

# **Disseny i desenvolupament d'una eina de monitorització remota per a Sistemes VoIP basats en FreePBX**

---

## **Instruccions de Instal·lació**

---

**Raül Martínez Díaz**

Màster Universitari en Programari Lliure  
rmartinezdi@uoc.edu

*Equip Docent UOC:*

*Santi Caballé Llobet*  
*Professor*

*Gregorio Robles Martínez*  
*Professor col·laborador*

El present projecte es realitza amb el suport i col·laboració de  
**Infordisa S.A**



Passeig de l'estació 13-15  
43800 Valls (Tarragona)

T. 977 612 073  
M. 694 429 933  
E. [info@infordisa.com](mailto:info@infordisa.com)

Equip Col·laborador Infordisa S.A:

*Robert Ferrando Bergadà*

*Gerent d' Infordisa SA*  
*[rferrando@infordisa.com](mailto:rferrando@infordisa.com)*

*José Suárez Laporta*

*Tècnic VoIP / Elastix Certified Engineer*  
*[jsuarez@infordisa.com](mailto:jsuarez@infordisa.com)*

Copyright (c) Raúl Martínez Díaz.

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.3 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".

## 1 Introducció

Al present document és descriuen els passos necessaris per a la implementació d'un entorn de probes amb la solució *bnode-suite*. Aquesta solució és el resultat de les pràctiques realitzades en l'àmbit del *Treball Final de Màster – Desenvolupament d'Aplicacions*

La solució *bnode-suite* la integren dos components:

- El component servidor *bnode-core*, desenvolupat amb una arquitectura *NodeJS + MongoDB*. La funcionalitat d'aquest component és centralitzar la gestió de totes les tasques de monitorització dels nodes client, permetent assignar i configurar els serveis a monitoritzar per cada node, així com recopilar els resultats de cada una de tasques de monitorització i dipositar-los en una base de dades pel seu anàlisi. El component servidor s'integra d'una API REST desenvolupada en *NodeJS + MongoDB*, així com una consola d'administració desenvolupada en *AngularJS*. Aquesta consola d'administració interacciona amb la API per configurar els serveis, assignar nodes i llistar els registres de monitorització.
- Components client *bnode* i *bnode-conf* desenvolupats en *Ansi C*. Són els components que s'executen al nodes. La utilitat *bnode-conf* s'encarrega de la configuració i registre de cada node al servidor, mentre que la aplicació *bnode*, dissenyada per executar-se com a servei, s'encarrega de descarregar del servidor la configuració dels serveis a monitoritzar, així com crear i executar les tasques de monitorització i enviar-ne els resultats al servidor.

## 2 Instruccions de Instal·lació

### 2.1 Instal·lació del component Servidor *bnode-core*

El component servidor *bnode-core* ha estat desenvolupat per a una arquitectura integrada per un entorn d'execució Node.js i un gestor de base de dades MongoDB. Aquesta arquitectura pot desplegar-se tant en servidors Windows com a la majoria de distribucions Linux existents. En aquest manual es documenta el procés de instal·lació d'un entorn d'execució de proves per a la distribució Ubuntu Server 16.04

#### Preparació de l'entorn d'execució

Per a la configuració de l'entorn d'execució cal disposar d'una instància de Ubuntu Server 16.04 i d'un usuari amb els corresponents permisos d'accés i administració del sistema. També cal disposar de connexió a internet per realitzar la instal·lació de les darreres versions de [NodeJS](#) i [MongoDB](#) des dels repositoris de la distribució.

Instal·lem *NodeJS* des dels repositoris de la distribució:

```
# sudo apt-get update
# sudo apt-get install nodejs
```

Instal·lem el paquet *npm* per a la gestió dels mòduls de Node.js:

```
# sudo apt-get install npm
```

Verifiquem el dos components abans de continuar amb la instal·lació del gestor de bases de dades:

```
# nodejs -v
# npm version
```

Instal·lem el gestor de bases de dades de *MongoDB*:

```
# sudo apt-get install mongodb
```

## Instal·lació i configuració bnode-core

Per a la instal·lació de l'aplicació ens cal crear la carpeta on ubicarem els fitxers de l'aplicació i assignar-li els permisos corresponents:

```
# cd /opt/  
# mkdir node-core  
# chown username node-core
```

Descarreguem i copiem els fitxers de l'aplicació servidor a la carpeta creada:

```
# unzip bnode-core.zip -d /opt/node-core
```

Accedim a la carpeta de l'aplicació i executem *npm* per instal·lar tots els mòduls de *Node.JS* necessaris.

```
# cd node-core  
# npm install
```

Finalment, cal configurar la base de dades de *MongoDB*. Per fer-ho utilitzarem el Shell de *Mongoddb*:

```
# mongo  
> use myproject          /* Indiquem el nom de la base de dades */  
> db.users.insertOne( /* Afegim l'usuari administrador */  
  {  
    "local" : {  
      "password" : "$2a$08$6k1FxuY1Pm0VubG1yu6U1O.A79A3cGAMGHIFcZzbb  
                  ZcePY1xBnlCK",  
      "email" : "admin@bnode.local"  
    },  
    "nickname" : "admin@bnode.local"  
  }  
)
```

Cal considerar que el password de l'usuari s'emmagatzema a la base de dades encriptat amb bcrypt, de manera que la cadena:

```
$2a$08$6k1FxuYIPm0VubG1yu6U1O.A79A3cGAMGHIFcZzbbZcePYlxBnICK
```

És equivalent al password `12345678`

```
Usuari: admin@bnode.local  
Password: 12345678
```

Un cop instal·lat i configurat l'entorn d'execució de l'aplicació servidor només resta executar la aplicació i verificar-ne l'accés:

```
# cd /opt/bnode-core  
# node bnode-core
```

## Més enllà de la instal·lació bàsica

Als apartats anteriors s'ha descrit el procés d'instal·lació i configuració bàsica de l'aplicació servidor `bnode-core` en un entorn de proves. Queden fora de l'abast d'aquest document altres aspectes avançats de la configuració, com ara l'execució de l'aplicació com a servei mitjançant `Systemd`, la modificació del port de publicació de l'aplicació (per defecte el port 443) o la utilització d'un certificat diferent al certificat auto signat que s'adjunta al codi del projecte.

## Documentació Addicional

Nodejs – *Descarga i instal·lació de Nodejs*

<https://nodejs.org/es/download/>

DigitalOcean – *How to Install NodeJs on Ubuntu 16.04*

<https://www.digitalocean.com/community/tutorials/how-to-install-node-js-on-ubuntu-16-04>

MongoDB - *Install MongoDB*

<https://docs.mongodb.com/manual/installation/>

MongoDB – *Mongo Shell*

<https://docs.mongodb.com/getting-started/shell/client/>

## 2.2 Instal·lació dels components Client: *bnode* i *bnode-conf*

El component client està integrat per dos utilitats desenvolupades en Ansi C, d'una banda la utilitat *bnode-conf* permet configurar i registrar el node al servidor, i d'altra banda, la aplicació *bnode* que s'executa com a servei (*daemon*) i realitza les tasques de monitorització al client.

Per a cada una d'elles s'adjunta una carpeta amb el codi font de l'aplicació. A cada una de les carpetes s'adjunten els *makefile* necessaris per compilar les aplicacions i realitzar-ne la instal·lació. En aquest apartat es descriu breument aquest procés:

### Compilació dels components client

Per a la configuració de l'entorn d'execució cal disposar d'una distribució GNU LINUX i d'un usuari amb els corrents permisos d'accés i administració del sistema.

Abans de poder compilar les aplicacions client ens cal disposar al sistema de les eines de compilació corresponents:

```
# apt-get update && apt-get install build-essential
```

També cal que disposem al sistema de les llibreries i eines de desenvolupament de la llibreria *libcurl* amb suport per SSL

```
# apt-get Update && apt-get install libcurl4-openssl-dev
```

Un cop instal·lades les eines necessàries, podem compilar cada una de les aplicacions client mitjançant el *makefile* que acompanya el codi font:

```
# make
```



Finalment cal fer un *make install* per instal·lar l'aplicació al nostre sistema. La instal·lació consisteix en un procés força senzill, cada un dels binaris es còpia a la carpeta */usr/share/bnode-code* i es creu un enllaç per a cada un d'ells al directori */usr/sbin* de manera que els binaris puguin executar-se des de qualsevol ubicació.

```
# sudo make install
```

## Plugins de monitorització

Amb el codi font de l'aplicació no s'adjunta cap pugin de monitorització. No obstant, el client ha estat dissenyat per ser compatible amb la majoria de plugins existents per la plataforma *Nagios Core* i similars. Podem instal·lar el conjunt de plugins oficials de *Nagios* mitjançant la comanda:

```
# sudo apt-get install nagios-plugins
```

## Configuració i execució de l'aplicació client

Un cop instal·lats els components clients cal configurar i registrar el node al servidor. Per fer-ho, cal que primer verifiquem que el component servidor s'està executant correctament i és accessible des de l'equip client. Un cop fet aquesta comprovació inicial, executem l'eina *bnode-conf* i seguim les passes indicades per configurar i registrar al servidor el nou node.

```
bnode 0.0.3b LINUX
Copyright (c) 2016-2017 Raul Martinez Diaz
Last Modified: 31 December, 2016
License: GPL

bnode - Configuration Assistant:
-----

Hostname: development-dektop
System version: Linux

# Insert short description: █
```

La utilitat sol·licita l'adreça IP o FQDN del servidor al qual s'ha de connectar el client, així com un usuari i contrasenya amb permisos d'accés. Amb aquestes dades la utilitat *bnode-conf* realitza una petició de registre al servidor obtenint el *token* d'autorització necessari per identificar el node al servidor. L'usuari i la contrasenya no es guarden enlloc, per contra es genera un fitxer *bnode.conf* al directori de l'aplicació. Aquest fitxer conté l'adreça del servidor i el *token* del node.

Si executem *bnode-conf* en un node ja registrat, mostrarà informació sobre l'estat del node i el servidor al qual està vinculat. Si volem tornar a registrar de nou el node, cal executar *bnode-conf -r*, o bé eliminar el fitxer de configuració *bnode.conf* per forçar un nou registre.

Un cop registrat el node al servidor podem executar l'aplicació *bnode* que llegirà el fitxer de configuració i contactarà amb el component servidor per descarregar la configuració dels serveis que ha de monitoritzar i crearà les corresponents tasques.

## Documentació Addicional

Libcurl - Using libcurl

<https://curl.haxx.se/libcurl/using/>

Nagios Core – Nagios Plugins

<https://www.nagios.org/downloads/nagios-plugins/>

<https://exchange.nagios.org/directory/Plugins>

## 3 Captures de l'aplicació

### 3.1 Captures del component client

A la següent figura es pot observar el resultat d'executar la utilitat de configuració **bnode-install**. En un node que ja es troba registrat al servidor la utilitat ens mostra informació genèrica del node, així com informació detallada sobre l'adreça del servidor i el seu estat.

```
bnode 0.0.2b LINUX
Copyright (c) 2016-2017 Raul Martinez Diaz
Last Modified: 4 December, 2016
License: GPL

-----
bnode [ Id 584adec41ea9fa40250045f0 ]
-----

Host Name: development-dektop
System:    Linux
Version:   #66-Ubuntu SMP Wed Oct 19 14:12:37 UTC 2016

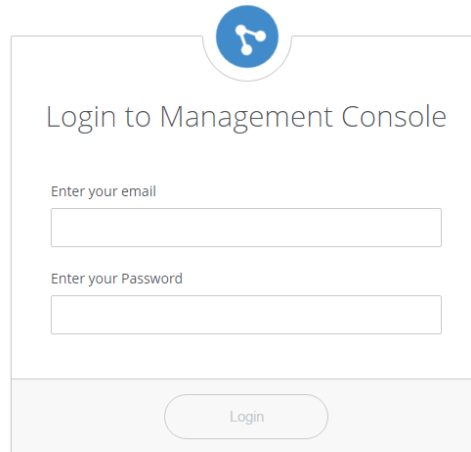
Server Address: https://192.168.1.240:8443
Server Status: { ONLINE }
Node status:   { registered }
```

A la figura següent es pode apreciar com la API del servidor rep els batecs o *heartbeats* d'un node. També podem observar la capçalera de les peticions, amb el corresponent registre **x-auth-token** que conté el token del node:

```
11 Dec 17:07:02 - Beluganode Core {beluga_core alpha.12.16} is working on port: 8443
{ host: '192.168.1.240:8443',
  accept: 'application/json',
  'content-type': 'application/json',
  'x-auth-token': 'fa8426a0-8eaf-4d22-8e13-7c1b16a9370c',
  'content-length': '164' }
POST /api/heartbeat 200 537.073 ms - 223
GET /api/nodes 200 17.705 ms - 1327
{ host: '192.168.1.240:8443',
  accept: 'application/json',
  'content-type': 'application/json',
  'x-auth-token': 'fa8426a0-8eaf-4d22-8e13-7c1b16a9370c',
  'content-length': '164' }
POST /api/heartbeat 200 10.481 ms - 223
```

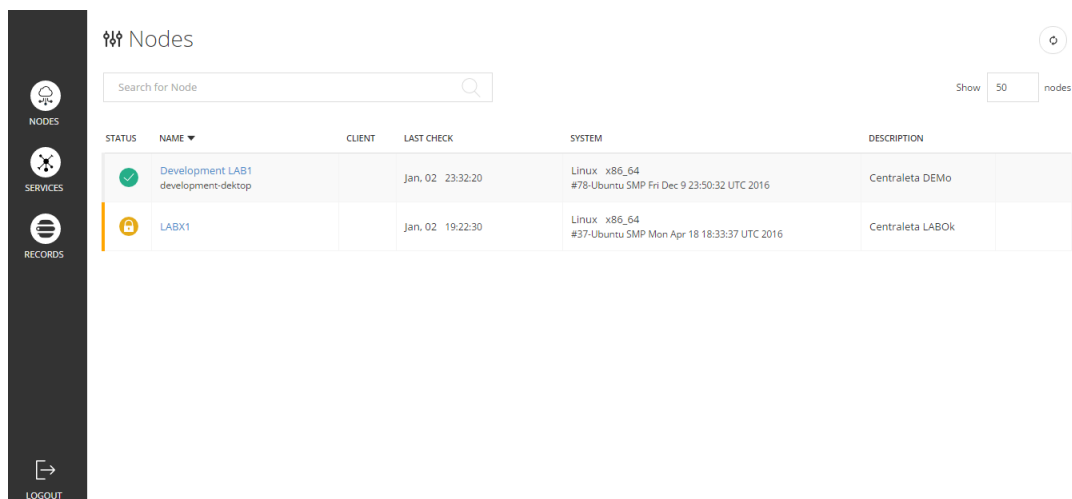
## 3.2 Captures del component Servidor

A la figura següent es pot apreciar el formulari d'identificació d'usuaris implementat a la Consola d'Administració Web. Per tal d'accedir a l'aplicació client l'usuari s'ha d'identificar mitjançant el seu *email* i contrasenya, obtenint un *token* d'identificació que li permetrà accedir a l'aplicació.



The image shows a login form titled "Login to Management Console". At the top center is a blue circular icon with a white network symbol. Below the title, there are two input fields: "Enter your email" and "Enter your Password". At the bottom of the form is a "Login" button.

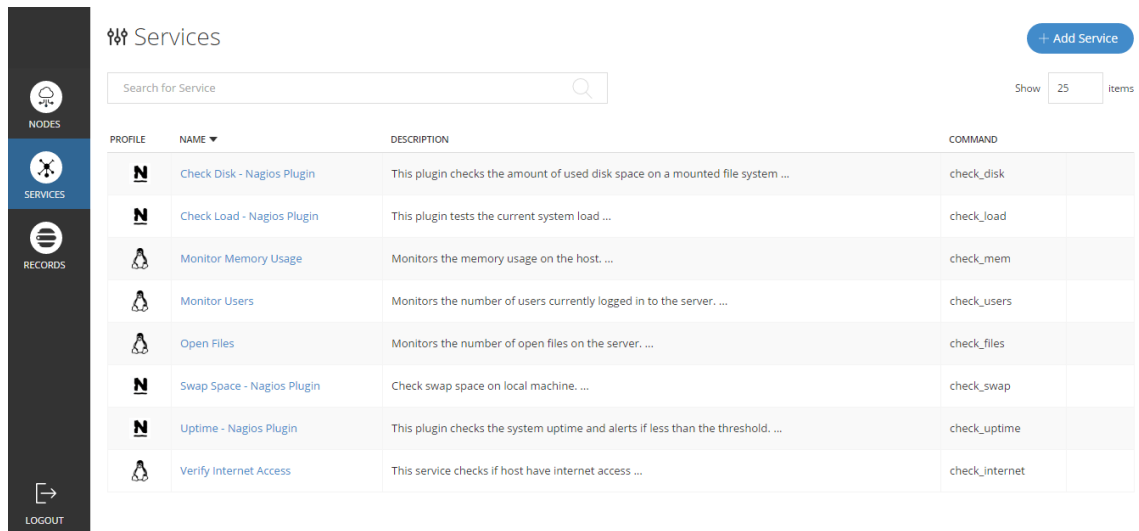
La següent captura mostra el llistat de nodes registrats al servidor. La llista de nodes mostra el nom i l'alias del node, el sistema, la descripció, així com la data de la darrera monitorització. També mostra l'estat actual de node.



The screenshot shows the "Nodes" management interface. It features a search bar, a "Show 50 nodes" dropdown, and a table with columns for STATUS, NAME, CLIENT, LAST CHECK, SYSTEM, and DESCRIPTION. The table contains two entries: "Development.LAB1" and "LABX1".

STATUS	NAME	CLIENT	LAST CHECK	SYSTEM	DESCRIPTION
✓	Development.LAB1 development-dektop		Jan. 02 23:32:20	Linux x86_64 #78-Ubuntu SMP Fri Dec 9 23:50:32 UTC 2016	Centraleta DEMO
⚠	LABX1		Jan. 02 19:22:30	Linux x86_64 #37-Ubuntu SMP Mon Apr 18 18:33:37 UTC 2016	Centraleta LABOK

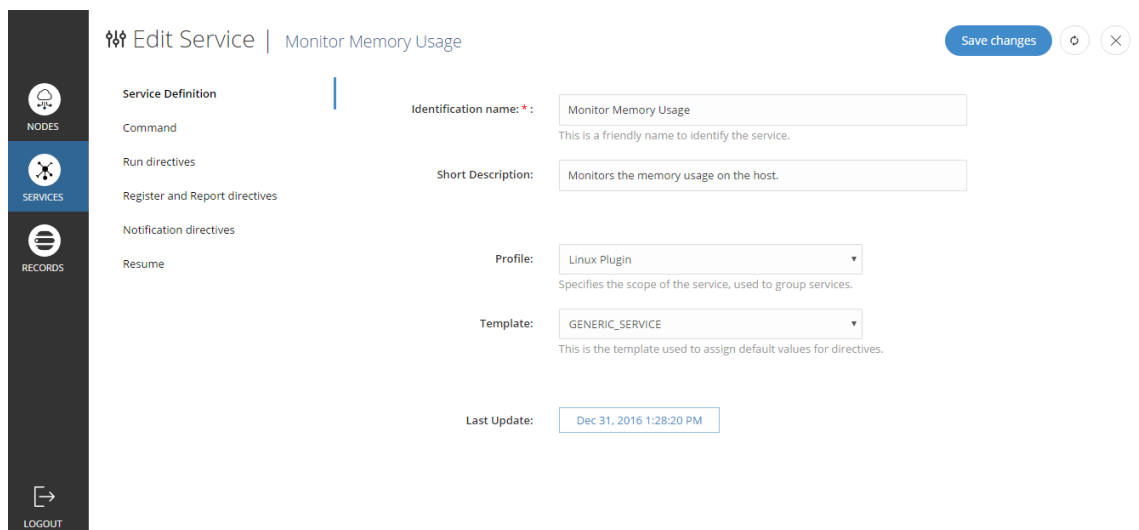
La següent captura mostra el llistat de serveis registrats al servidor



The screenshot shows the Nagios Services page. On the left is a sidebar with navigation options: NODES, SERVICES (selected), RECORDS, and LOGOUT. The main content area is titled 'Services' and includes a search bar, a '+ Add Service' button, and a 'Show 25 items' dropdown. Below this is a table listing various services.

PROFILE	NAME	DESCRIPTION	COMMAND
N	Check Disk - Nagios Plugin	This plugin checks the amount of used disk space on a mounted file system ...	check_disk
N	Check Load - Nagios Plugin	This plugin tests the current system load ...	check_load
A	Monitor Memory Usage	Monitors the memory usage on the host. ...	check_mem
A	Monitor Users	Monitors the number of users currently logged in to the server. ...	check_users
A	Open Files	Monitors the number of open files on the server. ...	check_files
N	Swap Space - Nagios Plugin	Check swap space on local machine. ...	check_swap
N	Uptime - Nagios Plugin	This plugin checks the system uptime and alerts if less than the threshold. ...	check_uptime
A	Verify Internet Access	This service checks if host have internet access ...	check_internet

La següent captura mostra el formulari d'edició d'un servei. L'editor permet configurar la comanda que s'executara així com les diferents directives de monitorització del servei.



The screenshot shows the 'Edit Service' page for 'Monitor Memory Usage'. The page has a sidebar with navigation options: NODES, SERVICES (selected), RECORDS, and LOGOUT. The main content area is titled 'Edit Service | Monitor Memory Usage' and includes a 'Save changes' button and a close button. The page is divided into sections for 'Service Definition', 'Command', 'Run directives', 'Register and Report directives', 'Notification directives', and 'Resume'. The 'Service Definition' section is active and shows the following fields:

- Identification name:** Monitor Memory Usage (This is a friendly name to identify the service.)
- Short Description:** Monitors the memory usage on the host.
- Profile:** Linux Plugin (Specifies the scope of the service, used to group services.)
- Template:** GENERIC\_SERVICE (This is the template used to assign default values for directives.)
- Last Update:** Dec 31, 2016 1:28:20 PM

Records

Search for Record

Show 100 records

HOST	SERVICE	STATUS	LAST CHECK	ATTEMPTS	STATUS INFORMATION
Development LAB1	check_ping	✓	23:32:12, 02 January	1 / 2	PING OK - Packet loss = 28%, RTA = 13.81 ms   rta=13.81400ms;3000.000000;5000.000000;0.000000 pl=28%;80;100;0
Development LAB1	check_disk	✗	23:32:16, 02 January	1 / 1	DISK CRITICAL - /dev/shd1 is not accessible: No existe el archivo o el directorio
Development LAB1	check_disk	✓	23:26:47, 02 January	1 / 3	DISK OK - free space: /dev 1956 MB (100% inode=99%);   /dev=0MB;1760;1858;0;1956
Development LAB1	check_load	✓	23:32:12, 02 January	1 / 3	OK - load average: 0.40, 0.12, 0.10   load1=0.400;15.000;30.000;0; load5=0.120;10.000;20.000;0; load15=0.100;5.000;10.000;0;
Development LAB1	check_swap	✗	23:31:56, 02 January	3 / 3	SWAP CRITICAL - 0% free (0 MB out of 0 MB)   swap=0MB;0;0;0
LABX1	check_disk	✓	19:22:19, 02 January	1 / 1	DISK OK - free space: / 5633 MB (80% inode=86%);   /=1396MB;6687;7058;0;7430
LABX1	check_load	✓	19:22:19, 02 January	1 / 3	OK - load average: 0.00, 0.01, 0.05   load1=0.000;15.000;30.000;0; load5=0.010;10.000;20.000;0; load15=0.050;5.000;10.000;0;
LABX1	check_disk	✓	19:18:09, 02 January	1 / 5	DISK OK - free space: / 5633 MB (80% inode=86%);   /=1396MB;6687;7058;0;7430

La darrera captura mostra el formulari d'assignació de serveis que permet autoritzar un node al sistema i assignar-li les tasques de monitorització que ha d'executar.

Node | Configuration Assistant

Define sensors to monitor:

- Check Load - Nagios Plugin  
This plugin tests the current system load
- Uptime - Nagios Plugin  
This plugin checks the system uptime and alerts if less than the threshold.
- Swap Space - Nagios Plugin  
Check swap space on local machine.
- Check Disk - Nagios Plugin  
This plugin checks the amount of used disk space on a mounted file system and generates an alert if free space is less than one of the threshold values
- Verify Internet Access  
This service checks if host have internet access
- Open Files  
Monitors the number of open files on the server.
- Monitor Users

GNU Free Documentation License  
Version 1.3, 3 November 2008

Copyright (C) 2000, 2001, 2002, 2007, 2008 Free Software Foundation, Inc.

<http://fsf.org/>

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 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, 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.

The "publisher" means any person or entity that distributes copies of the Document to the public.

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 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 (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 under this License. Any attempt otherwise to copy, modify, sublicense, or distribute it is void, and will automatically terminate your rights under this License.

However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally

terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, receipt of a copy of some or all of the same material does not give you any rights to use it.

#### 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 <http://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. If the Document specifies that a proxy can decide which future versions of this License can be used, that proxy's public statement of acceptance of a version permanently authorizes you to choose that version for the Document.

#### 11. RELICENSING

"Massive Multiauthor Collaboration Site" (or "MMC Site") means any World Wide Web server that publishes copyrightable works and also provides prominent facilities for anybody to edit those works. A public wiki that anybody can edit is an example of such a server. A "Massive Multiauthor Collaboration" (or "MMC") contained in the site means any set of copyrightable works thus published on the MMC site.

"CC-BY-SA" means the Creative Commons Attribution-Share Alike 3.0 license published by Creative Commons Corporation, a not-for-profit corporation with a principal place of business in San Francisco, California, as well as future copyleft versions of that license published by that same organization.

"Incorporate" means to publish or republish a Document, in whole or in part, as part of another Document.

An MMC is "eligible for relicensing" if it is licensed under this License, and if all works that were first published under this License

somewhere other than this MMC, and subsequently incorporated in whole or in part into the MMC, (1) had no cover texts or invariant sections, and (2) were thus incorporated prior to November 1, 2008.

The operator of an MMC Site may republish an MMC contained in the site under CC-BY-SA on the same site at any time before August 1, 2009, provided the MMC is eligible for relicensing.

ADDENDUM: How to use this License for your documents

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 (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 1.3
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.