data.
-z	Write the output in compressed gzip format.
-Z	Write the output in compressed lz4 format.

statmonitor records statistics for a repository and/or the operating system to a disk file.

statmonitor runs in the background, sampling specified data at a specified interval and recording the data to a text file. The data in this file can be viewed by the graphical application VSD, version 5.5 or later. See **vsd** (page 413) and the V*SD Users Guide* for more information.

For details on the statistics that statmonitor records, see the online documentation at https://docs.gemtalksystems.com/current/statisticsdefinitions.

Statistics are collected from the shared page cache and directly from the OS. Only data for GemStone processes attached to the shared page cache on the host on which statmonitor is running, are collected. To monitor Gems on systems with remote Gem servers, you must run statmonitor both on the Stone's machine and on the Gem server machine.

The *stonename* argument is used to specify the cache to monitor, both for caches that are local to the Stone and caches that are remote from the Stone with that name. Configurations in which a single machine is hosting remote caches for multiple stones that are running with the same Stone name are ambiguous and will not work correctly; this configuration is strongly discouraged.

In addition to running statmonitor from the command line, you can also specify that statmonitor be automatically started at stone startup, and the startup for remote gem caches and remote mid-level caches, to ensure statmonitor data is collected. See the configuration parameters STN_STATMONITOR_ARGS (page 356), GEM_STATMONITOR_ARGS (page 326), and GEM_STATMONITOR_MID_CACHE_ARGS (page 326).

Statmonitor Filenames and locations

Statmonitor by default writes to a file named `statmon`*NNNNN*`.out`, `statmon`*NNNNN*`.out.gz`, or `statmon`*NNNNN*`.out.lz4`., in the current directory from where statmonitor was started. NNNNN is the pid of the statmonitor process.

You can control both the directory and the filename, including pattern-based file naming.

To use the default statmontitor data file name, but write the statmonitor files to a different directory, use the -d option. This cannot be used with the -f or -F filename options. To specify both directory and filename, include the directory as part of the file name specification.

To simply provide a filename and optionally directory, use the -f option. For example,

```
statmonitor -f /gsadmin/stats/ManagerStats gs64stone
```

If this file already exists, statmonitor will append an -*N* to the filename, where *N* starts at 1, or the next available number, incrementing as needed.

statmonitor will append the correct `.out`, `.out.gz`, or `.out..lz4` extension to the specified filename, if it does not already exist, to ensure the file is correctly detected by VSD. It is recommended that you omit the extension, since using the incorrect ending will result in extra, possibly duplicate extensions.

The -F option allows you to specify a pattern used to generate the statmonitor filename. The following patterns are availabe:

GemStone specific filename pattern options:

%%C - name of the shared page cache
%%H - name of the host
%%i - sample interval in seconds
%%I - sample interval in milliseconds
%%P - process ID of statmonitor
%%S - name of the stone

Some useful values from stftime()

Note that this list does not include all possible values and may vary by operating system.

%b The abbreviated month name according to the current locale.
%B The full month name according to the current locale.
%c The preferred date and time representation for the current locale.
%d The day of the month as a decimal number (range 01 to 31).
%F Equivalent to %Y-%m-%d
%H The hour as a decimal number using a 24-hour clock (range 00 to 23).
%m The month as a decimal number (range 01 to 12).
%M The minute as a decimal number (range 00 to 59).
%R The time without seconds in 24-hour notation (%H:%M).
%S The second as a decimal number (range 00 to 60).
%T The time with seconds in 24-hour notation (%H:%M:%S).
%y The year as a decimal number without a century (range 00 to 99).
%Y The year as a decimal number including the century.

Automatic restart

It is recommended to have statmonitor running at all times, since if an error occurs, the information leading up to the problem may be important.

There are a number of feature that make this process easy to automate.

Using the -r or -R option, startmonitor will automatically restart monitoring when an existing statmonitor stops itself (this does not apply if you manually stop statmonitor).

Statmonitor will stop itself if:

- When using the -h option, the given number of hours has passed
- When using the -t option, the given number of samples are recorded
- If a list of times was passed in using the -k option, one of these times was reached

With the -R option, on restart, a new filename is calculated based on the pattern. With -r, on restart, the same filename is used (appending the -N as needed)

Using the -K option, you can specify how many old files you wish to keep. The number specified does not include the statmonitor file that is currently being written.

Limiting what is recorded

Statmonitor by default records a moderate amount of data that is most commonly needed. It can be configured to record fewer kinds of data, or more kinds of data.

The following options limit the GemStone processes that are collected:

-S — record stone and shrpcmon only

-P — record stone, shrpcmon, and aio pgsrvs only

-J — record stone, shrpcmon, and page manager only

-G — record stone, shrpcmon, admin and reclaim gems only

-T — do not record statistics on NetLDI processes.

-p*pid* — do not record gem statistics other than for the specified PID.

-U*userId* — do not record gem statistics other than for processes owned by the given UNIX userID

-Y — Disable collection of all system stats, including per-process data.

The following collect additional host information

-A — Collect all available system statistics.

-a — Collect all available system statistics except per-core CPU statistics.

-C — Collect system statistics for each individual CPU.

-D — Collect system statistics for all disks and partitions

-N — Collect system statistics for all network interfaces.

-Q*pid* — Collect system statistics for processIds, which do not need to be GemStone processes.

To not collect any GemStone statistics, but only statistics on the host machine itself, use:

-X — record host stats only

This can be combined with the other host information statitics to manage the amount of host information collected.

Example

To run statmonitor on an application named plantis, with:

- 30 second sample rate
- files zipped using gzip
- collect all system statistics except CPU stats, as well as GemStone statistics
- automatic restart at 2am every day
- keep three old files but delete older files as new ones are generated
- each file has a filename that includes the date and time. The stone name is hard coded into the filename, but statmonitor will automatically add the correct zip extension.

The following expression can be used:

```
statmonitor -i30 -z -a -R -K3 -k'02:00'
-F /gshost/GemStone3.6/statmon/plantis30sec-%y%m%d_%H%M plantis
```

This creates files with a filename such as `plantis30sec.200520_0500.out.gz`.

Up to four files will be in the directory `/gshost/GemStone3.6/statmon/` (this includes three older files and the current file).

Example 2

The previous example requires manual restart every time the stone is started. The following example shows setting up start statmonitor automatically every time the stone is started, using the STN_STATMONITOR_ARGS configuration parameter.

This example also sets up to collection two series of statstics; statistics with a small sample rate that are discarded after a week, and statistics with a longer sample rate that are kept indefinitely.

The first one:

- 1 second sample rate
- files zipped using LZ4
- new files are started every day at midnight; old files are deleted after one week
- each file has a filename that includes the stone name (the %%S pattern), and the date and time.

The second one:

- 5 minute sample rate
- files zipped using LZ4
- new files are started weekly (after 168 hours); old files are kept forever.
- each file has a filename that includes the stone name (the %%S pattern), and the date.

The following is added to the Stone's configuration file:

```
STN_STATMONITOR_ARGS =
"-i1 -Z -R -k '00:00' -K7 -F
/gshost/GemStone3.6/statmon/%%S-dailyStats_%F_%H-%M",
"-i360 -Z -R -h168 -F
/gshost/GemStone3.6/statmon/%%S-weeklyStats_%F";
```

When the stone is started, this creates files with a filenames such as:

```
plantis-dailyStats_2020-08-12_16-23.out.lz4
plantis-weeklyStats_2020-08-12.out.lz4
```

stoplogreceiver

stoplogreceiver -P *listeningPort*

stoplogreceiver -v | **-h**

-h	Print usage and exit.
-P *listeningPort*	The port that the logreceiver is listening on for **stoplogreceiver** connections. If **-p** was used in the **startlogreceiver** command, that port must be specified here; otherwise the port specified by the **-P** argument to **startlogreceiver**.
-v	Print version and exit.

This utility stops a logreceiver process that was started by a previous **startlogreceiver** command. This may only be executed on the same node as the logreceiver is running.

stoplogsender

stoplogsender -P *listeningPort*

stoplogsender -v | **-h**

-h	Print usage and exit.
-P *listeningPort*	The port on which this logsender is listening. It must be the same port as specified in the **-P** argument of the **startlogsender**.
-v	Print version and exit

This utility stops a logsender process that was started by a previous **startlogsender** command. This may only be executed on the same node as the logsender is running.

stopnetldi

stopnetldi [*netLdiName*]

stopnetldi -h | **-v**

netLdiName	The name of the GemStone network server; the default is `gs64ldi`. Network resource syntax is not permitted.
-h	Print usage and exit.
-v	Print version and exit

Gracefully stop a GemStone network server.

If *name* is not specified, the name of the NetLDI to stop is taken from GEMSTONE_NRS_ALL environment variable, if defined there. If GEMSTONE_NRS_ALL does not define a NetLDI name, then a NetLDI with the default name gs64ldi is stopped.

If a portNumber was used to start the netldi process, then the portNumber can be used to stop the netldi process.

Return values

The **stopnetldi** utility returns one of the following codes to the command line:

- 0 (success) Successful stop
- 1 (informational) The stone named *gemStoneName* is already running
- 2 (warning) The stone *gemStoneName* is already running, but the exectuables have been deleted oroverwritten
- 3 or above (error) an error occurred and *gemStoneName* was not started.

stopstone

stopstone [*gemStoneName* [*gemStoneUserName* [*gemStonePassword*]]] [**-i**] [**-t**] [**-h**]

gemStoneName	The name of the GemStone repository monitor, commonly `gs64stone`. Network resource syntax is not permitted.
gemStoneUserName	A privileged GemStone user account name, such as "DataCurator" or "SystemUser".
gemStonePassword	The GemStone password for the specified *gemStoneUserName*.
-h	Print usage and exit.
-i	Causes any current GemStone sessions to be terminated immediately.
-t	Specifies how long to wait for other processes to detach from the cache. Default is -1, wait forever.

Gracefully shut down a GemStone repository monitor. In the process, a checkpoint is performed in which all committed transactions are written to the extents. If you specify the **-i** (immediate) option, the repository monitor is shut down even if there are GemStone users logged in. The -t option specifies how long to wait for all session to detach from the cache before returning; if omitted, **stopstone** will wait forever. If you do not supply the *gemStoneName*, *gemStoneUserName*, and *gemStonePassword* on the command line, this command will prompt you for them.

Because this command uses a Gem session process to connect to *gemStoneName*, it fails if the Gem is unable to connect for any reason, such as inability to attach a shared page cache. For assistance, refer to "To Troubleshoot Session Login Failures" on page 113.

Return Values

stopstone returns one of the following codes:

- 0 (success) Successful stop
- 1 (informational) No running stone with *gemStoneName*
- 3 or above (error) an error occurred and *gemStoneName* was not stopped.
- 10 syntax error
- 11 bad user or password
- 12 *gemStoneUserName* does not have privilege to stop the stone.
- 13 stone not stopped; other users are logged in. Use -i to override.

topaz

topaz [-r] [**-q**] [**-i** | **-I** *topazini*] [**-S** *scriptFile*] [**-n** *hostName*:*netldiName*] [**-u** *useName*] [**-X** *caCertPaths*] [**--** *other args*]

topaz -l | -L [**-q**] [**-i** | **-I** *topazini*] [**-S** *scriptFile*] [**-u** *useName*] [**-e** *exeConfig*] [**-z** *systemConfig*] [**-T** *tocSizeKB*] [**-C** *configParams*] [**--** *other args*]

topaz -h | -v

-C *configParams*	Provides configuration parameters, in configuration file syntax, that override settings in the configuration files. Only applies to linked sessions (RPC sessions may use the -C syntax in the Gem's NRS).
-e *exeConfig*	The GemStone executable configuration file (only allowed with linked sessions). See "Executable Configuration File" on page 309.
-h	Print usage and exit.
-i	Ignore the initialization file, `.topazini`.
-I *topazini*	Specify a complete path and file to a topazini initialization files, and use this rather then any `.topazini` in the default location.
-l	Invoke the linked version of Topaz.
-L	Invoke the linked version of Topaz, and do not apply any command **set gemnetid** that may appear in the .topazini file or a file passed in using **-I**.
-n *hostName*:*netldiName*	For a login using X509-Secured GemStone, to specify the NetLDI to spawn the Gem, part of the X509-secured GemStone login parameters. The host name or IP, and the netldi name or listening port, for an X509-secured NetLDI.
-q	Start Topaz in quiet mode, suppressing printout of the banner and other information.
-r	Invoke the RPC (remote procedure call) version of Topaz.
-S *scriptFile*	Specifies a script file that will be processed with INPUT, suppressing output except if an error occurs.
-T *tocSizeKB*	The GEM_TEMPOBJ_CACHE_SIZE that will be used. Overrides any settings provided in configuration files passed as arguments with the **-e** or **-z** options. Only applies to linked sessions.
-u *useName*	Sets the cache name, as recorded by statmonitor for viewing in VSD. This is also useful for identifying processes in OS utilities such as `top` or `ps`.
-v	Print version and exit.
-w	On Windows client only; forces terminal behavior regardless of I/O device.

-X *caCertPaths*	For a login using X509-Secured GemStone, to set certificates. Requires additional infrastructure to be running, including X509-secured NetLDIs and caches. The argument specifies the CA cert, user cert, and user private key with 3 paths in this order: 'stoneCA-dev.cert.pem;DataCurator.chain.pem;DataCurator.privkey.pem'
-z *systemConfig*	The GemStone system configuration file (only allowed with linked sessions). See "System Configuration File" on page 308.
-- *otherArgs*	Arbitrary text arguments *otherArgs* may be included after the "--" end of arguments marker, which must follow any of the above topaz arguments are included.

This command invokes various forms of topaz. The default is to invoke the remote procedure call (RPC) version of topaz; to do this explicitly, use the -r option.

To invoke the linked version of topaz, which is recommended or required for some maintenance operations, use the -l or -L option. The advantage of the -L option is that `.topazini` initialization file command cannot inadvertently configure the login to be RPC rather than linked.

Several topaz arguments only apply in linked topaz. The arguments **-e***exeConfig* and **-z***systemConfig* determine the configuration files that linked topaz reads. For more information about this, see "How GemStone Uses Configuration Files" on page 307.

Settings within topaz can allow linked topaz to perform RPC logins.

Topaz is available for Windows, in addition to regular server platforms, as part of the Windows Client installation. Options are more limited since linked logins are not possible.

For further information, see the *Topaz Programming Environment*.

updatesecuredbf

updatesecuredbf [**-F**] [**-d**] [**-O**] *extentFile* **-e** *newEncrCert* **-D** *oldPrivEncrKey* **-K** *keyRingDir* [**-K** *keyRingDir*+] [**-j** *encrPP* | **-J** *encrPPFile*]

updatesecuredbf *tranlogFile* [**-F**] [**-d**] **-e** *newEncrCert* **-D** *oldPrivEncrKey* **-K** *keyRingDir* [**-K** *keyRingDir*+][**-j** *encrPP* | **-J** *encrPP*File]

updatesecuredbf *backupFile* [**-F**] [**-d**] **-e** *newEncrCert* **-D** *oldPrivEncrKey* **-K** *keyRingDir* [**-K** *keyRingDir*+] **-S** *sigPrivKey* [**-j** *encrPP* | **-J** *encrPPFile*] [**-t** *sigPP* | **-T** *sigPPFile*]

updatesecuredbf -h | **-v**

extentFile, *tranlogFile*, or *backupFile*	The name of the secure dbf file to be updated; either an extent, transaction log, or backup.
-d	Dry run; reports the output as if the updatesecuredbf operation was performed, but does not actually make the modifcation.
-D *oldPrivEncrKey*	Specifies the file containing the private key that corresponds to the public cert that was used to encrypt the source extent, backup or tranlog. Used to decrypt the dbf prior to reecrypting with the new key. If the private key has a passphrase, requires **-j** or **-J**.
-e *newEncrCert*	Specifies the public public key or certificate file to encrypt the data.
-F	(flush) Use fsync(2) to flush all data to disk before exit.
-h	Print usage and exit.
-j *encrPP*	The passphrase for the private key specified by **-D**.
-J *encrPPFile*	A file containing the passphrase for the private key specified by **-D**.
-K *keyRingDirs*	List of colon-separated directories which contain keys and certificates. -**K** may be included more than once.
-O	(Override) for use with secure extents only. Some operations on extent require a clean shutdown. Specifying this option overrides that requirement. Use with caution.
-S *sigPrivKey*	For use with secure backups only. Specifies a private signing key used to sign the secure backup. Requires **-t** or **-T** if the private signing key protected with a passphrase.
-t *sigPP*	The passphrase for the private signing key specified by **-S**.
-T *sigPPFile*	A file containing the passphrase for the private signing key specified by **-S**
-v	Print version information and exit.

updatesecuredbf accepts an encrypted extent, tranlog file, or full backup file, and replaces the private key with a new private key. the modification is done in place. It is strongly recommended to make a backup copy of the file prior to executing updatesecurebackup.

In order to decrypt the dbf file, required arguments include the private key corresponding to the public key that was used to encrypt the database file previously, and if this key has a passphrase, this must also be provided.

In addition, the new public key that will be used to re-encrypt the file is required. Since encrypted backups are always signed, additional arguments when using **updatesecuredbf** for a backup are required to provide the signing key and passphrase.

When using **updatesecuredbf** with encrypted backups, which may have up to 8 encryption keys, any single one of the keys can be replaced using **updatesecuredbf**. The other keys are not affected. Note that encrypted backups, which are always signed, also require the signing key and passphrase.

For example, for a backup that was encrypted using the `backup_encrypt_1_clientcert.pem` with passphrase `backup_encrypt_1_client_passwd.txt`, the following will replace that with `backup_encrypt_3_clientcert.pem`.

```
unix> updatesecuredbf backupEn1.sdbf
   -e backup_encrypt_3_clientcert.pem
   -D backup_encrypt_1_clientkey.pem
   -J $GEMSTONE/allcerts/backup_encrypt_1_client_passwd.txt
   -S backup_sign_2_clientkey.pem
   -T $GEMSTONE/allcerts/backup_sign_2_client_passwd.txt
   -K $GEMSTONE/allcerts
```

For more information on encrypted extents, transaction logs and backup files, and using **copydbf** and **updatesecuredbf** to manage them, see Chapter 12, “Encrypted Extents and Transaction Logs”, starting on page 247.

verify_backup_with_openssl

verify_backup_with_openssl [**-h**] *backupFile* [*publicKeyPathAndFile*]

-h	Display a usage line and exits
backupFile	The name of the signed GemStone backup file.
publicKeyPathAndFile	The full back to the public key file corresponding to the private key that was used to sign *backupFile*.

Use openSSL to verify the backup file *backupFile*, with the public certificate *publicKeyPathAndFile*.

The public key can be omitted, in which case it performs verification using the public key extracted from the private key, which is not useful for verification, and only demonstrates that the backup is signed.

vsd

vsd [-**b** *color* **]** [**-u**] [[**-a**] *statmonDataFile***+**] [*directory*]

vsd -h | -v

-a	Append mode. Files following the -a are appended to the first one; the data in these files is merged so statistics are viewed as if they were a single file.
-b *color*	Set the master background color. Color may be a hex RGB value (e.g.: #d3d3ff) or a valid color name (e.g.: white). The list of recognized color names may be found at: http://www.tcl.tk/man/tcl8.6/TkCmd/colors.htm
-h	Displays a usage line and exits.
-v	Print version information and exit.
statmonDataFile	The name of a statistics data file to load into the VSD as it is started.
directory	*directory* is the name of a directory; VSD will set this as the working directory for the executable, and after startup, opens the Open Statmonitor File dialog on this directory.

This command starts VSD, the graphical tool to view and analyze statmonitor data. The default is to open an empty instance of VSD, into which you can then load one or multiple statmonitor data files. After loading data files, you may select one or multiple GemStone processes, and view charts on one or multiple statistics for these processes.

VSD is available for Windows, in addition to regular server platforms, as part of the Windows Client installation.

For a complete description of VSD, see the *VSD User's Guide.*

waitstone

waitstone [**-h**] [*gemStoneName* | *netLdiNameOrPort*] [*timeout*] [*waitForWarming*]

-h	Display a usage line and exit
gemStoneName	The Stone name.
netLdiNameOrPort	The name or port of the NetLDI.
timeout	How many seconds to wait for GemStone to initialize before reporting a problem. The default (0) means wait forever; -1 means don't wait, try once and return the result. Only valid when specifying either *gemStoneName* or *netLdiName*.
waitForWarming	If larger than 0, block until cache warmers finish.

This command reports whether the GemStone repository *gemStoneName* is ready to accept logins or whether *netLdiName* is ready to accept requests. If neither *gemStoneName* nor *netLdiName* are specified, waitstone will report on the default stone name, `gs64stone`.

Waitstone checks every 0.5 seconds to see if the Stone or NetLDI is ready. When the service is ready, **waitstone** issues a message to `stdout`. If the service is not ready by the time the specified number of seconds have elapsed, **waitstone** reports an error.

With a -1 timeout, **waitstone** will make one connection attempt to the Stone or NetLDI. Note that if the stone is inaccessible, the timeout may be longer, since the configured TCP/IP timeout may apply. This can result in a 20 second timeout regardless of the specified *timeout* value.

Use of *timeout* requires that the Stone or NetLDI name is also specified.

If a positive value for the *waitForWarming* argument is specified, **waitstone** will block until cache warming completes; this is useful when cache warming is automatically run on startup. The specific value of the *waitForWarming* is not important. Use of the *waitForWarming* positional argument requires specifying each of the preceding arguments.

You may specify the *gemStoneName* and *netLdiName* arguments as a GemStone network resource string. (See Appendix C, "Network Resource Strings (NRS)")

This command returns 0 exit status if the operation is successful; otherwise, it returns a non-zero value.

Chapter

C Network Resource Strings (NRS)

The network resource string (NRS) is a GemStone-specific way to format a string that contains:

- unique identifiers for a GemStone file or process within a networked environment, such as the node and name of a running Stone.
- specific instructions for performing actions, such as spawning a Gem process.
- configuration details and arguments, such as authentication information or locations for writing log files.

A basic understanding of NRS to compose login parameters is unavoidable, for any but the most simple configurations. However, NRS has a number of features and syntactical elements and a full understanding is not needed.

C.1 Using NRS

The primary use for NRS by applications and end users are in login parameters, to specify the Stone, and for RPC logins, to specify the Gem service. Some utility commands also accept NRS in order to perform operations remotely.

The following table provides the most common formats for NRS syntax for Stone and Gem services. In these examples, you may use the IP address instead of the hostname, and the NetLDI listening port instead of the NetLDI name.

Table C.1 Examples for common NRS formats

Stone or Gem Service	NRS
Local stone named `devstone`	`devstone`
Gem service specifying the gem on local node, where NetLDI is named gs64ldi	`gemnetobject`

Table C.1 Examples for common NRS formats

Stone named devstone, running on node oboe. This example applies when oboe is remote or local. If remote, then there must be a NetLDI named gs64ldi running on oboe.	`!@oboe!devstone`
Gem service specifying the gem to run on node oboe, where oboe is running NetLDI named gs64ldi.	`!@oboe!gemnetobject`
Gem service specifying the Gem to run on the local node, with local NetLDI listening on port 54321.	`!#netldi:54321!gemnetobject`
Gem service specifying the Gem to run on the local node, with local NetLDI named devldi (devldi must be defined as a service).	`!#netldi:devldi!gemnetobject`
Specify a Stone named devstone, running on node oboe, with the NetLDI on oboe listening on port 54321..	`!@oboe#netldi:54321!devstone`
Gem service specifying the Gem to run on node oboe, with the NetLDI on oboe named devldi. (devldi must be defined as a service).	`!@oboe#netldi:devldi!gemnetobject`

GsNetworkResourceString

This GemStone Smalltalk class provides a programmatic API to construct correctly formatted NRS strings. The resulting string is in the most complete form, including default information, not in the most simplified form that you can enter as a parameter.

For example, the following expression recreates the NRS that can be used for the gemnetid parameter, based on the current RPC session.

```
topaz 1> run
GsNetworkResourceString defaultGemNRSFromCurrent asString
%
!@santiam#netldi:54321#task!gemnetobject
```

See the image for more information.

GEMSTONE_NRS_ALL

The environment variable GEMSTONE_NRS_ALL determines which modifiers GemStone will use by default in each NRS it processes on your behalf.

This is frequently used to configure a specific NetLDI name when the default NetLDI name is not used, avoiding having to specify the NetLDI name in every NRS. For example,

```
$ GEMSTONE_NRS_ALL="#netldi:devldi"
$ export GEMSTONE_NRS_ALL
```

GEMSTONE_NRS_ALL may include any or all of the directives **#netldi**, **#dir**, and **#log**, as described later in this chapter.

As an environment variable, it only affects processes created after it is set, and after making changes, you will need to restart the process before the changes take effect.

- If you set GEMSTONE_NRS_ALL before starting a NetLDI, which is a system-wide service, that setting is passed to all its children and becomes the default for all users of that service, i.e. RPC gems.
- If you set GEMSTONE_NRS_ALL before starting a Stone, an application, or a utility (such as **copydbf**), that setting applies only to your own processes and does not affect other users.

Because these settings are defaults, they take effect only if an explicit setting is not provided for the same modifier in a specific NRS setting or command-line argument.

Arguments to startnetldi

The NetLDI can pick up settings in the GEMSTONE_NRS_ALL environment variable. You may also pass in an NRS directly to the NetLDI on startup, using the startnetldi -x option. These settings take precedence over the GEMSTONE_NRS_ALL.

You may also specify a default log file directory for child processes using the startnetldi -D argument.

Arguments to gemnetobject

Within the NRS that specifies the Gem service (the topaz gemnetid parameter), you may also includes additional arguments that will be passed to the gemnetobject script. See the discussion for gemnetobject on page 372 for which arguments can be used.

Using gemnetobject arguments with topaz requires that the string passed to gemnetid be enclosed in single quotes.

For example, the following includes one directive to set the NetLDI, and two gemnetobject arguments, one of which sets two configuration parameter values.

```
topaz > set gemnetid '!#netldi:54321!gemnetobject -T 100MB -C
GEM_FREE_FRAME_CACHE_SIZE=2;GEM_HALT_ON_ERROR=2101;'
```

When using complex NRS, it is recommended to check the Gem log file to ensure that all settings were entered correctly. Incorrect arguments will be ignored rather than generating an error.

Controlling log file directory locations

All GemStone processes write log files to default locations, which are described in Chapter 7. The log files for processes that are forked by the NetLDI during login are described starting on page 128.

While these processes have default log names and locations, these can be further controlled by configuring the NetLDI or the NRS used during login.

To configure the log file directory, the following options are available:

- Use the **-D** flag to **startnetldi** to specify the log file directory location for child processes. This is the recommended way to define the log file directory.

- The **#dir** NRS directive sets the directory for log files. Set GEMSTONE_NRS_ALL to include the **#dir** directive in the environment in which the NetLDI is started up, or the environment in which the client process is executing.
- Include the **#dir** directive in the NRS for the Gem service login parameters.

startnetldi -D is a specific directory. However, **#dir** can include the following patterns, which gives many options to configure the directories for log files.

%H	home directory
%D	The value of the **startnetldi -D** option specified for the NetLDI that will service the request.
%M	machine's network node name
%N	executable's base name, such as gemnetobject for a Gem
%P	process pid
%U	user name

The combination of -D and/or any **#dir** directives must result in describing an existing, writable directory. Login will fail if a log file cannot be created.

The following is the precedence:

1. If there is a directory specified by **#dir** in the NRS for the Gem service login parameter (gemnetid), this directory is used.
2. Otherwise, a directory specified by **#dir** in the GEMSTONE_NRS_ALL in the environment of the client process.
3. Otherwise, a directory specified by the **-D** argument to startnetldi, or by a **#dir** setting in the GEMSTONE_NRS_ALL in the environment where the NetLDI was started.
4. Otherwise, the home directory, "%H".

The **startnetldi -D** option is the most reliable way to manage client process log file locations. This allows all log files to go to a known location, rather than the home directories of individual users; while avoiding the need to control environment variables or login parameters for each individual GemStone user.

You can easily have log files write to a new location (say, if you move the application to a different node, or from development into production), by just restarting the NetLDI with the new directory in the **-D** argument.

Keep in mind that **-D** and **#dir** sets the working directory for the process as well as the location in which to write log files.

Example C.1 NetLDI controls log file locations, log files have default name

Start the NetLDI using

```
unix> startnetldi -g -agsadmin -D $GEMSTONE/logs 54321
```

Do not include **#dir** in any GEMSTONE_NRS_ALL, and do not include **#dir** in the Gem login parameters.

A Gem with pid 27522 running on node santiam will then default to writing the log file `$GEMSTONE/logs/gemnetobject27522santiam.log`.

The same result comes from using the **#dir** directive in the GEMSTONE_NRS_ALL for the NetLDI or client environments, or in the Gem login parameters.

"%D" Pattern

When using the **-D** argument to **startnetldi**, there are additional options for controlling log file locations by including the %D pattern in NRS. In the location in which the %D appears in the NRS for #dir, the %D will be replaced by the argument to -D when composing the log file name.

Example C.2 Example using %D pattern

If you have multiple applications and want the logs for the sales application and the purchasing application to be in separate directories, you might define the following directories:

```
/node1/users/gsadmin/logs/sales/
/node1/users/gsadmin/logs/purchasing/
```

And to start the NetLDI, use the following command:

```
startnetldi -g -agsadmin -D /node1/users/gsadmin/logs/ 54321
```

In the sales application, use the Gem NRS:

```
set gemnetid !#netldi:54321#dir:%D/sales!gemnetobject
```

And in the purchasing application:

```
set gemnetid !#netldi:54321#dir:%D/purchasing!gemnetobject
```

These will write their log files in the correct subdirectory of `/node1/users/gsadmin/logs/`

Using %D requires that the NetLDI was started using the **-D** argument. If the NetLDI is inadvertently started without the **-D** argument, an empty string is subsituted for the %D. Unless this still allows the **#dir** to define a writable directory, login will fail. The error will be reported in the NetLDI log file:

```
WARNING: %D in NRS but no -D argument to startnetldi
    in #dir, %D/purchasing changed to /purchasing
```

Controlling log file names

The **#log** directive is used to specify the name of the log file, which by default for a Gem is `gemnetobject`*PIDNode*`.log` (%N%P%M.log). The **#log** argument must not be a directory.

For backwards compatibility, you may use an absolute or partial directory as part of the **#log** argument, along with the log filename pattern, but this is not recommended.

Example C.3 NetLDI controls log file locations and names

Start the NetLDI using

```
unix> setenv STONENAME devstone
unix> setenv GEMSTONE_NRS_ALL "#log:Gem-$STONENAME%M%P.log"
unix> startnetldi -g -agsadmin -D $GEMSTONE/logs 54321
```

Do not include **#dir** in any GEMSTONE_NRS_ALL, nor in the Gem login parameters.

A Gem with pid 27522 running on node santiam will then default to writing the log file `$GEMSTONE/logs/Gem-devstonesantiam27522.log`

The same result comes from using the **#log** directive in the GEMSTONE_NRS_ALL for the client environment, or in the Gem login parameters.

There is some flexibility in using directories within the **#log** argument, and composing paths using the **-D** argument, for backwards compatibility.

When using **-D**, %D, and **#dir** and **#log**, some care must be taken in making sure the use is consistent, such that the combination will always produce a valid, writable path and filename. Invalid log file paths and names will cause login to fail, with an error in the NetLDI log file.

C.2 NRS Syntax

The BNF below provides full NRS syntax. Many of the options are used internally for interprocess communication, and are not intended for general use.

These strings may appear in the full form in places where command arguments are recorded, such as GemStone log files.

Spaces and Special Characters

An NRS can contain spaces and special characters; in particular, !, #, and @ are frequently used.

While GemStone internally ensures that space and special characters are handled correctly, you may need to escape certain characters in NRS strings that are entered at a command prompt. The specific characters and escapes may vary on different UNIX shells.

```
% copydbf $GEMSTONE/data/extent0.dbf
   \!@node#auth:username@password#dbf\!/users/extent0.dbf_copy
```

If there is a space in the NRS, you can replace the space with a colon (:), or you can enclose the string in quotes (" ").

For example, the following network resource strings are equivalent:

```
% waitstone !@oboe#auth:user@password!gs64stone
% waitstone "!@oboe#auth user@password!gs64stone"
```

Syntax

nrs ::= [*nrs-header*] *nrs-body*

where:

nrs-header ::= **!** [*address-modifier*] {*keyword-modifier*} [*resource-modifier*]**!**

All modifiers are optional, and defaults apply if a modifier is omitted. The value of an environment variable can be placed in an NRS by preceding the name of the variable with "$". If the name needs to be followed by alphanumeric text, then it can be bracketed by "{" and "}". If an environment variable named `foo` exists, then either of the following will cause it to be expanded: `$foo` or `${foo}`. Environment variables are only expanded in the *nrs-header*. The *nrs-body* is never parsed.

address-modifier ::= [**tcp**] [**@** *node*]
Specifies where the network resource is.

node ::= *nrs-identifier*
If no node is specified, the current machine's network node name is used. The identifier may also be an Internet-style numeric address. For example:

```
!@120.0.0.4#server!cornerstone
```

nrs-identifier ::= *identifier*
Identifiers are runs of characters; the special characters !, #, $, @, ^ and white space (blank, tab, newline) must be preceded by a "^". Identifiers are words in the UNIX sense.

keyword-modifier ::= (*authorization-modifier* | *environment-modifier*)
Keyword modifiers may be given in any order. If a keyword modifier is specified more than once, the latter replaces the former. If a keyword modifier takes an argument, then the keyword may be separated from the argument by a space or a colon.

authorization-modifier ::= ((**#auth** | **#encrypted**) [**:**] *username* [**@** *password*])
#auth specifies a valid OS user name on the target network. A valid OS user password is needed only if the resource type requires authentication. **#encrypted** is used by GemStone utilities. This type of authorization is the default.

username ::= *nrs-identifier*

If no OS user name is specified, the default is the current OS user. See the earlier discussion of *authorization-modifier.*

password ::= *nrs-identifier*
Only needed if the resource type requires authentication; see the earlier discussion of *authorization-modifier.*

environment-modifier ::= (**#netldi** | **#dir** | **#log**) [**:**] *nrs-identifier*
#netldi causes the named NetLDI to be used to service the request. If no NetLDI is specified, the default is `gs64ldi`. When you specify the **#netldi** option, the *nrs-identifier* is either the name of a NetLDI service or the port number at which a NetLDI is running.

#dir sets the default directory for the child processes, and the directory into which log files for child processes will be written. It has no effect if the resource already exists. If a directory is not set, the pattern "`%H`" (home directory) is used. (See the definition of *nrs-identifier*.

#log sets the name of the log file for child processes. It has no effect if the resource already exists. If a log name is not set, the pattern "`%N%P%M.log`" is used, with the patterns described below, and following the syntax in the definition of *nrs-identifier*

The argument to **#dir** or **#log** can contain patterns that are expanded in the context of the created resource. The following patterns are supported:

%H	home directory
%D	a directory path supplied by the NetLDI. This is replaced by the contents of the **startnetldi -D** argument.
%M	machine's network node name
%N	executable's base name, such as `gemnetobject` for a Gem
%P	process PID
%U	user name

%% (escaped) %

resource-modifier ::= (**#server** | **#spawn** | **#task** | **#dbf** | **#monitor** | **#file**)
Identifies the intended purpose of the string in the *nrs-body*. An NRS can contain only one resource modifier. The default resource modifier is context sensitive. For instance, if the system expects an NRS for a database file, then the default is **#dbf**.

#server directs the NetLDI to search for the network address of a server, such as a Stone or another NetLDI. If successful, it returns the address. The *nrs-body* is a network server name. A successful lookup means only that the service has been defined; it does not indicate whether the service is currently running. A new process will not be started. (Authorization is needed only if the NetLDI is on a remote node and is running in secure mode.)

#task starts a new Gem. The *nrs-body* is a NetLDI service name (such as "gemnetobject"), followed by arguments to the command line. The NetLDI creates the named service by looking first for an entry in `$GEMSTONE/sys/services.dat`, and then in the user's home directory for an executable having that name. The NetLDI returns the network address of the service. (Authorization is needed to create a new process unless the NetLDI is in guest mode.) The **#task** resource modifier is also used internally to create page servers.

#dbf is used to access a database file. The *nrs-body* is the file spec of a GemStone database file. The NetLDI creates a page server on the given node to access the database and returns the network address of the page server. (Authorization is needed unless the NetLDI is in guest mode).

#spawn is used internally to start the garbage collection and other service Gem processes.

#monitor is used internally to start up a shared page cache monitor.

#file means the *nrs-body* is the file spec of a file on the given host (not currently implemented).

nrs-body ::= unformatted text, to end of string
The *nrs-body* is interpreted according to the context established by the *resource-modifier*. No extended identifier expansion is done in the *nrs-body*, and no special escapes are needed.

Chapter

D GemStone Kernel Objects

This appendix describes the predefined objects that are located in a freshly installed GemStone/S 64 Bit repository.

Non-Numeric Constants

The following non-numeric constants are defined in the Globals dictionary and protected by the SystemObjectSecurityPolicy:

- **true** (an instance of Boolean)
- **false** (an instance of Boolean)
- **nil** (an instance of UndefinedObject)

Numeric Constants

Floating point constants are instances of class Float or class DecimalFloat. They are defined in the Globals dictionary and are protected by the SystemObjectSecurityPolicy. Refer to the *Programming Guide* for more information on these values.

DecimalPlusInfinity
DecimalMinusInfinity
DecimalPlusQuietNaN
DecimalMinusQuietNaN
DecimalPlusSignalingNaN
DecimalMinusSignalingNaN
PlusInfinity
MinusInfinity
PlusQuietNaN
MinusQuietNaN
PlusSignalingNaN
MinusSignalingNaN

Repository and GsObjectSecurityPolicies

The Repository is the root of a GemStone system. This structure contains the GsObjectSecurityPolicies, which implement object-level security. For more information, refer to the *Programming Guide* for more information on the meaning and use of these objects.

SystemRepository. This single instance of Repository is defined in the Globals dictionary. Repository is a subclass of Collection, and the indexable part of SystemRepository contains references to all the security policies (all the instances of GsObjectSecurityPolicy) in GemStone.

The SystemRepository object initially contains eight security policies, three of which are public and named: the SystemObjectSecurityPolicy (owned by the SystemUser), the DataCuratorObjectSecurityPolicy (owned by the DataCurator), and the PublishedObjectSecurityPolicy (owned by SystemUser). The SystemRepository object itself is protected by the DataCuratorObjectSecurityPolicy. New GsObjectSecurityPolicies may be created and added to the SystemRepository object, using the methods `new`, `newInRepository:`, or by some methods that create new users.

For more on GsObjectSecurityPolicies, see the *Programming Guide for GemStone/S 64 Bit*.

SystemObjectSecurityPolicy. This security policy is defined in the Globals dictionary. For backwards compatibility, the key #SystemSegment also refers to this security policy, and may be used in upgraded repositories. The SystemObjectSecurityPolicy object itself is protected by the DataCuratorObjectSecurityPolicy.

The SystemObjectSecurityPolicy is the default security policy for its owner, the SystemUser (who has write authorization for any of the objects in this security policy). The "world" (that is, the set of all GemStone users) is authorized to read, but not write, the objects in this security policy. In addition, the group #System is authorized to write in this security policy.

DataCuratorObjectSecurityPolicy. This security policy is defined in the Globals dictionary. For backwards compatibility, the key #DataCuratorSegment also refers to this security policy, and may be used in upgraded repositories. The DataCuratorObjectSecurityPolicy object itself is protected by the DataCuratorObjectSecurityPolicy.

The DataCuratorObjectSecurityPolicy is the default security policy for its owner, the DataCurator (who has write authorization for any of the objects in this security policy). The "world" (that is, the set of all GemStone users) is authorized to read, but not write, the objects in this security policy. In addition, the #DataCuratorGroup is are authorized to write in this security policy.

Objects in the DataCuratorObjectSecurityPolicy include the Globals dictionary, the SystemRepository object, most instances of GsObjectSecurityPolicy, AllUsers (the set of all GemStone UserProfiles), AllGroups (the collection of groups authorized to read and write objects in security policies), and each UserProfile object.

PublishedObjectSecurityPolicy. This security policy is defined in the Globals dictionary. For backwards compatibility, the key #PublishedSegment also refers to this security policy, and may be used in upgraded repositories. The PublishedObjectSecurityPolicy object itself is protected by the DataCuratorObjectSecurityPolicy.

The PublishedObjectSecurityPolicy is owned by the SystemUser. The group #Subscribers is authorized to read in this security policy. The group #Publishers is authorized to read and write in this security policy. The "world" is not authorized to read or write the objects in this security policy.

Global Variables and Collections

AllUsers. The AllUsers object is an instance of UserProfileSet. It is defined in Globals, and is protected by the DataCuratorObjectSecurityPolicy. AllUsers contains the UserProfiles of all GemStone users. When GemStone is first installed, AllUsers contains five UserProfiles: SystemUser, DataCurator, GcUser, SymbolUser, and Nameless. For more information on the Special system accounts, see "Special System Users" on page 148.

AllDeletedUsers. This collection is defined in the Globals dictionary, and is protected by the DataCuratorObjectSecurityPolicy. AllDeletedUsers contains DeletedUserProfiles representing GemStone users that have been removed from AllUsers. When GemStone is first installed, AllDeletedUsers is empty.

AllGroups. This dictionary is defined in Globals, and is protected by the DataCuratorObjectSecurityPolicy. Each Symbol in AllGroups corresponds to an instance of UserProfileGroup. When GemStone is first installed, AllGroups contains UserProfileGroups named System, Publishers, Subscribers, DataCuratorGroup, and SymbolUser.

AllKerberosPrincipals. This dictionary is defined in Globals, and is protected by the DataCuratorObjectSecurityPolicy. Each Symbol in AllKerberosPrincipals corresponds to an instance of KerberosPrincipal. This dictionary is empty unless KerberosPrincipals have been explicitly created.

AllClusterBuckets. This ClusterBucketArray is defined in the Globals dictionary, and is protected by the DataCuratorObjectSecurityPolicy. AllClusterBuckets contains instances of ClusterBucket, which group objects on extent pages to improve performance. When GemStone is first installed, AllClusterBuckets contains the following predefined cluster buckets (listed by cluster id):

1. A generic bucket whose extent is "don't care". This bucket, the current default after session login, is invariant and may not be modified.
2. A generic bucket whose extent is "don't care".
3. A generic bucket whose extent is "don't care".
4. The kernel classes "behaviorBucket", extent 1.
5. The kernel classes "descriptionBucket", extent 1.
6. The kernel classes "otherBucket", extent 1.
7. A generic bucket whose extent is "don't care".

ConfigurationParameterDict. This dictionary is defined in the Globals dictionary, and is protected by the SystemObjectSecurityPolicy. Its keys list the names of the configuration parameters available to a session. Its values are only used internally in GemStone, to locate the values of the parameters themselves for an individual session.

DbfHistory. This String describes the history of this repository, from the version in which it was first created, and each subsequent upgrade.

DbfOrigin. This SmallInteger identifies the version in which this repository was first created, if the repository originated in v3.2 or later.

DeprecationEnabled. This is nil, or a keyword. When deprecation is enabled, it will be set to the configured handling instructions when a deprecated method is encountered. Deprecation is described in the *Programming Guide*.

ErrorSymbols. This SymbolDictionary is defined in the Globals dictionary, and is protected by the SystemObjectSecurityPolicy. It maps mnemonic symbols to error numbers.

GciStructsMd5String and **GciTsStructsMd5String**. These constants encode the GCI structures that this version of GemStone uses. On upgrade, they can be compared to determine if there are changes in the GCI structures that would impact C code using GemBuilder for C.

GemStoneError. This SymbolDictionary is defined in the Globals dictionary, and is protected by the DataCuratorObjectSecurityPolicy. Each key is a Symbol representing a native language, and is associated with an Array of error messages in that language. Initially, this dictionary contains the single key #English.

GemStone_Legacy_Streams. This SymbolDictionary contains classes implementing the legacy GemStone PositionableStream interface. See the *Programming Guide* for more information.

GemStone_Portable_Streams. This SymbolDictionary contains classes implementing the PositionableStream interface that is ANSI-complaint and portable to other Smalltalk dialects. See the *Programming Guide* for more information.

InstancesDisallowed. This IdentitySet is defined in the Globals dictionary, and is protected by the SystemObjectSecurityPolicy. This collection is used for error reporting for some cases where instance creation is disallowed.

NativeLanguage. This Symbol is not used in this version, but may exist in upgraded repositories.

NotTranloggedGlobals. This SymbolDictionary is defined in the Globals dictionary, and is protected by the DataCuratorObjectSecurityPolicy. This collection holds objects for which changes are committed but not recorded in the transaction logs. When GemStone is first installed, NotTranloggedGlobals is empty.NotTranloggedGlobals is described in the *Programming Guide*.

GsDefaultIndexOptions. This instance of GsIndexOptions provides the default indexing internal structures.

StringConfiguration. This is the default class used to instantiate literal strings, and to control the behavior of String comparison, including String equality, between traditional and Unicode strings. By default, this is set to the String class. When it is set to Unicode16 class, the repository is in Unicode Comparison Mode. Changing the value should be done with great caution, since it may break existing collections of Strings and other usages that depend on string comparison. Unicode Comparison Mode is described in the *Programming Guide*.

Transcript. An instance of TranscriptStreamPortable.

Table D.1 Initial Contents of the Globals Dictionary

	Key	The object's class
Numeric Constants	#DecimalMinusInfinity	DecimalFloat
	#DecimalMinusQuietNaN	DecimalFloat
	#DecimalMinusSignalingNaN	DecimalFloat
	#DecimalPlusInfinity	DecimalFloat
	#DecimalPlusQuietNaN	DecimalFloat
	#DecimalPlusSignalingNaN	DecimalFloat
	#MinusInfinity	Float
	#MinusQuietNaN	Float
	#MinusSignalingNaN	Float
	#PlusInfinity	Float
	#PlusQuietNaN	Float
	#PlusSignalingNaN	Float
Non-Numeric Constants	#false	Boolean
	#nil	UndefinedObject
	#true	Boolean
Repository and instances of GsObjectSecurityPolicy	#DataCuratorObjectSecurityPolicy, #DataCuratorSegment	GsObjectSecurityPolicy
	#DbfHistory	String
	#DbfOrigin	SmallInteger
	#PositionableStream_position	String
	#PublishedObjectSecurityPolicy, #PublishedSegment	GsObjectSecurityPolicy
	#SystemRepository	Repository
	#SystemObjectSecurityPolicy, #SystemSegment	GsObjectSecurityPolicy

Table D.1 Initial Contents of the Globals Dictionary (Continued)

	Key	The object's class
Collections	#AllClusterBuckets	ClusterBucketArray
	#AllDeletedUsers	IdentitySet
	#AllGroups	SymbolKeyValueDictionary
	#AllKerberosPrincipals	SymbolKeyValueDictionary
	#AllUsers	UserProfileSet
	#ConfigurationParameterDict	SymbolKeyValueDictionary
	#ErrorSymbols	SymbolDictionary
	#GemStoneError	SymbolDictionary
	#GemStone_Portable_Streams	SymbolDictionary
	#GemStone_Legacy_Streams	SymbolDictionary
	#Globals	SymbolDictionary
	#InstancesDisallowed	IdentitySet
	#LegacyErrNumMap	Array
	#NotTranloggedGlobals	SymbolDictionary
Other Customer-usable Globals	#DeprecationEnabled	Symbol
	#GciStructsMd5	String
	#GciTsStructsMd5	String
	#GsDefaultIndexOptions	GsIndexOptions
	#IcuLibraryVersion	String
	#StringConfiguration	Class
	#Transcript	TranscriptStreamPortable

Table D.1 Initial Contents of the Globals Dictionary (Continued)

	Key	The object's class
GemStone Internal Objects	#AsciiCollatingTable	ByteArray
	#ConversionReservedOopMap	Array
	#ConversionStatus	Array
	#DoubleByteAsciiCollatingTable	DoubleByteString
	#FdcResults	UndefinedObject
	#GcCandidates	UndefinedObject
	#GcCandidatesCount	UndefinedObject
	#GcHints	UndefinedObject
	#GcWeakReferences	Array
	#GsCompilerClasses	SymbolDictionary
	#GsIndexingObjectSecurityPolicy, #GsIndexingSegment	GsObjectSecurityPolicy
	#ImageVersion	SymbolDictionary
	#ObsoleteClasses	SymbolDictionary
	#QuadByteAsciiCollatingTable	QuadByteString
	#RcBtreeNode	UndefinedObject
	#_remoteNil	UndefinedObject
	#SecurityDataObjectSecurityPolicy, #SecurityDataSegment	GsObjectSecurityPolicy
	#SharedDependencyLists	DepListTable
	#VersionParameterDict	SymbolKeyValueDictionary
plus all kernel classes		

Current TimeZone

Each instance of DateTime includes a reference to a TimeZone object, which handles the conversion from the internally stored Greenwich Mean Time (GMT, also referred to as UTC or Coordinated Universal Time) and the local time. TimeZones encapsulate the daylight savings time (DST) rules, so a given GMT time is adjusted to local time based on TimeZone and the specific date. TimeZones are also used to calculate the internal stored GMT for newly created DateTime instances.

Each session has a current TimeZone and a default TimeZone, which are used to display times, and in DateTime creation when methods that do not explicitly specify the TimeZone are used. These are installed as part of application installation or configuration; by default, the GemStone distribution has the America/Los_Angeles TimeZone installed. This is described in the *GemStone/S 64 Bit Installation Guide*.

GemStone uses the public domain **zoneinfo** database to create TimeZone, loading the information from platform and language independent source files. If the rules change for

the TimeZone that your application uses, you must recreate the TimeZone instance from the source files. Depending on the nature of the rules change, you may also need to update references from DateTime instances to the new TimeZone instance, or possibly update the DateTime internal offsets.

There are a number of ways to create TimeZone instances for your application:

- **From the OS**. On most operating systems, you can create the TimeZone instance based on the current machine configuration using:

  ```
  newTZ := TimeZone fromOS
  ```

- **GemStone's time zone database.** With the time zone descriptor name for your time zone, you can create the new TimeZone instance using the time zone database provided with GemStone.

  ```
  newTZ := TimeZone named: 'Europe/Zurich'
  ```

- **Your own time zone database**. With the time zone descriptor name for your time zone, you can specify the full path to the time zone information.

  ```
  newTZ := TimeZone fromGemPath: yourPath, '/Europe/Zurich'.
  ```

You must then install this TimeZone instances as the current and default time zone.

Zoneinfo

The widely used public-domain time zone database, **ZoneInfo** or **tz**, and sometimes referred to as the Olson database, contains code and data that records time zone information for locations worldwide. It is updated periodically when boundaries or rules change in any of the represented locations.

Each record in the tz database represents a location where all clocks are kept on the same time as each other throughout the year, coordinating any time adjustments such as DST. Locations are identified by continent (or ocean, for islands) and name, which is usually the largest city within the region. For example, America/Los_Angeles, Europe/London, etc.

The tz database is compiled into binaries for use by applications; the GemStone distribution include these binaries. Most operating systems also include the tz binaries, and either the OS, GemStone, or custom binaries may be used.

For more information or get the latest source files, see:

```
http://www.iana.org/time-zones
```

The timezone sources may be compiled using the zic timezone compiler, which GemStone provides as a convenience.

Utilities

tzselect, **zdump** and **zic** are public domain, open source utilities that are useful in working with the zoneinfo database. These utilities are provided with the Solaris and Linux operating systems. For convenience, these utilities are provided in the GemStone distribution, along with the other zoneinfo database files.

NOTE

These are not GemStone utilities. Support for their use is not provided by GemStone.

You may download the source code for these utilities here:

```
http://www.iana.org/time-zones
```

Documentation for these utilities is provided as man pages. To read the man pages, add the directory `$GEMSTONE/pub/timezone/usr/share/man` to the MANPATH.

tzselect

tzselect is a command-line interactive application that allows to you interactively look up a time zone. The final output, a value such as `America/New_York`, is suitable as a value for the TZ environment variable and GemStone scripts.

```
unix> $GEMSTONE/pub/timezone/usr/bin/tzselect --version
tzselect (tzcode) 2020a
```

In some installations, you may need to set the environment variable $TZDIR to $GEMSTONE/pub/timezone/usr/share/zoneinfo (or the path to your zoneinfo database), for this script to work correctly. You may also need to set the environment variable $AWK, to any POSIX compliant awk program.

For further details on using **tzselect** see the man page or `tzselect --help`.

zdump

zdump prints time zone information. It prints the current time for each time zone (zonename) listed on the command line.

```
unix> $GEMSTONE/pub/timezone/usr/bin/zdump America/New_York
America/New_York  Wed Aug 26 18:24:22 2020 EDT
```

zdump is also used to print the transitions within a timezone; the dates and times of the transition to and from daylight savings time for each year in the database.

For further details on using **zdump**, including the command line options, see the man page or `zdump --help`

zic

zic compiles time zone source files. It reads input text in files named on the command line, and creates the time zone binary files.

```
unix> $GEMSTONE/pub/timezone/usr/sbin/zic --version
zic (tzcode) 2020a
```

For further details on using **zic**, including the command line options and the structure of the source code files, see the man page for **zic**.

Chapter

E Environment Variables

This appendix lists the environment variables used by GemStone/S 64 Bit. The list has two parts: variables intended for public use, and variables that are reserved for internal use.

Public Environment Variables

The following environment variables are intended for use by customers. The variable GEMSTONE is required; the others may be useful in particular situations.

GEMSTONE
: The location of the GemStone Object Server software, which must be a full path, beginning with a slash, such as `/user3/GemStone-hppa.hpux`.

GEMSTONE_ADMIN_GC_LOG_DIR
: The directory location for Admin Gem logs. By default, Admin Gem log files are created in the same directory as the Stone log, which is $GEMSTONE/data. You can set this environment variable to specify that Admin Gem log files are created in a different directory.

GEMSTONE_EXE_CONF
: The location of an executable-dependent configuration file; see "Creating an Executable Configuration File" on page 310.

GEMSTONE_GLOBAL_DIR
: The location for the global GemStone logs and locks file, overriding the default /opt/gemstone/. This directory must already exist.

  This directory controls visibility between GemStone processes, and must be the same for all GemStone processes that may want to interact with a given repository, including stone, gems, topaz, statmonitor, netldi, gslist, etc. GemStone processes that do not shared a common location for /gemstone/locks—either /opt/gemstone, /usr/gemstone, or a directory specified by $GEMSTONE_GLOBAL_DIR—operate as if they are in independent name spaces.

GEMSTONE_KEEP_LOG
To keep a process's log from being deleted when the process terminates normally, unset this variable in the appropriate script, such as `$GEMSTONE/sys/gemnetobject`. To configure the system to keep all logs, see GS_KEEP_ALL_LOGS.

GEMSTONE_KEYRING_TABS
Set to a list of colon-separated directories containing SSL keys and certificates, for use by **copydbf -V.**

GEMSTONE_LIB
Specifies the directory for the gem and gem dynamic libraries. This is primarily of use in debugging low-level problems, and is used by the gemnetdebug script to specify the slow gem and gem dynamic libraries.

GEMSTONE_LOG
The location of system log files for the Stone repository monitor and its child processes. For further information, see "GemStone Process Logs" on page 124.

GEMSTONE_MAX_FD
Limits the number of file descriptors requested by a GemStone process. Normally, most GemStone processes raise their file descriptor limit from the default (soft) limit to the hard limit set by the operating system. Setting this variable to a positive integer sets a lower limit; a value of 0 disables attempts to change the default limit. This does not apply to the shared page cache monitor.

GEMSTONE_NRS_ALL
Sets a number of NRS directives that can be used by GemStone processes, such as the NetLDI name and log directory locations. For further information, see "GEMSTONE_NRS_ALL" on page 416.

GEMSTONE_RECLAIM_GC_LOG_DIR
The directory location for all Reclaim Gem logs. By default, Reclaim Gem log files are created in the same directory as the Stone log, which is $GEMSTONE/data. You can set this environment variable to specify that Reclaim Gem log files are created in a different directory.

GEMSTONE_SOCKET_DEBUG
If set to any value, this environment variable will cause tracing messages to be written to stdout for bind(), connect(), getaddrinfo() and related socket calls.

GEMSTONE_SPCMON_STARTUP_TIMELIMIT
Internally, GemStone waits for five minutes for the shared page cache to start up and initialize. This environment variable overrides this timeout, and specifies the time, in seconds, that the Stone will wait for the shared page cache to startup before giving up.

GEMSTONE_SSL_LIB_DIR
A directory location in which to look for the SSL shared library.

GEMSTONE_SYMBOL_GEM_LOG_DIR
The directory location for SymbolGem logs. By default, Symbol Gem log files are created in the same directory as the Stone log, which is $GEMSTONE/data. You can set this environment variable to specify that Symbol Gem log files are created in a different directory.

GEMSTONE_SYS_CONF
Location of a system-wide configuration file; see "How GemStone Uses Configuration Files" on page 307.

GS_CFTIME
If defined, it should contain a date and time format string that overrides the GemStone LOCALE-based default. See "Localizing timestamps in log files" on page 133.

GS_CORE_TIME_OUT
If GS_WRITE_CORE_FILE is defined, this is the number of seconds to wait before a catastrophically failing GemStone/S process writes a core file and terminates—by default, 60 seconds. To determine the cause of a problem, GemStone/S Technical Support needs a stack trace, which is usually written to the process log file prior to the process shutdown.

If you need to derive a stack trace directly from a failing (but not yet terminated) process by attaching a debugger to it, you can set this variable to increase the time available to attach the debugger.

GS_DEBUG_PAM
If this variable is set to any value, PAM debugging information will be printed to stdout.

GS_DEBUG_SHARED_MEM
If this variable is set to any value, the shared page cache monitor process will print extra debugging to its log file.

GS_DEBUG_SSL_LOG_DIR
In a slow or no-op build only, not available in normal (fast) builds for security reasons. If this variable is set to a directory, a process that logs in RPC will write output of SSL calls made during to a file named `GsSslDebug_<`*pid*`>.log` in the specified directory. This file may get very large.

GS_DEBUG_VMGC_MKSW_MEMORY_USED_SOFT_BREAK
At the end of each mark/sweep, if the percent of memory used is greater than the threshold specified by this variable, a SoftBreak (error 6003) is generated, and the threshold is raised by 5 percent. We suggest a setting of 75%.

GS_DEBUG_VMGC_MKSW_PRINT_STACK
The mark/sweep count at which to begin printing the Smalltalk stack at each mark/sweep.

For this and all other GS_DEBUG_VMGC_* environment variables, the printout goes to the "output push" file of a linkable Topaz (topaz -l) session, for use in testing your application. If that file is not defined, the printouts go to standard output of the session's gem or topaz -l process.

GS_DEBUG_VMGC_MKSW_PRINT_C_STACK
The mark/sweep count at which to begin printing the C stack at each mark/sweep. This variable is very expensive, consuming 2 seconds plus the cost of fork() for each printout.

GS_DEBUG_VMGC_PRINT_MKSW
The mark/sweep count at which to begin printing mark/sweeps.

GS_DEBUG_VMGC_PRINT_MKSW_MEMORY
The mark/sweep count at which to begin printing detailed memory usage (20 lines) for each mark/sweep.

GS_DEBUG_VMGC_PRINT_MKSW_MEMORY_USED
Specifies when Smalltalk stack printing starts as the application approaches OutOfMemory conditions. At the end of each mark/sweep, if the percent of memory used is greater than the threshold specified by this variable, the mark/sweep is printed, the Smalltalk stack is printed, and the threshold is raised by 5 percent. In a situation producing an OutOfMemory error, you should get several Smalltalk stacks printed in the Gem log file before the session dies. The default setting is 75%.

GS_DEBUG_VMGC_PRINT_SCAV
The scavenge count at which to begin printing scavenges. Once this takes effect, all mark/sweeps will also be printed. Be aware that printing scavenges can produce large quantities of output.

GS_DEBUG_VMGC_PRINT_TRANS
Print transaction boundaries (begin/commit/abort) in the log file.

GS_DEBUG_VMGC_SCAV_PRINT_STACK
The scavenge count at which to begin printing the Smalltalk stack at each scavenge. Be aware that this print activity can produce large quantities of output.

GS_DEBUG_VMGC_SCAV_PRINT_C_STACK
The scavenge count at which to begin printing the C stack at each scavenge. This variable is very expensive, consuming 2 seconds plus the cost of fork() for each printout.

GS_DEBUG_VMGC_VERBOSE_OUTOFMEM
Automatically call the primitive for `System class>>_vmPrintInstanceCounts:0` when an OutOfMemory error occurs, and also print the Smalltalk stack. (For details about this method, see the comments in the image.) This applies to each Gem or linkable Topaz (topaz -l) process that you subsequently start.

GS_DEBUG_VMGC_VERIFY_MKSW
The mark/sweep count at which to begin verifying object memory before and after each mark/sweep.

GS_DEBUG_VMGC_VERIFY_SCAV
The scavenge count at which to begin verifying object memory before and after each scavenge. Once this takes effect, GS_DEBUG_VMGC_VERIFY_MKSW will also be in effect. Be aware that this activity uses significant amounts of CPU time.

GS_DISABLE_CHARACTER_TABLE_LOAD
Any value disables the loading of any customized Extended Character Set Character Data Tables. This feature is deprecated; see the *Programming Guide* for details.

GS_DISABLE_KEEPALIVE
A non-empty string disables the network keepalive facility. For further information about keepalive, see “Disrupted Communications” on page 88

GS_DISABLE_WARNING
A non-empty string disables a warning that GemStone is using `/opt/gemstone` instead of `/usr/gemstone` for log and lock files when both directories exist.Use of `/usr/gemstone` is only for compatibility with previous releases; the default location is `/opt/gemstone`.

GS_DISABLE_SHMDT
Disables the system call to shmdt() made on cache detach during logout.

GS_DISABLE_SIGNAL_HANDLERS
When this environment variable is enabled in the environment for a gem process, by setting it to any value, this gem sessions will not attempt to handle a SIGSEGV, SIGBUS or SIGILL signal, but will shut down immediately. It will not generate a core nor print C stacks. This avoids side effects with user action or client Smalltalk code.

GS_GSLIST_TIME_FORMAT
This can be set to UNIX-style date format string, to allow the output of the gslist utility to be displayed in a parse-able format.

GS_FORCE_CLEAN_LOG_FILE_DELETE
When set, delete GemStone log files on clean exit; affects all processes except for Stone or NetLDI logs, which are never deleted. Logs for processes that exit with errors are not affected.

GS_KEEP_ALL_LOGS
Ensure that no GemStone process log files are deleted, overriding any individual process settings for GEMSTONE_KEEP_LOG.

GS_PAGE_MGR_PRINT_REMOTE_STACKS
If this variable is set, if a remote cache page server becomes stuck, the page manager will request that the remote cache page server print its call stack to its log file.

GS_SOCK_SEND_BUF_SIZE
Sets the size of the socket send buffer for the socket between the Gem and GCI client for an RPC Gem.

GS_SOCK_RECV_BUF_SIZE
Sets the size of the socket receive buffer for the socket between the Gem and GCI client for an RPC Gem.

GS_WRITE_CORE_FILE
By default, core files are not created when a fatal error occurs. (The C level stack trace is written to the process log file prior to the process shutdown.) You can set this environment variable if you need a core file.

upgradeLogDir
The location for log files produced during the upgrade of a repository for a new version of GemStone.

System Variables Used by GemStone

GemStone uses the following system variables that exist for other purposes:

EDITOR	Used by Topaz to determine which editor to invoke.
PATH	The search path of locating executable files.
SHELL	Used to determine what shell to use for an exec, such as by `System class>>performOnServer:`.

Reserved Environment Variables

The following environment variables are reserved for internal use. Customers should not define these variables for use with GemStone unless specifically instructed to do so. Please refrain from using these variables for other purposes.

GCIRTL_BASELIBNAME

GEMSTONE*
: All environment variable names beginning with “GEMSTONE” other than those above are reserved.

GS_*
: All environment variable names beginning with “GS_” other than those above are reserved.

gs64ldi