Administering SLES Using `transactional-update`

The **`transactional-update`** command in SUSE Linux Enterprise Server lets administrators modify a read-only root file system by applying changes to a separate snapshot. This atomic update mechanism keeps the running system stable and consistent, as changes take effect only after a reboot. With transactional updates, users can safely manage software packages, minimize downtime and easily roll back system changes if an update fails.

Prerequisites

- A running instance of SUSE Linux Enterprise Server

Publication Date: 05 Nov 2026

Contents

1 Transactional updates 3

2 Usage of the **`transactional-update`** command 4

3 Applying multiple changes without rebooting 8

4 Performing snapshots cleanup 10

5 Registering products 11

6 Managing software packages 12

7 Performing system rollback 13

8 Managing automatic transactional updates 15

9 Legal Notice 17

A GNU Free Documentation License 17

1 Transactional updates

1.1 What are transactional updates?

To keep the base operating system stable and consistent, the SUSE Linux Enterprise Server uses a read-only root file system. Therefore, you cannot perform direct changes to the root file system, for example, by using the **`zypper`** command. Instead, SLES introduces *transactional updates* that allow you to apply one or more changes to the root file system.

The default **`transactional-update`** behavior is to create a new snapshot from the current root file system after each change. To apply the changes, you need to reboot the host. You cannot run the **`transactional-update`** command multiple times without rebooting to add more changes to the snapshot. This action creates separate independent snapshots that do not include changes from the previous snapshots.

1.2 How do transactional updates work?

Each time you call the **`transactional-update`** command to change your system—either to install a package, perform an update, or apply a patch—the following actions take place:

PROCEDURE 1: MODIFYING THE ROOT FILE SYSTEM

1. A new read-write snapshot is created from your current root file system, or from a snapshot that you specified.
2. All changes are applied (updates, patches or package installation).
3. The snapshot is switched back to read-only mode.
4. If the changes were applied successfully, the new root file system snapshot is set as default.
5. After rebooting, the system boots into the new snapshot.

1.3 Benefits of transactional updates

- They are atomic—the update is applied only if it completes successfully.
- Changes are applied in a separate snapshot and so do not influence the running system.
- Changes can easily be rolled back.

1.4 Environment within the **transactional-update** command

Each time you run the **transactional-update** command, the changes are performed in a new snapshot. The environment in the snapshot may differ from the one in the shell you run the **transactional-update** command from. For example, the current working directory (`$PWD`) is not set to the directory from which you run the **transactional-update**, but is set to `/`.

From within the snapshot, you cannot access the `/var` directory. This directory is also not included in the snapshot. However, some directories are not included in the snapshot but are accessible inside the **transactional-update** environment, for example, the `/root` directory.

2 Usage of the **transactional-update** command

The **transactional-update** command enables the atomic installation or removal of updates. Updates are applied only if all can be successfully installed. **transactional-update** creates a snapshot of your system and uses it to update the system. Later you can restore this snapshot. All changes become active only after reboot.

The **transactional-update** command syntax is as follows:

```
transactional-update [option] [general_command] [package_command] standalone_command
```



Note: Running **transactional-update** without arguments

If you do not specify any command or option while running the **transactional-update** command, the system updates itself.

Possible command parameters are described further.

transactional-update OPTIONS

`--interactive, -i`

Can be used along with a package command to turn on interactive mode.

`--non-interactive, -n`

Can be used along with a package command to turn on non-interactive mode.

`--continue [number], -c`

The `--continue` option is for making multiple changes to the root file system without rebooting. Refer to *Section 3, "Applying multiple changes without rebooting"* for more details.

Another useful feature of the `--continue` option is that you may select any existing snapshot as the base for your new snapshot. The following example demonstrates running **`transactional-update`** to install a new package in a new snapshot, and then running it again to install another package to the same snapshot:

```
> sudo transactional-update pkg install package_1
```

```
> sudo transactional-update --continue pkg install package_2
```

`--no-selfupdate`

Disables self-updating of **`transactional-update`**.

`--drop-if-no-change, -d`

Discards the snapshot created by **`transactional-update`** if there were no changes to the root file system. If there are changes to the `/etc` directory, those changes merged back to the current file system.

`--quiet`

The **`transactional-update`** command does not output to `stdout` .

`--help, -h`

Prints help for the **`transactional-update`** command.

`--version`

Displays the version of the **`transactional-update`** command.

2.1 General commands

This section lists general-purpose commands of **`transactional-update`**. You can use several general commands simultaneously and also pair them with one package management command.

`apply`

By mounting the current state of `/etc`, `/usr` and `/boot` directories to the newly created snapshot, the command enables you to modify the system without the need to reboot after the operation is complete. Keep in mind that `systemd` services are not restarted automatically and you have to do it manually.

`grub.cfg`

Use this command to rebuild the GRUB boot loader configuration file.

`bootloader`

The command reinstalls the boot loader.

`initrd`

Use the command to rebuild `initrd`.

`kdump`

In case you perform changes to your hardware or storage, you may need to rebuild the Kdump initrd.

`reboot`

The behavior of **`reboot`** depends on the configuration and changes performed to the system. If **`soft-reboot`** is enabled, only the user space may be restarted without rebooting the hardware and kernel. The enabling and configuration of **`soft-reboot`** are described in *Section 2.2, "Configuration of* **`soft-reboot`***"*.

`run` *<command>*

Runs the provided command in a new snapshot.

`shell`

Opens a read-write shell in the new snapshot before exiting. The command is typically used for debugging purposes.

`setup-fips`

The command performs all changes needed to enable FIPS on your system.

`setup-selinux`

Installs and enables targeted SELinux policy.

2.2 Configuration of **`soft-reboot`**

2.2.1 Enabling/disabling **`soft-reboot`**

To disable **`soft-reboot`** (https://documentation.suse.com/sle-micro/6.1/html/Micro-systemd-basics/index.html#systemctl-commands-managing-states) on **`transactional-update`**, proceed as follows:

1. Create a directory `/etc/tukit.conf.d/`

```
> sudo mkdir /etc/tukit.conf.d/
```

2. Create a file `/etc/tukit.conf.d/soft-reboot.conf` with the following content:

```
REBOOT_ALLOW_SOFT_REBOOT=false
```

For example, by running the following command:

```
> sudo echo "REBOOT_ALLOW_SOFT_REBOOT=false" > /etc/tukit.conf.d/soft-reboot.conf
```

To enable **`soft-reboot`** again, change `true` to `false` in the `/etc/tukit.conf.d/soft-reboot.conf` file.

2.2.2 Configuration of `soft-reboot`

You can define which packages require specific types of reboots in the `/usr/etc/zypp/zypp-boot-plugin.conf` file. To make changes, copy this file to `/etc/zypp/zypp-boot-plugin.conf`, which is writable and is not replaced during updates. The `/etc/zypp/zypp-boot-plugin.conf` file also has a higher priority than `/usr/etc/zypp/zypp-boot-plugin.conf`, so your configuration is preferred to the default one.

In the `/etc/zypp/zypp-boot-plugin.conf` file, under the `[main]` section, there are three reboot options:

reboot
: Here you specify the packages that require a hardware reboot when they are changed.

kexec
: Provides a list of packages whose changes require a kernel reboot. However, a hardware reboot does not take place, and GRUB2 is not triggered.

soft-reboot
: Specifies packages whose changes only require a reboot of the user space.

Entries can be a comma-separated list of package names or a list of all packages that provide a particular application or system component. Regular expressions can also be used. Here is an example:

```
soft-reboot = glibc, dbus-broker
```

Or using the `provides` statement:

```
soft-reboot = provides: dbus
```

3 Applying multiple changes without rebooting

The **`transactional-update`** command applies changes to the root file system on a transactional system. The default behavior is to create a new snapshot from the current root file system after each change and reboot to apply the changes.

To make multiple changes to the root file system without rebooting, you have several options, which are described in the following sections:

3.1 The **`transactional-update`**`--continue` option

Use the **`transactional-update`** command together with the `--continue` option to make multiple changes without rebooting. A separate snapshot is created on each run that contains all changes from the previous snapshot, plus your new changes. The final snapshot includes all changes. To apply them, reboot the system and your final snapshot becomes the new root file system.

3.2 The **`transactional-updateapply`** command

By mounting the current state of `/etc`, `/usr` and `/boot` directories to the newly created snapshot, the command enables you to modify the system without the need to reboot after the operation is complete. For example, to install the package `vim` without rebooting, run the command:

```
> sudo transactional-update apply pkg in vim
```

As the `apply` command does not reboot the system, consider the following things before using it:

- **Manual restart of services needed**: Even though the snapshot contains the provided changes, `systemd` services are not restarted automatically. You have to restart the affected services manually. Additionally, migration services are stopped, and standard boot-time initialization processes are bypassed. The sole exception is `systemd-tmpfiles`, which are processed normally, excluding those explicitly configured to run only during a full system boot.
- **When using `apply`, it is not an atomic operation**: Processes may get an inconsistent system for a short time because `/usr, /etc`, `/boot/` and so on are mounted separately.
- **Only simple operations are recommended**: we recommend using **`apply`** only for simple operations like package installation or removal, or for executing known commands. Performing a system upgrade or update is strongly discouraged.

3.3 The `transactional-update run` command

The **`transactional-update run`** command normally runs only a single command. However, you can use it to run multiple commands in one transactional session by concatenating them within a command shell such as **`bash`**, for example:

```
> sudo transactional-update run bash -c 'ls && date; if [ true ]; then echo -n "Hello ";
 echo '\''world'\''; fi'
```



Note

The **`transactional-update run`** command has the same limitations as the **`transactional-update shell`** command described in *Section 3.4, "The `transactional-update` shell"* except that the entered commands are logged in the `/var/log/transactional-update.log` file.

3.4 The `transactional-update` shell

The **`transactional-update shell`** command opens a shell in the transactional-update environment. In the shell, you can enter almost any Linux command to make changes to the file system, for example, install multiple packages with the **`zypper`** command or perform changes to files that are part of the read-only file system. You can also verify that the changes you previously made with the **`transactional-update`** command are correct.



Important

The transactional shell has several limitations. For example, you cannot operate start or stop services using `systemd` commands, or modify the `/var` partition because it is not mounted. Also, commands entered during a shell session are not logged in the `/transactional-update.log` file.

All changes that you make to the file system are part of a single snapshot. After you finish making changes to the file system and leave the shell with the **`exit`** command, you need to reboot the host to apply the changes.

4 Performing snapshots cleanup

You can use **transactional-update** to clean unused file system snapshots and unreferenced `/etc` overlay directories.

transactional-update recognizes the following cleanup commands:

cleanup-snapshots
: The command marks all unused snapshots for removal by Snapper.

cleanup-overlays
: The command removes all unused overlay layers of `/etc` in the `/var/lib/overlay` directory.

cleanup
: The command combines the **cleanup-snapshots** and **cleanup-overlays** commands.

4.1 How the cleanup works

If you run the command **transactional-update cleanup**, all old snapshots created by the **transactional-update** command without a cleanup algorithm will have one set. All important snapshots are also marked. The command also removes all unreferenced (and thus unused) `/etc` overlay directories in `/var/lib/overlay`.

The snapshots with the set `number` cleanup algorithm will be deleted according to the rules configured in `/etc/snapper/configs/root` by the following parameters:

NUMBER_MIN_AGE
: Defines the minimum age of a snapshot (in seconds) that can be automatically removed.

NUMBER_LIMIT/NUMBER_LIMIT_IMPORTANT
: Defines the maximum count of stored snapshots. The cleaning algorithms delete snapshots above the specified maximum value, without taking into account the snapshot and file system space. The algorithms also delete snapshots above the minimum value until the limits for the snapshot and file system are reached.

The snapshot cleanup is also regularly performed by `systemd`, so you do not need to perform the cleanup manually.

5 Registering products

You can use the **`transactional-update register`** command to handle all tasks regarding product registration and its subscription management. As the **`transactional-update register`** command passes its options to SUSEConnect, you can provide the same options as for the SUSEConnect tool. For example, you can supply the following options:

`--list-extensions`

With this option, the command lists available extensions for your system. You can use the output to find a product identifier for product activation.

`-p, --product`

Use this option to specify a product for activation. The product identifier has the following format: *<name>/<version>/<architecture>*, for example, `sle-module-live-patching/15.3/x86_64`. The corresponding command has the following form:

```
> sudo transactional-update register -p sle-module-live-patching/15.3/x86_64
```

`-r, --regcode`

Register your system with the registration code provided. The command registers the subscription and enables software repositories.

`-d, --de-register`

The option deregisters the system, or when used along with the `-p` option, deregisters an extension.

`-e, --email`

Specify an email address that is used in SUSE Customer Center for registration.

`--url`

Specify the URL of your registration server. The URL is stored in the configuration and is used in subsequent command invocations. For example:

```
> sudo transactional-update register --url https://scc.suse.com
```

`-s, --status`

Displays the current registration status in JSON format.

`--write-config`

Writes the provided options value to the `/etc/SUSEConnect` configuration file.

`--cleanup`

Removes old system credentials.

`--version`

Prints the version.

`--help`

Displays the usage of the command.

6 Managing software packages

You can use **`transactional-update`** to install, update or remove software packages.

SLES obtains software packages from repositories that are available after the product registration. Except for the main repository, SLES can access an extra repository with a collection of unsupported packages provided as a convenience for customers, mainly for testing and development purposes.

`transactional-update` uses the following commands to manage software packages.



Tip: The **`pkg`** command and Zypper options

With **`transactional-update pkg`** commands, you can use any Zypper option that corresponds to the used subcommand. For example, **`transactional-update pkg install`** understands all options that **`zypper install`** does.

`pkg install`

Installs individual packages from the available channels using the **`zypper install`** command. This command can also be used to install Program Temporary Fix (PTF) RPM files. The default option for this command is `--interactive`.

```
> sudo transactional-update pkg install package_name
```

or

```
> sudo transactional-update pkg install rpm1 rpm2
```

Or, to install a software pattern:

```
> sudo transactional-update pkg install -t pattern pattern_name
```

`pkg remove`

Removes individual packages from the active snapshot using the **`zypper remove`** command. This command can also be used to remove PTF RPM files. The default option for this command is `--interactive`.

```
> sudo transactional-update pkg remove package_name
```

pkg update

Updates individual packages from the active snapshot using the **zypper update** command. Only packages that are part of the snapshot of the base file system can be updated. The default option for this command is `--interactive`.

```
> sudo transactional-update pkg update package_name
```

patch

Checks for available patches and installs them. The default option for this command is `--non-interactive`.

dup

Performs an upgrade of your system. The default option for this command is `--non-interactive`.

up

Updates installed packages to newer versions. The default option for this command is `--non-interactive`.

migration

The command migrates your system to a selected target. Typically, it is used to upgrade your system if it has been registered via SUSE Customer Center.

7 Performing system rollback

GRUB 2 enables booting from btrfs snapshots and thus allows you to use any older functional snapshot in case the new snapshot does not work correctly.

When booting a snapshot, the parts of the file system included in the snapshot are mounted read-only; all other file systems and parts that are excluded from snapshots are mounted read-write and can be modified.



Tip: Rolling back to a specific installation state

An initial bootable snapshot is created at the end of the initial system installation. You can go back to that state at any time by booting this snapshot. The snapshot can be identified by the description `first root file system`.

There are two methods to perform a system rollback.

- From a running system, you can set the default snapshot, see more in *Procedure 2, "Rollback from a running system"*.
- Especially in cases where the current snapshot is broken, you can boot into the new snapshot and set it to default. For details, refer to *Procedure 3, "Rollback to a working snapshot"*.

If your current snapshot is functional, you can use the following procedure for a system rollback.

PROCEDURE 2: ROLLBACK FROM A RUNNING SYSTEM

1. Identify the snapshot that should be set as the default one and note its number.

```
> sudo snapper list
```

2. Set the snapshot as default.

```
> sudo transactional-update rollback snapshot_number
```

   If you omit the *`snapshot number`*, the current snapshot will be set as default.



Tip: Setting the last working snapshot

To set the last working snapshot as the default one, run **`rollback last`**.

3. Reboot your system to boot into the new default snapshot.

The following procedure is used in case the current snapshot is broken and you cannot boot into it.

PROCEDURE 3: ROLLBACK TO A WORKING SNAPSHOT

1. Reboot your system and select `Start bootloader from a read-only snapshot`.
2. Choose a snapshot to boot. The snapshots are sorted according to the date of creation, with the latest one at the top.
3. Log in to your system and check whether everything works as expected. The data written to directories excluded from the snapshots will stay untouched.
4. If the snapshot you booted into is not suitable for the rollback, reboot your system and choose another one.
   If the snapshot works as expected, you can perform the rollback by running the following command:

```
> sudo transactional-update rollback
```

> And reboot afterwards.

8 Managing automatic transactional updates

Automatic updates are controlled by **`systemd.timer`** that runs once per day. This applies all updates and informs **`rebootmgrd`** that the machine should be rebooted. You may adjust the time when the update runs, see systemd.timer(5) documentation.

8.1 Disabling automatic updates

The automatic updates are enabled by default. However, you can disable them with this command:

```
> sudo systemctl --now disable transactional-update.timer
```

8.2 Configuring notifications of failed updates

When an automatic **`transactional-update`** fails, the failed snapshot is deleted. Meanwhile the system may reboot, and then you cannot find out that the last automatic update failed. Therefore, you can configure a `systemd` service that will inform you about the failure of the automatic **`transactional-update`**. The procedure of doing so can be summarized into the following steps:

- Installing the required packages if not present on the system. For details, refer to *Section 8.2.1, "Installing required packages"*.
- Configuring the `systemd-status-mail` service. For details, refer to *Section 8.2.2, "Configuring the `systemd-status-mail` service"*.

8.2.1 Installing required packages

The packages `mailx` and `systemd-status-mail` are required to configure the notifications. They are present on the system by default. However, if you do not have them installed, install the packages by running the following command:

```
> sudo transactional-update pkg in systemd-status-mail mailx
```

Reboot the system.

8.2.2 Configuring the `systemd-status-mail` service

To configure the `systemd-status-mail` service, you can create a configuration file or you can use the `jeos-config` tool.

8.2.2.1 Configuring the service using `jeos-config`

To configure the email notifications, you can use the `jeos-config` tools as described bellow.

1. To open the configuration window, run the command:

```
> sudo jeos-config status_mail
```

2. In the dialog, configure the items according to your needs.
3. Confirm with *OK*.

8.2.2.2 Configuring the service by editing a configuration file

The default configuration file is in `/usr/etc/default/systemd-status-mail`. To modify it, create a copy in `/etc/default/` and edit the following items:

ADDRESS

A mandatory entry. Specify the e-mail address the notification is sent to. For example:

```
ADDRESS="tux@example.com"
```

FROM

The sender e-mail of the notification mail. Ensure that the address is valid. For example:

```
FROM="geeko@example.com"
```

MAILER

The type of mail application for sending notifications. Use the `mailx` value as follows:

```
MAILER="mailx"
```

RELAYHOST

Specify the mail relay used by mailx.

```
RELAYHOST="mail.example.com:587"
```

MAILX_OPTIONS

Specify necessary options to ensure that the mail provider will accept the notification mail. ``

```
MAILX_OPTIONS="-Sverbose -Ssmtp-use-starttls -Ssmtp-auth=login -Ssmtp-auth-
user='tux@example.com' -Ssmtp-auth-password='TopSecret'"
```

9 Legal Notice

Copyright© 2006– 2026 SUSE LLC and contributors. All rights reserved.

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2 or (at your option) version 1.3; with the Invariant Section being this copyright notice and license. A copy of the license version 1.2 is included in the section entitled “GNU Free Documentation License”.

For SUSE trademarks, see https://www.suse.com/company/legal/. All other third-party trademarks are the property of their respective owners. Trademark symbols (®, ™ etc.) denote trademarks of SUSE and its affiliates. Asterisks (*) denote third-party trademarks.

All information found in this book has been compiled with utmost attention to detail. However, this does not guarantee complete accuracy. Neither SUSE LLC, its affiliates, the authors, nor the translators shall be held liable for possible errors or the consequences thereof.

A GNU Free Documentation License

Copyright (C) 2000, 2001, 2002 Free Software Foundation, Inc. 51 Franklin St, Fifth Floor, Boston, MA 02110-1301 USA. Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

0. PREAMBLE

The purpose of this License is to make a manual, textbook, or other functional and useful document "free" in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or non-commercially. Secondarily, this License preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others.

This License is a kind of "copyleft", which means that derivative works of the document must themselves be free in the same sense. It complements the GNU General Public License, which is a copyleft license designed for free software.

We have designed this License to use it for manuals for free software, because free software needs free documentation: a free program should come with manuals providing the same freedoms that the software does. But this License is not limited to software manuals; it can be used for any textual work, regardless of subject matter or whether it is published as a printed book. We recommend this License principally for works whose purpose is instruction or reference.

1. APPLICABILITY AND DEFINITIONS

This License applies to any manual or other work, in any medium, that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. Such a notice grants a world-wide, royalty-free license, unlimited in duration, to use that work under the conditions stated herein. The "Document", below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as "you". You accept the license if you copy, modify or distribute the work in a way requiring permission under copyright law.

A "Modified Version" of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language.

A "Secondary Section" is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document's overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (Thus, if the Document is in part a textbook of mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them.

The "Invariant Sections" are certain Secondary Sections whose titles are designated, as being those of Invariant Sections, in the notice that says that the Document is released under this License. If a section does not fit the above definition of Secondary then it is not allowed to be designated as Invariant. The Document may contain zero Invariant Sections. If the Document does not identify any Invariant Sections then there are none.

The "Cover Texts" are certain short passages of text that are listed, as Front-Cover Texts or Back-Cover Texts, in the notice that says that the Document is released under this License. A Front-Cover Text may be at most 5 words, and a Back-Cover Text may be at most 25 words.

A "Transparent" copy of the Document means a machine-readable copy, represented in a format whose specification is available to the general public, that is suitable for revising the document straightforwardly with generic text editors or (for images composed of pixels) generic paint programs or (for drawings) some widely available drawing editor, and that is suitable for input to text formatters or for automatic translation to a variety of formats suitable for input to text formatters. A copy made in an otherwise Transparent

file format whose markup, or absence of markup, has been arranged to thwart or discourage subsequent modification by readers is not Transparent. An image format is not Transparent if used for any substantial amount of text. A copy that is not "Transparent" is called "Opaque".

Examples of suitable formats for Transparent copies include plain ASCII without markup, Texinfo input format, LaTeX input format, SGML or XML using a publicly available DTD, and standard-conforming simple HTML, PostScript or PDF designed for human modification. Examples of transparent image formats include PNG, XCF and JPG. Opaque formats include proprietary formats that can be read and edited only by proprietary word processors, SGML or XML for which the DTD and/or processing tools are not generally available, and the machine-generated HTML, PostScript or PDF produced by some word processors for output purposes only.

The "Title Page" means, for a printed book, the title page itself, plus such following pages as are needed to hold, legibly, the material this License requires to appear in the title page. For works in formats which do not have any title page as such, "Title Page" means the text near the most prominent appearance of the work's title, preceding the beginning of the body of the text.

A section "Entitled XYZ" means a named subunit of the Document whose title either is precisely XYZ or contains XYZ in parentheses following text that translates XYZ in another language. (Here XYZ stands for a specific section name mentioned below, such as "Acknowledgements", "Dedications", "Endorsements", or "History".) To "Preserve the Title" of such a section when you modify the Document means that it remains a section "Entitled XYZ" according to this definition.

The Document may include Warranty Disclaimers next to the notice which states that this License applies to the Document. These Warranty Disclaimers are considered to be included by reference in this License, but only as regards disclaiming warranties: any other implication that these Warranty Disclaimers may have is void and has no effect on the meaning of this License.

2. VERBATIM COPYING

You may copy and distribute the Document in any medium, either commercially or non-commercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of this License. You may not use technical measures to obstruct or control the reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section 3.

You may also lend copies, under the same conditions stated above, and you may publicly display copies.

3. COPYING IN QUANTITY

If you publish printed copies (or copies in media that commonly have printed covers) of the Document, numbering more than 100, and the Document's license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a computer-network location from which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

4. MODIFICATIONS

You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

A. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any, be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.

B. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you from this requirement.

C. State on the Title page the name of the publisher of the Modified Version, as the publisher.

D. Preserve all the copyright notices of the Document.

E. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.

F. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below.

G. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document's license notice.

H. Include an unaltered copy of this License.

I. Preserve the section Entitled "History", Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section Entitled "History" in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence.

J. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the "History" section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.

K. For any section Entitled "Acknowledgements" or "Dedications", Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.

L. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.

M. Delete any section Entitled "Endorsements". Such a section may not be included in the Modified Version.

N. Do not retitle any existing section to be Entitled "Endorsements" or to conflict in title with any Invariant Section.

O. Preserve any Warranty Disclaimers.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their titles to the list of Invariant Sections in the Modified Version's license notice. These titles must be distinct from any other section titles.

You may add a section Entitled "Endorsements", provided it contains nothing but endorsements of your Modified Version by various parties--for example, statements of peer review or that the text has been approved by an organization as the authoritative definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, you may not add another; but you may replace the old one, on explicit permission from the previous publisher that added the old one.

The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version.

5. COMBINING DOCUMENTS

You may combine the Document with other documents released under this License, under the terms defined in section 4 above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice, and that you preserve all their Warranty Disclaimers.

The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work.

In the combination, you must combine any sections Entitled "History" in the various original documents, forming one section Entitled "History"; likewise combine any sections Entitled "Acknowledgements", and any sections Entitled "Dedications". You must delete all sections Entitled "Endorsements".

6. COLLECTIONS OF DOCUMENTS

You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects.

You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document.

7. AGGREGATION WITH INDEPENDENT WORKS

A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an "aggregate" if the copyright resulting from the compilation is not used to limit the legal rights of the compilation's users beyond what the individual works permit. When the Document is included in an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document.

If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one half of the entire aggregate, the Document's Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole aggregate.

8. TRANSLATION

Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a disagreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail.

If a section in the Document is Entitled "Acknowledgements", "Dedications", or "History", the requirement (section 4) to Preserve its Title (section 1) will typically require changing the actual title.

9. TERMINATION

You may not copy, modify, sublicense, or distribute the Document except as expressly provided for under this License. Any other attempt to copy, modify, sublicense or distribute the Document is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.

10. FUTURE REVISIONS OF THIS LICENSE

The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See https://www.gnu.org/copyleft/.

Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License "or any later version" applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation.

ADDENDUM: How to use this License for your documents

```
Copyright (c) YEAR YOUR NAME.
```

```
Permission is granted to copy, distribute and/or modify this document
under the terms of the GNU Free Documentation License, Version 1.2
or any later version published by the Free Software Foundation;
with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts.
A copy of the license is included in the section entitled “GNU
Free Documentation License”.
```

If you have Invariant Sections, Front-Cover Texts and Back-Cover Texts, replace the “with...Texts.” line with this:

```
with the Invariant Sections being LIST THEIR TITLES, with the
Front-Cover Texts being LIST, and with the Back-Cover Texts being LIST.
```

If you have Invariant Sections without Cover Texts, or some other combination of the three, merge those two alternatives to suit the situation.

If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.