
The Indic Fonts HOWTO

Maninder Bali

Conversion from HTML to DocBook v4.1.2 (XML): Dan Scott

Revision 0.1
Revision History
2002/01/07 mb
First rendition released by Maninder Bali.

Abstract

This is a detailed guide on how to install and use Indic scripts (devanagri etc.) using UTF-8 encoding under GNU/Linux. This HOWTO is a work in progress. More sections regarding fonts and other related things shall be added to this HOWTO in due course of time. Special thanks to Dan Scott for conversion from HTML to DocBook v4.1.2(XML). Any feedback, suggestions, pointers, gifts, cds, BMWs will be gladly accepted. All flames will be redirected to `/mnt/praises_for_thee/` for future reference. Be afraid.

Table of Contents

Introduction	2
Installing the IndiX system	3
Installing IndiX	3
Running Simpm	3
Devanagri Input and Output setup	4
Linux console	4
X Window System	4
Locale Setup	5
Files and the kernel	5
Locale environment variables	6
Applications with Devanagri	6
Browsers	6
Editors	7
Mailers	7
References and sites	8
Frequently Asked Questions (FAQ)	9
Acknowledgements and Copyright	10
A. GNU Free Documentation License	10
0. PREAMBLE	10
1. APPLICABILITY AND DEFINITIONS	11
2. VERBATIM COPYING	11
3. COPYING IN QUANTITY	12
4. MODIFICATIONS	12
5. COMBINING DOCUMENTS	14
6. COLLECTIONS OF DOCUMENTS	14
7. AGGREGATION WITH INDEPENDENT WORKS	14
8. TRANSLATION	14
9. TERMINATION	15
10. FUTURE REVISIONS OF THIS LICENSE	15
Addendum	15

Introduction

This HOWTO has been written to help you setup your Linux box to use UTF-8 encoding for using various Indic scripts. You will have to install the IndiX system developed by NCST, Mumbai on your machine in order for you to use various Indic scripts. I have tested the IndiX system on Exodus GNU/Linux, RedHat Linux, and Mandrake Linux. Anyone who has tested this system on a machine running Debian, please let me know and I will include that in this HOWTO. I want to thank Mr. Keyur Shroff from NCST, Mumbai for allowing me to modify and redistribute his Devanagiri-HOWTO.

Please note that Exodus GNU/Linux, developed by the good guys at Centurion Linux, India will ship with the IndiX system installed, thanks to the Transfer of Technology deal signed by NCST, Mumbai and Centurion Linux Pvt. Ltd.

Almost all of the leading GNU/Linux distributions available today have been localized in various international languages like French, German, Spanish, Chinese, Arabic, etc. This HOWTO aims at documenting the steps involved in enabling you to localize your GNU/Linux distribution to Indic scripts of your choice. To begin with, you must be aware of the complexity involved in localizing any of the Indian languages. Any Indian language text input differs from that of English. Perhaps the most significant difference is that in English, each keystroke maps directly onto a letter where each letter has a unique code. On the other hand, a 'syllable' - the Indian language equivalent unit of writing letter is composed of one or more characters entered through the keyboard.

The syllable is composed of vowels, consonants, modifiers and other special graphics signs. These are encoded, just as roman letters are. The user types in a sequence of vowels, consonants, modifiers and the graphics signs. The machine then composes these syllables at run time based on language dependent rules. Every syllable is thus represented in the machine as a unique sequence of vowels, consonants and modifiers. In a text sequence, these characters are stored in logical (phonetic) order.

Indic characters can combine or change shape depending on their context. A character's appearance is affected by its ordering with respect to other characters, the font used to render the character, and the application or system environment. These variables can cause the appearance of Devanagari characters to be different from their nominal glyphs (used in the code charts). Additionally, characters cause a change in the order of the displayed glyphs. This reordering is not commonly seen in non-Indic scripts and occurs independent of any bi-directional character reordering that might be required.

Each syllable has a unique visual representation. However, there are too many syllables to design glyphs for each one individually. So a font normally contains certain component glyphs from which a syllable is composed at run time. The onscreen representation of a syllable is then a composition of glyphs from the Indian language font. There is no direct mapping of glyph codes to the consonant, vowel or modifier codes. However, for every syllable (a sequence of consonants, vowels and modifiers) there is a corresponding sequence of glyphs. This constitutes a many-to-many mapping from keystrokes to glyphs as opposed to a simplistic one-to-one mapping in roman scripts.

Please read the Unicode-HOWTO [<http://www.linuxdoc.org/HOWTO/Unicode-HOWTO.html>] and visit <http://www.unicode.org/> for more information on the UTF-8 encoding.

The IndiX system developed by NCST, Mumbai enables most applications in X Windows (irrespective of the toolkit used), to render Indic characters according to the unicode standard specification. IndiX provides support for OpenType fonts and Unicode encoding at X Windows level. This enables most of the existing applications to handle Indic scripts without any modification or recompilation.

Once you have installed the IndiX system, following all the steps mentioned in this HOWTO, you will be able to fly across seven seas and slap that annoying sailor who keeps goin' hic' hic'... Okay, on a more serious note, you will be able to enjoy your Linux experience in Devanagari and other Indic scripts of your choice.

Installing the IndiX system

You can obtain the IndiX system from NCST, Mumbai site <http://rohini.ncst.ernet.in/indix/>. The system is available in its source as well as binary form. This HOWTO covers the installation of the IndiX system using the binary files available for download. At a later stage, I plan to cover the source installation of IndiX on your box, too. You need to download the following files in order to install IndiX successfully onto your machine:

```
gtk.tar.gz
indix.tar.gz
```

Installing IndiX

NCST has written Simpm (Simple Package Manager) that takes care of the entire installation process on your system. Simpm carries out the following steps for a binary distribution of the IndiX system:

1. It reads the names of the files within the distribution by essentially running the command **tar -tzpPf package.tgz > .package.list**
2. It saves all these files and the file containing the list using the command **tar -czpPf .old.package.tgz .package.list `cat .package.list`**
3. Simpm then extracts the files from the package and installs them using **tar -xzpPf package.tgz**

Should you wish to go back to the old system state for any reason, you can easily do so using **tar -xzpPf .old.package.tgz**

Running Simpm

simplm with no arguments/parameters will display its usage.

```
# simplm -i package.tgz [-d savdir/]
```

does all the above steps, 1 through 3. The 'i' flag indicates install. Successful installation will create savdir/.old.package.tgz. If it finds an existing .old.package.tgz, simplm will not proceed as it means that the IndiX system has already been installed earlier. However, you can force an IndiX install by renaming it to a newpackage. Alternatively, you can uninstall the package and install it again.

```
# simplm -u package.tgz [-d savdir/]
```

uninstalls the package. Note, however, that this command will work only if it finds a readable .old.package.tgz. Having uninstalled the package, simplm will restore the original files that were overwritten by the package. The .old.package.tgz will be deleted after the uninstallation so that all instances of the previous installation are removed. Simpm maintains a log of all installs and uninstalls in the savdir/simplm.log file.

To install the IndiX system, all you have to do is (pray and do your favourite tribal dance) type in the following commands:

```
# simplm -i /path/to/gtk.tar.gz
# simplm -i /path/to/indix.tar.gz
```

and all the necessary files will be backed up, and the IndiX system installed on your machine. Hurrah.

Congratulations, o' most precious one, on having installed IndiX system on your machine. The remainder of this HOWTO will focus on setting up your Linux environment to support Indic fonts and scripts in X.

Devanagari Input and Output setup

Linux console

Devanagari characters do not display properly in a Linux console. However, NCST has developed ncst-term (a terminal emulator program in X Window System) which has support for converting keystrokes to UTF-8 before sending them to the application running in the ncst-term, and for displaying Unicode characters that the application outputs as UTF-8 byte sequence.

X Window System

You need to make some changes in your XF86Config-4 file (usually resides in /etc/X11/ directory). A sample config file XF86Config-4.indix is installed along with IndiX system. This file can be found in /etc/X11/ directory.

Devanagari Font

OpenType is the most suitable font format to render any Indic script properly. The IndiX system ships with one OpenType font called "raghu" for Hindi. Anyone can use and distribute this font free-of-cost. You can find this font in /usr/X11R6/lib/X11/fonts/TrueType/ directory.

Installing the Indic Fonts:

In order to install the Indic fonts, you must log in as root. The X Font Server (xfs) is known to have some problems with the IndiX system, so remove it from the FontPath of the X Server. This can be achieved by modifying your XF86Config-4 file (usually in /etc/X11/) and commenting the line in the Files section and adding /usr/X11R6/lib/X11/fonts/TrueType/ to the current FontPath.

After that, the FontPath should look something similar to this:

```
FontPath    "unix/:7100"
FontPath    "/usr/X11R6/lib/X11/fonts/misc"
FontPath    "/usr/X11R6/lib/X11/fonts/100dpi"
FontPath    "/usr/X11R6/lib/X11/fonts/75dpi"
FontPath    "/usr/X11R6/lib/X11/fonts/TrueType"
FontPath    "/usr/X11R6/lib/X11/fonts/Type1"
```

Next, in order to make use of the OpenType font you have, load the "freetype" module at startup. You can achieve this by adding the following line in the Module section of XF86Config-4 file.

```
Load "freetype"
```

Make sure you specify the modules search path in the Files section, too.

```
ModulePath  "/usr/X11R6/lib/modules/fonts"
ModulePath  "/usr/X11R6/lib/modules/drivers"
ModulePath  "/usr/X11R6/lib/modules"
ModulePath  "/usr/X11R6/lib"
ModulePath  "/usr/lib"
```

Any new Indic fonts you want to install should be placed in the /usr/X11R6/lib/X11/fonts/TrueType/ directory. Now, change to this directory and run the following commands:

```
$ mkfontdir
$ xset fp rehash
```

In case you want to place your new Indic fonts in some other directory, you must use **xset** to add the new FontPath. Please see the **xset** man-page for further assistance. You can check the new installed fonts by running the **xlsfonts** command. In case you don't see any Indic fonts using this command, you may need to restart X.

Devanagari Keyboard Layout

The IndiX system comes with a keyboard map file for xmodmap. You can use the utility **xmodmap** to map a Devanagari keyboard. For most distributions, when you start X, the X-Server will look for a Xmodmap in `/etc/X11/` directory. If that file does not exist, the server will look for a `.Xmodmap` in your \$HOME. Just putting the `.Xmodmap` in your \$HOME will be okay. When you start the X server, it will load this file. You can also load `.Xmodmap` from the command line:

```
$ xmodmap ~/.Xmodmap
```

Note

If you are using XFree86 version 4.0 or later, you need to add the line `XkbDisable` in `InputDevice` section of `XF86Config-4` file. You may config the keyboard section like the following sample.

```
Section "InputDevice"
Identifier "Keyboard0"
Driver      "keyboard"
Option      "XkbDisable"
EndSection
```

Locale Setup

Files and the kernel

You can now use any Unicode characters in file names. No kernel or file utilities need modifications. This is because file names in the kernel can be anything not containing a null byte, and `'/'` is used to delimit subdirectories. When encoded using UTF-8, non-ASCII characters will never be encoded using null bytes or slashes. All that happens is that file and directory names occupy more bytes than they contain characters. For example, a filename consisting of five greek characters will appear to the kernel as a 10-byte filename. The kernel does not know (and does not need to know) that these bytes are displayed as greek.

This is the general theory, so long as your files reside on Linux. On filesystems which are used from other operating systems, you have mount options to control conversion of filenames to or from UTF-8:

- The "vfat" filesystems has a mount option "utf8". See file `/usr/src/linux/Documentation/filesystems/vfat.txt`. When you give an "iocharset" mount option different from the default (which is "iso8859-1"), the results with and without "utf8" are not consistent. Therefore, it is not I recommend to use the "iocharset" mount option.
- The "msdos", "umsdos" filesystems have the same mount option, but appear to have no effect.
- The "iso9660" filesystem has a mount option "utf8". See file `/usr/src/linux/Documentation/filesystems/isofs.txt`.

- Since Linux 2.2.x kernels, the "ntfs" filesystem has a mount option "utf8". See file /usr/src/linux/Documentation/filesystems/ntfs.txt.

The other filesystems (nfs, smbfs, ncpfs, hpfs, etc.) don't convert filenames; therefore they support Unicode file names in UTF-8 encoding only if the other operating system supports them. Please note that to enable a mount option for all future remounts, you add it to the fourth column of the corresponding `/etc/fstab` line.

Locale environment variables

You should have the following environment variables set, containing locale names:

LANGUAGE	override for LC_MESSAGES
LC_ALL	override for all other LC_* variables
LC_CTYPE, LC_MESSAGES, LC_COLLATE, LC_NUMERIC, LC_MONETARY, LC_TIME	individual variables for: character types and encoding, natural language messages, sorting rules, number formatting, money amount formatting, date and time display.
LANG	default value for all LC_* variables. (See <code>`man 7 locale'</code> for a detailed description.)

In order to tell your system and all applications that you are using UTF-8, you need to add a codeset suffix of UTF-8 to your locale names. For example, if you want to run an application in UTF-8 Hindi locale then with bash shell, you can specify which environment variable to be passed to the application.

```
$ LANG=hi_IN.UTF-8 xman
```

In order to set locale the Hindi locale globally for a particular user, you can append the following line in `~/ .bashrc` file.

```
export LANG=hi_IN.UTF-8
```

After that you need not to set the LANG environment variable each time you run a specific application.

Applications with Devanagri

Browsers

Netscape Navigator

Netscape 6.01 or later can display HTML documents in UTF-8 encoding. All a document needs is the following line between the `<head>` and `</head>` tags:

```
<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">
```

To setup Netscape so that it displays Hindi characters:

```
Goto, Edit -> Preferences
Select category, Appearance -> Fonts
Select Language encoding "Unicode"
Set Variable-width and Fixed-width fonts to "raghu"
Check button "Always use my font settings, overriding web page font"
```

Also, ensure that the character coding scheme is set to UTF-8

Goto, View -> Character Coding
Select "Unicode (UTF-8)" from the list

Konqueror

Konqueror has good support for Unicode. To setup konqueror so that it displays Hindi characters:

Goto, Settings -> Configure Konqueror
Select "Konqueror Browser" from the left pan
Goto "Appearance" tab on the right pan
Select charset "iso106460-1"
Set all fonts to "raghu" for this encoding and also set Default encoding to "utf8"

Editors

yudit

yudit by Gáspár Sinai (<http://czyborra.com/yudit/>) is an excellent unicode text editor for the X Window System. It supports simultaneous processing of many languages, input methods, conversions for local character standards etc. It has facilities for entering text in all languages with only an English keyboard, using keyboard configuration maps. Customization is very easy. Typically you will first want to customize your font. From the font menu, choose "Unicode". Next, you should customize your input method. The input methods "Straight", "Unicode" and "SGML" are most remarkable. For details about the other built-in input methods, look in `/usr/local/share/yudit/data/`. To make a change the default for the next session, edit your `$HOME/.yuditrc` file. The general editor functionality is limited to editing, cut and paste and search and replace. There is no provision for an undo. **yudit** can display text using a TrueType font. But it doesn't seem to support combining characters.

Vim

Vim (as of version 6.0) has good support for UTF-8. When started in an UTF-8 locale, it assumes UTF-8 encoding for the console and the text files being edited. It supports double-wide (CJK) characters as well and combining characters and therefore fits perfectly into UTF-8 enabled ncst-term.

gedit

gedit is an editor developed using GtkText widget. gedit-0.9.0 does not support FontSet. This means that you can't edit both English and Hindi text simultaneously. But if you choose a proper font then you will be able to use any one language at a time.

xedit

With XFree86-4.0.1, **xedit** is capable of editing UTF-8 files if your locale is set appropriately. Add the line

```
"Xedit*international: true"
```

to your `$HOME/.Xdefaults` file.

Mailers

Mail clients released after January 1, 1999, should be capable of sending and displaying UTF-8 encoded mails, otherwise they are considered deficient. But these mails have to carry the MIME labels:

```
Content-Type: text/plain; charset=UTF-8
Content-Transfer-Encoding: 8bit
```

Simply piping an UTF-8 file into "mail" without caring about the MIME labels will not work. Mail client implementors should take a look at <http://www.imc.org/imc-intl/> and <http://www.imc.org/mail-i18n.html>.

Now about some of the individual mail clients (or "mail user agents"):

kmail

kmail (as of KDE 1.0) does not support UTF-8 mails at all.

Netscape Mail

Netscape Mail can send and display mails in UTF-8 encoding, but it needs a little bit of manual user intervention. To send an UTF-8 encoded mail:

1. After opening the "Mail" window, but before starting to compose the message, select from the menu "View -> Character Coding -> Unicode (UTF-8)".
2. Then compose the message and send it.

When you receive an UTF-8 encoded mail, Netscape does not display it in UTF-8 right away, and does not even give a visual clue that the mail was encoded in UTF-8. You have to manually select from the menu View -> Character Coding -> Unicode (UTF-8).

For displaying UTF-8 mails, Netscape uses different fonts. You can adjust your font settings in the Edit -> Preferences -> Fonts dialog by selecting the "Unicode" font category.

exmh

exmh 2.1.2 with Tk 8.4a1 can recognize and correctly display UTF-8 mails if you add the following lines to your `$HOME/.Xdefaults` file.

```
!
! Exmh
!
exmh.mimeUCharsets: utf-8
exmh.mime_utf-8_registry: iso10646
exmh.mime_utf-8_encoding: 1
exmh.mime_utf-8_plain_families: fixed
exmh.mime_utf-8_fixed_families: fixed
exmh.mime_utf-8_proportional_families: fixed
exmh.mime_utf-8_title_families: fixed
```

References and sites

IndiX links

- IndiX Homepage [<http://rohini.ncst.ernet.in/indix/>]
- IndiX Download [<http://rohini.ncst.ernet.in/indix/download/>]

Centurion Linux and Exodus GNU/Linux

The good guys at Centurion Linux have finished work on Exodus GNU/Linux™, a 100% Free Software distribution featuring full

Hindi language support for GNOME and KDE. The much awaited Exodus GNU/Linux™ (code named BitterCoffee) is expected to be released in the Indian market shortly.

- Centurion Linux Homepage [<http://centurionlinux.com/>]
- The Official GNOME i18n Team - India (hindi) [<http://cl-india.sourceforge.net/>]
- The official Unicode website [<http://www.unicode.org>]
- UTF-8 and Unicode FAQ [<http://www.cl.cam.ac.uk/~mgk25/unicode.html>]

Unicode

Frequently Asked Questions (FAQ)

1. I can't start the X windows system. It gives an error "Could not open default Indic font 'xyz'".

Please make sure that the font 'xyz' is correctly installed and is in the current FontPath. The Indic fonts usually reside in the `/usr/X11R6/lib/X11/fonts/TrueType/` directory. Your FontPath is defined in the `/etc/X11/XFree86Config-4` file. To learn more about howto specify your FontPath, read the section on X Window System (3.2) in this HOWTO.

2. Can I use any other font as the default system font instead of the raghu font shipped with the IndiX system?

You can load an Indic script font by giving command line server option while starting X Window System. e.g.

```
$ startx -- -devanagari "my_devanagari_font"
```

or

```
$ startx -- -tamil "my_tamil_font"
```

Here, "my_devanagari_font" and "my_tamil_font" should be replaced by the font name that you want to load. You can either specify alias name or full XLFD name for the font. However alias name must be there in `fonts.alias` file and XLFD name in `fonts.dir` file.

3. I have installed IndiX system but it doesn't show Hindi characters. Why?

This could possibly be due to the fact that your Hindi locale has not been setup correctly. To change/set the locale you should set LANG environment variable. Append the line

```
export LANG=hi_IN.UTF-8
```

in your `~/.bashrc` and `~/.bash_profile` files. Restart your terminal emulator program and run the application. After this the application should display Hindi characters.

4. Why are some of the pixels in Hindi characters distorted?

This is probably because the X Font Server (xfs) is running and is still in the current FontPath. You can either shutdown the X Font Server or remove it from the current FontPath. To shutdown xfs issue the following command after becoming root:

```
# /etc/rc.d/init.d/xfs stop
```

To remove xfs from the current FontPath, read the section the section called “X Window System” in this HOWTO.

5. All Hindi characters are displayed, but why are they not rendered properly?

IndiX system uses an OpenType font to render Indic script characters, as it is the most suitable font format for Indic scripts. If you use some other kind of font, for example a TrueType font or a Bitmap font, then the font does not have enough information that is required to render Indic script text properly. So it is recommended to use only OpenType fonts for Indic scripts. Also, in case you are already using an OpenType font, please update your glibc.

6. Why can't I download ISO images of Exodus GNU/Linux™, yet?

The good guys at Centurion Linux are looking for sponsors who can take care of their hosting needs. If you are interested in helping Centurion Linux out, please contact me on <bali@centurionlinux.com>.

Acknowledgements and Copyright

Parts of this HOWTO have been taken from The Unicode HOWTO [<http://www.linuxdoc.org/HOWTO/Unicode-HOWTO.html>] by Bruno Haible and The Devanagri HOWTO by Keyur Shroff.

I would also like to take this opportunity to thank my papa, mummy and my brothers Manvinder and Kulvinder for their unconditional love and support, without whom I could never have achieved anything in life. Forever, I love you. Loshaca :)

To Girija, my girlfriend: :) Thanks for everything.

I am very grateful to Keyur Shroff for allowing me to modify and redistribute his Devanagri HOWTO. Special thanks go out to him for his guidance, help, and support.

Thanks to Rohan D'Sa and Manvinder Bali of Centurion Linux for having helped me with various UTF-8 and Indic scripts issues. Also, thanks for representing Centurion Linux at the Business Technology meet organised by Ministry of Information Technology, New Delhi.

Once again, special thanks to Dan Scott for converting the HOWTO to DocBook XML format. Thanks Dan :)

This HOWTO is copyrighted # 2001-2002 by Maninder Bali, <bali@centurionlinux.com> and is distributed under the terms of the GNU Free Documentation License (GFDL) stated below.

A. GNU Free Documentation License

0. PREAMBLE

The purpose of this License is to make a manual, textbook, or other written 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 noncommercially. 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 in order 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 that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. The “Document”, below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as “you”.

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 [11] 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. (For example, 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 [11] whose titles are designated, as being those of Invariant Sections, in the notice that says that the Document [11] is released under this License.

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 [11] is released under this License.

A “Transparent” copy of the Document [11] means a machine-readable copy, represented in a format whose specification is available to the general public, whose contents can be viewed and edited directly and 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 has been designed to thwart or discourage subsequent modification by readers is not Transparent. 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 designed for human modification. Opaque formats include PostScript, PDF, 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 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.

2. VERBATIM COPYING

You may copy and distribute the Document [11] in any medium, either commercially or noncommercially, 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 of the Document [11] numbering more than 100, and the Document's license notice requires Cover Texts [11], 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 [11] 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 [11] copies of the Document [11] numbering more than 100, you must either include a machine-readable Transparent [11] copy along with each Opaque copy, or state in or with each Opaque copy a publicly-accessible computer-network location containing a complete Transparent copy of the Document, free of added material, which the general network-using public has access to download anonymously at no charge using public-standard network protocols. 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 [11] 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 [11] of the Document [11] 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 [11] (and on the covers, if any) a title distinct from that of the Document [11], 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 [11], as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version [11], together with at least five of the principal authors of the Document [11] (all of its principal authors, if it has less than five).
- **C.** State on the Title Page [11] the name of the publisher of the Modified Version [11], as the publisher.
- **D.** Preserve all the copyright notices of the Document [11].

- **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 [11] 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 [11] and required Cover Texts [11] given in the Document's [11] license notice.
- **H.** Include an unaltered copy of this License.
- **I.** Preserve the section entitled “History”, and its title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version [11] as given on the Title Page [11]. If there is no section entitled “History” in the Document [11], 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 [11] for public access to a Transparent [11] 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.** In any section entitled “Acknowledgements” or “Dedications”, preserve the section's title, 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 [11] of the Document [11], 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 [11].
- **N.** Do not retitle any existing section as “Endorsements” or to conflict in title with any Invariant Section [11].

If the Modified Version [11] includes new front-matter sections or appendices that qualify as Secondary Sections [11] 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 [11] 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 [11] 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 [11], and a passage of up to 25 words as a Back-Cover Text [11], to the end of the list of Cover Texts [11] in the Modified Version [11]. 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 [11] 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 [11] do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version [11].

5. COMBINING DOCUMENTS

You may combine the Document [11] 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 [11] of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice.

The combined work need only contain one copy of this License, and multiple identical Invariant Sections [11] 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 [11] 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 [11] or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, does not as a whole count as a Modified Version [11] of the Document, provided no compilation copyright is claimed for the compilation. Such a compilation is called an “aggregate”, and this License does not apply to the other self-contained works thus compiled with the Document, on account of their being thus compiled, if they are not themselves derivative works of the Document. If the Cover Text [11] requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one quarter of the entire aggregate, the Document's Cover Texts may be placed on covers that surround only the Document within the aggregate. Otherwise they must appear on covers around the whole aggregate.

8. TRANSLATION

Translation is considered a kind of modification, so you may distribute translations of the Document [11] under the terms of section 4. Replacing Invariant Sections [11] 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 provided that you also include the original English version of this License. In case of a disagreement between the translation and the original English version of this License, the original English version will prevail.

9. TERMINATION

You may not copy, modify, sublicense, or distribute the Document [11] 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 [<http://www.gnu.org/fsf/fsf.html>] 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 <http://www.gnu.org/copyleft/> [<http://www.gnu.org/copyleft/>].

Each version of the License is given a distinguishing version number. If the Document [11] 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

To use this License in a document you have written, include a copy of the License in the document and put the following copyright and license notices just after the title page:

Copyright # YEAR YOUR NAME.

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.1 or any later version published by the Free Software Foundation; with the Invariant Sections [11] being LIST THEIR TITLES, with the Front-Cover Texts [11] being LIST, and with the Back-Cover Texts [11] being LIST. A copy of the license is included in the section entitled “GNU Free Documentation License”.

If you have no Invariant Sections [11], write “with no Invariant Sections” instead of saying which ones are invariant. If you have no Front-Cover Texts [11], write “no Front-Cover Texts” instead of “Front-Cover Texts being LIST”; likewise for Back-Cover Texts [11].

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 [<http://www.gnu.org/copyleft/gpl.html>], to permit their use in free software.