GT.M

Release Notes

V7.1-005

Empowering
the Financial World

FIS

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Legal Notice

This document contains a description of GT.M and the operating instructions pertaining to the various functions that comprise the system. This document does not contain any commitment of FIS. FIS believes the information in this publication is accurate as of its publication date; such information is subject to change without notice. FIS is not responsible for any errors or defects.

Revision History		
Revision 1.0	24 September 2024	V7.1-005

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V7.1-005

Overview

V7.1-005 provides a number of limited performance improvements, including the removal of index block-specific items introduced in the last release which turned out to not justify the burden of maintaining them as well as numerous changes aimed at improving ease of use and also a number of fixes.

Items marked with the symbol document new or different capabilities.

Please pay special attention to the items marked with the symbol. as those document items that have a possible impact on existing code, practice or process. Please be sure to recompile all objects to ensure all the updates are in place.

Note

While FIS keeps message IDs and mnemonics quite stable, message texts change more frequently as we strive to improve them, especially in response to user feedback. Please ensure you review any automated scripting that parses GT.M messages.

Conventions

This document uses the following conventions:

Flag/Qualifiers	- (dash)
Program Names or Functions	upper case. For example, MUPIP BACKUP
Examples	lower case. For example: mupip backup -database ACN,HIST /backup
Reference Number	A reference number enclosed between parentheses () used to track software enhancements and support requests.
Platform Identifier	Where an item affects only specific platforms, the platforms are listed in square brackets, e.g., [AIX]

Note

The term UNIX refers to the general sense of all platforms on which GT.M uses a POSIX API. As of this date, this includes: AIX and GNU/Linux x86_64.

Effective V6.0-000, GT.M documentation adopted IEC standard Prefixes for binary multiples. This document therefore uses prefixes Ki, Mi and Ti (e.g., 1MiB for 1,048,576 bytes). Over time, we'll update all GT.M documentation to this standard.

denotes a new feature that requires updating the manuals.

denotes a new feature or an enhancement that may not be upward compatible and may affect an existing application.

denotes deprecated messages.

denotes revised messages.

denotes added messages.

Platforms

Over time, computing platforms evolve. Vendors obsolete hardware architectures. New versions of operating systems replace old ones. We at FIS continually evaluate platforms and versions of platforms that should be Supported for GT.M. In the table below, we document not only the ones that are currently Supported for this release, but also alert you to our future plans given the evolution of computing platforms. If you are an FIS customer, and these plans would cause you hardship, please contact your FIS account executive promptly to discuss your needs.

Each GT.M release is extensively tested by FIS on a set of specific versions of operating systems on specific hardware architectures, we refer to the combination of operating system and hardware architecture as a platform. We deem this set of specific versions: Supported. There may be other versions of the same operating systems on which a GT.M release may not have been tested, but on which the FIS GT.M Group knows of no reason why GT.M would not work. We deem this larger set of versions: Supportable. There is an even larger set of platforms on which GT.M may well run satisfactorily, but where the FIS GT.M team lacks the knowledge to determine whether GT.M is Supportable and therefore deem them: Unsupported. Contact FIS GT.M Support with inquiries about your preferred platform.

As of the publication date, FIS supports this release on the hardware and operating system versions below. Contact FIS for a current list of Supported platforms. The reference implementation of the encryption reference plugin has its own additional requirements.

Platform	Supported Versions	Notes
IBM Power Systems AIX	7.1 TL 5, 7.2 TL 5, 7.3 TL 2	Only 64-bit versions of AIX with POWER7 as the minimum required CPU architecture level are Supported. While GT.M supports both UTF-8 mode and M mode on this platform, there are problems with the AIX ICU utilities that prevent FIS from testing 4-byte UTF-8 characters as comprehensively on this platform as we do on others.

Platform	Supported Versions	Notes
		Running GT.M on AIX 7.1 requires APAR IZ87564, a fix for the POW() function, to be applied. To verify that this fix has been installed, execute **instfix -ik IZ87564.** Only the AIX jfs2 filesystem is Supported. Other filesystems, such as jfs1 are Supportable, but not Supported. FIS strongly recommends use of the jfs2 filesystem on AIX; use jfs1 only for existing databases not yet migrated to a jfs2 filesystem.
x86_64 GNU/Linux	Red Hat Enterprise Linux 7.9, 8.10, 9.4; Ubuntu 20.04 LTS, and 22.04 LTS; Amazon Linux 2	To run 64-bit GT.M processes requires both a 64-bit kernel as well as 64-bit hardware. As of V7.1-001, GT.M on x86-64 requires hardware/virtualized support for AVX instructions. GT.M should also run on recent releases of other major Linux distributions with a contemporary Linux kernel (2.6.32 or later), glibc (version 2.12 or later) and ncurses (version 5.7 or later). Due to build optimization and library incompatibilities, GT.M versions older than V6.2-000 are incompatible with glibc 2.24 and up. This incompatibility has not been reported by a customer, but was observed on internal test systems that use the latest Linux software distributions from Fedora (26), Debian (unstable), and Ubuntu (17.10). In internal testing, processes either hung or encountered a segmentation violation (SIG-11) during operation. Customers upgrading to Linux distributions that utilize glibc 2.24+ must upgrade their GT.M version at the same time as or before the OS upgrade. GT.M requires a compatible version of the libtinfo library. On Red Hat, the ncurses-libs and ncurses-compat-libs packages contain the libtinfo library. On Debian/Ubuntu, libtinfo5 and libncurses5 packages contain the libtinfo library. If any of these packages is not already installed on your system, please install using an appropriate package manager. To support the optional WRITE /TLS fifth argument (the ability to provide / override options in the tlsid section of the encryption configuration file), the reference implementation of the encryption plugin requires libconfig 1.4.x or later. Only the ext4 and xfs filesystems are Supported. Other filesystems are Supportable, but not Supported. Furthermore, if you use the NODEFER_ALLOCATE feature, FIS strongly recommends that you use xfs. If you must use NODEFER_ALLOCATE with ext4, you **must** ensure that your kernel includes commit d2dc317d564a46dfc683978a2e5a4f91434e9711 (search for d2dc317d564a46dfc683978a2e5a4f91434e9711 at https://www.kernel.org/pub/linux/kernel/v4.x/ChangeLog-4.0.3).

Platform	Supported Versions	Notes
		The Red Hat Bugzilla identifier for the bug is 1213487. With NODEFER_ALLOCATE, do not use any filesystem other than ext4 and a kernel with the fix, or xfs. Our testing has shown an interaction between glibc 2.36 and all versions of GT.M on Linux/x86_64 systems without AVX2 support. This can cause segmentation violations (SIG-11) in processes performing concurrent updates to the same database block, which terminate the process, but do not damage the database. The issue is due to the way glibc performs certain memory operations when using SSE2 instructions. The glibc behavior was subsequently modified to avoid this issue, and the change was included in glibc 2.37. Linux/x86_64 systems with support for AVX2 instructions are not vulnerable, as glibc chooses its AVX2 implementation, when available, over its SSE2 implementation, and the problematic behavior is specific to SSE2. Note, depending on how CPU virtualization is configured, that virtual environments may not support AVX2 even if the underlying hardware does. Ubuntu 24.04 LTS is Supportable.  **Note** FIS recommends recompiling the reference encryption plugins to match the target platform. See Compiling the Reference Implementation Plugin section for instructions. OpenSSL 3.0 by default does not allow client-side initiated TLSv1.2 renegotiation requests due to potential DoS attacks. Because of this, the reference TLS implementation in GT.M versions before V7.0-004 do not use the appropriate OpenSSL 3.0 API to enable support for client-side initiated TLSv1.2 renegotiation. Customers needing to replicate to/from GT.M versions before V7.0-004 with OpenSSL 3.0 must use -RENEGOTIATE_INTERVAL=0 in the Source Server startup. This limitation only affects database replication and not SOCKET devices.

Important

Effective V7.0-003, GT.M is no longer Supportable on the 32 bit x86 platform. Please contact your FIS account manager if you need ongoing support for GT.M on this platform.

Platform support lifecycle

FIS usually supports new operating system versions six months or so after stable releases are available, and we usually support each version for a two-year window.

We support GT.M releases in a rolling support model based on two years of certified releases. A release becomes no longer officially supported once a given release is more than one release beyond the two year window. Historically we have produced GT.M releases on a quarterly basis, subject to change. Note: customers always get the best support by staying current with releases as they are made available.

FIS will continue to attempt to support any release of GT.M in use by a Profile customer under that client's maintenance agreement, while that agreement is still in effect. FIS's ability to provide an appropriate level of support may become increasingly costly to the client. In other words, FIS may need to enact a special maintenance agreement to continue to provide support. The additional costs required would be maintain client release level specific servers, operating systems and other ancillary software for a given and reasonable time frame beyond the normal window.

FIS policy is only to provide remediation, in the current release, for identified issues in generally available and supported releases. It is not FIS policy to provide ongoing support of client specific release levels of unsupported software.

GT.M cannot be patched, and bugs are only fixed in new releases of software.

GT.M as Open Source Software (OSS)

FIS maintains and releases GT.M on Linux as OSS. GT.M does not include any OSS libraries.

However, using some GT.M capabilities activates APIs that require the user make some OSS software available:

- Compression: zlib
- Encryption: libconfig and openssl (or equivalent as determined by the encryption plugin); key management is the user's responsibility
- UTF-8 mode: libicuio

while those are what FIS tests with, as long as the API is compatible, substitutions should work.

Note

Linux distributions include various OSS components some of which GT.M relies on.

Additional Installation Instructions

To install GT.M, see the "Installing GT.M" section in the GT.M Administration and Operations Guide. For minimal down time, upgrade a current replicating instance and restart replication. Once that replicating instance is current, switch it to become the originating instance. Upgrade the prior originating instance to become a replicating instance, and perform a switchover when you want it to resume an originating primary role.

Caution

Never replace the binary image on disk of any executable file while it is in use by an active process. It may lead to unpredictable results. Depending on the operating system, these results include but are not limited to denial of service (that is, system lockup) and damage to files that these processes have open (that is, database structural damage).

- FIS strongly recommends installing each version of GT.M in a separate (new) directory, rather than overwriting a previously installed version. If you have a legitimate need to overwrite an existing GT.M installation with a new version, you must first shut down all processes using the old version. FIS suggests installing GT.M V7.1-005 in a Filesystem Hierarchy Standard compliant location such as /usr/lib/fis-gtm/V7.1-005_arch (for example, /usr/lib/fis-gtm/V7.1-005_x86_64 on Linux systems). A location such as /opt/fis-gtm/V7.1-005_arch would also be appropriate.

- Use the appropriate MUPIP command (e.g. ROLLBACK, RECOVER, RUNDOWN) of the old GT.M version to ensure all database files are cleanly closed.

- Make sure gtmsecshr is not running. If gtmsecshr is running, first stop all GT.M processes including the DSE, LKE and MUPIP utilities and then perform a **MUPIP STOP *pid_of_gtmsecshr***.

- Starting with V6.2-000, GT.M no longer supports the use of the deprecated $gtm_dbkeys and the master key file it points to for database encryption. To convert master files to the libconfig format, please click  to download the CONVDBKEYS.m program and follow instructions in the comments near the top of the program file. You can also download CONVDBKEYS.m from http://tinco.pair.com/bhaskar/gtm/doc/articles/downloadables/CONVDBKEYS.m. If you are using $gtm_dbkeys for database encryption, please convert master key files to libconfig format immediately after upgrading to V6.2-000 or later. Also, modify your environment scripts to include the use of gtmcrypt_config environment variable.

Recompile

- Recompile all M and C source files.

Rebuild Shared Libraries or Images

- Rebuild all Shared Libraries after recompiling all M and C source files.
- If your application is not using object code shared using GT.M's auto-relink functionality, please consider using it.

Compiling the Reference Implementation Plugin

If you plan to use the example / reference implementation plugin in support of database encryption, TLS replication, or TLS sockets, you must compile the reference plugin in order to match the shared library dependencies specific to your platform. The instructions for compiling the Reference Implementation plugin are as follows:

1. Install the development headers and libraries for libgcrypt, libgpgme, libconfig, and libssl. On Linux, the package names of development libraries usually have a suffix such as -dev or -devel and are available through the package manager. For example, on Ubuntu_x86_64 a command like the following installs the required development libraries:

   ```
   sudo apt-get install libgcrypt11-dev libgpgme11-dev libconfig-dev libssl-dev
   ```

   Note that the package names may vary by distribution / version. For example, on RHEL 9 the libraries required to recompile the reference implementation encryption plugin are libgcrypt-devel, gpgme-devel, libconfig-devel, and openssl-devel.

2. Unpack $gtm_dist/plugin/gtmcrypt/source.tar to a temporary directory.

   ```
   mkdir /tmp/plugin-build
   cd /tmp/plugin-build
   cp $gtm_dist/plugin/gtmcrypt/source.tar .
   tar -xvf source.tar
   ```

3. Follow the instructions in the README.

   - Open Makefile with your editor; review and edit the common header (IFLAGS) and library paths (LIBFLAGS) in the Makefile to reflect those on your system.
   - Define the gtm_dist environment variable to point to the absolute path for the directory where you have GT.M installed
   - Copy and paste the commands from the README to compile and install the encryption plugin with the permissions defined at install time

4. When reinstalling or upgrading GT.M, stop existing gpg-agents. The agents may be working with information about the prior GT.M installation, such as GNUPGHOME, that will not work with the new version. Additionally, if the process deletes the GPG agent's socket, proper operation requires a new agent.

5. It is a good idea to read the Administration and Operations Guide section entitled "Special note - GNU Privacy Guard and Agents" and re-evaluate the GPG configuration options in use.

Re-evaluate TLS configuration options

The GT.M TLS reference encryption plugin implements a subset of options as documented in the OpenSSL man page for SSL_set_options which modify the default behavior of OpenSSL. Future versions of the plugin will enable new options as and when the OpenSSL library adds them. To enable options not supported by the GT.M TLS reference plugin, it is possible to create an OpenSSL configuration for GT.M processes. See the OpenSSL man page for "config".
<para/>

Upgrading to V7.1-005

Before you begin

GT.M supports upgrade from V5*, V6.* and V7.* versions to V7.1-005.

GT.M does not support upgrading from V4* versions. Please upgrade V4 databases using instruction in the release notes of an appropriate GT.M V6.* version.

The GT.M database consists of four types of components- database files, journal files, global directories, and replication instance files.

GT.M upgrade procedure for V7.1-005 consists of 5 stages:

- Stage 1: Global Directory Upgrade
- Stage 2: Database Files Upgrade
- Stage 3: Replication Instance File Upgrade
- Stage 4: Journal Files Upgrade
- Stage 5: Trigger Definitions Upgrade

Before starting, read the upgrade instructions of all stages carefully. Your upgrade procedure for GT.M V7.1-005 depends on your GT.M upgrade history and your current version.

Stage 1: Global Directory Upgrade

FIS strongly recommends you back up your Global Directory file before upgrading. There is no one-step method for downgrading a Global Directory file to an older format.

To upgrade from any previous version of GT.M:

- Open your Global Directory with the GDE utility program of GT.M V7.1-005.
- Execute the EXIT command. This command automatically upgrades the Global Directory.
- If you inadvertently open a Global Directory of an old format with no intention of upgrading it, execute the QUIT command rather than the EXIT command.

If you inadvertently upgrade a global directory, perform the following steps to downgrade to an old GT.M release:

- Open the global directory with the GDE utility program of V7.1-005.
- Execute the SHOW -COMMAND -FILE=file-name command. This command stores the current Global Directory settings in the file-name command file. If the old version is significantly out of date, edit the command file to remove the commands that do not apply to the old format. Alternatively, you can use the output from SHOW -ALL or SHOW -COMMAND as a guide to manually enter equivalent GDE commands for the old version.

An analogous procedure applies in the reverse direction.

Stage 2: Database Files Upgrade

Before starting the database file upgrade, use the prior GT.M version to perform an appropriate MUPIP action (i.e. ROLLBACK, RECOVER, RUNDOWN) to remove abandoned GT.M database semaphores and release any IPC resources.

There are three upgrade paths available when you upgrade to V7.1-005.

V7 Upgrade Path 1: In-place Upgrade

To upgrade from GT.M V7*:

There is no explicit procedure to upgrade a V7 database file when upgrading to a newer V7 version. After upgrading the Global Directory, opening a V7 database with a newer V7 GT.M process automatically upgrades the fields in the database file header.

To upgrade from GT.M V6* (or V5*):

There are two phases to upgrade from V6 to V7:

- Phase 1: MUPIP UPGRADE phase; requires standalone access
- Phase 2: MUPIP REORG -UPGRADE (GVT Index Block Upgrade); may optionally run with concurrent access if performance is acceptable

Both phases operate once per region. Phase 1 is not restartable. Phase 2 is restartable.

While these are the basic steps, customers must integrate them with appropriate operational practice and risk mitigating procedures, such as comprehensive testing, backup, integrity checks, journal and replication management, and so on based on their environments and risk tolerance. FIS strongly recommends performing a MUPIP INTEG (-FAST), of the database and creating a backup prior to upgrade. Customers must test these utilities against copies of their own production files, using their planned procedures, before undertaking the conversion of current production files.

Using MUPIP UPGRADE and MUPIP REORG -UPGRADE should be a significantly faster alternative to using MUPIP EXTRACT and LOAD. FIS favors using a "rolling" upgrade using a replicated instance.

Whatever the approach you choose, FIS requests capturing all logs in case there are issues or questions leading to support requests.

Phase 1: Standalone MUPIP UPGRADE

MUPIP UPGRADE performs Phase 1 actions of upgrading a database to V7. The format of the UPGRADE command is:

```
MUPIP UPGRADE {-FILE <file name>; | [-REGION] <region list>}
```

As the GT.M version upgrade changes the journal format to support 64-bit block pointers, MUPIP UPGRADE does not maintain journal files or replication; configured journaling and replication resumes for activity after MUPIP UPGRADE.

UPGRADE:

- Requires standalone access
- Turns off journaling and replication for the duration of UPGRADE
- When encountering an error where the command specifies multiple regions, UPGRADE moves on to the next region, while for a single file/region, it terminates; avoid any unnecessary <CTRL_C> or MUPIP STOP (or kill) of an active MUPIP UPGRADE process, as such an action leaves the database region effectively unusable
- Estimates and reports the space required for its work
  - UPGRADE estimates are intended to be generous, and, particularly for small databases, they may seem unnecessarily large
  - If MUPIP is not authorized to perform a required file extension, that is, the extension amount is defined as zero (0), it produces an error before it does anything that would damage the selected database file
- Moves blocks from immediately after the existing master map to make room for a V7 master map
  - Depending on the block size and the GT.M version with which it was created, the new starting Virtual Block Number (VBN), the location of block zero for the database file, may exceed the starting VBN for a database created with V7, which causes a minor waste of space
  - UPGRADE relocates blocks in multiples of 512 to align blocks with their local bitmaps
- Eliminates any globals that previously existed, but have been KILL'd at the name level; these global variable trees (GVTs) contain only a level one (1) root block and an empty data (level zero) block and are "invisible" to the GT.M process run-time
- Stores the offset GT.M must apply to the original block pointers as a consequence of the relocation of the starting VBN
- Upgrades the directory tree (DT) block pointers from 32- to 64-bits; this requires splitting any blocks that do not have sufficient space to accommodate the larger block pointers

- Ensures that all is work is flushed to secondary storage
- Reports completion of its activity on a database file with a "MUPIP MASTERMAP UPGRADE completed" message

At this point, after a successful MUPIP UPGRADE:

- All DT blocks are in V7m format and all GVT index blocks remain in V6/V6p format
- Subsequent activity that updates index blocks for existing GVTs implicitly converts any V6 index blocks to V6p format after applying the offset
- No process other than MUPIP REORG -UPGRADE converts GVT index blocks from V6p format to V7m format; in other words, adding new nodes does not create GVT index blocks with V7 format - adding new nodes splits existing index blocks and such block splits retain the pre-existing block format
- Newly created GVTs, storing new global names, have V7m format
- Data blocks, at level zero (0), and local bit map blocks have the same format in V6 and V7, so, for consistency, normal updates also give those blocks a V7m format designation

These database changes are physical rather than logical, and thus do not require replication beyond noting the increase in transaction numbers.

Phase 2: MUPIP REORG -UPGRADE (GVT Index Block Upgrade)

MUPIP REORG -UPGRADE performs Phase 2 actions of upgrading a database to V7 format. The format of MUPIP REORG -UPGRADE is:

```
MUPIP REORG -UPGRADE {-FILE <file_name> | [-REGION] <region_list>}
```

Before image journaling with MUPIP REORG upgrade provides maximum resiliency. MUPIP REORG -UPGRADE reports it has completed its actions for a region with a MUPGRDSUCC message, at which point all index blocks have V7m format with 64-bit block pointers. You can resume and complete a MUPIP REORG -UPGRADE stopped with a MUPIP STOP (or <Ctrl-C>); avoid a kill -9, which carries a high risk of database damage.

MUPIP REORG -UPGRADE:

- Requires standalone access
- Runs on an entire region; as a result, MUPIP REORG -UPGRADE prevents multiple concurrent REORG -UPGRADE runs per region
- Stops execution when a concurrent Online ROLLBACK is detected because that operation changes the block content of the database
- Can be subject to stopping and restarting at any point
- Processes the GVTs within a database file

- Splitting any index blocks that do not have sufficient space to accommodate the block pointer upgrade from 32 to 64 bits
- Updating the block pointers from 32 to 64 bits, also changing the version of the block to V7m
- Journaling its work as before images (if so configured) and INCTN records

Phase 3: Optional GVT Data and Local Bit Map Block Upgrade

While it makes no operational or processing difference, GT.M does not consider the database "fully upgraded" until the block version format of all data blocks becomes V7m. Any of the following operations upgrade some or all of the remaining data blocks:

- MUPIP REORG

  Because this operation may not visit every block in the database it may fail to upgrade static/unchanging blocks

- MUPIP REORG -ENCRYPT
- MUPIP INTEG -TN_RESET

  This operation requires standalone access and resets the transaction number on all blocks in the database.

Failure to perform Phase 3 has **NO** implications for V7.1-005 but might be an issue for any as-yet unplanned further enhancement.

Important

Taking the steps in the following list that use MUPIP REORG -MIN_LEVEL=1 significantly reduce upgrade time.

The following lists the recommended ordered steps for the full upgrade process:

1. Offline Upgrade instance to use new GT.M V7.1-002+ version - at this point, customers can use the upgraded the GT.M version without any DB changes
2. Online MUPIP SET -INDEX_RESERVED_BYTES=n - where n is 1/3 the block size
3. Online MUPIP REORG -MIN_LEVEL=1 -NOSWAP - free up space in all index blocks to ease the block reference change from 32bits (4bytes) to 64bits (8bytes); this operation alters only index blocks (-MIN_LEVEL=1), and so generates a much lower volume of before image journal records.
4. Offline MUPIP UPGRADE -move blocks around to make space for the expanded master bitmap and upgrade the index blocks in the directory tree (tree of Global names).
5. Online MUPIP REORG -UPGRADE - upgrade the remaining index blocks

6. Online MUPIP SET -INDEX_RESERVED_BYTES=0 - remove the previously applied reservation as it is no longer needed; some application may find it produces a continuing performance benefit.

7. (optional) Online REORG -MIN_LEVEL=1 -NOSWAP -NOSPLIT - coalesce the index blocks to leave index blocks in a less fragmented state

V7 Upgrade Path 2: EXTRACT and LOAD

Two commonly used mechanisms are as follows. We recommend you use replication to stage the conversion and minimize down time.

- MUPIP EXTRACT -FREEZE followed by a MUPIP LOAD

  Using MUPIP EXTRACT with -FREEZE ensures that the V6 database files are frozen at the point of the extract, preventing updates without administrative action to unfreeze the database. MUPIP LOAD the extracts into newly created V7 database files

  Use this operation when there is insufficient space to make a database extract

- MERGE command with two global directories and Extended References

  Using this approach to transfer data from a V6 database file to a V7 database, administrators must take some action to prevent updates during the transfer

  This operation consumes less disk space and disk I/O. As a result the operation is faster than an EXTRACT and LOAD.

If you are using triggers, extract the triggers from the V6 database and load them in the new V7 database.

V7 Upgrade Path 3: No change

Continue using your V6 databases with GT.M V7.1-005. In case you do not wish to operate with files of differing format, specify the -V6 qualifier when invoking MUPIP CREATE.

Choosing the right upgrade path

Choose V7 Upgrade Path 1 or 2 if you anticipate a database file to grow to over 994Mi blocks or require trees of over 7 levels as V7.1-005 supports 16Gi blocks and 11 levels. Note that the maximum size of a V7 database file having 8KiB block size is 114TiB (8KiB*16Gi).

Choose the V7 Upgrade Path 3 if you do not anticipate a database file to grow beyond the V6 database limit of 994Mi blocks or a tree depth limit of 7 levels. Note that the maximum size of a V6 database file having 8KiB block size is 7TiB (8KiB*992Mi).

Other than the new maximum database file size and greater tree depth that comes with V7 Upgrade Path 1 and 2, there is no difference between V7 Upgrade Path 1 and 2 and V7 Upgrade Path 3. You can choose V7 Upgrade Path 3 first and then later choose V7 Upgrade Path 1 or 2 if a need arises.

For additional details on differences in factors involved in the V6 to V7 upgrade refer to Appendix G in the GT.M Administration and Operations Guide.

Database Compatibility Notes

- Changes to the database file header may occur in any release. GT.M automatically upgrades database file headers as needed. Any changes to database file headers are upward and downward compatible within a major database release number, that is, although processes from only one GT.M release can access a database file at any given time, processes running different GT.M releases with the same major release number can access a database file at different times.
- Databases created with V5.3-004 through V5.5-000 can grow to a maximum size of 224Mi (234,881,024) blocks. This means, for example, that with an 8KiB block size, the maximum database file size is 1,792GiB; this is effectively the size of a single global variable that has a region to itself and does not itself span regions; a database consists of any number of global variables. A database created with GT.M versions V5.0-000 through V5.3-003 can be upgraded with the V5 version of MUPIP UPGRADE to increase the limit on database file size from 128Mi to 224Mi blocks.
- Databases created with V5.0-000 through V5.3-003 have a maximum size of 128Mi (134, 217,728) blocks. GT.M versions V5.0-000 through V5.3-003 can access databases created with V5.3-004 and later as long as they remain within a 128Mi block limit.
- Database created with V6.0-000 through V6.3-014 have a maximum size of 1,040,187,392 (992Mi) blocks.
- Database created with V7.0-000 and up have a maximum size of 17,179,869,184 (16Gi) blocks.

Stage 3: Replication Instance File Upgrade

GT.M V7.1-005 does not require new replication instance files when upgrading from any version after V6.0-000.

Stage 4: Journal Files Upgrade

On every GT.M upgrade:

- Create a fresh backup of your database
- Generate new journal files (without back-links), typically by turning journaling OFF and then back ON

Important

This is necessary because MUPIP JOURNAL cannot use journal files from a release other than its own for e.g. RECOVER, ROLLBACK, or EXTRACT.

MUPIP UPGRADE temporarily disables journaling and replication settings for the duration of its activity. Once complete, MUPIP UPGRADE restores prior settings.

Stage 5: Trigger Definitions Upgrade

GT.M V7.1-005 does not require trigger definition upgrade when upgrading GT.M from any version after V6.3-000. If upgrading from a prior GT.M release, please see the instructions in the release notes for V6.3-014.

Managing M mode and UTF-8 mode

With International Components for Unicode® (ICU) version 3.6 or later installed, GT.M's UTF-8 mode provides support for Unicode® (ISO/IEC-10646) character strings. On a system that does not have ICU 3.6 or later installed, GT.M only supports M mode.

On a system that has ICU installed, GT.M optionally installs support for both M mode and UTF-8 mode, including a utf8 subdirectory of the directory where GT.M is installed. From the same source file, depending upon the value of the environment variable gtm_chset, the GT.M compiler generates an object file either for M mode or UTF-8 mode. GT.M generates a new object file when it finds both a source and an object file, and the object predates the source file and was generated with the same setting of $gtm_chset/$ZCHset. A GT.M process generates an error if it encounters an object file generated with a different setting of $gtm_chset/$ZCHset than that processes' current value.

Always generate an M object module with a value of $gtm_chset/$ZCHset matching the value processes executing that module will have. As the GT.M installation itself contains utility programs written in M, their object files also conform to this rule. In order to use utility programs in both M mode and UTF-8 mode, the GT.M installation ensures that both M and UTF-8 versions of object modules exist, the latter in the utf8 subdirectory. This technique of segregating the object modules by their compilation mode prevents both frequent recompiles and errors in installations where both modes are in use. If your installation uses both modes, consider a similar pattern for structuring application object code repositories.

GT.M is installed in a parent directory and a utf8 subdirectory as follows:

- Actual files for GT.M executable programs (mumps, mupip, dse, lke, and so on) are in the parent directory, that is, the location specified for installation.
- Object files for programs written in M (GDE, utilities) have two versions - one compiled with support for UTF-8 mode in the utf8 subdirectory, and one compiled without support for UTF-8 mode in the parent directory. Installing GT.M generates both versions of object files, as long as ICU 3.6 or greater is installed and visible to GT.M when GT.M is installed, and you choose the option to install UTF-8 mode support. During installation, GT.M provides an option that allows placing the object code in shared libraries in addition to individual files in the directory.
- The utf8 subdirectory has files called mumps, mupip, dse, lke, and so on, which are relative symbolic links to the executables in the parent directory (for example, mumps is the symbolic link ../mumps).
- When a shell process sources the file gtmprofile, the behavior is as follows:
  - If $gtm_chset is "m", "M" or undefined, there is no change from the previous GT.M versions to the value of the environment variable $gtmroutines.

- If $gtm_chset is "UTF-8" (the check is case-insensitive),
  - $gtm_dist is set to the utf8 subdirectory (that is, if GT.M is installed in /usr/lib/fis-gtm/gtm_V7.1-005_i686, then gtmprofile sets $gtm_dist to /usr/lib/fis-gtm/gtm_V7.1-005_i686/utf8).
  - On platforms where the object files have not been placed in a libgtmutil.so shared library, the last element of $gtmroutines is $gtm_dist($gtm_dist/..) so that the source files in the parent directory for utility programs are matched with object files in the utf8 subdirectory. On platforms where the object files are in libgtmutil.so, that shared library is the one with the object files compiled in the mode for the process.

For more information on gtmprofile, refer to the Basic Operations chapter of GT.M Administration and Operations Guide.

Although GT.M uses ICU for UTF-8 operation, ICU is not FIS software and FIS does not support ICU.

Setting the environment variable TERM

The environment variable TERM must specify a terminfo entry that accurately matches the terminal (or terminal emulator) settings. Refer to the terminfo man pages for more information on the terminal settings of the platform where GT.M needs to run.

- Some terminfo entries may seem to work properly but fail to recognize function key sequences or fail to position the cursor properly in response to escape sequences from GT.M. GT.M itself does not have any knowledge of specific terminal control characteristics. Therefore, it is important to specify the right terminfo entry to let GT.M communicate correctly with the terminal. You may need to add new terminfo entries depending on your specific platform and implementation. The terminal (emulator) vendor may also be able to help.
- GT.M uses the following terminfo capabilities. The full variable name is followed by the capname in parenthesis:

```
auto_right_margin(am), clr_eos(ed), clr_eol(el), columns(cols), cursor_address(cup),
 cursor_down(cud1), cursor_left(cub1), cursor_right(cuf1), cursor_up(cuu1),
 eat_newline_glitch(xenl), key_backspace(kbs), key_dc(kdch1),key_down(kcud1),
 key_left(kcub1), key_right(kcuf1), key_up(kcuu1), key_insert(kich1),
 keypad_local(rmkx),keypad_xmit(smkx), lines(lines).
```

GT.M sends keypad_xmit before terminal reads for direct mode and READs (other than READ *) if EDITING is enabled. GT.M sends keypad_local after these terminal reads.

Installing Compression Libraries

If you plan to use the optional compression facility for replication, you must provide the compression library. The GT.M interface for compression libraries accepts the zlib compression libraries without any need for adaptation. These libraries are included in many UNIX distributions and are downloadable from the zlib home page. If you prefer to use other compression libraries, you need to configure or adapt them to provide the same API as that provided by zlib.

If a package for zlib is available with your operating system, FIS suggests that you use it rather than building your own.

By default, GT.M searches for the libz.so shared library in the standard system library directories (for example, /usr/lib, /usr/local/lib, /usr/local/lib64). If the shared library is installed in a non-standard location, before starting replication, you must ensure that the environment variable LIBPATH (AIX) or LD_LIBRARY_PATH (GNU/Linux) includes the directory containing the library. The Source and Receiver Server link the shared library at runtime. If this fails for any reason (such as file not found, or insufficient authorization), the replication logic logs a DLLNOOPEN error and continues with no compression.

Although GT.M uses a library such as zlib for compression, such libraries are not FIS software and FIS does not support any compression libraries.

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Change History

V7.1-005

Fixes and enhancements specific to V7.1-005:

Id	Prior Id	Category	Summary
GTM-8124	GTM-F134711	Admin	MUPIP JOURNAL -ROLLBACK maintains the region sequence number during the forward phase
GTM-8604	GTM-F134990	Admin	MUPIP rundown command accepts both the -region and -relinkctl options on the same command line
GTM-9095	GTM-DE201242	Other	Relink control files maintain correct permissions, regardless of umask
GTM-9201	GTM-F135316	Language	REWIND resets $X, $Y and $ZEOF for fifos and PIPEs
GTM-9905	GTM-F134852	DB	MUPIP JOURNAL -ROLLBACK keeps the replication instance file open for the duration of the rollback
GTM-10100	GTM-F249273	DB	TPNOTACID mechanism has a default of .3 seconds and a maximum of 10 seconds
GTM-10573	-	Other	Single system call for journal file reads
GTM-10664	-	DB	Include database file names in DBFREEZEON and DBFREEZEOFF error messages
GTM-10729	-	DB	Index block statistics removed
GTM-10731	-	Language	$ZCONVERT() support W-1252 conversions to and from UTF
GTM-10749	-	Admin	REORG -UPGRADE performance improvements
GTM-10773	GTM-10747	Language	ZSHOW to a destination global prevents too many subscripts
GTM-10778	-	Language	Direct Mode skips literal optimizations to ensure evaluation consietency
GTM-10806	-	DB	GT.M reports SEMUNDOOVERFLOW for exceeding a semaphore limit
GTM-10807	-	Other	LOCK state changes protected from asynchronous events
GTM-10817	-	Admin	GT.M no longer issues DBVERPERFWARN messages

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Database

- MUPIP JOURNAL -ROLLBACK keeps the replication instance file open for the duration of the rollback and if it goes missing recreates it. Note that removing the instance file from a running instance is not a recommended action. Previously, deleting the instance file during a rollback produced a GTM-E-REPLINSTOPEN or GTM-E-REPLINSTACC error and potentially a GTM-F-NOCHLEFT error with an accompanying core file. (GTM-9905)

- The TPNOTACID mechanism controlled by the gtm_tpnotacidtime environment variable has a maximum of 10 seconds and a default of .3 seconds if the environment variable is undefined. GT.M evaluates the specific value with millisecond precision. GT.M uses the default value if the definition falls outside the range of zero (0) to 10 seconds. Previously the default value was two (2) seconds, and the maximum was 30 seconds. (GTM-10100)

- DBFREEZEON and DBFREEZEOFF provide the database file name along with the region name. Previously, these error messages did not provide the database file name (GTM-10664)

- GT.M does not provide the index block statistics introduced in V7.1-004, as they did not justify their runtime cost. In their place, GT.M adopts a layout for database control structures intended to minimize cache line contention at the hardware level. So this change should modestly improve performance, rather than modestly reduce it. If you have a need for the index block statistics, please contact your GT.M support channel. (GTM-10729)

- When initializing a database region, GT.M correctly detects a SEM_UNDO table overflow when a semop() system call fails and issues a fatal SEMUNDOOVERFLOW error message. This message notifies the user that their configured number of regions exceeds the operating system limit and the number of per-process concurrent regions must be reduced. AIX has a much lower limit than Linux. Previously, GT.M conflated this condition with the case where circumstances led it to pass a bad semaphore ID to semop(), issuing the less informative fatal error message CRITSEMFAIL in both cases. (GTM-10806)

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Language

- Specifying REWIND, INREWIND, or OUTREWIND for a FIFO or PIPE device, sets $X, $Y, and $ZEOF to zero. FIFO and PIPE devices do not support changing the file pointer. Previously, GT.M ignored REWIND, INREWIND, and OUTREWIND for those FIFO or PIPE devices. (GTM-9201)
- When the second or third argument specifies "M" or "W-1252" and the corresponding third or second argument specifies "UTF-8" or "UTF-16", $ZCONVERT() interprets its first argument encoding as specified by its second argument and returns a string reflecting the conversion of the first argument to the encoding of the third argument. $ZCONVERT() issues an ENCODING warning message when in UTF-8 mode (variable length encoding) with the second or third argument specified as "M" or "W-1252". Previously, the three-argument form of $ZCONVERT() did not support "M" or "W-1252" conversions. (GTM-10731)
- ZSHOW to a destination global gives a MAXNRSUBSCRIPTS error when the destination has too many subscripts to accommodate the two additional levels needed. Previously, it did not detect this condition and created references GT.M subsequently could not handle properly. (GTM-10773)
- GT.M skips literal optimizations in Direct Mode in order to avoid inconsistencies that can occur in code that modifies the environment in a way that might impact literal evaluation. Previously such constructions could give results that differed from those when the code was compiled. (GTM-10778)

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System Administration

- MUPIP JOURNAL -ROLLBACK maintains the region sequence number accurately during the forward phase of rollback; previously MUPIP only maintained that value at the end of forward recovery, which was not idempotent. (GTM-8124)
- MUPIP rundown command accepts both the -region and -relinkctl options on the same command line, allowing for greater flexibility and convenience when running MUPIP rundown operations. When using both the options together, please note that if only one parameter is provided, it applies to the region only; otherwise, MUPIP obeys the order. Previously MUPIP requires two separate commands to rundown both databases and the relink control file. (GTM-8604)
- MUPIP REORG -UPGRADE accounts for the effects of its own activity when determining whether it needs to process the current global variable tree from its root. Previously, reorg -upgrade recognized its own update of an index block as a concurrent modification and re-processed the tree from the root when this occurred. Users can expect substantial performance improvements, especially on upgrades of large datasets where the global buffers are not sufficient to hold all index blocks for a tree undergoing an upgrade. (GTM-10749)
- GT.M no longer issues DBVERPERFWARN messages; previously, those messages applied to a database upgraded from V4 to V5 format. (GTM-10817)

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Other

- GT.M give relink control files appropriate permissions independent of the user's umask setting. Previously, the permissions were affected by the user's umask, which caused inappropriate file permissions. (GTM-9095)
- GT.M uses a single system service call when reading from journal files, which should somewhat improve performance of related operations. Previously, GT.M used a series of system calls when reading from journal files. (GTM-10573)
- LOCK state changes are protected from asynchronous events. Previously, GTM-10617 in V7.1-004 protected many operations, but did not cover a few, such as compaction of structures associated with previous activity, which could result in a segmentation violation (SIG-11). (GTM-10807)

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Error and Other Messages

DBFREEZEOFF

DBFREEZEOFF, Region rrrr (dddd) is UNFROZEN ([NO]OVERRIDE [NO]AUTOREL)

Operator log/MUPIP Information: The region rrrr mapped to database file dddd is no longer frozen, most likely due to a MUPIP FREEZE -OFF, with the selected options. [NO]OVERRIDE ondicates whether the freeze was removed using an override [NO]AUTOREL indicates whether an autorelease of the region occurred prior to the MUPIP FREEZE -OFF command.

Action: Confirm that this was the desired action.

DBFREEZEON

DBFREEZEON, Region rrrr (dddd) is FROZEN ([NO]OVERRIDE [NO]ONLINE [NO]AUTOREL)

Operator log/MUPIP Information: The region rrrr mapped to database file dddd is frozen, most likely due to a MUPIP FREEZE -ON, with the reported options.

Action: Confirm that this was the desired action.

ENCODING

ENCODING, M or W-1252 code designation for character set encoding, might return unexpected results when ""UTF-8""=$ZCHSET

Compile Time Warning: When in UTF-8 mode (variable length encoding) and code contains $ZCONVERT() with the second or third argument specified as literal M or W-1252 (single byte encodings) the compiler warns there may be encoding issues.

Action: If the first argument (string to convert) is always pure ASCII, the conversion is unnecessary, so consider removing it. With a second argument of M or W-1252 unless the first argument has an external source or has been generated by $ZCHAR() it likely already has UTF-8 encoding, and an additional conversion won't yield desired results. With a third argument of M or W-1252 the result may contain characters unintended for, or incompatible (could generate BADCHAR errors) with, the running UTF-8 character set and therefore require handling with $Z* byte-oriented functions. In other words, the $ZCONVERT() second and third arguments specify how the function operates not whether its input or output are appropriate in the context of the specified operation so consider the use case carefully. Note that when the second and/or third arguments are non-literal expressions, the compiler cannot determine whether an ENCODING warning might be appropriate. Also note that the UTF-16 encodings supported by the function have compatibility issues but because GT.M does not natively support those encodings the issues are more overt and do not generate ENCODING warnings.

REPLINSTRECR

REPLINSTRECR, Error recreating replication instance file ffff

MUPIP Error: The replication instance file ffff has gone missing and GT.M has attempted to recover it from information in memory, but that attempt failed.

Action: See associated messages for additional context. While the error might be the result of some operational intent, it may mean that something in the replication instance file path has been inadvertently made inaccessible. If so, address the missing item or redirect the $gtm_repl_instance environment variable to name an appropriate revised path.

SEMUNDOOVERFLOW

SEMUNDOOVERFLOW, The operating system per-process SEM_UNDO table is full and region rrrr cannot be opened

Run Time Error: The number of database files in use exceeds the per-process operating system limit for handling SEM_UNDO semaphore operations.

Action: Reduce the number of database regions processed at one time.