Linear Tape File System (LTFS) Linux and Mac User Guide

Abstract

This document provides information about the Linear Tape File System (LTFS), which presents an LTO-5 or LTO-6 SAS tape drive and media as a disk volume.

Acknowledgements

Apple® and Mac OS® X are trademarks of Apple Inc., registered in the U.S. and other countries.

Linux® is the registered trademark of Linus Torvalds in the U.S. and other countries.

Linear Tape-Open, LTO, LTO Logo, Ultrium and Ultrium Logo are trademarks of Quantum, HP and IBM in the US, other countries or both.

Contents

1 Introduction

This guide provides information about the Linear Tape File System (LTFS) Software. LTFS makes tape self-describing, file-based, and easy-to-use and provides users with the ability to use standard file operations on tape media for accessing, managing and sharing files with an interface that behaves as a hard disk. In addition, LTFS provides the ability to share data across platforms, as you would with a USB drive or memory stick.

NOTE: A firmware update may be required. LTFS will check and tell you if your tape drive needs updating.

Features

- Provides all you need to use LTO tape media as a disk
- Based on Open Source software
- Precompiled application versions provided for supported platforms
- Full source code available
- Supported on Linux and Mac OS X

Intended usage

The LTFS application presents the contents of the tape as a disk volume. However it is important to bear in mind that it is not a true disk, and therefore there are some best practices to follow to ensure satisfactory performance and a good user experience.

- LTFS is designed to work best in a single-user environment, where just one user is copying files to or from the tape. Multiple users or processes trying to write and/or read at the same time will result in poor performance due to the sequential access nature of tape.
- For the same reasons, the tape drive should not be shared between different systems. A single tape drive should be connected to a single host bus adapter (HBA).
- The expected usage model is to transfer large files between systems, by mounting the tape on one system, writing the files, unmounting, mounting on the second system, and reading the files. Treating the tape volume as a true random access device (for example frequently reading and updating individual files) will not perform as well as streaming large files to and from tape.
- The LTFS application will work in conjunction with graphical file explorer programs such as Nautilus or Konqueror (on Linux). However because these types of applications tend to try to pre-read files in the directory, using the graphical explorer window may lead to poor performance. For optimum performance, use a terminal window and issue shell commands to copy data, view directory contents, and so on.

Architecture

LTFS is a user space application, making use of the FUSE kernel mode subsystem included in Linux systems. On the Apple Mac OS platform it uses the OSXFUSE module (or, for Leopard or Snow Leopard systems, the MacFUSE module).

Supported configurations

LTFS supports:

- LTO-5 Ultrium tape drives with SAS interfaces
- LTO-6 Ultrium tape drives with SAS interfaces
- Red Hat Enterprise Linux (RHEL) 5.5 or later (32-bit and 64-bit)

- SuSE Enterprise Linux (SLES) 11 (32-bit and 64-bit)
- Mac OS X (Leopard, Snow Leopard, Lion and Mountain Lion—that is, 10.6 through 10.9)

NOTE: Only the binaries supplied are supported, not those built from the source.

2 Linux: Installation and configuration

When using LTFS with LTO-5 or LTO-6 tape drives, the following components are required:

- A drive firmware revision that supports dual partitioning. LTFS will check and tell you if your tape drive needs updating. HP L&TT should be used if a firmware update is required.

- The software package that contains the "run-time" executable.

- The FUSE kernel module

NOTE: HP L&TT can be downloaded from http://www.hp.com/support/tapetools.

Downloading and installing LTFS (precompiled binaries)

1. Before starting to install and use LTFS, you must ensure that the FUSE kernel module is present and loaded.

   To check, execute the following command:

   `$ lsmod | grep fuse`

   - If the module is not listed as currently loaded, you must load it before proceeding:

     `$ modprobe fuse`

   - If the module is not present on your system, you must first obtain and install it. Details of how to do this are beyond the scope of this guide; refer to http://fuse.sourceforge.net/ for further information.

2. Determine whether you want to use precompiled binaries or build your own version of the LTFS application.

   To build your own, download and unpack the tar source file and then follow the instructions in `ltfs-<version>/doc/BUILDING.linux`.

   IMPORTANT: Currently, only installations using the precompiled binaries are supported.

3. To use precompiled binaries, download the appropriate Binaries file and unpack it.

   The installation package for RHEL contains the below files:

   - Compressed tar file for installation on 32–bit systems
   - Compressed tar file for installation on 64–bit systems

   NOTE: Although the file name for the first two files may include `RHEL5.5`, the executables have been tested and verified for correct operation on versions up to and including RHEL 6.4.

   - `README` (general usage information)
   - `INSTALLING.linux` (prerequisites and installation instructions)
   - `COPYING.lib` (LGPL v2.1 required licensing text)

   The installer package for SuSE Linux contains a similar set of files with appropriate binaries for 32-bit and 64-bit systems.

4. Unpack the appropriate package for your architecture into the root directory.

   `$ gunzip <File_Name>`

   `$ tar-xvf <File_Name> -C /`

   This will place four executables in `/usr/local/bin/` (`ltfs`, `mkltfs`, `ltfsck`, `unltfs`).

   It will also place a number of dynamic libraries in `/usr/local/lib/` and in a new subdirectory called `/usr/local/lib/ltfs/`.

5. LTFS is now installed. See ??? for next steps.

To uninstall LTFS

If at a later date you want to uninstall LTFS from your system, delete the following files and directories:

- `/usr/local/bin/*ltfs*`
- `/usr/local/etc/ltfs*`
- `/usr/local/share/ltfs*`
- `/usr/local/lib/libltfs*`
- `/usr/local/lib/ltfs/*`

3 Mac OS X: Installation and configuration

When using LTFS with LTO-5 or LTO-6 tape drives, the following components are required:

- A drive firmware revision that supports dual partitioning
- The software package that contains the "run-time" executable
- The OSXFUSE kernel module (or, for older systems, the MacFUSE kernel module)

NOTE: LTFS will check and tell you if your tape drive needs updating. HP L&TT should be used if a firmware update is required. It can be downloaded from http://www.hp.com/support/tapetools.

Downloading and installing LTFS (precompiled binaries)

1. Determine whether you want to use precompiled binaries or build your own version of the LTFS application.

   To build your own, download and unpack the source tar file and then follow the instructions in `ltfs-<version>/doc/BUILDING.macosx`. Note that in this case you must also obtain and install the OSXFUSE and ICU packages.

   IMPORTANT: Only installations using the precompiled binaries are supported.

2. To use precompiled binaries, download the install file for Mac Os.

   This contains the three packages that are necessary for operation: OSXFUSE, ICU, and LTFS.

3. Install the ICU package first by double-clicking on the file `ICUFramework-<version>.pkg` and following the instructions.

4. Install the OSXFUSE package in a similar way.

5. Install the LTFS package by double-clicking on the install file and following the instructions.

6. LTFS is now installed. The installation package also places a "Linear Tape File System" application in your Applications folder which can be used to simplify the tasks of preparing, formatting and mounting an Linear Tape File System volume.

   See "Using LTFS" (page 11) for next steps.

To uninstall LTFS

If at a later date you want to uninstall LTFS from your system, delete `/usr/local/bin/*ltfs*` and then delete the tree under `/Library/Frameworks/LTFS.framework`.

The GUI management application can be uninstalled by dragging it to the Trash. To cause the Package Manager subsystem to remove references to LTFS, execute the command:

```
pkgutil --forget com.hp.ltfs
```

To delete the ICU package as well, delete the tree under `/Library/Frameworks/ICU.framework`.

4 Using LTFS

How to use LTFS

NOTE: On Mac OS X, you can execute steps 1–3 and 5 more easily using the Linear Tape File System application, installed by default in your Applications folder when LTFS is installed. This graphical user interface (GUI) application will guide you through the steps required to select a tape drive, load and format a tape cartridge, and then mount the cartridge into the file system. However command line tools are also installed and, if you prefer, you can use them instead of the GUI application.

---

1. Open a terminal window on your system. Ensure that `/usr/local/bin/` is in your command search path. For example:

   ```
   $ export PATH="$PATH:/usr/local/bin"
   ```

2. Load a tape cartridge into the drive, and then format it in LTFS format:

   For Linux:

   ```
   $ mkltfs -d /dev/st0
   ```

   For Mac OS X:

   ```
   $ mkltfs -d 0
   ```

   `mkltfs` options:

`-d, --device=<name>`	Tape device (required). For Linux, use the device name, such as `/dev/st0`. For MacOS X, use the instance number of the tape drive, assigned sequentially by the system, starting from `0`.
`-s, --tape-serial=<id>`	Tape serial number (6 alphanumeric ASCII characters)
`-n, --volume-name=<name>`	Tape volume name (empty by default)
`-r, --rules=<rules>`	Rules for choosing files to write to the index partition. The syntax of the rules argument is: • `size=1M` • `size=1M/name=pattern` • `size=1M/name=pattern1:pattern2:pattern3` A file is written to the index partition if it is no larger than the given size AND matches at least one of the name patterns (if specified). The size argument accepts K, M and G suffixes. Name patterns may contain the special characters '`?`' (match any single character) and '`*`' (match zero or more characters).
`-o, --no-override`	Disallow mount-time data placement policy changes.
`-w, --wipe`	Restore the LTFS medium to an unpartitioned medium (format to a legacy scratch medium).
`-q, --quiet`	Suppress progress information and general messages.
`-f, --force`	Force reformat of the existing LTFS volume (normally disallowed).
`-t, --trace`	Enable function call tracing (only useful for debugging).
`-h, --help`	This help
`-p, --advanced-help`	Full help, including advanced options

3. Mount the formatted tape cartridge:

   ```
   $ mkdir /mnt/lto5
   $ ltfs /mnt/lto5
   ```

`ltfs` options:

`-o devname=<dev>`	Tape device (*default:*/dev/st0)
`-o work_directory=<dir>`	LTFS work directory (*default:*/tmp/ltfs/)
`-o trace`	Enable diagnostic output
`-o eject`	Eject the cartridge after unmount
`-o sync_type=<type>`	Specify sync type (*default:*time@5). `<type>` should be specified as follows: • `time@min`: LTFS attempts to write an index each `min` minutes; `min` should be a decimal number from 1 to 65536 (*default:* min=5). • `close`: LTFS attempts to write an index when a file is closed. • `unmount`: LTFS attempts to write an index when the medium is ummounted.
`-o force_mount_no_eod`	Skip the EOD existence check when mounting (read-only mount). Only use for a CM-corrupted medium.
`-o rollback_mount=<gen>`	Attempt to mount on previous index generation (read-only mount).
`-o release_device`	Clear device reservation (should be specified with —o devname)
`-o symlink_type=<type>`	Specify symbolic link type (default: posix). <type> should be specified with one of the following values: • posix: LTFS behavior is same as standard symbolic link • live: LTFS replaces mount point path by current mount point
`-o nosizelimit`	Attempt to use a block size of 1 MB, overriding the normal restriction of 512 kB. This should be used only when necessary as it may lead to interchange difficulties in the future.
`-a`	Advanced help, including standard FUSE options
`-V, --version`	Output version information and exit.
`-h, --help`	Display this help and exit.
FUSE options:	
`-o umask=M`	Set file permissions (octal)
`-o uid=N`	Set file owner
`-o gid=N`	Set file group

NOTE: On Mac OS X, the LTFS application always runs as a foreground process and the terminal window will now be dedicated to the running LTFS process. Open another terminal tab or window to continue.

4. Write files to the LTFS volume. For example:

```
$ cp -r /root /mnt/lto5/
```

5. Unmount the tape cartridge. This flushes the data buffer of the file system to the tape cartridge, and prepares for eject.

```
$ umount /mnt/lto5
```

or

```
$ fusermount -u /mnt/lto5
```

> **CAUTION:** The `umount` (or `fusermount`) command will return immediately, but the drive may still be busy writing cached data to tape. Do not attempt to remove the tape cartridge from the drive until all activity has finished. Check the front panel LEDs and wait for them to stop flashing. Attempting to remove the cartridge before this may cause corruption of the tape format.

> **NOTE:** `fusermount` is only available on Linux.

Usage details

Format version compatibility

Earlier versions of the LTFS application supported the original 1.0 LTFS format specification; version 2.1.0 onwards supports the updated 2.1.0 LTFS format specification. LTFS volumes created with application v2.1.0 or later will not be readable in older versions of the LTFS application, as shown in the following table:

Table 1 LTFS compatibility

LTFS application	Cartridge written by LTFS application v1.1.0 or earlier	Cartridge written by v2.1.0 or later
v1.1.0 or earlier	Can be read and written	Cannot be mounted
v2.1.0 or later	Can be read; will automatically be converted to the new format if written	Can be read and written

All instances of LTFS should be updated to v2.1.0 or later to avoid these compatibility issues.

If, for some reason, it is important to maintain cartridges readable by previous versions of the LTFS application, care should be taken to avoid writing to those cartridges with the new version of the application. This may be accomplished by mounting the volume as read-only, or by using the cartridge write-protect tab to prevent cartridge updates. However, this should be regarded as a temporary measure until all the application instances can be updated to v2.1.0 or later.

Use of sync_type options

Previous versions of LTFS supported a single mechanism for updating the tape index, in which the index was written to tape only when the volume was unmounted. In normal operation this is sufficient since the LTFS usage model requires the volume to be unmounted after use, so there is always a valid index. However, if power is removed from the drive without unmounting, for example due to an unplanned power outage or accidental unplugging, the volume will be left in an inconsistent state and all files added since the last dismount operation will be inaccessible. The `ltfsck` utility may be able to recover the file data to the `_ltfs_lostandfound` directory but the metadata (such as filename, access dates) will be lost.

To address this exposure, LTFS offers two additional mechanisms for updating the tape index. The first is to write a copy of the index to tape periodically while writing data; this is the new default behavior and the index is written out every five minutes. The time interval can be set with a resolution of one minute. This method of index update reduces the window of exposure to power loss events, since there will always be an index on tape no more than five minutes old (if using the default interval).

The second additional mechanism provided in LTFS is to update the index every time a file is closed after writing. This further reduces the exposure window to a single file, or (if several processes are using the volume simultaneously) to the number of files being written concurrently. However, this does add some overhead to LTFS, both in terms of the tape capacity used for each index, and also in terms of performance since the writing of the index will take bandwidth away from writing data. These overhead effects are more severe with smaller file sizes.

In most cases the default LTFS behavior offers the best solution, but the new features allow the behavior to be tailored to a particular situation. The following table summarizes the options now available for choosing when the index is updated.

Table 2 Index update options

sync_type	Index is flushed to tape	Potential benefits	Potential downsides
unmount	When a volume is unmounted (default LTFS v1.1.0 behavior)	• Minimal capacity overhead • No impact on performance	• Exposure to risk of power fails during writing
time@n	Every n minutes during writing (default LTFS behavior from v1.2.0, n=5)	• Exposure to risk of power fails is limited to the last n minutes	• Some capacity overhead since the index is written more frequently • Negligible impact on performance
close	When any file opened for writing is closed	• Exposure to risk of power fails is limited to a single file (more if several processes are writing to different files concurrently)	• Greater capacity and performance overhead, especially if writing small files

User permissions

Note that on some systems, the logged-in user may not have access rights to the tape device (such as /dev/st0). You can address this in two ways:

- Have a super-user change the permissions on the tape device file
- Execute the ltfs command with the sudo command (such as sudo ltfs /mnt/lto5).

The second approach is recommended as this preserves the integrity of the system.

File permissions

The LTFS application manages a common set of file permissions for all files and users; file and directory ownership is not recorded to tape. The only permission that is tracked is write-protect information. Files or directories that are write-protected have their permission bits set to 555; write-enabled files and directories have their permission set to 777. By default the user and group information is set to that of the current user; this can be overridden by use of the -o uid and -o gid options to the LTFS application.

File types

The LTFS application does not support the creation of symbolic links or hard links within the tape file system. Attempting to create a link or copy a link to tape will result in a "Function not implemented" error. If using the cp command to copy to tape, the '-L' option may be helpful to follow symlinks.

The LTFS application also does not support creation of special files and will report "Function not implemented".

File names

To maintain compatibility when copying files between multiple platforms, it is strongly recommended that the following characters should not be used in LTFS for file names, directory names, or extended attributes: `* ? < > : " | / \`

Limitations

- When the tape cartridge is almost full, further write operations will be prevented. The free space on the tape (such as from the `df` command) will indicate that there is still some capacity available, but that is reserved for updating the index when the tape is unmounted.

- Future mounts of a cartridge that is almost full (has passed the point at which "early warning" is reported) will mount as Read Only, to prevent further modifications which may not fit on tape. This status is cleared when a cartridge is reformatted (using `mkltfs`) or when the volume is rolled back, erasing history (using `ltfsck`).

MAC OS X only

- The `ltfs` program will currently always run in the foreground (equivalent to passing `-f` option). This is done automatically and may be changed in future releases.

- LTFS does not support moving a folder within LTFS. Any attempt to move a folder in such a manner will result in an "`operation not permitted`" error, and the operation will be ignored. The user can still move a file within LTFS, and the also move a folder to and fro between an LTFS and a non-LTFS file system.

- Mac OS X's Spotlight will not display the files on LTFS as a result of a search.

Removing LTFS format

If at some time in the future you wish to remove the LTFS format from the cartridge so that it can be reused for a different purpose, use the `unltfs` utility.

CAUTION: This will *irretrievably destroy* all contents of the cartridge, so use it only when you are sure that you wish to erase the LTFS volume.

`unltfs` options:

`-d, --device=<name>`	Specifies the tape drive to use.
`-y, --justdoit`	Omits normal verification steps, reformats without further prompting.
`-e, --eject`	Ejects the tape after the operation completes successfully.
`-q, --quiet`	Suppresses all progress output.
`-t, --trace`	Displays detailed progress.
`-h, --help`	Shows this help.
`-i, --configure=<file>`	Overrides the default config file.
`-b, --backend`	Specifies a different tape backend subsystem.
`-x, --fulltrace`	Displays debug information (verbose).

5 Troubleshooting

General

If problems occur during LTFS operation, entries may be made in the system log (such as `/var/log/messages` on RHEL systems). Check for entries made with the service name "`ltfs`".

Both `ltfs` and `mkltfs` have command line options to report further details of the operations undertaken, which may help when trying to troubleshoot problems.

If there is a problem with drive interaction, LTFS will attempt to create a snapshot of the drive's internal state at the time of failure. A snapshot may also be taken at unmount time.

- **On Linux systems:** this will be stored in the system log directory (such as `/var/log/`) and will take the form `ltfs_datestamp_timestamp_driveSerialNum.ltd`.

- **On Mac OS X systems:** the snapshots are stored in the directory `~/Library/Logs/LTFS/`.

These files are not otherwise used by LTFS and you can safely be remove them from the system, if they are not needed for troubleshooting.

Note that logs may not be created, and warning messages issued, in either of the following cases:

- The `ltfs` process does not have write permissions for the log directory

  Resolution: Run `ltfs` as root, or use the *`log_directory`* option to specify a directory for which it does have the required permissions.

- The log directory does not exist

  Resolution: Create the log directory indicated, or use the *`log_directory`* option to specify a directory which already exists.

Shared libraries

On some systems, trying to execute the `ltfs` command may result in an error message of the form "`libltfs.so.0: cannot open shared object file: No such file or directory`".

To resolve this, it is necessary to tell the linker/loader how to locate the required dynamic library files. There are several ways of doing this:

- Add `/usr/local/lib/` to the environment variable `LD_LIBRARY_PATH`.

  Or

- (As root) Add `/usr/local/lib/` to the file `/etc/ld.so.conf`, and then execute `/sbin/ldconfig`.

Refer to the man pages for `ld.so` and `ldconfig` for further details.

Similar error messages may occur if one or more required shared libraries are not present on the system, or are present but at the wrong revision. Refer to the Release Notes for the particular dependencies of the LTFS release.

Drive connection

The LTFS application requires that the LTO-5 or LTO-6 tape drive is powered up and connected to the system. This can be verified using:

- **Linux:** `cat /proc/scsi/sg/device_strs`

- **Mac OS X:** Use the System Profiler tool (**Applications > Utilities**) to check specific devices connected to your SAS controller.

If the LTO drive is not shown, check the cabling, power, and so on. LTFS will not be able to operate until the drive is detected.

Using LTFS to check the cartridge

Every time a cartridge is mounted onto the system, the LTFS application will perform a consistency check to ensure that the index information is accurate and up-to-date with the data on the tape. If for some reason there is a problem, the mount operation will fail.

In order to recover the tape to a consistent state, you can use the `ltfsck` utility to check and repair the LTFS volume. The options to `ltfsck` are shown below; the only required parameter is the device name (such as `/dev/st0` on Linux), but the behavior of `ltfsck` can be controlled through the following:

Usage: `ltfsck <options> filesys`

where `filesys` is the device file for the tape drive

`-g, --generation=<generation>`	Specify the generation to roll back.
`-t, --time=<time>`	Specify the time to rollback. Time value should be "*yyyy-mm-dd HH:MM:SS.nanosec*".
`-r, --rollback`	Rollback to the point specified by `-g` or `-t`.
`-n, --no-rollback`	Do not roll back, just verify the point specified by `-g` or `-t` (*default*).
`-f, --full-recovery`	Recover extra data blocks into directory `_ltfs_lostandfound`.
`-z, --deep-recovery`	Recover a cartridge that has EOD missing. Note that some blocks may be erased but recover to final unmount point which has an index version "2.0.0" or earlier.
`-l, --list-rollback-points`	List rollback points.
`-j, --erase-history`	Erase the history at rollback.
`-k, --keep-history`	Keep the history at rollback (Rollback).
`-q, --quiet`	Suppress informational messages.
`-a, --trace`	Enable function call tracing.
`-h, --help`	This help
`-p, --advanced-help`	Full help, including advanced options

NOTE: You should only need to use the `-z` option when a mount operation has failed and `ltfs` has advised that deep recovery is required.

Note also that the "erase history" operation cannot be undone, so only use this option when you are sure that you need it.

6 Frequently asked questions

Q: How do I get LTFS?

A: All application downloads and documentation are available from your tape drive supplier.

Q: What are the minimum system requirements?

A: Any server that fulfills the needs of the supported configurations detailed in Supported configurations (page 5).

Q: Does LTFS support DDS/DAT devices?

A: No. Only LTO-5 and LTO-6 drives are supported.

Q: Why does LTFS not work with my LTO-4 or earlier drives?

A: LTFS relies on a drive feature called partitioning, which was added to the LTO-5 format. It is not part of the LTO-4 or earlier tape formats and they cannot be used.

Q: Can I use LTO-4 media in my LTO-5 or LTO-6 drive?

A: LTO-5 drives can load, read and write LTO-4 media, and LTO-6 drives can load and read (but not write) LTO-4 media. However, the LTO-4 format does not support partitioning, so LTO-4 media cannot be used with LTFS.

Q: Can I use WORM media with LTFS?

A: No, WORM media cannot be partitioned, and so is not usable with LTFS.

Q: Can I uninstall LTFS?

A: Yes.

Linux: Delete the four executable files (`ltfs`, `mkltfs`, `ltfsck`, `unltfs`) from `/usr/local/bin`. Delete the `ltfs` library files `/usr/local/lib/libltfs*` and `/usr/local/lib/ltfs/*`. Delete the ltfs support files `/usr/local/etc/ltfs*` and `/usr/local/share/ltfs/ltfs`.

Mac OS X: Delete the tree under `/Library/Frameworks/LTFS.framework` and the four `ltfs` symbolic links in `/usr/local/bin` (`ltfs`, `mkltfs`, `ltfsck`, `unltfs`). To delete the ICU package as well, delete the tree under `/Library/Frameworks/ICU.framework`.

Q: Where do I go if I have a problem?

A: For most common issues, see Troubleshooting (page 17). If this does not address the issue, call support.

Q: Does LTFS replace my existing backup software?

A: In most cases it is recommended that you continue to use your existing backup application. LTFS provides a good method of storing and transporting large files but is not generally a direct replacement for a backup application.

Q: Is source code available for LTFS?

A: Yes, full source code is released under the terms of the LGPLv2.1 and can be obtained from your tape drive supplier. Customers who choose to download and build their own versions of the LTFS application are not supported.