

Synchronizing Time Using NTP

WHAT?

This article describes what time synchronization is and how to configure it.

WHY?

Keeping the system time synchronized is crucial when sharing tasks and resources with other team members over the network.

EFFORT

Up to 60 minutes to read this article and perform a basic configuration of time synchronization on your computer.

REQUIREMENTS

A basic knowledge of Linux system administration is required.

- Specific tasks require root privileges.

Working network connection to the internal network or Internet

- to reach the source time server.

Publication Date: 20 May 2024

Contents

- 1 Introduction 3
- 2 Configuring NTP by adjusting `/etc/chrony.conf` 5
- 3 Managing `chronyd` at runtime 8

- 4 The chronyd systemd service 9
- 5 Troubleshooting 10
- 6 For more information 11
- 7 Legal Notice 11
- A GNU Free Documentation License 12

1 Introduction

Maintaining an accurate and synchronized system time on the computer is vital for teamwork. Planning and calendaring applications rely on it to track time correctly and notify users about appointments on time. For clustered applications, individual host machines often require synchronized system time for mutual communication. The built-in hardware clock is not a reliable time source. A manual correction of the system time may cause malfunction of critical applications due to sudden time leaps. Therefore, the system time needs to be synchronized against an external reliable time source over the network.

1.1 What is NTP?

The Network Time Protocol (NTP) is designed to synchronize the system time over the network. Its goal is to maintain the absolute time and use it to synchronize the system time of all machines within a network.

1.2 How does NTP work?

When the NTP service is properly configured, it continuously queries and adjusts the system time with reliable time servers. Typically, home computers and other devices connected to the internet are configured to query a public time server on the Internet.

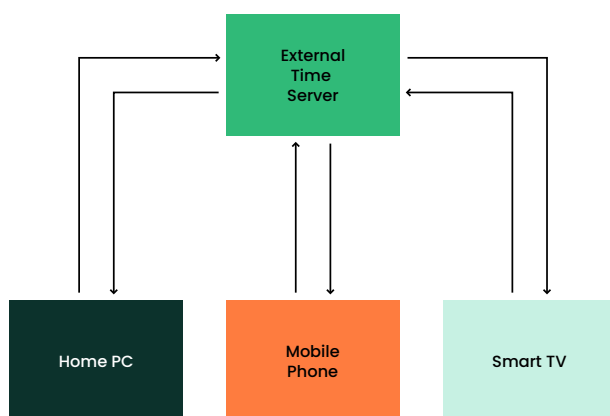


FIGURE 1: INDIVIDUAL DEVICES QUERYING A PUBLIC TIME SERVER

Conversely, desktop computers and servers that reside inside a corporate subnet are configured to query a dedicated time server within the local network. The time server itself synchronizes its time with a public time server.

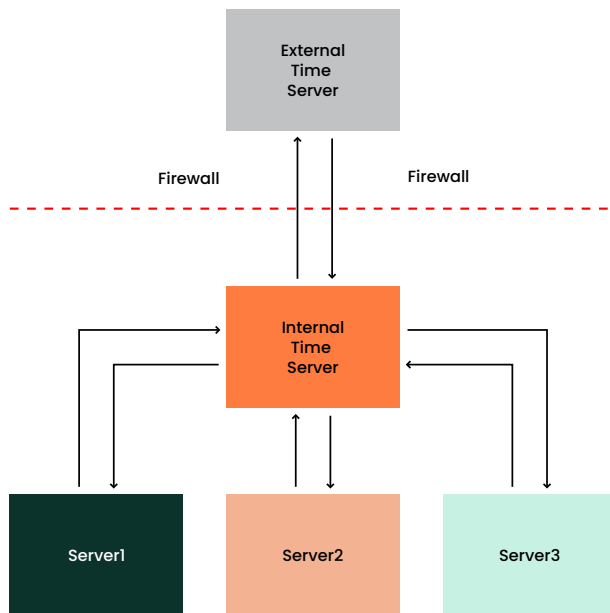


FIGURE 2: MULTIPLE HOSTS QUERYING AN INTERNAL TIME SERVER

1.2.1 Implementation

chrony is the default implementation of NTP in SUSE Linux Micro. chrony includes two parts:

- chronyd is a systemd service that can be started at boot time.
- **chronyc** is a command-line interface program to monitor the performance of chronyd and to change specific operating parameters at runtime.

1.3 Benefits

Using NTP to maintain the accurate time has the following benefits:

- People can rely on their clocks when following a planned schedule.
- Applications can trigger scheduled desktop or system actions accurately.

- Cluster nodes can keep their data synchronized and up to date.
- Using an internal time server helps maintain synchronized system time in networks with restricted access to the Internet.

2 Configuring NTP by adjusting `/etc/chrony.conf`

When `chronyd` starts, it reads its configuration from the `/etc/chrony.conf` file. The following sections list important parameters that can affect `chronyd` behavior.

2.1 Specifying time sources

To keep the computer clock synchronized, you need to tell `chronyd` what time sources to use. For this purpose, use `server`, `pool` and `peer` directives. You can use each of them multiple times.

The `server` directive tells `chronyd` to use a specific host as a time server by its name or IP address.

```
server 0.europe.pool.ntp.org offline❶  
server 1.europe.pool.ntp.org offline prefer❷  
server 192.168.2.254
```

- ❶ The `offline` option prevents `chronyd` from querying the time server. This option is useful if the server is not reachable when `chronyd` is started. You need to put the time server online when it is reachable by using `chronyc`. Refer to [Section 3, “Managing chronyd at runtime”](#) for more details.
- ❷ The `prefer` option tells `chronyd` to prefer the time source over others that do not include such an option.

The `pool` directive lets you specify a network name that resolves to multiple IP addresses that may change over time.

```
pool pool.ntp.org iburst❶ maxsources 3❷
```

- ❶ The `iburst` option means that `chronyd` starts with a burst of 4 to 8 requests to make the first update of the clock sooner.
- ❷ The `maxsources` option tells `chronyd` to use up to three sources from the pool.

The `peer` directive specifies an NTP peer host instead of a time server. System time synchronization among *peers* uses a symmetric architecture instead of the client/server mode invoked by `server` and `pool` options. You can use `peer` multiple times to specify more than one peer.

```
peer 192.168.1.116
peer ntp.example.com
```

2.2 Running chronyd as an NTP server

By default, `chronyd` works as a client to specified NTP servers. To make it operate as an NTP server as well, add the `allow` directive to the `/etc/chrony.conf` file. It opens the NTP server port (123 by default) and responds to client requests.

You can either specify a single IP of an NTP client, or a subnet to include multiple clients. You can use the `allow` directive multiple times:

```
allow 1.2.3.4
allow 3.4.5.0/24
```



Tip

If you do not specify an IP address or a subnet, the stand-alone `allow` directive allows access from all IPv4 and IPv6 addresses.

To limit the access of the previous `allow` directive, use the `deny` directive:

```
allow 1.2.3.4
deny 1.2.3.0/24
allow 1.2.0.0/16
```

In the above example, the effect is the same regardless of the order of the three directives. The `1.2.0.0/16` subnet is allowed access except for the `1.2.3.0/24` subnet, which is denied access. However, the host `1.2.3.4` is allowed access.

2.3 Configuring a local reference clock

`chronyd` relies on other programs (such as `gpsd`) to access the timing data via a specific driver. Use the `refclock` directive in `/etc/chrony.conf` to specify a hardware reference clock to be used as a time source. It has two mandatory parameters: a driver name and a driver-specific parameter. The two parameters are followed by zero or more `refclock` options. `chronyd` includes the following drivers:

PPS

Driver for the kernel *pulse per second* API. For example:

```
refclock PPS /dev/pps0 lock NMEA refid GPS
```

SHM

NTP shared memory driver. For example:

```
refclock SHM 0 poll 3 refid GPS1  
refclock SHM 1:perm=0644 refid GPS2
```

SOCK

Unix domain socket driver. For example:

```
refclock SOCK /var/run/chrony.ttyS0.sock
```

PHC

PTP hardware clock driver. For example:

```
refclock PHC /dev/ptp0 poll 0 dpoll -2 offset -37  
refclock PHC /dev/ptp1:nocrossts poll 3 pps
```



Tip

For more information on individual drivers' options, see [`man 8 chrony.conf`](#).

2.4 Activating offline time sources

Although `chronyd` starts up normally on a system that boots without a network connection, it cannot access the time servers specified in `/etc/chrony.conf`. To prevent `chronyd` from trying to query inaccessible time servers, use the `offline` option next to the time source directive, for example:

```
server ntp.example.org offline
```

`chronyd` then does not try to poll the server until it is enabled using the following command:

```
# chronyc online ntp.example.org
```



Tip

When the `auto_offline` option is set instead of the `offline` option, `chronyd` assumes that the time server has gone offline when two requests have been sent to it without receiving a response. This option avoids the need to run the `offline` command from `chronyc` when disconnecting the network link.

3 Managing `chronyd` at runtime

3.1 What is `chronyc`?

`chronyc` is the client part of the `chrony` NTP implementation. You can use the `chronyc` command to change the behavior of the `chronyd` service at runtime. It also generates status reports about the operation of `chronyd`.



Note: Temporary changes

Changes made using `chronyc` are not permanent. They are lost after the next `chronyd` restart. For permanent changes, modify `/etc/chrony.conf` as described in [Section 2, “Configuring NTP by adjusting `/etc/chrony.conf`”](#).

3.2 How does `chronyc` work?

You can run `chronyc` either in an interactive or non-interactive mode. To run `chronyc` interactively, enter `chronyc` on the command line and press `Enter`. It displays a prompt and waits for your command input. For example, to check how many NTP sources are online or offline, run the `activity` command:

```
# chronyc
chronyc> activity
```



```
200 OK
4 sources online
2 sources offline
1 sources doing burst (return to online)
1 sources doing burst (return to offline)
0 sources with unknown address
```

To exit `chronyc`'s prompt, enter `quit` or `exit`.

If you do not need to use the interactive prompt, enter the command directly, for example:

```
# chronyc activity
```

4 The `chronyd` `systemd` service

The main part of `chrony` is the `chronyd` `systemd` service that runs in the background and synchronizes system time with selected time servers. You can use the following `systemd` commands to operate the `chronyd` service:

`systemctl status chronyd.service`

Prints extended information about the current status of the `chronyd` service.

`systemctl is-enabled chronyd.service`

Checks whether the automatic start of the `chronyd` service at system boot is enabled.

`systemctl enabled chronyd.service`

Enables the automatic start of the `chronyd` service at system boot.

`systemctl disable chronyd.service`

Disables the automatic start of the `chronyd` service at system boot.

`systemctl is-active chronyd.service`

Checks whether the `chronyd` service was started and is running.

`systemctl start chronyd.service`

Starts the `chronyd` service.

`systemctl stop chronyd.service`

Stops the `chronyd` service.

`systemctl restart chronyd.service`

Restarts the `chronyd` service and reloads `/etc/chronyd.conf`.

5 Troubleshooting

In case of errors, check the following.

- Verify that your computer is connected to a network and that the network is configured correctly:

```
> sudo systemctl status network.service
● NetworkManager.service - Network Manager
   Loaded: loaded (/usr/lib/systemd/system/NetworkManager.service; enabled; vendor preset: disabled)
   Active: active (running) since Sat 2021-08-07 20:09:44 CEST; 4 days ago
   [...]

```

- Verify that the time servers that you entered as a time source exist and are reachable over the network. For example:

```
> ping pool.ntp.org
PING pool.ntp.org (85.199.214.101) 56(84) bytes of data.
64 bytes from 85.199.214.101 (85.199.214.101): icmp_seq=1 ttl=37 time=29.9 ms
[...]

```

- If the `firewalld` service is active on your computer, verify that the NTP service is allowed.
- Verify that the `chronyd` service is running:

```
> sudo systemctl status chronyd.service
● chronyd.service - NTP client/server
   Loaded: loaded (/usr/lib/systemd/system/chronyd.service; enabled; vendor preset: disabled)
   Active: active (running) since Sat 2021-08-07 20:09:44 CEST; 4 days ago
   [...]

```

- If the system time on a virtualized guest diverges from the exact time, make sure that the VM Host Server system time is synchronized with a valid time server and that the guest is synchronized with the same time source as the host.
- If the NTP service fails to start properly during system boot, it can be caused by network switches configured to use the Spanning Tree Protocol while ports are not configured as Edge Ports but Portfast. In this case, it can take up to a minute until the network connectivity is established.

- If the NTP service fails to start during system boot when the NetworkManager is used, edit the `/etc/sysconfig/network/config` file and change the value of `NM_ONLINE_TIMEOUT` value to 30. If the problem persists, increase the timeout value by 15 and try again.
- If NTP sources cannot be reached, identify them with the following command:

```
> chronyc sources -v
[...]
```

MS	Name/IP address	Stratum	Poll	Reach	LastRx	Last sample
^*	time.mydomain.com	3	10	377	81	-5354us[-8257us] +/- 191ms
^?	ntp1.example.com	0	10	0	-	+0ns[+0ns] +/- 0ns
^?	77.177.77.177	0	10	0	-	+0ns[+0ns] +/- 0ns
^?	ntp3.example.com	0	10	0	-	+0ns[+0ns] +/- 0ns
^?	ntp4.example.net	0	10	0	-	+0ns[+0ns] +/- 0ns
^?	2a02:3d8:1::1:1	0	6	0	-	+0ns[+0ns] +/- 0ns
^?	ntp2.example.org	0	10	0	-	+0ns[+0ns] +/- 0ns

In this case, the only server that is really serving time is `time.mydomain.com`. It is necessary to generally troubleshoot the network connection to the failing remote NTP time sources.


6 For more information

- Securing your computer with `firewalld` is described in <https://documentation.suse.com/sles/html/SLES-all/cha-security-firewall.html#sec-security-firewall-firewalld>.
- Commands for operating `systemd` services are listed in <https://susedoc.github.io/doc-modular/main/html/reference-systemctl-enable-disable-services/>.
- For a complete reference, see related manual pages:
 For a complete list of configuration directives, run `man 1 chrony.conf`.
 For a complete list of `chronyc` commands, run `man 1 chronyc`.
 For a complete list of `chronyd` command-line options, run `man 8 chronyd`.

7 Legal Notice

Copyright© 2006–2024 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. Secondly, 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.