Installing and Configuring an RMT Server

RMT (Repository Mirroring Tool) is a proxy system that mirrors software repositories and registers client machines within a private network. As a local intermediary for SUSE Customer Center, RMT enables administrators to manage package updates and register systems locally without direct external Internet access. This setup reduces bandwidth usage, enhances network security and streamlines package management.

Prerequisites

- Running instance of SUSE Linux Enterprise Server 16.1
- Valid SUSE Customer Center organization credentials
- Sufficient local storage space (approximately 1.5 times the size of all enabled repositories)

Publication Date: 05 Nov 2026

Contents

1 What is an RMT server? 3

2 RMT server storage and disk space requirements 3

3 Installing RMT during system installation 4

4 Installing RMT on a running SLES system 4

5 Upgrading an RMT server from SUSE Linux Enterprise 15 to SLES 16.1 5

6 Deploying RMT on top of the Kubernetes cluster 8

7 Configuring RMT with Ansible 11

8 Enabling SLP announcements 14

9 Accessing SUSE Customer Center from behind a firewall 15

10 Main configuration file `/etc/rmt.conf` 16

11 Managing TLS/SSL certificates 18

12 For more information 20

13 Legal Notice 20

A GNU Free Documentation License 21

1 What is an RMT server?

This article describes how to run an RMT server on SUSE Linux Enterprise Server 16.1. Install RMT directly during the installation of SUSE Linux Enterprise Server or install it on a running system. After the packages are installed, use Ansible to do an initial configuration.



Warning: RMT server conflicts with installation server

Configuring a host to be an RMT server installs and configures the NGINX Web server, listening on port 80. However, configuring a host to be an installation server automatically installs the Apache Web server, which also listens on port 80. If both use the same IP address, the service that starts second cannot bind the port and does not start.

Do not try to enable both these functions on the same server. It is not possible for a single server to host both simultaneously.

2 RMT server storage and disk space requirements

The amount of storage your RMT server requires depends on several variables: the number of repositories and architectures that you mirror and the number of products that are enabled. As a general guide, 1.5 times the total size of all enabled repositories is sufficient. The total is about 200 GB per SUSE Linux Enterprise release, including all extensions.

Downloaded packages are stored in `/var/lib/rmt/public/repo/`. Plan the size of the file system that contains `/var/lib/rmt/` accordingly.

The `rmt-server` package also installs the symbolic link `/usr/share/rmt/public/repo/`, which points to `/var/lib/rmt/public/repo/`. Because the link is part of the package and RMT writes only to `/var/lib/rmt/public/repo/`, mirroring also works on systems where `/usr` is read-only, such as immutable systems.



Important: RMT mirroring fails when `/tmp` runs out of space

When RMT mirrors repositories from SUSE Customer Center, it writes large temporary files in `/tmp`. If `/tmp` is too small, or is part of the `/root` file system, and this file system is small in size, `/tmp` quickly runs out of space, resulting in a mirroring failure. For more information, see https://support.scc.suse.com/s/kb/RMT-mirroring-fails-when-tmp-runs-out-of-disk-space/.

3 Installing RMT during system installation

Install RMT while installing SUSE Linux Enterprise Server with Agama by adding the `rmt-server` package to the installation profile.

RMT is not available as a software pattern, and the Agama Web interface only lets you select patterns. To install RMT during installation, add the `rmt-server` package to the `software` section of an Agama installation profile:

```
"software": {
  "packages": [
    "rmt-server"
  ]
}
```

The `rmt-server` package is available from the SUSE Linux Enterprise Server product repository, so no additional repository is required. If you install with the Agama Web interface instead, install RMT after the installation as described in *Section 4, "Installing RMT on a running SLES system"*.

Immediately after the SLES installation, run **`zypper patch`** to get the latest RMT updates. SUSE continuously releases maintenance updates for RMT.

4 Installing RMT on a running SLES system

Install RMT on an active SUSE Linux Enterprise Server using the **`zypper`** package manager.

For RMT installation, run the following **`zypper`** command:

```
> sudo zypper install rmt-server
```

On an immutable system, install RMT with the **`transactional-update`** command and reboot the system to switch to the new snapshot:

```
> sudo transactional-update pkg install rmt-server
> sudo reboot
```

5 Upgrading an RMT server from SUSE Linux Enterprise 15 to SLES 16.1

After you upgrade an existing RMT server from SUSE Linux Enterprise 15 SP7 to SUSE Linux Enterprise Server 16.1, repair two platform changes. Until you do, RMT remains unavailable.

Repair the following two platform changes:

- **Network stack replacement:** SLES 16.1 removes the legacy `wicked` networking framework and standardizes on NetworkManager as the sole network control stack.
- **Mandatory access control framework:** SLES 16.1 replaces `AppArmor` with SELinux in `enforcing` mode by default.

Upgrade the host itself using the distribution migration system, as described in Upgrading to SUSE Linux Enterprise Server 16.1 (https://documentation.suse.com/sles/html/SLES-upgrading/). This section covers only the steps specific to a host running RMT.

Important: A successful upgrade can still leave RMT unavailable

The distribution migration system reports success for the distribution upgrade, not for the services running on the host. Even when every `suse-migration-*` unit finishes with `Result=success` and `/var/log/distro_migration.exitcode` contains `0`, RMT does not start until you complete the steps below.

5.1 Preparing for the upgrade

1. Back up the RMT configuration file and the RMT database to a location outside the host:

```
# cp /etc/rmt.conf /root/rmt.conf.backup
# mysqldump --single-transaction rmt > /root/rmt.sql
```

2. Record the ownership of the MariaDB data directory. On SUSE Linux Enterprise 15, as it belongs to the group `root`, which breaks MariaDB after the upgrade:

```
# ls -ld /var/lib/mysql
```

```
drwx------ 1 mysql root 442 /var/lib/mysql
```



Note: Registered clients follow the RMT server address

The upgrade replaces `wicked` with NetworkManager, which changes the DHCP client identifier. Consequently, a host using DHCP is likely to receive a new IP address. Because clients registered against this RMT server reach it through the URL stored in their Zypper service definitions, assign the server a stable IP address or host name before upgrading.

5.2 Completing the upgrade

1. Check which services are running. RMT depends on MariaDB through `Requires=mariadb.service`, so a failed database keeps RMT inactive:

   ```
   # systemctl --failed
   # systemctl is-active mariadb nginx rmt-server
   ```

2. Correct the group ownership of the MariaDB data directory:

   ```
   # chgrp -R mysql /var/lib/mysql
   ```

   On SUSE Linux Enterprise Server 16.1, `mariadb.service` combines `StateDirectory=mysql` with `User=mysql` and `Group=mysql`. systemd therefore adjusts the ownership of `/var/lib/mysql` on every start, and the `mysql:root` ownership inherited from SUSE Linux Enterprise 15 makes that fail:

   ```
   mariadb.service: Failed to set up special execution directory in /var/lib:
    Permission denied
   mariadb.service: Control process exited, code=exited, status=238/STATE_DIRECTORY
   ```

   The error is reported as a permission problem rather than an ownership one, which makes it easy to mistake for a file system or SELinux fault.

3. Start MariaDB:

   ```
   # systemctl start mariadb
   ```

4. Allow nginx to connect to the RMT back-end:

   ```
   # setsebool -P httpd_can_network_connect on
   ```

SUSE Linux Enterprise Server 16.1 uses SELinux in enforcing mode instead of AppArmor. The `httpd_can_network_connect` boolean is off by default, which prevents nginx from opening a connection to the RMT back-end on `127.0.0.1:4224`. Without this setting, nginx answers every request that it proxies to RMT with `502`.

5. Verify that RMT answers correctly:

```
# curl -o /dev/null -w '%{http_code}\n' http://localhost/connect/subscriptions/
products
401
# curl -o /dev/null -w '%{http_code}\n' http://localhost/repo/
200
```

`401` is the expected answer on the registration endpoint: it shows that the RMT application is reachable and requires authentication. A `502` means that the previous step is incomplete.

6. Restart the host and repeat the checks. Confirming the changes across a reboot is essential: The SELinux boolean only persists when it is set with `-P`, and MariaDB may not be independently enabled because `rmt-server.service` manages it via `Requires=`.



Note: RMT 2 is upgraded to RMT 3

SUSE Linux Enterprise 15 SP7 offers both RMT 2 and RMT 3, while SUSE Linux Enterprise Server 16.1 ships only RMT 3. A host still running RMT 2 therefore moves to RMT 3 as part of the distribution upgrade.

No action is required. `/etc/rmt.conf` and the contents of the database are preserved, and `rmt-server-migration.service` updates the database schema before `rmt-server.service` starts. RMT 3 differs from RMT 2 in the Ruby and Rails versions it runs on, not in its configuration file or its **`rmt-cli`** commands.

Confirm the version after the upgrade:

```
# rmt-cli version
```



Warning: Mirrored repositories keep working while registration is broken

nginx serves `/repo/` directly from disk, so clients continue to download packages even when the RMT application is unreachable and no client can register. Check the registration endpoint, not just the repository paths.

6 Deploying RMT on top of the Kubernetes cluster

This section describes how to deploy RMT on a Kubernetes cluster. It uses Helm as the package manager to interact with the Kubernetes cluster. For more information about using Helm, see https://helm.sh/docs/intro/using_helm/.

6.1 Prerequisites

- Running Kubernetes cluster
- **`helm`** command configured to interact with the cluster
- A storage class for the persistent volumes of RMT and MariaDB. The example in *Section 6.3, "The `values.yaml` file"* uses the `local-path` storage class, which is only available in Rancher workloads. On other clusters, install the `local-path` storage provisioner:

  ```
  > kubectl apply -f \
  https://raw.githubusercontent.com/rancher/local-path-provisioner/\
  v0.0.26/deploy/local-path-storage.yaml
  ```

  Alternatively, set `app.storage.class` and `db.storage.class` to a storage class that already exists in your cluster.

6.2 Application components

Each component of the RMT application is deployed in its own container. RMT consists of the following components:

RMT server

Containerized version of the RMT application server with the ability to pass its configuration via Helm values. Storage is done on a volume that is allocated to the Kubernetes cluster. Adjust the size of the storage depending on the number of repositories you need to mirror.

MariaDB

The database back-end for RMT. No post-installation task is needed since RMT creates the required database and tables at start-up. If passwords are not specified in the `values.yaml` file, they are generated automatically.

nginx

A Web server configured for RMT routes. Having a properly configured Web server allows you to target your Ingress traffic (for RMT) to this nginx service directly. You do not need to configure Ingress for RMT-specific path handling, as nginx handles path routing automatically.

6.3 The `values.yaml` file

The RMT chart includes the `values.yaml` file where all parameters are documented and their default values are defined. You can override these values by providing your own values file, for example:

```
> cat << EOF > rmt-config.yaml
---
app:
  storage:
    class: local-path ❶
  scc:
    enabled: false
    username: "UXXXXXXX"
    password: "PASSXXXX"
    products_enable:
      - SLES/15.3/x86_64
      - sle-module-python2/15.3/x86_64
    products_disable:
      - sle-module-legacy/15.3/x86_64
      - sle-module-cap-tools/15.3/x86_64
db:
  storage:
```

```
    class: local-path❷
ingress:
  enabled: true
  hosts:
    - host: chart-example.local
      paths:
        - path: "/"
          pathType: Prefix
  tls:
    - secretName: rmt-cert
      hosts:
        - chart-example.local
EOF
```

❶ ❷ The storage class for the RMT and MariaDB persistent volumes. The storage class must exist in the cluster. For more information, see *Section 6.1, "Prerequisites"*.

And to install RMT, run:

```
> helm install rmtsle oci://registry.suse.com/suse/rmt-helm -f rmt-config.yaml
```

REQUIRED VALUES

Key: app.scc.password

Type: string

Default: `nil`

Description: SUSE Customer Center (https://scc.suse.com/) proxy password. The password string needs to be put inside quotes. If the quote character `"` is part of the string, it has to be escaped with `\`.

Key: app.scc.username

Type: string

Default: `nil`

Description: SUSE Customer Center (https://scc.suse.com/) proxy user name. The user name string needs to be put inside quotes. If the quote character `"` is part of the string, it has to be escaped with `\`.

Key: app.scc.products_enable

Type: list

Default: `[]`

Description: list of products to enable for mirroring

Key: app.scc.products_disable

Type: list

Default: `[]`

Description: list of products to disable for mirroring

Key: app.storage.class

Type: string

Default: `""`

Description: Kubernetes `storageclass`.

Key: db.storage.class

Type: string

Default: `""`

Description: Kubernetes `storageclass`.

Key: ingress.enabled

Type: bool

Default: `false`

Description: Ingress Enabled

Key: ingress.hosts[0]

Type: object

Default: `{"host":"chart-example.local","paths":[{"path":"/","pathType":"Prefix"}]}`

Description: DNS name at which the RMT service will be accessible from clients

Key: ingress.tls[0].hosts[0]

Type: string

Default: `"chart-example.local"`

Description: DNS name at which the RMT service will be accessible from clients

Key: ingress.tls[0].secretName

Type: string

Default: `"rmt-cert"`

Description: TLS Ingress Certificate

7 Configuring RMT with Ansible

Configure RMT with Ansible as described in the following procedure. The `ansible-rmt-server` package provides pre-built playbooks and roles for automated RMT configuration.

1. Install the `ansible-rmt-server` package:

   - On a mutable system:

     ```
     # zypper in ansible-rmt-server
     ```

   - On an immutable system, also install the packages that the playbook requires, then reboot the system to switch to the new snapshot. If you skip these packages, the playbook installs them into a new snapshot that is not active until the next reboot, and the services that the playbook starts are missing.

     ```
     # transactional-update pkg install ansible-rmt-server mariadb nginx python3-
     PyMySQL
     # reboot
     ```

2. Navigate to the Ansible configuration directory:

   ```
   # cd /usr/share/ansible/rmt
   ```

3. Create the configuration file based on the provided example:

   - On a mutable system, create `group_vars/all.yml`:

     ```
     # cp group_vars/all.yml.example group_vars/all.yml
     ```

   - On an immutable system, `/usr` is read-only. Create the configuration file in a writable location, for example, `/root/rmt-vars.yml`, and make it readable only by `root`, because it contains credentials:

     ```
     # install -m 600 group_vars/all.yml.example /root/rmt-vars.yml
     ```

4. Edit the configuration file and configure the following variables:

   `rmt_db_username`
   : Database user name for RMT (default: `rmt`)

   `rmt_db_password`
   : Secure password for the RMT database user

   `RMT_ORGANIZATION_USERNAME`
   : Your SUSE Customer Center organization credentials. To retrieve your credentials, log in to Mirroring credentials (https://scc.suse.com/).

`RMT_ORGANIZATION_PASSWORD`

Your SUSE Customer Center organization password

Example configuration:

```
---
rmt_db_username: rmt
rmt_db_password: "your_secure_password"

rmt:
  RMT_ORGANIZATION_USERNAME: "your_scc_username"
  RMT_ORGANIZATION_PASSWORD: "your_scc_password"
```

5. Run the Ansible playbook to configure RMT:

   On an immutable system, pass the configuration file that you created in `/root` as an extra variable:

   ```
   # ansible-playbook site.yml -e @/root/rmt-vars.yml
   ```

   The playbook performs the following tasks:

   - Install required dependencies (MariaDB, nginx, Python modules)
   - Configure and start the MariaDB database service
   - Create the RMT database and database user
   - Generate SSL certificates for HTTPS
   - Configure nginx virtual hosts
   - Create `/etc/rmt.conf` configuration file
   - Run database migrations
   - Start and enable the RMT server service

6. On systems with SELinux in enforcing mode, allow nginx to connect to the RMT back-end service:

   ```
   # setsebool -P httpd_can_network_connect 1
   ```

7. Verify the installation by checking the API health status:

   ```
   # curl -s http://localhost/api/health/status
   {"state":"online"}
   ```



Tip: SSL certificate locations

The Ansible playbook generates SSL certificates at the following locations:

CA certificate

`/etc/rmt/ssl/rmt-ca.crt`

CA private key

`/etc/rmt/ssl/rmt-ca.key`

Server certificate

`/etc/rmt/ssl/rmt-server.crt`

Server private key

`/etc/rmt/ssl/rmt-server.key`

8 Enabling SLP announcements

Enable SLP (Service Location Protocol) announcements so that clients can discover the RMT service on the network.

RMT includes the SLP service description file `/etc/slp.reg.d/rmt-server.reg`. To enable SLP announcements of the RMT service, follow these steps:

1. If `firewalld` is running:

   a. Open relevant ports:

   ```
   > sudo firewall-cmd --permanent --add-port=427/tcp
     success
   ```

   ```
   > sudo firewall-cmd --permanent --add-port=427/udp
   success
   ```

   b. Reload the `firewalld` configuration:

   ```
   > sudo firewall-cmd --reload
   ```

2. Verify that the SLP server is installed and install it if it is not:

```
> sudo zypper install openslp-server
```

3. Enable and start the SLP service:

```
> sudo  systemctl enable --now slpd.service
```

9 Accessing SUSE Customer Center from behind a firewall

Allow the RMT server to reach SUSE Customer Center when it is located behind a firewall that does not support host name `allowlisting`.

If the RMT server is behind a firewall and cannot access SUSE Customer Center directly, you need to allow connections to the following domains on both ports 80 and 443 on the firewall.

- scc.suse.com
- updates.suse.com
- installer-updates.suse.com

If the firewall you are using does not support allowing connections from host names—such as `firewalld`—allow connections to the corresponding IP addresses below.

1. Resolve the IP address of the domain, for example, `installer-updates.suse.com`.

```
> nslookup installer-updates.suse.com
[...]
Address: 152.199.22.115
```

2. Add firewall rules for ports 80 and 443 for each discovered IP address.

    a. Port 80:

```
> sudo firewall-cmd --permanent --zone=public \
--add-rich-rule='rule family="ipv4" source address="152.199.22.115" \
 port protocol="tcp" port="80" accept'
```

b. Port 443:

```
> sudo firewall-cmd --permanent --zone=public \      --add-rich-rule='rule
 family="ipv4" source address="152.199.22.115" \
port protocol="tcp" port="443" accept'
```

3. Reload the firewall configuration.

```
> sudo firewall-cmd --reload
```

10 Main configuration file `/etc/rmt.conf`

This section documents the configuration options available in the main RMT configuration file, `/etc/rmt.conf`.

The Ansible playbooks provided in the `ansible-rmt-server` package perform the initial configuration. You only need to specify the proxy configuration manually. The remaining configuration parameters are documented below for reference.

10.1 Mirroring settings

The `mirroring` section lets you adjust mirroring behavior.

`mirror_src`
: Decides whether to mirror source RPM packages (architecture is `src`).

`dedup_method`
: Creates hard links during mirroring when set to `hardlink`. If the file system does not support hard links, it can be set to `copy` instead. Possible values: `hardlink`, `copy`.

10.2 HTTP client settings

The `http_client` section defines the global HTTP connection settings of RMT.

`verbose`
: Enables additional debug output to the `systemd` journal.

`proxy`

The proxy server URL including the protocol and the port number. For example: `http://proxy_url:8080`.

`noproxy`

A list of domains that should *not* go through the proxy, separated by commas. For example: `localhost.mylocaldomain`.

`proxy_auth`

This setting determines the proxy authentication mechanism. Possible values are: `none`, `basic`, `digest`, `gssnegotiate`, `ntlm`, `digest_ie`, `ntlm_wb`.

`proxy_user`

The proxy server user name.

`proxy_password`

The proxy server password.

`low_speed_limit`

Lower speed limit when a download is aborted in bytes per second.

`low_speed_time`

Time until a download is aborted, when download speed is below `low_speed_limit`.

10.3 Settings for accessing SUSE repositories

The `scc` section contains your mirroring credentials for contacting SUSE Customer Center. To obtain your mirroring credentials, see Mirroring credentials (https://documentation.suse.com/sles/15-SP7/single-html/SLES-rmt/#sec-rmt-mirroring-credentials).

Valid configuration keys for the section are:

`username`

Mirroring credentials user name.

`password`

Mirroring credentials password.

10.4 Web server settings

The `web_server` section lets you tune the performance of your RMT server.

`min_threads`

Specifies the minimum number of threads that an RMT server worker should spawn.

Acceptable values: integer greater than or equal to 1.

`max_threads`

Specifies the maximum number of threads that an RMT server worker should spawn.

Acceptable values: integer greater than or equal to 1.

`workers`

Specifies the number of Web workers for RMT.

Acceptable values: integer greater than or equal to 1.

11 Managing TLS/SSL certificates

Regenerate the TLS/SSL certificates of your RMT server using the Ansible playbook when they expire.

11.1 SSL certificates and HTTPS

By default access to API endpoints consumed by **`SUSEConnect`** is limited to HTTPS only. nginx is configured to use an SSL certificate and a private key from the following locations:

- Certificate: `/etc/rmt/ssl/rmt-server.crt`
- Private key: `/etc/rmt/ssl/rmt-server.key`

The Ansible playbook generates a custom certificate authority which is used to sign HTTPS certificates. To register, client machines must trust the certificate authority:

- For registrations during installation from the media or with YaST Registration module, a message prompts you to trust the server certificate.
- For registering a client system on the command line, use the **`rmt-client-setup`** script.

11.2 Regenerating HTTPS certificates

HTTPS certificates must be regenerated before they expire. No additional actions are required on the client machines registered to the RMT server if only HTTPS certificates are regenerated.

Note: Certificates generated by the playbook are self-signed

The playbook generates a self-signed server certificate that carries neither a common name nor subject alternative names, and that is not signed by the CA certificate in `/etc/rmt/ssl/rmt-ca.crt`. Clients that verify host names reject such a certificate. If your clients verify the server certificate, issue one yourself with a common name, the required subject alternative names and a signature from your CA, then store it as `/etc/rmt/ssl/rmt-server.crt` together with its key in `/etc/rmt/ssl/rmt-server.key`.

Warning: Overwriting existing certificates

Any subsequent run of the playbook overwrites the existing server certificates.

1. Stop nginx and rmt-server services.

```
# systemctl stop nginx
# systemctl stop rmt-server
```

2. Remove previously generated certificates.

```
# rm /etc/rmt/ssl/rmt-server.*
```

3. Regenerate certificates using the Ansible playbook:

```
# cd /usr/share/ansible/rmt
# ansible-playbook site.yml
```

11.3 Regenerating CA certificates and HTTPS certificates

CA certificates can be regenerated after they have expired or in case of security issues.

Warning: Import CA certificate on all clients

The newly generated CA certificate must be imported on all clients registered to the RMT server. If the certificate is not imported, clients cannot establish a secure connection to the RMT server, and all subsequent package updates and registration requests will fail with SSL/TLS verification errors.

To import the certificate, run the **`rmt-client-setup`** script on the client machines.

1. Stop nginx service. rmt-server services.

```
# systemctl stop nginx
```

2. Stop rmt-server service.

```
# systemctl stop rmt-server
```

3. Remove previously generated CA and HTTPS certificates.

```
# rm /etc/rmt/ssl/rmt-ca.*
  rm /etc/rmt/ssl/rmt-server.*
```

4. Regenerate certificates using the Ansible playbook:

```
# cd /usr/share/ansible/rmt
# ansible-playbook site.yml
```

12 For more information

To learn more about RMT, see the following resource:

- RMT source code and issue tracker on GitHub (https://github.com/SUSE/rmt).

13 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.