

# CipherTrust Transparent Encryption

## CTE-Live Data Transformation with CipherTrust Manager

Release 7.0.0

Document Version 1

September 22, 2020

The bottom half of the page features a dark blue background with abstract geometric shapes. On the left, there is a large teal triangle pointing upwards. Below it, a black triangle points upwards. At the bottom left, a teal semi-circle is visible. The bottom right area has a fine grid of small white dots.

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# Preface

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*CTE-Live Data Transformation with CipherTrust Manager* describes how to configure and use CipherTrust Transparent Encryption - Live Data Transformation (CTE-LDT) when the host is registered to CipherTrust Manager. If you want to use a Vormetric Data Security Manager (DSM) as your key manager, see the *CTE-Live Data Transformation with Data Security Manager* guide.

CTE-LDT is an optional, separately licensed feature of CipherTrust Transparent Encryption (CTE). With CTE-LDT, a CipherTrust Manager Administrator can change the encryption key and re-encrypt GuardPoint data without suspending user or application access to the data.

## Intended Audience

*CTE-Live Data Transformation with CipherTrust Manager* is for security teams who want to rekey the existing GuardPoint data, or who need to perform an initial encryption of their GuardPoint data.

## Assumptions

CipherTrust Transparent Encryption - Live Data Transformation is an enhancement to existing functionality. This documentation assumes the reader is familiar with the following CipherTrust products and processes:

- CipherTrust Manager
- CipherTrust Transparent Encryption (CTE)
- Key management
- Data encryption

## The CTE Agent Documentation Set

The following guides are available for CTE Agent:

- *CTE Agent for Linux Quick Start Guide*
- *CTE Agent for Linux Advanced Configuration and Integration Guide*
- *CTE Agent for Windows Quick Start Guide*
- *CTE Agent for Windows Advanced Configuration and Integration Guide*
- *CTE Agent for AIX Installation and Configuration Guide*
- *CTE-Live Data Transformation with Data Security Manager*
- *CTE-Live Data Transformation with CipherTrust Manager*
- *Compatibility Matrix for CTE Agent with CipherTrust Manager*
- *Compatibility Matrix for CTE Agent with Data Security Manager*
- *Compatibility Matrix for CTE Agent for AIX with CipherTrust Manager*
- *Compatibility Matrix for CTE Agent for AIX with Data Security Manager*
- *Release Notes for CTE for Linux Version 7.0.0.47*
- *Release Notes for CTE for Windows Version 7.0.0.47*
- *Release Notes for CTE for AIX Version 7.0.0.11*



## Document Conventions

The document conventions describe common typographical conventions and important notice and warning formats used in Thales technical publications.

## Typographical Conventions

This section lists the common typographical conventions for Thales technical publications.

**Table 3-1: Typographical Conventions**

Convention	Usage	Example
<b>bold regular font</b>	GUI labels and options.	Click the <b>System</b> tab and select <b>General</b> Preferences.
<i><b>bold italic monospaced font</b></i>	variables or text to be replaced	https://<Token Server name>/admin/ Enter password: <Password>
<code>regular monospaced font</code>	Command and code examples XML examples	Example: session start iptarget=192.168.253.102
<i>italic regular font</i>	GUI dialog box titles	The <i>General Preferences</i> window opens.
	File names, paths, and directories	/usr/bin/
	Emphasis	<i>Do not</i> resize the page.
	New terminology	<i>Key Management Interoperability Protocol (KMIP)</i>
	Document titles	See <i>CTE-Live Data Transformation with CipherTrust Manager</i> for information about CipherTrust Transparent Encryption.
quotes	File extensions Attribute values Terms used in special senses	“.js”, “.ext” “true” “false”, “0” “1+1” hot standby failover

## Notes, tips, cautions, and warnings

Notes, tips, cautions, and warning statements may be used in this document.

A Note provides guidance or a recommendation, emphasizes important information, or provides a reference to related information. For example:

### Note

It is recommended to keep tokenization keys separate from the other encryption/decryption keys.

A tip is used to highlight information that helps you complete a task more efficiently, such as a best practice or an alternate method of performing the task.

### Tip

You can also use Ctrl+C to copy and Ctrl+P to paste.

Caution statements are used to alert you to important information that may help prevent unexpected results or data loss. For example:



**CAUTION**

**Make a note of this passphrase. If you lose it, the card will be unusable.**

A warning statement alerts you to situations that can be potentially hazardous to you or cause damage to hardware, firmware, software, or data. For example:



**WARNING**

**Do not delete keys without first backing them up. All data that has been encrypted with deleted keys cannot be restored or accessed once the keys are gone.**

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# Chapter 1: Introduction to CTE-LDT

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This chapter contains the following sections:

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## Overview of CTE-LDT

CipherTrust Transparent Encryption - Live Data Transformation (CTE-LDT) is an optional, separately licensed feature of CipherTrust Transparent Encryption (CTE). With CTE-LDT, after enabling a GuardPoint, a CipherTrust Manager Administrator can encrypt, or rekey, GuardPoint data without blocking user or application access to the data. In CTE-LDT, *rekey* means decrypting data with the current cryptographic key and then encrypting it with a new cryptographic key. The concept of rekey, and how CTE-LDT rekeys data, is described in this document.

After enabling GuardPoints, CTE-LDT performs *initial* encryption or rekeying in the background, unnoticed by users. The data stays live and available. This accelerates CTE deployments and eliminates the need to block application and user access to data during encryption or rekey operations, which can seriously inconvenience users and affect operational efficiency.

With CTE-LDT, the CipherTrust Manager Administrator can create a single CTE-LDT policy for both initial encryption and subsequent rekeying. The same policy applies to production access and security rules without restricting user or application access to data. Applications have continuity of access to GuardPoint data during CTE-LDT.



### WARNING

**To prevent data loss or corruption, you must stop all applications and users that are accessing files inside a GuardPoint before enabling a Live Data Transformation encryption policy for that GuardPoint. Terminating the applications closes all files that are currently being accessed inside the GuardPoint.**

**Unlike non-Live Data Transformation policies, however, you do *not* need to keep the GuardPoint offline while data transformation takes place. Instead, you can restart all applications as soon as the GuardPoint has been applied to the host, and CTE will perform the data encryption in the background. This is the only application service downtime required when using CTE-LDT.**

## Use Cases

This section provides a summary of typical uses for CTE-LDT. The concepts mentioned in this section are described in more detail throughout the rest of this guide.

1. Encrypt unprotected data.

When protecting files in a directory, you must encrypt them. This process is called *initial data encryption*.

2. Convert non-CTE-LDT GuardPoints to CTE-LDT GuardPoints

Use when you have existing GuardPoints that are protected with policies created before you started using CTE-LDT.

3. Rekey process.

Changing the key from one version to another version of the same key provides more security. Using CTE-LDT, you can change the encryption keys to more secure keys.

4. Transform the encrypted data to clear data.

## Keys in CTE-LDT (Versioned Keys)

CTE-LDT uses *versioned* keys. Each version of a particular versioned key has the same key name and encryption algorithm, but its own unique cryptographic material. That means that data encrypted with version 3 of a key named `LDT-Key` *cannot* be decrypted by *any* other version of `LDT-Key`, even though the key name remains the same.

Versioning allows you to add one key to your CTE-LDT encryption policy and then use different versions of that same key to periodically re-encrypt your data over time. CTE-LDT uses the new key material to transform data to the new key version, as part of the same Live Data Transformation policy that also protects the data. The process of re-encrypting data with a new version of the existing key is called *Key Rotation*.

In CipherTrust Manager, you can create a versioned key and then add that key to one or more Live Data Transformation policies. When you use CipherTrust Manager to create a new version of the key, CipherTrust Manager automatically pushes the new key version to any CTE clients associated with the Live Data Transformation policies that contain the key. As soon as the CTE Agent receives the new key, it begins transforming the data to the new key version in the background.

You can also create a Key Rotation Schedule in CipherTrust Manager that automatically rotates your keys periodically. When the scheduled rekey date is reached, CipherTrust Manager automatically creates a new key version and pushes it to any CTE clients that are associated with any policies that include the key. When CTE receives the new key version, it automatically starts the rekey process on the affected CTE-LDT GuardPoints.

## Rekey | Key Rotation

In CTE-LDT, *rekeying* or *key rotation* means decrypting the data with a previous version of the key and re-encrypting it with a new version of the key. CTE-LDT allows users and applications to access data while CTE-LDT is rekeying the data. Rotating the key and re-encrypting the GuardPoint data with the new version of the key helps to maintain a high level of data security.

Most often, the rekey happens automatically based the Key Schedule defined in CipherTrust Manager, but you can also generate a new version of the key whenever you want to rekey the GuardPoints associated with that key.

## CTE-LDT Policies

In CTE-LDT, you define a single policy for initial data encryption and subsequent rekeying. The policy specifies:

- **Current key**

Associated with data that you want to protect using CTE-LDT. This is either a non-versioned key from an earlier policy, or `clear_key`, which means that the data is not currently encrypted.

- **Transformation key**

The versioned key that CTE-LDT applies to transform the data from the key used for initial data transformation. When the transformation key rotates, it transforms the data from a previous version of the transformation key to a new version.

**Note**

Transformation key and versioned key are used interchangeably throughout this document.

As soon as CTE-LDT applies the policy to a GuardPoint and enables protection for it, CTE-LDT triggers an initial transformation from the current key to the transformation key.

When the transformation key expires, it generates the next version of the versioned key with new cryptographic material. The CipherTrust Manager then pushes the policy to the hosts. The policy now contains the new version of the key. This initiates a rekey process on the GuardPoint to transform data to the new version of the transformation key specified in the policy.

Users and applications can continue accessing data without any interruption during initial encryption and subsequent key transformations.

**Note**

During CTE-LDT policy creation, you must use the Apply Key effect in your policy. If you do not, then end users can see the clear text data until the file is transformed.

## CTE-LDT Runtime Flow

This section presents an overview of how CTE-LDT works and what to expect when CTE-LDT is enabled and running in your environment. All of the tasks mentioned here are described in more detail later in this chapter.

First, the administrator completes CTE-LDT setup:

1. Upload the CTE-LDT license on the CipherTrust Manager.
2. Register CTE-LDT hosts with the CipherTrust Manager and be sure that the hosts are licensed for CTE-LDT.
3. Create one or more versioned keys.
4. Optionally create a Key Rotation Schedule or add your new keys to an existing schedule.
5. Define Live Data Transformation policies which use the versioned key(s) and contain rules governing CTE-LDT operations.
6. Optionally provide Quality of Service (QoS) settings for the CTE-LDT hosts. The QoS settings control the:
  - Window of time in which CTE-LDT operations are allowed to run.
  - Percentage of CPU resources that CTE-LDT can use, or the amount of data to transform according to the QoS setting per the CipherTrust Manager Administrator.

**Note:** Configuring the QoS settings is highly recommended as a best practice.

When these items are set up, CTE-LDT is ready to transform and encrypt data by applying policies to GuardPoints for live initial transformation and subsequent rekeys, as well as enforcement of security rules.

CTE-LDT goes through the following phases after the keys and Live Data Transformation policies are defined:

### 1. Initial data transformation starts

CTE-LDT begins when an Live Data Transformation policy is first applied to a GuardPoint or an LDT key is automatically rotated through a key rotation schedule in CipherTrust Manager. When a client that uses the associated policy contacts CipherTrust Manager, CipherTrust Manager sends the new policy, or the the key rotation notification, to the client. (If the same versioned key is used in multiple policies, *all* of the clients associated with the policies that contain the key are notified when the key changes.)

## 2. New key version triggers a rekey on the affected GuardPoints

On each client, CTE determines which GuardPoints are using the key that has just rotated to a new version. CTE starts an CTE-LDT rekey on each of those GuardPoints.

On Windows, you must wait for the current key rotation process to finish before you can launch another rekey request. On Linux, if another rekey is already underway on that GuardPoint, the new rekey is queued for later execution. For details, see ["Rotating Encryption Keys While a Rekey is in Progress \(Relaunch\)" on page 45](#).

## 3. Scan for files

On each GuardPoint where CTE has started a rekey, CTE-LDT determines which files to transform. CTE-LDT takes inventory of files encrypted with earlier versions of the rotated key and makes a persistent list of the files for transformation.

The scan phase might be interrupted, such as by a host reboot. In this case, when the host reboots and the GuardPoint is enabled again, the scan operation starts over from the beginning.

## 4. Rekey/Key Rotation

- a. Each file, from the persistent list of files, is decrypted using the old version of the key. The old key is applied to each file and then re-encrypted using the new version of the key. Note that new files created during the CTE-LDT process do not need to be rekeyed, as they inherit the new version of the key. Multiple files and multiple regions of files are rekeyed simultaneously.
- b. The CTE-LDT extended attribute of each file is updated. (For more about extended attributes, see ["CTE-LDT Metadata in Extended Attributes" on page 57](#).)
- c. You can suspend and resume the CTE-LDT rekey operation manually, or through the QoS schedule. This manages the impact CTE-LDT has on other applications and processes.

If system errors occur during rekeying, such as IO errors or crashes, CTE-LDT can manage and recover from them after the system error is fixed.

## 5. Finish

When all of the required files in the GuardPoint have been rekeyed, the system and storage resources used by CTE-LDT are released, except for the storage required for the extended attributes.

CTE-LDT creates a rekey report, listing all of the files that were rekeyed. For more information, see ["Obtaining a Rekey Report" on page 79](#).

Upon completion of rekey, the Rekey Status in the GuardPoint Status window of the CipherTrust Manager Console shows Rekeyed.

# CTE-LDT Administrator Roles

Using CTE-LDT requires coordination and collaboration between several different administrators. Security, system, application performance and backup schedules are critical factors that affect planning. It is very important for the **CipherTrust Manager Administrator** to coordinate with the **system administrator** and the **backup administrators**. The following table describes the roles and responsibilities for these administrators.

## CTE-LDT Administrators

Role	Responsibility	Actions
CipherTrust Manager Administrator	Administers CipherTrust Manager	Coordinates with system and backup administrators. Creates security policies, key rotation schedules, and rules for CTE-LDT. Defines Quality of Service settings for CTE-LDT, applications, and backups.

Role	Responsibility	Actions
System administrator	Administers servers on which CipherTrust Transparent Encryption (CTE) is deployed	Coordinates with the CipherTrust Manager Administrator to create Quality of Service schedule, taking into consideration the backup schedules.
Backup administrator	Manages data backups for data encrypted by CTE	Coordinates with the CipherTrust Manager Administrator to create Quality of Service schedule, taking into consideration the backup schedules.

## Resiliency

CipherTrust Transparent Encryption - Live Data Transformation is resilient to many user actions and system occurrences. Since it is designed to run periodically without intervention, it includes various features to provide this resilience.

Before CTE-LDT enables a GuardPoint, it checks for any inconsistencies in files that were undergoing rekey at the time when system operations were interrupted. If it finds any inconsistencies, CTE-LDT corrects them before it enables the GuardPoint. It should only take a few seconds to identify and correct any inconsistency. On Windows, this process is delayed until applications access the affected files.

During rekey, if an issue such as an I/O problem or system crash occurs, the resiliency features of CTE-LDT ensures the consistency of user data. Such issues can cause an interruption in the middle of a rekey operation. When system operations resume, CTE-LDT corrects the problems and then resumes rekeying.

## Chapter 2: Getting Started

---

This chapter contains the following sections:

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Backup/Restore .....	17
Restrictions .....	17

### Using CTE-LDT

#### Notes

- If you are new to CTE and CTE-LDT, read the CipherTrust Manager documentation first to familiarize yourself with the concepts of GuardPoints and Policies.
- Before installing CTE-LDT, see the *Compatibility Matrix for CTE Agent with CipherTrust Manager* to verify that your version of Linux is supported. Contact Thales Technical Support (<https://supportportal.thalesgroup.com>) for the matrix.

The following list contains the steps for successfully setting up and using CTE-LDT.

1. Install the CTE-LDT License on the CipherTrust Manager.  
CipherTrust Transparent Encryption - Live Data Transformation is a separately-licensed feature of CTE. Before you can use it, you have to install the license to activate it. CTE-LDT is licensed for a specific number of hosts. For details about licensing, see the CipherTrust Manager documentation.
2. Install the CTE Agent and select the CTE-LDT feature during the install. For more information, see ["Installing and Registering the CTE Agent Software" on page 20](#).  
If the client is already registered with CipherTrust Manager, you can enable CTE-LDT on the client through the CipherTrust Manager Console. For more information, see ["Enabling CTE-LDT on a Protected Host" on page 22](#).
3. Create Versioned Keys.  
CTE-LDT uses *versioned keys*. A versioned key rotates to the next version of the key generating new key material automatically without policy change. CTE-LDT encrypts data with keys that use encryption standards like AES-256. This allows data to be re-encrypted without users having to edit the policy.  
For more information, see ["Keys in CTE-LDT \(Versioned Keys\)" on page 12](#) and ["Creating and Viewing Versioned Keys" on page 24](#).
4. Optionally create a Key Rotation Schedule that will automatically rotate the versioned keys periodically. For more information, see ["Creating a Key Rotation Schedule" on page 39](#).
5. Create CTE-LDT Policies.  
CTE-LDT uses a single Live Data Transformation policy to address both initial encryption and subsequent rekeying. The same policy applies to production access and security rules without restricting user or application access to data. Applications have continuity of access to GuardPoint data during CTE-LDT.  
For more information, see ["Creating CTE-LDT Policies" on page 26](#).
6. Set QoS Settings.  
QoS enables administrators to manage and control CTE-LDT impact to application workloads by monitoring and controlling the use of host system resources, such as memory or I/O utilization, during CipherTrust Transparent Encryption - Live Data Transformation. Administrators can also choose schedules for data transformation, or manually pause or resume transformation operations.  
For more information, see ["Quality of Service" on page 29](#).



## 7. Create GuardPoints and Apply CTE-LDT policies to the GuardPoints

A GuardPoint is a directory in the file system hierarchy, where its contents have a CipherTrust data protection policy applied to it. The CTE Agent intercepts any attempt to access anything in the GuardPoint and uses the policies obtained from the CipherTrust Manager to grant or deny the access attempt. Typically data copied into a GuardPoint is encrypted, and only authorized users can decrypt and use that GuardPoint data.

For more information, see ["Create an CTE-LDT GuardPoint" on page 37](#).

## Backup/Restore

Before you enable GP with CTE-LDT policies, make sure that you back up your data.

For more information, see ["Backing Up and Restoring CTE-LDT GuardPoints" on page 62](#).

## Restrictions

Remember the following restrictions when using CTE-LDT:

- CTE-LDT does not support nested GuardPoints, where a GuardPoint is contained inside another GuardPoint.
- For HA clusters, CTE-LDT only supports the Asymmetric (active/passive) configuration. CTE-LDT does not support Symmetric (active/active) configuration.

## Windows Only Limitations

CTE-LDT does not support GuardPoints on CIFS network shared directories.

## Linux Only Limitations

- CTE-LDT does not support Linux automounted file systems.
- CTE-LDT does not support system hibernation (`pm-hibernate`) on Linux hosts where CTE-LDT is in use.
- CTE-LDT does not support GuardPoints on NFS shares and `secvm` configured devices.
- Do not use CTE-LDT on GuardPoints over XFS and VxFS file systems at the same time.
- You cannot use CTE-LDT and Docker container on the same host.
- You cannot use CTE-LDT and OpenShift container on the same host.

# Chapter 3: Setting Up CTE-LDT

---

This chapter contains the following sections:

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Installing and Registering the CTE Agent Software .....	20
Setting the Linux Kernel Time Zone .....	22
Enabling CTE-LDT on a Protected Host .....	22

## System Requirements

CipherTrust Transparent Encryption - Live Data Transformation (CTE-LDT) requires the following environment.

### Note

See the latest *Compatibility Matrix for CTE Agent with Data Security Manager*, in the online support portal, for a list of CTE versions and supported operating systems.

## CipherTrust Software Requirements

- CTE Agent version 7.0.0 or higher must be installed on every client that you want to protect.
- The CipherTrust Manager with which these clients are registered must be version 2.0.0 or higher.

## CTE-LDT License Requirements

One CTE-LDT license is required for *each* protected host.

## Host System Requirements

**Memory requirements:** Both Linux and Windows require a minimum of 8 GB memory on each protected host.

**Disk space requirements:** CTE-LDT requires a specific amount of disk space in the file system, over and above the space required for the guarded files themselves. CTE-LDT uses the additional space to store CTE-LDT metadata.

- For Linux, to estimate the amount of free file system disk space required by CTE-LDT on a Linux host, use the `voradmin ldt space` command.
- For Windows, the typical minimum space requirement for a GuardPoint is the number of files in the GuardPoint multiplied by 4K, plus 256MB. To estimate the amount of free space required for a GuardPoint, use the `voradmin ldt space <GuardPoint-name>` command.

## Backup Requirements

The backup application must have the capability to back up user-extended attributes. For example, Thales tested CTE-LDT with NetBackup. You can also use other applications that can back up user-extended attributes.

### Note

For Windows, the application must use Volume Shadow Copy service (VSS) for backup and restore.

## Linux-Specific Requirements

To use CTE-LDT on an ext3 or ext4 file system, the block size **must** be 4K. Run `dumpe2fs` to determine the block size of the ext3 or ext4 file systems before using CTE-LDT. This limitation does not apply to XFS or VxFS file systems. You can use CTE-LDT on XFS with a block size of 1K or 2K.

For CTE-LDT to work properly, the underlying file system must support and enable user-extended attributes. All of the file systems supported by CTE-LDT support these attributes. If you are using CTE-LDT with ext3 or ext4 mount points, you must explicitly enable the extended attribute mount option by editing `/etc/fstab` and adding the `user_xattr` mount option. In the other file systems supported by CTE-LDT, user extended attributes are enabled by default, so you do not have to explicitly enable them.

Example `/etc/fstab` entry for ext3 on Red Hat 6 or SLES:

```
/dev/sdb1 /disk2 ext3 defaults,user_xattr 0 0
```

Example `/etc/fstab` entry for ext4 on Red Hat 6 or SLES 12 (ext4 is not supported on SLES 11):

```
/dev/sdc1 /disk3 ext4 auto,users,user_xattr,exec 0 0
```

For more information about extended attributes, see ["CTE-LDT Metadata in Extended Attributes" on page 57](#).

## Supported Applications in Linux

For all of the supported operating systems for database applications, see the *Compatibility Matrix for CTE Agent with CipherTrust Manager*.

## Replication

- `rsync`.
- Hardware/software based replication system.

## SAP HANA Fibre Channel Systems

SAP HANA is compatible with CTE-LDT. See the *Compatibility Matrix for CTE Agent with CipherTrust Manager* and the *CTE Agent for Linux Advanced Configuration and Integration Guide*.

## Installing the CTE-LDT License

CTE-LDT installs with the CTE Agent software, but it is a separately-licensed CTE feature. Before you can use it, you have to install the license on the CipherTrust Manager to activate CTE-LDT on any CTE clients. CTE-LDT is licensed for a specific number of clients.

1. Obtain an CTE-LDT license from Thales. You can purchase CTE-LDT along with the CipherTrust Manager software or you can add CTE-LDT later.
2. Install the license on the CipherTrust Manager.  
For details, see the CipherTrust Manager documentation.

To confirm that the CTE-LDT license is in effect:

1. In the CipherTrust Manager Applications Page, open the **Admin Settings** application.
2. Click **Licensing** in the left-hand menu bar.
3. Expand the entry for **CTE - Live Data Transformation** in the License table. CipherTrust Manager shows the total number of client licenses in the **Total Clients** field and the total number of licenses used in the **Used Clients** field.

## Installing and Registering the CTE Agent Software

Install the CTE Agent software with the CTE-LDT feature on each client you want to protect. The following procedure describes how to use the interactive installer to install CTE and register CTE-LDT. For additional registration options, see the *CTE Agent for Linux Advanced Configuration and Integration Guide* or the *CTE Agent for Windows Advanced Configuration and Integration Guide*.

### Prerequisites

Make sure you have the following information from the CM Administrator:

- The registration token for the CipherTrust Manager with which you plan to register the CTE Agent.
- The name of the profile you intend to assign to the client if you want to use a profile other than the default client profile.
- Optionally, the name of the host group you want this client to be a part of.

### Procedure

1. Log on to the host where you will install the CTE Agent as `root`. You cannot install the CTE Agent without `root` access.
2. Copy or mount the installation file to the host system. If necessary, make the file executable with the `chmod` command.
3. Install the CTE Agent. A typical installation uses the following syntax:

```
# ./vee-fs-<release>-<build>-<system>.bin
```

For example:

```
# ./vee-fs-7.0.0-47-rh8-x86_64.bin
```

To install the CTE Agent in a custom directory, use the `-d <custom-dir>` option. For example:

```
# ./vee-fs-7.0.0-47-rh8-x86_64.bin -d /home/my-cte-dir/
```

**Note:** If possible, Thales recommends that you use the default directory `/opt/vormetric`.

To view all installer options, use the `-h` parameter. For example:

```
# ./vee-fs-7.0.0-47-rh8-x86_64.bin -h
```

4. The Thales License Agreement displays. When prompted, type **y** and press Enter to accept.

The install script installs the CTE Agent software in either `/opt/vormetric` or your custom installation directory and then prompts you about registering the CTE Agent with a key manager.

```
Welcome to the CipherTrust Transparent Encryption File System Agent
Registration Program.
```

```
Agent Type: CipherTrust Transparent Encryption File System Agent
Agent Version: 7.0.0.47
```

```
In order to register the CipherTrust Transparent Encryption File System Agent
with a Vormetric Data Security Manager
```

- 1) you must know the host name of the machine running the DSM (the host name is displayed on the Dashboard window of the Management Console), and
- 2) unless you intend to use the 'shared secret' registration method, the agent's host machine must be pre-configured on the DSM as a host with the 'Reg. Allowed' checkbox enabled for this agent type on the Hosts window of the Management Console.

```
In order to register with a CipherTrust Manager you need a valid registration
token from the CM.
```

```
Do you want to continue with agent registration? (Y/N) [Y]:
```

5. Enter **y** to continue with the registration process. The install script prompts you to enter the host name or IP address of the CipherTrust Manager with which you want to register CTE. For example:

```
Do you want to continue with agent registration? (Y/N) [Y]: y
```

```
Please enter the primary key manager host name: 10.3.200.141
```

```
You entered the host name 10.3.200.141
Is this host name correct? (Y/N) [Y]: y
```

6. Enter the client host name when prompted.

```
Please enter the host name of this machine, or select from the following
list.
```

```
[1] sys31186.qa.com
[2] 10.3.31.186
```

```
Enter a number, or type a different host name or IP address in manually:
What is the name of this machine? [1]: 2
You selected "10.3.31.186".
```

7. Enter the CipherTrust Manager registration token, profile name, host group and host description. If you omit the profile name, CipherTrust Manager associates the default client profile with this client.

```
Please enter the registration token: 12345
Please enter the profile name for this host: My-Profile
Please enter the host group name for this host, if any:
Please enter a description for this host: RHEL7 system West Coast Datacenter
```

```
Token           : 12345
Profile name     : My-Profile
Host Group      : (none)
Host description : RHEL7 system West Coast Datacenter
Are the above values correct? (Y/N) [Y]: y
```

- At the hardware association prompt, select whether you want to enable the hardware association feature to prevent cloning. The default is **y** (enabled):

```
It is possible to associate this installation with the hardware of this
machine.  If selected, the agent will not contact the key manager or use any
cryptographic keys if any of this machine's hardware is changed.  This
can be rectified by running this registration program again.
Do you want to enable this functionality? (Y/N) [Y]: y
```

- At the LDT prompt, specify that you want this client to use CTE-LDT by typing **Y** and pressing Enter:

```
Do you want this host to have LDT support enabled on the server? (Y/N) [N]: y
```

- At the Cloud Object Storage (COS) prompt, specify whether you want this client to use CTE COS.

```
Do you want to configure this host for Cloud Object Storage? (Y/N) [N]:
```

- CTE finishes the installation and registration process.

```
Generating key pair for the kernel component...done.
Extracting SECFS key
Generating EC certificate signing request for the vmd...done.
Signing certificate...done.
Enrolling agent with service on 10.3.200.141...done.
Successfully registered the CipherTrust Transparent Encryption File System Agent with the
CipherTrust Manager on 10.3.200.141.
```

```
Installation success.
```

- In CipherTrust Manager, change the client password using the manual password creation method. This password allows users to access encrypted data if the client is ever disconnected from the CipherTrust Manager. For details on changing the password, see the CipherTrust Manager documentation.

## Setting the Linux Kernel Time Zone

The Linux kernel contains an internal time structure that may or may not contain time zone information. On system configurations that do not contain time zone information, CTE-LDT stores and displays timestamps for rekey beginning and ending in UTC (Coordinated Universal Time) rather than the system's local time zone. If this occurs, the administrator can set the kernel's internal time zone to the local time zone if they desire timestamps in their local time zone.

To set the Linux Kernel time zone information, at boot time type:

```
# hwclock --systz
```

The command sets the kernel's time zone to the local time zone and resets the System Time based on the current time zone.

### Note

On systems that do not set the time zone by default, existing timestamps for completed rekeys remain in UTC, even if you run `hwclock --systz`. Only timestamps for new rekeys display the local time zone.

## Enabling CTE-LDT on a Protected Host

When you install CTE on a host, you can enable CTE-LDT during the registration process as described in "[Installing and Registering the CTE Agent Software](#)" on page 20. If you have already registered the host with CipherTrust Manager, you can enable CTE-LDT in the client entry in CipherTrust Manager.

**Note**

The CTE-LDT license is valid for a certain number of clients. Once you reach this limit, you can either purchase additional CTE-LDT licenses, or reclaim a license by removing a CTE-LDT client. For details, see ["Removing CTE-LDT and Security Encryption" on page 73](#).

You cannot disable CTE-LDT on a client once it has been enabled.

**To enable CTE-LDT on an existing host:**

1. In the CipherTrust Manager Applications Page, open the **CTE** application and click **Clients** in the left-hand menu bar.
2. Click on the name of the client on whom you want to enable CTE-LDT.
3. On the Client Details page, select the **Live Data Transformation** check box, then click **Apply** to enable CTE-LDT on the protected host.

**Note:** After CTE-LDT has been enabled for the host, the check box is greyed out because you cannot change this option once it has been set.

# Chapter 4: Using CTE-LDT

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Setting up keys, policies, and GuardPoints with CTE-LDT is very similar to performing the same tasks in CTE without CTE-LDT. However, there are some differences.

This chapter contains the steps, in order, for successfully setting up and using CTE-LDT.

## Creating and Viewing Versioned Keys

For CTE-LDT, you create a versioned key that you can add to any number of Live Data Transformation policies. When you add a new key version, CipherTrust Manager pushes the new version to every CTE client that is associated with any of they Live Data Transformation policies that contain that key.

Use the **Keys & Access Management** application in the CipherTrust Manager Applications Page when creating or viewing versioned keys.



### CAUTION

**Make sure that all keys you create for CTE-LDT are Symmetric. CTE-LDT does not support asymmetric keys.**

## Creating a Versioned Key

1. Log into the CipherTrust Manager Console as an administrator.
2. Open the **Keys & Access Management** application.
3. Click **Create a New Key**.
4. Enter a Key Name so that you will be able to find this key easily when you want to rotate it. For example, LDT-Key-1.

### Note

When CipherTrust Manager displays the list of available keys, you cannot filter the list by versioned vs. non-versioned. Therefore, it is especially important to name the key in such a way that you can easily search for it by name.

Using a standard naming convention will also help if you want to create an automatic key rotation schedule for all your CTE-LDT keys.

5. In the **Key Metadata > Groups for Key sharing** section, do the following:
  - a. In the **Search** box, type "cte".
  - b. Add CTE Admins and CTE Clients to the key sharing groups by clicking the green **Add** button. The **Key Shared?** check box is automatically selected and the **Add** button changes to a **Remove** button.



- c. Below the Groups table, click the **CTE Key Properties** check box.

CipherTrust Manager displays the following options for CTE keys:

- **CTE Versioned:** Specifies that this is a versioned key. Make sure this option is selected.
- **Persistent on Client:** Specifies whether the key is stored in persistent memory on the client.

If this option is selected, the key is downloaded and stored (in an encrypted form) in persistent memory on the client.

If this option is *not* selected, the key is downloaded to non-persistent memory on the client. Every time the key is needed, the client retrieves it from the CipherTrust Manager. This is the default setting.

- **Encryption Mode:** Encryption mode of the key. Choose one of the following for CTE-LDT keys:
  - CBC
  - CBC CS1

Encryption using CBC CS1 keys is known as enhanced encryption. For details, see the *CTE Agent for Linux Advanced Configuration and Integration Guide* or the *CTE Agent for Windows Advanced Configuration and Integration Guide*.

**Note:** XTS encryption is not supported for protecting directory-based GuardPoints. Do not select XTS as your encryption mode.

Group Names	Key Shared?
CTE Admins	<input checked="" type="checkbox"/>
CTE Clients	<input checked="" type="checkbox"/>

2 Groups 10 per page

☐ Set as "Versioned Key" for backwards compatibility

☒ CTE Key Properties

☒ CTE Versioned ☒ Persistent on Client

Encryption Mode: CBC CS1

6. In the Key Behaviors section at the bottom of the page, clear the **Prevent this key from being exported** check box. If the key cannot be exported, the key will not appear in the keys list when you add the key rule to the policy. If you want the option to delete this key later on, clear the **Prevent this key from being deleted** check box. Use caution when deleting keys, as any data encrypted with that key will be inaccessible if you delete the encryption key.

**Key Behaviors**

☒ Prevent this key from being deleted ☐ Prevent this key from being exported

Create Cancel

7. Click **Create**. The new key appears in the Keys table.

## Viewing Versioned Key Information

1. Log into the CipherTrust Manager Console as an administrator.
2. Open the **Keys & Access Management** application.
3. Click the **Latest Version Only** check box to show only one entry for each versioned key.
4. Find the key in the Keys table.

**Tip:** You can filter the list by key name using wildcard searches. For example, if you know that the key name contains "LDT", you can search for `*ldt*`. The search is *not* case sensitive.

If the **Version** for a key is 0, then this is the first version of the key and no key rotation has taken place. If the **Version** is greater than 0, the key has been rotated.

**Note:** When you create a CBC CS1 key, CipherTrust Manager automatically makes a second key called `<key-name>_xts`. This key is maintained and used by CipherTrust Manager, and it can be ignored when you are looking at your CTE-LDT keys.

The screenshot shows the 'Keys' management interface. At the top, there's a search bar with 'Name' selected and '\*ldt\*' entered. Below it, there are filter tabs for 'Basic' (selected) and 'Raw'. Under the 'Basic' tab, there are dropdown menus for 'Types', 'Size', 'Status', and 'Dates'. A checkbox labeled 'Latest Version Only' is checked. Below this, there are two filter buttons: 'Name: \*ldt\*' and 'Version: latest'. A '+ Create a New Key' button is on the right. The main part of the interface is a table with the following columns: Key Name, Version, Owner, Modified, Type, Algorithm, Size, and Links. The table contains two rows: 'LDT-Key-1' with version 4, and 'LDT-Key-1\_xts' with version 4. Both keys are owned by 'local|admin' and were modified on '03 Sep 2020, 02:14'. They are both 'Symmetric' type and use 'AES' algorithm, with a size of '256'. The 'LDT-Key-1' row is highlighted with a red box around the 'Key Name' and 'Version' columns.

Key Name	Version	Owner	Modified	Type	Algorithm	Size	Links
LDT-Key-1	4	local admin	03 Sep 2020, 02:14	Symmetric	AES	256	<a href="#">↗</a>
LDT-Key-1_xts	4	local admin	03 Sep 2020, 02:14	Symmetric	AES	256	<a href="#">↗</a>

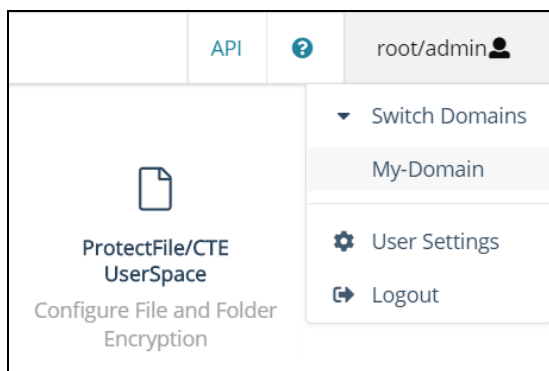
5. To find all versions of a key, click the name of the key in the **Key Name** column. CipherTrust Manager displays the ID, version number, state, and date created information for each version of the key.

## Creating CTE-LDT Policies

CTE-LDT uses a single Live Data Transformation encryption policy to address both data transformation and ongoing protection. In contrast, if you do not use CTE-LDT, you need a separate policy for initial data transformation, or rekey, and another policy to protect the data while it is in production use. For more information about CTE-LDT policies, see ["CTE-LDT Policies" on page 12](#).

To create an Live Data Transformation encryption policy:

1. In a web browser, navigate to the URL of the CipherTrust Manager you want to use and log in with CipherTrust Manager Administrator credentials.
2. If the client you want to protect is registered to the default domain (root), proceed to the next step. If you need to change to a different domain, do the following:
  - a. In the top menu bar, click the domain/user name (default: **root/admin**) on the right-hand side.
  - b. Select **Switch Domains**, then select the domain in which the client is registered.
  - c. The logged in user now shows the new domain name/user name.



3. In the CipherTrust Manager Applications Page, open the **CTE** application.
4. In the left-hand menu bar on the Clients page, click **Policies**.
5. Click **Create Policy**. CipherTrust Manager displays the Create Policy Wizard.
6. On the General Info page, set the following options:

Field	Description
<b>Name</b>	A unique name for the policy. Make sure you use a name that is descriptive and easy to remember so that you can find it quickly when you want to associate it with a GuardPoint. For example: LDT-Policy-West
<b>Policy Type</b>	Select Live Data Transformation.
<b>Description</b>	A user-defined description to help you identify the policy later. For example: LDT policy for the West Coast Datacenter.
<b>Learn Mode</b>	Learn Mode provides a temporary method for disabling the blocking behavior of CTE/CTE-LDT policies. While useful for quality assurance, troubleshooting, and mitigating deployment risk, Learn Mode is not intended to be enabled permanently for a policy in production. This prevents the policy Deny rules from functioning as designed in the policy rule set.  Ensure that the policy is properly configured for use in Learn Mode. Any Security Rule that contains a Deny effect must have Apply Key applied as well. This is to prevent data from being written in mixed states, resulting in the loss of access or data corruption.  Apply Key will have no effect when combined with a Deny rule unless the policy is in Learn Mode.

7. Click **Next**.

8. On the Security Rules page, define the security rules you want to use.

CipherTrust Manager automatically adds a default security access rule with an action of `key_op` and the effects `Permit` and `Apply Key`. This rule permits key operations on all resources, without denying user or application access to resources. This allows it to perform a rekey operation whenever the encryption key rotates to a new version. This rule is required by CTE-LDT, so you cannot edit it, move it, or delete it.

To add additional security rules, click **Create Security Rule** and enter the requested information. If you want to grant user and application access to files at all times, including during initial CTE-LDT and subsequent key rotations, add a security rule with the action `all_ops` and the effects `Permit` and `Audit`.

For details about adding security rules, see the CipherTrust Manager documentation.

9. On the Create Key Rule page, click **Create Key Rule** and enter the following information:

Field	Description
<b>Resource Set</b>	If you want to select a resource set for this key rule, click <b>Select</b> and either choose an existing resource set or create a new one.  Resource sets let you specify which directories or files will either be encrypted with the key or will be excluded from encryption with this key.
<b>Current Key Name</b>	Click <b>Select</b> to choose an existing key or create a new one.  If the data has not yet been encrypted, select <b>clear_key</b> . Otherwise select the name of the non-versioned key that is currently being used to encrypt the data.
<b>Transformation Key Name</b>	Click <b>Select</b> to choose an existing versioned key or to create a new one.  CTE uses the versioned key specified in this field to encrypt the data in the GuardPoint. If the data is currently encrypted, CTE decrypts it using the key specified in the <b>Current Key Name</b> field and re-encrypts it using the key specified in this field.

When you are done specifying key rules, click **Next**.

10. On the Confirmation page, review the information you entered and click **Save** when you are ready to save the policy.

The following example shows a simple CTE-LDT policy that encrypts clear-text files using a versioned key named LDT-Key-1. The `key_op` and `all_ops` actions in the Security Rules panel grant user and application access to files at all times, including during initial CTE-LDT and subsequent key rotations.

1 General Info

Name: LDT-Policy-West  
Policy Type: Live Data Transformation  
Description: LDT policy for the West Coast Datacenter

2 Security Rules

Resource Set	User Set	Process Set	Action	Effect	Browsing
			key_op	permit,applykey	No
			all_ops	permit,audit	Yes

3 Key Rules

Resource Set	Current Key Name	Transformation Key Name	Exclusion Rule
	clear_key	LDT-Key-1_xts	No

## Quality of Service

CTE-LDT runs in real time, while users actively interact with applications. This could impact performance. However, CTE-LDT is designed to not adversely affect application or system performance.

### Purpose of QoS

Quality of Service (QoS) provides tools for an administrator to minimize the effect of CTE-LDT on system and application performance. It provides a set of parameters that administrators can set to control CTE-LDT use of system resources, primarily CPU and I/O bandwidth. When the QoS parameters are set appropriately, CTE-LDT stays within the defined boundaries to ensure that critical user applications are not adversely affected by CTE-LDT operations.

### Manage CTE-LDT Impact

Administrators can pause or resume CTE-LDT operations to manage and control CTE-LDT impact to application workload. When data transformation occurs, either during initial or subsequent transformations, it requires substantial host CPU and I/O resources. This can cause contention for resources between the applications simultaneously running on the protected host. The administrator specifies QoS settings on each host, or at a host group level, that is using CTE-LDT. When CTE-LDT is running, QoS monitors CPU or rekey/scan rate on the host and enforces the QoS settings. QoS can also monitor and enforce an administrator imposed limit on the volume of data undergoing rekey per second. The QoS settings enable you to strike a balance between completing an CTE-LDT process and not interfering with host application performance.

### Monitor and Control CPU Usage

QoS monitors and controls the use of host system resources during CTE-LDT, specifically, CPU usage and rekey/scan rate.

#### Note

You can control CPU usage or rekey/scan I/O rate, but not both. The CPU usage and rekey/scan I/O rate options are mutually exclusive.

### Monitor and Control Rekey/Scan I/O Rate

You can choose Rekey I/O Rate as a threshold to control the CTE-LDT processing rate. When this threshold is entered, the Quality of Service continuously monitors CTE-LDT transformation and enforces the specified amount of data during:

- **Rekeying**—CTE-LDT is transforming the data on active GuardPoints based on the new key version.
- **Scanning**—CTE-LDT is analyzing files in GuardPoints. Scanning occurs:
  - Before initial transformation (Linux only)
  - Before a rekey (Linux only)
  - Following an interrupted rekey, such as a reboot on Linux or Windows, and also a directory rename or directory deletion on Windows

You can set the Rekey I/O Rate or CPU Threshold for multiple clients through the QoS Settings section in a CipherTrust Manager client profile. All clients associated with a given client profile will use the QoS thresholds set in that profile unless the thresholds are overridden locally on the individual client. (The default setting for Rekey I/O Rate in the client profile is 0 (zero), which means QoS will run full throttle.)

To set the QoS thresholds locally on a particular client, use the `voradmin ldt ior <iorate>` command on that client. When you do so, the `voradmin` setting overrides the Rekey I/O Rate or CPU Threshold set in the CipherTrust Manager client profile. If QoS was already set locally on this client and you use `voradmin` to set the Rekey I/O Rate, CTE-LDT ignores any CPU threshold previously set.

To resume using the client profile QoS values for a client, use `voradmin ldt ior 0` to set the Rekey I/O Rate to 0 (zero). When you do so, CTE returns to using the Quality of Service settings in the client profile.

A tolerance level is associated with the Rekey I/O Rate. Together, the tolerance and Rekey I/O Rate specify a range for the CTE-LDT processing rate. The Quality of Service selects a proper tolerance for a Rekey I/O Rate provided through the `voradmin` command, and maintains the CTE-LDT processing rate at the specified Rekey I/O Rate plus or minus the tolerance. The tolerance is selected as follows:

- When the Rekey I/O Rate is less than or equal to 10MB/sec, the tolerance is 3MB/sec.
- When the Rekey I/O Rate is greater than 10MB/sec. and less than 50MB/sec, the tolerance is 4MB/sec.
- When the Rekey I/O Rate is at 50MB/sec or higher, the tolerance is 10% of the specified Rekey I/O Rate.

To set or reset Rekey I/O Rate on a single host, use the `voradmin` command as follows:

- To set the threshold of 50 MB/sec., use the following command:

```
# voradmin ldt ior 50
```

- To reset the current threshold:

```
# voradmin ldt ior 0
```

For more information about setting the Rekey I/O Rate using `voradmin`, see ["Select and Set Rekey I/O Rate" on page 35](#).

## QoS Scheduling During Backup/Restore

QoS scheduling plays an important role when backing up/restoring data without the *Apply Key* rule applied to the backup/restore process. During backup/restore, you **must** pause CTE-LDT operations before taking backups. QoS scheduling allows the administrator to enter the schedule for QoS aligned with the backup schedule, and pause the CTE-LDT processes for the duration of the backup. The schedule specifies which days of the week, and what times of day, CTE-LDT is permitted to run. CTE-LDT cannot run at any time that is not permitted by the QoS schedule. QoS suspends CTE-LDT operations at all times outside of the schedule.

When setting a QoS schedule, consider your system and application peak demand periods during the day and week. Also consider your schedule for data backups. Schedule CTE-LDT to pause when you need all available system resources for other tasks, such as meeting peak user demand or performing data backups.

### Note

On Windows, if your backup applications are using VSS, then you do not need to pause CTE-LDT on Windows.

## How to Set QoS

To set QoS for a host to enforce a threshold on CTE-LDT based on CPU percentage:

1. Log into the CipherTrust Manager Console as an administrator.
2. Open the **CTE** application.
3. In the left-hand menu, select click **Profiles**.
4. If you want to add a new profile, click **Create Profile** and specify a profile name and description.

5. Click the profile name in the **Profiles** table.
6. Click the Quality of Service Configuration section heading to open the QoS options and select one of the following radio buttons:
  - **Rekey by Rate** — Specifies that you want to set a Rekey I/O Rate threshold. Enter a value between 0 and 100 in the associated **LDT QoS Rekey Rate** field. If you specify 0, CTE does not throttle the CTE-LDT rekey or scanning processes.
  - **Rekey by CPU**— Specifies that you want to set a CPU Rate threshold. Enter a value between 0 and 99 in the associated **CPU Percentage** field.

If you select this option, CTE-LDT applies a tolerance of +/- 2% on CPU threshold settings up to 7%. For threshold over 7%, CTE-LDT applies a tolerance of +/- 4%.

If CPU% is set to 0, QoS stops monitoring CPU usage and CTE-LDT operations run at maximum rekey rate within the available system resources. Setting CPU percentage to 0 does not affect CTE-LDT schedules, so CTE-LDT operations are suspended and resumed per QoS schedule.

If you do not enter CPU threshold percentage, CTE-LDT applies CPU threshold of 5% capped by default.

If CPU% is set to a very high value, such as 25%, the rekey process competes with other applications to use as many CPU cycles as it can. As a best practice, start with a setting of 10%, and increase or decrease it slowly by 5% until it reaches a reasonable level that does not adversely affect the performance of user applications. The higher the percentage, the more quickly CTE-LDT completes its processing. However, this speed causes increased competition for resources, which can significantly degrade the performance of other applications using this host.



**CAUTION**

**Do not set CPU% to a very high value in an attempt to force faster data transformation. This can potentially exhaust other system resources.**

When you select **Rekey by CPU**, the **Cap CPU Allocation** check box becomes available. Check this box to specify that the CPU allowance must never exceed the percentage set in CPU%. If **Cap CPU Allocation** is not checked, and additional CPU resources are available on the host, CTE-LDT consumes part of the available resources for rekey above the CPU threshold. Exceeding the threshold may impact your production workload as your production CPU resource consumption fluctuates over time.

For example, if CPU% is set to 10%, but **Cap CPU Allocation** is not set, the rekey process continues consuming available CPU cycles after reaching 10% CPU utilization, at which point the rekey process starts contending with applications for CPU cycles.

7. In the QoS Schedules section, select the schedule you want to use from the **LDT QoS Schedule** drop-down list. This list includes the following options:
  - ANYTIME
  - WEEKNIGHTS
  - WEEKENDS
  - CUSTOM

If you select anything other than CUSTOM, CipherTrust Manager displays the time ranges in which CTE-LDT can run in the **Time Ranges** column. If you select CUSTOM, you can then click the **Create New QoS Schedule** button to create a custom schedule. Add one custom schedule entry for each time range in which you want QoS to run.

By limiting CTE-LDT to periods of low application usage, you minimize the potential for resource contention between applications and CTE-LDT.

The following example shows a profile with the CPU threshold capped at 10%. The QoS schedule is set for 1 am to 4 am on Mondays, Wednesdays, and Fridays.

QUALITY OF SERVICE CONFIGURATION

☐ Rekey by Rate  
LDT QoS Rekey Rate (MB/s)

☒ Rekey by CPU  
☒ Cap CPU Allocation  
CPU Percentage

QoS Schedules  
LDT QoS Schedule:  [Create New QoS Schedule](#)

Name	Time Ranges	
CUSTOM	Monday 1:00 AM - Monday 4:00 AM	...
CUSTOM	Wednesday 1:00 AM - Wednesday 4:00 AM	...
CUSTOM	Friday 1:00 AM - Friday 4:00 AM	...

## QoS Best Practices

This section gives tips and examples to help you set QoS parameters for the best results.

### General Best Practices for QoS

- Use Rekey I/O Rate threshold to limit CTE-LDT impact, if any, to your production workloads. Rekey I/O Rate approach is a simpler method for a CipherTrust Manager Administrator or system administrator to enforce a limit on the volume of data that CTE-LDT should rekey per second. You can choose a threshold, in units of MBs per second, which is a small percentage of peak IOPS from your production workload.
- You will see the effects of QoS settings only if the number and/or types of files in the GuardPoints stress the rekey or scan processes. On hosts with a relatively small number of files, the rekey or scan process may complete quickly without hitting a threshold and causing throttling to occur.

- Use QoS CPU parameters as an alternate method for controlling the effect CTE-LDT has on application performance.

Set limits on CTE-LDT CPU usage whenever runtime monitoring shows that user applications are affected by CTE-LDT. Start by setting the CPU parameter to 10%, then increase or decrease in 5% intervals, as needed, to tune the CPU allocation. When an acceptable level is reached, and CTE-LDT is not noticeably affecting user applications, leave the QoS CPU parameters at a constant setting.

- Use monitoring tools.

Monitor host CPU utilization with tools like `vmstat`, `top`, and `iotop` on Linux and `perfmon` on Windows.

You can also monitor and obtain statistics with the `voradmin ldt stats` command.

For more information about `voradmin ldt stats`, see ["Obtaining CTE-LDT Statistics at the Command Line" on page 78](#).



- Select CPU resource allocation for CTE-LDT from 1% to the available limit minus 5%.

If the monitoring tools indicate system CPU usage, without CTE-LDT, it is at N%, available CPU resource is M%, where  $M = 100 - N$ . Select a percentage within  $1 - (M - 5)$  to allocate to CTE-LDT CPU usage. However, remember that QoS tolerates 2% - 4% leeway in the actual CPU usage, so adjust your selection by 2 - 4%.

- Do not set CPU resources to 0% or 99% in an attempt to minimize or stop CTE-LDT

A CPU% value of 0 or 99 is reserved for disabling the QoS CPU monitoring function. This does not stop CTE-LDT or minimize its resource usage; rather the opposite. It enables CTE-LDT to run with its maximum rekey rate. Note that when CPU % is not set, CTE-LDT clients enforce a 5% CPU threshold by default.

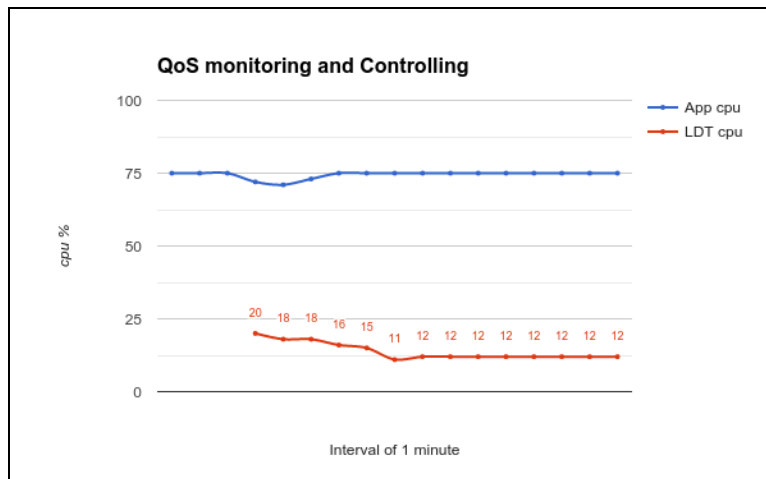
- Cap the CPU allocation.

QoS provides a **CAP CPU Allocation** parameter. Set this parameter to **True**. This ensures that CTE-LDT resource usage never exceeds the allocated percentage.

### Example: Setting QoS before starting CTE-LDT

You can be proactive and set up QoS parameters before enabling GuardPoints that are protected with CTE-LDT policies. This ensures QoS starts monitoring and controlling CTE-LDT resource usage from the start. The following graph shows an example where 10% of the CPU is assigned to CTE-LDT. QoS makes sure that CTE-LDT is restricted to use only 10% of the CPU. There is a tolerance level of +/- 4%, so actual CTE-LDT usage can range between 5% and 15% of CPU. In the following example, applications use 75% of the CPU resources. As the graph shows, when CTE-LDT starts, application CPU utilization drops for a moment, because CTE-LDT exceeds the CPU threshold. QoS immediately reduces CTE-LDT's CPU usage to 12%, which is within tolerance levels for a 10% setting, and the application CPU share returns to normal.

Figure 4-1: QoS makes visible improvement immediately when CTE-LDT starts



The graph above was obtained on a Linux system running sysbench.

- To find the amount of CPU resources currently in use by applications, type:

```
# top -n 1 -b | grep sysbench | awk 'BEGIN {cpu=0} {cpu += $9} END {print cpu}'
```

- To find the amount of CPU currently in use by the CTE-LDT-protected host, type:

```
# top | grep Cpu
```

- To find the amount of CPU currently in use by CTE-LDT, type:

```
# voradmin ldt stats | grep CPU
```

## Example: Monitoring and controlling resource usage during CTE-LDT

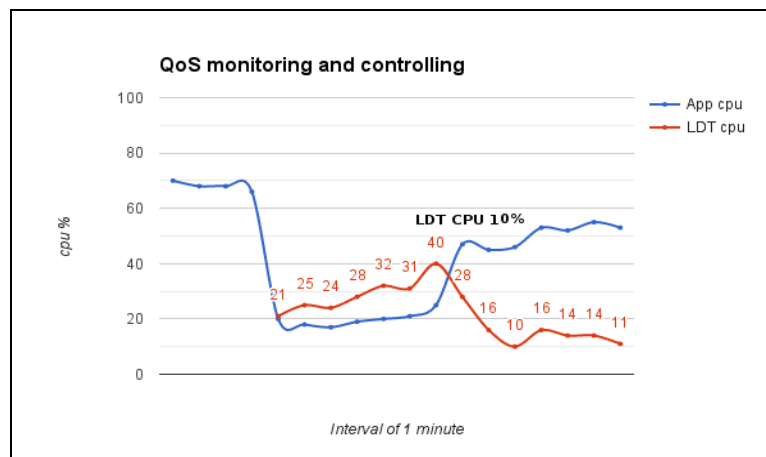
Suppose that CTE-LDT has started with CPU set to 25%, and users realize their applications are affected. For example, there might be a higher than expected level of CTE-LDT I/O operations. To return application performance to normal, reduce the CPU allocation for CTE-LDT.

1. Set the **CPU parameter** to a lower value, such as 10%.
2. Select the **Cap CPU Allocation** option.

QoS restricts CTE-LDT CPU usage to 10%. The application user should monitor their application. If the application's performance is still affected, reduce the CPU parameter further, such as to 5%. Repeat this procedure until application performance returns to a satisfactory level.

The following graph shows an example where QoS is not enabled to monitor and control CTE-LDT CPU usage from the start. When CTE-LDT starts, application CPU usage drops from 65% to 20%. By setting the QoS CPU parameter to 10%, application usage is greatly improved.

**Figure 4-2: CPU usage allocation before and after QoS CPU parameter is set**



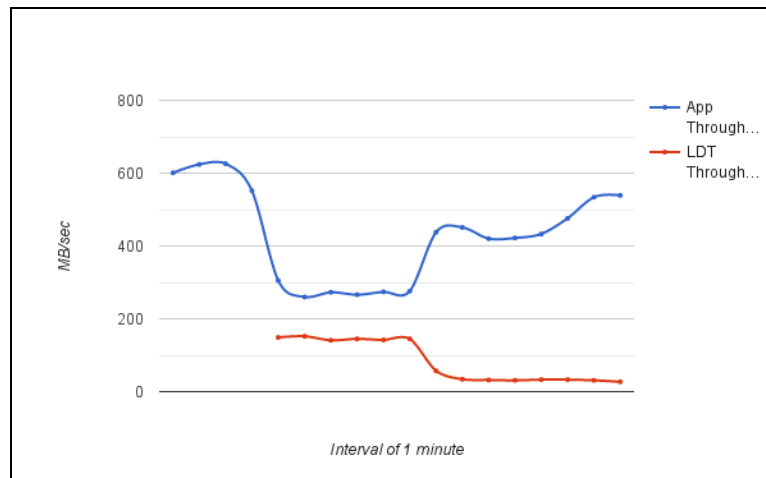
## Example: How QoS CPU settings affect I/O bandwidth

Controlling CPU utilization indirectly controls I/O bandwidth. When CTE-LDT is consuming less CPU resources, it is usually performing fewer operations of all kinds, including input and output.

The following graph shows how an application's I/O throughput is affected by CTE-LDT, and how QoS can reduce this effect through monitoring and controlling the CTE-LDT CPU resource usage.

This graph is from the same system described in ["Example: Monitoring and controlling resource usage during CTE-LDT" above](#). No QoS parameters are set at first. When CTE-LDT starts, application I/O drops from more than 600 MB per second to below 30 MB per second. By setting the QoS CPU parameter to 10%, the CTE-LDT I/O operations drop to below the application's ability to perform so application I/O operations is greatly improved.

**Figure 4-3: I/O operations before and after QoS CPU limit is set**



To obtain the data for this graph:

- Use `iotop` and benchmarking tools on an RHEL system to obtain application I/O throughput.
- Use `voradmin ldt stats` to obtain the CTE-LDT I/O throughput and rekey rate.

## Select and Set Rekey I/O Rate

You can choose to set the Rekey I/O Rate to control I/O operations from CTE-LDT to minimize CTE-LDT impact to your production workload. It's assumed that you already know the maximum IOPS on your host system during your production workload. With this information, you can choose a threshold for Rekey I/O Rate and enforce the selected threshold during CipherTrust Transparent Encryption - Live Data Transformation. The work flow is as follows:

1. Set **Rekey I/O Rate** threshold using `voradmin` or in the CipherTrust Manager Console.
2. QoS retrieves the threshold and starts monitoring and controlling CTE-LDT according to the specified threshold and the tolerance factor corresponding to the threshold.
3. The selected threshold will be in effect within 2 to 4 minutes after entering the threshold.

When Rekey I/O Rate and CPU or IOWAIT thresholds are set, QoS will monitor and control the CTE-LDT processing rate based on the Rekey I/O Rate threshold. The CPU threshold will be ignored.

## Set Rekey I/O Rate Threshold

1. Set **Rekey I/O Rate** threshold by using `voradmin`:

```
# voradmin ldt ior 10
```

You can also set the Rekey I/O Rate for one or more managed hosts using the Quality of Service section in a client profiles. For more information about using this method, see ["How to Set QoS" on page 30](#).

In the `voradmin` example above, QoS enforces the threshold of 10MB/sec with the tolerance of +/- 3MB/second. Effectively, CTE-LDT attempts to rekey the amount of data in the range of 7MBs/second to 13MB/second.

On Linux and Windows, you can use `voradmin ldt ior` to report the current threshold setting without specifying a value for threshold:

```
# voradmin ldt ior
QoS Rekey I/O rate threshold: 10 MB/sec
QoS Rekey I/O tolerance: 3 MB/sec
```

2. Be sure the threshold you enter is appropriate for your production workload. To verify this:

- a. Observe the Rekey I/O Rate for a few minutes using `voradmin`.

On Linux, you can do this using:

```
# voradmin ldt stats
Host level statistics:
File stats: rekeyed=202390, passed=0, created=0, removed=0
Data stats: rekeyed=6.2GB, truncated=0.0MB
QoS: IOR threshold=10MB/sec, tolerance=3MB/sec
current_rekey_rate=2MB/sec, current_iow=0ms
load_factor=50, delay_factor=0, delay_scan=0
```

On Windows, you can do this using:

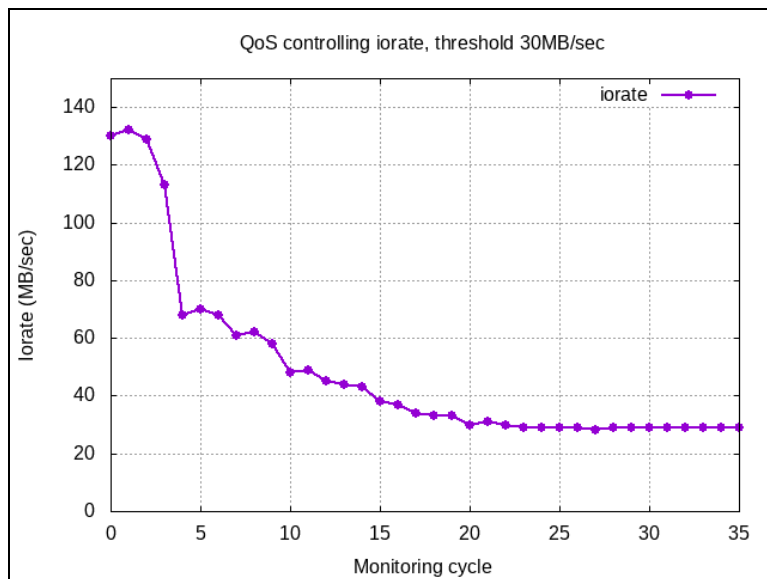
```
voradmin ldt monitor
Host Stats:
Total number of Guard Points      = 1
Rekey Status                      = Rekey done (Finished rekey on 1 out of 1 GP's)
Total files to be transformed     = 0
Total files transformed           = 0
Total files in progress           = 0
Total transformation threads      = 0

Current rekey rate                = 0 KB/s
Rekey IO rate threshold           = 1000 MB/s
Rekey IO rate tolerance           = 4 MB/s
```

- b. Set an appropriate threshold. Do not set the threshold value too high, as QoS might not be able to achieve it because of other resource bottlenecks.

3. Check the QoS controlling rekey rate.

QoS will monitor and control CTE-LDT utilization using the specified threshold. The following figure shows an example of how QoS monitors and controls CTE-LDT utilization. In this example, the threshold is 30 MB/sec. Throughput of CTE-LDT was nearly 130 MB/sec. QoS brings it down to within the range of 30 MB/second.



4. Disable QoS.

QoS will not monitor and control resources when all the thresholds, CPU, Rekey I/O rate, and IOWAIT are set to 0. When Rekey I/O Rate and IOWAIT are not explicitly set, it is considered to be set to 90 MB/second.

QoS continues to apply its schedules for suspending CTE-LDT operations at certain days and times regardless of what values are set for CPU, Rekey I/O Rate, and IOWAIT thresholds.

## Summary of QoS Resources

The following table summarizes the available thresholds and the actions of QoS module to enforce the set thresholds:

Scenario	QoS Action
Only Rekey I/O Rate threshold is set	Monitor and control the CTE-LDT processing rate based on Rekey I/O Rate
Rekey I/O Rate and CPU threshold are set	Monitor and control the CTE-LDT processing rate based on Rekey I/O Rate. CPU threshold is ignored.

## Create an CTE-LDT GuardPoint

After you have installed the license and registered the CTE-LDT host (see [Chapter 3: "Setting Up CTE-LDT" on page 18](#)), you can create an CTE-LDT GuardPoint on the host. When you create the CTE-LDT GuardPoint, you select a Live Data Transformation policy and apply that policy with its transformation keys to that GuardPoint. CTE automatically gets the Quality of Service settings from the associated Client Profile in CipherTrust Manager.

This section describes two scenarios:

- ["Create an CTE-LDT GuardPoint for an Unguarded Directory" below](#)
- ["Converting a Non-CTE-LDT GuardPoint to an CTE-LDT GuardPoint" on the facing page](#)

### Create an CTE-LDT GuardPoint for an Unguarded Directory

To create an CTE-LDT GuardPoint on what was previously an unprotected/unguarded directory:

1. Create an Live Data Transformation policy that transforms data from clear text to a versioned key. In the policy, set Current Key to `clear_key` and Transformation Key to the versioned key. For details, see ["Creating CTE-LDT Policies" on page 26](#).
2. Set, or modify, the Quality of Service (QoS) parameters in the Client Profile associated with the CTE client to account for CTE-LDT on all GuardPoints on this client. For details see ["Quality of Service" on page 29](#).
3. In the CipherTrust Manager Applications Page, select the **CTE** application.
4. In the Clients table, click on the name of the client you want to protect.
5. Above the GuardPoints table, click **Create GuardPoint**.

6. In the Create GuardPoint page:
  - a. In the **Policy** field, select the CTE-LDT policy you created earlier.
  - b. In the **Type** field, select the type of device. For CTE-LDT, you can select **Auto Directory** or **Manual Directory**.
  - c. In the **Path** field, enter the directories you want to protect with this policy or click **Browse** to select them from a Windows-style explorer.

If you want to enter multiple paths, put each path on its own line.
  - d. Keep the **Preserve Sparse Regions** option selected if you want CTE to ignore sparse regions during data transformation.

A *sparse region* is a region within the file size that has not yet been written to. Therefore, it is not allocated with disk blocks. Any attempt to read a sparse region reads stream of zeros as data. A file may have one or more sparse regions, or an entire file may be sparse.

If you select **Preserve Sparse Regions**, CTE-LDT detects and skips transforming sparse regions. Therefore, it does not change the number of blocks utilized in the file system. This is the default.

If you disable **Preserve Sparse Regions**, CTE-LDT transforms a file without checking or skipping sparse regions, if they exist. Consequently, as CTE-LDT operations transform and fill sparse regions with encrypted stream of zeros, sparse regions are allocated with disk blocks. This increases the number of disk blocks utilized in the file system.
  - e. Click **Create**.
  - f. If you want to use the same policy and GuardPoint type on another path, click **Yes** when prompted. Otherwise, click **No**.

The CipherTrust Manager pushes the GuardPoint configuration to the client and CTE immediately begins transforming the data in the specified folders from clear-text to cipher-text.
7. When the data transformation has finished, applications can resume accessing the now-protected data.

## Converting a Non-CTE-LDT GuardPoint to an CTE-LDT GuardPoint

After enabling CTE-LDT on a client, you can change a non-LDT GuardPoint to a CTE-LDT GuardPoint. CTE-LDT GuardPoints provide the advantage of allowing users to access all files in the GuardPoints while encryption is occurring. There is no downtime for the user except for the time needed to apply the GuardPoint.

1. Write a new CTE-LDT policy that transforms data from the non-CTE-LDT/non-versioned key used in the existing GuardPoint, to an CTE-LDT versioned key. See ["Creating CTE-LDT Policies" on page 26](#).
2. Make sure there is no application activity within the GuardPoint.



### CAUTION

**This step is critical. Do not skip it. Make sure there is no application activity within the GuardPoint.**

3. Remove the current GuardPoint.
  - a. Open the **CTE** application and click **Clients** in the left-hand menu bar.
  - b. Click on the name of the client whose GuardPoint you want to change.
  - c. Find the GuardPoint you want to change in the GuardPoints table, then click the (...) button at the end of the row and select **Remove**.
4. Guard the directory again using the new CTE-LDT policy. Use the steps in ["Create an CTE-LDT GuardPoint for an Unguarded Directory" on the previous page](#), but choose the policy that starts from the non-versioned/non-LDT key rather than a policy that starts from `clear_key`.

## Rotating Encryption Keys (Rekey)

This following sections describe procedures related to encrypting an existing GuardPoint with a new key (also called rekeying).

### Manual Key Rotation

If you need to rekey your GuardPoint prior to the expiration of the current key version, you can manually start a rekey process.

On Windows, you cannot rotate a key until all current data transformations that use the same key have completed, whether those transformations are an initial data transformation or a rekey. On Linux, you can rotate the key at any time. For details, see ["Rotating Encryption Keys While a Rekey is in Progress \(Relaunch\)" on page 45](#).

1. In the CipherTrust Manager Applications Page, open the **Keys & Access Management** application.
2. Click **Keys** in the left-hand menu bar.
3. In the Keys table, click on the name of the key that you want to rotate.
4. On the Key Detail page, click the Add button (+) above the table to add a new version.



The new version appears in the Versions table.



### Creating a Key Rotation Schedule

In CipherTrust Manager, you can create an automatic key rotation schedule that will automatically rotate all of the keys included in the schedule on a periodic basis. As soon as CipherTrust Manager creates a new version of a key, it pushes the new version to any clients associated with the policies that use the key. If the policy is a Live Data Transformation policy, CTE automatically begins rekeying the data in the CTE-LDT GuardPoint with the new version of the key.

1. In the CipherTrust Manager Applications Page, open the **Admin Settings** application.
2. Click **Schedules** in the left-hand menu bar.

CipherTrust Manager displays the existing key rotation and backup schedules that have been defined in the system. Thales strongly recommends that you look at any existing key rotation schedules to make sure that the keys you want to rotate are *not* already included in one of those existing schedules.

If the existing key rotation schedules do not include the keys you want to rotate, continue with this procedure to create a new schedule.

3. On the **Schedules** page, click **Add Schedule**.
4. On the **Select Schedule Type** page, click **Key Rotation** and click **Next**.
5. Add a schedule name and description. Make sure you name the schedule as descriptively as possible so that other users can tell at a glance what keys that schedule includes. For example, you could name the schedule "Rotate-LDT-Keys" and use the description "Rotates all keys with "LDT" in their name on a yearly basis."

When you are done, click **Next**.

6. On the **Schedule Config** page, enter the following information:
  - **Duration.** Enter the day and time on which CipherTrust Manager should start using the key rotation schedule in the **Schedule Starts** field. When this day and time is reached, CipherTrust Manager looks at the date in the **Frequency** section and automatically creates a new version on that date.

Enter the day the schedule should end in the **Schedule Ends** field, or select the **Never** check box to tell CipherTrust Manager there is no end date for this key rotation schedule. If you select a date in this field, CipherTrust Manager automatically stops creating new key versions when that day and time are reached.

- **Frequency.** Select the **Basic** radio button to specify the frequency (daily, weekly, monthly, or yearly) and the UTC time at which CipherTrust Manager should automatically rotate the key after the schedule starts.

Select the **Raw (Cron)** radio button to create a cron job to control the key rotation schedule. Specify cron format in the following order:

minute, hour, day of month, month, and day of week

These five values indicate when the job should be executed. These values are mandatory and must be specified in the order given. The allowable values are:

Field	Allowed Values
minute	0-59 or * / , -
hour	0-23 or * / , -
day of month	1-31 or * / , -
month	1-12 or JAN-DEC or * / , - This field is case in-sensitive, so JAN, Jan, or jan are all equally valid.
day of week	0-6 or SUN-SAT or * / , - This field is case in-sensitive, so SAT, Sat, or sat are all equally valid.

Examples:

- December 31 at 2:35 AM UTC could be specified as: 35 2 31 Dec \*
- On the 25th of every April, August, and December at midnight UTC could be specified as:  
0 25 APR,Aug,dec \*.
- Every Monday, Wednesday, and Friday at 8:00 PM UTC could be specified as: 0 20 \* \* 1,3,5



When you enter a **Duration** and a **Frequency**, CipherTrust Manager displays the next several times the key rotation will be run under the **Frequency** field. Make sure the key rotation will be done on the days you expect.

**Note:** While the specified time is in UTC, the scheduled run times are shown in your local time. Therefore there may not be an exact match between the time set in the **Frequency** field and the displayed run time.

When you are done, click **Next**.

7. On the **Key Rotation Page**, specify the selection criteria you want CipherTrust Manager to use when it selects the keys it will rotate.



**CAUTION**

**Make sure you are extremely careful when you specify the selection criteria so that you do not accidentally rotate keys that should not be rotated using this schedule. Whenever a new key is added to CipherTrust Manager, CipherTrust Manager compares its name and details to the filters set in all key rotation schedules defined in the Admin Settings application, and it automatically adds the new key to ALL key rotation schedules where it matches the selection criteria.**

**If your selection criteria is too broad, you could accidentally rotate keys that should not be rotated by this key rotation schedule.**

You can enter a key name in the **Name** field, or select any of the available filters from the drop-down lists. The Selected Keys table shows the keys that will be rotated by this schedule.

CipherTrust Manager displays the current list of keys that match this criteria in the **Selected Keys** table. Make sure you go through this list carefully so that you do not rotate keys you do not want to rotate.

For example, you can rotate all keys with "ldt" anywhere in their name by specifying `*ldt*` in the **Name** field:

## Add Key Rotation Schedule

1 Select Schedule Type

2 General Info

3 Schedule Config

4 Key Rotation Query

A key rotation query is an object that specifies the keys that need to be rotated. All keys are rotated when it is not provided.

Name ▾

\*ldt\*

Q

Filters

☒ Basic ☐ Raw

Types ▾

Size ▾

Status ▾

Dates ▾

☒ Latest Version Only

Name: \*ldt\* X

Version: latest X

Selected Keys

Key Name	Ver	Modified	Type	Alg	Size
LDT-Key-West-Coast	2	08 Sep 2020, 10:10	Symmetric	AES	256
LDT-Key-East-Coast	3	08 Sep 2020, 10:10	Symmetric	AES	256
My_LDT_Key	0	08 Sep 2020, 10:07	Symmetric	AES	256

Back

Save

If you only want to rotate the keys whose names begin with "ldt", use the query `ldt*` in the **Name** field. In the example above, that removes `My_LDT_Key` from the list of keys that will be rotated.

The search is case insensitive, so "ldt" will also match `LDT`, `ldT`, `ldT`, or any variation thereof.

When you are certain the list of keys to be rotated is accurate, click **Save**.

## Checking the Rekey Status

During a rekey, you can check the progress in the CipherTrust Manager Console, however GuardPoint status is not relayed to the CipherTrust Manager in real time. A delay of several minutes before the CipherTrust Manager displays events on the client is likely. When the number of GuardPoints on the managed host is high, for example 100+, the delay in relaying GuardPoint status is due to delays in scheduling and the execution of CTE-LDT operations on the managed host for GuardPoints.

To see the progress of a rekey and the estimated completion time:

1. In the CipherTrust Manager Applications Page, open the **CTE** application.
2. Click **Clients** in the left-hand menu bar.
3. Click the **Client Name** of the client whose CTE-LDT status you want to check in the Clients table.

4. Find an active CTE-LDT GuardPoint and click **Active** in the **Status** column.

CipherTrust Manager displays the GuardPoint Health page, which includes transformation status information such as the basic status (Rekeyed or Rekeying), the last transformation completion time, the last transformation start time, and the estimated rekey completion time.

## Obtaining Information About Keys Applied to Files

### Key Report Option

In the following command, you can use the `report` option of the `voradmin` command to obtain information about all of the keys in use on the GuardPoint. The report lists all keys used in the GuardPoint. For each key, it gives the key name and key version number. It lists each unique key name and version combination only once, no matter how many files use the key.

The following example shows three keys used in the GuardPoint `/oxf-fs1/gp1`:

```
# voradmin ldt key report /oxf-fs1/gp1
LDT_KEY1,1
LDT_KEY2,2
LDT_KEY3,5
```

For an overview of `voradmin ldt`, see ["CTE-LDT Command-Line Administration: voradmin command" on page 71](#).

### Key Map Option

In the `voradmin ldt key [report|map] <key_name> <guard_path>` command, you can use the `map` option to obtain information about which files in a GuardPoint were transformed with a specific key, where:

- `<key_name>` is the name of the key.
- `<guard_path>` is the path of the GuardPoint where the key was used.

For example, to view information about the key `LDT_KEY2` in the GuardPoint `/oxf-fs1/gp1`, you would enter:

```
# voradmin ldt key map LDT_KEY2 /oxf-fs1/gp1
/oxf-fs1/gp1/file12345.dat10
/oxf-fs1/gp1/file12345.dat10
/oxf-fs1/gp1/file12345.dat10
/oxf-fs1/gp1/file12345.dat10
/oxf-fs1/gp1/file12345.dat10
```

Keys without a version number are used by files in an exclusion key rule or files that have yet to undergo initial key rotation. Use `voradmin ldt key map` in conjunction with `voradmin ldt attr get` to determine if a file using a key without a version number is part of an exclusion key rule or awaiting initial key rotation.

## Showing GuardPoints During Rekey (Linux)

Use the following command to display a list of known CTE-LDT metadata stores and any associated GuardPoints currently undergoing transformation.

```
# voradmin ldt list all
MDS_1:  type=file, nguards=0, name=/disk2/::vorm:mds::
        Guard Table: version 1 nentries 0
MDS_2:  type=file, nguards=0, name=/disk3/::vorm:mds::
        Guard Table: version 1 nentries 0
MDS_3:  type=file, nguards=0, name=/disk4/::vorm:mds::
        Guard Table: version 1 nentries 0
```

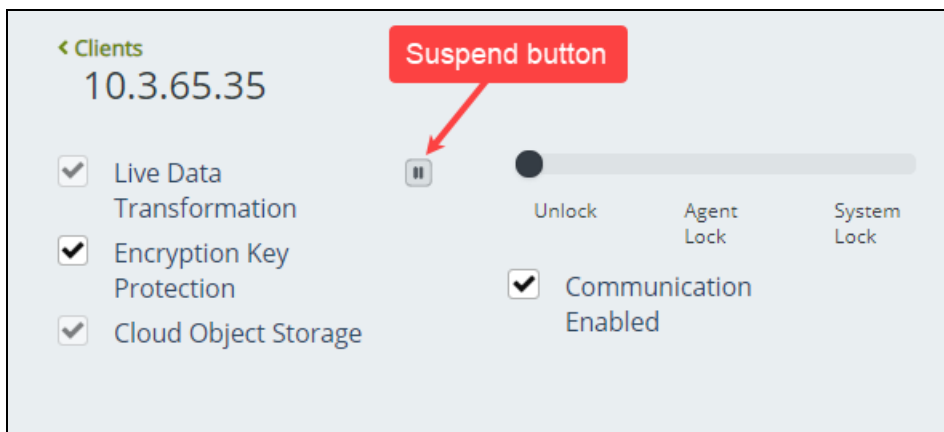
For an overview of `voradmin ldt` commands, see ["CTE-LDT Command-Line Administration: voradmin command" on page 71](#).

## Suspending and Resuming Rekey and/or Scan Phase

The QoS schedule specifies certain time windows when CTE-LDT operations must be stopped temporarily. However, you can also suspend or resume CTE-LDT at the client level at any time.

To suspend CTE-LDT through the CipherTrust Manager Console:

1. Open the **CTE** application.
2. Click **Clients** in the left-hand menu bar.
3. Click the **Client Name** of the client on which you want to pause CTE-LDT in the Clients table.
4. In the Client Details area, click the **Suspend** button next to the Live Data Transformation field to suspend all CTE-LDT operations on the client.



After you pause CTE-LDT, the button turns into a Play button so that you can resume CTE-LDT operations when ready.

## Considerations

- Disabling, or unguarding, an CTE-LDT GuardPoint where a rekey is in progress automatically suspends the CTE-LDT rekey operation.
- You can also use the `voradmin suspend/resume` command in Windows Powershell to suspend and resume the rekey. However, if you use the `voradmin ldt suspend` command to pause the rekey process, the CTE-LDT suspended state is not retained when the system reboots. If you want to retain the state after reboot, suspend the rekey from the CipherTrust Manager.
- On Linux, you can pause CTE-LDT during the scan phase of CTE-LDT. When paused during scan, CTE-LDT suspends operations that traverse through the namespace of GuardPoints in the scan phase of transformation. Suspending CTE-LDT during scan stops file lookup operations of CTE-LDT. This eliminates performance impact to I/O intensive production workloads, such as file serving type workloads, that access large number of files.

## Automatic Suspend and Resume of CTE-LDT Operations Due to Insufficient Disk Space (Linux)

CTE-LDT requires adequate storage space headroom to perform CTE-LDT operations such as rekeying on GuardPoints. On Linux, if available storage space drops below the threshold required for CTE-LDT operations to continue, the CTE-LDT operations are automatically suspended. Once additional storage space is available in the file

system, CTE-LDT operations automatically resume.

As available space approaches the threshold for automatic suspension, CTE-LDT sends an alert to the CipherTrust Manager to notify you that you should free up more storage space before CTE-LDT operations are suspended. The alert on the CipherTrust Manager is:

Low space on guard point [GuardPoint], increase free space or CTE-LDT will be suspended.

## Behavior of Automatic Suspend and Resume of CTE-LDT Operations on ext4 File Systems

By default, ext4 file systems reserve a portion of the storage space for use only by privileged processes to prevent running out of storage space in file systems. In this situation, non-privileged processes are automatically blocked from writing to the file system until the free disk space level reaches the minimum threshold. As CTE-LDT operates in privileged mode, CTE-LDT operations continue without blockage even if the free disk space threshold is low. Because of this ext4 feature, CTE-LDT operations on ext4 file systems may not be suspended due to low available storage space, even when the `df` command reports storage is 100% allocated.

## Rotating Encryption Keys While a Rekey is in Progress (Relaunch)

On Linux, if a key is rotated (either manually or automatically when a key version expires) while CTE-LDT is in progress on a GuardPoint, the key rotation is processed and queued, and the GuardPoint is marked for relaunch. Relaunch indicates the need to restart CTE-LDT after the current transformation completes. If the GuardPoint has been rekeyed and is flagged for relaunch, CTE-LDT launches as soon as the GuardPoint is enabled.

Files already undergoing transformation at the time of the new key rotation complete rekey to the key version already in progress. Files that start transformation after the new key rotation request are rekeyed to the new key version. Once the current CTE-LDT of the GuardPoint is complete, CTE-LDT automatically relaunches to transform any files that are not rekeyed to the latest key version.

For example:

```
# voradmin ldt attr get /oxf-fs1/gp1
LDT stats: version=2, rekey_status=rekeying,relaunch
  Number of times rekeyed:          1 time
  Rekey start time:                 2020/03/18 16:54:00
  Last rekey completion time:       2020/03/18 16:53:38
  Estimated rekey completion time:   0 days 0 hours 6 minutes
  Policy key version:               344
  Data stats:
    total=9.8GB, rekeyed=0.0MB
    truncated=0.0MB, sparse=0.0MB
  File stats:
    total=1000, rekeyed=0, failed=0
    passed=0, skipped=0, created=0, removed=0, excluded=0
```

### Note

Relaunch is supported on Linux only. It is not supported on Windows.

## File System Operations

The following sections describe the file system operations that may require attention from the CipherTrust Manager Administrator.

## Renaming Files and Folders

On both Linux and Windows hosts, you can rename files during initial transformation or rekey operations.

- On Linux, you cannot rename folders (directories) in a GuardPoint during a rekey operation. Any attempt to rename a directory is rejected with the error EAGAIN (try again) while CTE-LDT is in progress including the period during which transformation is suspended.
- On Windows, CTE-LDT stops if it is transforming the contents of a folder and a user attempts to rename/move that folder.

You can change the stopping behavior of CTE-LDT using the configuration parameter `oxf_stop_on_rename`.

Using the Registry Editor, or the Windows command line, add a registry entry in `HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\Vmmgmt\Parameters` for `oxf_stop_on_rename`.

Registry Name	Values	Comments
<code>oxf_stop_on_rename</code>	0 - Disabled	CTE-LDT <b>does not</b> stop if there is contention.
	1 - Enabled	CTE-LDT <b>stops</b> if there is contention. Default: Enabled

For the target folder in rename operation, CTE-LDT is never stopped.

## Deleting a File

When a file is removed before it is rekeyed, the file is not included in the total number of files transformed in the GuardPoint Health dialog box. Any discrepancy between total number of files to transform and those transformed is due to the removal of files from GuardPoints during CTE-LDT.

The `voradmin` command provides more detailed file level statistics related to rekey operations on the host. You can run `voradmin` to get file level statistics:

```
# voradmin ldt stats <guard_path>
```

## File Handling (Windows Only)

It is critical that you understand how the CTE-LDT process handles read-only, binary (executable), NTFS encrypted and NTFS compressed files.

The CTE-LDT process is subjected to all of the File System policies and attributes set on the files. In some cases, this prevents CTE-LDT from encrypting a file. If users or applications are accessing files while CTE-LDT is in progress, CTE-LDT cannot change the attributes of the files and encrypt the file. It is critical that you understand how CTE-LDT handles various types of files:

- **NTFS Encryption and Compression**

If NTFS encryption and compression is enabled on a file or folder, the CTE-LDT process cannot encrypt these files. To maintain the data coherency, CTE-LDT skips the encryption of the these files. These files display as “passthrough” files in the CTE-LDT statistics.

- **Read-Only Files**

When CTE-LDT encounters read-only files, it rekeys the file by resetting the read-only attribute and then setting the attributes back again when the rekey completes. If a file is open, CTE-LDT skips this file.

1. If the file is not opened, CTE-LDT changes the attributes of the file and stores the original attributes in the file metadata.
2. CTE-LDT starts Rekey on this file.
3. If a user requests to open a file for writing while rekey is in progress, access is denied. User can only open files for reading.
4. CTE-LDT restores the attributes once rekey is done.

- **Executable Files**

If an executable is running, or files are exclusively locked by the application, the CTE-LDT process cannot encrypt those files as it is unable to acquire the required locks on the files. CTE-LDT skips these files and changes to the INCOMPLETE state.

## Enabling GuardPoints in Read-Only mounted file systems (Linux)

Access to a GuardPoint enabled in a read-only mounted file system is restricted to read operations. You cannot modify data in such file systems, therefore, you cannot perform CTE-LDT operations on GuardPoints in read-only file systems. For this reason, CTE-LDT automatically suspends operations when GuardPoints are enabled on read-only file systems. CTE-LDT ignores all attempts to resume CTE-LDT operations until the underlying file system is remounted with read/write access.



### **WARNING**

**You must disable a GuardPoint before changing the read/write mount options of the underlying file system. After changing the mount options, you can re-enable the GuardPoint. CTE-LDT operations adapt to the read/write options of the underlying file system when you enable the GuardPoint. Changing the mount options while a GuardPoint is enabled is unsupported and may result in unexpected errors.**

## Copying Files Into a GuardPoint

If you copy a file into a GuardPoint without an Apply Key rule, make sure that the file was previously copied from the same GuardPoint, or a GuardPoint protected with the same policy/versioned key. A copy operation, without an Apply Key rule, is the same as a backup or restore of a file from/to an CTE-LDT protected GuardPoint.

CTE enforces key rules of an CTE-LDT policy while a GuardPoint is enabled. CTE cannot enforce the key rules while a GuardPoint is disabled. Modifying or adding data/files inside a disabled GuardPoint is not only unsupported, but it also results in unrecoverable data corruption.



### **WARNING**

**Do not add new files or modify existing files inside CTE-LDT protected GuardPoints while the GuardPoint is not enabled. This results in unrecoverable data corruption and/or files that cannot be accessed when the GuardPoint is enabled.**

## Behavior of Hard Links Inside and Outside of GuardPoints (Windows)

When using hard links on Windows, all the hard links to a file must be within the boundary of a GuardPoint and must use the same key. The following scenarios provide additional details:

- If hard links to the same file are inside a GuardPoint and outside a GuardPoint, the effect on the file depends on what process accesses which hard link first. If the hard link within the GuardPoint is opened first, the file is transformed. If the hard link outside the GuardPoint is opened first, the file won't be transformed.
- If hard links to the same file exist in different GuardPoints with different keys, the file will be corrupted.
- If hard links to the same file exist in the same GuardPoint but with different keys, such as if folder-based rules are used, there will be a conflict in the key.

## Excluding Files or Directories from Rekey

When you add a resource set to a key rule in a policy, you can select the **Exclude Rule** option. That tells CipherTrust Manager that the directories and/or files in the resource set should use a different key than the rest of the data in the CTE-LDT GuardPoint. If you specify `clear_key` for the key rule, then the directories and/or files in the resource set will be left unencrypted. Otherwise, you can select any non-versioned key to apply to those directories and/or files.

## Examples of Exclusion Key Rules

This section describes some examples of how to use an exclusion key rule.

### Encrypt Files With Exclusion Property a Non-Versioned Key

The following exclusion key rule applies the non-versioned key, `Key_TextFiles`, to any *new* files that are created with a `*.txt` extension.

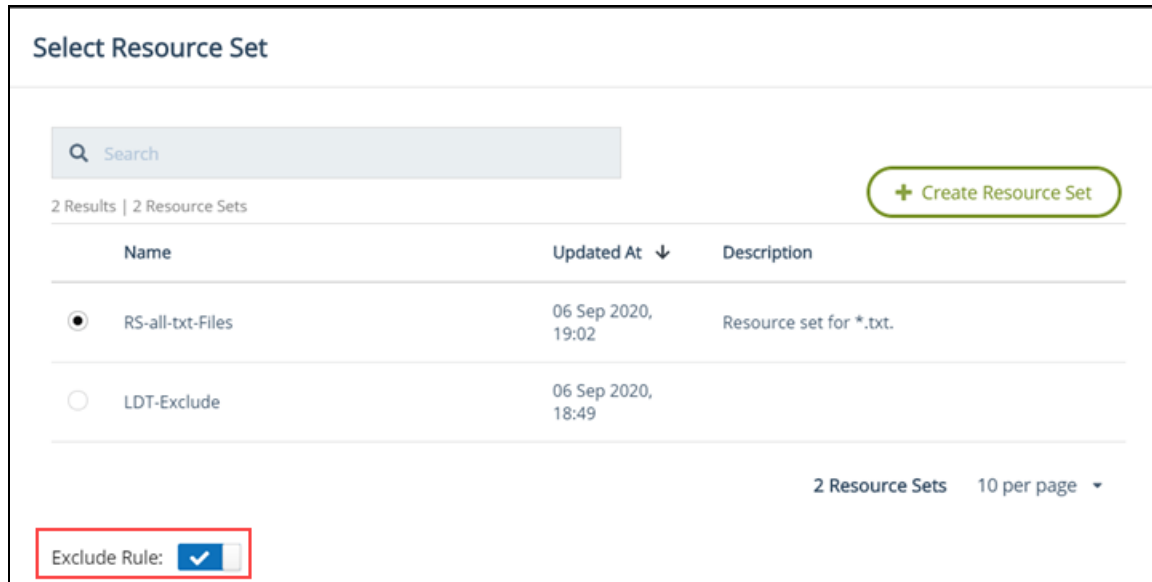
#### Note

Existing `*.txt` files in the GuardPoint during the initial CTE-LDT data transformation process are assumed to be already encrypted with the same key that you specify in the exclusion key rule. These existing files are *not* transformed during the initial encryption or during any subsequent rekeys. The key you specify in the exclusion key rule is applied to new `*.txt` files only.



In the Policy, do the following:

1. Add a Key Rule.
2. In the **Resource Set** field, click **Select**.
3. Select a resource set that specifies \*.txt in the **File** field and click the **Exclude Rule** option.



4. Click **Select**. CipherTrust Manager displays the resource set name in the Resource Set field with an icon indicating that this is an Exclusion Rule.
5. Select the `Key_TextFiles` key in the **Current Key Name** field.
6. Click **Add**.
7. Add any other key rules or exclusion key rules to the policy that you want. You must add at least one non-exclusion key rule that specifies the current encryption key and the versioned encryption key that you want to use with this Live Data Transformation policy.

For example, you could add another exclusion key rule that specifies all **.doc** files should be encrypted with the key `Key_DocFiles`, or one that specifies all **.zip** files should be left unencrypted by specifying the key `clear_key`.

## Exempt Excluded Files from Encryption (Set to `clear_key`)

The following exclusion key rule sets all files in the resource set `/oxf-fs1/gp1/Clear_Files_Folder` (Linux) or `\oxf-fs1\gp1\Clear_Files_Folder` (Windows) to `clear_key` (in other words, not encrypted). Files in other directories that match other key rules in the same policy may be encrypted. This could allow unrestricted access to the files in `/oxf-fs1/gp1/Clear_Files_Folder` (Linux) or `\oxf-fs1\gp1\Clear_Files_Folder` (Windows) while access may be restricted to files in parallel directories.

- Linux Exclusion Key Rule: The Resource Set **Directory** field should contain `/oxf-fs1/gp1/Clear_Files_Folder`, and the **Key** should be `clear_key`.
- Windows Exclusion Key Rule: The Resource Set **Directory** field should contain `\oxf-fs1\gp1\Clear_Files_Folder`, and the **Key** should be `clear_key`.

## Requirements for Exclusion Key Rules

Keep in mind the following requirements when configuring exclusion key rules:

- Before adding an exclusion key rule to an existing policy, you must disable all GuardPoints protected with the policy. Log on to the CipherTrust Manager to disable the GuardPoint.
- You cannot choose a versioned key for the key in an exclusion key rule. Only non-versioned keys or `clear_key` (no encryption) are valid for exclusion key rules.
- All exclusion key rules must be *above* all CTE-LDT transformation key rules in the **Key Rules** area in the policy.

## Usage Notes and Limitations for Configuring Exclusion Key Rules

Keep in mind the information in the following sections when configuring an exclusion key rule.

### Adding an Exclusion Key Rule to an Existing Policy with Versioned Keys (Linux)

When adding an exclusion key rule to an existing policy, the exclusion rule only applies to newly created files. Existing files that match the exclusion key rule remain encrypted with the same versioned key(s) specified in the non-exclusion key rule in the policy and will be rekeyed to the key in the exclusion key rule when the versioned key(s) rotates.

To force an existing file that matches an exclusion key rule to be transformed to the key in the exclusion key rule (non-versioned in this example), use one of the following methods:

- Rotate the versioned key specified in the policy to initiate rekey operations on the GuardPoint.
- Copy the existing file within the GuardPoint. The new file will be associated with the resource set in the exclusion key rule and will be encrypted with the non-versioned key. You can then delete the original file.

To perform a similar conversion on Windows, see ["Changing a Folder or Files from Versioned to Non-Versioned Key \(Windows\)" on page 52](#).

### Adding an Exclusion Key Rule That is Part of an Active GuardPoint (Linux)

To edit and/or add an exclusion key rule to an CTE-LDT policy, all GuardPoints using the policy must first be disabled before the new key rule can be added.

### Changing an Exclusion Key Rule That is Part of an Active GuardPoint (Windows)

Changes that you make to an exclusion key rule that is part of an existing policy in an active GuardPoint do not take effect until the GuardPoint that the exclusion key rule is part of is disabled and enabled again.

## Conflicting Keys as the Result of Rename Operations

Do not attempt to move or rename a file encrypted with a versioned key to a name associated with an exclusion key rule with `clear_key`. If you attempt such a move or rename, the original file is unaffected but following error is output on Linux systems and a log entry is created:

```
<command name>: setting attribute 'user::secfs:xattr:' for 'user::secfs:xattr:': Invalid argument
<command name>: failed to close '<filename>': Invalid argument
```

No error is displayed on Windows systems. The target moved or renamed file is corrupted and should be deleted. The target file is also flagged with the `xattr_error` flag on Linux and `Rekey Status Excluded` on Windows. This flag prevents subsequent read/write access to the file. You can check the CTE-LDT attributes for the presence of this flag. See ["About the Exclusion Attribute for Files Matching an Exclusion Key Rule" on page 53](#).

Also, a log entry is sent to the CipherTrust Manager on Linux systems when this occurs. For example, if you moved the versioned file `/gp/foo.txt` into the GuardPoint `/gp/subdir/foo.txt` with an exclusion key rule that excludes matching files with the `clear_key`, the following log message would be created on the CipherTrust Manager:

```
[CGA] [WARN ] [29261] [CGS3268W] LDT-ALERT: encrypted data detected in filename [foo.txt] inode [35720037] in guard point [/gp] under clear exclusion key rule
```

## Overlapping Exclusion Key Rules

Multiple exclusion key rules in the same policy may overlap each other. For example on Linux, if the non-versioned key `Key_A` is associated with resource `/oxf-fs1/gp1/Folder_Enc_With_KEY_A` and the non-versioned key `Key_B` is associated with resource `*.txt`, placement of the file `/oxf-fs1/gp1/Folder_Enc_With_KEY_A/foo.txt` overlaps the two key rules. In such a case, the first rule in the policy is enforced on `/oxf-fs1/gp1/Folder_Enc_With_KEY_A/foo.txt` when the file is created and in subsequent file access.

On Windows, if the non-versioned key `Key_A` is associated with resource `c:\oxf-fs1\gp1\Folder_Enc_With_KEY_A` and the non-versioned key `Key_B` is associated with resource `*.txt`, then they would overlap on the file `c:\oxf-fs1\gp1\Folder_Enc_With_KEY_A\foo.txt`. In such a case, the first rule in the policy is enforced on `c:\oxf-fs1\gp1\Folder_Enc_With_KEY_A\foo.txt` when the file is created and in subsequent file access.

## Caution About Applications That Create Temporary Files (Windows)

Some applications on Windows create a temporary file version of the original file when you open and modify a file. This behavior can affect how you implement exclusion key rules.

If you have an exclusion key rule that uses a file extension to exclude files that may be opened and modified by such an application, exclude the temporary file name extension also. If you don't exclude the temporary file, the temporary file may be encrypted by another policy that matches the temporary file extension. Then the original file, which is copied from the temporary file, will be unreadable. Also keep in mind that other applications that may create temporary files with the same file extension and consider what policies should affect those temporary files.

This situation can happen with Microsoft Office files such as the `.docx` files used by Microsoft Word. When you open and modify a `.docx` file, Word creates a `.tmp` file version of that file. So for Microsoft Word you should add `*.tmp` to the exclusion key rule resource set if you add `*.docx`.

## Rename Operations Crossing Key Rules (Linux)

On Linux, when a rename operation crosses key rules, the rename operation copies the source file to a new file using the new name and removes the original file. If the source file is flagged for exclusion key rule property, the target new file is disassociated with the exclusion key rule if the new name no longer matches the resource set associated with exclusion key rule. For more information, see ["About the Exclusion Attribute for Files Matching an Exclusion Key Rule" on page 53](#).

## Using Linked Files with Exclusion Key Rules (Linux)

On Linux, do not create multiple hard links to the same target file such that the pathname of each hard link is associated with a resource set of an exclusion key and the key rules have different keys. Accessing the file through the pathname of each hard link results in a different key to be applied to the file resulting in data corruption in the target file due to application of multiple keys to the same data.

If you must create hard links, be sure the pathnames of hard links and the target file are within the same resource set.

## Changing a Folder or Files from Versioned to Non-Versioned Key (Windows)

Exclusion key rules provide a way to convert a subset of guarded files or the contents of a folder from being encrypted by a versioned key to being encrypted by a non-versioned key. After this conversion, the excluded files or directory contents will be encrypted at the last version of the versioned key but the encryption keys for those items will not rotate to a new version when the keys for other non-excluded files are rotated. In other words, the excluded files or folder contents will be encrypted by a non-versioned key.

Follow these steps to change selected files or folder contents to a non-versioned key:

1. In the CipherTrust Manager, clone the versioned key that is used in the policy that you plan to edit. Cloning a key creates a non-versioned copy of the existing version of the versioned key.
2. In the CipherTrust Manager, disable the GuardPoint. Disabling the GuardPoint is required before modifying a policy applied in that GuardPoint.
3. Configure one or more resource sets to match the files that you want to exclude. For example, the resource set `star-dot-text` could contain `*.txt` and the resource set `sales-folder` could contain `\sales\*`.
4. Add one or more exclusion key rules to convert matching files to a non-versioned key. In the following example, files matching `*.txt` and files in the `sales` folder (as defined in resource sets) will be converted from the current version of the versioned key `AES256_versioned` to `AES256_clone`, assuming `AES256_clone` is a clone of `AES256_versioned`.

Order	Resource	Current Key	Transformation Key	Exclusion Rule
1	star-dot-txt	AES256_clone	AES256_clone	Y
2	sales-folder	AES256_clone	AES256_clone	Y
3		clear_key	AES256_versioned	N

Exclusion key rules must be ordered before other rules.

5. On the command line, run the following command to remove the CTE-LDT metadata from the files that you want to convert from versioned key to non-versioned key encryption:

```
voradmin ldt attr delete <path_to_files>
```

To recursively delete the CTE-LDT metadata from all files matching a pattern in all subfolders, use the following form, including `*` as a wildcard where needed:

```
voradmin ldt attr delete <path_to_files> -filter <filename>.<extension>
```

**Note:** Be careful when deleting the CTE-LDT metadata from files. If you delete the metadata from a file that does not match an exclusion key rule policy, the file will be unreadable after the next rekey.

Given the example exclusion key rule described in step 4, you would need to run this command on all files with the extension `.txt` (first example below) and on the files in `\sales` (second example below).

```
voradmin ldt attr delete c:\gp1 -filter *.txt
voradmin ldt attr delete c:\gp1\sales
```

For more information about using `voradmin` on CTE-LDT metadata, run `voradmin ldt attr /?` on the command line.

6. In the CipherTrust Manager, re-enable the GuardPoint that includes the new exclusion key rule.
7. In the CipherTrust Manager, rotate the key for the policy that includes the new exclusion key rule.

Using the example exclusion key rule in step 4, after completing this procedure, files matching `*.txt` and files in the `sales` folder will have the exclusion attribute set and will be excluded from rekeying (see ["About the Exclusion Attribute for Files Matching an Exclusion Key Rule" on the next page](#)). Files not matching the exclusion key rule will be rekeyed to the next version of the `AES256_versioned` key.

To perform a similar conversion on Linux, see ["Adding an Exclusion Key Rule to an Existing Policy with Versioned Keys \(Linux\)" on page 50](#).

## About the Exclusion Attribute for Files Matching an Exclusion Key Rule

Files matching an exclusion key rule have the status `rekey_excluded` in the CTE-LDT attribute. For more information about CTE-LDT attributes, see ["CTE-LDT Metadata in Extended Attributes" on page 57](#). To check for the exclusion attribute on a file, see ["Determining if a File is Included in an Exclusion Key Rule" below](#).

## The Exclusion Attribute is Persistent

Exclusion from rekey is a persistent property. A file excluded from rekey is not rekeyed regardless of changes that may seem to disassociate the file from the exclusion key rule. For example, if you rename a file to a new name within the same GuardPoint that no longer matches the exclusion key rule that the original name matched, the file with the new name retains the encryption type (non-versioned key or `clear_key`) of the exclusion key rule. To remove the exclusion attribute from a file you must copy the file rather than move or rename it (see ["Removing the Exclusion Attribute From a File" below](#)).

## Determining if a File is Included in an Exclusion Key Rule

Use the `voradmin ldt attr get <path to file>` command to check whether a file is associated with an exclusion key rule.

- On Linux, an excluded file will include the status `rekey_excluded` in the `voradmin` output. For example:

```
# voradmin ldt attr get /oxf-fs1/gp1/foo.txt
CTE-LDT attributes: rekeyed_size=0, rekey_status=rekey_excluded
```

- On Windows, an excluded file will include the attribute `Rekey Status Excluded` in the `voradmin` output. For example:

```
C:\> voradmin ldt attr get c:\gp1\foo.txt
CTE-LDT attributes:
Rekey Status Excluded
Initial Rekeyed Size 9 Bytes
Data Transformed 0 Bytes

Key:
Current Key Name/Version (Clear_Key)
New Key Name/Version (Clear_Key)
```

## Removing the Exclusion Attribute From a File

To disassociate a file from an exclusion key rule, you must copy the file to a new file not associated with the resource set of the same or another exclusion key rule as the source file. You can then remove the original file. The new file is created under the default key rule of whatever policy applies to the new file. Moving or renaming a file does not disassociate a file from an exclusion key rule (see ["The Exclusion Attribute is Persistent" above](#)).

For example, assume the following exclusion key rule where `Key_TextFiles` is a non-versioned key:

Exclusion Key Rule: Resource set = \*.txt, Key = `Key_TextFiles`

If you copy the file `test1.txt` to `test1.foo`, `test1.foo` is created with whatever key is specified in the policy that matches the new file. The key for the new file could be a non-versioned key, versioned key, `clear_key`, or, no key at all if the new file is outside of a GuardPoint. The original file `test1.txt` remains unchanged and encrypted with the `Key_TextFiles` non-versioned key because the file remains in the exclusion key rule.

## Rename and Restore Operations (Linux)

The effect of rename or backup/restore operations involving files associated or not associated with exclusion key rules is mixed and somewhat confusing. In some cases, the operations to restore or rename cause conflicts between the key associated with the source file and the key associated with the target file. For example, the result of a rename operation involving a source file not associated with an exclusion key rule and target file name associated with a resource set of an exclusion key rule is different from the result of the same operation when target file name is associated with the resource set of an exclusion key rule with clear\_key.

### Note

Be sure to review the effect of the operations below and avoid administrative operations that cross associations of files across multiple resource sets with conflicting key rules.

## Backup/Restore

The table below illustrates the status and the key effect of restore operations involving mixed keys associated with source files from backup image and existing target files inside GuardPoint.

Key Applied to File in Backup	Key Applied to existing file in GuardPoint	Key Effect of Restore Operation on Existing file
Versioned	Versioned	Versioned
Versioned	Exclusion key	xattr_error (failed)
Versioned	Exclusion clear key	xattr_error (failed)
Exclusion key	Versioned	Exclusion key
Exclusion key	Exclusion key	Exclusion key
Exclusion key	Exclusion clear key	xattr_error (failed)
Exclusion clear key	Versioned	Exclusion clear key
Exclusion clear key	Exclusion key	xattr_error (failed)
Exclusion clear key	Exclusion clear key	Exclusion clear key

The table below illustrates the status and the key effect of restore operations involving mixed keys associated with source files from backup image and new target files not present inside GuardPoint.

Key Applied to File in Backup	Key Applied to existing file in GuardPoint	Key Effect of Restore Operation on Existing file
Versioned	Versioned	Versioned
Versioned	Exclusion key	xattr_error (failed)
Versioned	Exclusion clear key	xattr_error (failed)
Exclusion key	Versioned	Exclusion key
Exclusion key	Exclusion key	Exclusion key
Exclusion key	Exclusion clear key	xattr_error (failed)
Exclusion clear key	Versioned	Exclusion clear key

Key Applied to File in Backup	Key Applied to existing file in GuardPoint	Key Effect of Restore Operation on Existing file
Exclusion clear key	Exclusion key	xattr_error (failed)
Exclusion clear key	Exclusion clear key	Exclusion clear key

## Rename Operation

The table below illustrates the status and the key effect of rename operations for different combinations of versioned, exclusion key, and exclusion clear key.

Key Applied to File in Backup	Key Applied to existing file in GuardPoint	Key Effect of Restore Operation on Existing file
Versioned	Versioned	Versioned
Versioned	Exclusion key	Exclusion key
Versioned	Exclusion clear key	xattr_error (failed)
Exclusion key	Versioned	Exclusion key
Exclusion key	Exclusion key	Exclusion key
Exclusion key	Exclusion clear key	Exclusion key
Exclusion clear key	Versioned	Exclusion clear key
Exclusion clear key	Exclusion key	Exclusion clear key
Exclusion clear key	Exclusion clear key	Exclusion clear key

## Listing All Files Included in an Exclusion Key Rule (Linux)

Determining the files that match an exclusion key rule involves two steps. You list all the keys in a GuardPoint, choose the key that you're interested in, and then run a command to list the files that match that key. This process works for both standard key rules and exclusion key rules.

1. Decide on the GuardPoint that you want to check for excluded files. For example, for the GuardPoint `/oxf-fs1/gp1`, type the following on the command line:

```
# voradmin ldt key report /oxf-fs1/gp1
LDT_KEY1,1
LDT_KEY2,2
LDT_KEY3,5
NON_VERSIONED_KEY
```

The number after the comma is the key version number. See ["Key Report Option" on page 43](#) for more information about the `voradmin` key report.

2. From the key report output, choose the key rule for which you want to list matching files. For example, to see the files associated with the NON\_VERSIONED\_KEY in the previous step, you would type:

```
# voradmin ldt key map NON_VERSIONED_KEY /oxf-fs1/gp1
/oxf-fs1/gp1/file1.dat10
/oxf-fs1/gp1/file2.dat10
/oxf-fs1/gp1/file3.dat10
/oxf-fs1/gp1/file4.dat10
/oxf-fs1/gp1/file5.dat10
```

See "Key Map Option" on page 43 for more information about the `voradmin` key map report.

## Listing All Files Included in an Exclusion Key Rule (Windows)

Determining the files that match an exclusion key rule involves two steps. You list all the keys in a GuardPoint, choose the key that you're interested in, and then run a command to list the files that match that key. This process works for both standard key rules and exclusion key rules.

1. Decide on the GuardPoint that you want to check for excluded files. For example, for the GuardPoint `c:\gp1`, type the following on the command line:

```
C:\> voradmin ldt key report c:\gp1
Keys used for GP, c:\gp1 :
clear_key,0
CS1-CTE-LDT-AES256,11
```

The number after the comma is the key version number. The `clear_key` key is not versioned, so the version number is 0.

2. From the key report output, choose the key rule for which you want to list matching files. For example, to show the files associated with the `clear_key` listed above, you would type:

```
C:\> voradmin ldt key map c:\gp1 clear_key,0
Files rekey with key (clear_key,0)-
c:\gp1\file1.txt
c:\gp1\file2.txt
c:\gp1\file3.txt
c:\gp1\file4.txt
c:\gp1\file5.txt
```

## Using CTE-LDT with SAP HANA Fibre Channel Systems (Linux Only)

You must add additional CTE commands to the HANA administrator entry. To do so, edit the `/etc/sudoers` with a text editor and add entries for `/usr/bin/voradmin` and `/usr/bin/vmsec`. For example:

```
# hanadm ALL=NOPASSWD:
/usr/bin/secfsd,/usr/bin/voradmin,/usr/bin/vmsec,/sbin/multipath,/sbin/multipathd,/etc/init.d/multipathd,/usr/bin/sq_persist,/bin/mount,/bin/umount,/bin/kill,/usr/bin/lsof,/sbin/vgchange,/sbin/vgscan
```

If you are using an ext3 file system, you must mount it with extended attributes. To do so, edit the storage section of the `global.ini` file using a text editor and add the following lines:

```
partition_*_data__mountOptions = -o user_xattr
partition_*_log__mountOptions = -o user_xattr
```

### Note

See the *CTE Agent for Linux Advanced Configuration and Integration Guide* or the *CTE Agent for Windows Advanced Configuration and Integration Guide* for more information about SAP HANA.



# Chapter 5: CTE-LDT Administration

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This chapter contains the following sections:

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## CTE-LDT Metadata in Extended Attributes

An *extended attribute* is a name/value pair permanently associated with a file or directory stored in a file system. CipherTrust Transparent Encryption (CTE) creates and maintains its own user extended attributes on CTE-LDT GuardPoint directories and files. The extended attributes are used to store metadata related to each file or directory that is protected using an CTE-LDT policy.

On Linux, CTE-LDT sets extended attributes on GuardPoint directories. The CTE-LDT attribute of an CTE-LDT GuardPoint stores the following metadata:

- Current key version.
- Rekey status.
- Rekey start and end times.
- Estimated completion time.
- Total amount of data transformed.
- Total number of files transformed.
- Current key signature and applied key signature.

On both Linux and Windows, CTE-LDT sets extended attributes on files. The CTE-LDT attribute of a file stores the following metadata:

- Name of the current key.
- Name of the versioned key.  
Also referred to in the CipherTrust Manager Console and product documentation as the new key or the transformation key.
- Version number of the versioned key.
- CTE-LDT rekey status of the file.

In most cases, the current and new key names are the same. The exception is during initial transformation from a legacy policy to an CTE-LDT policy, when the file has been encrypted with the current key and is being transformed to the current version of the transformation key.

#### Note

Before you set up a GuardPoint for CTE-LDT, ensure that there is sufficient disk space available in your file system for CTE-LDT metadata. The amount of disk space you need depends on the number of files in your GuardPoint. For more information about the disk space requirement, see ["Planning for CTE-LDT Attribute Storage" on page 60](#).

The state of a file changes during CTE-LDT operations. The extended attributes are continually updated to reflect the current file status, which falls into one of the following categories:

- Rekeyed to the current version of the key.
- Rekeyed to the previous version of the key, or the initial key state (before the first CTE-LDT rekey has been performed).
- Partially rekeyed, where some regions of the file are rekeyed to the new key version and other regions are still keyed to the previous key version or the initial key.

## Listing Extended Attributes

You can list extended attributes by using native operating system commands, or system calls. As part of GuardPoint administration, CTE can modify or delete extended attributes.

In Linux, CTE-LDT attributes are set on GuardPoint directories and regular files in GuardPoint directories protected with CTE-LDT policies. The CTE extended attribute name is `::secfs:xattr:.`

The following example uses the native Linux operating system command `attr` to display the CTE-LDT attribute for the GuardPoint `/oxf-fs1/gp1` and the file `/oxf-fs1/gp1/File_1.txt`.

#### Example 1:

```
# attr -l /oxf-fs1/gp1/File_1.txt
Attribute "::secfs:xattr:" has a 1044 byte value for /oxf-fs1/gp1/File_1.txt
Attribute "selinux" has a 37 byte value for /oxf-fs1/gp1/File_1.txt
```

#### Example 2:

```
# attr -l /oxf-fs1/gp1
Attribute "::secfs:xattr:" has a 1044 byte value for /oxf-fs1/gp1
Attribute "selinux" has a 37 byte value for /oxf-fs1/gp1
```

#### Example 3:

In the following example, the file `/oxf-fs1/gp1/File_1.txt` has the same name for current and new keys at the same key version. In the following example, if the versioned key `LDT_KEY` is at version 755, the file is rekeyed to the latest key version under the CTE-LDT policy.

```
# voradmin ldt attr get /oxf-fs1/gp1/File_1.txt
CTE-LDT attributes: rekeyed_size=4096, rekey_status=none
Key:    name=LDT_KEY, version=755
```

#### Example 4: (Linux)

The following is example of an CTE-LDT attribute on a GuardPoint directory on Linux:

```
# voradmin ldt attr get /oxf-fs1/gp1
LDT stats: version=1, rekey_status=rekeying
  Number of times rekeyed:      3 times
  Rekey start time:             2018/08/04 16:24:45
  Last rekey completion time:   2018/07/04 16:24:04
  Estimated rekey completion time: N/A
  Policy key version:           2043
```

```
Data stats:
    total=3.3GB, rekeyed=1.5GB, truncated=0.0MB
File stats:
    total=4307, rekeyed=1181,
    passed=2, skipped=0, created=0, removed=0
```

### Example 5: (Windows)

The attribute for the GuardPoint `c:\GP 1` contains the status (rekeyed) and statistics specific to the GuardPoint and CTE-LDT. Following is sample output of `voradmin` command on Windows for statistics on a file:

```
C:\> voradmin ldt attr get c:\GP\Test.txt
LDT attributes:
    Rekey Status          Rekeyed
    Initial Rekeyed Size  10 Bytes
Key:
    Key Name/Version      (LDT_KEY, 28)
```

The attribute for GuardPoint `C:\GP` contains the status (rekeyed) and statistics specific to the GuardPoint and CTE-LDT:

```
C:\> voradmin ldt attr get c:\gp\
LDT Stats
-----
    Rekey Status          LDT_ST_REKEYED
    Last rekey completion time    10/2/2017 4:26:50
    Rekey Start time            10/2/2017 4:26:17
    Estimated rekey completion time    000:00:00

File Stats:
    Total      444
    Rekeyed    444
    Skipped    0
    Errored    0
    Passed     0
    Removed    0

Data Stats:
    Total      11 GB (12649143417 Bytes)
    Rekeyed    11 GB (12649143417 Bytes)
    Truncated  0 Bytes
```

## MDS File (Linux)

In addition to CTE-LDT attributes, the CTE-LDT process on Linux requires persistent storage for additional metadata related to encrypting, or rekeying, files in GuardPoints. CTE-LDT allocates the storage space as soon as the CTE-LDT process starts on a GuardPoint. It maintains this storage space during the entire transformation process, until the GuardPoint is completely transformed.

Storage for this metadata is allocated and managed in a special file, called the MDS (metadata store) file. The MDS file resides inside a GuardPoint directory so each GuardPoint has its own MDS file.

The MDS file is a CTE protected file with the name `::vorm:mds::`. For example:

```
# ls -l /oxf-fs1/gp1/::vorm:mds::
-rwxr-xr-x. 1 root  root 31754474496 Dec  8 09:09 /oxf-fs1/::vorm:mds::
# du -B 1024 /oxf-fs1/gp1/::vorm:mds::
25056    /oxf-fs1/::vorm:mds::
```

As shown above, the MDS file is sparse. In the example, the file size is approximately 30GB, however the file is allocated with approximately 25MB of disk storage. CTE-LDT automatically creates the MDS file the first time the CTE-LDT process starts on any GuardPoint in the file system namespace. It populates the MDS file with all of the metadata for the GuardPoint at the beginning of the CTE-LDT process. Disk space allocated to the MDS file is freed and the MDS file in the GuardPoint directory is removed when the CTE-LDT process completes on the GuardPoint.



#### **WARNING**

**The MDS file is protected. You cannot remove it unless the administrator runs the `voradmin` command to manually remove the MDS file once it is no longer needed. See ["Deleting CTE-LDT Metadata \(Linux\)" on page 76](#) for more information.**

CTE-LDT automatically allocates and deallocates disk space for the MDS file as part of the CTE-LDT process. Deallocation of disk space for a GuardPoint does not change the MDS file size, although it frees the disk blocks. MDS files are sparse and very large in size. With no GuardPoint undergoing CTE-LDT, the minimum allocation of an MDS file is approximately 25MB.

## **Planning for CTE-LDT Attribute Storage**

Before a GuardPoint is enabled for CTE-LDT, make sure that there is sufficient free disk space in the file system to which the GuardPoint belongs. Free space is required for CTE-LDT attributes (CTE extended attributes) and (in Linux) metadata in the MDS file. CTE-LDT attributes are created during initial encryption and are never freed until the GuardPoint is permanently unguarded and removed from the protection of an CTE-LDT policy. In contrast, disk space for metadata in the MDS file is temporary, kept only during the live transformation process.

When planning how much free disk space to reserve for CTE-LDT on a GuardPoint, consider the following:

- Number of files in the GuardPoint
- (Linux) Average length of absolute pathnames of files in the GuardPoint

The CTE-LDT process pre-allocates disk space for the Linux MDS file based on a minimum of 200K files with an average pathname of 1024 bytes per GuardPoint. The minimum space amounts to 325MB of disk space for the MDS file for each GuardPoint, even if file count is very low. (In Windows, CTE-LDT reserves the space when the file is rekeyed.)

## **Using voradmin To Estimate Disk Space Required for CTE-LDT (Linux)**

In Linux, you can use the `voradmin ldt space` command to estimate the amount of disk space required for CTE-LDT attributes and the MDS file. The result is rounded to the nearest MB. The syntax of the command is:

```
# voradmin ldt space <guard path>
```

The following example shows how to estimate the required disk space to perform CipherTrust Transparent Encryption - Live Data Transformation on 1501 files in the GuardPoint `/oxf-fs1/gp1`. Estimate the disk space before protecting `/oxf-fs1/gp1` using an CTE-LDT policy. For example:

```
# voradmin ldt space /oxf-fs1/gp1
/oxf-fs1/gp1: found 1501 files without CTE-LDT extended attributes
CTE-LDT disk space requirements: total 169MB (CTE-LDT attributes=6MB, MDS=163MB)
```

The `voradmin` command reports that 1501 files in `/oxf-fs1/gp1` without CTE-LDT attributes. These files are new to CTE-LDT. 6MB of space is required for the CTE-LDT extended attributes and 163MB for metadata in the MDS file.

The following example shows the output of the same command after encryption completes. This estimates the additional disk space needed for the next CTE-LDT rekey operation. For example:

```
# voradmin ldt space /oxf-fs1/gp1
/oxf-fs1/gp1: found 0 files without CTE-LDT extended attributes
CTE-LDT disk space requirements: total 163MB (CTE-LDT attributes=0MB, MDS=163MB)
```

The voradmin command still reports on the same 1501 files, but because encryption has occurred using CTE-LDT, the files all have their CTE-LDT attributes. No additional space is required for CTE-LDT extended attributes on the next run. However, since the MDS file is transient and deletes after it finishes encrypting the GuardPoint, it requires additional space for the next key rotation.

#### Note

Windows estimates space using the following equations:

- Permanent Space = Number of Files \* 4K
- Temporary Space = 128K \* (Number of CPU \* 2)

## Displaying Metadata

Use the following command to see CTE-LDT file attributes or GuardPoint attributes:

```
# voradmin ldt attr get [<file name path> | <guard path>]
```

For an overview of voradmin ldt, see ["CTE-LDT Command-Line Administration: voradmin command" on page 71](#).

## Verifying Metadata (Windows only)

Use the following command to verify if the metadata is corrupt:

```
# voradmin ldt attr verify [<file name path> | <guard path>]
```

For an overview of voradmin ldt, see ["CTE-LDT Command-Line Administration: voradmin command" on page 71](#).

## DFSR and Replication (Windows)

The Distributed File System Replication (DFSR) service is a multi-master replication engine used to maintain synchronized folders on multiple servers. Replicating data to multiple servers increases data availability and provides users in remote sites with fast, reliable access to files.

If you are creating GuardPoints in a DFSR environment, you must first add the DFSR private folder guard path to the exclusion list in the Windows Registry. CTE-LDT should not attempt data transformation on this read-only directory.

1. Using the Registry Editor, or the Windows command line, add a registry entry in: `HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\Vmmgmt\Parameters` named "LDTEExclusionGPList" of type REG\_MULTI\_SZ.
2. Add the `DfsrPrivate` directory path to the `LDTEExclusionGPList`.  
For example, if the DFSR private directory path is `D:\data\DfsrPrivate`, add this string in `LDTEExclusionGPList`.
3. Reboot the system to make the change take effect.

#### Note

CTE-LDT does not perform a rekey on the DFSR private directory. Its rekey status is always "N/A".

If an application, or user, is performing a rename or a delete folder operation inside a GuardPoint with an CTE-LDT policy, this may restart the rekey process. Files which are already rekeyed will not be rekeyed again.

- If a rename or a delete operation is already performed on rekeyed files/folder, then the rekey process does not restart.
- If a rename or delete operation is performed in a folder where a rekey is in progress, CTE-LDT needs to stop the rekey process and restart the rekey again.

## Multi-Node Configuration and Operation

This section describes what to expect at runtime when CTE-LDT operates in a multi-node cluster environment.

### CTE-LDT Behavior on Failover

In a multi-node cluster, CTE-LDT runs in active-passive mode. A GuardPoint is only enabled on the active node, and CTE-LDT only runs on the active node. On the CipherTrust Manager Console, you can only view statistics for the active host.

If the active host fails over, and the standby host takes control, CTE-LDT also fails over to the second host. On the CipherTrust Manager Console, CTE-LDT statistics now appear on the other host.

### Veritas Cluster Server

In an HA environment with Veritas Cluster Server, manual failover of service to a stand-by host may require manual intervention. If any GuardPoint is in the scan phase at the time of the manual failover, the failover process fails with the error "UNABLE to OFFLINE". The reason for the failure may be the scan state of a GuardPoint that cannot be suspended. CTE-LDT suspends CTE-LDT operations during the rekey state of transformation. Because CTE-LDT scan operations cannot be suspended, the Veritas Cluster Server fails to suspend CTE-LDT on GuardPoints in the scan phase of CTE-LDT operation. This state of CTE-LDT operation prevents Veritas Cluster Server to manually offline the service for fail-over.

## Backing Up and Restoring CTE-LDT GuardPoints

This section describes procedures and considerations related to backing up and restoring data in CTE-LDT GuardPoints.

In addition to the files in a GuardPoint, CTE-LDT stores metadata in extended file attributes. These CTE-LDT attributes contain information that is required for decrypting the files and for the proper operation of CTE-LDT. Therefore, it is critical that your backup application also backs up the extended attributes of the files along with file data.

### Clear Text Backup and Restore

A policy that applies a Security Rule with the Apply Key effect on backup/restore operations does not require any special rules for data access by backup applications. Under such a policy, backup applications always read clear data and store clear data in backup media. The backup application is not required to back up the CTE-LDT extended attributes, and a QoS schedule is not required to suspend CTE-LDT during backups.

### Encrypted Backup and Restore

When a policy does not enforce a Security Rule with the Apply Key effect on backup/restore operations, the policy does not decrypt data on I/O operations from that backup application. Under such a policy, the backup application stores encrypted data and the CTE-LDT extended attributes of the file on the backup media.

In Linux, CTE-LDT operations must be suspended during backup. Suspending CTE-LDT completes the ongoing rekey operations on regions of files before starting the backup. During live transformation, CTE-LDT first preserves those regions of a file to be rekeyed in the MDS file. Then it updates some of the metadata in order to update the status of the data preserved in the MDS file in preparation for the rekey. Then it starts rekeying and updating those regions in the underlying file.

Suspending CTE-LDT waits for ongoing rekey operations to complete, and saves the metadata in the CTE-LDT extended attribute section of the MDS file. Suspending CTE-LDT ensures that the rekey status stored in the CTE-LDT extended attribute accurately reflects the rekey status of the data in the entire file during backup.

**Note**

This requirement does not apply to CTE-LDT for Windows.

The following table summarizes the state of the data in files in backup media:

CTE-LDT State of File	Security Policy	Backup Metadata or Alternate Data Streams Along with File data	Effect
Not rekeyed	Permit	Yes	Data in backup may be in clear format or encrypted with older key version.
Rekey in progress	Permit	Yes	File in backup storage is partially rekeyed. Some parts are in clear format or encrypted with older key version, and other parts are encrypted with current key version.
Rekey complete	Permit	Yes	File in backup storage is in the encrypted format with new key version.

## CTE-LDT Policy for Encrypted Backup and Restore

Suppose you have an CTE-LDT policy allowing a backup user, or a backup process, to perform an encrypted backup. The backup user, or the backup process, reads encrypted data from files and stores the same encrypted data in backup media.

For example, suppose you wanted to back up GuardPoint `/oxf-fs1/gp1` protected by `My_LDT_Policy_1`. The key version before the key rotation is 8. The following steps occur:

1. Key version 8 expires and is rotated to version 9.
2. Rotating the encryption key triggers CTE-LDT to start running on the data under the GuardPoint.
3. The QoS schedule suspends CTE-LDT because a backup process is running.
4. The backup process begins, runs and later ends.
5. The QoS schedule resumes CTE-LDT.
6. CTE-LDT on the GuardPoint completes.

**Note**

Although the backup/restore scenarios and examples described in the rest of this section are specific to CTE-LDT on Linux platform, the concepts also apply to CTE-LDT on the Windows platform.

Consider the state of the three files in the GuardPoint during the CTE-LDT process, right after CTE-LDT is suspended in preparation for the backup. You can obtain the state of each file through the `voradmin ldt attr get` command, which examines the CTE-LDT state of each file captured in the CTE-LDT extended attributes of those files. (For an overview of `voradmin CTE-LDT`, see ["CTE-LDT Command-Line Administration: voradmin command" on page 71](#)).

- **File\_1.dat** is rekeyed/encrypted to completion. The applied and new key versions are at version 9 of the key.

```
# voradmin ldt attr get /oxf-fs1/gp1/data_files/file_1.dat
LDT attributes: rekeyed_size=1440743424, rekey_status=none
Key:      name=LDT_AES256_KEY, version=9
```

- **File\_2.dat** is partially rekeyed/encrypted. The applied key version is at version 8 and the transformation key is at version 9.

```
# voradmin ldt attr get /oxf-fs1/gp1/data_files/file_2.dat
LDT attributes: rekeyed_size=1440743424, rekey_status=rekeying,state_saved
Current Key:      name=LDT_AES256_KEY, version=8
New Key:          name=LDT_AES256_KEY, version=9
```

- **File\_3.dat** has not been rekeyed/encrypted. The applied key and transformation key are both at version 8, which is the version before the current key rotation.

```
# voradmin ldt attr get /oxf-fs1/gp1/data_files/file_3.dat
LDT attributes: rekeyed_size=1440743424, rekey_status=none
Key:      name=LDT_AES256_KEY, version=8
```

While CTE-LDT is suspended on the GuardPoint, the backup process starts and archives these three files, including extended attributes, in the backup media.

```
# my_backup --preserve=xattr /oxf-fs1/gp1/data_files/file_1.dat \
    /backup-media/oxf-fs1/gp1/data_files/file_1.dat
# my_backup --preserve=xattr /oxf-fs1/gp1/data_files/file_2.dat \
    /backup-media/oxf-fs1/gp1/data_files/file_2.dat
# my_backup --preserve=xattr /oxf-fs1/gp1/data_files/file_3.dat \
    /backup-media/oxf-fs1/gp1/data_files/file_3.dat
```

#### Notes

- On Linux platforms, you must perform backups on a GuardPoint during periods when CTE-LDT is not actively transforming data in the GuardPoint. You must schedule backups in conjunction with CTE-LDT schedules or during periods when CTE-LDT is paused. Make sure to coordinate with the backup administrator and schedule accordingly.
- If the preferred method of backup is to create device level snapshots of the file system on the managed host or in the storage array subsystem, you must ensure that the schedule for creating snapshots pauses CTE-LDT before a snapshot is created.

## Backup/Restore of Metadata Store File (MDS) in GuardPoints Undergoing Rekey

Backing up an entire GuardPoint using commands such as `cp`, `tar`, or `rsync`, or even commercial backup products that sweep the file system namespace for backing up files is supported. This method of backup performed while live transformation is in progress over GuardPoint poses some challenges when files in GuardPoint are backed up in encrypted format. The challenge with this method of backup is existence of the CTE-LDT Metadata Store file (MDS) in GuardPoint during backup or restore process and strict protection enforced on MDS files preventing deletion or modification to MDS files. Second, your backup utility must backup and restore extended attributes of files, and because CTE-LDT extended attributes are also protected similar to MDS files, your backup must be enabled to restore extended attribute of files. To overcome both restrictions, your policy on GuardPoint must include a security rule without Apply Key Effect to enable your backup utility to replace MDS file and CTE-LDT extended attribute of files as



part of backup/restore operations. Additionally, your backup utility must be signed with a signature set from the CipherTrust Manager for added security, and be executed with the option to preserve extended attribute options available with the standard Linux utilities.

The following table lists the supported backup utilities, required options to preserve extended attributes, and supported versions of the utilities.

Command	Required options	Supported version
cp	--preserve=all	OS default
tar	--xattrs	OS default
rsync	-vapIXWP --inplace	OS default
netbackup	overwrite existing files	v7.6.1 and v7.7.3

You can also backup and restore GuardPoint data, including the MDS file, if the requirements listed above on the backup utility are satisfied. GuardPoints associated with an MDS file located outside of GuardPoint namespace cannot be backed up or restore using this method of backup.

#### Note

You must suspend CTE-LDT on GuardPoint before performing backup or restore.

You can check your GuardPoint to determine if you can use this method of backup. If the directory of your GuardPoint is a mount point, MDS files reside inside your GuardPoint and this method of backup can be used for backing up or restoring your GuardPoint. However, GuardPoint directories below file system mount points must be checked and verified to use this method of backup. To verify, you can run the `voradmin` command to determine the MDS file associated your GuardPoint.

For example:

```
# voradmin ldt list all
MDS_1:  type=file, nguards=1, name=/oxf-fs1/gp1/:vorm:mds::

Guard Table: version 1 nentries 1
Guard 0: type=GP, state=REKEYING SUSPENDED (vadm), flags=GP LOCKED, gp=/oxf-fs1/gp1
File List: count 4308
```

The report on `/oxf-fs1/gp1` GuardPoint indicates association of the MDS file `/oxf-fs1/gp1/:vorm:mds::` with the GuardPoint. As the MDS file resides inside the GuardPoint directory, you can use this method of backup to backup and restore this GuardPoint.

Before restoring the GuardPoint, you must suspend CTE-LDT operations on the GuardPoint if live transformation is in progress. Failure to do so will fail to restore the MDS file in the backup image. Failure to restore MDS file affects partially rekeyed files restored to the GuardPoint. In such a situation the restored data is invalid, and you must remove all the files restored to the GuardPoint and repeat the restore operation after suspending CTE-LDT.

## Restoring a GuardPoint from a Backup

To properly restore GuardPoint along with the MDS file, the following steps must be done in order:

1. Verify if live transformation is in progress on the GuardPoint and suspend the CTE-LDT operations. (Skip this step if no live transformation is occurring.)
2. With the same tool that was used for backup, restore to the GuardPoint.

3. Once restore is complete, GuardPoint needs to be disabled and enabled again. Run the `voradmin` command as shown below to determine how the GuardPoint was suspended at the time of backup. For manual GuardPoint, run the `secfsd` command as shown below. For auto-guards, disable and enable GuardPoints on CipherTrust Manager.

```
# secfsd -unguard <GuardPoint>
# secfsd -guard <GuardPoint>
```

4. Since GuardPoint was in suspended state during the time of backup, it will be restored in suspended state. You must resume CTE-LDT to complete CTE-LDT on the restored GuardPoint. You must resume CTE-LDT on the CipherTrust Manager if CTE-LDT was suspended on the CipherTrust Manager at the time of backup, otherwise you will resume CTE-LDT using `voradmin` command.

Run the `voradmin` command below to determine if CTE-LDT must be resumed on CipherTrust Manager or through `voradmin`. If the tag string next to SUSPENDED state of GuardPoint is `vadm`, run `voradmin` command to resume CTE-LDT, otherwise the tag value is `qos` and CTE-LDT must be resumed on CipherTrust Manager. In the example below, GuardPoint `/oxf-fs1/gp1` was suspended using `voradmin`, and it must be resumed after restore using `voradmin` command.

```
# voradmin ldt list all
MDS_1: type=file, nguards=1, name=/oxf-fs1/gp1::vorm:mds::
Guard Table: version 1 nentries 1
Guard 0: type=GP, state=REKEYING SUSPENDED (vadm), flags=GP LOCKED, gp=/oxf-fs1/gp1
File List: count 4308
# voradmin ldt resume /oxf-fs1/gp1
```

5. Wait for CTE-LDT completion on GuardPoint.
6. We strongly recommend that you disable and re-enable the GuardPoint once more.

The restore is now complete and files in your GuardPoint can be accessed.

The CTE Agent sends the following alert message to CipherTrust Manager if the restore operation is rejected:

```
LDT-ALERT: Restore of LDT protected file <GuardPoint> not allowed by policy
```

## Potential Warnings During Restore Operation

When using `cp` for backup/restore, the `cp` command may report a failed attempt to preserve permissions on the Metadata Store File (MDS) during a restore. If you encounter the below message, continue to proceed with the restore steps since this will not affect the MDS file or dataset that is being restored.

```
cp: preserving permissions for '/oxf-fs1/gp1::vorm:mds::': Permission denied
```

When using `rsync` for backup/restore, the `rsync` command may report a failed attempt to set extended attribute when restoring the MDS file on system with selinux configured in enforced mode. If user encounters the below message, continue to proceed with the restore steps since this will not affect the MDS file or dataset that is being restored.

```
rsync: copy_xattrs: lsetxattr("/oxf-fs1/gp1::vorm:mds::", "security.selinux") failed:
Permission denied (13)
rsync: rsync_xal_set: lsetxattr("/oxf-fs1/gp1::vorm:mds::", "security.selinux") failed:
Permission denied (13)
```

## Restore an Encrypted Backup

This section illustrates restoration of the three files from the backup media to the same GuardPoint, `/oxf-fs1/gp1`. The files are restored to a different directory under the GuardPoint.

## Restore a File Fully Rekeyed to the Latest Key Version

Recall that *file\_1.dat* was archived in the backup media when it was fully rekeyed to version 9 of the key. As the current version of the key is also 9, *file\_1.dat* is restored from backup without any changes. After restoring the file, the state of the restored file and its applied and current key versions remain unchanged, as compared to the original file that was backed up.

```
# my_backup --preserve=xattr /backup-media/oxf-fs1/gp1/data_files \ /file_1.dat /oxf-fs1/gp1/restored_files/file_1.dat

# voradmin ldt attr get /oxf-fs1/gp1/restored_files/file_1.dat
LDT attributes: rekeyed_size=1440743424, rekey_status=none
Key:      name=LDT_AES256_KEY, version=9

# voradmin ldt attr get /oxf-fs1/gp1/data_files/file_1.dat
LDT attributes: rekeyed_size=1440743424, rekey_status=none
Key:      name=LDT_AES256_KEY, version=9
```

## Restore a Partially Rekeyed/encrypted File

Recall that *file\_2.dat*, archived in the backup media, was partially rekeyed between versions 8 and 9. As the current version of the key was 9 at the time of backup, *file\_2.dat* is restored to the GuardPoint with the same version of the key from the time of backup. The file is flagged for *lazy rekey*, meaning that a background rekey operation is scheduled to transform the file to the latest key version the next time an application tries to access the file.

At the completion of restoration, the file is fully transformed to the key version (v9). The key version is also the latest one in the policy. Although the file is flagged for lazy rekey (LAZY\_RK), the file does not need to be transformed to the latest key version because it's already there. Had the file been partially rekeyed from version 7 to version 8 of the key at the time of backup, the restored file would have completed rekeying to version 8 at the end of the restoration. Therefore, the LAZY\_RK flag would initiate a background transformation to update the key version to the latest key version when the file is accessed.

If this file is not accessed by any application, the file remains unchanged in the GuardPoint. It is not transformed to the latest key version. To trigger a rekey, either re-push the CTE-LDT policy from the CipherTrust Manager, or access the file with an application, such as a file explorer.

```
# my_backup --preserve=xattr /backup-media/oxf-fs1/gp1/data_files/\ file_1.dat /oxf-fs1/gp1/restored_files/file_2.dat

# voradmin ldt attr get /oxf-fs1/gp1/restored_files/file_2.dat
LDT attributes: rekeyed_size=1440743424, rekey_status=lazy_rekey
Key:      name=LDT_AES256_KEY, version=9

# voradmin ldt attr get /oxf-fs1/gp1/restored_files/file_2.dat
LDT attributes: rekeyed_size=1440743424, rekey_status=none
Key:      name=LDT_AES256_KEY, version=9
```

## Restore a File Not Rekeyed/encrypted with an Older Key Version

Recall *file\_3.dat* was archived in the backup media when it was keyed to version 8 of the key, one version below the latest version at the time of backup. At completion of the restoration, *file\_3.dat* is restored from backup to the same version, version 8, that it was keyed to when it was backed up.

However, the file is flagged for lazy rekey. After restoring the file, it is keyed to version 8 and flagged for lazy rekey (LAZY\_RK). The file is rekeyed to the latest key version, version 9, as soon as an application accesses the file. If this file is not accessed by any application, the file remains unchanged in the GuardPoint.

```
# my_backup --preserve=xattr /backup-media/oxf-fs1/gp1/data_files \ /file_3.dat /oxf-  
fs1/gp1/restored_files/file_3.dat  
  
# voradmin ldt attr get /oxf-fs1/gp1/restored_files/file_3.dat  
LDT attributes: rekeyed_size=1440743424, rekey_status=lazy_rekey  
Key:      name=LDT_AES256_KEY, version=8  
  
# sum /oxf-fs1/gp1/restored_files/file_3.dat  
39994 1406976  
  
# voradmin ldt attr get /oxf-fs1/gp1/restored_files/file_3.dat  
LDT attributes: rekeyed_size=1440743424, rekey_status=none  
Key:      name=LDT_AES256_KEY, version=9
```

## Restoring Non-CTE-LDT Backup Data to an CTE-LDT GuardPoint

This section describes how to restore data encrypted with a non-versioned key to an CTE-LDT GuardPoint.

If the backup was performed with the Apply Key effect, the backup files are in clear text. Simply restore the clear text files to the CTE-LDT GuardPoint with the Apply Key effect. All files will be encrypted with the versioned key.

If the backup of the non-CTE-LDT GuardPoint was performed without the Apply Key effect, the backup is encrypted, and you must do the following:

### Note

The following example is for a manual guarding. The steps may differ slightly if your GuardPoint is configured for auto guard.

1. Create a temporary directory for restoring the files, type:  

```
# mkdir -p /oxf-fs1/tmp_restore
```
2. Restore the encrypted backup files into the temporary directory, type:  

```
# cp -pr /backup-media/oxf-fs1/gp1/data_files/* /oxf-fs1/tmp_restore
```
3. Create a Standard Policy with the Apply Key effect for all operations, using the same key as the policy applied on the GuardPoint at the time of backup.
4. Create and enable a new GuardPoint for the temporary directory using the Standard Policy just created.  

```
# secfsd -guard /oxf-fs1/tmp_restore
```
5. Ensure that the temporary GuardPoint and CTE-LDT GuardPoint are both enabled.  

```
# secfsd -status guard
```

GuardPoint	Policy	Type	ConfigState	Status	Reason
-----	-----	----	-----	-----	-----
/oxf-fs1/gp1	LDT_AES256	manual	guarded	guarded	N/A
/oxf-fs1/tmp_restore	AES256	manual	guarded	guarded	N/A
6. Move the restored files from the temporary folder to the GuardPoint enabled with the CTE-LDT policy. The CTE agent encrypts the files in the CTE-LDT GuardPoint using the current key version in effect for the CTE-LDT policy.  

```
# mv /oxf-fs1/tmp_restore/* /oxf-fs1/gp1
```
7. Disable the temporary GuardPoint and remove the temporary restore directory.  

```
# secfsd -unguard /oxf-fs1/tmp_restore  
# rm -fr /oxf-fs1/tmp_restore
```
8. Delete the temporary GuardPoint on the CipherTrust Manager.

## Using fsfreeze (Linux only)

If you use the `fsfreeze` command to quiesce access to the file system before creating a snapshot, refer to the `fsfreeze` section in CTE Admin Guide in the Linux Utilities chapter on how to run the `fsfreeze` command to quiesce access to both the file system and the GuardPoint(s).



### WARNING

**Do not use CTE-LDT schedules and do not pause CTE-LDT to align backup schedules with CTE-LDT. Instead, use the `fsfreeze` command.**

- Running `fsfreeze -f` on the GuardPoint directory pauses CTE-LDT operations in-progress and freezes access to both the GuardPoint and the underlying file system.
- Running `freeze -u` reverses `freeze -f`, allowing access to underlying file system and resuming CTE-LDT operations.

## CTE-LDT Backups Using a File System or Storage-Level Snapshot Tool

You can make a file system snapshot using a Logical Volume Manager service or mirroring/splitting storage level LUNs of a file system inside the storage subsystem. CTE-LDT does not have requirements for where and how you create a file system snapshot. However, it is required that you **suspend CTE-LDT processes before you take the file system snapshot**. Suspending CTE-LDT ensures data and metadata consistency between files and CTE-LDT extended attributes.

You may choose to suspend CTE-LDT manually on the managed host using `voradmin ldt suspend` command or `fsfreeze -f`, or suspend CTE-LDT on the CipherTrust Manager.

### Note

Be aware that suspending CTE-LDT on the CipherTrust Manager suspends CTE-LDT on the entire host.

After creating a file system snapshot, you can resume CTE-LDT processes on the GuardPoint using `voradmin ldt resume`, or `fsfreeze -u`, or resuming CTE-LDT on the CipherTrust Manager. Do not mix the use of `fsfreeze` and `voradmin ldt suspend` to pause and resume CTE-LDT. CTE suspends or resumes CTE-LDT processes during live transformation when freezing or unfreezing GuardPoint access using `fsfreeze -f` or `-u` option. See the *CTE Agent for Linux Advanced Configuration and Integration Guide* on the use of the `fsfreeze` command on a GuardPoint.

### Note

You can make sure CTE-LDT is suspended at backup time by setting the QoS schedule.

You can mount a file system snapshot for data recovery. Configuration for GuardPoints must be duplicated over the mount point of the snapshot file system. Make sure to use the same CTE-LDT policy. Enabling GuardPoints over or under the snapshot mount point provides access to the protected files for recovery. You can choose to manually resume key rotation on the GuardPoints of the snapshot file system, although this is not necessary.

Following is an example of the `fsfreeze` command used to freeze access to the file system `/oxf-fs1` in order to create a snapshot of the file system device. This examples illustrates three GuardPoints enabled inside the file system namespace, `/oxf-fs1/gp-1`, `/oxf-fs1/gp-2`, and `/oxf-fs1/gp-3`. Executing the command `fsfreeze -f` targets any of the GuardPoints in the `/oxf-fs1` mount point and suspends CTE-LDT processes on all of the GuardPoints. Then it freezes access to the file system.

```
# fsfreeze -f /oxf-fs1/gp-1
# voradmin ldt list all
MDS_1:  type=file, nguards=1, name=/oxf-fs1/gp-3/:vorm:mds::
        Guard Table: version 1 nentries 1
        Guard 0: type=GP, state=REKEYING SUSPENDED (vadm), flags=GP LOCKED,
```

fs1/gp-3

File List: count 4308

MDS\_2: type=file, nguards=1, name=/oxf-fs1/gp-2/::vorm:mds::

Guard Table: version 1 nentries 1

Guard 0: type=GP, state=REKEYING DIRTY, flags=GP LOCKED, gp=/oxf-fs1/gp-2

File List: count 4308

MDS\_3: type=file, nguards=1, name=/oxf-fs1/gp-1/::vorm:mds::

Guard Table: version 1 nentries 1

Guard 0: type=GP, state=REKEYING SUSPENDED (vadm), flags=GP LOCKED, gp=/oxf-fs1/gp-1

File List: count 4308

After the file system snapshot is created, executing the `fsfreeze -u` command on any of the GuardPoints in the file system namespace unfreezes access to the file system and resumes CTE-LDT processes on all of the GuardPoints.

```
# fsfreeze -u /oxf-fs1/gp-1
```

```
# voradmin ldt list all
```

MDS\_1: type=file, nguards=1, name=/oxf-fs1/gp-3/::vorm:mds::

Guard Table: version 1 nentries 1

Guard 0: type=GP, state=REKEYING DIRTY, flags=GP LOCKED, gp=/oxf-fs1/gp-3

File List: count 4308

MDS\_2: type=file, nguards=1, name=/oxf-fs1/gp-2/::vorm:mds::

Guard Table: version 1 nentries 1

Guard 0: type=GP, state=REKEYING DIRTY, flags=GP LOCKED, gp=/oxf-fs1/gp-2

File List: count 4308

MDS\_3: type=file, nguards=1, name=/oxf-fs1/gp-1/::vorm:mds::

Guard Table: version 1 nentries 1

Guard 0: type=GP, state=REKEYING DIRTY, flags=GP LOCKED, gp=/oxf-fs1/gp-1

File List: count 4308

## Windows Backup and Snapshots

On Windows, most backup applications use Volume Snapshot Service (VSS) for the backup. Using VSS is required for backing up files in CTE-LDT GuardPoints. VSS service provides a consistent view of the data to backup and restore applications by taking a snapshot of the volume. Windows Backup uses the snapshot volume, while other applications can continue using the original volume for normal I/O operations. VSS snapshot volume uses a “Copy on write” mechanism to provide a consistent view of the data. Some of the high-level steps of the Windows backup process are:

1. Backup application takes a snapshot of the volume using the VSS service.
2. Backup application mounts this VSS volume to read the data to be backed up.
3. The CTE Agent uses the same policy as that of the original volume to protect these snapshots.
4. The CTE Agent applies the policy and rules to all the I/O requests coming from the backup and restore applications.

## CTE-LDT Backup and Restore Troubleshooting

### Restored files to a GuardPoint protected with conflicting key rules

When restoring an encrypted file from backup media to an CTE-LDT protected GuardPoint without the Apply Key effect, and the file in the backup media does not have an CTE-LDT extended attribute, the file restored to the GuardPoint is set with an CTE-LDT extended attribute that specifies the current key version of the key in the policy

associated with the data in the restored file. As the key and key version in the policy do not match the key that was applied to the data at the time of backup, the file restored to the CTE-LDT protected GuardPoint is unreadable.

When restoring an encrypted file from backup media to an CTE-LDT protected GuardPoint without Apply Key effect, and the key specified in the CTE-LDT extended attribute of the file in backup media conflicts with the key rules of the policy on the GuardPoint, the restore operation fails and flags the restored file in error. You can only remove the file, or truncate it, to clear the error status on the file. Access to such files, except remove or truncate, fail with an EINVAL error.

## CTE-LDT Command-Line Administration: voradmin command

Use the `voradmin` utility to gather statistics and administer CTE-LDT on a client. It has slightly different syntax and command capabilities depending on whether the client is running Linux or Windows.

### Note

Refer to the `voradmin` man page for `voradmin` usage in Linux.

To use `voradmin`:

1. Log in to the host running the CTE Agent with CTE-LDT enabled.
2. At the command line, type `voradmin`.
3. Follow the usage outputs onscreen to find the available commands and their syntax. The general syntax is:

```
# voradmin ldt <command> [args]
```

Command	Description
<code>voradmin ldt attr get delete &lt;guard path&gt; &lt;object path&gt;</code>	Get or delete attributes for a GuardPoint or Object path.
<code>voradmin ldt key &lt;report map &lt;key&gt; &gt; &lt;guard path&gt;</code>	Creates a report, or map, containing statistics after each key rotation on a GuardPoint.
<code>voradmin ldt list all</code>	(Linux only) List all MDS files and GuardPoints undergoing CTE-LDT processing.
<code>voradmin ldt monitor [interval]</code>	(Windows only) Monitor CTE-LDT progress. If an interval is specified (in units of seconds), it continually updates the monitoring output at the specified interval.
<code>voradmin ldt rekey report &lt;guard path&gt; [ &lt;output file&gt;]</code>	Generate a rekey report manually for a Guardpath.
<code>voradmin ldt resume &lt;guard path&gt; all</code>	Resume guarding the GuardPoint directory.
<code>voradmin ldt space &lt;guard path&gt;</code>	Estimates disk space needed for metadata and mds store information.
<code>voradmin ldt stats [&lt;guard path&gt;] [&lt;interval&gt;]</code>	Obtains transformation CTE-LDT statistics such as: <ul style="list-style-type: none"><li>• Current rekey status</li><li>• Start time</li><li>• Estimated completion time</li><li>• Percentage completed</li><li>• Total data</li><li>• Amount of data transformed</li><li>• Total files</li><li>• Number of files transformed</li><li>• Number of files skipped</li><li>• Number of files remaining for rekey</li></ul>

## Moving a CTE-LDT GuardPoint from One CTE-LDT Policy to Another

To change the CTE-LDT policy that an CTE-LDT GuardPoint uses, complete the following steps to ensure that the GuardPoint is migrated properly from one CTE-LDT policy to another CTE-LDT policy.

### Scenario

The GuardPoint is currently attached to LDT-Policy-1, which rekeys from `clear_key` to `LDT-Key-1`. The objective is to migrate the data in the GuardPoint to another versioned key, `LDT-Key-2`. Migration to `LDT-Key-2` requires detaching the GuardPoint from `LDT-Policy-1`, and then attaching it to `LDT-Policy-2`, assuming `LDT-Key-2` is the versioned key specified in `LDT-Policy-2`. This is a two step migration:

1. Migrate a GuardPoint out of the CTE-LDT policy to protection under a standard policy.  
The step requires cloning `LDT-Key-1` to a non-versioned key, and migrating the GuardPoint out of the CTE-LDT policy. Because the cloned key and the the current version of `LDT-Key-1` have the same key material, the data in the GuardPoint directory remains encrypted to the same key after migration of the GuardPoint out of CTE-LDT.
2. Migrate a GuardPoint protected under a standard policy to protection with an CTE-LDT policy.

Note that you may set the transformation key to `clear_key` instead of `LDT-Key-2` in the second policy (`LDT-Policy-2`). The effect of `clear_key` is transformation of the data in the GuardPoint directory to clear text. Although the transformation key in CTE-LDT policies must be a versioned key, `clear_key` is an exception. It allows CTE-LDT GuardPoints to be transformed to clear using the CTE-LDT process.

**To properly move the GuardPoint from LDT-Policy-1 to LDT-Policy-2:**

#### Note

Ensure that no active processes or users are accessing files in the GuardPoint, or its subdirectories, until all steps have been completed.

1. Follow the instructions for, ["Converting a GuardPoint from an CTE-LDT policy to a non-CTE-LDT policy" on the facing page](#).
2. Assuming the current version of the `LDT-Key-1` is version 5, then clone version 5 of the key to `Cloned-LDT-Key-1v5`.
  - a. In the CipherTrust Manager Applications Page, open the **Keys & Access Management** application.
  - b. Click the name of the versioned key that you want to clone.
  - c. In the Key Details area, find the version that you want to clone.
  - d. Click the (...) button at the end of the row and select **Clone** to clone the selected version of the key.
3. Follow the instructions for ["Using voradmin To Estimate Disk Space Required for CTE-LDT \(Linux\)" on page 60](#).
4. Follow instructions for ["Converting a GuardPoint from an CTE-LDT policy to a non-CTE-LDT policy" on the facing page](#) using the cloned key (`Cloned-LDT-Key-1v5`) as the Initial Key and `LDT-Key-2` as the key for the new CTE-LDT policy. The files are now rekeyed from `Cloned-LDT-Key-1v5` to `LDT-Key-2`.



## Removing CTE-LDT and Security Encryption

If you want to stop using CTE-LDT on a GuardPoint or on a whole client, follow the instructions in the following sections.

### Migrating a GuardPoint Out of CTE-LDT

Migrating a GuardPoint from CTE-LDT removes the security encryption. It also provides a CipherTrust Manager Administrator with the flexibility to relax the compliance requirement, when strict compliance for frequent key rotation on specific data is no longer mandatory. The following sections describe how to migrate a GuardPoint from CTE-LDT to a non-CTE-LDT policy, or to remove encryption protection from it.

### Converting a GuardPoint from an CTE-LDT policy to a non-CTE-LDT policy

If you want to do more than just change the policy on a GuardPoint from an CTE-LDT policy to a non-CTE-LDT policy, see ["Deleting CTE-LDT Metadata \(Linux\)" on page 76](#) or ["Deleting CTE-LDT Metadata \(Windows\)" on page 76](#).

1. Clone the versioned key associated with the CTE-LDTGuardPoint to a non-versioned key.  
The clone function creates a new key with the same cryptographic encryption material as the current version of the cloned versioned key.  
This allows CTE-LDT to use the cloned key in a non-CTE-LDT policy to convert the GuardPoint from an CTE-LDT to a non-CTE-LDT managed policy.
  - a. In the CipherTrust Manager Applications Page, open the **Keys & Access Management** application.
  - b. Click the name of the versioned key that you want to clone.
  - c. In the Key Details area, click the (...) button at the end of the row showing the current version of the key and select **Clone** to clone the current version.
  - d. Enter a new name for the key in the **Key Name** field. Do *not* select the **CTE Versioned** option for the clone.
  - e. Click **Clone**.
2. Open the **CTE** application and click **Clients** in the left-hand menu bar.
3. Click on the name of the client whose GuardPoint you want to migrate.
4. Find the GuardPoint you want to migrate in the GuardPoints table, then click the (...) button at the end of the row and select **Disable**.
5. After CTE-LDT disables the GuardPoint, click the (...) button at the end of the row and select **Remove**.
6. (Linux only) Ensure that the GuardPoint is removed on the managed host:

```
# secfsd -status guard
No GuardPoints configured
```
7. CTE-LDT creates extended attributes for every file under the GuardPoint as well as the GuardPoint directory. Now that the CTE-LDT policy does not manage the GuardPoint, you must remove the extended attributes for every file in the GuardPoint, type:

```
# voradmin ldt attr delete /<GuardPoint>
```
8. The command may take some time depending on the number of files in the GuardPoint.

**Note:** For all of the file system mount points that contain an CTE-LDT protected GuardPoint, you must clean up the metadata first. See ["Deleting CTE-LDT Metadata \(Linux\)" on page 76](#).

9. Create a non-CTE-LDT policy using the cloned key you created earlier in this procedure.
  - a. In the **CTE** application, click **Policies** in the left-hand menu bar and then click **Create Policy**.
  - b. Enter a name for the policy in the **Name** field.
  - c. In **Policy Type**, choose **Standard**.
  - d. Click **Next**.
  - e. On the Security Rules page, click **Next** to skip adding a security rule.
  - f. On the Key Selection Rules, click **Create Key Rule**.
  - g. In the **Key Name** field, select the cloned key you created earlier.
  - h. Click **Add**.
  - i. Click **Next**.
  - j. Confirm that the key rule is correct and click **Save**.
10. Apply the non-CTE-LDT policy to the GuardPoint.



#### CAUTION

**Make sure that you have removed all of the CTE-LDT metadata from the GuardPoint before applying the non-CTE-LDT policy.**

- a. Open the **CTE** application and click **Clients** in the left-hand menu bar.
- b. Click on the name of the client whose GuardPoint you want to migrate.
- c. Click **Create GuardPoint**.
- d. In the *Create GuardPoint* dialog box, select the Policy that you just created in the **Policy** field.
- e. Select the **Type: Auto Directory** or **Manual Directory**.
- f. In the **Path** field, and enter or browse to the directory to protect.
- g. When you are done, click **Create**.

## Remove Protection from a GuardPoint

When compliance may no longer require protecting data in a GuardPoint, you may choose to unprotect/decrypt it. Before removing protection from your GuardPoint, you must decrypt the data in your GuardPoint by setting it to clear. You have two options to decrypt your data:

- While a GuardPoint is protected and enabled under an CTE-LDT policy, you can use copy or backup/restore commands to save files in your GuardPoint to a location outside of your GuardPoint.
- Use the `dataxform` command to transform your GuardPoint to clear in an offline transformation process.

## Copying Files to Decrypt Them

If you choose to copy your files, you must create a directory outside of the GuardPoint and then copy the files into the GuardPoint directory. After finishing copying, complete the following steps:

1. Open the **CTE** application and click **Clients** in the left-hand menu bar.
2. Click on the name of the client whose GuardPoint you want to remove.
3. Find the GuardPoint you want to remove in the GuardPoints table, then click the (...) button at the end of the row and select **Disable**.
4. After CTE-LDT disables the GuardPoint, click the (...) button at the end of the row and select **Remove**.

5. (Linux only) Ensure that the GuardPoint is removed on the managed host:

```
# secfsd -status guard
No GuardPoints configured
```

This completes removal of the GuardPoint under an CTE-LDT policy. You can now remove the original files and data within the GuardPoint namespace.

## Using Dataxform Command to Transform the Files

If you choose to use the dataxform command to transform data in your GuardPoint to clear, use the `voradmin` command to verify that earlier versions of the versioned key are not in use on your GuardPoint. Complete the following steps to clear all metadata in your GuardPoint. Then, transform your GuardPoint to clear.

1. Clone the versioned key associated with the CTE-LDT GuardPoint to a non-versioned key.
  - a. In the CipherTrust Manager Applications Page, open the **Keys & Access Management** application.
  - b. Click the name of the versioned key that you want to clone.
  - c. In the Key Details area, click the (...) button at the end of the row showing the current version of the key and select **Clone** to clone the current version.
  - d. Enter a new name for the key in the **Key Name** field. Do *not* select the **CTE Versioned** option for the clone.
  - e. Click **Clone**.
2. Create a Standard policy using the cloned key you just created.
  - a. In the **CTE** application, click **Policies** in the left-hand menu bar and then click **Create Policy**.
  - b. Enter a name for the policy in the **Name** field.
  - c. In **Policy Type**, choose **Standard**.
  - d. Enable the **Data Transformation** option.
  - e. Click **Next**.
  - f. On the Security Rules page, click **Next** to skip adding a security rule.
  - g. On the Key Selection Rules, click **Create Key Rule**.
  - h. In the **Key Name** field, select the cloned key you created earlier.
  - i. Click **Add**, then click **Next**.
  - j. On the Data Transformation page, click **Create Data Transformation Rule**.
  - k. In the **Transformation Key Name** field, select `clear_key`.
  - l. Click **Add**, then click **Next**.
  - m. Confirm that the key rule and data transformation rule are correct and click **Save**.
3. Click **Clients** in the left-hand menu bar.
4. In the Clients table, click on the name of the client whose GuardPoint you want to remove.
5. Find the GuardPoint you want to remove in the GuardPoints table, then click the (...) button at the end of the row and select **Disable**.
6. After CTE-LDT disables the GuardPoint, click the (...) button at the end of the row and select **Remove**.

Before you apply the offline data transformation policy to your GuardPoint, you must clean up the CTE-LDT metadata from your GuardPoint. CTE-LDT creates extended attributes for every file under the GuardPoint, as well as the GuardPoint directory. Now that the CTE-LDT policy does not manage the GuardPoint, you can remove the extended attributes for every file in the GuardPoint.

7. Remove the extended attributes of files in a GuardPoint, type:

```
# voradmin ldt attr delete <GuardPoint>
```

The command may take some time depending on the number of files in the GuardPoint. After metadata deletion is complete, you can apply the offline transformation policy on the GuardPoint.

8. CipherTrust Manager, guard and enable the GuardPoint with the Standard policy you created earlier.
9. After enabling your GuardPoint, run the `dataxform` command on the managed host to transform the GuardPoint to a `clear_key`, type:  

```
# dataxform --rekey --gp /<GuardPoint>/ --preserve_modified_time --preserve_access_time --cleanup_on_success
```
10. After completion of `dataxform`, unguard the GuardPoint.
11. Remove the GuardPoint from the `dataxform` policy in CipherTrust Manager.

## Deleting CTE-LDT Metadata (Linux)

To remove the metadata associated with the GuardPoint, you must run the `voradmin` command on the managed host to remove the CTE-LDT metadata associated with the GuardPoint.



### WARNING

**Before you attempt to remove an MDS file, make sure that no CTE-LDT-protected GuardPoints remain configured under the file system mount point.**

In the following example:

- `/oxf-fs1` is the mount point
- `/oxf-fs1/gp1` is the CTE-LDT-protected GuardPoint

To delete the metadata associated with the GuardPoint:

1. Ensure that the GuardPoint is not enabled on the host. Run the command below and verify that the GuardPoint pathname does not appear in the output of the `secfsd` command, type:

```
# secfsd -status guard
```

2. Run the `voradmin` command to remove CTE-LDT attributes on the GuardPoint, type:

```
# voradmin ldt attr delete <GuardPoint path>
```

For example:

```
# voradmin ldt attr delete /oxf-fs1/gp1
```

LDT metadata has been removed from all files in GuardPoint `/oxf-fs1/gp1`

## Deleting CTE-LDT Metadata (Windows)

Use the following command to delete the CTE extended attribute for a file or a GuardPoint. This is useful when removing a GuardPoint from under an CTE-LDT policy (see ["Migrating a GuardPoint Out of CTE-LDT" on page 73](#)).

```
# voradmin ldt attr delete [<file name path> | <guard path>]
```

For an overview of `voradmin ldt`, see ["CTE-LDT Command-Line Administration: voradmin command" on page 71](#).

## Removing CTE-LDT from a Host

Once you have registered a host and enabled CTE-LDT, you cannot disable the CTE-LDT feature by unchecking the CTE-LDT box. You must unregister the host from the CipherTrust Manager, then register it again without CTE-LDT. When you remove the CTE-LDT feature from a host entirely, the host's CTE-LDT license becomes available for use on another host.

1. Stop all applications from accessing data in CTE-LDT GuardPoints on the host.
2. Migrate data in every CTE-LDT GuardPoint using the steps described in the section ["Remove Protection from a GuardPoint" on page 74](#).



### **WARNING**

**Potential data loss. Ensure that you have decrypted the data and, optionally, copied it out of the GuardPoint. Once the CTE Agent software is removed, access to data is no longer controlled by CTE. If the data was encrypted, it remains encrypted, and there is no way to read it.**

3. Remove the GuardPoints on the host from the CipherTrust Manager.
  - a. Remove the CTE-LDT metadata from those GuardPoints.
  - b. Remove the MDS files associated with those GuardPoints, if necessary. See ["Deleting CTE-LDT Metadata \(Linux\)" on the previous page](#) for more information.
4. Remove the host from the CipherTrust Manager. For details, see the *CTE Agent for Linux Advanced Configuration and Integration Guide* or the *CTE Agent for Windows Advanced Configuration and Integration Guide*.
5. Re-install the agent on the host.
6. Register the host with the CipherTrust Manager. This time, do not select the CipherTrust Transparent Encryption - Live Data Transformation option. See ["Enabling CTE-LDT on a Protected Host" on page 22](#).

## Uninstalling the Agent while CTE-LDT is Rekeying GuardPoints

You cannot uninstall the CTE Agent if CTE-LDT is rekeying any GuardPoints on that client.

If you want to uninstall the CTE Agent from a client that contains CTE-LDT GuardPoints, you must first unencrypt the files on each CTE-LDT GuardPoint using the steps noted in the previous sections.

# Chapter 6: Troubleshooting CTE-LDT

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The CTE-LDT administrator needs to monitor and respond to runtime statistics and alerts.

## Monitoring and Statistics

This section describes how to find the runtime status of CTE-LDT and how to get statistics about its operation.

### Note

When you check GuardPoint status on the CipherTrust Manager, be aware that the status is not relayed in real time. There can be a delay of several minutes before the CipherTrust Manager becomes aware of events on the host. When you configure the host and v for one-way communication, the delay is longer, up to an hour, because CTE-LDT sends statistics to the CipherTrust Manager only once per hour.

To find out when the CipherTrust Manager last received a status update from the host, check the Last Status Update timestamp in the GuardPoint Health dialog (for information about how to display this dialog, see ["Obtaining Statistics in the CipherTrust Manager with GuardPoint Status" below](#)). For the most up-to-date statistics, inspect the client. Run the `voradmin` command on the managed hosts to retrieve status and statistics pertaining to GuardPoints.

## Obtaining Statistics in the CipherTrust Manager with GuardPoint Status

During and after data transformation, you can view statistics about any GuardPoint on any client in your system. Either use the CipherTrust Manager, as described in this section, or use the `voradmin` command, as described in ["Obtaining CTE-LDT Statistics at the Command Line" below](#).

To display the GuardPoint status in CipherTrust Manager:

1. Open the **CTE** application and click **Clients** in the left-hand menu bar.
2. Click on the name of the client whose GuardPoint you want to view.
3. Click the Status of the GuardPoint you want to view in the GuardPoints table.

CipherTrust Manager displays the GuardPoint Health dialog box with various statistics about the GuardPoint.

## Obtaining CTE-LDT Statistics at the Command Line

You can obtain CTE-LDT statistics from the command line using the following command:

```
# voradmin ldt stats <guard path> [interval]
```

This command displays transformation statistics for a GuardPoint, or for all GuardPoints, if none are specified. If you specify an interval (in units of seconds), the command continually updates the statistics on the given interval. If no GuardPoint is specified, the command returns the aggregate statistics at the host level, including specific statistics related to QoS. If a GuardPoint is specified, statistics include:

- Current rekey status
- Rekey Start time
- Last rekey completion time
- Estimated Rekey completion time
- Data Statistics including the amount of data transformed
- File statistics including:
  - Number of files transformed
  - Number of files skipped
  - Number of files remaining for rekey

## Obtaining a Rekey Report

CTE-LDT generates a report automatically after completion of a key rotation. The report lists the files in the GuardPoint and the key and version of the key applied to each file. This kind of report may be a common compliance requirement.

The administrator can also request a rekey report during rekey, if the need to see the partial transformation results so far.

## About the rekey report

On Linux hosts, CTE-LDT writes rekey reports to a local file on the agent host in `/var/log/vormetric/`. The file name begins with `ldaudit-log-`. It is followed by the file system directory name, GuardPoint directory name, and a timestamp. For example, for a GuardPoint at `/oxf-fs2/gp2` with rekey completed on November 19, 2016, just after 2:00 p.m. (hour 14), the rekey report file name would be `ldaudit-log-_oxf-fs2_gp2-2016111914917`.

The report includes:

- Total number of files in the GuardPoint
- Number of files transformed
- Rekey start and end times
- List of all files transformed
- Applied key and key version for each file (for example, files in different resource sets might have used different keys)

## Manually generating a rekey report

To generate a rekey report manually, use the following command:

```
# voradmin ldt rekey report <GuardPoint> [<logfile>]
```

In `<GuardPoint>`, type the GuardPoint path. In `<logfile>`, you can optionally direct the output to a file. If no logfile is specified, the report displays on `stdout`.

## Monitoring Ongoing CTE-LDT Operations at the Command Line (Windows only)

Use the following syntax to monitor CTE-LDT progress. If an interval is specified (in units of seconds), it continually updates the monitoring output at the specified interval.

```
C:\> voradmin ldt monitor [interval]
```

For an overview of `voradmin ldt`, see ["CTE-LDT Command-Line Administration: voradmin command" on page 71](#).

## Protecting CTE-LDT GuardPoints against Failure in Underlying Filesystems (Linux)

### CTE-LDT Recovery Challenges

The main challenge with CTE-LDT recovery is a failure to access files or specific blocks in files inside a GuardPoint. Before CTE-LDT runs the recovery process on a GuardPoint, the underlying file system was recovered before file system was mounted. File system recovery may create orphan files in the `lost+found` directory inside the mount point. If an orphan file belongs to the GuardPoint, CTE-LDT cannot recover the file as the file is no longer in the same directory as it was prior to the crash while it was undergoing rekey.

### CTE-LDT Recovery Enhancement

CTE-LDT has been improved for handling inconsistencies in the underlying file system during execution of CTE-LDT recovery. When enabling a GuardPoint after a system crash, CTE-LDT performs consistency checks on the files undergoing rekey at the time of crash before enabling GuardPoint. If the CTE-LDT recovery process is unable to recover any of the affected files, the GuardPoint will not be enabled and CTE-LDT will send the following alert to the CipherTrust Manager:

```
[CGS3266E] LDT-ALERT: Cannot enable guard point [GuardPoint] due to inconsistencies in
underlying file system encountered during LDT recovery.
```

You can check the status of a GuardPoint and the reason for failing to enable a GuardPoint using the `secfsd -status guard` command. For example, the GuardPoint `/mnt/gp` failed to guard because Guard point needs LDT recovery as reported in the `Reason` column for the following example GuardPoint.

GuardPoint	Policy	Type	ConfigState	Status	Reason
/mnt/gp	LDT220	manual	guarded	not guarded	Guard point needs LDT recovery

Details on the specific issues encountered, including any files that could not be recovered, are reported to a log file in the `/var/log/vormetric` directory. The log file name is in the format:

```
ldt_recovery_log:<guardpoint_name>:<timestamp>.txt
```

The log file name starts with `ldt_recovery_log`, followed by the GuardPoint pathname and the date and time of the recovery attempt. The GuardPoint pathname and date and time are separated with `:"`. For example:

```
/var/log/vormetric/ldt_recovery_log:_mnt_gp:2018-12-08-14:6:12.txt
```

Refer to the issues listed in the log file, and resolve those issues before enabling the GuardPoint again. A GuardPoint cannot be enabled in subsequent guard attempts until those issues are resolved. Each attempt generates a new log file. Check the CTE-LDT log file for missing files whose inode numbers match inode numbers of orphan files in `lost+found`. If there is a match, restore the file from `lost+found` to the pathname specified in the CTE-LDT recovery log file. Be sure to run the `mv` command to restore the file to the original location, do not run the `cp` command. After resolving all or some of the reported issues, you must run the command `voradmin ldt recover <GuardPoint>` to repeat the recovery process.



```
voradmin ldt recover <GuardPoint>
```

Running this command resolves the problems that can be corrected and clears the failed recovery status on the GuardPoint, allowing the GuardPoint to enable automatically within 30 seconds. If the GuardPoint does not enable, you can enable it using `secfsd -guard` command, if manual guard, or enable it on the CipherTrust Manager, if auto-guard. Note that if you are unable to resolve all of the reported issues, you accept the loss of some data or files, as reported in the latest recovery log file for the GuardPoint, when you run the command `voradmin ldt recover <GuardPoint>`.

## Recovery Alerts

CTE-LDT sends two alerts to CipherTrust Manager if CTE-LDT fails to resolve the issues encountered during recovery.

The alert below is an error report sent to the CipherTrust Manager whenever CTE-LDT encounters failure during recovery prior to enabling GuardPoint. This alert also reports the GuardPoint specified in the message is not enabled:

```
[CGS3266E] LDT-ALERT: Cannot enable guard point [GuardPoint] due to inconsistencies in  
underlying file system encountered during LDT recovery.
```

The alert below is a warning report sent to the CipherTrust Manager only if `voradmin ldt recover` encounters errors and continues anyway. This alert reports the GuardPoint specified in the message has been enabled with some files in error status.

```
[CGS3267W] LDT-ALERT: LDT manual recovery on guard point [GuardPoint] completed with [#]  
errors.
```

The full message body does not currently appear in the logs on the CipherTrust Manager. At this time, the CipherTrust Manager shows the message ID without the message body.

## Alerts Playbook

This section lists the CTE-LDT alerts and describes what to do in each case. CTE-LDT generates alerts when issues arise that require attention from the CipherTrust Manager Administrator. Without prompt attention, alerts can delay the rekey process or cause the process to remain incomplete.

### Failure to Suspend or Resume CTE-LDT Operation

- **LDT-ALERT: Failed to suspend rekey on GuardPoint [GuardPoint]**

**Solution:** An I/O error is the most common cause of failure when updating the persistent state of a GuardPoint. For I/O errors, you must fix the problem at the host OS or storage level.

The appropriate corrective action depends on when this problem occurs and the reason for the suspension. If the suspend request was at the host level as part of a QoS schedule, or it was initiated by a user on the CipherTrust Manager, the failure occurred at the host level rather than the specified GuardPoint.

Otherwise, the source is probably the initiation of a suspension on a specific GuardPoint before backup. If the backup operation is in progress when this alert message occurs, you must fix the cause of the suspension failure and then restart the backup. If the backup has already completed when the alert message occurs, the backup image on the GuardPoint may have inconsistent data and CTE-LDT metadata. Discard this backup image and do a fresh backup.

If you cannot find and fix the host OS or storage issue, contact Thales Support for troubleshooting and recovery.

- **LDT-ALERT: Failed to resume rekey on GuardPoint [GuardPoint]**

- **LDT-ALERT: Failed to resume rekey on all GuardPoints**

**Solution:** An I/O error is the most common cause of failure when updating persistent state of a GuardPoint. For I/O errors, you must fix the problem at the host OS or storage level.

The appropriate corrective action depends on when this problem occurs and the source of the problem. If the resume request was at the host level as part of a QoS schedule, or the resume request was initiated by a user on the CipherTrust Manager, the failure occurred at the host level rather than the specified GuardPoint.

Otherwise, the source is probably initiation of a resume operation on a specific GuardPoint after a backup is completed.

If you cannot find and fix the host OS or storage issue, contact Thales Support for troubleshooting and recovery.

## Insufficient Resources

The following alerts trigger when there are not enough resources for CTE-LDT operations.

- **LDT-ALERT: Aborting rekey of file [FileName] due to insufficient disk space**

The key rotation process was stopped on a GuardPoint because there was not enough available disk space.

**Solution:** Resize or free up space in the file system where the PathName resides. Key rotation automatically starts again when sufficient free space becomes available.

- **LDT-ALERT: Failed to launch transformation on [GuardPoint]**

CTE-LDT failed to launch the data transformation process on the specified GuardPoint.

**Solution:** The most common causes of this failure are:

- Low amount of system resources, such as free disk space.
- Check the system logs for insufficient free space in underlying file systems. You can free up space by removing older files or resizing your underlying file system. You may resize the file system on-line or off-line.

For other issues, contact Customer Support.

- **LDT-ALERT: QoS failed to start**

The Quality of Service subsystem failed to launch QoS services due to lack of system resources.

**Solution:** A low amount of available memory is the most common cause of this failure.

Contact Customer Support.

- **LDT-ALERT: Skipped key rotation on GuardPoint [GuardPoint] due to insufficient disk space**

- **LDT-ALERT: MDS file [PathName] exceeded disk space quota on gp [GuardPoint]**

There was not enough storage space in one or more file systems containing GuardPoints undergoing rekey.

**Solution:** Check the file systems where your GuardPoints reside to see how much space it is using. Add more storage space as needed. After the condition is corrected and disk space is available, CTE-LDT operations resume automatically.

- **LDT-ALERT: Low space on guard point [GuardPoint], increase free space or LDT will be suspended.**

Available storage space in the file system containing the GuardPoint is nearing the threshold below which CTE-LDT rekeying cannot continue. If available space does drop below that threshold, rekeying will be automatically suspended.

**Solution:** Check the file system where your GuardPoint resides to see how much space is available. Make more free space available if necessary. After the condition is corrected and storage space is available, rekeying resumes automatically.

## Failed to Update CTE-LDT Attribute

The following alerts trigger when CTE-LDT extended attributes are not properly updated.

- **LDT-ALERT: Failed to update LDT attribute on GuardPoint [GuardPoint]. Error: [ErrorNumber]**

**Solution:** I/O error is the most common cause of failure when updating CTE-LDT extended attributes. For I/O errors, fix the problems at the host OS or storage level. In Linux, if you experience an I/O error, identify the file that had the error, and restore it from backup. See ["Backing Up and Restoring CTE-LDT GuardPoints" on page 62](#).

In Windows, you can recover a file that has corrupt metadata as follows:

- If the file is fully encrypted, remove the metadata. Type:

```
# voradmin ldt attr delete <file name path>
```

Then apply the same policy that was used to encrypt the data.

- If the file was only partially rekeyed, restore the file from a backup.

If you cannot find and fix the underlying host OS or storage issue that is causing corrupt metadata, contact Customer Support for troubleshooting and recovery.

- **LDT-ALERT: Failed to update LDT attribute**

CTE-LDT failed to create or update an CTE-LDT extended attribute of a file in a GuardPoint.

**Solution:** An I/O error is the most common cause of failure when updating an CTE-LDT extended attribute. For I/O errors, fix the problem at the host OS or storage level.

If you cannot find and fix the host OS or storage issue, contact Customer Support for troubleshooting and recovery.

## Rekey Stopped

The following alert is specific to Windows and is triggered when rekey is stopped before it completes normally.

### **LDT-ALERT: Suspending rekey of binary file [PathName] during its execution**

CTE-LDT operations encountered an executable file that is running.

CTE-LDT cannot rekey a running executable file until the execution of the binary file stops.

#### **Solution (Windows)**

1. Obtain the name of the executable file from the alert message.
2. Stop execution of the binary file.

## Incomplete Key Rotation

- **LDT-ALERT: Failed to rotate key on GuardPoint [GuardPoint]. Another rekey operation is already in progress** (Windows only)
- **LDT-ALERT: Key rotation failed on GuardPoint [GuardPoint]**

CTE-LDT failed to complete the key rotation process on the specified GuardPoint. On Windows, this may occur if a key rotation process is already in progress on the GuardPoint. This pre-existing rekey operation could be active, or it could be in a suspended state, either because of the QoS schedule or a manual pause initiated by the administrator. See ["Suspending and Resuming Rekey and/or Scan Phase" on page 44](#).

## Solution

1. On Linux, you can run the following command to see whether key rotation is in progress on the GuardPoint.  

```
# voradmin ldt list all
```
2. On Linux or Windows, check the rekey status of GuardPoints in the CipherTrust Manager Console.
3. If key rotation is already in progress on a Windows GuardPoint, wait for the key rotation to complete.

Contact Customer Support if this error occurs on Linux or if the cause of key rotation failure on Windows is not a key rotation in progress.

## Skipped Key Rotation

The following alerts trigger when CTE-LDT skips key rotation.

- **LDT-ALERT: Skipped key rotation on GuardPoint [GuardPoint]. It is on a read-only file system**

Key rotation is skipped on a specified GuardPoint because the mount point where the GuardPoint resides does not permit write operations.

### Solution:

1. Remount the file system where the GuardPoint resides, and change the mount option to read/write.
  2. On the GuardPoint page on the CipherTrust Manager, press **Re-push Policies** to manually re-push the policies to the host to initiate key rotation on GuardPoints ready for key rotation.
- **LDT-ALERT: Failed to rotate key on GuardPoint [GuardPoint] during pre-commit**
  - **LDT-ALERT: Failed to rotate key on GuardPoint [GuardPoint] during commit**
  - **LDT-ALERT: Skipped key rotation on GuardPoint [GuardPoint]. Error: [ErrorNumber]**
  - **LDT-ALERT: Failed to update LDT attribute on GuardPoint [GuardPoint]. Error: [ErrorNumber]**

CTE-LDT failed to start a key rotation process on a GuardPoint during a guard operation or when processing a key rotation notification from the CipherTrust Manager. For [ErrorNumber], a Linux error number is substituted, such as `errorcode 17`.

**Solution:** The host returns error code 17 during CTE-LDT key rotation if it cannot perform the key rotation because there is already a rekey in progress. This pre-existing rekey operation could be active, or it could be in a suspended state, either because of the QoS schedule or a manual pause initiated by the administrator. See ["Suspending and Resuming Rekey and/or Scan Phase" on page 44](#).

An I/O error is the most common cause of failure when updating the persistent state of a GuardPoint. For I/O errors, fix the problem at the host OS or storage level.

If you cannot find and fix the host OS or storage issue, contact Customer Support for troubleshooting and recovery.

## Failed to Update CTE-LDT Metadata During Scan Phase

CTE-LDT triggers the following alerts when CTE-LDT cannot properly update metadata during the scan phase. (See ["CTE-LDT Runtime Flow" on page 13](#) for information about the scan phase.)

- **LDT-ALERT: Scan error on [GuardPoint] removing MDS guard for relaunching dataxform**

CTE-LDT failed to update metadata when restarting a scan on the specified GuardPoint.

**Solution:** An I/O error is the most common cause of failure when updating CTE-LDT metadata. For I/O errors, fix the problem at the host OS or storage level and then restart operations.

If you cannot find and fix the underlying host OS or storage issue that is causing the error, contact Thales Support for troubleshooting and recovery.

- **LDT-ALERT: Online Dataform failed during post scan stage on [GuardPoint]**

CTE-LDT failed to update metadata when transitioning from scan to rekey phase on the specified GuardPoint.

**Solution:** An I/O error is the most common cause of failure when updating CTE-LDT metadata. For I/O errors, the problem must be fixed at the host OS or storage level and the operation restarted.

If you cannot find and fix the underlying host OS or storage issue that is causing the error, contact Customer Support for troubleshooting and recovery.

## File system inconsistencies after system crash

CTE-LDT sends two alerts to the CipherTrust Manager if CTE-LDT fails to resolve the issues encountered during recovery.

The alert below is an error report sent to the CipherTrust Manager whenever CTE-LDT encounters failure during recovery prior to enabling GuardPoint. This alert also reports the GuardPoint specified in the message is not enabled:

- **LDT-ALERT: Cannot enable guard point [GuardPoint] due to inconsistencies in underlying file system encountered during LDT recovery**

The alert below is a warning report sent to the CipherTrust Manager only if `voradmin ldt recover` encounters errors and continues anyway. This alert reports the GuardPoint specified in the message has been enabled with some files in error status.

- **LDT-ALERT: LDT manual recovery on guard point [GuardPoint] completed with [#] errors.**

**Solution:** See ["Protecting CTE-LDT GuardPoints against Failure in Underlying Filesystems \(Linux\)" on page 80](#).

## Error Messages

This section describes runtime error messages. For information about other types of runtime messages, see ["Alerts Playbook" on page 81](#) and ["Warning and Info Messages" on page 87](#).

### Failed to Transform File During Rekey

CTE-LDT could not complete transformation on a file.

#### Related Messages:

- **LDT: Rekey failed for file [PathName] on GuardPoint [GuardPoint]**
- **LDT: Extended attribute of inode [InodeNumber] is corrupted under GuardPoint [GuardPoint]**

**Solution:** An I/O error is the most common cause of failure when updating CTE-LDT metadata. For I/O errors, fix the problem at the host OS or storage level, and then restore the file from a backup.

If you cannot find and fix the underlying host OS or storage issue that is causing the error, contact Customer Support for troubleshooting and recovery.

### Failure to Suspend CTE-LDT

A request to stop CTE-LDT processing did not succeed. The suspend request was at the host level as part of a QoS schedule, or the suspend request was initiated by a user on the CipherTrust Manager.

#### Related Messages:

- **LDT: Failed to suspend rekey on all GuardPoints**
- **LDT operations could not be suspended on the host**

**Solution:** An I/O error is the most common cause of failure when updating the persistent state of a GuardPoint. For I/O errors, fix the problem at the host OS or storage level.

If a backup operation is in progress when this message occurs, you must fix the cause of the suspend failure and then restart the backup. If the backup has already completed when the alert message occurs, the backup image on the GuardPoint may have inconsistent data and CTE-LDT metadata. Discard this backup image and do a fresh backup.

If you cannot find and fix the host OS or storage issue, contact Customer Support for troubleshooting and recovery.

## Failure to Start or Stop Transformation

The following general messages are recorded when there are errors attempting to start or stop CTE-LDT:

- **LDT: Failed to abort key rotation on GuardPoint [GuardPoint]**
- **LDT: Failed to start**
- **LDT: Failed to stop**
- **LDT: Failed to exit**

**Solution:** Examine system logs for additional information as to the cause. If you cannot find and fix the underlying host OS or storage issue that is causing the error, contact Customer Support for troubleshooting and recovery.

## Failure to Restart Transformation

The following message is recorded when an attempt to restart transformation after a system reboot fails because the file system is mounted as read-only. Transformation on the specified GuardPoint cannot continue until the file system is mounted with write permission.

- **LDT: Skipped LDT recovery on read-only file system [GuardPoint]**

**Solution:** Re-mount the file system with write permissions.

## Temporary Failure to Start Transformation on a File

The following messages are recorded when there are communication issues or lack of resources on the host. Once the condition is corrected, transformation of the file continues automatically:

- **LDT: Insufficient memory condition encountered during LDT on GuardPoint [GuardPoint]**
- **LDT: Encryption key for file [PathName] unavailable for LDT, possibly due to loss of communication to CipherTrust Manager**
- **LDT: Aborting rekey of file [PathName] due to lack of free memory. Try closing other application to resolve the issue**

**Solution:** Resolve the communication issues or increase the available resources, then verify that CTE-LDT has resumed processing.

## Transient Condition while enabling GuardPoint

The following messages are recorded when a request is made to guard an CTE-LDT GuardPoint when GuardPoint initialization is already in progress. During the GuardPoint initialization, the system initializes MDS file associated with the GuardPoint in preparation for CTE-LDT. Initialization of the MDS file can take a few minutes. During this time, if

the system retries the guard operation, one of the following messages displays.

**Related Messages:**

- **Not re-guarding path *[path]* (Reason: GuardPoint initialization already in progress)**
- **Not re-guarding path *[path]* from container *[container]* (Reason: GuardPoint initialization already in progress)**

**Solution:** Wait for the current GuardPoint initialization to complete and then resubmit the new GuardPoint initialization request if desired.

## Failed to transform passthrough files for AD database files (Windows Only)

CTE-LDT skipped the transformation of passthrough files for all AD database files. The problem occurs when the AD database remains in the default folder location.

**Related Messages:**

- **Skipping transformation of passthrough file *[filename]*. The file resides in the boot directory. CTE cannot encrypt boot directory files.**
- **Skipping transformation of passthrough file *[filename]*. CTE cannot encrypt these files. They are already encrypted using NTFS encryption or compressed.**
- **Skipping transformation of passthrough file *[filename]*. File is not in a GuardPoint directory.**

**Solution:** To fix this issue, move the AD database to any folder other than `c:\windows` or `c:\program files`.

## Warning and Info Messages

This section describes runtime error messages. For information about other types of runtime messages, see ["Alerts Playbook" on page 81](#) and ["Error Messages" on page 85](#).

## Stopping Transformation of a File on Volume Dismount (Windows only)

The following warning message is recorded when transformation of a file is stopped because the containing volume is dismounted.

- **LDT: Volume dismounted. Aborting transformation at file *[PathName]***

## Issues with Policy or System Configuration

The following warning messages are recorded when CTE cannot perform CTE-LDT on the GuardPoint, because there are errors in the policy associated with the GuardPoint, or the file system containing the GuardPoint is not supported by CTE-LDT. Files in the GuardPoint can still be accessed, but no CTE-LDT encryption occurs.

- **LDT: The GuardPoint *[GuardPoint]* does not have a valid transformation policy, there is no new key rule**
- **LDT: The GuardPoint *[GuardPoint]* does not have a valid transformation policy, there is no key\_op rule**
- **LDT: The GuardPoint *[GuardPoint]* does not support online rekey, only file operations from the offline data transform process will be allowed**

## Failure to Enable GuardPoint During Cleanup

CTE-LDT records the following informational message when a user attempts to enable a newly added GuardPoint. This message displays if the GuardPoint directory was previously guarded with an CTE-LDT policy and the CTE-LDT metadata cleanup is in progress when user is guarding under the new policy.

- **LDT: Cannot enable GuardPoint [GuardPoint] during LDT clean-up process**

**Solution:** Retry the operation once the cleanup completes.

## General CTE-LDT Operations

The following informational messages are recorded during various CTE-LDT operations. No action is required.

- **LDT: Successfully suspended rekey on GuardPoint [GuardPoint]**
- **LDT: Successfully suspended rekey on all GuardPoints**
- **LDT: Successfully resumed rekey on GuardPoint [GuardPoint]**
- **LDT: Successfully resumed rekey on all GuardPoints**
- **LDT: Rekey operation completed on GuardPoint [GuardPoint]**

## Missing CTE-LDT extended attribute

The following warning message reports that the file with the specified inode number in the specified GuardPoint directory does not have an CTE-LDT extended attribute, therefore, access to the file is denied.

- **LDT: Extended attribute of inode [InodeNumber] is missing under GuardPoint [GuardPoint]**

**Solution:**CTE-LDT cannot determine the encryption key associated with the data in the file, therefore, you can only remove the file.

## Locking Contention

The following messages are recorded during the rekey process on a file. When user access to the file is very high, it causes a high degree of locking contention between the rekey process and user access. The second message reports when the contention is no longer in effect and the rekey process has resumed accessing file to rekey.

- **LDT: Exclusive access for rekey delayed on inode [InodeNumber]**
- **LDT: Exclusive access for rekey granted after delay on inode [InodeNumber]**

## Initiation and completion of CTE-LDT metadata cleanup

The following messages are recorded at the beginning and completion of CTE-LDT metadata cleanup through voradmin command.

- **LDT: Metadata will start getting removed from all files in GuardPoint [GuardPoint]**
- **LDT: Metadata has been removed from all files in GuardPoint [GuardPoint]**

## Recommendations and Considerations

The following information provides guidance for a better user experience.



## All Platform Recommendations and Considerations

### Binary Re-signing

Any executable that is part of either a Signature set or a Host setting, and that resides in a GuardPoint that uses an CTE-LDT policy, will use different signatures for an CTE-LDT key rotation. The result is that the Host Settings binaries will no longer be authenticated, or that the Signature Set policy rules will no longer trigger for those binaries.

To prevent these issues, the Security Administrator must manually re-sign each affected binary after each key rotation.

Alternatively, CTE can generate unencrypted signatures of binaries inside GuardPoints to avoid these problems. For details, see the CipherTrust Manager documentation.

### Check for available disk space for CTE-LDT metadata

Before launching CTE-LDT on a GuardPoint:

1. Check the available free disk space in the file system where your GuardPoint resides.
2. Type the following command to check the disk space requirement of CTE-LDT on a target GuardPoint:

```
# voradmin ldt space /oxf-fs1/gp1
/oxf-fs1/gp1: found 1501 files without LDT extended attributes
LDT disk space requirements: total 169MB (LDT attributes=6MB, MDS=163MB)
```

In this example, the output shows that CTE-LDT requires 169MB of available disk space to launch and execute CTE-LDT on /oxf-fs1/gp1.

#### Note

Make sure that the free space in your file system exceeds the disk space requirement for CTE-LDT.

### CTE-LDT Requirements for Backup

CTE offers the option to backup encrypted data from files through a security rule, which skips the Apply Key function when reading encrypted files by backup applications or processes. Such files can also be restored from backup streams, to the same or a different GuardPoint, without Apply Key. If you choose to restore to another GuardPoint, the target GuardPoint must be protected with the same key and security rules as the source GuardPoint.

If you backup encrypted data from files inside GuardPoints with CTE-LDT policies, CTE-LDT imposes a hard requirement on the backup application, or process, to backup or restore CTE-LDT metadata. The CTE-LDT metadata is stored as an extended attribute on Linux and as alternate data streams on files on Windows platforms. If the backup process cannot backup the metadata, then CTE-LDT protected GuardPoints must be backed up in clear key.

Customers are required to verify their backup application, or process, to ensure extended attributes (on Linux) or alternate data streams (on Windows) are backed up and restored through their backup/restore processes.

#### Note

Make sure that you suspend CTE-LDT operations before you start the backup process, and resume them after the backup process completes.

### Learn Mode

Learn Mode provides a temporary method for disabling the blocking behavior of regular CTE or CTE-LDT policies. While useful for quality assurance, troubleshooting, and mitigating deployment risk, Learn Mode is not intended to be enabled permanently for a policy in production. This prevents the policy Deny rules from functioning as designed in the policy rule set.

Ensure that the policy is properly configured for use in Learn Mode. Any Security Rule that contains a Deny effect must have Apply Key applied as well. This is to prevent data from being written in mixed states, resulting in the loss of access or data corruption.

**Note**

Apply Key will have no effect when combined with a Deny rule unless the policy is in Learn Mode.

## Quality of Service (QoS)

By default, the QoS component of CTE-LDT does not monitor live transformation operations unless you enable QoS on your host by entering QoS parameters in the CipherTrust Manager profile associated with the client. To avoid overhead of CTE-LDT on your production system, you must select QoS parameters suitable to your production environment. For information on tuning QoS, see ["Quality of Service" on page 29](#). It is critical that you understand the impact of CTE-LDT on your system and how to manage this impact using QoS.

## Upgrade to CTE 7.0.0

Since the first release of the CTE-LDT feature, Thales has made several improvements in the areas of error handling, interoperability with applications, and Quality of Service (QoS). Thales strongly recommends that new deployments use version 7.0.0 (or later) of CTE. Thales further recommends that customers who have already deployed the CTE-LDT feature upgrade to version 7.0.0.

## Windows Recommendations and Considerations

### File Handling

The CTE-LDT process is subjected to all of the File System policies and attributes set on the files. In some cases, this prevents CTE-LDT from encrypting a file. If users or applications are accessing files while CTE-LDT is in progress, CTE-LDT cannot change the attributes of the files and encrypt the file. It is critical that you understand how CTE-LDT handles various types of files:

- **NTFS Encryption and Compression**

If NTFS encryption or compression is enabled on a file or folder, the CTE-LDT process cannot encrypt these files. To maintain the data coherency, CTE-LDT skips the encryption of these files. These files display as "passthrough" files in the CTE-LDT statistics.

- **Read-Only Files**

As the CTE-LDT process performs a read-encrypt-write operation on a file, it cannot encrypt read-only files. The CTE-LDT process skips these files and changes to the INCOMPLETE state.

- **Executable Files**

If an executable is running or files are exclusively locked by the application, the CTE-LDT process cannot encrypt those files as it is unable to acquire the required locks on the files. CTE-LDT skips these files and changes to the INCOMPLETE state.

### File Modification

The CTE-LDT process performs a read-encrypt-write operation on the files that need to be encrypted, (also known as rekeying). Previously, file modification and access dates were changed when CTE-LDT was processing. In order to maintain compatibility for applications, we addressed this issue by saving a copy of the original access and modification times, and restoring them after the encryption completed. Preserved timestamps are updated during the rekey process, if an application/user accesses the files during rekey.

#### Note

Thales strongly recommends that you upgrade to the newly released v6.1.0 so that the access time and modification time is restored correctly.

## CTE-LDT Limitations

- CTE-LDT on CIFS is not supported.
- CTE-LDT on a ReFS file system runs slowly because of limited support from the Extended Attributes on the ReFS file system.

#### Note

Customers running older versions of ReFS.sys on Windows Server 2012 R2 should be aware of the memory growth issue encountered by the Thales engineering team. This issue seems to occur only when CTE-LDT is running on a large number of files. As the system memory consumption by REFS file system increases, it can eventually make the system unresponsive. This issue does not occur with the recent versions of ReFS file system drivers available on Windows Server 2016. After consulting with Microsoft, they suggest that all customers migrate to Windows Server 2016 if they are using ReFS file.

## Logical Sector Size

CTE-LDT Windows transformation is supported if the **logical sector size** is more than 512 Bytes. (A logical sector size of 4K is supported.) To find the logical sector size of the file system, type:

```
> fsutil fsinfo ntfsInfo <volume pathname>
```

For example:

```
> fsutil fsinfo ntfsInfo C:
NTFS Volume Serial Number :      0x5092568a92567506
NTFS Version      :              3.1
LFS Version      :              2.0
Number Sectors :      0x000000001c004eeb
Total Clusters :      0x00000000038009dd
Free Clusters  :      0x00000000008bb274
Total Reserved :      0x0000000000001864
Bytes Per Sector :              512
.
.
.
```

## CTE-LDT Limitations on Linux

- CTE-LDT on NFS share is not supported.
- CTE-LDT support is limited to `ext3`, `ext4`, `XFS`, and `VxFS` file systems when `user_xattr` mount option is enabled.