

# GT.M

## Release Notes

V7.1-000

Empowering  
the Financial World

FIS

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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 1.1	14 June 2023	Changed GTM-DE378224 to GTM-DE376224
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# GT.M Release Notes


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## V7.1-000

### Overview

V7.1-000 adds MUPIP UPGRADE and MUPIP REORG -UPGRADE to upgrade V6 format database files in place to V7 format as well as various fixes. For more information, refer to the Upgrading to V7.1-000 and Change History sections.

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, messages 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:

<b>Flag/Qualifiers</b>	-
<b>Program Names or Functions</b>	upper case. For example, MUPIP BACKUP
<b>Examples</b>	lower case. For example: mupip backup -database ACN,HIST /backup
<b>Reference Number</b>	A reference number is used to track software enhancements and support requests. It is enclosed between parentheses ().
<b>Platform Identifier</b>	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.






The following table summarizes the new and revised replication terminology and qualifiers.

Pre V5.5-000 terminology	Pre V5.5-000 qualifier	Current terminology	Current qualifiers
originating instance or primary instance	-rootprimary	originating instance or originating primary instance.	-updok (recommended)

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Pre V5.5-000 terminology	Pre V5.5-000 qualifier	Current terminology	Current qualifiers
		Within the context of a replication connection between two instances, an originating instance is referred to as source instance or source side. For example, in an B<-A->C replication configuration, A is the source instance for B and C.	-rootprimary (still accepted)
replicating instance (or secondary instance) and propagating instance	N/A for replicating instance or secondary instance.  -propagateprimary for propagating instance	replicating instance.  Within the context of a replication connection between two instances, a replicating instance that receives updates from a source instance is referred to as receiving instance or receiver side. For example, in an B<-A->C replication configuration, both B and C can be referred to as a receiving instance.	-updnok
N/A	N/A	supplementary instance.  For example, in an A->P->Q replication configuration, P is the supplementary instance. Both A and P are originating instances.	-updok

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.

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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	<p>Only 64-bit versions of AIX with POWER7 as the minimum required CPU architecture level are Supported.</p> <p>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.</p> <p>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 <b>instfix -ik IZ87564</b>.</p> <p>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.</p>
x86_64 GNU/Linux	Red Hat Enterprise Linux 7.9, 8.7; Ubuntu 18.04 LTS, 20.04 LTS, and 22.04 LTS; Amazon Linux 2	<p>To run 64-bit GT.M processes requires both a 64-bit kernel as well as 64-bit hardware.</p> <p>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).</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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 <b>must</b> ensure that your kernel includes commit d2dc317d564a46dfc683978a2e5a4f91434e9711 (search for d2dc317d564a46dfc683978a2e5a4f91434e9711 at <a href="https://www.kernel.org/pub/linux/kernel/v4.x/ChangeLog-4.0.3">https://www.kernel.org/pub/linux/kernel/v4.x/ChangeLog-4.0.3</a>). The Red Hat Bugzilla identifier for</p>

Platform	Supported Versions	Notes
		<p>the bug is 1213487. With NODEFER_ALLOCATE, do not use any filesystem other than ext4 and a kernel with the fix, or xfs.</p> <p>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, however, we have not yet confirmed the change resolved issue. 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.</p> <p>Ubuntu 21.10 and Red Hat Enterprise Linux 9 are Supportable.</p> <div style="display: flex; align-items: flex-start;"> <div style="margin-right: 10px;">  </div> <div> <p><b>Note</b></p> <ul style="list-style-type: none"> <li>● To use TLSv1.3 with OpenSSL 1.1.1 and up, you must recompile the reference encryption plugins</li> <li>● RHEL 8 includes compat-openssl10.x86_64 for binaries compiled against OpenSSL 1.0.2 on RHEL 7</li> </ul> </div> </div>



### 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. GT.M releases are also normally supported for two years after release. While FIS attempts to provide support for customers in good standing on any GT.M release and operating system version, our ability to provide support diminishes after the two year window.

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


## 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 V7.1-000 in a Filesystem Hierarchy Standard compliant location such as `/usr/lib/fis-gtm/V7.1-000_arch` (for example, `/usr/lib/fis-gtm/V7.1-000_x86_64` on Linux systems). A location such as `/opt/fis-gtm/V7.1-000_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 `gtmsechr` is not running. If `gtmsechr` is running, first stop all GT.M processes including the DSE, LKE and MUPIP utilities and then perform a **MUPIP STOP *pid\_of\_gtmsechr***.
- 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 `gtmencrypt_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 `libcrypt`, `libpgme`, `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 libcrypt11-dev libpgme11-dev libconfig-dev libssl-dev
```

Note that the package names may vary by distribution / version.

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



The encryption plugin currently uses functionality that is deprecated in OpenSSL 3.0. This will be fixed in a future release.

## Re-evaluate TLS configuration options

The GT.M TLS reference encryption plugin implements a subset of options as documented in the OpenSSL 1.0.2 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".

## Upgrading to V7.1-000



### Before you begin

GT.M supports upgrade from V5\*, V6.\* and V7.\* versions to V7.1-000.

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 V7.1-000 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

Read the upgrade instructions of each stage carefully. Your upgrade procedure for GT.M V7.1-000 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 V7.1-000.
- 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 V7.1-000.
- 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 removes abandoned GT.M database semaphores and releases any IPC resources.

There are three upgrade paths available when you upgrade to V7.1-000.

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

Both phases operate once per region and require standalone access. 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.

While FIS has done considerable testing of MUPIP UPGRADE and MUPIP REORG -UPGRADE, the duration of that testing has not reached the level FIS typically performs for work of this complexity and impact. While our goal is to allow MUPIP REORG -UPGRADE to run with concurrent activity, our testing has not reached a level to allow it to run without standalone access. 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

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- 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 V7.1-000 but might be an issue for any as-yet unplanned further enhancement.

### 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

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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 V7.1-000. 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 V7.1-000 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 V7.1-000 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)



### 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 V7.1-000 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:

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- 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_V7.1-000_i686`, then `gtmprofile` sets `$gtm_dist` to `/usr/lib/fis-gtm/gtm_V7.1-000_i686/utf8`).
  - On platforms where the object files have not been placed in a `libgtmutil.so` shared library, the last element of `$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 sect1 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(xen1), 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(smkn), 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.

## Change History

### V7.1-000

Fixes and enhancements specific to V7.1-000:

Id	Prior Id	Category	Summary
GTM-DE325871	-	Other	Remove limit affecting sockets and improve error message where it still exists for GT.CM
GTM-DE340906	-	Language	Attempting a LOCK with more identical arguments than GT.M supports for the command generates an error
GTM-DE340950	-	Language	Exceeding the LOCK level limit for the same resource name generates a LOCKINCR2HIGH error
GTM-DE376223	-	Language	\$FNUMBER() handles fill requests up to close to the maximum string length
GTM-DE376224	-	Language	Modulo of non-canonical number by a divisor greater than 999,999 returns a canonical result
GTM-DE376239	-	Language	When GT.M inserts an implicit QUIT to prevent a possible error, it generates a FALLINTOFLST WARNING message 
GTM-DE388565	-	Language	Avoid inappropriate NUMFLOW from a literal Boolean argument with exponential (E) form
GTM-DE402020	-	DB	Prevent Block SIG-11 splits under rare concurrency conditions involving empty string values
GTM-DE408789	-	Admin	 MUPIP BACKUP -DATABASE uses faster copy mechanism when available 
GTM-DE411385	-	Language	Prevent rare terminations during compilation of certain nested global variable references under FULL_BOOLEAN
GTM-DE411386	-	Language	Prevent hangs when compiling certain indirectly nested Boolean expressions under FULL_BOOLEAN
GTM-DE421008	-	Admin	Triple MUPIP STOP within a minute similar, but slightly better than kill -9 
GTM-DE422089	-	Other	Improved detection and reporting of issues with utility command length and parsing 
GTM-DE422245	-	Language	GT.M correctly compiles certain indirectly nested Boolean expressions and provides a new option to control Boolean evaluation 
GTM-DE493831	-	Language	Prevent rare deadlock while using JOB command
GTM-F135385	GTM-9380	Admin	MUPIP RTCLDUMP reports the number of times a routine has been replaced (rtnsupersede) in the autorelink cache 
GTM-F135427	GTM-9450	Admin	 Support in-place conversion from V6 to V7 database formats 
GTM-F221672	-	Admin	Additional context in SHMHUGETLB syslog message



## Database

- GT.M deals appropriately with a concurrency issue encountered when splitting a block, the record triggering the split has a zero-length value, concurrent changes make the previous record appear identical to the one triggering the split, and GT.M attempts to calculate a parent key to demarcate the split. This apparently longstanding issue was detected by a customer using a stress test with the default proactive block split setting. While more likely with proactive block splits, the issue is difficult to reproduce without using carefully constructed update patterns. We have no indication that it has ever been previously reported by a customer or detected in our testing. Previously, the condition caused a process to fail with a segmentation violation (SIG-11) but did not result in any database damage. (GTM-DE402020)

## Language

- GT.M appropriately handles a command with multiple (more than 255) LOCKs with the same name. Previously, a GT.M command that created more than 255 LOCKs with the same name caused a segmentation violation (SIG-11). (GTM-DE340906)
- An attempt by a process to incrementally LOCK the same resource name more than 511 times produces a LOCKINCR2HIGH with accurate context. Previously LOCK processing did not appropriately detect the limit or supply correct context. (GTM-DE340950)
- \$FNUMBER() reserves appropriate memory to handle a third expr that approaches the maximum string length (currently 1MiB). Note that this function and \$JUSTIFY() reserve 65 bytes for their actual formatting. Previously, a large specification for this amount could cause a segmentation violation (SIG-11). (GTM-DE376223)
- Modulo of non-canonical number by a divisor greater than 999,999 returns a canonical result. Previously, it might not. (GTM-DE376224)
- GT.M reports a FALLINTOFLST error after an argumentless DO embedded subroutine followed by a label with a formallist when no QUIT terminates the code after the DO block, except when there are no lines between the end of the embedded subroutine and the label with the formallist, in which case GT.M infers a QUIT would be appropriate to separate them. When GT.M inserts an implicit QUIT, it issues a FALLINOFLLST warning unless compilation has a -NOWARNING qualifier. Previously, since the FALLINTOFLST error was introduced in V6.0-002, GT.M inappropriately gave that error for cases of that combination under circumstances where the QUIT was on the same line as the argumentless DO rather than explicitly between the embedded subroutine and the label with the formallist. (GTM-DE376239) 🟢
- GT.M handles string literal operands to a Boolean string relational operator where the literal contains an exponential format appropriately. Previously such a combination inappropriately produced a NUMOFLOW error if the numeric evaluation would have produced an error. (GTM-DE388565)
- GT.M correctly processes Boolean expressions with side effects which occur as subscripts to global variable references which are themselves subscripts of global variable references, when both gtm\_boolean>=1 and gtm\_side\_effects>=1. Previously, this circumstance could lead to process termination due to a segmentation violation during compilation. Constructions known to produce this error did so inconsistently and under rare compilation conditions. These cases were not reported as appearing in customer code but rather identified using a "fuzzer." (GTM-DE411385)
- GT.M appropriately processes relational expressions which operate on a negated Boolean expression, are operated on by another Boolean expression, contain at least one side effect, and are compiled under FULL\_BOOLEAN or FULL\_BOOLWARN settings. Previously, GT.M hung during compilation under these conditions. These cases were not reported as appearing in customer code but rather identified using a "fuzzer." (GTM-DE411386)
- GT.M appropriately handles indirectly nested Boolean expressions where a parent Boolean operates on a non-arithmetic, non-Boolean expression, that expression itself operates on at least one Boolean, at least one sub-expression except for the first contains a side-effect, and gtm\_boolean>=1. Previously, this situation would result in out-of-order execution of certain operations and could produce an incorrect truth value. This construction was discovered in "fuzzer" testing, and machine code scans of several million lines of mumps source code did not reveal any instances of this issue in application code. As part of these changes, GT.M provides the option of eliminating all Boolean short-circuiting by setting 'extended Boolean' with the environment variable gtm\_boolean=3. Under this setting, GT.M evaluates all operations in a Boolean expression from left to right, even those without visible side effects. The Boolean expression itself is evaluated only after all operands. Enabling this setting comes with a serious performance cost. These changes also increase the effectiveness of GT.M's Boolean literal optimizations under all settings. (GTM-DE422245) 🟢

- GT.M properly handles interrupts while jobbing off of a child process. Previously, in rare circumstances and related to timing, an interrupt could result in a deadlock. This was only seen in development and not reported by a customer. (GTM-DE493831)

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## System Administration

- MUPIP BACKUP -DATABASE attempts to use a faster copy mechanism depending on the support by the kernel, and by source and destination filesystems. If the source and destination filesystems are different or the faster copy mechanisms are not available in the kernel, MUPIP BACKUP -DATABASE uses the default copy mechanism (/bin/cp). Previously, GT.M used faster copy mechanisms only on Linux Kernel 5.3 or above, and changes due to backporting in Linux kernels could cause MUPIP BACKUP to report an EXDEV error on filesystems where backups had earlier been supported.

MUPIP BACKUP -ONLINE does not retry backup when it detects a concurrent rollback or on certain errors during the copy phase of BACKUP. Previously, MUPIP BACKUP -ONLINE incorrectly retried backup when it encountered a concurrent rollback or an error in the first backup attempt; the workaround was to specify -RETRY=0. [Linux] (GTM-DE408789) 🚫🟢

- MUPIP STOP three times within a minute logs the event to syslog and otherwise acts like a kill -9 by stopping a process at points that may not be safe, except that it may produce a core file; previously any three MUPIP STOPS over the life of a process acted like a kill -9 and produced no record of the event. (GTM-DE421008) 🟢
- MUPIP RTCLDUMP reports the number of times a routine has been superseded (rtnsupersede) in the autorelink cache. Previously, MUPIP RTCLDUMP did not record this value, and only recorded the number of times a routine has been referenced. (GTM-F135385) 🟢
- GT.M V7.1-000 provides the capability to upgrade a V6 database to V7 in-place. There is no ability to downgrade a V7 database to V6 in place. You can use MUPIP EXTRACT on V7 and MUPIP LOAD on V6 as long as the data does not cause the V6 database file to exceed the V6 maximum limits or revert to a prior version using a suitable combination of replicating instances. GT.M V7.1-000 blocks all access to a V6 database marked as not fully upgraded from V4 format.

GT.M V7 databases differ from V6 in the following ways. Please refer to the Administration and Operations Guide for more details about these differences.

- Starting Virtual Block Number (VBN) is 8193, or slightly more on upgraded files, in V7 vs. 513 in V6
- Block "Pointers" are 64-bit in V7 rather than 32-bit in V6

A GT.M V7 instance can originate BC/SI replication stream to or replicate from a V6 BC/SI replication stream as long as the V7 database remains within the maximum V6 limits.

The V6 to V7 database upgrade process is split into two phases intended to reduce the downtime necessary for a database upgrade. This process is considerably faster and consumes less disk space than a traditional extract, transfer and load cycle. Please refer to Upgrading to GT.M V7.1-000 for more details. (GTM-F135427) 🚫🟢

- The SHMHUGETLB syslog warning message provides information about the operation of the calling process. Previously, SHMHUGETLB failure messages did not include operational information necessary to understand the reasons for such failures. (GTM-F221672)

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## Other

- GT.M processes can use sockets created when over 1021 files, pipes, fifos, sockets, and/or regions are already open. GT.M issues an FDSIZELMT error message when there are too many descriptors needed by GT.M servers. Previously, sockets created when there were too many open descriptors caused an GTMASSERT2 error. (GTM-DE325871)
- GT.M command line parser correctly terminates input with a null byte. Previously, in rare cases, the parser appended random characters for a PIPE device usage where a WRITE followed by the format control character "!" did not precede WRITE /EOF. This was seen only in development/testing and never reported by a user.

GT.M reports the LINETOOLONG error when input to a DSE, MUPIP, or LKE utility prompt exceeds the allowed maximum of 33022 bytes. Additionally, GT.M reports the ARGTRUNC warning when a shell argument of a GDE, MUPIP, or LKE utility executable exceeds

the allowed maximum of 33022 bytes. Previously, GT.M silently truncated shell arguments that exceeded these limits and did not produce an error when input to a utility prompt exceeded the allowed 33022 bytes. (GTM-DE422089) 🟢

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## Error and Other Messages

### ARGTRUNC

**ARGTRUNC**, UUUU argument number CCCC truncated. Keep the size of total command line within NNNN bytes

DSE/LKE/MUPIP Warning: This warning appears when the GT.M parser truncates an argument of a GT.M Utility (DSE, LKE, or MUPIP) executable exceeding the allowed maximum of NNNN bytes. CCCC is the argument number with 1 being the first argument for the GT.M Utility executable.

Action: Reduce the size of the argument number CCCC.

### DBUPGRDREQ

**DBUPGRDREQ**, Database file DDDD is not fully upgraded (format FFFF) and cannot be used by this version of GT.M. Please upgrade the database.

MUPIP Error: The database file DDDD with block format FFFF has the fully upgraded flag set to FALSE indicating that it holds a mix of block versions.

Action: While GT.M V6.\* can use database files with formats V4/V5/V6 to V6, GT.M V7.\* cannot handle the V4 block format. Use GT.M V6.\* to fully upgrade the database file to V6 format before using with GT.M V7.\*. Note that a partial MUPIP UPGRADE of a V6 database leaves database in an incomplete state because MUPIP UPGRADE is not repeatable. Any attempt to access such a database results in this error.

### FALLINTOFLST

**FALLINTOFLST**, Fall-through to a label with formallist is not allowed

Run Time/Compile Time Error: This error indicates that M code reached a label with a formallist by falling through from the previous label. When issued as a warning, it indicates the compiler determined such an error could happen and may have inserted an implicit QUIT to prevent the run-time error

Action: Revisit your code to ensure that all invocations of labels with a formallist occur using a DO command or extrinsic function (\$\$).

### LINETOOLONG

**LINETOOLONG**, UUUU prompt input exceeds NNNN bytes

DSE/LKE/MUPIP Error: This error appears when the GT.M parser detects the input to a GT.M Utility (DSE, LKE, or MUPIP) prompt exceeds the allowed maximum of NNNN bytes.

Action: Reduce the size of input to the utility prompt. If input to the UUUU prompt is from a GT.M PIPE device, set the RECORDSIZE deviceparameter to a value less than NNNN bytes.

### ORLBKDBUPGRDREQ

**ORLBKDBUPGRDREQ**, Region RRR (DDDD) is not fully upgraded. ONLINE ROLLBACK cannot continue

MUPIP Error: Region RRR pointing to database file DDDD has the fully upgraded flag set to FALSE and the database format is not V7 indicating that there are V4 blocks in the database. ONLINE ROLLBACK in GT.M V7.\* cannot process these database files.

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Action: Because an ONLINE ROLLBACK is not possible for this database, stop all access to the database files and perform a ROLLBACK with standalone access.

### REORGUPCNFLCT

**REORGUPCNFLCT**, MUPIP AAAA encountered a conflict due to OOOO (PID:PPPP)

MUPIP Error: MUPIP action AAAA encountered a conflict due to a concurrent operation OOOO run as process ID PPPP.

Action: MUPIP operations REORG UPGRADE and ONLINE ROLLBACK cannot run concurrently due to conflicting database changes. REORG UPGRADE exits if an ONLINE ROLLBACK is in progress or if it detects that an ONLINE ROLLBACK has started. ONLINE ROLLBACK pauses while waiting for the REORG UPGRADE to exit. ONLINE ROLLBACK has priority over REORG UPGRADE.