Linux Servers

Paul Cobbaut
Abstract

This book is meant to be used in an instructor-led training. For self-study, the intent is to read this book next to a working Linux computer so you can immediately do every subject, practicing each command.

This book is aimed at novice Linux system administrators (and might be interesting and useful for home users that want to know a bit more about their Linux system). However, this book is not meant as an introduction to Linux desktop applications like text editors, browsers, mail clients, multimedia or office applications.


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# Table of Contents

## I. apache and squid

1. apache web server
   1.1. introduction to apache ................................................................. 4
   1.2. port virtual hosts on Debian ...................................................... 11
   1.3. named virtual hosts on Debian ................................................ 15
   1.4. password protected website on Debian .................................... 17
   1.5. port virtual hosts on CentOS .................................................. 18
   1.6. named virtual hosts on CentOS ................................................ 22
   1.7. password protected website on CentOS .................................... 24
   1.8. troubleshooting apache ............................................................. 26
   1.9. virtual hosts example ............................................................... 27
   1.10. aliases and redirects ............................................................... 27
   1.11. more on .htaccess ................................................................. 27
   1.12. traffic .......................................................... 27
   1.13. self signed cert on Debian .................................................... 28
   1.14. self signed cert on RHEL/CentOS .......................................... 30
   1.15. practice: apache ................................................................. 32

2. introduction to squid
   2.1. about proxy servers ................................................................. 33
   2.2. installing squid ................................................................. 34
   2.3. port 3128 ................................................................. 34
   2.4. starting and stopping ........................................................... 34
   2.5. client proxy settings ............................................................. 35
   2.6. upside down images ............................................................. 37
   2.7. /var/log/squid ................................................................. 39
   2.8. access control ................................................................. 39
   2.9. testing squid ................................................................. 39
   2.10. name resolution ................................................................. 39

## II. mysql database

3. introduction to sql using mysql
   3.1. installing mysql ................................................................. 44
   3.2. accessing mysql ................................................................. 45
   3.3. mysql databases ................................................................. 47
   3.4. mysql tables ................................................................. 49
   3.5. mysql records ................................................................. 51
   3.6. joining two tables ............................................................... 54
   3.7. mysql triggers ................................................................. 55

## III. dns server

4. introduction to DNS
   4.1. about dns ................................................................. 60
   4.2. dns namespace ................................................................. 63
   4.3. caching only servers ........................................................... 68
   4.4. authoritative dns servers .................................................... 71
   4.5. primary and secondary ....................................................... 71
   4.6. zone transfers ................................................................. 71
   4.7. master and slave ............................................................... 73
   4.8. SOA record ................................................................. 73
   4.9. full or incremental zone transfers ....................................... 74
   4.10. DNS cache ................................................................. 75
   4.11. forward lookup zone example .......................................... 76
   4.12. example: caching only DNS server .................................... 77
   4.13. example: caching only with forwarder ................................ 79
   4.14. example: primary authoritative server ............................... 81
   4.15. example: a DNS slave server ........................................... 85
   4.16. practice: dns ............................................................... 87
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.</td>
<td>a read only file server</td>
<td>156</td>
</tr>
<tr>
<td>11.1.</td>
<td>Setting up a directory to share</td>
<td>157</td>
</tr>
<tr>
<td>11.2.</td>
<td>configure the share</td>
<td>157</td>
</tr>
<tr>
<td>11.3.</td>
<td>restart the server</td>
<td>158</td>
</tr>
<tr>
<td>11.4.</td>
<td>verify the share</td>
<td>158</td>
</tr>
<tr>
<td>11.5.</td>
<td>a note on netcat</td>
<td>160</td>
</tr>
<tr>
<td>11.6.</td>
<td>practice: read only file server</td>
<td>161</td>
</tr>
<tr>
<td>11.7.</td>
<td>solution: read only file server</td>
<td>162</td>
</tr>
<tr>
<td>12.</td>
<td>a writable file server</td>
<td>163</td>
</tr>
<tr>
<td>12.1.</td>
<td>set up a directory to share</td>
<td>164</td>
</tr>
<tr>
<td>12.2.</td>
<td>share section in smb.conf</td>
<td>164</td>
</tr>
<tr>
<td>12.3.</td>
<td>configure the share</td>
<td>164</td>
</tr>
<tr>
<td>12.4.</td>
<td>test connection with windows</td>
<td>164</td>
</tr>
<tr>
<td>12.5.</td>
<td>test writing with windows</td>
<td>165</td>
</tr>
<tr>
<td>12.6.</td>
<td>How is this possible?</td>
<td>165</td>
</tr>
<tr>
<td>12.7.</td>
<td>practice: writable file server</td>
<td>166</td>
</tr>
<tr>
<td>13.</td>
<td>samba first user account</td>
<td>168</td>
</tr>
<tr>
<td>13.1.</td>
<td>creating a samba user</td>
<td>169</td>
</tr>
<tr>
<td>13.2.</td>
<td>ownership of files</td>
<td>169</td>
</tr>
<tr>
<td>13.3.</td>
<td>/usr/bin/smbpasswd</td>
<td>169</td>
</tr>
<tr>
<td>13.4.</td>
<td>/etc/samba/smbpasswd</td>
<td>169</td>
</tr>
<tr>
<td>13.5.</td>
<td>passdb backend</td>
<td>170</td>
</tr>
<tr>
<td>13.6.</td>
<td>forcing this user</td>
<td>170</td>
</tr>
<tr>
<td>13.7.</td>
<td>practice: first samba user account</td>
<td>171</td>
</tr>
<tr>
<td>13.8.</td>
<td>solution: first samba user account</td>
<td>172</td>
</tr>
<tr>
<td>14.</td>
<td>samba authentication</td>
<td>173</td>
</tr>
<tr>
<td>14.1.</td>
<td>creating the users on Linux</td>
<td>174</td>
</tr>
<tr>
<td>14.2.</td>
<td>creating the users on samba</td>
<td>174</td>
</tr>
<tr>
<td>14.3.</td>
<td>security = user</td>
<td>174</td>
</tr>
<tr>
<td>14.4.</td>
<td>configuring the share</td>
<td>175</td>
</tr>
<tr>
<td>14.5.</td>
<td>testing access with net use</td>
<td>175</td>
</tr>
<tr>
<td>14.6.</td>
<td>testing access with smbclient</td>
<td>175</td>
</tr>
<tr>
<td>14.7.</td>
<td>verify ownership</td>
<td>176</td>
</tr>
<tr>
<td>14.8.</td>
<td>common problems</td>
<td>176</td>
</tr>
<tr>
<td>14.9.</td>
<td>practice: samba authentication</td>
<td>178</td>
</tr>
<tr>
<td>14.10.</td>
<td>solution: samba authentication</td>
<td>179</td>
</tr>
<tr>
<td>15.</td>
<td>samba securing shares</td>
<td>180</td>
</tr>
<tr>
<td>15.1.</td>
<td>security based on user name</td>
<td>181</td>
</tr>
<tr>
<td>15.2.</td>
<td>security based on ip-address</td>
<td>181</td>
</tr>
<tr>
<td>15.3.</td>
<td>security through obscurity</td>
<td>182</td>
</tr>
<tr>
<td>15.4.</td>
<td>file system security</td>
<td>182</td>
</tr>
<tr>
<td>15.5.</td>
<td>practice: securing shares</td>
<td>184</td>
</tr>
<tr>
<td>15.6.</td>
<td>solution: securing shares</td>
<td>185</td>
</tr>
<tr>
<td>16.</td>
<td>samba domain member</td>
<td>187</td>
</tr>
<tr>
<td>16.1.</td>
<td>changes in smb.conf</td>
<td>188</td>
</tr>
<tr>
<td>16.2.</td>
<td>joining an Active Directory domain</td>
<td>189</td>
</tr>
<tr>
<td>16.3.</td>
<td>winbind</td>
<td>190</td>
</tr>
<tr>
<td>16.4.</td>
<td>winfo</td>
<td>190</td>
</tr>
<tr>
<td>16.5.</td>
<td>getent</td>
<td>191</td>
</tr>
<tr>
<td>16.6.</td>
<td>file ownership</td>
<td>192</td>
</tr>
<tr>
<td>16.7.</td>
<td>practice: samba domain member</td>
<td>193</td>
</tr>
<tr>
<td>17.</td>
<td>samba domain controller</td>
<td>194</td>
</tr>
<tr>
<td>17.1.</td>
<td>about Domain Controllers</td>
<td>195</td>
</tr>
<tr>
<td>17.2.</td>
<td>About security modes</td>
<td>195</td>
</tr>
<tr>
<td>17.3.</td>
<td>About password backends</td>
<td>196</td>
</tr>
</tbody>
</table>
List of Tables

4.1. the first top level domains ..................................................................................................................... 65
4.2. new general purpose tld's ....................................................................................................................... 65
7.1. Packet Forwarding Exercise ................................................................................................................. 117
7.2. Packet Forwarding Solution .................................................................................................................. 119
Part I. apache and squid
Table of Contents

1. apache web server ................................................................................................................................. 3
   1.1. introduction to apache .................................................................................................................. 4
   1.2. port virtual hosts on Debian ....................................................................................................... 11
   1.3. named virtual hosts on Debian .................................................................................................. 15
   1.4. password protected website on Debian ....................................................................................... 17
   1.5. port virtual hosts on CentOS ..................................................................................................... 18
   1.6. named virtual hosts on CentOS ................................................................................................. 22
   1.7. password protected website on CentOS .................................................................................... 24
   1.8. troubleshooting apache ................................................................................................................ 26
   1.9. virtual hosts example .................................................................................................................... 27
   1.10. aliases and redirects .................................................................................................................... 27
   1.11. more on .htaccess ....................................................................................................................... 27
   1.12. traffic ......................................................................................................................................... 27
   1.13. self signed cert on Debian .......................................................................................................... 28
   1.14. self signed cert on RHEL/CentOS ............................................................................................ 30
   1.15. practice: apache .......................................................................................................................... 32
2. introduction to squid ............................................................................................................................... 33
   2.1. about proxy servers ...................................................................................................................... 33
   2.2. installing squid ............................................................................................................................. 34
   2.3. port 3128 ..................................................................................................................................... 34
   2.4. starting and stopping ..................................................................................................................... 34
   2.5. client proxy settings ....................................................................................................................... 35
   2.6. upside down images ....................................................................................................................... 37
   2.7. /var/log/squid ............................................................................................................................... 39
   2.8. access control ............................................................................................................................... 39
   2.9. testing squid .................................................................................................................................. 39
   2.10. name resolution ............................................................................................................................ 39
Chapter 1. apache web server

In this chapter we learn how to setup a web server with the apache software.

According to NetCraft (http://news.netcraft.com/archives/web_server_survey.html) about seventy percent of all web servers are running on Apache. The name is derived from a patchy web server, because of all the patches people wrote for the NCSA httpd server.

Later chapters will expand this web server into a LAMP stack (Linux, Apache, Mysql, Perl/PHP/Python).
1.1. introduction to apache

1.1.1. installing on Debian

This screenshot shows that there is no apache server installed, nor does the /var/www directory exist.

```
root@debian7:~# ls -l /var/www
ls: cannot access /var/www: No such file or directory
root@debian7:~# dpkg -l | grep apache
```

To install apache on Debian:

```
root@debian7:~# aptitude install apache2
The following NEW packages will be installed:
   apache2 apache2-mpm-worker(a) apache2-utils(a) apache2.2-bin(a) apache2.2-com\n   mon(a) libapr1(a) libaprutil1(a) libaprutil1-dbd-sqlite3(a) libaprutil1-ldap(a)\n   ssl-cert(a)
0 packages upgraded, 10 newly installed, 0 to remove and 0 not upgraded.
Need to get 1,487 kB of archives. After unpacking 5,673 kB will be used.
Do you want to continue? [Y/n/?]
```

After installation, the same two commands as above will yield a different result:

```
root@debian7:~# ls -l /var/www
total 4
-rw-r--r-- 1 root root 177 Apr 29 11:55 index.html
root@debian7:~# dpkg -l | grep apache | tr -s ' ' 
ii apache2 2.2.22-13+deb7u1 amd64 Apache HTTP Server metapackage
ii apache2-mpm-worker 2.2.22-13+deb7u1 amd64 Apache HTTP Server - high speed th\nreaded model
ii apache2-utils 2.2.22-13+deb7u1 amd64 utility programs for webservers
ii apache2.2-bin 2.2.22-13+deb7u1 amd64 Apache HTTP Server common binary files
ii apache2.2-common 2.2.22-13+deb7u1 amd64 Apache HTTP Server common files
```
1.1.2. installing on RHEL/CentOS

Note that Red Hat derived distributions use httpd as package and process name instead of apache.

To verify whether apache is installed in CentOS/RHEL:

```
[rroot@centos65 ~]# rpm -q httpd
package httpd is not installed
[rroot@centos65 ~]# ls -l /var/www
ls: cannot access /var/www: No such file or directory
```

To install apache on CentOS:

```
[rroot@centos65 ~]# yum install httpd
```

After running the yum install httpd command, the Centos 6.5 server has apache installed and the /var/www directory exists.

```
[rroot@centos65 ~]# rpm -q httpd
httpd-2.2.15-30.el6.centos.x86_64
[rroot@centos65 ~]# ls -l /var/www
total 16
drwxr-xr-x. 2 root root 4096 Apr  3 23:57 cgi-bin
drwxr-xr-x. 3 root root 4096 May  6 13:08 error
drwxr-xr-x. 2 root root 4096 Apr  3 23:57 html
drwxr-xr-x. 3 root root 4096 May  6 13:08 icons
[rroot@centos65 ~]#
```
1.1.3. running apache on Debian

This is how you start **apache2** on Debian.

```
root@debian7:~# service apache2 status
Apache2 is NOT running.
root@debian7:~# service apache2 start
Starting web server: apache2
apache2: Could not reliably determine the server's \ 
fully qualified domain name, using 127.0.1.1 for ServerName.
```

To verify, run the **service apache2 status** command again or use **ps**.

```
root@debian7:~# service apache2 status
Apache2 is running (pid 3680).
root@debian7:~# ps -C apache2
    PID  TTY         TIME CMD
   3680 ?       00:00:00 apache2
   3683 ?       00:00:00 apache2
   3684 ?       00:00:00 apache2
   3685 ?       00:00:00 apache2
root@debian7:~#
```

Or use **wget** and **file** to verify that your web server serves an html document.

```
root@debian7:~# wget 127.0.0.1
Connecting to 127.0.0.1:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 177 [text/html]
Saving to: `index.html'
100%[==============================================] 177   --.-K/s in 0s
2014-05-06 13:27:02 (15.8 MB/s) - `index.html' saved [177/177]
root@debian7:~# file index.html
index.html: HTML document, ASCII text
root@debian7:~#
```

Or verify that apache is running by opening a web browser, and browse to the ip-address of your server. An Apache test page should be shown.

You can do the following to quickly avoid the 'could not reliably determine the fqdn' message when restarting apache.

```
root@debian7:~# echo ServerName Debian7 >> /etc/apache2/apache2.conf
root@debian7:~# service apache2 restart
Restarting web server: apache2 ... waiting.
root@debian7:~#
```
### 1.1.4. running apache on CentOS

Starting the `httpd` on RHEL/CentOS is done with the `service` command.

```
[root@centos65 ~]# service httpd status
httpd is stopped
[root@centos65 ~]# service httpd start
Starting httpd: httpd: Could not reliably determine the server's fully qualified
domain name, using 127.0.0.1 for ServerName
[  OK  ]
[root@centos65 ~]#
```

To verify that `apache` is running, use `ps` or issue the `service httpd status` command again.

```
[root@centos65 ~]# service httpd status
httpd (pid 2410) is running...
[root@centos65 ~]# ps -C httpd
   PID  TTY       TIME CMD
  2410 ?        00:00:00 httpd
  2412 ?        00:00:00 httpd
  2413 ?        00:00:00 httpd
  2414 ?        00:00:00 httpd
  2415 ?        00:00:00 httpd
  2416 ?        00:00:00 httpd
  2417 ?        00:00:00 httpd
  2418 ?        00:00:00 httpd
  2419 ?        00:00:00 httpd
[root@centos65 ~]#
```

To prevent the 'Could not reliably determine the fqdn' message, issue the following command.

```
[root@centos65 ~]# echo ServerName Centos65 >> /etc/httpd/conf/httpd.conf
[root@centos65 ~]# service httpd restart
Stopping httpd: [  OK  ]
Starting httpd: [  OK  ]
[root@centos65 ~]#
```
1.1.5. index file on CentOS

CentOS does not provide a standard index.html or index.php file. A simple `wget` gives an error.

```
[root@centos65 ~]# wget 127.0.0.1
--2014-05-06 15:10:22--  http://127.0.0.1/
Connecting to 127.0.0.1:80... connected.
HTTP request sent, awaiting response... 403 Forbidden
```

Instead when visiting the ip-address of your server in a web browser you get a **noindex.html** page. You can verify this using `wget`.

```
[root@centos65 ~]# wget http://127.0.0.1/error/noindex.html
Connecting to 127.0.0.1:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 5039 (4.9K) [text/html]
Saving to: “noindex.html”

100%[=============================================>] 5,039 --.-K/s in 0s
2014-05-06 15:16:05 (289 MB/s) - “noindex.html” saved [5039/5039]
[root@centos65 ~]# file noindex.html
noindex.html: HTML document text
[root@centos65 ~]#
```

Any custom **index.html** file in `/var/www/html` will immediately serve as an index for this web server.

```
[root@centos65 ~]# echo 'Welcome to my website' > /var/www/html/index.html
[root@centos65 ~]# wget http://127.0.0.1
Connecting to 127.0.0.1:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 22 [text/html]
Saving to: “index.html”

100%[=============================================>] 22 --.-K/s in 0s
2014-05-06 15:19:16 (1.95 MB/s) - “index.html” saved [22/22]
[root@centos65 ~]# cat index.html
Welcome to my website
```

1.1.6. default website

Changing the default website of a freshly installed apache web server is easy. All you need to do is create (or change) an index.html file in the DocumentRoot directory.

To locate the DocumentRoot directory on Debian:

```
root@debian7:~# grep DocumentRoot /etc/apache2/sites-available/default
DocumentRoot /var/www
```

This means that `/var/www/index.html` is the default web site.

```
root@debian7:~# cat /var/www/index.html
<html><body><h1>It works!</h1>
<p>This is the default web page for this server.</p>
<p>The web server software is running but no content has been added, yet.</p>
</body></html>
```

This screenshot shows how to locate the `DocumentRoot` directory on RHEL/CentOS.

```
[root@centos65 ~]# grep ^DocumentRoot /etc/httpd/conf/httpd.conf
DocumentRoot "/var/www/html"
```

RHEL/CentOS have no default web page (only the noindex.html error page mentioned before). But an `index.html` file created in `/var/www/html` will automatically be used as default page.

```
[root@centos65 ~]# echo '<html><head><title>Default website</title></head><body><p>A new web page</p></body></html>' > /var/www/html/index.html
[root@centos65 ~]# cat /var/www/html/index.html
<html><head><title>Default website</title></head><body><p>A new web page</p></body></html>
```
1.1.7. apache configuration

There are many similarities, but also a couple of differences when configuring apache on Debian or on CentOS. Both Linux families will get their own chapters with examples.

All configuration on RHEL/CentOS is done in `/etc/httpd`.

```
[root@centos65 ~]# ls -l /etc/httpd/
total 8
drwxr-xr-x. 2 root root 4096 May  6 13:08 conf
drwxr-xr-x. 2 root root 4096 May  6 13:08 conf.d
lrwxrwxrwx. 1 root root 19 May  6 13:08 logs -> ../../../var/log/httpd
lrwxrwxrwx. 1 root root 29 May  6 13:08 modules -> ../../../usr/lib64/httpd/modules
lrwxrwxrwx. 1 root root 19 May  6 13:08 run -> ../../../var/run/httpd
[root@centos65 ~]#
```

Debian (and ubuntu/mint/...) use `/etc/apache2`.

```
root@debian7:~# ls -l /etc/apache2/
total 72
-rw-r--r-- 1 root root  9659 May  6 14:23 apache2.conf
drwxr-xr-x 2 root root  4096 May  6 13:19 conf.d
-rw-r--r-- 1 root root 1465 Jan 31 18:35 envvars
-rw-r--r-- 1 root root 31063 Jul 20  2013 magic
drwxr-xr-x 2 root root  4096 May  6 13:19 mods-available
drwxr-xr-x 2 root root  4096 May  6 13:19 mods-enabled
-rw-r--r-- 1 root root  750 Jan 26 12:13 ports.conf
drwxr-xr-x 2 root root  4096 May  6 13:19 sites-available
drwxr-xr-x 2 root root  4096 May  6 13:19 sites-enabled
root@debian7:~#
```
1.2. port virtual hosts on Debian

1.2.1. default virtual host

Debian has a virtualhost configuration file for its default website in `/etc/apache2/sites-available/default`.

```
root@debian7:~# head -2 /etc/apache2/sites-available/default
<VirtualHost *:80>
    ServerAdmin webmaster@localhost
</VirtualHost>
```

1.2.2. three extra virtual hosts

In this scenario we create three additional websites for three customers that share a clubhouse and want to jointly hire you. They are a model train club named Choo Choo, a chess club named Chess Club 42 and a hackerspace named hunter2.

One way to put three websites on one web server, is to put each website on a different port. This screenshot shows three newly created virtual hosts, one for each customer.

```
root@debian7:~# vi /etc/apache2/sites-available/choochoo
root@debian7:~# cat /etc/apache2/sites-available/choochoo
<VirtualHost *:7000>
    ServerAdmin webmaster@localhost
    DocumentRoot /var/www/choochoo
</VirtualHost>
root@debian7:~# vi /etc/apache2/sites-available/chessclub42
root@debian7:~# cat /etc/apache2/sites-available/chessclub42
<VirtualHost *:8000>
    ServerAdmin webmaster@localhost
    DocumentRoot /var/www/chessclub42
</VirtualHost>
root@debian7:~# vi /etc/apache2/sites-available/hunter2
root@debian7:~# cat /etc/apache2/sites-available/hunter2
<VirtualHost *:9000>
    ServerAdmin webmaster@localhost
    DocumentRoot /var/www/hunter2
</VirtualHost>
```

Notice the different port numbers 7000, 8000 and 9000. Notice also that we specified a unique `DocumentRoot` for each website.

Are you using Ubuntu or Mint, then these configfiles need to end in `.conf`.
1.2.3. three extra ports

We need to enable these three ports on apache in the `ports.conf` file. Open this file with `vi` and add three lines to `listen` on three extra ports.

```
root@debian7:~# vi /etc/apache2/ports.conf
```

Verify with `grep` that the `Listen` directives are added correctly.

```
root@debian7:~# grep ^Listen /etc/apache2/ports.conf
Listen 80
Listen 7000
Listen 8000
Listen 9000
```

1.2.4. three extra websites

Next we need to create three `DocumentRoot` directories.

```
root@debian7:~# mkdir /var/www/choochoo
root@debian7:~# mkdir /var/www/chessclub42
root@debian7:~# mkdir /var/www/hunter2
```

And we have to put some really simple website in those directories.

```
root@debian7:~# echo 'Choo Choo model train Choo Choo' > /var/www/choochoo/index.html
root@debian7:~# echo 'Welcome to chess club 42' > /var/www/chessclub42/index.html
root@debian7:~# echo 'HaCkInG iS fUn At HuNtEr2' > /var/www/hunter2/index.html
```
1.2.5. enabling extra websites

The last step is to enable the websites with the `a2ensite` command. This command will create links in `sites-enabled`.

The links are not there yet...

```bash
root@debian7:~# cd /etc/apache2/
root@debian7:/etc/apache2# ls sites-available/
chessclub42  choochoo  default  default-ssl  hunter2
root@debian7:/etc/apache2# ls sites-enabled/
000-default
```

So we run the `a2ensite` command for all websites.

```bash
root@debian7:/etc/apache2# a2ensite choochoo
Enabling site choochoo.
To activate the new configuration, you need to run:
  service apache2 reload
root@debian7:/etc/apache2# a2ensite chessclub42
Enabling site chessclub42.
To activate the new configuration, you need to run:
  service apache2 reload
root@debian7:/etc/apache2# a2ensite hunter2
Enabling site hunter2.
To activate the new configuration, you need to run:
  service apache2 reload
```

The links are created, so we can tell `apache`.

```bash
root@debian7:/etc/apache2# ls sites-enabled/
000-default chessclub42 choochoo hunter2
root@debian7:/etc/apache2# service apache2 reload
Reloading web server config: apache2.
root@debian7:/etc/apache2#
```
1.2.6. testing the three websites

Testing the model train club named Choo Choo on port 7000.

```
root@debian7:/etc/apache2# wget 127.0.0.1:7000
--2014-05-06 21:16:03--  http://127.0.0.1:7000/
Connecting to 127.0.0.1:7000... connected.
HTTP request sent, awaiting response... 200 OK
Length: 32 [text/html]
Saving to: `index.html'

100%[============================================>] 32          --.-K/s   in 0s
2014-05-06 21:16:03 (2.92 MB/s) - `index.html' saved [32/32]
root@debian7:/etc/apache2#
```

Testing the chess club named Chess Club 42 on port 8000.

```
root@debian7:/etc/apache2# wget 127.0.0.1:8000
Connecting to 127.0.0.1:8000... connected.
HTTP request sent, awaiting response... 200 OK
Length: 25 [text/html]
Saving to: `index.html.1'

100%[===========================================>] 25          --.-K/s   in 0s
root@debian7:/etc/apache2#
```

Testing the hacker club named hunter2 on port 9000.

```
root@debian7:/etc/apache2# wget 127.0.0.1:9000
Connecting to 127.0.0.1:9000... connected.
HTTP request sent, awaiting response... 200 OK
Length: 26 [text/html]
Saving to: `index.html.2'

100%[===========================================>] 26          --.-K/s   in 0s
2014-05-06 21:16:30 (2.01 MB/s) - `index.html.2' saved [26/26]
root@debian7:/etc/apache2#
```

Cleaning up the temporary files.

```
root@debian7:/etc/apache2# rm index.html index.html.1 index.html.2
```

Try testing from another computer using the ip-address of your server.
1.3. named virtual hosts on Debian

1.3.1. named virtual hosts

The chess club and the model train club find the port numbers too hard to remember. They would prefer to have their website accessible by name.

We continue work on the same server that has three websites on three ports. We need to make sure those websites are accessible using the names choochoo.local, chessclub42.local and hunter2.local.

We start by creating three new virtualhosts.

```
root@debian7:/etc/apache2/sites-available# vi choochoo.local
root@debian7:/etc/apache2/sites-available# vi chessclub42.local
root@debian7:/etc/apache2/sites-available# vi hunter2.local
root@debian7:/etc/apache2/sites-available# cat choochoo.local
<VirtualHost *:80>
    ServerAdmin webmaster@localhost
    ServerName choochoo.local
    DocumentRoot /var/www/choochoo
</VirtualHost>
root@debian7:/etc/apache2/sites-available# cat chessclub42.local
<VirtualHost *:80>
    ServerAdmin webmaster@localhost
    ServerName chessclub42.local
    DocumentRoot /var/www/chessclub42
</VirtualHost>
root@debian7:/etc/apache2/sites-available# cat hunter2.local
<VirtualHost *:80>
    ServerAdmin webmaster@localhost
    ServerName hunter2.local
    DocumentRoot /var/www/hunter2
</VirtualHost>
```

Notice that they all listen on port 80 and have an extra ServerName directive.

1.3.2. name resolution

We need some way to resolve names. This can be done with DNS, which is discussed in another chapter. For this demo it is also possible to quickly add the three names to the /etc/hosts file.

```
root@debian7:/etc/apache2/sites-available# grep ^192 /etc/hosts
192.168.42.50 choochoo.local
192.168.42.50 chessclub42.local
192.168.42.50 hunter2.local
```

Note that you may have another ip address...
1.3.3. enabling virtual hosts

Next we enable them with `a2ensite`.

```
root@debian7:/etc/apache2/sites-available# a2ensite choochoo.local
Enabling site choochoo.local.
To activate the new configuration, you need to run:
  service apache2 reload
root@debian7:/etc/apache2/sites-available# a2ensite chessclub42.local
Enabling site chessclub42.local.
To activate the new configuration, you need to run:
  service apache2 reload
root@debian7:/etc/apache2/sites-available# a2ensite hunter2.local
Enabling site hunter2.local.
To activate the new configuration, you need to run:
  service apache2 reload
```

1.3.4. reload and verify

After a `service apache2 reload` the websites should be available by name.

```
root@debian7:/etc/apache2/sites-available# service apache2 reload
Reloading web server config: apache2.
root@debian7:/etc/apache2/sites-available# wget chessclub42.local
Resolving chessclub42.local (chessclub42.local)... 192.168.42.50
Connecting to chessclub42.local (chessclub42.local)|192.168.42.50|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 25 [text/html]
Saving to: `index.html'

100%[=============================================>] 25       --.-K/s   in 0s
2014-05-06 21:37:13 (2.06 MB/s) - `index.html' saved [25/25]
root@debian7:/etc/apache2/sites-available# cat index.html
Welcome to chess club 42
```
1.4. password protected website on Debian

You can secure files and directories in your website with a .htaccess file that refers to a .htpasswd file. The htpasswd command can create a .htpasswd file that contains a userid and an (encrypted) password.

This screenshot creates a user and password for the hacker named cliff and uses the -c flag to create the .htpasswd file.

```
root@debian7:~# htpasswd -c /var/www/.htpasswd cliff
New password:
Re-type new password:
```

```
Adding password for user cliff
root@debian7:~# cat /var/www/.htpasswd
cliff:$apr1$vujll0KL$./SZ4w9q0swhX93pQ0PVp.
```

Hacker rob also wants access, this screenshot shows how to add a second user and password to .htpasswd.

```
root@debian7:~# htpasswd /var/www/.htpasswd rob
New password:
Re-type new password:
```

```
Adding password for user rob
root@debian7:~# cat /var/www/.htpasswd
cliff:$apr1$vujll0KL$./SZ4w9q0swhX93pQ0PVp.
rob:$apr1$HNln1FFt$nRlpF0H.IW11/1DRq41Qo0
```

Both Cliff and Rob chose the same password (hunter2), but that is not visible in the .htpasswd file because of the different salts.

Next we need to create a .htaccess file in the DocumentRoot of the website we want to protect. This screenshot shows an example.

```
root@debian7:~# cd /var/www/hunter2/
root@debian7:/var/www/hunter2# cat .htaccess
AuthUserFile /var/www/.htpasswd
AuthName "Members only!"
AuthType Basic
require valid-user
```

Note that we are protecting the website on port 9000 that we created earlier.

And because we put the website for the Hackerspace named hunter2 in a subdirectory of the default website, we will need to adjust the AllowOverride parameter in /etc/apache2/sites-available/default as this screenshot shows (with line numbers on Debian7, your may vary).

```
9         <Directory /var/www/>
10                 Options Indexes FollowSymLinks MultiViews
11                 AllowOverride Authconfig
12                 Order allow,deny
13                 allow from all
14         </Directory>
```

Now restart the apache2 server and test that it works!
1.5. port virtual hosts on CentOS

1.5.1. default virtual host

Unlike Debian, CentOS has no virtualHost configuration file for its default website. Instead the default configuration will throw a standard error page when no index file can be found in the default location (/var/www/html).

1.5.2. three extra virtual hosts

In this scenario we create three additional websites for three customers that share a clubhouse and want to jointly hire you. They are a model train club named Choo Choo, a chess club named Chess Club 42 and a hackerspace named hunter2.

One way to put three websites on one web server, is to put each website on a different port. This screenshot shows three newly created virtual hosts, one for each customer.

```
[root@CentOS65 ~]# vi /etc/httpd/conf.d/choochoo.conf
[root@CentOS65 ~]# cat /etc/httpd/conf.d/choochoo.conf
<VirtualHost *:7000>
  ServerAdmin webmaster@localhost
  DocumentRoot /var/www/html/choochoo
</VirtualHost>
[root@CentOS65 ~]# vi /etc/httpd/conf.d/chessclub42.conf
[root@CentOS65 ~]# cat /etc/httpd/conf.d/chessclub42.conf
<VirtualHost *:8000>
  ServerAdmin webmaster@localhost
  DocumentRoot /var/www/html/chessclub42
</VirtualHost>
[root@CentOS65 ~]# vi /etc/httpd/conf.d/hunter2.conf
[root@CentOS65 ~]# cat /etc/httpd/conf.d/hunter2.conf
<VirtualHost *:9000>
  ServerAdmin webmaster@localhost
  DocumentRoot /var/www/html/hunter2
</VirtualHost>
```

Notice the different port numbers 7000, 8000 and 9000. Notice also that we specified a unique DocumentRoot for each website.

1.5.3. three extra ports

We need to enable these three ports on apache in the httpd.conf file.

```
[root@CentOS65 ~]# vi /etc/httpd/conf/httpd.conf
root@debian7:~# grep ^Listen /etc/httpd/conf/httpd.conf
Listen 80
Listen 7000
Listen 8000
Listen 9000
```
1.5.4. SELinux guards our ports

If we try to restart our server, we will notice the following error:

```
[root@CentOS65 ~]# service httpd restart
Stopping httpd:                           [  OK  ]
Starting httpd:
   (13)Permission denied: make_sock: could not bind to address 0.0.0.0:7000
no listening sockets available, shutting down
[FAILED]
```

This is due to SELinux reserving ports 7000 and 8000 for other uses. We need to tell SELinux we want to use these ports for http traffic

```
[root@CentOS65 ~]# semanage port -m -t http_port_t -p tcp 7000
[root@CentOS65 ~]# semanage port -m -t http_port_t -p tcp 8000
[root@CentOS65 ~]# service httpd restart
Stopping httpd:                           [  OK  ]
Starting httpd:                           [  OK  ]
```

1.5.5. three extra websites

Next we need to create three DocumentRoot directories.

```
[root@CentOS65 ~]# mkdir /var/www/html/choochoo
[root@CentOS65 ~]# mkdir /var/www/html/chessclub42
[root@CentOS65 ~]# mkdir /var/www/html/hunter2
```

And we have to put some really simple website in those directories.

```
[root@CentOS65 ~]# echo 'Choo Choo model train Choo Choo' > /var/www/html/choochoo/index.html
[root@CentOS65 ~]# echo 'Welcome to chess club 42' > /var/www/html/chessclub42/index.html
[root@CentOS65 ~]# echo 'HaCkInG iS fUn At HuNtEr2' > /var/www/html/hunter2/index.html
```

1.5.6. enabling extra websites

The only way to enable or disable configurations in RHEL/CentOS is by renaming or moving the configuration files. Any file in /etc/httpd/conf.d ending on .conf will be loaded by Apache. To disable a site we can either rename the file or move it to another directory.

```
The files are created, so we can tell apache.

[root@CentOS65 ~]# ls /etc/httpd/conf.d/
chessclub42.conf choochoo.conf hunter2.conf README welcome.conf
[root@CentOS65 ~]# service httpd reload
Reloading httpd:
```
1.5.7. testing the three websites

Testing the model train club named Choo Choo on port 7000.

[root@CentOS65 ~]# wget 127.0.0.1:7000
Connecting to 127.0.0.1:7000... connected.
HTTP request sent, awaiting response... 200 OK
Length: 32 [text/html]
Saving to: 'index.html'

100%[===========================================>] 32        --.-K/s   in 0s


[root@CentOS65 ~]# cat index.html
Choo Choo model train Choo Choo

Testing the chess club named Chess Club 42 on port 8000.

[root@CentOS65 ~]# wget 127.0.0.1:8000
--2014-05-11 12:01:30-- http://127.0.0.1:8000/
Connecting to 127.0.0.1:8000... connected.
HTTP request sent, awaiting response... 200 OK
Length: 25 [text/html]
Saving to: 'index.html.1'

100%[===========================================>] 25        --.-K/s   in 0s

2014-05-11 12:01:30 (4.25 MB/s) - 'index.html.1' saved [25/25]

[root@debian7:/etc/apache2 # cat index.html.1
Welcome to chess club 42

Testing the hacker club named hunter2 on port 9000.

[root@CentOS65 ~]# wget 127.0.0.1:9000
Connecting to 127.0.0.1:9000... connected.
HTTP request sent, awaiting response... 200 OK
Length: 26 [text/html]
Saving to: 'index.html.2'

100%[===========================================>] 26        --.-K/s   in 0s

2014-05-11 12:02:37 (4.49 MB/s) - 'index.html.2' saved [26/26]

[root@debian7:/etc/apache2 # cat index.html.2
HaCkInG iS fUn At HuNtEr2

Cleaning up the temporary files.

[root@CentOS65 ~]# rm index.html index.html.1 index.html.2
1.5.8. firewall rules

If we attempt to access the site from another machine however, we will not be able to view the website yet. The firewall is blocking incoming connections. We need to open these incoming ports first

[root@CentOS65 ~]# iptables -I INPUT -p tcp --dport 80 -j ACCEPT
[root@CentOS65 ~]# iptables -I INPUT -p tcp --dport 7000 -j ACCEPT
[root@CentOS65 ~]# iptables -I INPUT -p tcp --dport 8000 -j ACCEPT
[root@CentOS65 ~]# iptables -I INPUT -p tcp --dport 9000 -j ACCEPT

And if we want these rules to remain active after a reboot, we need to save them

[root@CentOS65 ~]# service iptables save
iptables: Saving firewall rules to /etc/sysconfig/iptables:[ OK ]
1.6. named virtual hosts on CentOS

1.6.1. named virtual hosts

The chess club and the model train club find the port numbers too hard to remember. They would prefere to have their website accessible by name.

We continue work on the same server that has three websites on three ports. We need to make sure those websites are accesible using the names choochoo.local, chessclub42.local and hunter2.local.

First, we need to enable named virtual hosts in the configuration

[root@CentOS65 ~]# vi /etc/httpd/conf/httpd.conf
[root@CentOS65 ~]# grep ^NameVirtualHost /etc/httpd/conf/httpd.conf
NameVirtualHost *:80
[root@CentOS65 ~]#

Next we need to create three new virtualhosts.

[root@CentOS65 ~]# vi /etc/httpd/conf.d/choochoo.local.conf
[root@CentOS65 ~]# vi /etc/httpd/conf.d/chessclub42.local.conf
[root@CentOS65 ~]# vi /etc/httpd/conf.d/hunter2.local.conf
[root@CentOS65 ~]# cat /etc/httpd/conf.d/choochoo.local.conf
<VirtualHost *:80>
  ServerAdmin webmaster@localhost
  ServerName choochoo.local
  DocumentRoot /var/www/html/choochoo
</VirtualHost>
[root@CentOS65 ~]# cat /etc/httpd/conf.d/chessclub42.local.conf
<VirtualHost *:80>
  ServerAdmin webmaster@localhost
  ServerName chessclub42.local
  DocumentRoot /var/www/html/chessclub42
</VirtualHost>
[root@CentOS65 ~]# cat /etc/httpd/conf.d/hunter2.local.conf
<VirtualHost *:80>
  ServerAdmin webmaster@localhost
  ServerName hunter2.local
  DocumentRoot /var/www/html/hunter2
</VirtualHost>
[root@CentOS65 ~]#

Notice that they all listen on port 80 and have an extra ServerName directive.

1.6.2. name resolution

We need some way to resolve names. This can be done with DNS, which is discussed in another chapter. For this demo it is also possible to quickly add the three names to the /etc/hosts file.

[root@CentOS65 ~]# grep ^192 /etc/hosts
192.168.1.225 choochoo.local
192.168.1.225 chessclub42.local
192.168.1.225 hunter2.local

Note that you may have another ip address...
1.6.3. reload and verify

After a service `httpd reload` the websites should be available by name.

```bash
[root@CentOS65 ~]# service httpd reload
Reloading httpd:
[root@CentOS65 ~]# wget chessclub42.local
Resolving chessclub42.local... 192.168.1.225
Connecting to chessclub42.local|192.168.1.225|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 25 [text/html]
Saving to: `index.html`
100%[=============================================>] 25  --.-K/s in 0s
[root@CentOS65 ~]# cat index.html
Welcome to chess club 42
```
1.7. password protected website on CentOS

You can secure files and directories in your website with a `.htaccess` file that refers to a `.htpasswd` file. The `htpasswd` command can create a `.htpasswd` file that contains a userid and an (encrypted) password.

This screenshot creates a user and password for the hacker named `cliff` and uses the `-c` flag to create the `.htpasswd` file.

```
[root@CentOS65 ~]# htpasswd -c /var/www/.htpasswd cliff
New password: 
Re-type new password: 
Adding password for user cliff
```

```
[root@CentOS65 ~]# cat /var/www/.htpasswd
cliff:QNwTrymMLBctU
```

Hacker `rob` also wants access, this screenshot shows how to add a second user and password to `.htpasswd`.

```
[root@CentOS65 ~]# htpasswd /var/www/.htpasswd rob
New password: 
Re-type new password: 
Adding password for user rob
```

```
[root@CentOS65 ~]# cat /var/www/.htpasswd
cliff:QNwTrymMLBctU
rob:EC2vOCcrMXDoM
```

Both Cliff and Rob chose the same password (hunter2), but that is not visible in the `.htpasswd` file because of the different salts.

Next we need to create a `.htaccess` file in the `DocumentRoot` of the website we want to protect. This screenshot shows an example.

```
[root@CentOS65 ~]# cat /var/www/html/hunter2/.htaccess
AuthUserFile /var/www/.htpasswd
AuthName "Members only!"
AuthType Basic 
require valid-user
```

Note that we are protecting the website on port 9000 that we created earlier.

And because we put the website for the Hackerspace named hunter2 in a subdirectory of the default website, we will need to adjust the `AllowOvveride` parameter in `/etc/httpd/conf/httpd.conf` under the `<Directory "/var/www/html"">` directive as this screenshot shows.
[root@CentOS65 ~]# vi /etc/httpd/conf/httpd.conf

<Directory "/var/www/html">

# Possible values for the Options directive are "None", "All",
# or any combination of:
# Indexes Includes FollowSymLinks SymLinksifOwnerMatch ExecCGI MultiViews

# Note that "MultiViews" must be named *explicitly* --- "Options All"
# doesn't give it to you.

# The Options directive is both complicated and important. Please see
# http://httpd.apache.org/docs/2.2/mod/core.html#options
# for more information.

Options Indexes FollowSymLinks

# AllowOverride controls what directives may be placed in .htaccess files.
# It can be "All", "None", or any combination of the keywords:
# Options FileInfo AuthConfig Limit

   AllowOverride Authconfig

# Controls who can get stuff from this server.

   Order allow,deny
   Allow from all

</Directory>

Now restart the apache2 server and test that it works!
1.8. troubleshooting apache

When apache restarts, it will verify the syntax of files in the configuration folder /etc/apache2 on debian or /etc/httpd on CentOS and it will tell you the name of the faulty file, the line number and an explanation of the error.

```
root@debian7:~# service apache2 restart
apache2: Syntax error on line 268 of /etc/apache2/apache2.conf: Syntax error on line 1 of /etc/apache2/sites-enabled/chessclub42: /etc/apache2/sites-enabled/chessclub42:4: <VirtualHost> was not closed.
/etc/apache2/sites-enabled/chessclub42:1: <VirtualHost> was not closed.
Action 'configtest' failed.
The Apache error log may have more information.
failed!
```

Below you see the problem... a missing / before on line 4.

```
root@debian7:~# cat /etc/apache2/sites-available/chessclub42
<VirtualHost *:8000>
   ServerAdmin webmaster@localhost
   DocumentRoot /var/www/chessclub42
<VirtualHost>
```

Let us force another error by renaming the directory of one of our websites:

```
root@debian7:~# mv /var/www/choochoo/ /var/www/chooshoo
root@debian7:~# !ser
```

As you can see, apache will tell you exactly what is wrong.

You can also troubleshoot by connecting to the website via a browser and then checking the apache log files in /var/log/apache.
1.9. virtual hosts example

Below is a sample virtual host configuration. This virtual hosts overrules the default Apache ErrorDocument directive.

```
<VirtualHost 83.217.76.245:80>
 ServerName cobbaut.be
 ServerAlias www.cobbaut.be
 DocumentRoot /home/paul/public_html
 ErrorLog /home/paul/logs/error_log
 CustomLog /home/paul/logs/access_log common
 ScriptAlias /cgi-bin/ /home/paul/cgi-bin/
 <Directory /home/paul/public_html>
   Options Indexes IncludesNOEXEC FollowSymLinks
   allow from all
 </Directory>
</VirtualHost>
```

1.10. aliases and redirects

Apache supports aliases for directories, like this example shows.

```
Alias /paul/ "~/home/paul/public_html/"
```

Similarly, content can be redirected to another website or web server.

```
Redirect permanent /foo http://www.foo.com/bar
```

1.11. more on .htaccess

You can do much more with .htaccess. One example is to use .htaccess to prevent people from certain domains to access your website. Like in this case, where a number of referer spammers are blocked from the website.

```
paul@lounge:~/cobbaut.be$ cat .htaccess
# Options +FollowSymLinks
RewriteEngine On
RewriteCond %{HTTP_REFERER} ^http://(www\.)?buy-adipex.fw.nu.*$ [OR]
RewriteCond %{HTTP_REFERER} ^http://(www\.)?buy-levitra.asso.ws.*$ [NC,OR]
RewriteCond %{HTTP_REFERER} ^http://(www\.)?buy-tramadol.fw.nu.*$ [NC,OR]
RewriteCond %{HTTP_REFERER} ^http://(www\.)?buy-viagra.lookin.at.*$ [NC,OR]
...
RewriteCond %{HTTP_REFERER} ^http://(www\.)?www.healthinsurancehelp.net.*$ [NC]
RewriteRule .* - [F,L]
paul@lounge:~/cobbaut.be$
```

1.12. traffic

Apache keeps a log of all visitors. The webalizer is often used to parse this log into nice html statistics.
1.13. self signed cert on Debian

Below is a very quick guide on setting up Apache2 on Debian 7 with a self-signed certificate.

Chances are these packages are already installed.

```
root@debian7:~# aptitude install apache2 openssl
No packages will be installed, upgraded, or removed.
0 packages upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
Need to get 0 B of archives. After unpacking 0 B will be used.
```

Create a directory to store the certs, and use `openssl` to create a self signed cert that is valid for 999 days.

```
root@debian7:~# mkdir /etc/ssl/localcerts
root@debian7:~# openssl req -new -x509 -days 999 -nodes -out /etc/ssl/localcerts/apache.pem -keyout /etc/ssl/localcerts/apache.key
Generating a 2048 bit RSA private key
...
...
writing new private key to '/etc/ssl/localcerts/apache.key'
-----
You are about to be asked to enter information that will be incorporated into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [AU]:BE
State or Province Name (full name) [Some-State]:Antwerp
Locality Name (eg, city) []:Antwerp
Organization Name (eg, company) [Internet Widgits Pty Ltd]:linux-training.be
Organizational Unit Name (eg, section) []:
Common Name (e.g. server FQDN or YOUR name) []:Paul
Email Address []: 
```

A little security never hurt anyone.

```
root@debian7:~# ls -l /etc/ssl/localcerts/
total 8
-rw-r--r-- 1 root root 1704 Sep 16 18:24 apache.key
-rw-r--r-- 1 root root 1302 Sep 16 18:24 apache.pem
root@debian7:~# chmod 600 /etc/ssl/localcerts/*
root@debian7:~# ls -l /etc/ssl/localcerts/
total 8
-rw------- 1 root root 1704 Sep 16 18:24 apache.key
-rw------- 1 root root 1302 Sep 16 18:24 apache.pem
```

Enable the apache ssl mod.

```
root@debian7:~# a2enmod ssl
Enabling module ssl.
See /usr/share/doc/apache2.2-common/README.Debian.gz on how to configure SSL\ and create self-signed certificates.
To activate the new configuration, you need to run:
   service apache2 restart
```

Create the website configuration.

```
root@debian7:~# vi /etc/apache2/sites-available/choochoos
```
root@debian7:~# cat /etc/apache2/sites-available/choochoos
<VirtualHost *:7000>
  ServerAdmin webmaster@localhost
  DocumentRoot /var/www/choochoos
  SSLEngine On
  SSLCertificateFile /etc/ssl/localcerts/apache.pem
  SSLCertificateKeyFile /etc/ssl/localcerts/apache.key
</VirtualHost>

And create the website itself.

root@debian7:/var/www/choochoos# vi index.html
root@debian7:/var/www/choochoos# cat index.html
Choo Choo HTTPS secured model train Choo Choo

Enable the website and restart (or reload) apache2.

root@debian7:/var/www/choochoos# a2ensite choochoos
Enabling site choochoos.
To activate the new configuration, you need to run:
  service apache2 reload
root@debian7:/var/www/choochoos# service apache2 restart
Restarting web server: apache2 ... waiting.

Chances are your browser will warn you about the self signed certificate.
1.14. self signed cert on RHEL/CentOS

Below is a quick way to create a self signed cert for https on RHEL/CentOS. You may need these packages:

```
[root@paulserver ~]# yum install httpd openssl mod_ssl
Loaded plugins: fastestmirror
Loading mirror speeds from cached hostfile
  * base: ftp.belnet.be
  * extras: ftp.belnet.be
  * updates: mirrors.vooservers.com
base           | 3.7 kB     00:00
Setting up Install Process
Package httpd-2.2.15-31.el6.centos.x86_64 already installed and latest version
Package openssl-1.0.1e-16.el6_5.15.x86_64 already installed and latest version
Package 1:mod_ssl-2.2.15-31.el6.centos.x86_64 already ins... and latest version
Nothing to do
```

We use `openssl` to create the certificate.

```
[root@paulserver ~]# mkdir certs
[root@paulserver ~]# cd certs
[root@paulserver certs]# openssl genrsa -out ca.key 2048
Generating RSA private key, 2048 bit long modulus
.........+++  
e is 65537 (0x10001)
[root@paulserver certs]# openssl req -new -key ca.key -out ca.csr
You are about to be asked to enter information that will be incorporated into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN. There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [XX]:BE
State or Province Name (full name) []:antwerp
Locality Name (eg, city) [Default City]:antwerp
Organization Name (eg, company) [Default Company Ltd]:antwerp
Organizational Unit Name (eg, section) []: 
Common Name (eg, your name or your server's hostname) []:paulserver
Email Address []:
Please enter the following 'extra' attributes to be sent with your certificate request:
A challenge password []:
An optional company name []:
[root@paulserver certs]# openssl x509 -req -days 365 -in ca.csr -signkey ca.key -out ca.crt
Signature ok
subject=/C=BE/ST=antwerp/L=antwerp/O=antwerp/CN=paulserver
Getting Private key
```

We copy the keys to the right location (You may be missing SELinux info here).

```
[root@paulserver certs]# cp ca.crt /etc/pki/tls/certs/
[root@paulserver certs]# cp ca.key ca.csr /etc/pki/tls/private/
```

We add the location of our keys to this file, and also add the `NameVirtualHost *:443` directive.

```
[root@paulserver certs]# vi /etc/httpd/conf.d/ssl.conf
```
Create a website configuration.

```
[root@paulserver certs]# grep ^SSLCerti /etc/httpd/conf.d/ssl.conf
SSLCertificateFile /etc/pki/tls/certs/ca.crt
SSLCertificateKeyFile /etc/pki/tls/private/ca.key

[root@paulserver certs]# vi /etc/httpd/conf.d/choochoos.conf
[root@paulserver certs]# cat /etc/httpd/conf.d/choochoos.conf
<VirtualHost *:443>
  SSLEngine on
  SSLCertificateFile /etc/pki/tls/certs/ca.crt
  SSLCertificateKeyFile /etc/pki/tls/private/ca.key
  DocumentRoot /var/www/choochoos
  ServerName paulserver
</VirtualHost>
[root@paulserver certs]#
```

Create a simple website and restart apache.

```
[root@paulserver certs]# mkdir /var/www/choochoos
[root@paulserver certs]# echo HTTPS model train choochoos > /var/www/choochoos/index.html
[root@paulserver httpd]# service httpd restart
Stopping httpd: [  OK  ]
Starting httpd: [  OK  ]
```

And your browser will probably warn you that this certificate is self signed.
1.15. practice: apache

1. Verify that Apache is installed and running.

2. Browse to the Apache HTML manual.

3. Create three virtual hosts that listen on ports 8472, 31337 and 1201. Test that it all works.

4. Create three named virtual hosts startrek.local, starwars.local and stargate.local. Test that it all works.

5. Create a virtual hosts that listens on another ip-address.

6. Protect one of your websites with a user/password combo.
Chapter 2. introduction to squid

2.1. about proxy servers

2.1.1. usage

A proxy server is a server that caches the internet. Clients connect to the proxy server with a request for an internet server. The proxy server will connect to the internet server on behalf of the client. The proxy server will also cache the pages retrieved from the internet server. A proxy server may provide pages from his cache to a client, instead of connecting to the internet server to retrieve the (same) pages.

A proxy server has two main advantages. It improves web surfing speed when returning cached data to clients, and it reduces the required bandwidth (cost) to the internet.

Smaller organizations sometimes put the proxy server on the same physical computer that serves as a NAT to the internet. In larger organizations, the proxy server is one of many servers in the DMZ.

When web traffic passes via a proxy server, it is common practice to configure the proxy with extra settings for access control. Access control in a proxy server can mean user account access, but also website(url), ip-address or dns restrictions.

2.1.2. open proxy servers

You can find lists of open proxy servers on the internet that enable you to surf anonymously. This works when the proxy server connects on your behalf to a website, without logging your ip-address. But be careful, these (listed) open proxy servers could be created in order to eavesdrop upon their users.

2.1.3. squid

This module is an introduction to the squid proxy server (http://www.squid-cache.org). We will first configure squid as a normal proxy server.
2.2. installing squid

This screenshot shows how to install squid on Debian with *aptitude*. Use *yum* if you are on Red Hat/CentOS.

```
root@debian7:~# aptitude install squid
The following NEW packages will be installed:
  squid squid-common[a] squid-langpack[a]
0 packages upgraded, 3 newly installed, 0 to remove and 0 not upgraded.
Need to get 1,513 kB of archives. After unpacking 4,540 kB will be used.
Do you want to continue? [Y/n/?]
...output truncated...
Setting up squid-langpack (20120616-1) ...
Setting up squid-common (2.7.STABLE9-4.1) ...
Setting up squid (2.7.STABLE9-4.1) ...
Creating squid spool directory structure
2014/08/01 15:19:31| Creating Swap Directories
Restarting Squid HTTP proxy: squid.
```

*squid*’s main configuration file is */etc/squid/squid.conf*. The file explains every parameter in great detail.

```
root@debian7:~# wc -l /etc/squid/squid.conf
4948 /etc/squid/squid.conf
```

2.3. port 3128

By default the *squid* proxy server will listen to port **3128**.

```
root@debian7:~# grep ^http_port /etc/squid/squid.conf
http_port 3128
root@debian7:~#
```

2.4. starting and stopping

You can manage *squid* with the standard *service* command as shown in this screenshot.

```
root@debian7:~# service squid start
Starting Squid HTTP proxy: squid.
root@debian7:~# service squid restart
Restarting Squid HTTP proxy: squid.
root@debian7:~# service squid status
squid is running.
root@debian7:~# service squid stop
Stopping Squid HTTP proxy: squid.
root@debian7:~#
```
2.5. client proxy settings

To enable a proxy server in Firefox or Iceweasel go to Edit Preferences and configure as shown in this screenshot (replace 192.168.1.60 with the ip address of your proxy server).

Test that your internet works with the proxy enabled. Also test that after a service squid stop command on your proxy server that you get a message similar to this screenshot.
To enable a proxy server with Google Chrome (or Debian Chromium) start the program from the command line like this:

```
paul@debian7:~$ chromium --proxy-server='192.168.1.60:3128'
```

Disabling the proxy with `service squid stop` should result in an error message similar to this screenshot.
introduction to squid

2.6. upside down images
A proxy server sits inbetween your browser and the internet. So besides caching of internet
data (the original function of a proxy server) and besides firewall like restrictions based on
www content, a proxy server is in the perfect position to alter the webpages that you visit.
You could for instance change the advertising on a webpage (or remove certain advertisers),
or like we do in this example; change all images so they are upside down.
The server needs command line tools to manipulate images and a perl script that uses these
tools (and wget to download the images locally and serve them with apache2). In this
example we use imagemagick (which provides tools like convert and mogrify).
root@debian7:~# aptitude install imagemagick wget perl apache2
...output truncated...
root@debian7:~# dpkg -S $(readlink -f $(which mogrify))
imagemagick: /usr/bin/mogrify.im6
root@debian7:~#

The perl script that is shown in the screenshot below can be found on several websites, yet
I have not found the original author. It is however a very simple script that uses wget and
mogrify to download images (.jpg .gif and .png), flip them and store them in /var/www/
images.
root@debian7:~# cat /usr/local/bin/flip.pl
#!/usr/bin/perl
$|=1;
$count = 0;
$pid = $$;
while (<>) {
chomp $_;
if ($_ =~ /(.*\.jpg)/i) {
$url = $1;
system("/usr/bin/wget", "-q", "-O","/var/www/images/$pid-$count.jpg", "$url");
system("/usr/bin/mogrify", "-flip","/var/www/images/$pid-$count.jpg");
print "http://127.0.0.1/images/$pid-$count.jpg\n";
}
elsif ($_ =~ /(.*\.gif)/i) {
$url = $1;
system("/usr/bin/wget", "-q", "-O","/var/www/images/$pid-$count.gif", "$url");
system("/usr/bin/mogrify", "-flip","/var/www/images/$pid-$count.gif");
print "http://127.0.0.1/images/$pid-$count.gif\n";
}
elsif ($_ =~ /(.*\.png)/i) {
$url = $1;
system("/usr/bin/wget", "-q", "-O","/var/www/images/$pid-$count.png", "$url");
system("/usr/bin/mogrify", "-flip","/var/www/images/$pid-$count.png");
print "http://127.0.0.1/images/$pid-$count.png\n";
}
else {
print "$_\n";;
}
$count++;
}

Change (or enable) also the following line in /etc/squid/suiqd.conf.
http_access allow localnet
http_port 3128 transparent

37


url_rfwrite_program /usr/local/bin/flip.pl

The directory this script uses is /var/www/images and should be accessible by both the squid server (which uses the user named proxy and by the apache2 webserver (which uses the user www-data). The screenshot below shows how to create this directory, set the permissions and make the users a member of the other groups.

root@debian7:~# mkdir /var/www/images
root@debian7:~# chown www-data:www-data /var/www/images
root@debian7:~# chmod 755 /var/www/images
root@debian7:~# usermod -aG www-data proxy
root@debian7:~# usermod -aG proxy www-data

Test that it works after restarting squid and apache2.
2.7. /var/log/squid

The standard log file location for squid is /var/log/squid.

```
[root@RHEL4 ~]# grep "/var/log" /etc/squid/squid.conf
# cache_access_log /var/log/squid/access.log
# cache_log /var/log/squid/cache.log
# cache_store_log /var/log/squid/store.log
```

2.8. access control

The default squid setup only allows localhost access. To enable access for a private network range, look for the "INSERT YOUR OWN RULE(S) HERE..." sentence in squid.conf and add two lines similar to the screenshot below.

```
# INSERT YOUR OWN RULE(S) HERE TO ALLOW ACCESS FROM YOUR CLIENTS

acl company_network src 192.168.1.0/24
http_access allow company_network
```

2.9. testing squid

First, make sure that the server running squid has access to the internet.

```
[root@RHEL4 ~]# wget -q http://linux-training.be/index.html
[root@RHEL4 ~]# ls -l index.html
-rw-r--r--  1 root root 2269 Sep 18 13:18 index.html
[root@RHEL4 ~]#
```

Then configure a browser on a client to use the proxy server, or you could set the HTTP_PROXY (sometimes http_proxy) variable to point command line programs to the proxy.

```
[root@fedora ~]# export HTTP_PROXY=http://192.168.1.39:8080
[root@ubuntu ~]# export http_proxy=http://192.168.1.39:8080
```

Testing a client machine can then be done with wget (wget -q is used to simplify the screenshot).

```
[root@RHEL5 ~]# > /etc/resolv.conf
[root@RHEL5 ~]# wget -q http://www.linux-training.be/index.html
[root@RHEL5 ~]# ls -l index.html
-rw-r--r--  1 root root 2269 Sep 18  2008 index.html
[root@RHEL5 ~]#
```

2.10. name resolution

You need name resolution working on the squid server, but you don't need name resolution on the clients.

```
[paul@RHEL5 ~]$ wget http://grep.be
--14:35:44--  http://grep.be
Resolving grep.be... failed: Temporary failure in name resolution.
[paul@RHEL5 ~]$ wget http://grep.be
--14:35:49--  http://grep.be/
```
Connecting to 192.168.1.39:8080... connected.  
Proxy request sent, awaiting response... 200 OK  
Length: 5390 (5.3K) [text/html]  
Saving to: `index.html.1'

100%[================================>] 5,390  --.K/s  in 0.1s

14:38:29 (54.8 KB/s) - `index.html' saved [5390/5390]

[paul@RHEL5 ~]$
Part II. mysql database
Table of Contents

3. introduction to sql using mysql ................................................................. 43
  3.1. installing mysql ................................................................................. 44
  3.2. accessing mysql .............................................................................. 45
  3.3. mysql databases ............................................................................... 47
  3.4. mysql tables ..................................................................................... 49
  3.5. mysql records ................................................................................. 51
  3.6. joining two tables ........................................................................... 54
  3.7. mysql triggers .................................................................................. 55
Chapter 3. Introduction to SQL using MySQL

MySQL is a database server that understands Structured Query Language (SQL). MySQL was developed by the Swedish Company MySQL AB. The first release was in 1995. In 2008 MySQL AB was bought by Sun Microsystems (which is now owned by Oracle).

MySQL is very popular for websites in combination with PHP and Apache (the M in LAMP servers), but MySQL is also used in organizations with huge databases like Facebook, Flickr, Google, Nokia, Wikipedia and Youtube.

This chapter will teach you SQL by creating and using small databases, tables, queries and a simple trigger in a local MySQL server.
3.1. installing mysql

On Debian/Ubuntu you can use **aptitude install mysql-server** to install the **mysql server** and **client**.

```
root@ubuntu1204~# aptitude install mysql-server
The following NEW packages will be installed:
   libdbd-mysql-perl(a) libdbi-perl(a) libhtml-template-perl(a)
   libnet-daemon-perl(a) libplrpc-perl(a) mysql-client-5.5(a)
   mysql-client-core-5.5(a) mysql-server mysql-server-5.5(a)
   mysql-server-core-5.5(a)
0 packages upgraded, 10 newly installed, 0 to remove and 1 not upgraded.
Need to get 25.5 MB of archives. After unpacking 88.4 MB will be used.
Do you want to continue? [Y/n/?]
```

During the installation you will be asked to provide a password for the **root mysql user**, remember this password (or use **hunter2** like i do).

To verify the installed version, use **dpkg -l** on Debian/Ubuntu. This screenshot shows version 5.0 installed.

```
root@ubuntu1204~# dpkg -l mysql-server | tail -1 | tr -s ' ' | cut -c-72
ii mysql-server 5.5.24-0ubuntu0.12.04.1 MySQL database server (metapacka
```

Issue **rpm -q** to get version information about MySQL on Red Hat/Fedora/CentOS.

```
[paul@RHEL52 ~]$ rpm -q mysql-server
mysql-server-5.0.45-7.el5
```

You will need at least version 5.0 to work with **triggers**.
3.2. accessing mysql

3.2.1. Linux users

The installation of mysql creates a user account in /etc/passwd and a group account in /etc/group.

```bash
kevin@ubu1204$ tail -1 /etc/passwd
mysql:x:120:131:MySQL Server,,,:/nonexistent:/bin/false
kevin@ubu1204$ tail -1 /etc/group
mysql:x:131:
```

The mysql daemon mysqld will run with the credentials of this user and group.

```bash
root@ubu1204# ps -eo uid,user,gid,group,comm | grep mysqld
  120 mysql      131 mysql    mysqld
```

3.2.2. mysql client application

You can now use mysql from the commandline by just typing mysql -u root -p and you'll be asked for the password (of the mysql root account). In the screenshot below the user typed exit to exit the mysql console.

```bash
root@ubu1204# mysql -u root -p
Enter password:
Welcome to the MySQL monitor. Commands end with ; or \g.
Your MySQL connection id is 43
Server version: 5.5.24-0ubuntu0.12.04.1 (Ubuntu)
Copyright (c) 2000, 2011, Oracle and/or its affiliates. All rights reserved.
Oracle is a registered trademark of Oracle Corporation and/or its affiliates. Other names may be trademarks of their respective owners.
Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.
mysql>
```

You could also put the password in clear text on the command line, but that would not be very secure. Anyone with access to your bash history would be able to read your mysql root password.

```bash
root@ubu1204# mysql -u root -phunter2
Welcome to the MySQL monitor. Commands end with ; or \g.
...```
3.2.3. ~/.my.cnf

You can save configuration in your home directory in the hidden file `.my.cnf`. In the screenshot below we put the root user and password in `.my.cnf`.

```bash
kevin@ubuntu:~$ pwd
/home/kevin
kevin@ubuntu:~$ cat .my.cnf
[client]
user=root
password=hunter2
kevin@ubuntu:~$
```

This enables us to log on as the root mysql user just by typing `mysql`.

```bash
kevin@ubuntu:~$ mysql
Welcome to the MySQL monitor. Commands end with ; or \g.
Your MySQL connection id is 56
Server version: 5.5.24-0ubuntu0.12.04.1 (Ubuntu)
```

3.2.4. the mysql command line client

You can use the `mysql` command to take a look at the databases, and to execute SQL queries on them. The screenshots below show you how.

Here we execute the command `show databases`. Every command must be terminated by a delimiter. The default delimiter is `;` (the semicolon).

```sql
mysql> show databases;
+----------------------+
| Database             |
+----------------------+
| information_schema   |
| mysql                |
| performance_schema   |
| test                 |
+----------------------+
4 rows in set (0.00 sec)
```

We will use this prompt in the next sections.
3.3. mysql databases

3.3.1. listing all databases

You can use the `mysql` command to take a look at the databases, and to execute SQL queries on them. The screenshots below show you how. First, we log on to our MySQL server and execute the command `show databases` to see which databases exist on our mysql server.

```
kevin@ubuntu:~$ mysql
Welcome to the MySQL monitor. Commands end with ; or \g.
Your MySQL connection id is 57
Server version: 5.5.24-0ubuntu0.12.04.1 (Ubuntu)
Copyright (c) 2000, 2011, Oracle and/or its affiliates. All rights reserved.

Oracle is a registered trademark of Oracle Corporation and/or its affiliates. Other names may be trademarks of their respective owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

mysql> show databases;
+--------------------+
| Database           |
+--------------------+
| information_schema |
| mysql              |
| performance_schema |
| test               |
+--------------------+
4 rows in set (0.00 sec)
```

3.3.2. creating a database

You can create a new database with the `create database` command.

```
mysql> create database famouspeople;
Query OK, 1 row affected (0.00 sec)

mysql> show databases;
+--------------------+
| Database           |
+--------------------+
| information_schema |
| famouspeople       |
| mysql              |
| performance_schema |
| test               |
+--------------------+
5 rows in set (0.00 sec)
```
3.3.3. using a database

Next we tell mysql to use one particular database with the use $database command. This screenshot shows how to make wikidb the current database (in use).

mysql> use famouspeople;
Database changed
mysql>

3.3.4. access to a database

To give someone access to a mysql database, use the grant command.

mysql> grant all on famouspeople.* to kevin@localhost IDENTIFIED BY "hunter2";
Query OK, 0 rows affected (0.00 sec)

3.3.5. deleting a database

When a database is no longer needed, you can permanently remove it with the drop database command.

mysql> drop database demodb;
Query OK, 1 row affected (0.09 sec)

3.3.6. backup and restore a database

You can take a backup of a database, or move it to another computer using the mysql and mysqldump commands. In the screenshot below, we take a backup of the wikidb database on the computer named laika.

mysqldump -u root famouspeople > famouspeople.backup.20120708.sql

Here is a screenshot of a database restore operation from this backup.

mysql -u root famouspeople < famouspeople.backup.20120708.sql
3.4. mysql tables

3.4.1. listing tables

You can see a list of tables in the current database with the `show tables;` command. Our `famouspeople` database has no tables yet.

```
mysql> use famouspeople;
Database changed
mysql> show tables;
Empty set (0.00 sec)
```

3.4.2. creating a table

The `create table` command will create a new table.

This screenshot shows the creation of a country table. We use the `countrycode` as a primary key (all country codes are uniquely defined). Most country codes are two or three letters, so a `char` of three uses less space than a `varchar` of three. The `country name` and the name of the capital are both defined as `varchar`. The population can be seen as an `integer`.

```
mysql> create table country (  
   -> countrycode char(3) NOT NULL,  
   -> countryname varchar(70) NOT NULL,  
   -> population int,  
   -> countrycapital varchar(50),  
   -> primary key (countrycode)  
   -> );
Query OK, 0 rows affected (0.19 sec)
```

```
mysql> show tables;
+------------------------+
| Tables_in_famouspeople |
+------------------------+
| country                |
+------------------------+
1 row in set (0.00 sec)
```

You are allowed to type the `create table` command on one long line, but administrators often use multiple lines to improve readability.

```
mysql> create table country (  
   -> countrycode char(3) NOT NULL,  
   -> countryname varchar(70) NOT NULL,  
   -> population int,  
   -> countrycapital varchar(50),  
   -> primary key (countrycode)  
   -> );
Query OK, 0 rows affected (0.18 sec)
```
3.4.3. describing a table

To see a description of the structure of a table, issue the `describe $tablename` command as shown below.

mysql> describe country;
+----------------+-------------+------+-----+---------+-------+
| Field          | Type        | Null | Key | Default | Extra |
+----------------+-------------+------+-----+---------+-------+
| countrycode    | char(3)     | NO   | PRI | NULL    |       |
| countryname    | varchar(70) | NO   |     | NULL    |       |
| population     | int(11)     | YES  |     | NULL    |       |
| countrycapital | varchar(50) | YES  |     | NULL    |       |
+----------------+-------------+------+-----+---------+-------+
4 rows in set (0.00 sec)

3.4.4. removing a table

To remove a table from a database, issue the `drop table $tablename` command as shown below.

mysql> drop table country;
Query OK, 0 rows affected (0.00 sec)
3.5. mysql records

3.5.1. creating records

Use `insert` to enter data into the table. The screenshot shows several insert statements that insert values depending on the position of the data in the statement.

```
mysql> insert into country values ('BE','Belgium','11000000','Brussels');
Query OK, 1 row affected (0.05 sec)

mysql> insert into country values ('DE','Germany','82000000','Berlin');
Query OK, 1 row affected (0.05 sec)

mysql> insert into country values ('JP','Japan','128000000','Tokyo');
Query OK, 1 row affected (0.05 sec)
```

Some administrators prefer to use uppercase for SQL keywords. The mysql client accepts both.

```
mysql> INSERT INTO country VALUES ('FR','France','64000000','Paris');
Query OK, 1 row affected (0.00 sec)
```

Note that you get an error when using a duplicate primary key.

```
mysql> insert into country values ('DE','Germany','82000000','Berlin');
ERROR 1062 (23000): Duplicate entry 'DE' for key 'PRIMARY'
```

3.5.2. viewing all records

Below an example of a simple `select` query to look at the contents of a table.

```
mysql> select * from country;
+-------------+---------------+------------+----------------+
| countrycode | countryname   | population | countrycapital |
|-------------+---------------+------------+----------------|
| BE          | Belgium       |   11000000 | Brussels       |
| CN          | China         | 1400000000 | Beijing        |
| DE          | Germany       |   82000000 | Berlin         |
| FR          | France        |  640000000 | Paris          |
| IN          | India         | 1300000000 | New Delhi      |
| JP          | Japan         | 128000000  | Tokyo          |
| MX          | Mexico        |  113000000 | Mexico City    |
| US          | United States |  313000000 | Washington     |
+-------------+---------------+------------+----------------+
8 rows in set (0.00 sec)
```
3.5.3. updating records

Consider the following `insert` statement. The capital of Spain is not Barcelona, it is Madrid.

```sql
mysql> insert into country values ('ES','Spain','48000000','Barcelona');
Query OK, 1 row affected (0.08 sec)
```

Using an `update` statement, the record can be updated.

```sql
mysql> update country set countrycapital='Madrid' where countrycode='ES';
Query OK, 1 row affected (0.07 sec)
Rows matched: 1  Changed: 1  Warnings: 0
```

We can use a `select` statement to verify this change.

```sql
mysql> select * from country;
+-------------+---------------+------------+----------------+
<table>
<thead>
<tr>
<th>countrycode</th>
<th>countryname</th>
<th>population</th>
<th>countrycapital</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE</td>
<td>Belgium</td>
<td>11000000</td>
<td>Brussels</td>
</tr>
<tr>
<td>CN</td>
<td>China</td>
<td>1400000000</td>
<td>Beijing</td>
</tr>
<tr>
<td>DE</td>
<td>Germany</td>
<td>82000000</td>
<td>Berlin</td>
</tr>
<tr>
<td>ES</td>
<td>Spain</td>
<td>48000000</td>
<td>Madrid</td>
</tr>
<tr>
<td>FR</td>
<td>France</td>
<td>64000000</td>
<td>Paris</td>
</tr>
<tr>
<td>IN</td>
<td>India</td>
<td>1300000000</td>
<td>New Delhi</td>
</tr>
<tr>
<td>JP</td>
<td>Japan</td>
<td>1280000000</td>
<td>Tokyo</td>
</tr>
<tr>
<td>MX</td>
<td>Mexico</td>
<td>1130000000</td>
<td>Mexico City</td>
</tr>
<tr>
<td>US</td>
<td>United States</td>
<td>3130000000</td>
<td>Washington</td>
</tr>
</tbody>
</table>
+-------------+---------------+------------+----------------+
9 rows in set (0.00 sec)
```

3.5.4. viewing selected records

Using a `where` clause in a `select` statement, you can specify which record(s) you want to see.

```sql
mysql> SELECT * FROM country WHERE countrycode='ES';
+-------------+---------------+------------+----------------+
<table>
<thead>
<tr>
<th>countrycode</th>
<th>countryname</th>
<th>population</th>
<th>countrycapital</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES</td>
<td>Spain</td>
<td>48000000</td>
<td>Madrid</td>
</tr>
</tbody>
</table>
+-------------+---------------+------------+----------------+
1 row in set (0.00 sec)
```

Another example of the `where` clause.

```sql
mysql> select * from country where countryname='Spain';
+-------------+---------------+------------+----------------+
<table>
<thead>
<tr>
<th>countrycode</th>
<th>countryname</th>
<th>population</th>
<th>countrycapital</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES</td>
<td>Spain</td>
<td>48000000</td>
<td>Madrid</td>
</tr>
</tbody>
</table>
+-------------+---------------+------------+----------------+
1 row in set (0.00 sec)
```

3.5.5. primary key in where clause?

The primary key of a table is a field that uniquely identifies every record (every row) in the table. When using another field in the `where` clause, it is possible to get multiple rows returned.

```sql
mysql> insert into country values ('EG','Egypt','82000000','Cairo');
```
3.5.6. ordering records

We know that `select` allows us to see all records in a table. Consider this table.

```sql
mysql> select countryname,population from country;
+---------------+------------+
| countryname   | population |
+---------------+------------+
| Belgium       | 11000000   |
| China         | 1400000000 |
| Germany       | 82000000   |
| Egypt         | 82000000   |
| Spain         | 48000000   |
| France        | 64000000   |
| India         | 1300000000 |
| Japan         | 128000000  |
| Mexico        | 113000000  |
| United States | 313000000  |
+---------------+------------+
10 rows in set (0.00 sec)
```

Using the `order by` clause, we can change the order in which the records are presented.

```sql
mysql> select countryname,population from country order by countryname;
+---------------+------------+
| countryname   | population |
+---------------+------------+
| Belgium       | 11000000   |
| China         | 1400000000 |
| Egypt         | 82000000   |
| France        | 64000000   |
| Germany       | 82000000   |
| India         | 1300000000 |
| Japan         | 128000000  |
| Mexico        | 113000000  |
| Spain         | 48000000   |
| United States | 313000000  |
+---------------+------------+
10 rows in set (0.00 sec)
```

3.5.7. grouping records

Consider this table of people. The screenshot shows how to use the `avg` function to calculate an average.

```sql
mysql> select * from people;
+-----------------+-----------+-----------+-------------+
| Name            | Field     | birthyear | countrycode |
+-----------------+-----------+-----------+-------------+
| Barack Obama    | politics  | 1961      | US          |
| Deng Xiaoping   | politics  | 1904      | CN          |
+-----------------+-----------+-----------+-------------+
```

Query OK, 1 row affected (0.33 sec)
| Guy Verhofstadt | politics | 1953 | BE  |
| Justine Henin  | tennis   | 1982 | BE  |
| Kim Clijsters  | tennis   | 1983 | BE  |
| Li Na          | tennis   | 1982 | CN  |
| Liu Yang       | astronaut| 1978 | CN  |
| Serena Williams| tennis   | 1981 | US  |
| Venus Williams | tennis   | 1980 | US  |

Using the `group by` clause, we can have an average per field.

```sql
mysql> select Field,AVG(birthyear) from people group by Field;
```

```sql
+-----------+--------------------+
| Field     | AVG(birthyear)     |
|-----------+--------------------+
| astronaut |               1978 |
| politics  | 1939.3333333333333 |
| tennis    |             1981.6 |
+-----------+--------------------+
```

### 3.5.8. deleting records

You can use the `delete` to permanently remove a record from a table.

```sql
mysql> delete from country where countryname='Spain';
```

Query OK, 1 row affected (0.06 sec)

```sql
mysql> select * from country where countryname='Spain';
```

Empty set (0.00 sec)

### 3.6. joining two tables

#### 3.6.1. inner join

With an `inner join` you can take values from two tables and combine them in one result. Consider the country and the people tables from the previous section when looking at this screenshot of an `inner join`.

```sql
mysql> select Name,Field,countryname
    -> from country
    -> inner join people on people.countrycode=country.countrycode;
```

```sql
+-----------------+-----------+---------------+
| Name            | Field     | countryname   |
|-----------------+-----------+---------------+
| Barack Obama    | politics  | United States |
| Deng Xiaoping   | politics  | China         |
| Guy Verhofstadt | politics  | Belgium       |
| Justine Henin   | tennis    | Belgium       |
| Kim Clijsters   | tennis    | Belgium       |
| Li Na           | tennis    | China         |
```
This **inner join** will show only records with a match on **countrycode** in both tables.

### 3.6.2. left join

A **left join** is different from an **inner join** in that it will take all rows from the left table, regardless of a match in the right table.

```sql
mysql> select Name, Field, countryname from country left join people on people.countrycode=country.countrycode;
```

<table>
<thead>
<tr>
<th>Name</th>
<th>Field</th>
<th>countryname</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guy Verhofstadt</td>
<td>politics</td>
<td>Belgium</td>
</tr>
<tr>
<td>Justine Henin</td>
<td>tennis</td>
<td>Belgium</td>
</tr>
<tr>
<td>Kim Clijsters</td>
<td>tennis</td>
<td>Belgium</td>
</tr>
<tr>
<td>Deng Xiaoping</td>
<td>politics</td>
<td>China</td>
</tr>
<tr>
<td>Li Na</td>
<td>tennis</td>
<td>China</td>
</tr>
<tr>
<td>Liu Yang</td>
<td>astronaut</td>
<td>China</td>
</tr>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>Germany</td>
</tr>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>Egypt</td>
</tr>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>Spain</td>
</tr>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>France</td>
</tr>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>India</td>
</tr>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>Japan</td>
</tr>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>Mexico</td>
</tr>
<tr>
<td>Barack Obama</td>
<td>politics</td>
<td>United States</td>
</tr>
<tr>
<td>Serena Williams</td>
<td>tennis</td>
<td>United States</td>
</tr>
<tr>
<td>Venus Williams</td>
<td>tennis</td>
<td>United States</td>
</tr>
</tbody>
</table>
```

16 rows in set (0.00 sec)

You can see that some countries are present, even when they have no matching records in the **people** table.

### 3.7. mysql triggers

#### 3.7.1. using a before trigger

Consider the following **create table** command. The last field (**amount**) is the multiplication of the two fields named **unitprice** and **unitcount**.

```sql
mysql> create table invoices (
    -> id char(8) NOT NULL,
    -> customerid char(3) NOT NULL,
    -> unitprice int,
    -> unitcount smallint,
    -> amount int );
Query OK, 0 rows affected (0.00 sec)
```

We can let mysql do the calculation for that by using a **before trigger**. The screenshot below shows the creation of a trigger that calculates the amount by multiplying two fields that are about to be inserted.

```sql
mysql> create trigger total_amount before INSERT on invoices
```
Here we verify that the trigger works by inserting a new record, without providing the total amount.

mysql> insert into invoices values ('20090526','ABC','199','10','');
Query OK, 1 row affected (0.02 sec)

Looking at the record proves that the trigger works.

mysql> select * from invoices;
+----------+------------+-----------+-----------+--------+
| id       | customerid | unitprice | unitcount | amount |
+----------+------------+-----------+-----------+--------+
| 20090526 | ABC        |       199 |        10 |   1990 |
+----------+------------+-----------+-----------+--------+
1 row in set (0.00 sec)

3.7.2. removing a trigger

When a trigger is no longer needed, you can delete it with the drop trigger command.

mysql> drop trigger total_amount;
Query OK, 0 rows affected (0.00 sec)
Part III. dns server
# Table of Contents

## 4. introduction to DNS
- 4.1. about dns ................................................................. 60
- 4.2. dns namespace ............................................................. 63
- 4.3. caching only servers ....................................................... 68
- 4.4. authoritative dns servers ............................................... 71
- 4.5. primary and secondary ................................................. 71
- 4.6. zone transfers ............................................................... 71
- 4.7. master and slave ......................................................... 73
- 4.8. SOA record ................................................................. 73
- 4.9. full or incremental zone transfers ................................. 74
- 4.10. DNS cache ................................................................. 75
- 4.11. forward lookup zone example .................................... 76
- 4.12. example: caching only DNS server ............................. 77
- 4.13. example: caching only with forwarder ......................... 79
- 4.14. example: primary authoritative server ....................... 81
- 4.15. example: a DNS slave server .................................... 85
- 4.16. practice: dns ............................................................. 87
- 4.17. solution: dns ............................................................. 88

## 5. advanced DNS ............................................................... 89
- 5.1. example: DNS round robin .......................................... 90
- 5.2. DNS delegation ........................................................... 91
- 5.3. example: DNS delegation ............................................ 92
- 5.4. example: split-horizon dns .......................................... 94
- 5.5. old dns topics ............................................................. 96
Chapter 4. introduction to DNS

dns is a fundamental part of every large computer network. dns is used by many network services to translate names into network addresses and to locate services on the network (by name).

Whenever you visit a web site, send an e-mail, log on to Active Directory, play Minecraft, chat, or use VoIP, there will be one or (many) more queries to dns services.

Should dns fail at your organization, then the whole network will grind to a halt (unless you hardcoded the network addresses).

You will notice that even the largest of organizations benefit greatly from having one dns infrastructure. Thus dns requires all business units to work together.

Even at home, most home modems and routers have builtin dns functionality.

This module will explain what dns actually is and how to set it up using Linux and bind9.
4.1. about dns

4.1.1. name to ip address resolution

The **domain name system** or **dns** is a service on a tcp/ip network that enables clients to translate names into ip addresses. Actually **dns** is much more than that, but let's keep it simple for now.

When you use a browser to go to a website, then you type the name of that website in the url bar. But for your computer to actually communicate with the web server hosting said website, your computer needs the ip address of that web server. That is where **dns** comes in.

In wireshark you can use the **dns** filter to see this traffic.

![Where is google.com?](image)

192.168.1.30

212.71.8.10

4.1.2. history

In the Seventies, only a few hundred computers were connected to the internet. To resolve names, computers had a flat file that contained a table to resolve hostnames to ip addresses. This local file was downloaded from **hosts.txt** on an ftp server in Stanford.

In 1984 **Paul Mockapetris** created **dns**, a distributed treelike hierarchical database that will be explained in detail in these chapters.

Today, **dns** or **domain name system** is a worldwide distributed hierarchical database controlled by **ICANN**. Its primary function is to resolve names to ip addresses, and to point to internet servers providing **smtp** or **ldap** services.

The old **hosts.txt** file is still active today on most computer systems under the name **/etc/hosts** (or C:/Windows/System32/Drivers/etc/hosts). We will discuss this file later, as it can influence name resolution.
4.1.3. forward and reverse lookup queries

The question a client asks a DNS server is called a query. When a client queries for an IP address, this is called a forward lookup query (as seen in the previous drawing).

The reverse, a query for the name of a host, is called a reverse lookup query.

Below a picture of a reverse lookup query.

Here is a screenshot of a reverse lookup query in nslookup.

```
root@debian7:~# nslookup
> set type=PTR
> 188.93.155.87
Server:         192.168.1.42
Address:        192.168.1.42#53
Non-authoritative answer:
87.155.93.188.in-addr.arpa name = antares.ginsys.net.
```

This is what a reverse lookup looks like when sniffing with tcpdump.

```
root@debian7:~# tcpdump udp port 53
listening on eth0, link-type EN10MB (Ethernet), capture size 65535 bytes
11:01:29.357685 IP 192.168.1.103.42041 > 192.168.1.42.domain: 14763+ PTR
87.155.93.188.in-addr.arpa. (44)
11:01:29.640093 IP 192.168.1.42.domain > 192.168.1.103.42041: 14763 1/0
/0 PTR antares.ginsys.net. (76)
```

And here is what it looks like in Wireshark (note this is an older screenshot).
4.1.4. /etc/resolv.conf

A client computer needs to know the ip address of the dns server to be able to send queries to it. This is either provided by a dhcp server or manually entered.

Linux clients keep this information in the /etc/resolv.conf file.

```bash
root@debian7:~# cat /etc/resolv.conf
domain linux-training.be
search linux-training.be
nameserver 192.168.1.42
root@debian7:~#
```

You can manually change the ip address in this file to use another dns server. For example Google provides a public name server at 8.8.8.8 and 8.8.4.4.

```bash
root@debian7:~# cat /etc/resolv.conf
nameserver 8.8.8.8
root@debian7:~#
```

Please note that on dhcp clients this value can be overwritten when the dhcp lease is renewed.
4.2. dns namespace

4.2.1. hierarchy

The dns namespace is hierarchical tree structure, with the root servers (aka dot-servers) at the top. The root servers are usually represented by a dot.

Below the root-servers are the Top Level Domains or tld's.

There are more tld's than shown in the picture. Currently about 200 countries have a tld. And there are several general tld's like .com, .edu, .org, .gov, .net, .mil, .int and more recently also .aero, .info, .museum, ...

4.2.2. root servers

There are thirteen root servers on the internet, they are named A to M. Journalists often refer to these servers as the master servers of the internet, because if these servers go down, then nobody can (use names to) connect to websites.

The root servers are not thirteen physical machines, they are many more. For example the F root server consists of 46 physical machines that all behave as one (using anycast).

http://root-servers.org
http://f.root-servers.org
4.2.3. root hints

Every **dns server software** will come with a list of **root hints** to locate the **root servers**.

This screenshot shows a small portion of the root hints file that comes with **bind 9.8.4**.

```bash
root@debian7:~# grep -w 'A ' /etc/bind/db.root
A.ROOT-SERVERS.NET.      3600000      A     198.41.0.4
B.ROOT-SERVERS.NET.      3600000      A     192.228.79.201
C.ROOT-SERVERS.NET.      3600000      A     192.33.4.12
D.ROOT-SERVERS.NET.      3600000      A     199.7.91.13
E.ROOT-SERVERS.NET.      3600000      A     192.203.230.10
F.ROOT-SERVERS.NET.      3600000      A     192.5.5.241
G.ROOT-SERVERS.NET.      3600000      A     192.112.36.4
H.ROOT-SERVERS.NET.      3600000      A     128.63.2.53
I.ROOT-SERVERS.NET.      3600000      A     192.36.148.17
J.ROOT-SERVERS.NET.      3600000      A     192.58.128.30
K.ROOT-SERVERS.NET.      3600000      A     193.0.14.129
L.ROOT-SERVERS.NET.      3600000      A     199.7.83.42
M.ROOT-SERVERS.NET.      3600000      A     202.12.27.33
root@debian7:~#
```

4.2.4. domains

One level below the **top level domains** are the **domains**. Domains can have subdomains (also called child domains).

This picture shows **dns domains** like google.com, chess.com, linux-training.be (there are millions more).

![Diagram showing DNS domains like google.com, chess.com, linux-training.be](image)

DNS domains are registered at the **tld servers**, the **tld servers** are registered at the **dot servers**.
### 4.2.5. top level domains

Below the root level are the **top level domains** or **tld's**. Originally there were only seven defined:

**Table 4.1. the first top level domains**

<table>
<thead>
<tr>
<th>Year</th>
<th>TLD</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>.arpa</td>
<td>Reverse lookup via in-addr.arpa</td>
</tr>
<tr>
<td>1985</td>
<td>.com</td>
<td>Commercial Organizations</td>
</tr>
<tr>
<td>1985</td>
<td>.edu</td>
<td>US Educational Institutions</td>
</tr>
<tr>
<td>1985</td>
<td>.gov</td>
<td>US Government Institutions</td>
</tr>
<tr>
<td>1985</td>
<td>.mil</td>
<td>US Military</td>
</tr>
<tr>
<td>1985</td>
<td>.net</td>
<td>Internet Service Providers, Internet Infrastructure</td>
</tr>
<tr>
<td>1985</td>
<td>.org</td>
<td>Non profit Organizations</td>
</tr>
<tr>
<td>1988</td>
<td>.int</td>
<td>International Treaties like nato.int</td>
</tr>
</tbody>
</table>

Country **tld's** were defined for individual countries, like **.uk** in 1985 for Great Britain (yes really), **.be** for Belgium in 1988 and **.fr** for France in 1986. See RFC 1591 for more info.

In 1998 seven new general purpose **tld's** were chosen, they became active in the 21st century.

**Table 4.2. new general purpose tld's**

<table>
<thead>
<tr>
<th>Year</th>
<th>TLD</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>.aero</td>
<td>aviation related</td>
</tr>
<tr>
<td>2001</td>
<td>.biz</td>
<td>businesses</td>
</tr>
<tr>
<td>2001</td>
<td>.coop</td>
<td>for co-operatives</td>
</tr>
<tr>
<td>2001</td>
<td>.info</td>
<td>informative internet resources</td>
</tr>
<tr>
<td>2001</td>
<td>.museum</td>
<td>for museums</td>
</tr>
<tr>
<td>2001</td>
<td>.name</td>
<td>for all kinds of names, pseudonyms and labels...</td>
</tr>
<tr>
<td>2004</td>
<td>.pro</td>
<td>for professionals</td>
</tr>
</tbody>
</table>

Many people were surprised by the choices, claiming not much use for them and wanting a separate **.xxx** domain (introduced in 2011) for adult content, and **.kidz** a save haven for children. In the meantime more useless **tld's** were create like **.travel** (for travel agents) and **.tel** (for internet communications) and **.jobs** (for jobs sites).

In 2012 **ICANN** released a list of 2000 new **tld's** that would gradually become available.
4.2.6. fully qualified domain name

The fully qualified domain name or fqdn is the combination of the hostname of a machine appended with its domain name.

If for example a system is called gwen and it is in the domain linux-training.be, then the fqdn of this system is gwen.linux-training.be.

On Linux systems you can use the hostname and dnsdomainname commands to verify this information.

```bash
root@gwen:~# hostname
gwen
root@gwen:~# dnsdomainname
linux-training.be
root@gwen:~# hostname --fqdn
gwen.linux-training.be
root@gwen:~# cat /etc/debian_version
6.0.10
```

4.2.7. dns zones

A zone (aka a zone of authority) is a portion of the DNS tree that covers one domain name or child domain name. The picture below represents zones as blue ovals. Some zones will contain delegate authority over a child domain to another zone.

A dns server can be authoritative over 0, 1 or more dns zones. We will see more details later on the relation between a dns server and a dns zone.

A dns zone consists of records, also called resource records. We will list some of those resource records on the next page.
4.2.8. dns records

A record

The A record, which is also called a host record contains the ipv4-address of a computer. When a DNS client queries a DNS server for an A record, then the DNS server will resolve the hostname in the query to an ip address. An AAAA record is similar but contains an ipv6 address instead of ipv4.

PTR record

A PTR record is the reverse of an A record. It contains the name of a computer and can be used to resolve an ip address to a hostname.

NS record

A NS record or nameserver record is a record that points to a DNS name server (in this zone). You can list all your name servers for your DNS zone in distinct NS records.

glue A record

An A record that maps the name of an NS record to an ip address is said to be a glue record.

SOA record

The SOA record of a zone contains meta information about the zone itself. The contents of the SOA record is explained in detail in the section about zone transfers. There is exactly one SOA record for each zone.

CNAME record

A CNAME record maps a hostname to a hostname, creating effectively an alias for an existing hostname. The name of the mail server is often aliased to mail or smtp, and the name of a web server to www.

MX record

The MX record points to an smtp server. When you send an email to another domain, then your mail server will need the MX record of the target domain's mail server.
4.3. caching only servers

A **dns server** that is set up without **authority** over a **zone**, but that is connected to other name servers and caches the queries is called a **caching only name server**. Caching only name servers do not have a **zone database** with resource records. Instead they connect to other name servers and cache that information.

There are two kinds of caching only name servers. Those with a **forwarder**, and those that use the **root servers**.
4.3.1. caching only server without forwarder

A caching only server without forwarder will have to get information elsewhere. When it receives a query from a client, then it will consult one of the root servers. The root server will refer it to a tld server, which will refer it to another dns server. That last server might know the answer to the query, or may refer to yet another server. In the end, our hard working dns server will find an answer and report this back to the client.

In the picture below, the clients asks for the ip address of linux-training.be. Our caching only server will contact the root server, and be refered to the .be server. It will then contact the .be server and be refered to one of the name servers of Openminds. One of these name servers (in this case ns1.openminds.be) will answer the query with the ip address of linux-training.be. When our caching only server reports this to the client, then the client can connect to this website.

Sniffing with tcpdump will give you this (the first 20 characters of each line are cut).

```
M.ROOT-SERVERS.NET.domain > 192.168.1.103.41251: 37279- 0/11/13 (740)
d.ns.dns.be.domain > 192.168.1.103.65268: 38555- 0/7/5 (737)
ns2.openminds.be.domain > 192.168.1.103.7514: 60888*- 1/0/1 A 188.93.155.87 (62)
```
4.3.2. caching only server with forwarder

A caching only server with a forwarder is a DNS server that will get all its information from the forwarder. The forwarder must be a dns server for example the dns server of an internet service provider.

This picture shows a dns server on the company LAN that has set the dns server from their isp as a forwarder. If the ip address of the isp dns server is 212.71.8.10, then the following lines would occur in the named.conf file of the company dns server:

```plaintext
forwarders {
    212.71.8.10;
};
```

You can also configure your dns server to work with conditional forwarder(s). The definition of a conditional forwarder looks like this.

```plaintext
zone "someotherdomain.local" {
    type forward;
    forward only;
    forwarders { 10.104.42.1; };
};
```

4.3.3. iterative or recursive query

A recursive query is a DNS query where the client that is submitting the query expects a complete answer (Like the fat red arrow above going from the Macbook to the DNS server). An iterative query is a DNS query where the client does not expect a complete answer (the three black arrows originating from the DNS server in the picture above). Iterative queries usually take place between name servers. The root name servers do not respond to recursive queries.
4.4. authoritative dns servers

A DNS server that is controlling a zone, is said to be the authoritative DNS server for that zone. Remember that a zone is a collection of resource records.

4.5. primary and secondary

When you set up the first authoritative dns server for a zone, then this is called the primary dns server. This server will have a readable and writable copy of the zone database. For reasons of fault tolerance, performance or load balancing you may decide to set up another dns server with authority over that zone. This is called a secondary dns server.

4.6. zone transfers

The slave server receives a copy of the zone database from the master server using a zone transfer. Zone transfers are requested by the slave servers at regular intervals. Those intervals are defined in the soa record.

You can force a refresh from a zone with rndc. The example below force a transfer of the fred.local zone, and shows the log from /var/log/syslog.

```
root@debian7:/etc/bind# rndc refresh fred.local
```
root@debian7:/etc/bind# grep fred /var/log/syslog | tail -7 | cut -c38-
zone fred.local/IN: sending notifies (serial 1)
received control channel command 'refresh fred.local'
zone fred.local/IN: Transfer started.
transfer of 'fred.local/IN' from 10.104.109.1#53: connected using 10.104.33.30#57367
zone fred.local/IN: transferred serial 2
transfer of 'fred.local/IN' from 10.104.109.1#53: Transfer completed: 1 messages, 10 records, 264 bytes, 0.001 secs (264000 bytes/sec)
zone fred.local/IN: sending notifies (serial 2)
root@debian7:/etc/bind#
4.7. master and slave

When adding a secondary dns server to a zone, then you will configure this server as a slave server to the primary server. The primary server then becomes the master server of the slave server.

Often the primary dns server is the master server of all slaves. Sometimes a slave server is master server for a second line slave server. In the picture below ns1 is the primary dns server and ns2, ns3 and ns4 are secondaries. The master for slaves ns2 and ns3 is ns1, but the master for ns4 is ns2.

4.8. SOA record

The soa record contains a refresh value. If this is set to 30 minutes, then the slave server will request a copy of the zone file every 30 minutes. There is also a retry value. The retry value is used when the master server did not reply to the last zone transfer request. The value for expiry time says how long the slave server will answer to queries, without receiving a zone update.

Below an example of how to use nslookup to query the soa record of a zone (linux-training.be).

```
root@debian6:~# nslookup
> set type=SOA
> server ns1.openminds.be
> linux-training.be
Server:         ns1.openminds.be
Address:        195.47.215.14#53

linux-training.be
 origin = ns1.openminds.be
 mail addr = hostmaster.openminds.be
 serial = 2321001133
 refresh = 14400
 retry = 3600
 expire = 604800
 minimum = 3600
```

Zone transfers only occur when the zone database was updated (meaning when one or more resource records were added, removed or changed on the master server). The slave server
will compare the **serial number** of its own copy of the SOA record with the serial number of its master’s SOA record. When both serial numbers are the same, then no update is needed (because no records were added, removed or deleted). When the slave has a lower serial number than its master, then a zone transfer is requested.

Below a zone transfer captured in wireshark.

<table>
<thead>
<tr>
<th>Time</th>
<th>Source</th>
<th>Destination</th>
<th>Protocol</th>
<th>Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 0.000000</td>
<td>192.168.1.37</td>
<td>192.168.1.35</td>
<td>DNS</td>
<td>Standard query SOA cobbau.paul</td>
</tr>
<tr>
<td>2 0.000502</td>
<td>192.168.1.35</td>
<td>192.168.1.37</td>
<td>DNS</td>
<td>Standard query response SOA ns.cobbau.paul</td>
</tr>
<tr>
<td>3 0.014672</td>
<td>192.168.1.37</td>
<td>192.168.1.35</td>
<td>TCP</td>
<td>33713 &gt; domain [SYN] Seq=0 Win=5840 Len=0 MS</td>
</tr>
<tr>
<td>4 0.015215</td>
<td>192.168.1.35</td>
<td>192.168.1.37</td>
<td>TCP</td>
<td>domain &gt; 33713 [SYN, ACK] Seq=0 Ack=1 Win=57</td>
</tr>
<tr>
<td>5 0.015307</td>
<td>192.168.1.37</td>
<td>192.168.1.35</td>
<td>TCP</td>
<td>33713 &gt; domain [ACK] Seq=1 Ack=1 Win=5856 Len=0</td>
</tr>
<tr>
<td>6 0.015954</td>
<td>192.168.1.37</td>
<td>192.168.1.35</td>
<td>TCP</td>
<td>[TCP segment of a reassembled PDU]</td>
</tr>
<tr>
<td>7 0.018359</td>
<td>192.168.1.35</td>
<td>192.168.1.37</td>
<td>TCP</td>
<td>domain &gt; 33713 [ACK] Seq=1 Ack=3 Win=5792 Len=0</td>
</tr>
<tr>
<td>8 0.018411</td>
<td>192.168.1.35</td>
<td>192.168.1.35</td>
<td>DNS</td>
<td>Standard query IXFR cobbau.paul</td>
</tr>
<tr>
<td>9 0.018023</td>
<td>192.168.1.35</td>
<td>192.168.1.37</td>
<td>TCP</td>
<td>domain &gt; 33713 [ACK] Seq=1 Ack=77 Win=5792 Len=0</td>
</tr>
<tr>
<td>10 0.019784</td>
<td>192.168.1.35</td>
<td>192.168.1.35</td>
<td>DNS</td>
<td>Standard query response SOA ns.cobbau.paul</td>
</tr>
<tr>
<td>11 0.019821</td>
<td>192.168.1.35</td>
<td>192.168.1.35</td>
<td>TCP</td>
<td>33713 &gt; domain [ACK] Seq=77 Ack=295 Win=6912</td>
</tr>
<tr>
<td>12 0.028618</td>
<td>192.168.1.35</td>
<td>192.168.1.35</td>
<td>TCP</td>
<td>33713 &gt; domain [FIN, ACK] Seq=77 Ack=295 Win=6912</td>
</tr>
<tr>
<td>13 0.021011</td>
<td>192.168.1.35</td>
<td>192.168.1.35</td>
<td>TCP</td>
<td>domain &gt; 33713 [FIN, ACK] Seq=295 Ack=78 Win=6912</td>
</tr>
</tbody>
</table>

### 4.9. full or incremental zone transfers

When a zone transfer occurs, this can be either a full zone transfer or an incremental zone transfer. The decision depends on the size of the transfer that is needed to completely update the zone on the slave server. An incremental zone transfer is preferred when the total size of changes is smaller than the size of the zone database. Full zone transfers use the **axfr** protocol, incremental zone transfer use the **ixfr** protocol.
4.10. DNS cache

DNS is a caching protocol.

When a client queries its local DNS server, and the local DNS server is not authoritative for the query, then this server will go looking for an authoritative name server in the DNS tree. The local name server will first query a root server, then a tld server and then a domain server. When the local name server resolves the query, then it will relay this information to the client that submitted the query, and it will also keep a copy of these queries in its cache. So when a(nother) client submits the same query to this name server, then it will retrieve this information form its cache.

For example, a client queries for the A record on www.linux-training.be to its local server. This is the first query ever received by this local server. The local server checks that it is not authoritative for the linux-training.be domain, nor for the .be tld, and it is also not a root server. So the local server will use the root hints to send an iterative query to a root server.

The root server will reply with a reference to the server that is authoritative for the .be domain (root DNS servers do not resolve fqdn's, and root servers do not respond to recursive queries).

The local server will then sent an iterative query to the authoritative server for the .be tld. This server will respond with a reference to the name server that is authoritative for the linux-training.be domain.

The local server will then sent the query for www.linux-training.be to the authoritative server (or one of its slave servers) for the linux-training.be domain. When the local server receives the ip address for www.linux-training.be, then it will provide this information to the client that submitted this query.

Besides caching the A record for www.linux-training.be, the local server will also cache the NS and A record for the linux-training.be name server and the .be name server.
4.11. forward lookup zone example

The way to set up zones in /etc/bind/named.conf.local is to create a zone entry with a reference to another file (this other file contains the zone database).

Here is an example of such an entry in /etc/bind/named.conf.local:

```
root@debian7:~# cat /etc/bind/named.conf.local
//
// Do any local configuration here
//
// Consider adding the 1918 zones here, if they are not used in your organization
//include "/etc/bind/zones.rfc1918";

zone "paul.local" IN {
    type master;
    file "/etc/bind/db.paul.local";
    allow-update { none; };
};
root@debian7:~#
```

To create the zone file, the easy method is to copy an existing zone file (this is easier than writing from scratch).

```
root@debian7:/etc/bind# cp db.empty db.paul.local
root@debian7:/etc/bind# vi db.paul.local
```

Here is an example of a zone file.

```
root@debian7:/etc/bind# cat db.paul.local
; zone for classroom teaching
$TTL 86400
@ IN SOA debianpaul.paul.local. root.paul.local (2014100100 ; Serial
1h ; Refresh
1h ; Retry
2h ; Expire
86400 ) ; Negative Cache TTL
;
; name servers
;
IN NS ns1
IN NS debianpaul
IN NS debian7
;
; servers
;
debianpaul IN A 10.104.33.30
debian7 IN A 10.104.33.30
ns1 IN A 10.104.33.30
;www IN A 10.104.33.30
```
4.12. example: caching only DNS server

1. installing DNS software on Debian

```bash
root@debian7:~# aptitude update && aptitude upgrade
...
root@debian7:~# aptitude install bind9
...
root@debian7:~# dpkg -l | grep bind9 | tr -s ' '
ii bind9 1:9.8.4.dfsg.1-6+nmu2+deb7u2 amd64 Internet Domain Name Server
ii bind9-host 1:9.8.4.dfsg.1-6+nmu2+deb7u2 amd64 Version of 'host' bundled...
ii bind9-utils 1:9.8.4.dfsg.1-6+nmu2+deb7u2 amd64 Utilities for BIND
ii libbind9-80 1:9.8.4.dfsg.1-6+nmu2+deb7u2 amd64 BIND9 Shared Library use...
root@debian7:~#
```

2. Discover the default configuration files. Can you define the purpose of each file?

```bash
root@debian7:~# ls -l /etc/bind
```
```
total 52
-rw-r--r-- 1 root root 2389 Sep  5 20:25 bind.keys
-rw-r--r-- 1 root root  237 Sep  5 20:25 db.0
-rw-r--r-- 1 root root  271 Sep  5 20:25 db.127
-rw-r--r-- 1 root root  237 Sep  5 20:25 db.255
-rw-r--r-- 1 root root  353 Sep  5 20:25 db.empty
-rw-r--r-- 1 root root  270 Sep  5 20:25 db.local
-rw-r--r-- 1 root root  3048 Sep  5 20:25 db.root
-rw-r--r-- 1 root bind  463 Sep  5 20:25 named.conf
-rw-r--r-- 1 root bind  490 Sep  5 20:25 named.conf.default-zones
-rw-r--r-- 1 root bind  374 Oct  1 20:01 named.conf.local
-rw-r--r-- 1 root bind  913 Oct  1 13:24 named.conf.options
-rw-r--r-- 1 bind bind  77 Oct  1 11:14 rndc.key
-rw-r--r-- 1 root root 1317 Sep  5 20:25 zones.rfc191
```

3. Setup caching only dns server. This is normally the default setup. A caching-only name server will look up names for you and cache them. Many tutorials will tell you to add a **forwarder**, but we first try without this!

Hey this seems to work without a **forwarder**. Using a sniffer you can find out what really happens. Your freshly install dns server is not using a cache, and it is not using your local dns server (from `/etc/resolv.conf`). So where is this information coming from? And what can you learn from sniffing this dns traffic?
4. Explain in detail what happens when you enable a caching only DNS server without a forwarder. This Wireshark screenshot can help, but you learn more by sniffing the traffic yourself.

You should see traffic to a root name server whenever you try a new TLD for the first time. Remember that DNS is a caching protocol, which means that repeating a query will generate a lot less traffic since your DNS server will still have the answer in its memory.
4.13. example: caching only with forwarder

5. Add the public Google dns server as a forwarder. The ip address of this server is 8.8.8.

Before the change:

```
root@debian7:~# grep -A2 'forwarders {' /etc/bind/named.conf.options
// forwarders {
//      0.0.0.0;
// };
```

changing:
```
root@debian7:~# vi /etc/bind/named.conf.options
```

After the change:
```
root@debian7:~# grep -A2 'forwarders {' /etc/bind/named.conf.options
forwarders {
   8.8.8.8;
};
```

Restart the server:
```
root@debian7:~# service bind9 restart
Stopping domain name service...: bind9.
Starting domain name service...: bind9.
```

6. Explain the purpose of adding the forwarder. What is our dns server doing when it receives a query ?

```
root@debian7:~# nslookup
> server
Default server: 10.104.33.30
Address: 10.104.33.30#53
> linux-training.be
Server: 10.104.33.30
Address: 10.104.33.30#53

Non-authoritative answer:
Name: linux-training.be
Address: 188.93.155.87
```

This is the output of tcpdump udp port 53 while executing the above query for linux-training.be in nslookup.

```
root@debian7:~# tcpdump udp port 53
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on eth0, link-type EN10MB (Ethernet), capture size 65535 bytes

You should find the following two lines in the output of tcpdump:

```
googel-public-dns-a.google.com.domain > 10.104.33.30.19381: 18237 1/0/1 A 188\n.93.155.87 (62)
```
Below is an (old) wireshark screenshot that can help, you should see something similar (but with different ip addresses).

7. What happens when you query for the same domain name more than once ?

8. Why does it say "non-authoritative answer" ? When is a dns server authoritative ?

9. You can also use **dig** instead of **nslookup**.

```
root@debian7:~# dig @10.104.33.30 linux-training.be +short
188.93.155.87
root@debian7:~#
```

10. How can we avoid having to set the server in dig or nslookup ?

Change this:

```
root@debian7:~# cat /etc/resolv.conf
nameserver 10.46.101.1
root@debian7:~#
```

into this:

```
root@debian7:~# cat /etc/resolv.conf
nameserver 10.104.33.30
root@debian7:~#
```

11. When you use **dig** for the first time for a domain, where is the answer coming from ? And the second time ? How can you tell ?
4.14. example: primary authoritative server

1. Instead of only caching the information from other servers, we will now make our server authoritative for our own domain.

2. I choose the top level domain .local and the domain paul.local and put the information in /etc/bind/named.conf.local.

   ```
   root@debian7:~# cat /etc/bind/named.conf.local
   //
   // Do any local configuration here
   //
   // Consider adding the 1918 zones here, if they are not used in your
   // organization
   //include "/etc/bind/zones.rfc1918";
   
   zone "paul.local" IN {
     type master;
     file "/etc/bind/db.paul.local";
     allow-update { none; };
   };
   
   Also add a zone database file, similar to this one (add some A records for testing). Set the Refresh and Retry values not too high so you can sniff this traffic (this example makes the slave server contact the master every hour).

   ```

   ```
   root@debian7:~# cat /etc/bind/db.paul.local
   $TTL    86400
   @       IN      SOA     debianpaul.paul.local. root.paul.local ( 
       2014100101      ; Serial
       1h              ; Refresh
       1h              ; Retry
       2h              ; Expire
       900 )           ; Negative Cache TTL
   ;
   ; name servers
   ;
   IN      NS      nsl
   IN      NS      debianpaul
   IN      NS      debian7
   ;
   ; servers
   debianpaul   IN      A       10.104.33.30
   debian7      IN      A       10.104.33.30
   nsl          IN      A       10.104.33.30
   www          IN      A       10.104.33.30
   root@debian7:~#```

   Note that the www record is commented out, so it will not resolve.
4.14.1. using your own DNS server

If you are confident that your dns server works, then set it as default and only dns server in /etc/resolv.conf.

```
root@debian7:~# cat /etc/resolv.conf
nameserver 10.104.33.30
root@debian7:~#
```

In case you also use dhclient, you will need to add your dns server to /etc/dhcp/dhclient.conf.

```
root@debian7:~# diff /etc/dhcp/dhclient.conf /etc/dhcp/dhclient.conf.original
21c21
< prepend domain-name-servers 10.104.33.30;
---
> #prepend domain-name-servers 127.0.0.1;
23,24c23
< #     domain-name, domain-name-servers, domain-search, host-name,
<    domain-name, domain-name-servers, domain-search, host-name,
---
>    domain-name, domain-name-servers, domain-search, host-name,
root@debian7:~#
```

The above screenshot shows that 10.104.33.30 is now a default option that the dhcp client should no longer request from the dhcp server.

Adjust /etc/hosts to reflect your domain name and verify with hostname and dnsdomainname.

```
root@debian7:~# grep debian7 /etc/hosts
127.0.1.1 debian7.paul.local debian7
root@debian7:~# hostname
debian7
root@debian7:~# hostname --fqdn
debian7.paul.local
root@debian7:~# dnsdomainname
paul.local
```
4.14.2. using your own domain

Consider the following screenshot:

```
root@debian7b:~# cat /etc/resolv.conf
nameserver 10.104.33.30
root@debian7b:~# ping -c1 www
ping: unknown host www
root@debian7b:~# vi /etc/resolv.conf
root@debian7b:~# cat /etc/resolv.conf
nameserver 10.104.33.30
domain paul.local
root@debian7b:~# ping -c1 www
PING www.paul.local (10.104.33.31) 56(84) bytes of data.
64 bytes from 10.104.33.31: icmp_req=1 ttl=64 time=0.021 ms
--- www.paul.local ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.021/0.021/0.021/0.000 ms
root@debian7b:~#
```

Adding the **domain paul.local** directive to `/etc/resolv.conf` allows omitting the domain when using hostnames.

You can accomplish this feature automatically by adjusting **dhclient.conf**.

```
root@debian7:~# grep paul.local /etc/dhcp/dhclient.conf
prepend domain-name "paul.local";
prepend domain-search "paul.local";
root@debian7:~#
```
4. Restart the DNS server and check your zone in the error log.

```
root@debian7:~# service bind9 restart
Stopping domain name service...: bind9.
Starting domain name service...: bind9.
root@debian7:~# grep paul.local /var/log/syslog
Oct  6 09:22:18 debian7 named[2707]: zone paul.local/IN: loaded seria\l
Oct  6 09:22:18 debian7 named[2707]: zone paul.local/IN: sending notifi\\n```

5. Use `dig` or `nslookup` (or even `ping`) to test your A records.

```
root@debian7:~# ping -c1 ns1.paul.local
PING ns1.paul.local (10.104.33.30) 56(84) bytes of data.
64 bytes from 10.104.33.30: icmp_req=1 ttl=64 time=0.006 ms
--- ns1.paul.local ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.006/0.006/0.006/0.000 ms
root@debian7:~# ping -c1 www.paul.local
ping: unknown host www.paul.local
```

Note that the `www` record was commented out, so it should fail.

```
root@debian7:~# dig debian7.paul.local
; <<>> DiG 9.8.4-rcpz2+rl005.12-P1 <<>> debian7.paul.local
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 50491
;; flags: qr aa rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 3, ADDITIONAL: 2

;; QUESTION SECTION:
debian7.paul.local. IN A

;; ANSWER SECTION:
debian7.paul.local. 86400 IN A 10.104.33.30

;; AUTHORITY SECTION:
paul.local. 86400 IN NS ns1.paul.local.
paul.local. 86400 IN NS debian7.paul.local.
paul.local. 86400 IN NS debianpaul.paul.local.

;; ADDITIONAL SECTION:
ns1.paul.local. 86400 IN A 10.104.33.30
debianpaul.paul.local. 86400 IN A 10.104.33.30

;; Query time: 4 msec
;; SERVER: 10.104.33.30#53(10.104.33.30)
;; WHEN: Mon Oct  6 09:35:25 2014
;; MSG SIZE  rcvd: 141
```

6. Our primary server appears to be up and running. Note the information here:

```
server os : Debian 7
ip address : 10.104.33.30
domain name: paul.local
server name: ns1.paul.local
```
4.15. example: a DNS slave server

1. A slave server transfers zone information over the network from a master server (a slave can also be a master). A primary server maintains zone records in its local file system. As an exercise, and to verify the work of all students, set up a slave server of all the master servers in the classroom.

2. Before configuring the slave server, we may have to allow transfers from our zone to this server. Remember that this is not very secure since transfers are in clear text and limited to an ip address. This example follows our demo from above.

Imagine a student named Jesse having completed the setup as shown before, with the domain name jesse.local and the ip address 10.104.15.20. The goal is to have a slave server of paul.local on Jesse's computer and a slave zone of jesse.local on my computer.

Below is an example of an allow-transfer statement. Careful, maybe the default allows transfer to any.

```bash
root@debian7:/etc/bind# cat named.conf.local
#
# Do any local configuration here
#
#
# Consider adding the 1918 zones here, if they are not used in your
# organization
#include "/etc/bind/zones.rfc1918";

zone "paul.local" IN {
    type master;
    file "/etc/bind/db.paul.local";
    allow-update { none; };
    allow-transfer { 10.104.15.20; };
};
```
3. With the configuration below I can make my server a slave for the **jesse.local** zone.

```bash
root@debian7:/etc/bind# tail -6 named.conf.local
zone "jesse.local" IN {
    type slave;
    file "/var/cache/named/db.jesse.local";
    masters { 10.104.15.20; };
};
```

Note that we put the **slave zones** in `/var/cache/named` and not in `/etc/bind`.

4. Restarting bind on the slave server should transfer the zone database file. Verify this in `/var/log/syslog`.

```bash
root@debian7:/etc/bind# grep jesse /var/log/syslog
named[2731]: zone jesse.local/IN: Transfer started.
named[2731]: transfer of 'jesse.local/IN' from 10.104.15.20#53: connected using 10.104.33.30#44719
named[2731]: zone jesse.local/IN: transferred serial 20110516
named[2731]: transfer of 'jesse.local/IN' from 10.104.15.20#53: Transfer completed: 1 messages, 8 records, 239 bytes, 0.001 secs (239000 bytes/sec)
```

And the contents of the **slave zone**:

```bash
root@debian7:/etc/bind# cat /var/cache/named/db.jesse.local
$ORIGIN .
$TTL 604800 ; 1 week
jesse.local IN SOA ns.jesse.local. root.jesse.local.jesse.local. ( 20110516 ; serial
300 ; refresh (5 minutes)
200 ; retry (3 minutes 20 seconds)
2419200 ; expire (4 weeks)
604800 ; minimum (1 week)
)
NS ns.jesse.local.
$ORIGIN jesse.local.
anya A 10.104.15.1
mac A 10.104.15.30
ns A 10.104.15.20
ubu1010srv A 10.104.15.20
www A 10.104.15.25
```

root@debian7:/etc/bind#
4.16. practice: dns

1. Install **bind9** and verify with a sniffer how it works.

2. Add a **forwarder** and verify that it works.

3. Create a **primary forward lookup zone** named yourname.local with at least two NS records and four A records.

4. Use **dig** and **nslookup** to verify your NS and A records.

5. Create a **slave** of your primary zone (on another server) and verify the **zone transfer**.

6. Set up two primary zones on two servers and implement a **conditional forwarder** (you can use the two servers from before).
4.17. solution: dns

1. Install **bind9** and verify with a sniffer how it works.

You should see queries to the root name servers with **tcpdump** or **wireshark**.

2. Add a **forwarder** and verify that it works.

The forwarder can be added in named.conf.options as seen in the theory.

3. Create a **primary forward lookup zone** named yourname.local with at least two NS records and four A records.

This is literally explained in the theory.

4. Use **dig** and **nslookup** to verify your NS and A records.

This is literally explained in the theory.

5. Create a **slave** of your primary zone (on another server) and verify the **zone transfer**.

This is literally explained in the theory.

6. Set up two primary zones on two servers and implement a **conditional forwarder** (you can use the two servers from before).

A conditional forwarder is set in named.conf.local as a zone.

(see the theory on forwarder)
Chapter 5. advanced DNS

This chapter expands your DNS server with topics like round robin dns for load balancing servers, dns delegation to delegate child domains to another team and split horizon dns so you can provide local service locations to clients.

There is more to dns, content will be added rsn.
5.1. example: DNS round robin

When you create multiple A records for the same name, then bind will do a round robin of the order in which the records are returned. This allows the use of DNS as a load balancer between hosts, since clients will usually take the first ip-address offered.

Consider this example from the /etc/bind/db.paul.local zone configuration file. There are two A records for www pointing to two distinct ip addresses.

```
root@debian7:~# grep www /etc/bind/db.paul.local
www             IN      A       10.104.33.30
www             IN      A       10.104.33.31
```

Below a screenshot of nslookup querying a load balanced A record. Notice the order of ip addresses returned.

```
root@debian7:~# nslookup www.paul.local 10.104.33.30
Server:         10.104.33.30
Address:        10.104.33.30#53
Name:   www.paul.local
Address: 10.104.33.31
Name:   www.paul.local
Address: 10.104.33.30

root@debian7:~# nslookup www.paul.local 10.104.33.30
Server:         10.104.33.30
Address:        10.104.33.30#53
Name:   www.paul.local
Address: 10.104.33.30
Name:   www.paul.local
Address: 10.104.33.31
```

Try to set up a website on two web servers (with a small difference so you can distinguish the websites) and test the round robin.
5.2. DNS delegation

You can delegate a child domain to another DNS server. The child domain then becomes a new zone, with authority at the new DNS server.

When delegation is properly set up, then clients that query your parent zone will also be able to resolve the delegated child zones.
5.3. example: DNS delegation

We have another Linux server named `debian7b` and we want to make it responsible for the child domain `test42.paul.local`.

*Note the name of the servers in the screenshots are either `debian7` (hosting the parent domain) or `debian7b` (hosting the child domain).*

We start by adjusting the `/etc/bind/named.conf.local` file (on the server hosting the parent domain) to make sure that no forwarder will be used when resolving authoritative names.

```
root@debian7:~# grep -A4 paul.local /etc/bind/named.conf.local
zone "paul.local" IN {
    type master;
    file "/etc/bind/db.paul.local";
    allow-update { none; }
    allow-transfer { 10.104.15.20; }
    forwarders { }
};
```

Technically, you could also set `allow-transfer` to `{ any; }` while troubleshooting and then refine it later, but this is not needed for delegation.

Then we add the delegation to our zone database:

```
root@debian7:~# tail -3 /etc/bind/db.paul.local
$ORIGIN test42.paul.local.
@       IN      NS      ns2.test42.paul.local.
ns2     IN      A       10.104.33.31 ; the glue record
```

Don’t forget to restart `bind` and verify `/var/log/syslog`.

```
root@debian7:~# service bind9 restart
Stopping domain name service...: bind9.
Starting domain name service...: bind9.
```

```
root@debian7:~# grep paul.local /var/log/syslog | cut -c28- | tail -2
named[3202]: zone paul.local/IN: loaded serial 2014100801
named[3202]: zone paul.local/IN: sending notifies (serial 2014100801)
```

*Note that on your terminal you can type `tail -40 /var/log/syslog` because the only reason I use `grep`, `cut` and `tail -2` is to limit the size of the screenshots in this book.*
Next we create a zone database file on the second server, as seen in this screenshot:

```sh
root@debian7b:~# cat /etc/bind/db.test42.paul.local
; child zone for classroom teaching
$TTL 86400
$ORIGIN test42.paul.local.
@       IN      SOA     ns2.test42.paul.local. root.test42.paul.local. (2014100802 ; Serial
1h        ; Refresh
1h        ; Retry
2h        ; Expire
900 )     ; Negative Cache TTL

; name servers
;
IN      NS      ns2.test42.paul.local.
IN      NS      debian7b.test42.paul.local.

; servers
;
ns2             IN      A       10.104.33.31
debian7b        IN      A       10.104.33.31
testsrv         IN      A       10.104.33.31
```

The second server also needs a zone definition in `named.conf.local`, followed by a restart of `bind`.

```sh
root@debian7b:~# cat /etc/bind/named.conf.local
//
// Do any local configuration here
//
// Consider adding the 1918 zones here, if they are not used in your organization
// include "/etc/bind/zones.rfc1918";
zone "test42.paul.local" IN {
    type master;
    file "/etc/bind/db.test42.paul.local";
    allow-update { none; };
    allow-transfer { any; };
};
```

Testing on the parent server:

```sh
root@debian7:~# dig ns1.paul.local +short
10.104.33.30
root@debian7:~# dig ns2.test42.paul.local +short
10.104.33.31
root@debian7:~# dig debian7b.test42.paul.local +short
10.104.33.31
```
5.4. example: split-horizon dns

Suppose you want to answer dns queries depending on who is asking. For example when someone from the 10.104.15.0/24 network (managed by Jesse) asks for the A record www.paul.local, then dns answers with 10.104.33.30. But when someone from the 10.104.42.0/24 network (managed by Keith) asks for the same A record of www.paul.local, he will get 10.104.33.31 as an answer.

A **split-horizon** setup can be used to redirect people to local copies of certain services.

In this example we want to decide on specific answers for two networks (Jesse’s and Keith’s) and prevent them from using our dns server for recursion, while maintaining the capability to resolve the internet and our paul.local zone from our own network.

We start by creating three view clauses in `named.conf.local`.

```
root@debian7:/etc/bind# cat named.conf.local
view "paul" {
    match-clients { 10.104.33.0; localhost; };
    include "/etc/bind/named.conf.default-zones";
    zone "paul.local" IN {
        type master;
        file "/etc/bind/db.paul.local";
        allow-update { none; };
    };
}; // end view internal

view "jesse" {
    match-clients { 10.104.15/24; };
    zone "paul.local" IN {
        type master;
        file "/etc/bind/db.paul.local.jesse";
        allow-update { none; };
    };
}; // end view jesse

view "keith" {
    match-clients { 10.104.42/24; };
    zone "paul.local" IN {
        type master;
        file "/etc/bind/db.paul.local.keith";
        allow-update { none; };
    };
}; // end view keith
```

Note that we included the default-zones in the internal zone. It is mandatory to put all zones inside views when using a view.

The zone files are identical copies, except for the www record. You can see that the round robin is still active for internal users, computers from 10.104.15.0/24 (Jesse) will always receive 10.104.33.30 while computers from 10.104.42.0/24 (Keith) will receive 10.104.33.31.

```
root@debian7:/etc/bind# grep www db.paul.local db.paul.local.[jk]*
db.paul.local:www               IN      A       10.104.33.30
db.paul.local:www               IN      A       10.104.33.31
db.paul.local.jesse:www         IN      A       10.104.33.30
db.paul.local.keith:www         IN      A       10.104.33.31
```
5.5. old dns topics

All the dns things below this paragraph are old and in urgent need of review.

5.5.1. old example: reverse DNS

1. We can add ip to name resolution to our dns-server using a reverse dns zone.

2. Start by adding a .arpa zone to /etc/bind/named.conf.local like this (we set notify to no to avoid sending of notify messages to other name servers):

```bash
root@ubu1010srv:/etc/bind# grep -A4 arpa named.conf.local
zone "1.168.192.in-addr.arpa" {
    type master;
    notify no;
    file "/etc/bind/db.192";
};
```

3. Also create a zone database file for this reverse lookup zone.

```bash
root@ubu1010srv:/etc/bind# cat db.192
;
; BIND reverse data file for 192.168.1.0/24 network
;
$TTL 604800
@ IN SOA ns.cobbaut.paul root.cobbaut.paul. ( 
    20110516 ; Serial
    604800 ; Refresh
    86400 ; Retry
    2419200 ; Expire
    604800 ) ; Negative Cache TTL
;
@ IN NS ns.
37 IN PTR ns.cobbaut.paul.
1 IN PTR anya.cobbaut.paul.
30 IN PTR mac.cobbaut.paul.
root@ubu1010srv:/etc/bind#
```

4. Test with nslookup or dig:

```bash
root@ubu1010srv:/etc/bind# dig 1.168.192.in-addr.arpa AXFR
```
5.5.2. old DNS load balancing

Not as above. When you have more than one DNS server authoritative for a zone, you can spread queries amongst all server. One way to do this is by creating NS records for all servers that participate in the load balancing of external queries.

You could also configure different name servers on internal clients.

5.5.3. old DNS notify

The original design of DNS in rfc 1034 and rfc 1035 implemented a refresh time in the SOA record to configure a time loop for slaves to query their master server. This can result in a lot of useless pull requests, or in a significant lag between updates.

For this reason dns notify (rfc 1996) was designed. The server will now notify slaves whenever there is an update. By default this feature is activated in bind.

Notify can be disabled as in this screenshot.

```
zone "1.168.192.in-addr.arpa" {
  type master;
  notify no;
  file "/etc/bind/db.192";
};
```

5.5.4. old testing IXFR and AXFR

Full zone transfers (AXFR) are initiated when you restart the bind server, or when you manually update the zone database file directly. With nsupdate you can update a zone database and initiate an incremental zone transfer.

You need DDNS allowed for nsupdate to work.

```
root@ubu1010srv:/etc/bind# nsupdate
> server 127.0.0.1
> update add mac14.linux-training.be 86400 A 192.168.1.23
> send
update failed: REFUSED
```

5.5.5. old DDNS integration with DHCP

Some organizations like to have all their client computers in DNS. This can be cumbersome to maintain. Luckily rfc 2136 describes integration of DHCP servers with a DNS server. Whenever DHCP acknowledges a client ip configuration, it can notify DNS with this clients ip-address and name. This is called dynamic updates or DDNS.

5.5.6. old reverse is forward in-addr.arpa

Reverse lookup is actually implemented as a forward lookup in the in-addr.arpa domain. This domain has 256 child domains (from 0.in-addr.arpa to 255.in-addr.arpa), with each child domain having again 256 child domains. And this twice more to a structure of over four billion (2 to the power 32) domains.
5.5.7. old ipv6

With rfc 3596 came ipv6 extensions for DNS. There is the AAAA record for ipv6 hosts on the network, and there is the ip6.int domain for reverse lookup (having 16 child domains from 0.ip6.int to f.ip6.int, each of those having again 16 child domains...and this 16 times.

5.5.8. old DNS security: file corruption

To mitigate file corruption on the zone files and the bind configuration files protect them with Unix permissions and take regular backups.

5.5.9. old DNS security: zone transfers

Limit zone transfers to certain ip addresses instead of to any. Nevermind that ip-addresses can be spoofed, still use this.

5.5.10. old DNS security: zone transfers, ip spoofing

You could setup DNSSEC (which is not the easiest to maintain) and with rfc 2845(tsig?) and with rfc 2930(tkey, but this is open to brute force), or you could disable all zone transfers and use a script with ssh to copy them manually.

5.5.11. old DNS security: queries

Allow recursion only from the local network, and iterative queries from outside only when necessary. This can be configured on master and slave servers.

```plaintext
view "internal" {
    match-clients { 192.168.42/24; }
    recursion yes;
    ...
};

view "external" {
    match-clients { any; }
    recursion no;
    ...
};

options {
    allow-query { 192.168.42.0/24; localhost; }
};

zone "cobbaut.paul" {
    allow-query { any; }
};

Or allow only queries from the local network.

```plaintext
options {
    allow-recursion { 192.168.42.0/24; localhost; }
};
```

Or only allow recursive queries from internal clients.
5.5.12. old DNS security: chrooted bind

Most Linux distributions allow an easy setup of bind in a chrooted environment.

5.5.13. old DNS security: DNSSEC

DNSSEC uses public/private keys to secure communications, this is described in rfc's 4033, 4034 and 4035.

5.5.14. old DNS security: root

Do not run bind as root. Do not run any application daemon as root.
Part IV. dhcp server
Table of Contents

6. introduction to dhcp ......................................................................................................................... 102
   6.1. four broadcasts ......................................................................................................................... 103
   6.2. picturing dhcp ......................................................................................................................... 104
   6.3. installing a dhcp server ......................................................................................................... 105
   6.4. dhcp server for RHEL/CentOS ............................................................................................... 105
   6.5. client reservations ................................................................................................................. 106
   6.6. example config files ............................................................................................................... 106
   6.7. older example config files ..................................................................................................... 107
   6.8. advanced dhcp ....................................................................................................................... 109
   6.9. Practice: dhcp ......................................................................................................................... 110
Chapter 6. introduction to dhcp

Dynamic Host Configuration Protocol (or short dhcp) is a standard tcp/ip protocol that distributes ip configurations to clients. dhcp is defined in rfc 2131 (before that it was defined as an update to bootp in rfc 1531/1541.

The alternative to dhcp is manually entering the ip configuration on each client computer.
6.1. four broadcasts

dhcp works with layer 2 broadcasts. A dhcp client that starts, will send a dhcp discover on the network. All dhcp servers (that have a lease available) will respond with a dhcp offer. The client will choose one of those offers and will send a dhcp request containing the chosen offer. The dhcp server usually responds with a dhcp ack (knowledge).

In wireshark it looks like this.

![Wireshark DHCP Example]

When this procedure is finished, then the client is allowed to use that ip-configuration until the end of its lease time.
6.2. picturing dhcp

Here we have a small network with two dhcp servers named DHCP-SRV1 and DHCP-SRV2 and two clients (SunWS1 and Mac42). All computers are connected by a hub or switch (pictured in the middle). All four computers have a cable to the hub (cables not pictured).

1. The client SunWS1 sends a dhcp discover on the network. All computers receive this broadcast.

2. Both dhcp servers answer with a dhcp offer. DHCP-SRV1 is a dedicated dhcp server and is faster in sending a dhcp offer than DHCP-SRV2 (who happens to also be a file server).

3. The client chooses the offer from DHCP-SRV1 and sends a dhcp request on the network.

4. DHCP-SRV1 answers with a dhcp ack (short for acknowledge).

All four broadcasts (or five when you count both offers) can be layer 2 ethernet broadcast to mac address ff:ff:ff:ff:ff and a layer 3 ip broadcast to 255.255.255.255.

The same story can be read in rfc 2131.
6.3. installing a dhcp server

dhcp server for Debian/Mint

debian5:~# aptitude install dhcp3-server
Reading package lists... Done
Building dependency tree
Reading state information... Done
Reading extended state information
Initializing package states... Done
Reading task descriptions... Done
The following NEW packages will be installed:
  dhcp3-server

You get a configuration file with many examples.

debian5:~# ls -l /etc/dhcp3/dhcpd.conf
  -rw-r--r-- 1 root root 3551 2011-04-10 21:23 /etc/dhcp3/dhcpd.conf

6.4. dhcp server for RHEL/CentOS

Installing is easy with `yum`.

[root@rhel71 ~]# yum install dhcp
Loaded plugins: product-id, subscription-manager
Resolving Dependencies
--- Running transaction check
---> Package dhcp.x86_64 12:4.2.5-36.el7 will be installed
---> Finished Dependency Resolution

Dependencies Resolved

Package Arch Version Repository Size
=================================================================================================
Installing: dhcp x86_64 12:4.2.5-36.el7 rhel-7-server-rpms 510 k

Transaction Summary
=================================================================================================
Install 1 Package

Total download size: 510 k
Installed size: 1.4 M
Is this ok [y/d/N]: y

Downloading packages:
  dhcp-4.2.5-36.el7.x86_64.rpm | 510 kB  00:01

Running transaction check
Running transaction test
Transaction test succeeded
Running transaction
  Installing : 12:dhcp-4.2.5-36.el7.x86_64 1/1
  Verifying : 12:dhcp-4.2.5-36.el7.x86_64 1/1

Installed:
  dhcp.x86_64 12:4.2.5-36.el7

Complete!
[root@rhel71 ~]#

After installing we get a `/etc/dhcp/dhcpd.conf` that points us to an example file named `dhcpd.conf.sample`.
So we copy the sample and adjust it for our real situation. We name the copy `/etc/dhcp/dhcpd.conf`.

The 'routers' option is valid for the subnet alone, whereas the 'domain-name' option is global (for all subnets).

Time to start the server. Remember to use `systemctl start dhcpd` on RHEL7/CentOS7 and `service dhcpd start` on previous versions of RHEL/CentOS.

### 6.5. client reservations

You can reserve an ip configuration for a client using the mac address.

```conf
host pc42 {
    fixed-address 192.168.42.42;
}
```

You can add individual options to this reservation.

```conf
host pc42 {
    fixed-address 192.168.42.42;
    option domain-name "linux-training.be";
    option routers 192.168.42.1;
}
```

### 6.6. example config files

Below you see several sections of `/etc/dhcp/dhcpd.conf` on a Debian 6 server.

```conf
# NetSec Antwerp Network
```
Above the general configuration for the network, with a pool of 180 addresses.

Below two client reservations:

```
# laptops

host mac {
    hardware ethernet 00:26:bb:xx:xx:xx;
    fixed-address mac.netsec.local;
}

host vmac {
    hardware ethernet 8c:7b:9d:xx:xx:xx;
    fixed-address vmac.netsec.local;
}
```

### 6.7. older example config files

For dhcpd.conf on Fedora with dynamic updates for a DNS domain.

```
[root@fedora14 ~]# cat /etc/dhcp/dhcpd.conf
authoritative;
include "/etc/rndc.key";

log-facility local6;

server-identifier    fedora14;

ddns-domainname  "office.linux-training.be";
ddns-update-style interim;
ddns-updates  on;
update-static-leases on;

option domain-name "office.linux-training.be";
option domain-name-servers 192.168.42.100;
option ip-forwarding off;

default-lease-time 1800;
max-lease-time  3600;

zone office.linux-training.be {
    primary 192.168.42.100;
}

subnet 192.168.4.0 netmask 255.255.255.0 {
    range 192.168.4.24 192.168.4.40;
}
```

Allowing any updates in the zone database (part of the named.conf configuration)

```
zone "office.linux-training.be" {
```
introduction to dhcp

```plaintext
type master;
file "/var/named/db.office.linux-training.be";
allow-transfer { any; };
allow-update { any; };
};

Allowing secure key updates in the zone database (part of the named.conf configuration)

```plaintext
zone "office.linux-training.be" {
    type master;
    file "/var/named/db.office.linux-training.be";
    allow-transfer { any; };
    allow-update { key mykey; };
};
```

Sample key file contents:

```plaintext
[root@fedora14 ~]# cat /etc/rndc.key
key "rndc-key" {
    algorithm hmac-md5;
    secret "4Ykd58uIeUr3Ve6ad1qTfQ==";
};
```

Generate your own keys with **dnssec-keygen**.

How to include a key in a config file:

```plaintext
include "/etc/bind/rndc.key";
```

Also make sure that **bind** can write to your db.zone file (using chmod/chown). For Ubuntu this can be in /etc/bind, for Fedora in /var/named.
6.8. advanced dhcp

6.8.1. 80/20 rule

DHCP servers should not be a single point of failure. Let us discuss redundant dhcp server setups.

6.8.2. relay agent

To avoid having to place a dhcp server on every segment, we can use dhcp relay agents.

6.8.3. rogue dhcp servers

Rogue dhcp servers are a problem without a solution. For example accidental connection of a (believed to be simple) hub/switch to a network with an internal dhcp server.

6.8.4. dhcp and ddns

DHCP can dynamically update DNS when it configures a client computer. DDNS can be used with or without secure keys.

When set up properly records can be added automaticall to the zone file:

```
root@fedora14~# tail -2 /var/named/db.office.linux-training.be
ubu1010srv         A     192.168.42.151
TXT   "00dfbb15e144a273c3cf2d6ae933885782"
```
6.9. Practice: dhcp

1. Make sure you have a unique fixed ip address for your DNS and DHCP server (easier on the same machine).

2. Install DHCP and browse the explanation in the default configuration file /etc/dhcp/ dhcpd.conf or /etc/dhcp3/dhcpd.conf.

3. Decide on a valid scope and activate it.

4. Test with a client that your DHCP server works.

5. Use wireshark to capture the four broadcasts when a client receives an ip (for the first time).

6. Use wireshark to capture a DHCPNAK and a DHCPrelease.

7. Reserve a configuration for a particular client (using mac address).

8. Configure your DHCP/DNS server(s) with a proper hostname and domainname (/etc/ hosts, /etc/hostname, /etc/sysconfig/network on Fedora/RHEL, /etc/resolv.conf ...). You may need to disable NetworkManager on *buntu-desktops.

9. Make sure your DNS server still works, and is master over (at least) one domain.

There are several ways to do steps 10-11-12. Google is your friend in exploring DDNS with keys, with key-files or without keys.

10. Configure your DNS server to allow dynamic updates from your DHCP server.

11. Configure your DHCP server to send dynamic updates to your DNS server.

12. Test the working of Dynamic DNS.
Part V. iptables firewall
# Table of Contents

7. **introduction to routers** ........................................................................................................... 113
   7.1. router or firewall .................................................................................................................. 114
   7.2. packet forwarding ............................................................................................................... 114
   7.3. packet filtering .................................................................................................................... 114
   7.4. stateful .................................................................................................................................. 114
   7.5. nat (network address translation) ......................................................................................... 115
   7.6. pat (port address translation) ............................................................................................. 115
   7.7. snat (source nat) .................................................................................................................. 115
   7.8. masquerading ....................................................................................................................... 115
   7.9. dnat (destination nat) .......................................................................................................... 115
   7.10. port forwarding .................................................................................................................. 115
   7.11. /proc/sys/net/ipv4/ip_forward ........................................................................................ 116
   7.12. /etc/sysctl.conf .................................................................................................................. 116
   7.13. sysctl .................................................................................................................................. 116
   7.15. solution: packet forwarding .............................................................................................. 119

8. **iptables firewall** .................................................................................................................... 122
   8.1. iptables tables ..................................................................................................................... 123
   8.2. starting and stopping iptables ............................................................................................ 123
   8.3. the filter table ..................................................................................................................... 124
   8.4. practice: packet filtering .................................................................................................... 129
   8.5. solution: packet filtering .................................................................................................... 130
   8.6. network address translation ............................................................................................... 131
Chapter 7. introduction to routers

What follows is a very brief introduction to using Linux as a router.
7.1. router or firewall

A router is a device that connects two networks. A firewall is a device that besides acting as a router, also contains (and implements) rules to determine whether packets are allowed to travel from one network to another. A firewall can be configured to block access based on networks, hosts, protocols and ports. Firewalls can also change the contents of packets while forwarding them.

7.2. packet forwarding

Packet forwarding means allowing packets to go from one network to another. When a multihomed host is connected to two different networks, and it allows packets to travel from one network to another through its two network interfaces, it is said to have enabled packet forwarding.

7.3. packet filtering

Packet filtering is very similar to packet forwarding, but every packet is individually tested against rules that decide on allowing or dropping the packet. The rules are stored by iptables.

7.4. stateful

A stateful firewall is an advancement over stateless firewalls that inspect every individual packet. A stateful firewall will keep a table of active connections, and is knowledgeable enough to recognise when new connections are part of an active session. Linux iptables is a stateful firewall.
7.5. nat (network address translation)

A nat device is a router that is also changing the source and/or target ip-address in packets. It is typically used to connect multiple computers in a private address range (rfc 1918) with the (public) internet. A nat can hide private addresses from the internet.

It is important to understand that people and vendors do not always use the right term when referring to a certain type of nat. Be sure you talk about the same thing. We can distinguish several types of nat.

7.6. pat (port address translation)

nat often includes pat. A pat device is a router that is also changing the source and/or target tcp/udp port in packets. pat is Cisco terminology and is used by snat, dnat, masquerading and port forwarding in Linux. RFC 3022 calls it NAPT and defines the nat/pat combo as "traditional nat". A device sold to you as a nat-device will probably do nat and pat.

7.7. snat (source nat)

A snat device is changing the source ip-address when a packet passes our nat. snat configuration with iptables includes a fixed target source address.

7.8. masquerading

Masquerading is a form of snat that will hide the (private) source ip-addresses of your private network using a public ip-address. Masquerading is common on dynamic internet interfaces (broadband modem/routers). Masquerade configuration with iptables uses a dynamic target source address.

7.9. dnat (destination nat)

A dnat device is changing the destination ip-address when a packet passes our nat.

7.10. port forwarding

When static dnat is set up in a way that allows outside connections to enter our private network, then we call it port forwarding.
7.11. /proc/sys/net/ipv4/ip_forward

Whether a host is forwarding packets is defined in `/proc/sys/net/ipv4/ip_forward`. The following screenshot shows how to enable packet forwarding on Linux.

```bash
root@router~# echo 1 > /proc/sys/net/ipv4/ip_forward
```

The next command shows how to disable packet forwarding.

```bash
root@router~# echo 0 > /proc/sys/net/ipv4/ip_forward
```

Use `cat` to check if packet forwarding is enabled.

```bash
root@router~# cat /proc/sys/net/ipv4/ip_forward
```

7.12. /etc/sysctl.conf

By default, most Linux computers are not configured for automatic packet forwarding. To enable packet forwarding whenever the system starts, change the `net.ipv4.ip_forward` variable in `/etc/sysctl.conf` to the value 1.

```bash
root@router~# grep ip_forward /etc/sysctl.conf
net.ipv4.ip_forward = 0
```

7.13. sysctl

For more information, take a look at the man page of `sysctl`.

```bash
root@debian6~# man sysctl
root@debian6~# sysctl -a 2>/dev/null | grep ip_forward
net.ipv4.ip_forward = 0
```

0. You have the option to select (or create) an internal network when adding a network card in **VirtualBox** or **VMWare**. Use this option to create two internal networks. I named them **leftnet** and **rightnet**, but you can choose any other name.

1. Set up two Linux machines, one on leftnet, the other on rightnet. Make sure they both get an ip-address in the correct subnet. These two machines will be 'left' and 'right' from the 'router'.

2. Set up a third Linux computer with three network cards, one on leftnet, the other on rightnet. This computer will be the 'router'. Complete the table below with the relevant names, ip-addresses and **mac-addresses**.

<table>
<thead>
<tr>
<th>Table 7.1. Packet Forwarding Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>leftnet computer</td>
</tr>
<tr>
<td>MAC</td>
</tr>
<tr>
<td>IP</td>
</tr>
</tbody>
</table>

3. How can you verify whether the router will allow packet forwarding by default or not? Test that you can **ping** from the router to the two other machines, and from those two machines to the router. Use **arp -a** to make sure you are connected with the correct **mac addresses**.
4. **Ping** from the leftnet computer to the rightnet computer. Enable and/or disable packet forwarding on the **router** and verify what happens to the ping between the two networks. If you do not succeed in pinging between the two networks (on different subnets), then use a sniffer like **wireshark** or **tcpdump** to discover the problem.

5. Use **wireshark** or **tcpdump** -xx to answer the following questions. Does the source MAC change when a packet passes through the filter? And the destination MAC? What about source and destination IP-addresses?

6. Remember the third network card on the router? Connect this card to a LAN with internet connection. On many LAN’s the command **dhclient eth0** just works (replace **eth0** with the correct interface).

```
root@router~# dhclient eth0
```

You now have a setup similar to this picture. What needs to be done to give internet access to **leftnet** and **rightnet**.
7.15. solution: packet forwarding

1. Set up two Linux machines, one on leftnet, the other on rightnet. Make sure they both get an ip-address in the correct subnet. These two machines will be 'left' and 'right' from the 'router'.

   Set up two Linux machines, one on leftnet, the other on rightnet. Make sure they both get an ip-address in the correct subnet. These two machines will be 'left' and 'right' from the 'router'.

   ![Diagram of network setup](image)

   The ip configuration on your computers should be similar to the following two screenshots. Both machines must be in a different subnet (here 192.168.60.0/24 and 192.168.70.0/24). I created a little script on both machines to configure the interfaces.

   ```bash
   root@left~# cat leftnet.sh
   pkill dhclient
   ifconfig eth0 192.168.60.8 netmask 255.255.255.0
   root@right~# cat rightnet.sh
   pkill dhclient
   ifconfig eth0 192.168.70.9 netmask 255.255.255.0
   ```

2. Set up a third Linux computer with three network cards, one on leftnet, the other on rightnet. This computer will be the 'router'. Complete the table below with the relevant names, ip-addresses and mac-addresses.

   ![Network Adapter List](image)

   Set up a third Linux computer with three network cards, one on leftnet, the other on rightnet. This computer will be the 'router'. Complete the table below with the relevant names, ip-addresses and mac-addresses.

   ```bash
   root@router~# cat router.sh
   ifconfig eth1 192.168.60.1 netmask 255.255.255.0
   ifconfig eth2 192.168.70.1 netmask 255.255.255.0
   #echo 1 > /proc/sys/net/ipv4/ip_forward
   ```

   Your setup may use different ip and mac addresses than the ones in the table below.

<table>
<thead>
<tr>
<th>leftnet computer</th>
<th>the router</th>
<th>rightnet computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:00:27:f6:ab:b9</td>
<td>08:00:27:43:1f:5a</td>
<td>08:00:27:be:4a:6b</td>
</tr>
<tr>
<td>192.168.60.8</td>
<td>192.168.60.1</td>
<td>192.168.70.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>192.168.70.9</td>
</tr>
</tbody>
</table>
3. How can you verify whether the router will allow packet forwarding by default or not? Test that you can ping from the router to the two other machines, and from those two machines to the router. Use `arp -a` to make sure you are connected with the correct mac addresses.

This can be done with "grep ip_forward /etc/sysctl.conf" (1 is enabled, 0 is disabled) or with `sysctl -a | grep ip_for`.

```
root@router~# grep ip_for /etc/sysctl.conf
net.ipv4.ip_forward = 0
```

4. Ping from the leftnet computer to the rightnet computer. Enable and/or disable packet forwarding on the router and verify what happens to the ping between the two networks. If you do not succeed in pinging between the two networks (on different subnets), then use a sniffer like wireshark or tcpdump to discover the problem.

Did you forget to add a default gateway to the LAN machines? Use `route add default gw 'ip-address'`.

```
root@left~# route add default gw 192.168.60.1
root@right~# route add default gw 192.168.70.1
```

You should be able to ping when packet forwarding is enabled (and both default gateways are properly configured). The ping will not work when packet forwarding is disabled or when gateways are not configured correctly.

5. Use wireshark or tcpdump -xx to answer the following questions. Does the source MAC change when a packet passes through the filter? And the destination MAC? What about source and destination IP-addresses?

Both MAC addresses are changed when passing the router. Use `tcpdump -xx` like this:

```
root@router~# tcpdump -xx -i eth1
root@router~# tcpdump -xx -i eth2
```
6. Remember the third network card on the router? Connect this card to a LAN with internet connection. On many LAN’s the command `dhclient eth0` just works (replace `eth0` with the correct interface).

```
root@router~# dhclient eth0
```

You now have a setup similar to this picture. What needs to be done to give internet access to **leftnet** and **rightnet**.

The clients on **leftnet** and **rightnet** need a working **dns server**. We use one of Google's dns servers here.

```
echo nameserver 8.8.8.8 > /etc/resolv.conf
```
Chapter 8. iptables firewall

This chapter introduces some simple firewall rules and how to configure them with `iptables`. `iptables` is an application that allows a user to configure the firewall functionality built into the Linux kernel.
8.1. iptables tables

By default there are three tables in the kernel that contain sets of rules.

The **filter table** is used for packet filtering.

```
root@debian6~# iptables -t filter -L
Chain INPUT (policy ACCEPT)
  target     prot opt source               destination
Chain FORWARD (policy ACCEPT)
  target     prot opt source               destination
Chain OUTPUT (policy ACCEPT)
  target     prot opt source               destination
```

The **nat table** is used for address translation.

```
root@debian6~# iptables -t nat -L
Chain PREROUTING (policy ACCEPT)
  target     prot opt source               destination
Chain POSTROUTING (policy ACCEPT)
  target     prot opt source               destination
Chain OUTPUT (policy ACCEPT)
  target     prot opt source               destination
```

The **mangle table** can be used for special-purpose processing of packets.

Series of rules in each table are called a **chain**. We will discuss chains and the nat table later in this chapter.

8.2. starting and stopping iptables

The following screenshot shows how to stop and start **iptables** on Red Hat/Fedora/CentOS and compatible distributions.

```
[root@centos6 ~]# service iptables stop
iptables: Applying firewall rules                          [ ok ]
[root@centos6 ~]# service iptables start
```

Debian and *buntu distributions do not have this script, but allow for an uninstall.

```
root@debian6~# aptitude purge iptables
```
8.3. the filter table

8.3.1. about packet filtering

Packet filtering is a bit more than packet forwarding. While packet forwarding uses only a routing table to make decisions, packet filtering also uses a list of rules. The kernel will inspect packets and decide based on these rules what to do with each packet.

8.3.2. filter table

The filter table in **iptables** has three chains (sets of rules). The INPUT chain is used for any packet coming into the system. The OUTPUT chain is for any packet leaving the system. And the FORWARD chain is for packets that are forwarded (routed) through the system.

![Packet Filtering Diagram](image)

The screenshot below shows how to list the filter table and all its rules.

```
[root@RHEL5 ~]# iptables -t filter -nL
Chain INPUT (policy ACCEPT)
 target     prot opt source               destination
Chain FORWARD (policy ACCEPT)
 target     prot opt source               destination
Chain OUTPUT (policy ACCEPT)
 target     prot opt source               destination
[root@RHEL5 ~]#
```

As you can see, all three chains in the filter table are set to ACCEPT everything. ACCEPT is the default behaviour.
8.3.3. setting default rules

The default for the default rule is indeed to ACCEPT everything. This is not the most secure firewall.

A more secure setup would be to DROP everything. A package that is dropped will not continue in any chain, and no warning or error will be sent anywhere.

The below commands lock down a computer. Do not execute these commands inside a remote ssh shell.

```
root@debianpaul~# iptables -P INPUT DROP
root@debianpaul~# iptables -P OUTPUT DROP
root@debianpaul~# iptables -P FORWARD DROP
root@debianpaul~# iptables -L
Chain INPUT (policy DROP)
 target     prot opt source               destination
Chain FORWARD (policy DROP)
 target     prot opt source               destination
Chain OUTPUT (policy DROP)
 target     prot opt source               destination
```

8.3.4. changing policy rules

To start, let's set the default policy for all three chains to drop everything. Note that you might lose your connection when typing this over ssh ;-).

```
[root@RHEL5 ~]# iptables -P INPUT DROP
[root@RHEL5 ~]# iptables -P FORWARD DROP
[root@RHEL5 ~]# iptables -P OUTPUT DROP
```

Next, we allow the server to use its own loopback device (this allows the server to access its services running on localhost). We first append a rule to the INPUT chain to allow (ACCEPT) traffic from the lo (loopback) interface, then we do the same to allow packets to leave the system through the loopback interface.

```
[root@RHEL5 ~]# iptables -A INPUT -i lo -j ACCEPT
[root@RHEL5 ~]# iptables -A OUTPUT -o lo -j ACCEPT
```

Looking at the filter table again (omitting -t filter because it is the default table).

```
[root@RHEL5 ~]# iptables -nL
Chain INPUT (policy DROP)
 target     prot opt source               destination
ACCEPT     all --  0.0.0.0/0            0.0.0.0/0
Chain FORWARD (policy DROP)
 target     prot opt source               destination
Chain OUTPUT (policy DROP)
 target     prot opt source               destination
ACCEPT     all --  0.0.0.0/0            0.0.0.0/0
```
8.3.5. Allowing ssh over eth0

This example shows how to add two rules to allow ssh access to your system from outside.

```
[root@RHEL5 ~]# iptables -A INPUT -i eth0 -p tcp --dport 22 -j ACCEPT
[root@RHEL5 ~]# iptables -A OUTPUT -o eth0 -p tcp --sport 22 -j ACCEPT
```

The filter table will look something like this screenshot (note that -v is added for more verbose output).

```
[root@RHEL5 ~]# iptables -nvL
Chain INPUT (policy DROP 7 packets, 609 bytes)
 pkts bytes target prot opt in    out   source     destination
  0     0 ACCEPT all  --  lo    *     0.0.0.0/0  0.0.0.0/0
  0     0 ACCEPT tcp -- eth0  *     0.0.0.0/0  0.0.0.0/0  tcp dpt:22
Chain FORWARD (policy DROP 0 packets, 0 bytes)
pkts bytes target prot opt in    out   source     destination
Chain OUTPUT (policy DROP 3 packets, 228 bytes)
pkts bytes target prot opt in    out   source     destination
  0     0 ACCEPT all  -- *      lo    0.0.0.0/0  0.0.0.0/0
  0     0 ACCEPT tcp -- eth0  *     0.0.0.0/0  0.0.0.0/0  tcp spt:22
```

8.3.6. Allowing access from a subnet

This example shows how to allow access from any computer in the 10.1.1.0/24 network, but only through eth1. There is no port (application) limitation here.

```
[root@RHEL5 ~]# iptables -A INPUT -i eth1 -s 10.1.1.0/24 -p tcp -j ACCEPT
[root@RHEL5 ~]# iptables -A OUTPUT -o eth1 -d 10.1.1.0/24 -p tcp -j ACCEPT
```

Together with the previous examples, the policy is expanding.

```
[root@RHEL5 ~]# iptables -nvL
Chain INPUT (policy DROP 7 packets, 609 bytes)
 pkts bytes target prot opt in    out   source     destination
  0     0 ACCEPT all  -- lo    *     0.0.0.0/0  0.0.0.0/0
  0     0 ACCEPT tcp -- eth0  *     0.0.0.0/0  0.0.0.0/0  tcp dpt:22
  0     0 ACCEPT tcp -- eth1  *     0.0.0.0/0  10.1.1.0/24
Chain FORWARD (policy DROP 0 packets, 0 bytes)
pkts bytes target prot opt in    out   source     destination
Chain OUTPUT (policy DROP 3 packets, 228 bytes)
pkts bytes target prot opt in    out   source     destination
  0     0 ACCEPT all  -- *      lo    0.0.0.0/0  0.0.0.0/0
  0     0 ACCEPT tcp -- eth0  *     0.0.0.0/0  0.0.0.0/0  tcp spt:22
  0     0 ACCEPT tcp -- eth1  *     0.0.0.0/0  10.1.1.0/24
```
8.3.7. iptables save

Use `iptables save` to automatically implement these rules when the firewall is (re)started.

```
[root@RHEL5 ~]# /etc/init.d/iptables save
Saving firewall rules to /etc/sysconfig/iptables: [ OK ]
[root@RHEL5 ~]#
```

8.3.8. scripting example

You can write a simple script for these rules. Below is an example script that implements the firewall rules that you saw before in this chapter.

```
#!/bin/bash
# first cleanup everything
iptables -t filter -F
iptables -t filter -X
iptables -t nat -F
iptables -t nat -X

# default drop
iptables -P INPUT DROP
iptables -P FORWARD DROP
iptables -P OUTPUT DROP

# allow loopback device
iptables -A INPUT -i lo -j ACCEPT
iptables -A OUTPUT -o lo -j ACCEPT

# allow ssh over eth0 from outside to system
iptables -A INPUT -i eth0 -p tcp --dport 22 -j ACCEPT
iptables -A OUTPUT -o eth0 -p tcp --sport 22 -j ACCEPT

# allow any traffic from 10.1.1.0/24 to system
iptables -A INPUT -i eth1 -s 10.1.1.0/24 -p tcp -j ACCEPT
iptables -A OUTPUT -o eth1 -d 10.1.1.0/24 -p tcp -j ACCEPT
```
8.3.9. Allowing ICMP(ping)

When you enable iptables, you will get an 'Operation not permitted' message when trying to ping other hosts.

```
[root@RHEL5 ~]# ping 192.168.187.130
PING 192.168.187.130 (192.168.187.130) 56(84) bytes of data.
ping: sendmsg: Operation not permitted
ping: sendmsg: Operation not permitted
```

The screenshot below shows you how to setup iptables to allow a ping from or to your machine.

```
[root@RHEL5 ~]# iptables -A INPUT -p icmp --icmp-type any -j ACCEPT
[root@RHEL5 ~]# iptables -A OUTPUT -p icmp --icmp-type any -j ACCEPT
```

The previous two lines do not allow other computers to route ping messages through your router, because it only handles INPUT and OUTPUT. For routing of ping, you will need to enable it on the FORWARD chain. The following command enables routing of icmp messages between networks.

```
[root@RHEL5 ~]# iptables -A FORWARD -p icmp --icmp-type any -j ACCEPT
```
8.4. practice: packet filtering

1. Make sure you can ssh to your router-system when iptables is active.

2. Make sure you can ping to your router-system when iptables is active.

3. Define one of your networks as 'internal' and the other as 'external'. Configure the router to allow visits to a website (http) to go from the internal network to the external network (but not in the other direction).

4. Make sure the internal network can ssh to the external, but not the other way around.
8.5. solution: packet filtering

A possible solution, where leftnet is the internal and rightnet is the external network.

```bash
#!/bin/bash

# first cleanup everything
iptables -t filter -F
iptables -t filter -X
iptables -t nat -F
iptables -t nat -X

# default drop
iptables -P INPUT DROP
iptables -P FORWARD DROP
iptables -P OUTPUT DROP

# allow loopback device
iptables -A INPUT -i lo -j ACCEPT
iptables -A OUTPUT -o lo -j ACCEPT

# question 1: allow ssh over eth0
iptables -A INPUT -i eth0 -p tcp --dport 22 -j ACCEPT
iptables -A OUTPUT -o eth0 -p tcp --sport 22 -j ACCEPT

# question 2: Allow icmp(ping) anywhere
iptables -A INPUT -p icmp --icmp-type any -j ACCEPT
iptables -A FORWARD -p icmp --icmp-type any -j ACCEPT
iptables -A OUTPUT -p icmp --icmp-type any -j ACCEPT

# question 3: allow http from internal(leftnet) to external(rightnet)
iptables -A FORWARD -i eth1 -o eth2 -p tcp --dport 80 -j ACCEPT
iptables -A FORWARD -i eth2 -o eth1 -p tcp --sport 80 -j ACCEPT

# question 4: allow ssh from internal(leftnet) to external(rightnet)
iptables -A FORWARD -i eth1 -o eth2 -p tcp --dport 22 -j ACCEPT
iptables -A FORWARD -i eth2 -o eth1 -p tcp --sport 22 -j ACCEPT

# allow http from external(rightnet) to internal(leftnet)
iptables -A FORWARD -i eth2 -o eth1 -p tcp --dport 80 -j ACCEPT
iptables -A FORWARD -i eth1 -o eth2 -p tcp --sport 80 -j ACCEPT

# allow rpcinfo over eth0 from outside to system
iptables -A INPUT -i eth2 -p tcp --dport 111 -j ACCEPT
iptables -A OUTPUT -o eth2 -p tcp --sport 111 -j ACCEPT
```
8.6. network address translation

8.6.1. about NAT

A NAT device is a router that is also changing the source and/or target ip-address in packets. It is typically used to connect multiple computers in a private address range with the (public) internet. A NAT can hide private addresses from the internet.

NAT was developed to mitigate the use of real ip addresses, to allow private address ranges to reach the internet and back, and to not disclose details about internal networks to the outside.

The nat table in iptables adds two new chains. PREROUTING allows altering of packets before they reach the INPUT chain. POSTROUTING allows altering packets after they exit the OUTPUT chain.

Use `iptables -t nat -nvL` to look at the NAT table. The screenshot below shows an empty NAT table.

```
[root@RHEL5 ~]# iptables -t nat -nL
Chain PREROUTING (policy ACCEPT)
target    prot opt source               destination
Chain POSTROUTING (policy ACCEPT)
target    prot opt source               destination
Chain OUTPUT (policy ACCEPT)
target    prot opt source               destination
[root@RHEL5 ~]#```

---

iptables firewall

---

131
8.6.2. SNAT (Source NAT)

The goal of source nat is to change the source address inside a packet before it leaves the system (e.g. to the internet). The destination will return the packet to the NAT-device. This means our NAT-device will need to keep a table in memory of all the packets it changed, so it can deliver the packet to the original source (e.g. in the private network).

Because SNAT is about packets leaving the system, it uses the POSTROUTING chain.

Here is an example SNAT rule. The rule says that packets coming from 10.1.1.0/24 network and exiting via eth1 will get the source ip-address set to 11.12.13.14. (Note that this is a one line command!)

```
iptables -t nat -A POSTROUTING -o eth1 -s 10.1.1.0/24 -j SNAT --to-source 11.12.13.14
```

Of course there must exist a proper iptables filter setup to allow the packet to traverse from one network to the other.

8.6.3. SNAT example setup

This example script uses a typical nat setup. The internal (eth0) network has access via SNAT to external (eth1) webservers (port 80).

```bash
#!/bin/bash
#
# iptables script for simple classic nat websurfing
# eth0 is internal network, eth1 is internet
#
echo 0 > /proc/sys/net/ipv4/ip_forward
iptables -P INPUT ACCEPT
iptables -P OUTPUT ACCEPT
iptables -P FORWARD DROP
iptables -A FORWARD -i eth0 -o eth1 -s 10.1.1.0/24 -p tcp --dport 80 -j ACCEPT
iptables -A FORWARD -i eth1 -o eth0 -d 10.1.1.0/24 -p tcp --sport 80 -j ACCEPT
iptables -t nat -A POSTROUTING -o eth1 -s 10.1.1.0/24 -j SNAT --to-source 11.12.13.14
echo 1 > /proc/sys/net/ipv4/ip_forward
```
8.6.4. IP masquerading

IP masquerading is very similar to SNAT, but is meant for dynamic interfaces. Typical example are broadband 'router/modems' connected to the internet and receiving a different ip-address from the isp, each time they are cold-booted.

The only change needed to convert the SNAT script to a masquerading is one line.

```
iptables -t nat -A POSTROUTING -o eth1 -s 10.1.1.0/24 -j MASQUERADE
```

8.6.5. DNAT (Destination NAT)

DNAT is typically used to allow packets from the internet to be redirected to an internal server (in your DMZ) and in a private address range that is inaccessible directly form the internet.

This example script allows internet users to reach your internal (192.168.1.99) server via ssh (port 22).

```
#!/bin/bash
#
# iptables script for DNAT
# eth0 is internal network, eth1 is internet
#
echo 0 > /proc/sys/net/ipv4/ip_forward
iptables -P INPUT ACCEPT
iptables -P OUTPUT ACCEPT
iptables -P FORWARD DROP
iptables -A FORWARD -i eth0 -o eth1 -s 10.1.1.0/24 -j ACCEPT
iptables -A FORWARD -i eth1 -o eth0 -p tcp --dport 22 -j ACCEPT
iptables -t nat -A PREROUTING -i eth1 -p tcp --dport 22 --j DNAT --to-destination 10.1.1.99
echo 1 > /proc/sys/net/ipv4/ip_forward
```
Part VI. Introduction to Samba
**Table of Contents**

9. introduction to samba ................................................................. 137
   9.1. verify installed version ......................................................... 138
   9.2. installing samba ................................................................. 139
   9.3. documentation ................................................................. 140
   9.4. starting and stopping samba ............................................... 141
   9.5. samba daemons ................................................................. 142
   9.6. the SMB protocol ............................................................. 143
   9.7. practice: introduction to samba ......................................... 144

10. getting started with samba ....................................................... 145
    10.1. /etc/samba/smb.conf ..................................................... 146
    10.2. /usr/bin/testparm .......................................................... 147
    10.3. /usr/bin/smbclient ........................................................ 148
    10.4. /usr/bin/smbtree ........................................................... 149
    10.5. server string ................................................................. 149
    10.6. Samba Web Administration Tool (SWAT) ......................... 150
    10.7. practice: getting started with samba ................................ 151
    10.8. solution: getting started with samba ................................. 152

11. a read only file server ............................................................. 156
    11.1. Setting up a directory to share ....................................... 157
    11.2. configure the share ....................................................... 157
    11.3. restart the server ........................................................ 158
    11.4. verify the share ........................................................... 158
    11.5. a note on netcat ........................................................... 158
    11.6. practice: read only file server ....................................... 159
    11.7. solution: read only file server ....................................... 159

12. a writable file server .............................................................. 163
    12.1. set up a directory to share ........................................... 164
    12.2. share section in smb.conf ............................................. 164
    12.3. configure the share ....................................................... 164
    12.4. test connection with windows ....................................... 164
    12.5. test writing with windows ............................................ 165
    12.6. How is this possible? .................................................... 165
    12.7. practice: writable file server ........................................ 166
    12.8. solution: writable file server ........................................ 167

13. samba first user account .......................................................... 168
    13.1. creating a samba user .................................................... 169
    13.2. ownership of files ....................................................... 169
    13.3. /usr/bin/smbpasswd .................................................... 169
    13.4. /etc/samba/smbpasswd ................................................ 169
    13.5. passdb backend ........................................................... 170
    13.6. forcing this user ........................................................ 170
    13.7. practice: first samba user account ................................. 171
    13.8. solution: first samba user account ................................. 172

14. samba authentication .............................................................. 173
    14.1. creating the users on Linux .......................................... 174
    14.2. creating the users on samba .......................................... 174
    14.3. security = user ............................................................ 174
    14.4. configuring the share ................................................... 175
    14.5. testing access with net use ......................................... 175
    14.6. testing access with smbclient ...................................... 175
    14.7. verify ownership ........................................................ 176
    14.8. common problems ....................................................... 176
    14.9. practice: samba authentication ..................................... 178
    14.10. solution: samba authentication ..................................... 179

15. samba securing shares ........................................................... 180
Chapter 9. introduction to samba

This introduction to the Samba server simply explains how to install Samba 3 and briefly mentions the SMB protocol.
9.1. verify installed version

9.1.1. .rpm based distributions

To see the version of samba installed on Red Hat, Fedora or CentOS use `rpm -q samba`.

```
[root@RHEL5 ~]# rpm -q samba
samba-3.0.28-1.el5_2.1
```

The screenshot above shows that RHEL5 has Samba version 3.0 installed. The last number in the Samba version counts the number of updates or patches.

Below the same command on a more recent version of CentOS with Samba version 3.5 installed.

```
[root@centos ~]# rpm -q samba
samba-3.5.10-116.el6_2.i686
```

9.1.2. .deb based distributions

Use `dpkg -l` or `aptitude show` on Debian or Ubuntu. Both Debian 7.0 (Wheezy) and Ubuntu 12.04 (Precise) use version 3.6.3 of the Samba server.

```
root@debian7~# aptitude show samba | grep Version
Version: 2:3.6.3-1
```

Ubuntu 12.04 is currently at Samba version 3.6.3.

```
root@ubuntu1204:~# dpkg -l samba | tail -1
ii samba 2:3.6.3-2ubuntu2.1 SMB/CIFS file, print, and login server for Unix
```
9.2. installing samba

9.2.1. .rpm based distributions

Samba is installed by default on Red Hat Enterprise Linux. If Samba is not yet installed, then you can use the graphical menu (Applications -- System Settings -- Add/Remove Applications) and select "Windows File Server" in the Server section. The non-graphical way is to use `rpm` or `yum`.

When you downloaded the .rpm file, you can install Samba like this.

```bash
[paul@RHEL52 ~]$ rpm -i samba-3.0.28-1.el5_2.1.rpm
```

When you have a subscription to RHN (Red Hat Network), then `yum` is an easy tool to use. This `yum` command works by default on Fedora and CentOS.

```bash
[root@centos6 ~]# yum install samba
```

9.2.2. .deb based distributions

Ubuntu and Debian users can use the `aptitude` program (or use a graphical tool like Synaptic).

```bash
root@debian7~# aptitude install samba
```

The following NEW packages will be installed:

samba samba-common samba-common-bin tdb-tools

0 packages upgraded, 4 newly installed, 0 to remove and 1 not upgraded.
Need to get 15.1 MB of archives. After unpacking 42.9 MB will be used.
Do you want to continue? [Y/n/?]

...
9.3. documentation

9.3.1. samba howto

Samba comes with excellent documentation in html and pdf format (and also as a free download from samba.org and it is for sale as a printed book).

The documentation is a separate package, so install it if you want it on the server itself.

```
[root@centos6 ~]# yum install samba-doc
... [root@centos6 ~]# ls -l /usr/share/doc/samba-doc-3.5.10/
```

```
total 10916
  drwxr-xr-x. 6 root root  4096 May  6 15:50 htmldocs
  -rw-r--r--. 1 root root 4605496 Jun 14  2011 Samba3-ByExample.pdf
  -rw-r--r--. 1 root root  608260 Jun 14  2011 Samba3-Developers-Guide.pdf
  -rw-r--r--. 1 root root 5954602 Jun 14  2011 Samba3-HOWTO.pdf
```

This action is very similar on Ubuntu and Debian except that the pdf files are in a separate package named `samba-doc-pdf`.

```
root@ubu1204:~# aptitude install samba-doc-pdf
The following NEW packages will be installed:
   samba-doc-pdf
...```

9.3.2. samba by example

Besides the howto, there is also an excellent book called *Samba By Example* (again available as printed edition in shops, and as a free pdf and html).
9.4. starting and stopping samba

You can start the daemons by invoking `/etc/init.d/smb start` (some systems use `/etc/init.d/samba`) on any Linux.

```bash
root@laika:~# /etc/init.d/samba stop
    * Stopping Samba daemons [ OK ]
root@laika:~# /etc/init.d/samba start
    * Starting Samba daemons [ OK ]
root@laika:~# /etc/init.d/samba restart
    * Stopping Samba daemons [ OK ]
    * Starting Samba daemons [ OK ]
root@laika:~# /etc/init.d/samba status
    * SMBD is running [ OK ]
```

Red Hat derived systems are happy with `service smb start`.

```bash
[root@RHEL4b ~]# /etc/init.d/smb start
    Starting SMB services: [ OK ]
    Starting NMB services: [ OK ]
[root@RHEL4b ~]# service smb restart
    Shutting down SMB services: [ OK ]
    Shutting down NMB services: [ OK ]
    Starting SMB services: [ OK ]
    Starting NMB services: [ OK ]
[root@RHEL4b ~]#
```
9.5. samba daemons

Samba 3 consists of three daemons, they are named **nmbd**, **smbd** and **winbindd**.

### 9.5.1. nmbd

The **nmbd** daemon takes care of all the names and naming. It registers and resolves names, and handles browsing. According to the Samba documentation, it should be the first daemon to start.

```
[root@RHEL52 ~]# ps -C nmbd
PID TTY          TIME CMD
5681 ?          00:00:00 nmbd
```

### 9.5.2. smbd

The **smbd** daemon manages file transfers and authentication.

```
[root@RHEL52 ~]# ps -C smbd
PID TTY          TIME CMD
5678 ?          00:00:00 smbd
5683 ?          00:00:00 smbd
```

### 9.5.3. winbindd

The **winbind** daemon (winbindd) is only started to handle Microsoft Windows domain membership.

Note that **winbind** is started by the `/etc/init.d/winbind` script (two dd's for the daemon and only one d for the script).

```
[root@RHEL52 ~]# /etc/init.d/winbind start
Starting Winbind services: [ OK ]
[root@RHEL52 ~]# ps -C winbindd
PID TTY          TIME CMD
5752 ?          00:00:00 winbindd
5754 ?          00:00:00 winbindd
```

On Debian and Ubuntu, the winbindd daemon is installed via a separate package called **winbind**.
9.6. the SMB protocol

9.6.1. brief history

Development of this protocol was started by IBM in the early eighties. By the end of the eighties, most development was done by Microsoft. SMB is an application level protocol designed to run on top of NetBIOS/NetBEUI, but can also be run on top of tcp/ip.

In 1996 Microsoft was asked to document the protocol. They submitted CIFS (Common Internet File System) as an internet draft, but it never got final rfc status.

In 2004 the European Union decided Microsoft should document the protocol to enable other developers to write compatible software. December 20th 2007 Microsoft came to an agreement. The Samba team now has access to SMB/CIFS, Windows for Workgroups and Active Directory documentation.

9.6.2. broadcasting protocol

SMB uses the NetBIOS service location protocol, which is a broadcasting protocol. This means that NetBIOS names have to be unique on the network (even when you have different IP-addresses). Having duplicate names on an SMB network can seriously harm communications.

9.6.3. NetBIOS names

NetBIOS names are similar to hostnames, but are always uppercase and only 15 characters in length. Microsoft Windows computers and Samba servers will broadcast this name on the network.

9.6.4. network bandwidth

Having many broadcasting SMB/CIFS computers on your network can cause bandwidth issues. A solution can be the use of a NetBIOS name server (NBNS) like WINS (Windows Internet Naming Service).
9.7. practice: introduction to samba

0. !! Make sure you know your student number, anything *ANYTHING* you name must include your student number!

1. Verify that you can logon to a Linux/Unix computer. Write down the name and ip address of this computer.

2. Do the same for all the other (virtual) machines available to you.

3. Verify networking by pinging the computer, edit the appropriate hosts files so you can use names. Test the names by pinging them.

4. Make sure Samba is installed, write down the version of Samba.

5. Open the Official Samba-3 howto pdf file that is installed on your computer. How many A4 pages is this file ? Then look at the same pdf on samba.org, it is updated regularly.

6. Stop the Samba server.
Chapter 10. getting started with samba
10.1. /etc/samba/smb.conf

10.1.1. smbd -b

Samba configuration is done in the `smb.conf` file. The file can be edited manually, or you can use a web based interface like webmin or swat to manage it. The file is usually located in `/etc/samba`. You can find the exact location with `smbd -b`.

```bash
[root@RHEL4b ~]# smbd -b | grep CONFIGFILE
CONFIGFILE: /etc/samba/smb.conf
```

10.1.2. the default smb.conf

The default smb.conf file contains a lot of examples with explanations.

```bash
[paul@RHEL4b ~]$ ls -l /etc/samba/smb.conf
-rw-r--r-- 1 root root 10836 May 30 23:08 /etc/samba/smb.conf
```

Also on Ubuntu and Debian, smb.conf is packed with samples and explanations.

```bash
paul@laika:~$ ls -l /etc/samba/smb.conf
-rw-r--r-- 1 root root 10515 2007-05-24 00:21 /etc/samba/smb.conf
```

10.1.3. minimal smb.conf

Below is an example of a very minimalistic `smb.conf`. It allows samba to start, and to be visible to other computers (Microsoft shows computers in Network Neighborhood or My Network Places).

```bash
[paul@RHEL4b ~]$ cat /etc/samba/smb.conf
[global]
workgroup = WORKGROUP
[firstshare]
path = /srv/samba/public
```

10.1.4. net view

Below is a screenshot of the `net view` command on Microsoft Windows Server 2003 sp2. It shows how a Red Hat Enterprise Linux 5.3 and a Ubuntu 9.04 Samba server, both with a minimalistic smb.conf, are visible to Microsoft computers nearby.

```
C:\Documents and Settings\Administrator>net view
Server Name            Remark
----------------------------------------------------------------------
\LAIKA                Samba 3.3.2
\RHEL53               Samba 3.0.33-3.7.el5
\W2003
The command completed successfully.
```

10.1.5. long lines in smb.conf

Some parameters in smb.conf can get a long list of values behind them. You can continue a line (for clarity) on the next by ending the line with a backslash.

```bash
valid users = Serena, Venus, Lindsay \
```
10.1.6. curious smb.conf

Curious but true: smb.conf accepts synonyms like `create mode` and `create mask`, and (sometimes) minor spelling errors like `browsable` and `browseable`. And on occasion you can even switch words, the `guest only` parameter is identical to `only guest`. And `writable = yes` is the same as `readonly = no`.

10.1.7. man smb.conf

You can access a lot of documentation when typing `man smb.conf`.

```
[root@RHEL4b samba]# apropos samba
 cupsaddmb       (8)  - export printers to samba for windows clients
 lmhosts         (5)  - The Samba NetBIOS hosts file
 net             (8)  - Tool for administration of Samba and remote CIFS servers
 pdbedit         (8)  - manage the SAM database (Database of Samba Users)
 samba           (7)  - A Windows SMB/CIFS fileserver for UNIX
 smb.conf [smb]  (5)  - The configuration file for the Samba suite
 smbpasswd       (5)  - The Samba encrypted password file
 smbstatus       (1)  - report on current Samba connections
 swat             (8)  - Samba Web Administration Tool
 tdbbackup        (8)  - tool for backing up and ... of samba .tdb files
[root@RHEL4b samba]#
```

10.2. /usr/bin/testparm

10.2.1. syntax check smb.conf

To verify the syntax of the smb.conf file, you can use `testparm`.

```
[paul@RHEL4b ~]# testparm
 Load smb config files from /etc/samba/smb.conf
 Processing section "[firstshare]"
 Loaded services file OK.
 Server role: ROLE_STANDALONE
 Press enter to see a dump of your service definitions
```

10.2.2. testparm -v

An interesting option is `testparm -v`, which will output all the global options with their default value.

```
[root@RHEL52 ~]# testparm -v | head
 Load smb config files from /etc/samba/smb.conf
 Processing section "[pub0]"
 Processing section "[global$]"
 Loaded services file OK.
 Server role: ROLE_STANDALONE
 Press enter to see a dump of your service definitions

[global]
 dos charset = CP850
 unix charset = UTF-8
 display charset = LOCALE
 workgroup = WORKGROUP
```
realm =
netbios name = TEACHER0
netbios aliases =
netbios scope =
server string = Samba 3.0.28-1.el5_2.1
...

There were about 350 default values for smb.conf parameters in Samba 3.0.x. This number grew to almost 400 in Samba 3.5.x.

10.2.3. testparm -s

The samba daemons are constantly (once every 60 seconds) checking the smb.conf file, so it is good practice to keep this file small. But it is also good practice to document your samba configuration, and to explicitly set options that have the same default values. The testparm -s option allows you to do both. It will output the smallest possible samba configuration file, while retaining all your settings. The idea is to have your samba configuration in another file (like smb.conf.full) and let testparm parse this for you. The screenshot below shows you how. First the smb.conf.full file with the explicitly set option workgroup to WORKGROUP.

[root@RHEL4b samba]# cat smb.conf.full
[global]
workgroup = WORKGROUP

# This is a demo of a documented smb.conf
# These two lines are removed by testparm -s
server string = Public Test Server

[firstshare]
path = /srv/samba/public

Next, we execute testparm with the -s option, and redirect stdout to the real smb.conf file.

[root@RHEL4b samba]# testparm -s smb.conf.full > smb.conf
Load smb config files from smb.conf.full
Processing section "[firstshare]"
Loaded services file OK.

And below is the end result. The two comment lines and the default option are no longer there.

[root@RHEL4b samba]# cat smb.conf

# Global parameters
[global]
server string = Public Test Server

[firstshare]
path = /srv/samba/public

[root@RHEL4b samba]#

10.3. /usr/bin/smbclient

10.3.1. smbclient looking at Samba

With smbclient you can see browsing and share information from your smb server. It will display all your shares, your workgroup, and the name of the Master Browser. The -N switch
is added to avoid having to enter an empty password. The -L switch is followed by the name of the host to check.

[root@RHEL4b init.d]# smbclient -NL rhel4b
Anonymous login successful
Domain=[WORKGROUP] OS=[Unix] Server=[Samba 3.0.10-1.4E.9]

<table>
<thead>
<tr>
<th>Sharename</th>
<th>Type</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>firstshare</td>
<td>Disk</td>
<td></td>
</tr>
<tr>
<td>IPC$</td>
<td>IPC</td>
<td>IPC Service (Public Test Server)</td>
</tr>
<tr>
<td>ADMIN$</td>
<td>IPC</td>
<td>IPC Service (Public Test Server)</td>
</tr>
</tbody>
</table>

Anonymous login successful
Domain=[WORKGROUP] OS=[Unix] Server=[Samba 3.0.10-1.4E.9]

Server               Comment
---------            -------
RHEL4B               Public Test Server
WINXP

Workgroup            Master
---------            -------
WORKGROUP            WINXP

10.3.2. smbclient anonymous

The screenshot below uses **smbclient** to display information about a remote smb server (in this case a computer with Ubuntu 11.10).

root@ubuntu110:/etc/samba# testparm smbclient -NL 127.0.0.1
Anonymous login successful
Domain=[LINUXTR] OS=[Unix] Server=[Samba 3.5.11]

<table>
<thead>
<tr>
<th>Sharename</th>
<th>Type</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>share1</td>
<td>Disk</td>
<td></td>
</tr>
<tr>
<td>IPC$</td>
<td>IPC</td>
<td>IPC Service (Samba 3.5.11)</td>
</tr>
</tbody>
</table>

Anonymous login successful
Domain=[LINUXTR] OS=[Unix] Server=[Samba 3.5.11]

Server               Comment
---------            -------
Workgroup            Master
---------            -------
LINUXTR              DEBIAN6
WORKGROUP            UBUNUT10

10.3.3. smbclient with credentials

Windows versions after xp sp2 and 2003 sp1 do not accept guest access (the NT_STATUS_ACCESS_DENIED error). This example shows how to provide credentials with **smbclient**.

[paul@RHEL53 ~]$ smbclient -L w2003 -U administrator%stargate

<table>
<thead>
<tr>
<th>Sharename</th>
<th>Type</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>C$</td>
<td>Disk</td>
<td>Default share</td>
</tr>
</tbody>
</table>
10.4. /usr/bin/smbtree

Another useful tool to troubleshoot Samba or simply to browse the SMB network is **smbtree**. In its simplest form, smbtree will do an anonymous browsing on the local subnet, displaying all SMB computers and (if authorized) their shares.

Let's take a look at two screenshots of smbtree in action (with blank password). The first one is taken immediately after booting four different computers (one MS Windows 2000, one MS Windows xp, one MS Windows 2003 and one RHEL 4 with Samba 3.0.10).

```
[paul@RHEL4b ~]$ smbtree
Password:
WORKGROUP
PEGASUS
\WINXP
\RHEL4B Pegasus Domain Member Server
Error connecting to 127.0.0.1 (Connection refused)
cli_full_connection: failed to connect to RHEL4B<20> (127.0.0.1)
\HM2003
[paul@RHEL4b ~]$ smbtree --version
Version 3.0.10-1.4E.9
[paul@RHEL4b ~]
```

The information displayed in the previous screenshot looks incomplete. The browsing elections are still ongoing, the browse list is not yet distributed to all clients by the (to be elected) browser master. The next screenshot was taken about one minute later. And it shows even less.

```
[paul@RHEL4b ~]$ smbtree
Password:
WORKGROUP
\W2000
[paul@RHEL4b ~]$
```

So we wait a while, and then run **smbtree** again, this time it looks a lot nicer.

```
[paul@RHEL4b ~]$ smbtree
Password:
WORKGROUP
\W2000
PEGASUS
\WINXP
\RHEL4B Pegasus Domain Member Server
\RHEL4B\ADMIN$ IPC Service (Pegasus Domain Member Server)
\RHEL4B\IPC$ IPC Service (Pegasus Domain Member Server)
\RHEL4B\domaindata Active Directory users only
\HM2003
[paul@RHEL4b ~]$ smbtree --version
Version 3.0.10-1.4E.9
[paul@RHEL4b ~]$
```

I added the version number of **smbtree** in the previous screenshot, to show you the difference when using the latest version of smbtree (below a screenshot taken from Ubuntu Feisty Fawn). The latest version shows a more complete overview of machines and shares.
paul@laika:~$ smbtree
Password:
WORKGROUP
\\W2000
\\W2000\firstshare
\\W2000\C$ Default share
\\W2000\ADMIN$ Remote Admin
\\W2000\IPC$ Remote IPC
PEGASUS
\\WINXP
cli_rpc_pipe_open: cli_nt_create failed on pipe \srvsvc to machine WINXP.
Error was NT_STATUS_ACCESS_DENIED
\\RHEL4B\ADMIN$ IPC Service (Pegasus Domain Member Server)
\\RHEL4B\IPC$ IPC Service (Pegasus Domain Member Server)
\\RHEL4B\domaindata Active Directory users only
\\HM2003
cli_rpc_pipe_open: cli_nt_create failed on pipe \srvsvc to machine HM2003.
Error was NT_STATUS_ACCESS_DENIED
paul@laika:~$

The previous screenshot also provides useful errors on why we cannot see shared info on computers winxp and w2003. Let us try the old smbtree version on our RHEL server, but this time with Administrator credentials (which are the same on all computers).

[paul@RHEL4b ~]$ smbtree -UAdministrator%Stargate1
WORKGROUP
\\W2000
PEGASUS
\\WINXP
\\WINXP\C$ Default share
\\WINXP\ADMIN$ Remote Admin
\\WINXP\IPC$ Remote IPC
\\RHEL4B\ADMIN$ IPC Service (Pegasus Domain Member Server)
\\RHEL4B\IPC$ IPC Service (Pegasus Domain Member Server)
\\RHEL4B\domaindata Active Directory users only
\\HM2003
\\HM2003\NETLOGON Logon server share
\\HM2003\SYSVOL Logon server share
\\HM2003\WSUSTemp A network share used by Local Publishing ...
\\HM2003\ADMIN$ Remote Admin
\\HM2003\tools
\\HM2003\IPC$ Remote IPC
\\HM2003\WsusContent A network share to be used by Local ...
\\HM2003\C$ Default share
[paul@RHEL4b ~]$ 

As you can see, this gives a very nice overview of all SMB computers and their shares.

10.5. server string

The comment seen by the net view and the smbclient commands is the default value for the server string option. Simply adding this value to the global section in smb.conf and restarting samba will change the option.

[root@RHEL53 samba]# testparm -s 2>/dev/null | grep server
server string = Red Hat Server in Paris

After a short while, the changed option is visible on the Microsoft computers.
10.6. Samba Web Administration Tool (SWAT)

Samba comes with a web based tool to manage your samba configuration file. SWAT is accessible with a web browser on port 901 of the host system. To enable the tool, first find out whether your system is using the *inetd* or the *xinetd* superdaemon.

```
[root@RHEL4b samba]# ps fax | grep inet
15026 pts/0    S+     0:00                      \_ grep inet
2771 ?        Ss     0:00 xinetd -stayalive -pidfile /var/run/xinetd.pid
[root@RHEL4b samba]#
```

Then edit the *inetd.conf* or change the disable = yes line in `/etc/xinetd.d/swat` to disable = no.

```
[root@RHEL4b samba]# cat /etc/xinetd.d/swat
# default: off
# description: SWAT is the Samba Web Admin Tool. Use swat \ #
# to configure your Samba server. To use SWAT, \ #
# connect to port 901 with your favorite web browser.
service swat
{
    port            = 901
    socket_type     = stream
    wait            = no
    only_from       = 127.0.0.1
    user            = root
    server          = /usr/sbin/swat
    log_on_failure  += USERID
    disable         = no
}
[root@RHEL4b samba]# /etc/init.d/xinetd restart
Stopping xinetd:                                           [  OK  ]
Starting xinetd:                                           [  OK  ]
[root@RHEL4b samba]#
```

Change the **only from** value to enable swat from remote computers. This examples shows how to provide swat access to all computers in a /24 subnet.

```
[root@RHEL53 xinetd.d]# grep only /etc/xinetd.d/swat
only_from  = 192.168.1.0/24
```

Be careful when using SWAT, it erases all your manually edited comments in *smb.conf*. 
10.7. practice: getting started with samba

1. Take a backup copy of the original smb.conf, name it smb.conf.orig

2. Enable SWAT and take a look at it.

3. Stop the Samba server.

4. Create a minimalistic smb.conf.minimal and test it with testparm.

5. Use testparm -s to create /etc/samba/smb.conf from your smb.conf.minimal.

6. Start Samba with your minimal smb.conf.

7. Verify with smbclient that your Samba server works.

8. Verify that another (Microsoft) computer can see your Samba server.


10. Change the "Server String" parameter in smb.conf. How long does it take before you see the change (net view, smbclient, My Network Places,...) ?

11. Will restarting Samba after a change to smb.conf speed up the change ?

12. Which computer is the master browser master in your workgroup ? What is the master browser ?

13. If time permits (or if you are waiting for other students to finish this practice), then install a sniffer (wireshark) and watch the browser elections.
10.8. solution: getting started with samba

1. Take a backup copy of the original smb.conf, name it smb.conf.orig
   
   cd /etc/samba ; cp smb.conf smb.conf.orig

2. Enable SWAT and take a look at it.
   
   on Debian/Ubuntu: vi /etc/inetd.conf (remove # before swat)
   on RHEL/Fedora: vi /etc/xinetd.d/swat (set disable to no)

3. Stop the Samba server.
   
   /etc/init.d/smb stop (Red Hat)
   /etc/init.d/samba stop (Debian)

4. Create a minimalistic smb.conf.minimal and test it with testparm.
   
   cd /etc/samba ; mkdir my_smb_confs ; cd my_smb_confs
   vi smb.conf.minimal
   testparm smb.conf.minimal

5. Use testparm -s to create /etc/samba/smb.conf from your smb.conf.minimal.
   
   testparm -s smb.conf.minimal > ../smb.conf

6. Start Samba with your minimal smb.conf.
   
   /etc/init.d/smb restart (Red Hat)
   /etc/init.d/samba restart (Debian)

7. Verify with smbclient that your Samba server works.
   
   smbclient -NL 127.0.0.1

8. Verify that another computer can see your Samba server.
   
   smbclient -NL 'ip-address' (on a Linux)

   
   on Linux: smbtree
   on Windows: net view (and WindowsKey + e)

10. Change the "Server String" parameter in smb.conf. How long does it take before you see the change (net view, smbclient, My Network Places,...) ?
   
   vi /etc/samba/smb.conf
   (should take only seconds when restarting samba)

11. Will restarting Samba after a change to smb.conf speed up the change?

   yes
12. Which computer is the master browser master in your workgroup? What is the master browser?

The computer that won the elections.
This machine will make the list of computers in the network

13. If time permits (or if you are waiting for other students to finish this practice), then install a sniffer (Wireshark) and watch the browser elections.

On Ubuntu: sudo aptitude install wireshark
Then: sudo wireshark, select interface
Chapter 11. a read only file server
11.1. Setting up a directory to share

Let's start with setting up a very simple read only file server with Samba. Everyone (even anonymous guests) will receive read access.

The first step is to create a directory and put some test files in it.

```
[root@RHEL52 ~]# mkdir -p /srv/samba/readonly
[root@RHEL52 ~]# cd /srv/samba/readonly/
[root@RHEL52 readonly]# echo "It is cold today." > winter.txt
[root@RHEL52 readonly]# echo "It is hot today." > summer.txt
[root@RHEL52 readonly]# ls -l
 total 8
-rw-r--r-- 1 root root 17 Jan 21 05:49 summer.txt
-rw-r--r-- 1 root root 18 Jan 21 05:49 winter.txt
```

11.2. configure the share

11.2.1. smb.conf [global] section

In this example the samba server is a member of WORKGROUP (the default workgroup). We also set a descriptive server string, this string is visible to users browsing the network with net view, windows explorer or smbclient.

```
[root@RHEL52 samba]# head -5 smb.conf
[global]
  workgroup = WORKGROUP
  server string = Public Anonymous File Server
  netbios name = TEACHER0
  security = share
```

You might have noticed the line with `security = share`. This line sets the default security mode for our samba server. Setting the security mode to `share` will allow clients (smbclient, any windows, another Samba server, ...) to provide a password for each share. This is one way of using the SMB/CIFS protocol. The other way (called `user mode`) will allow the client to provide a username/password combination, before the server knows which share the client wants to access.

11.2.2. smb.conf [share] section

The share is called pubread and the path is set to our newly created directory. Everyone is allowed access (guest ok = yes) and security is set to read only.

```
[pubread]
  path = /srv/samba/readonly
  comment = files to read
  read only = yes
  guest ok = yes
```

Here is a very similar configuration on Ubuntu 11.10.
root@ubu1110:~# cat /etc/samba/smb.conf
[global]
workgroup = LINUXTR
netbios name = UBU1110
security = share
[roshare1]
path = /srv/samba/readonly
read only = yes
guest ok = yes

It doesn't really matter which Linux distribution you use. Below the same config on Debian 6, as good as identical.

root@debian6:~# cat /etc/samba/smb.conf
[global]
workgroup = LINUXTR
netbios name = DEBIAN6
security = share
[roshare1]
path = /srv/samba/readonly
read only = yes
guest ok = yes

### 11.3. restart the server

After testing with `testparm`, restart the samba server (so you don't have to wait).

```
[root@RHEL4b readonly]# service smb restart
Shutting down SMB services: [ OK ]
Shutting down NMB services: [ OK ]
Starting SMB services: [ OK ]
Starting NMB services: [ OK ]
```

### 11.4. verify the share

#### 11.4.1. verify with smbclient

You can now verify the existence of the share with `smbclient`. Our `pubread` is listed as the fourth share.

```
[root@RHEL52 samba]# smbclient -NL 127.0.0.1
Sharename       Type      Comment
---------       ----      -------
IPC$            IPC       IPC Service (Public Anonymous File Server)
global$         Disk      global$
pub0            Disk      pub0
pubread         Disk      files to read
Server               Comment
---------            -------
TEACHER0             Samba 3.0.33-3.7.el5
W2003EE
Workgroup            Master
---------            -------
WORKGROUP            W2003EE
```
11.4.2. verify on windows

The final test is to go to a Microsoft windows computer and read a file on the Samba server. First we use the **net use** command to mount the pubread share on the driveletter k.

```
C:\>net use K: \\teacher0\pubread
The command completed successfully.
```

Then we test looking at the contents of the share, and reading the files.

```
C:\>dir k:
Volume in drive K is pubread
Volume Serial Number is 0C82-11F2

Directory of K:

21/01/2009  05:49    <DIR>          .
21/01/2009  05:49    <DIR>          ..
21/01/2009  05:49                17 summer.txt
21/01/2009  05:49                18 winter.txt
  2 File(s)            35 bytes
  2 Dir(s)  13.496.242.176 bytes free
```

Just to be on the safe side, let us try writing.

```
K:\>echo very cold > winter.txt
Access is denied.
K:\>
```

Or you can use windows explorer...
11.5. a note on netcat

The Windows command line screenshot is made in a Linux console, using netcat as a pipe to a Windows command shell.

The way this works, is by enabling netcat to listen on the windows computer to a certain port, executing cmd.exe when a connection is received. Netcat is similar to cat, in the way that cat does nothing, only netcat does nothing over the network.

To enable this connection, type the following on the windows computer (after downloading netcat for windows).

```
nc -l -p 23 -t -e cmd.exe
```

And then connect to this machine with netcat from any Linux computer. You end up with a cmd.exe prompt inside your Linux shell.

```
paul@laika:~$ nc 192.168.1.38 23
Microsoft Windows [Version 5.2.3790]
(C) Copyright 1985-2003 Microsoft Corp.

C:\>net use k: /delete
net use k: /delete
k: was deleted successfully.
```
11.6. practice: read only file server

1. Create a directory in a good location (FHS) to share files for everyone to read.

2. Make sure the directory is owned properly and is world accessible.

3. Put a textfile in this directory.

4. Share the directory with Samba.

5. Verify from your own and from another computer (smbclient, net use, ...) that the share is accessible for reading.

6. Make a backup copy of your smb.conf, name it smb.conf.ReadOnlyFileServer.
11.7. solution: read only file server

1. Create a directory in a good location (FHS) to share files for everyone to read.

   choose one of these...
   mkdir -p /srv/samba/readonly
   mkdir -p /home/samba/readonly
   /home/paul/readonly is wrong!!
   /etc/samba/readonly is wrong!!
   /readonly is wrong!!

2. Make sure the directory is owned properly and is world accessible.

   chown root:root /srv/samba/readonly
   chmod 755 /srv/samba/readonly

3. Put a textfile in this directory.

   echo Hello World > hello.txt

4. Share the directory with Samba.

   You smb.conf.readonly could look like this:
   [global]
   workgroup = WORKGROUP
   server string = Read Only File Server
   netbios name = STUDENTx
   security = share

   [readonlyX]
   path = /srv/samba/readonly
   comment = read only file share
   read only = yes
   guest ok = yes

   test with testparm before going in production!

5. Verify from your own and from another computer (smbclient, net use, ...) that the share is accessible for reading.

   On Linux: smbclient -NL 127.0.0.1
   On Windows Explorer: browse to My Network Places
   On Windows cmd.exe: net use L: //studentx/readonly

6. Make a backup copy of your smb.conf, name it smb.conf.ReadOnlyFileServer.

   cp smb.conf smb.conf.ReadOnlyFileServer
Chapter 12. a writable file server
12.1. set up a directory to share

In this second example, we will create a share where everyone can create files and write to files. Again, we start by creating a directory

```
[root@RHEL52 samba]# mkdir -p /srv/samba/writable
[root@RHEL52 samba]# chmod 777 /srv/samba/writable/
```

12.2. share section in smb.conf

There are two parameters to make a share writable. We can use read only or writable. This example shows how to use writable to give write access to a share.

```
writable = yes
```

And this is an example of using the read only parameter to give write access to a share.

```
read only = no
```

12.3. configure the share

Then we simply add a share to our file server by editing smb.conf. Below the check with testparm. (We could have changed the description of the server...)

```
[root@RHEL52 samba]# testparm
Load smb config files from /etc/samba/smb.conf
Processing section "[pubwrite]"
Processing section "[pubread]"
Loaded services file OK.
Server role: ROLE_STANDALONE
Press enter to see a dump of your service definitions

[global]
 netbios name = TEACHER0
 server string = Public Anonymous File Server
 security = SHARE

[pubwrite]
 comment = files to write
 path = /srv/samba/writable
 read only = No
 guest ok = Yes

[pubread]
 comment = files to read
 path = /srv/samba/readonly
 guest ok = Yes
```

12.4. test connection with windows

We can now test the connection on a windows 2003 computer. We use the net use for this.

```
C:\>net use L: \\teacher0\pubwrite
net use L: \\teacher0\pubwrite
The command completed successfully.
```
12.5. test writing with windows

We mounted the **pubwrite** share on the L: drive in windows. Below we test that we can write to this share.

```
L:\>echo hoi > hoi.txt
L:\>dir
```

```
Volume in drive L is pubwrite
Volume Serial Number is 0C82-272A
Directory of L:\
21/01/2009  06:11    <DIR>          .
21/01/2009  06:11    <DIR>          ..
21/01/2009  06:16                 6 hoi.txt
  1 File(s)              6 bytes
  2 Dir(s)  13.496.238.080 bytes free
```

12.6. How is this possible ?

Linux (or any Unix) always needs a user account to gain access to a system. The windows computer did not provide the samba server with a user account or a password. Instead, the Linux owner of the files created through this writable share is the Linux guest account (usually named nobody).

```
[root@RHEL52 samba]# ls -l /srv/samba/writable/
total 4
-rw-r--r-- 1 nobody nobody 6 Jan 21 06:16 hoi.txt
```

So this is not the cleanest solution. We will need to improve this.
12.7. practice: writable file server

1. Create a directory and share it with Samba.

2. Make sure everyone can read and write files, test writing with `smbclient` and from a Microsoft computer.

3. Verify the ownership of files created by (various) users.
12.8. solution: writable file server

1. Create a directory and share it with Samba.

```bash
mkdir /srv/samba/writable
chmod 777 /srv/samba/writable
```

The share section in `smb.conf` can look like this:

```
[pubwrite]
path = /srv/samba/writable
comment = files to write
read only = no
guest ok = yes
```

2. Make sure everyone can read and write files, test writing with `smbclient` and from a Microsoft computer.

To test writing with `smbclient`:

```bash
echo one > count.txt
echo two >> count.txt
echo three >> count.txt
smbclient //localhost/pubwrite
Password:
smb: \> put count.txt
```

3. Verify the ownership of files created by (various) users.

```bash
ls -l /srv/samba/writable
```
Chapter 13. samba first user account
13.1. creating a samba user

We will create a user for our samba file server and make this user the owner of the directory and all of its files. This anonymous user gets a clear description, but does not get a login shell.

```
[root@RHEL52 samba]# useradd -s /bin/false sambanobody
[root@RHEL52 samba]# usermod -c "Anonymous Samba Access" sambanobody
[root@RHEL52 samba]# passwd sambanobody
Changing password for user sambanobody.
New UNIX password: 
Retype new UNIX password: 
passwd: all authentication tokens updated successfully.
```

13.2. ownership of files

We can use this user as owner of files and directories, instead of using the root account. This approach is clear and more secure.

```
[root@RHEL52 samba]# chown -R sambanobody:sambanobody /srv/samba/
[root@RHEL52 samba]# ls -al /srv/samba/writable/
total 12
drwxrwxrwx 2 sambanobody sambanobody 4096 Jan 21 06:11 .
drwxr-xr-x 6 sambanobody sambanobody 4096 Jan 21 06:11 ..
-rwxr--r-- 1 sambanobody sambanobody 6 Jan 21 06:16 hoi.txt
```

13.3. /usr/bin/smbpasswd

The sambanobody user account that we created in the previous examples is not yet used by samba. It just owns the files and directories that we created for our shares. The goal of this section is to force ownership of files created through the samba share to belong to our sambanobody user. Remember, our server is still accessible to everyone, nobody needs to know this user account or password. We just want a clean Linux server.

To accomplish this, we first have to tell Samba about this user. We can do this by adding the account to `smbpasswd`.

```
[root@RHEL52 samba]# smbpasswd -a sambanobody
New SMB password: 
Retype new SMB password: 
Added user sambanobody.
```

13.4. /etc/samba/smbpasswd

To find out where Samba keeps this information (for now), use `smbd -b`. The `PRIVATE_DIR` variable will show you where the smbpasswd database is located.

```
[root@RHEL52 samba]# smbd -b | grep PRIVATE
PRIVATE_DIR: /etc/samba
[root@RHEL52 samba]# ls -l smbpasswd
-rw------- 1 root root 110 Jan 21 06:16 smbpasswd
```

You can use a simple cat to see the contents of the `smbpasswd` database. The sambanobody user does have a password (it is secret).

```
[root@RHEL52 samba]# cat smbpasswd
```
13.5. passdb backend

Note that recent versions of Samba have `tdbsam` as default for the `passdb backend` parameter.

```
root@ubu1110:~# testparm -v 2>/dev/null| grep 'passdb backend'
passdb backend = tdbsam
```

13.6. forcing this user

Now that Samba knows about this user, we can adjust our writable share to force the ownership of files created through it. For this we use the `force user` and `force group` options. Now we can be sure that all files in the Samba writable share are owned by the same sambanobody user.

Below is the renewed definition of our share in smb.conf.

```
[pubwrite]
path = /srv/samba/writable
comment = files to write
force user = sambanobody
force group = sambanobody
read only = no
guest ok = yes
```

When you reconnect to the share and write a file, then this sambanobody user will own the newly created file (and nobody needs to know the password).
13.7. practice: first samba user account

1. Create a user account for use with samba.

2. Add this user to samba's user database.

3. Create a writable shared directory and use the "force user" and "force group" directives to force ownership of files.

4. Test the working of force user with smbclient, net use and Windows Explorer.
13.8. solution: first samba user account

1. Create a user account for use with samba.

```
useradd -s /bin/false smbguest
usermod -c 'samba guest'
passwd smbguest
```

2. Add this user to samba's user database.

```
smbpasswd -a smbguest
```

3. Create a writable shared directory and use the "force user" and "force group" directives to force ownership of files.

```
[userwrite]
path = /srv/samba/userwrite
comment = everyone writes files owned by smbguest
read only = no
guest ok = yes
force user = smbguest
force group = smbguest
```

4. Test the working of force user with smbclient, net use and Windows Explorer.

```
ls -l /srv/samba/userwrite (and verify ownership)
```
Chapter 14. samba authentication
14.1. creating the users on Linux

The goal of this example is to set up a file share accessible to a number of different users. The users will need to authenticate with their password before access to this share is granted. We will first create three randomly named users, each with their own password. First we add these users to Linux.

```
[root@RHEL52 ~]# useradd -c "Serena Williams" serena
[root@RHEL52 ~]# useradd -c "Justine Henin" justine
[root@RHEL52 ~]# useradd -c "Martina Hingis" martina
[root@RHEL52 ~]# passwd serena
Changing password for user serena.
New UNIX password: 
Retype new UNIX password: 
passwd: all authentication tokens updated successfully.
[root@RHEL52 ~]# passwd justine
Changing password for user justine.
New UNIX password: 
Retype new UNIX password: 
passwd: all authentication tokens updated successfully.
[root@RHEL52 ~]# passwd martina
Changing password for user martina.
New UNIX password: 
Retype new UNIX password: 
passwd: all authentication tokens updated successfully.
```

14.2. creating the users on samba

Then we add them to the `smbpasswd` file, with the same password.

```
[root@RHEL52 ~]# smbpasswd -a serena
New SMB password: 
Retype new SMB password: 
Added user serena.
[root@RHEL52 ~]# smbpasswd -a justine
New SMB password: 
Retype new SMB password: 
Added user justine.
[root@RHEL52 ~]# smbpasswd -a martina
New SMB password: 
Retype new SMB password: 
Added user martina.
```

14.3. security = user

Remember that we set samba's security mode to share with the `security = share` directive in the `[global]` section? Since we now require users to always provide a userid and password for access to our samba server, we will need to change this. Setting `security = user` will require the client to provide samba with a valid userid and password before giving access to a share.

Our `[global]` section now looks like this.
14.4. configuring the share

We add the following [share] section to our smb.conf (and we do not forget to create the directory /srv/samba/authwrite).

```
[authwrite]
path = /srv/samba/authwrite
comment = authenticated users only
read only = no
guest ok = no
```

14.5. testing access with net use

After restarting samba, we test with different users from within Microsoft computers. The screenshots use the `net use` First serena from Windows XP.

```
C:\>net use m: \teacher0\authwrite stargate /user:serena
The command completed successfully.
C:\>m:
M:\>echo greetings from Serena > serena.txt
```

The next screenshot is martina on a Windows 2000 computer, she succeeds in writing her files, but fails to overwrite the file from serena.

```
C:\>net use k: \teacher0\authwrite stargate /user:martina
The command completed successfully.
C:\>k:
K:\>echo greetings from martina > Martina.txt
K:\>echo test overwrite > serena.txt
Access is denied.
```

14.6. testing access with smbclient

You can also test connecting with authentication with `smbclient`. First we test with a wrong password.

```
[root@RHEL52 samba]# smbclient //teacher0/authwrite -U martina wrongpass
session setup failed: NT_STATUS_LOGON_FAILURE
```

---

samba authentication

Then we test with the correct password, and verify that we can access a file on the share.

    [root@RHEL52 samba]# smbclient //teacher0/authwrite -U martina stargate
    Domain=[TEACHER0] OS=[Unix] Server=[Samba 3.0.33-3.7.el5]
    getting file \serena.txt of size 14 as /tmp/smbmore.QQfmSN (6.8 kb/s)
    one
two
three
    smb: \> q

14.7. verify ownership

    We now have a simple standalone samba file server with authenticated access. And the files
    in the shares belong to their proper owners.

    [root@RHEL52 samba]# ls -l /srv/samba/authwrite/
    total 8
    -rwxr--r-- 1 martina martina  0 Jan 21 20:06 martina.txt
    -rwxr--r-- 1 serena  serena  14 Jan 21 20:06 serena.txt
    -rwxr--r-- 1 serena  serena   6 Jan 21 20:09 ser.txt

14.8. common problems

14.8.1. NT_STATUS_BAD_NETWORK_NAME

    You can get NT_STATUS_BAD_NETWORK_NAME when you forget to create the
    target directory.

    [root@RHEL52 samba]# rm -rf /srv/samba/authwrite/
    [root@RHEL52 samba]# smbclient //teacher0/authwrite -U martina stargate
    Domain=[TEACHER0] OS=[Unix] Server=[Samba 3.0.33-3.7.el5]
    tree connect failed: NT_STATUS_BAD_NETWORK_NAME

14.8.2. NT_STATUS_LOGON_FAILURE

    You can get NT_STATUS_LOGON_FAILURE when you type the wrong password or
    when you type an unexisting username.

    [root@RHEL52 samba]# smbclient //teacher0/authwrite -U martina STARGATE
    session setup failed: NT_STATUS_LOGON_FAILURE

14.8.3. usernames are (not) case sensitive

    Remember that usernames on Linux are case sensitive.

    [root@RHEL52 samba]# su - MARTINA
    su: user MARTINA does not exist
samba authentication

But usernames on Microsoft computers are not case sensitive.

```bash
[root@RHEL52 samba]# su - martina
[martina@RHEL52 ~]$ 
```

```bash
[root@RHEL52 samba]# smbclient //teacher0/authwrite -U martina stargate
Domain=[TEACHER0] OS=[Unix] Server=[Samba 3.0.33-3.7.el5]
smb: \> q
```

```bash
[root@RHEL52 samba]# smbclient //teacher0/authwrite -U MARTINA stargate
Domain=[TEACHER0] OS=[Unix] Server=[Samba 3.0.33-3.7.el5]
smb: \> q
```
14.9. practice: samba authentication

0. Make sure you have properly named backups of your smb.conf of the previous practices.

1. Create three users (on the Linux and on the samba), remember their passwords!

2. Set up a shared directory that is only accessible to authenticated users.

3. Use smbclient and a windows computer to access your share, use more than one user account (windows requires a logoff/logon for this).

4. Verify that files created by these users belong to them.

5. Try to change or delete a file from another user.
14.10. solution: samba authentication

1. Create three users (on the Linux and on the samba), remember their passwords!

```bash
useradd -c 'SMB user1' userx
passwd userx
```

2. Set up a shared directory that is only accessible to authenticated users.

The shared section in smb.conf could look like this:

```ini
[authwrite]
path = /srv/samba/authwrite
comment = authenticated users only
read only = no
guest ok = no
```

3. Use smbclient and a windows computer to access your share, use more than one user account (windows requires a logoff/logon for this).

On Linux: `smbclient //studentX/authwrite -U user1 password`

On windows `net use p: \studentX\authwrite password /user:user2`

4. Verify that files created by these users belong to them.

`ls -l /srv/samba/authwrite`

5. Try to change or delete a file from another user.

you should not be able to change or overwrite files from others.
Chapter 15. samba securing shares
15.1. security based on user name

15.1.1. valid users

To restrict users per share, you can use the **valid users** parameter. In the example below, only the users listed as valid will be able to access the tennis share.

```
[tennis]
path = /srv/samba/tennis
comment = authenticated and valid users only
read only = No
guest ok = No
valid users = serena, kim, venus, justine
```

15.1.2. invalid users

If you are paranoid, you can also use **invalid users** to explicitly deny the listed users access. When a user is in both lists, the user has no access!

```
[tennis]
path = /srv/samba/tennis
read only = No
guest ok = No
valid users = kim, serena, venus, justine
invalid users = venus
```

15.1.3. read list

On a writable share, you can set a list of read only users with the **read list** parameter.

```
[football]
path = /srv/samba/football
read only = No
guest ok = No
read list = martina, roberto
```

15.1.4. write list

Even on a read only share, you can set a list of users that can write. Use the **write list** parameter.

```
[football]
path = /srv/samba/golf
read only = Yes
guest ok = No
write list = eddy, jan
```

15.2. security based on ip-address

15.2.1. hosts allow

The **hosts allow** or **allow hosts** parameter is one of the key advantages of Samba. It allows access control of shares on the ip-address level. To allow only specific hosts to access a share, list the hosts, separated by comma's.
allow hosts = 192.168.1.5, 192.168.1.40

Allowing entire subnets is done by ending the range with a dot.

allow hosts = 192.168.1.

Subnet masks can be added in the classical way.

allow hosts = 10.0.0.0/255.0.0.0

You can also allow an entire subnet with exceptions.

hosts allow = 10. except 10.0.0.12

### 15.2.2. hosts deny

The *hosts deny* or *deny hosts* parameter is the logical counterpart of the previous. The syntax is the same as for hosts allow.

hosts deny = 192.168.1.55, 192.168.1.56

### 15.3. security through obscurity

#### 15.3.1. hide unreadable

Setting *hide unreadable* to yes will prevent users from seeing files that cannot be read by them.

hide unreadable = yes

#### 15.3.2. browsable

Setting the *browseable = no* directive will hide shares from My Network Places. But it will not prevent someone from accessing the share (when the name of the share is known).

Note that *browsable* and *browseable* are both correct syntax.

```
[pubread]
path = /srv/samba/readonly
comment = files to read
read only = yes
guest ok = yes
browseable = no
```

### 15.4. file system security

#### 15.4.1. create mask

You can use *create mask* and *directory mask* to set the maximum allowed permissions for newly created files and directories. The mask you set is an AND mask (it takes permissions away).

```
[tennis]
path = /srv/samba/tennis
read only = No
```
15.4.2. force create mode

Similar to create mask, but different. Where the mask from above was a logical AND, the mode you set here is a logical OR (so it adds permissions). You can use the force create mode and force directory mode to set the minimal required permissions for newly created files and directories.

```
[tennis]
path = /srv/samba/tennis
read only = No
guest ok = No
force create mode = 444
force directory mode = 550
```

15.4.3. security mask

The security mask and directory security mask work in the same way as create mask and directory mask, but apply only when a windows user is changing permissions using the windows security dialog box.

15.4.4. force security mode

The force security mode and force directory security mode work in the same way as force create mode and force directory mode, but apply only when a windows user is changing permissions using the windows security dialog box.

15.4.5. inherit permissions

With inherit permissions = yes you can force newly created files and directories to inherit permissions from their parent directory, overriding the create mask and directory mask settings.

```
[authwrite]
path = /srv/samba/authwrite
comment = authenticated users only
read only = no
guest ok = no
create mask = 600
directory mask = 555
inherit permissions = yes
```
15.5. practice: securing shares

1. Create a writable share called sales, and a readonly share called budget. Test that it works.

2. Limit access to the sales share to ann, sandra and veronique.

3. Make sure that roberto cannot access the sales share.

4. Even though the sales share is writable, ann should only have read access.

5. Even though the budget share is read only, sandra should also have write access.

6. Limit one shared directory to the 192.168.1.0/24 subnet, and another share to the two computers with ip-addresses 192.168.1.33 and 172.17.18.19.

7. Make sure the computer with ip 192.168.1.203 cannot access the budget share.

8. Make sure (on the budget share) that users can see only files and directories to which they have access.

9. Make sure the sales share is not visible when browsing the network.

10. All files created in the sales share should have 640 permissions or less.

11. All directories created in the budget share should have 750 permissions or more.

12. Permissions for files on the sales share should never be set more than 664.

13. Permissions for files on the budget share should never be set less than 500.

14. If time permits (or if you are waiting for other students to finish this practice), then combine the "read only" and "writable" statements to check which one has priority.

15. If time permits then combine "read list", "write list", "hosts allow" and "hosts deny". Which of these has priority?
15.6. solution: securing shares

1. Create a writable share called sales, and a readonly share called budget. Test that it works.

   see previous solutions on how to do this...

2. Limit access to the sales share to ann, sandra and veronique.

   valid users = ann, sandra, veronique

3. Make sure that roberto cannot access the sales share.

   invalid users = roberto

4. Even though the sales share is writable, ann should only have read access.

   read list = ann

5. Even though the budget share is read only, sandra should also have write access.

   write list = sandra

6. Limit one shared directory to the 192.168.1.0/24 subnet, and another share to the two computers with ip-addresses 192.168.1.33 and 172.17.18.19.

   hosts allow = 192.168.1.
   hosts allow = 192.168.1.33, 172.17.18.19

7. Make sure the computer with ip 192.168.1.203 cannot access the budget share.

   hosts deny = 192.168.1.203

8. Make sure (on the budget share) that users can see only files and directories to which they have access.

   hide unreadable = yes

9. Make sure the sales share is not visible when browsing the network.

   browsable = no

10. All files created in the sales share should have 640 permissions or less.

    create mask = 640

11. All directories created in the budget share should have 750 permissions or more.

    force directory mode = 750

12. Permissions for files on the sales share should never be set more than 664.

    security mask = 750

13. Permissions for files on the budget share should never be set less than 500.

    force security directory mask = 500

14. If time permits (or if you are waiting for other students to finish this practice), then combine the "read only" and "writable" statements to check which one has priority.
15. If time permits then combine "read list", "write list", "hosts allow" and "hosts deny". Which of these has priority?
Chapter 16. samba domain member
16.1. changes in smb.conf

16.1.1. workgroup

The workgroup option in the global section should match the netbios name of the Active Directory domain.

```
workgroup = STARGATE
```

16.1.2. security mode

Authentication will not be handled by samba now, but by the Active Directory domain controllers, so we set the security option to domain.

```
security = Domain
```

16.1.3. Linux uid's

Linux requires a user account for every user accessing its file system, we need to provide Samba with a range of uid's and gid's that it can use to create these user accounts. The range is determined with the idmap uid and the idmap gid parameters. The first Active Directory user to connect will receive Linux uid 20000.

```
idmap uid = 20000-22000
idmap gid = 20000-22000
```

16.1.4. winbind use default domain

The winbind use default domain parameter makes sure winbind also operates on users without a domain component in their name.

```
winbind use default domain = yes
```

16.1.5. [global] section in smb.conf

Below is our new global section in smb.conf.

```
[global]
workgroup = STARGATE
security = Domain
server string = Stargate Domain Member Server
idmap uid = 20000-22000
idmap gid = 20000-22000
winbind use default domain = yes
```
16.1.6. realm in /etc/krb5.conf

To connect to a Windows 2003 sp2 (or later) you will need to adjust the kerberos realm in /etc/krb5.conf and set both lookup statements to true.

```
[libdefaults]
default_realm = STARGATE.LOCAL
dns_lookup_realm = true
dns_lookup_kdc = true
```

16.1.7. [share] section in smb.conf

Nothing special is required for the share section in smb.conf. Remember that we do not manually create users in smbpasswd or on the Linux (/etc/passwd). Only Active Directory users are allowed access.

```
[domaindata]
path = /srv/samba/domaindata
comment = Active Directory users only
read only = No
```

16.2. joining an Active Directory domain

While the Samba server is stopped, you can use `net rpc join` to join the Active Directory domain.

```
[root@RHEL52 samba]# service smb stop
Shutting down SMB services: [ OK ]
Shutting down NMB services: [ OK ]
[root@RHEL52 samba]# net rpc join -U Administrator
Password:
Joined domain STARGATE.
```

We can verify in the aduc (Active Directory Users and Computers) that a computer account is created for this samba server.
16.3. winbind

16.3.1. adding winbind to nsswitch.conf

The *winbind* daemon is talking with the Active Directory domain.

We need to update the `/etc/nsswitch.conf` file now, so user group and host names can be resolved against the winbind daemon.

```
[root@RHEL52 samba]# vi /etc/nsswitch.conf
[root@RHEL52 samba]# grep winbind /etc/nsswitch.conf
passwd:     files winbind
group:      files winbind
hosts:      files dns winbind
```

16.3.2. starting samba and winbindd

Time to start Samba followed by *winbindd*.

```
[root@RHEL4b samba]# service smb start
Starting SMB services:                                     [  OK  ]
Starting NMB services:                                     [  OK  ]
[root@RHEL4b samba]# service winbind start
Starting winbindd services:                                [  OK  ]
```

16.4. wbinfo

16.4.1. verify the trust

You can use `wbinfo -t` to verify the trust between your samba server and Active Directory.
16.4.2. list all users

We can obtain a list of all user with the `wbinfo -u` command. The domain is not shown when the `winbind use default domain` parameter is set.

```
[root@RHEL52 ~]# wbinfo -u
TEACHER0\serena
TEACHER0\justine
TEACHER0\martina
STARGATE\administrator
STARGATE\guest
STARGATE\support_388945a0
STARGATE\pol
STARGATE\krbtgt
STARGATE\arthur
STARGATE\harry
```

16.4.3. list all groups

We can obtain a list of all domain groups with the `wbinfo -g` command. The domain is not shown when the `winbind use default domain` parameter is set.

```
[root@RHEL52 ~]# wbinfo -g
BUILTIN\administrators
BUILTIN\users
BATMAN\domain computers
BATMAN\domain controllers
BATMAN\schema admins
BATMAN\enterprise admins
BATMAN\domain admins
BATMAN\domain users
BATMAN\domain guests
BATMAN\group policy creator owners
BATMAN\dnsupdateproxy
```

16.4.4. query a user

We can use `wbinfo -a` to verify authentication of a user against Active Directory. Assuming a user account `harry` with password `stargate` is just created on the Active Directory, we get the following screenshot.

```
[root@RHEL52 ~]# wbinfo -a harry%stargate
plaintext password authentication succeeded
challenge/response password authentication succeeded
```

16.5. getent

We can use `getent` to verify that winbindd is working and actually adding the Active directory users to `/etc/passwd`. 
If the user already exists locally, then the local user account is shown. This is because winbind is configured in `/etc/nsswitch.conf` after `files`.

All the Active Directory users can now easily connect to the Samba share. Files created by them, belong to them.

### 16.6. file ownership

```bash
[root@RHEL4b samba]# ll /srv/samba/domaindata/
total 0
-rwxr--r--  1 justine 20000 0 Jun 22 19:54 create_by_justine_on_winxp.txt
-rwxr--r--  1 venus 20000 0 Jun 22 19:55 create_by_venus.txt
-rwxr--r--  1 maria 20000 0 Jun 22 19:57 Maria.txt
```
16.7. practice : samba domain member

1. Verify that you have a working Active Directory (AD) domain.

2. Add the domain name and domain controller to /etc/hosts. Set the AD-DNS in /etc/resolv.conf.

3. Setup Samba as a member server in the domain.

4. Verify the creation of a computer account in AD for your Samba server.

5. Verify the automatic creation of AD users in /etc/passwd with wbinfo and getent.

6. Connect to Samba shares with AD users, and verify ownership of their files.
Chapter 17. samba domain controller
17.1. about Domain Controllers

17.1.1. Windows NT4

Windows NT4 works with single master replication domain controllers. There is exactly one PDC (Primary Domain Controller) in the domain, and zero or more BDC's (Backup Domain Controllers). Samba 3 has all features found in Windows NT4 PDC and BDC, and more. This includes file and print serving, domain control with single logon, logon scripts, home directories and roaming profiles.

17.1.2. Windows 200x

With Windows 2000 came Active Directory. AD includes multimaster replication and group policies. Samba 3 can only be a member server in Active Directory, it cannot manage group policies. Samba 4 can do this (in beta).

17.1.3. Samba 3

Samba 3 can act as a domain controller in its own domain. In a Windows NT4 domain, with one Windows NT4 PDC and zero or more BDC's, Samba 3 can only be a member server. The same is valid for Samba 3 in an Active Directory Domain. In short, a Samba 3 domain controller can not share domain control with Windows domain controllers.

17.1.4. Samba 4

Samba 4 can be a domain controller in an Active Directory domain, including managing group policies. As of this writing, Samba 4 is not released for production!

17.2. About security modes

17.2.1. security = share

The 'Windows for Workgroups' way of working, a client requests connection to a share and provides a password for that connection. Anyone who knows a password for a share can access that share. This security model was common in Windows 3.11, Windows 95, Windows 98 and Windows ME.

17.2.2. security = user

The client will send a userid + password before the server knows which share the client wants to access. This mode should be used whenever the samba server is in control of the user database. Both for standalone and samba domain controllers.

17.2.3. security = domain

This mode will allow samba to verify user credentials using NTLM in Windows NT4 and in all Active Directory domains. This is similar to Windows NT4 BDC's joining a native Windows 2000/3 Active Directory domain.
17.2.4. security = ads

This mode will make Samba use Kerberos to connect to the Active Directory domain.

17.2.5. security = server

This mode is obsolete, it can be used to forward authentication to another server.

17.3. About password backends

The previous chapters all used the `smbpasswd` user database. For domain control we opt for the `tdbsam` password backend. Another option would be to use LDAP. Larger domains will benefit from using LDAP instead of the not so scalable `tdbsam`. When you need more than one Domain Controller, then the Samba team advises to not use `tdbsam`.

17.4. [global] section in smb.conf

Now is a good time to start adding comments in your `smb.conf`. First we will take a look at the naming of our domain and server in the `[global]` section, and at the domain controlling parameters.

17.4.1. security

The security must be set to user (which is the default). This mode will make Samba control the user accounts, so it will allow Samba to act as a domain controller.

```
security = user
```

17.4.2. os level

A Samba server is the most stable computer in the network, so it should win all browser elections (`os level` above 32) to become the browser master.

```
os level = 33
```

17.4.3. passdb backend

The `passdb backend` parameter will determine whether Samba uses `smbpasswd`, `tdbsam` or ldap.

```
passdb backend = tdbsam
```

17.4.4. preferred master

Setting the `preferred master` parameter to yes will make the nmbd daemon force an election on startup.

```
preferred master = yes
```

17.4.5. domain logons

Setting the `domain logons` parameter will make this Samba server a domain controller.
17.4.6. domain master

Setting the **domain master** parameter can cause samba to claim the **domain master browser** role for its workgroup. Don't use this parameter in a workgroup with an active NT4 PDC.

domain master = yes

17.4.7. [global] section

The screenshot below shows a sample [global] section for a samba domain controller.

```plaintext
[global]
# names
workgroup = SPORTS
netbios name = DCSPORTS
server string = Sports Domain Controller
# domain control parameters
security = user
os level = 33
preferred master = Yes
domain master = Yes
domain logons = Yes
```

17.5. netlogon share

Part of the microsoft definition for a domain controller is that it should have a **netlogon share**. This is the relevant part of smb.conf to create this netlogon share on Samba.

```plaintext
[netlogon]
comment = Network Logon Service
path = /srv/samba/netlogon
admin users = root
guest ok = Yes
browseable = No
```

17.6. other [share] sections

We create some sections for file shares, to test the samba server. Users can all access the general sports file share, but only group members can access their own sports share.

```plaintext
[sports]
comment = Information about all sports
path = /srv/samba/sports
valid users = @ntsports
read only = No

[tennis]
comment = Information about tennis
path = /srv/samba/tennis
valid users = @nttennis
read only = No
```
17.7. Users and Groups

To be able to use users and groups in the Samba domain controller, we can first set up some groups on the Linux computer.

```
[root@RHEL52 samba]# groupadd ntadmins
[root@RHEL52 samba]# groupadd ntsports
[root@RHEL52 samba]# groupadd ntfootball
[root@RHEL52 samba]# groupadd nttennis
```

This enables us to add group membership info to some new users for our Samba domain. Don't forget to give them a password.

```
[root@RHEL52 samba]# useradd -m -G ntadmins Administrator
[root@RHEL52 samba]# useradd -m -G ntsports,nttennis venus
[root@RHEL52 samba]# useradd -m -G ntsports,nttennis kim
[root@RHEL52 samba]# useradd -m -G ntsports,nttennis jelena
[root@RHEL52 samba]# useradd -m -G ntsports,ntfootball figo
[root@RHEL52 samba]# useradd -m -G ntsports,ntfootball ronaldo
[root@RHEL52 samba]# useradd -m -G ntsports,ntfootball pfaff
```

It is always safe to verify creation of users, groups and passwords in /etc/passwd, /etc/shadow and /etc/group.

```
[root@RHEL52 samba]# tail -11 /etc/group
ntadmins:x:507:Administrator
ntsports:x:508:venus,kim,jelena,figo,ronaldo,pfaff
ntfootball:x:509:figo,ronaldo,pfaff
nttennis:x:510:venus,kim,jelena
Administrator:x:511:
venus:x:512:
kim:x:513:
jelena:x:514:
figo:x:515:
ronaldo:x:516:
pfaff:x:517:
```

17.8. tdbmsam

Next we must make these users known to Samba with the smbpasswd tool. When you add the first user to tdbmsam, the file /etc/samba/passdb.tdb will be created.

```
[root@RHEL52 samba]# smbpasswd -a root
New SMB password:
```
Retype new SMB password:
tdbsam_open: Converting version 0 database to version 3.
Added user root.

Adding all the other users generates less output, because tdbsam is already created.

17.9. about computer accounts

Every NT computer (Windows NT, 2000, XP, Vista) can become a member of a domain. Joining the domain (by right-clicking on My Computer) means that a computer account will be created in the domain. This computer account also has a password (but you cannot know it) to prevent other computers with the same name from accidentally becoming member of the domain. The computer account created by Samba is visible in the /etc/passwd file on Linux. Computer accounts appear as a normal user account, but end their name with a dollar sign. Below a screenshot of the windows 2003 computer account, created by Samba 3.

To be able to create the account, you will need to provide credentials of an account with the permission to create accounts (by default only root can do this on Linux). And we will have to tell Samba how to to this, by adding an add machine script to the global section of smb.conf.

You can now join a Microsoft computer to the sports domain (with the root user). After reboot of the Microsoft computer, you will be able to logon with Administrator (password Stargate1), but you will get an error about your roaming profile. We will fix this in the next section.

When joining the samba domain, you have to enter the credentials of a Linux account that can create users (usually only root can do this). If the Microsoft computer complains with The parameter is incorrect, then you possibly forgot to add the add machine script.

17.10. local or roaming profiles

For your information, if you want to force local profiles instead of roaming profiles, then simply add the following two lines to the global section in smb.conf.
Microsoft computers store a lot of User Metadata and application data in a user profile. Making this profile available on the network will enable users to keep their Desktop and Application settings across computers. User profiles on the network are called **roaming profiles** or **roving profiles**. The Samba domain controller can manage these profiles. First we need to add the relevant section in `smb.conf`.

```plaintext
[Profiles]
   comment = User Profiles
   path = /srv/samba/profiles
   readonly = No
   profile acls = Yes
```

Besides the share section, we also need to set the location of the profiles share (this can be another Samba server) in the global section.

```plaintext
logon path = \%L\Profiles\%U
```

The `%L` variable is the name of this Samba server, the `%U` variable translates to the username. After adding a user to `smbpasswd` and letting the user log on and off, the profile of the user will look like this.

```bash
[root@RHEL4b samba]# ll /srv/samba/profiles/Venus/
total 568
drwxr-xr-x  4 Venus Venus   4096 Jul  5 10:03 Application Data
drwxr-xr-x  2 Venus Venus   4096 Jul  5 10:03 Cookies
drwxr-xr-x  3 Venus Venus   4096 Jul  5 10:03 Desktop
drwxr-xr-x  3 Venus Venus   4096 Jul  5 10:03 Favorites
drwxr-xr-x  4 Venus Venus   4096 Jul  5 10:03 My Documents
drwxr-xr-x  2 Venus Venus   4096 Jul  5 10:03 NetHood
-rwxr---r--  1 Venus Venus 524288 Jul  5 2007 NTUSER.DAT
-rwxr---r--  1 Venus Venus 1024 Jul  5 2007 NTUSER.DAT.LOG
-rwxr---r--  1 Venus Venus   268 Jul  5 10:03 ntuser.ini
drwxr-xr-x  2 Venus Venus   4096 Jul  5 10:03 PrintHood
drwxr-xr-x  2 Venus Venus   4096 Jul  5 10:03 Recent
drwxr-xr-x  2 Venus Venus   4096 Jul  5 10:03 SendTo
drwxr-xr-x  3 Venus Venus   4096 Jul  5 10:03 Start Menu
drwxr-xr-x  2 Venus Venus   4096 Jul  5 10:03 Templates
```

### 17.11. Groups in NTFS acls

We have users on Unix, we have groups on Unix that contain those users.

```bash
[root@RHEL4b samba]# grep nt /etc/group
...
ntadmins:x:506:Administrator
ntsports:x:507:Venus,Serena,Kim,Figo,Pfaff
nttennis:x:508:Venus,Serena,Kim
ntfootball:x:509:Figo,Pfaff
```
samba domain controller

We already added Venus to the **tdbsam** with **smbpasswd**.

```
[root@RHEL4b samba]#
smbpasswd -a Venus
```

Does this mean that Venus can access the tennis and the sports shares? Yes, all access works fine on the Samba server. But the nttennis group is not available on the windows machines. To make the groups available on windows (like in the ntfs security tab of files and folders), we have to map unix groups to windows groups. To do this, we use the **net groupmap** command.

```
[root@RHEL4b samba]# net groupmap add ntgroup="tennis" unixgroup=nttennis type=d
Successfully added group tennis to the mapping db
[root@RHEL4b samba]# net groupmap add ntgroup="football" unixgroup=ntfootball type=d
Successfully added group football to the mapping db
[root@RHEL4b samba]# net groupmap add ntgroup="sports" unixgroup=ntsports type=d
Successfully added group sports to the mapping db
```

Now you can use the Samba groups on all NTFS volumes on members of the domain.

**17.12. logon scripts**

Before testing a logon script, make sure it has the proper carriage returns that DOS files have.

```
[root@RHEL4b netlogon]# cat start.bat
net use Z: \DCSPORTS0\SPORTS
[root@RHEL4b netlogon]# unix2dos start.bat
unix2dos: converting file start.bat to DOS format ...
[root@RHEL4b netlogon]#
```

Then copy the scripts to the netlogon share, and add the following parameter to smb.conf.

```
logon script = start.bat
```
17.13. practice: samba domain controller

1. Setup Samba as a domain controller.

2. Create the shares salesdata, salespresentations and meetings. Salesdata must be accessible to all sales people and to all managers. SalesPresentations is only for all sales people. Meetings is only accessible to all managers. Use groups to accomplish this.

3. Join a Microsoft computer to your domain. Verify the creation of a computer account in /etc/passwd.

4. Setup and verify the proper working of roaming profiles.

5. Find information about home directories for users, set them up and verify that users receive their home directory mapped under the H:-drive in MS Windows Explorer.

6. Use a couple of samba domain groups with members to set acls on ntfs. Verify that it works!

7. Knowing that the %m variable contains the computername, create a separate log file for every computer(account).

8. Knowing that %s contains the client operating system, include a smb.%s.conf file that contains a share. (The share will only be visible to clients with that OS).

9. If time permits (or if you are waiting for other students to finish this practice), then combine "valid users" and "invalid users" with groups and usernames with "hosts allow" and "hosts deny" and make a table of which get priority over which.
Chapter 18. a brief look at samba 4
a brief look at samba 4
18.1. Samba 4 alpha 6

A quick view on Samba 4 alpha 6 (January 2009). You can also follow this guide http://wiki.samba.org/index.php/Samba4/HOWTO

Remove old Samba from Red Hat

```
yum remove samba
```

set a fix ip address (Red Hat has an easy GUI)

download and untar

```
samba.org, click 'download info', choose mirror, dl samba4 latest alpha
```

once untarred, enter the directory and read the howto4.txt

```
cd samba-4.0.0alpha6/
more howto4.txt
```

first we have to configure, compile and install samba4

```
cd source4/
./configure
make
make install
```

Then we can use the provision script to setup our realm. I used booi.schot as domain name (instead of example.com).

```
./setup/provision --realm=BOOI.SCHOT --domain=BOOI --adminpass=stargate --server-role='domain controller'
```

i added a simple share for testing

```
vi /usr/local/samba/etc/smb.conf
```

then i started samba

```
cd /usr/local/samba/sbin/
./samba
```

I tested with smbclient, it works

```
smbclient //localhost/test -Uadministrator%stargate
```

I checked that bind (and bind-chroot) were installed (yes), so copied the srv records

```
cp booi.schot.zone /var/named/chroot/etc/
```

then appended to named.conf

```
cat named.conf >> /var/named/chroot/etc/named.conf
```
I followed these steps in the howto4.txt

```bash
vi /etc/init.d/named  [added two export lines right after start()]
chmod a+r /usr/local/samba/private/dns.keytab
cp krb5.conf /etc/
vi /var/named/chroot/etc/named.conf
  --> remove a lot, but keep allow-update { any; };
```

restart bind (named!), then tested dns with dig, this works (stripped screenshot!)

```bash
[root@RHEL52 private]# dig _ldap._tcp.dc._msdcs.booi.schot SRV @localhost
 ; (1 server found)
 ;; global options:  printcmd
 ;; Got answer:
 ;; flags: qr rd ra; QUERY: 1, ANSWER: 0, AUTHORITY: 1, ADDITIONAL: 0

 ;; QUESTION SECTION:
 ;_ldap._tcp.dc._msdcs.booi.schot. IN SRV

 ;; AUTHORITY SECTION:
 .   10800 IN SOA A.ROOT-SERVERS.NET....

 ;; Query time: 54 msec
 ;; SERVER: 127.0.0.1#53(127.0.0.1)
 ;; WHEN: Tue Jan 27 20:57:05 2009
 ;; MSG SIZE  rcvd: 124
```

made sure /etc/resolv.conf points to himself

```bash
[root@RHEL52 private]# cat /etc/resolv.conf
search booi.schot
nameserver 127.0.0.1
```

start windows 2003 server, enter the samba4 as DNS!

ping the domain, if it doesn't work, then add your redhats hostname and your realm to windows/system32/drivers/etc/hosts

join the windows computer to the domain

reboot the windows

log on with administrator stargate

start run dsa.msc to manage samba4

create an OU, a user and a GPO, test that it works
Part VII. selinux
# Table of Contents

19. introduction to SELinux ................................................................. 209

19.1. selinux modes ................................................................. 210
19.2. logging ................................................................. 210
19.3. activating selinux ................................................................. 210
19.4. getenforce ................................................................. 211
19.5. setenforce ................................................................. 211
19.6. sestatus ................................................................. 212
19.7. policy ................................................................. 212
19.8. /etc/selinux/config ................................................................. 212
19.9. DAC or MAC ................................................................. 213
19.10. ls -Z ................................................................. 213
19.11. -Z ................................................................. 213
19.12. /selinux ................................................................. 214
19.13. identity ................................................................. 214
19.14. role ................................................................. 214
19.15. type (or domain) ................................................................. 215
19.16. security context ................................................................. 216
19.17. transition ................................................................. 216
19.18. extended attributes ................................................................. 217
19.19. process security context ................................................................. 217
19.20. chcon ................................................................. 217
19.21. an example ................................................................. 218
19.22. setroubleshoot ................................................................. 220
19.23. booleans ................................................................. 222
Chapter 19. introduction to SELinux

Security Enhanced Linux or SELinux is a set of modifications developed by the United States National Security Agency (NSA) to provide a variety of security policies for Linux. SELinux was released as open source at the end of 2000. Since kernel version 2.6 it is an integrated part of Linux.

SELinux offers security! SELinux can control what kind of access users have to files and processes. Even when a file received chmod 777, SELinux can still prevent applications from accessing it (Unix file permissions are checked first!). SELinux does this by placing users in roles that represent a security context. Administrators have very strict control on access permissions granted to roles.

SELinux is present in the latest versions of Red Hat Enterprise Linux, Debian, CentOS, Fedora, and many other distributions.
19.1. selinux modes

selinux knows three modes: enforcing, permissive and disabled. The enforcing mode will enforce policies, and may deny access based on selinux rules. The permissive mode will not enforce policies, but can still log actions that would have been denied in enforcing mode. The disabled mode disables selinux.

19.2. logging

Verify that syslog is running and activated on boot to enable logging of deny messages in /var/log/messages.

[root@rhe155 ~]# chkconfig --list syslog
syslog          0:off 1:off 2:on 3:on 4:on 5:on 6:off

Verify that auditd is running and activated on boot to enable logging of easier to read messages in /var/log/audit/audit.log.

[root@rhe155 ~]# chkconfig --list auditd
auditd          0:off 1:off 2:on 3:on 4:on 5:on 6:off

If not activated, then run chkconfig --levels 2345 auditd on and service auditd start.

[root@rhe155 ~]# service auditd status
auditd (pid  1660) is running...
[root@rhe155 ~]# service syslog status
syslogd (pid  1688) is running...
klogd (pid  1691) is running...

The /var/log/messages log file will tell you that selinux is disabled.

root@deb503:~# grep -i selinux /var/log/messages
Jun 25 15:59:34 deb503 kernel: [    0.084083] SELinux:  Disabled at boot.

Or that it is enabled.

root@deb503:~# grep SELinux /var/log/messages | grep -i Init
Jun 25 15:09:52 deb503 kernel: [    0.084094] SELinux: Initializing.

19.3. activating selinux

On RHEL you can use the GUI tool to activate selinux, on Debian there is the selinux-activate command. Activation requires a reboot.

root@deb503:~# selinux-activate
Activating SE Linux
Searching for GRUB installation directory ... found: /boot/grub
Searching for default file ... found: /boot/grub/default
Testing for an existing GRUB menu.lst file ... found: /boot/grub/menu.lst
Searching for splash image ... none found, skipping ...
Found kernel: /boot/vmlinuz-2.6.26-2-686
Updating /boot/grub/menu.lst ... done
SE Linux is activated. You may need to reboot now.
19.4. getenforce

Use getenforce to verify whether selinux is enforced, disabled or permissive.

```
[root@rhe155 ~]# getenforce
Permissive
```

The /selinux/enforce file contains 1 when enforcing, and 0 when permissive mode is active.

```
root@fedora13 ~# cat /selinux/enforce
1
root@fedora13 ~#
```

19.5. setenforce

You can use setenforce to switch between the Permissive or the Enforcing state once selinux is activated..

```
[root@rhe155 ~]# setenforce Enforcing
Enforcing
[root@rhe155 ~]# setenforce Permissive
Permissive
```

Or you could just use 0 and 1 as argument.

```
[root@centos65 ~]# setenforce 1
Enforcing
[root@centos65 ~]# setenforce 0
Permissive
```

19.6. sestatus

You can see the current selinux status and policy with the sestatus command.

```
[root@rhe155 ~]# sestatus
SELinux status: enabled
SELinuxfs mount: /selinux
Current mode: permissive
Mode from config file: permissive
Policy version: 21
Policy from config file: targeted
```

19.7. policy

Most Red Hat server will have the targeted policy. Only NSA/FBI/CIA/DOD/HLS use the mls policy.

The targeted policy will protect hundreds of processes, but lets other processes run 'unconfined' (= they can do anything).

19.8. /etc/selinux/config

The main configuration file for selinux is /etc/selinux/config. When in permissive mode, the file looks like this.

```
[root@centos65 ~]# cat /etc/selinux/config
# This file controls the state of SELinux on the system.
# SELINUX= can take one of these three values:
#       enforcing - SELinux security policy is enforced.
#       permissive - SELinux prints warnings instead of enforcing.
#       disabled - SELinux is fully disabled.
SELINUX=permissive
# SELINUXTYPE= type of policy in use. Possible values are:
#       targeted - Only targeted network daemons are protected.
#       strict - Full SELinux protection.
SELINUXTYPE=targeted
```
19.9. DAC or MAC

Standard Unix permissions use Discretionary Access Control to set permissions on files. This means that a user that owns a file, can make it world readable by typing `chmod 777 $file`.

With `selinux` the kernel will enforce Mandatory Access Control which strictly controls what processes or threads can do with files (superseding DAC). Processes are confined by the kernel to the minimum access they require.

SELinux MAC is about labeling and type enforcing! Files, processes, etc are all labeled with an SELinux context. For files, these are extended attributes, for processes this is managed by the kernel.

The format of the labels is as follows:

```
user:role:type:(level)
```

We only use the type label in the targeted policy.

19.10. ls -Z

To see the DAC permissions on a file, use `ls -l` to display user and group owner and permissions.

For MAC permissions there is new `-Z` option added to `ls`. The output shows that file in `/root` have a XXXtype of `admin_home_t`.

```
[root@centos65 ~]# ls -Z
-rw-------. root root system_u:object_r:admin_home_t:s0 anaconda-ks.cfg
-rw-r--r--. root root system_u:object_r:admin_home_t:s0 install.log
-rw-r--r--. root root system_u:object_r:admin_home_t:s0 install.log.syslog
```

```
[root@centos65 ~]# useradd -m -s /bin/bash pol
```

```
[root@centos65 ~]# ls -Z /home/pol/.bashrc
-rw-r--r--. pol pol unconfined_u:object_r:user_home_t:s0 /home/pol/.bashrc
```

19.11. -Z

There are also some other tools with the -Z switch:

```
mkdir -Z
cp -Z
ps -Z
netstat -Z
...```
19.12. /selinux

When selinux is active, there is a new virtual file system named /selinux. (You can compare it to /proc and /dev.)

```
[root@centos65 ~]# ls -l /selinux/
total 0
-rw-rw-rw-. 1 root root 0 Apr 12 19:40 access
dr-xr-xr-x. 2 root root 0 Apr 12 19:40 avc
-dr-xr-xr-x. 2 root root 0 Apr 12 19:40 booleans
-rw-r--r--. 1 root root 0 Apr 12 19:40 checkreqprot
dr-xr-xr-x. 83 root root 0 Apr 12 19:40 class
-rw-------. 1 root root 0 Apr 12 19:40 commit_pending_bools
dr-xr-xr-x. 1 root root 0 Apr 12 19:40 context
-rw-rw-rw-. 1 root root 0 Apr 12 19:40 create
-r--r--r--. 1 root root 0 Apr 12 19:40 deny_unknown
-dr-xr-xr-x. 2 root root 0 Apr 12 19:40 disable
-rw-r--r--. 1 root root 0 Apr 12 19:40 enforce
-dr-xr-xr-x. 2 root root 0 Apr 12 19:40 initial_contexts
-r-------. 1 root root 0 Apr 12 19:40 load
-rw-rw-rw-. 1 root root 0 Apr 12 19:40 member
-r-r-r-r-. 1 root root 0 Apr 12 19:40 mls
-crw-rw-rw-. 1 root root 1, 3 Apr 12 19:40 null
-r-------. 1 root root 0 Apr 12 19:40 policy
dr-xr-xr-x. 2 root root 0 Apr 12 19:40 policy_capabilities
-r--r--r--. 1 root root 0 Apr 12 19:40 policyvers
-r-r-r-r-. 1 root root 0 Apr 12 19:40 reject_unknown
-rw-rw-rw-. 1 root root 0 Apr 12 19:40 relabel
-r-r-r-r-. 1 root root 0 Apr 12 19:40 status
-rw-rw-rw-. 1 root root 0 Apr 12 19:40 user
```

Although some files in /selinux appear with size 0, they often contain a boolean value. Check /selinux/enforce to see if selinux is running in enforced mode.

```
[root@RHEL5 ~]# ls -l /selinux/enforce
-rw-r--r-- 1 root root 0 Apr 29 08:21 /selinux/enforce
[root@RHEL5 ~]# echo $(cat /selinux/enforce)
1
```

19.13. identity

The SELinux Identity of a user is distinct from the user ID. An identity is part of a security context, and (via domains) determines what you can do. The screenshot shows user root having identity user_u.

```
[root@rhel55 ~]# id -Z
user_u:system_r:unconfined_t
```

19.14. role

The selinux role defines the domains that can be used. A role is denied to enter a domain, unless the role is explicitly authorized to do so.
19.15. type (or domain)

The **selinux context** is the security context of a process. An **selinux type** determines what a process can do. The screenshot shows init running in type `init_t` and the mingetty's running in type `getty_t`.

```
[root@centos65 ~]# ps fax -Z | grep /sbin/init
system_u:system_r:init_t:s0         1 ?        Ss     0:00 /sbin/init
[root@centos65 ~]# ps fax -Z | grep getty_t
system_u:system_r:getty_t:s0   1307 tty1    Ss+   0:00 /sbin/mingetty /dev/tty1
system_u:system_r:getty_t:s0   1309 tty2    Ss+   0:00 /sbin/mingetty /dev/tty2
system_u:system_r:getty_t:s0   1311 tty3    Ss+   0:00 /sbin/mingetty /dev/tty3
system_u:system_r:getty_t:s0   1313 tty4    Ss+   0:00 /sbin/mingetty /dev/tty4
system_u:system_r:getty_t:s0   1320 tty5    Ss+   0:00 /sbin/mingetty /dev/tty5
system_u:system_r:getty_t:s0   1322 tty6    Ss+   0:00 /sbin/mingetty /dev/tty6
```

The **selinux type** is similar to an **selinux domain**, but refers to directories and files instead of processes.

Hundreds of binaries also have a type:

```
[root@centos65 sbin]# ls -lZ useradd usermod userdel httpd postcat postfix
-rwxr-xr-x. root root system_u:object_r:httpd_exec_t:s0 httpd
-rwxr-xr-x. root root system_u:object_r:postfix_master_exec_t:s0 postcat
-rwxr-x---. root root system_u:object_r:useradd_exec_t:s0 useradd
-rwxr-x---. root root system_u:object_r:useradd_exec_t:s0 userdel
-rwxr-x---. root root system_u:object_r:useradd_exec_t:s0 usermod
```

Ports also have a context.

```
[root@centos65 sbin]# netstat -nptlZ | tr -s ' ' | cut -d' ' -f6-
Foreign Address State PID/Program name Security Context
LISTEN 1096/rpcbind system_u:system_r:rpcbind_t:s0
LISTEN 1208/sshd system_u:system_r:sshd_t:s0-s0:c0.c1023
LISTEN 1284/master system_u:system_r:postfix_master_t:s0
LISTEN 1114/rpc.statd system_u:system_r:rpcd_t:s0
LISTEN 1096/rpcbind system_u:system_r:rpcbind_t:s0
LISTEN 1666/httpd unconfined_u:system_r:httpd_t:s0
LISTEN 1208/sshd system_u:system_r:sshd_t:s0-s0:c0.c1023
LISTEN 1114/rpc.statd system_u:system_r:rpcd_t:s0
LISTEN 1284/master system_u:system_r:postfix_master_t:s0
```

You can also get a list of ports that are managed by SELinux:

```
[root@centos65 sbin]# semanage port -l | tail
xfs_port_t         tcp    7100
xserver_port_t     tcp    6000-6150
zabbix_agent_port_t tcp    10050
zabbix_port_t      tcp    10051
zarafa_port_t      tcp    236, 237
zebra_port_t       tcp    2600-2604, 2606
zebra_port_t       udp    2600-2604, 2606
zented_port_t      tcp    1229
zented_port_t      udp    1229
zope_port_t        tcp    8021
```
19.16. security context

The combination of identity, role and domain or type make up the **selinux security context**. The **id** will show you your security context in the form identity:role:domain.

```
[paul@RHEL5 ~]$ id | cut -d' ' -f4
context=user_u:system_r:unconfined_t
```

The **ls -Z** command shows the security context for a file in the form identity:role:type.

```
[paul@RHEL5 ~]$ ls -Z test
-rw-rw-r--  paul paul user_u:object_r:user_home_t      test
```

The security context for processes visible in /proc defines both the type (of the file in /proc) and the domain (of the running process). Let's take a look at the init process and /proc/1/.

The init process runs in domain **init_t**.

```
[root@RHEL5 ~]# ps -ZC init
LABEL                             PID TTY          TIME CMD
system_u:system_r:init_t            1 ?        00:00:01 init
```

The /proc/1/ directory, which identifies the init process, has type **init_t**.

```
[root@RHEL5 ~]# ls -Zd /proc/1/
dr-xr-xr-x  root root system_u:system_r:init_t         /proc/1/
```

It is not a coincidence that the domain of the init process and the type of /proc/1/ are both init_t.

Don't try to use **chcon** on /proc! It will not work.

19.17. transition

An **selinux transition** (aka an selinux labelling) determines the security context that will be assigned. A transition of process domains is used when you execute a process. A transition of file type happens when you create a file.

An example of file type transition.

```
[pol@centos65 ~]$ touch test /tmp/test
[pol@centos65 ~]$ ls -Z test
-rw-rw-r--. pol pol unconfined_u:object_r:user_home_t:s0 test
[pol@centos65 ~]$ ls -Z /tmp/test
-rw-rw-r--. pol pol unconfined_u:object_r:user_tmp_t:s0 /tmp/test
```
19.18. extended attributes

Extended attributes are used by `selinux` to store security contexts. These attributes can be viewed with `ls` when `selinux` is running.

```
[root@RHEL5 home]# ls --context
drwx------  paul paul system_u:object_r:user_home_dir_t paul
drwxr-xr-x  root root user_u:object_r:user_home_dir_t project42
drwxr-xr-x  root root user_u:object_r:user_home_dir_t project55
[root@RHEL5 home]# ls -Z
drwx------  paul paul system_u:object_r:user_home_dir_t paul
drwxr-xr-x  root root user_u:object_r:user_home_dir_t project42
drwxr-xr-x  root root user_u:object_r:user_home_dir_t project55
```

When `selinux` is not running, then `getfattr` is the tool to use.

```
[root@RHEL5 etc]# getfattr -m . -d hosts
# file: hosts
security.selinux="system_u:object_r:etc_t:s0\000"
```

19.19. process security context

A new option is added to `ps` to see the `selinux` security context of processes.

```
[root@RHEL5 etc]# ps -ZC mingetty
LABEL                             PID TTY          TIME CMD
system_u:system_r:getty_t        2941 tty1     00:00:00 mingetty
system_u:system_r:getty_t        2942 tty2     00:00:00 mingetty
```

19.20. chcon

Use `chcon` to change the `selinux` security context.

This example shows how to use `chcon` to change the type of a file.

```
[root@rhel55 ~]# ls -Z /var/www/html/test42.txt
-rw-r--r--  root root user_u:object_r:httpd_sys_content_t /var/www/html/test42.txt
[root@rhel55 ~]# chcon -t samba_share_t /var/www/html/test42.txt
[root@rhel55 ~]# ls -Z /var/www/html/test42.txt
-rw-r--r--  root root user_u:object_r:samba_share_t /var/www/html/test42.txt
```

Be sure to read `man chcon`.
19.21. an example

The Apache2 webserver is by default targeted with SELinux. The next screenshot shows that any file created in /var/www/html will by default get the httpd_sys_content_t type.

```
[root@centos65 ~]# touch /var/www/html/test42.txt
[root@centos65 ~]# ls -Z /var/www/html/test42.txt
-rw-r--r--. root root unconfined_u:object_r:httpd_sys_content_t:s0 /var/www/html/test42.txt
```

Files created elsewhere do not get this type.

```
[root@centos65 ~]# touch /root/test42.txt
[root@centos65 ~]# ls -Z /root/test42.txt
-rw-r--r--. root root unconfined_u:object_r:admin_home_t:s0 /root/test42.txt
```

Make sure Apache2 runs.

```
[root@centos65 ~]# service httpd restart
Stopping httpd: [ OK ]
Starting httpd:   [ OK ]
```

Will this work? Yes it does.

```
[root@centos65 ~]# wget http://localhost/test42.txt
--2014-04-12 20:56:47--  http://localhost/test42.txt
Resolving localhost... ::1, 127.0.0.1
Connecting to localhost|::1|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 0 [text/plain]
Saving to: “test42.txt”

... 
```

Why does this work? Because Apache2 runs in the httpd_t domain and the files in /var/www/html have the httpd_sys_content_t type.

```
[root@centos65 ~]# ps -C httpd | head -4
LABEL                             PID TTY          TIME CMD
unconfined_u:system_r:httpd_t:s0 1666 ?        00:00:00 httpd
unconfined_u:system_r:httpd_t:s0 1668 ?        00:00:00 httpd
unconfined_u:system_r:httpd_t:s0 1669 ?        00:00:00 httpd
```

introduction to SELinux
So let's set SELinux to **enforcing** and change the **type** of this file.

```
[root@centos65 ~]# chcon -t samba_share_t /var/www/html/test42.txt
[root@centos65 ~]# ls -Z /var/www/html/test42.txt
-rw-r--r--. root root unconfined_u:object_r:samba_share_t:s0 /var/www/html/test42.txt
[root@centos65 ~]# setenforce 1
[root@centos65 ~]# getenforce
Enforcing
```

There are two possibilities now: either it works, or it fails. It works when **selinux** is in **permissive mode**, it fails when in **enforcing mode**.

```
[root@centos65 ~]# wget http://localhost/test42.txt
--2014-04-12 21:05:02--  http://localhost/test42.txt
Resolving localhost... ::1, 127.0.0.1
Connecting to localhost|::1|:80... connected.
HTTP request sent, awaiting response... 403 Forbidden
```

The log file gives you a cryptic message...

```
[root@centos65 ~]# tail -3 /var/log/audit/audit.log
type=SYSCALL msg=audit(1398200702.803:64): arch=c000003e syscall=4 success=no exit=-13 a0=7f5fbc334d70 a1=7fff553b4f10 a2=7fff553b4f10 a3=0 itmes=0 ppid=1666 pid=1673 auid=500 uid=48 gid=48 euid=48 suid=48 fsuid=48 egid=48 sgid=48 fsgid=48 tty=(none) ses=1 comm="httpd" exe="/usr/sbin/httpd" subj=unconfined_u:system_r:httpd_t:s0 key=(null)
type=AVC msg=audit(1398200702.804:65): avc: denied {getattr} for p id=1673 comm="httpd" path="/var/www/html/test42.txt" dev=dm-0 ino=263241 scontext=unconfined_u:system_r:httpd_t:s0 tcontext=unconfined_u:object_r:samba_share_t:s0 tclass=file
type=SYSCALL msg=audit(1398200702.804:65): arch=c000003e syscall=6 success=no exit=-13 a0=7f5fbc334e40 a1=7fff553b4f10 a2=7fff553b4f10 a3=1 itmes=0 ppid=1666 pid=1673 auid=500 uid=48 gid=48 euid=48 suid=48 fsuid=48 egid=48 sgid=48 fsgid=48 tty=(none) ses=1 comm="httpd" exe="/usr/sbin/httpd" subj=unconfined_u:system_r:httpd_t:s0 key=(null)
```

And `/var/log/messages` mentions nothing of the failed download.
19.22. setroubleshoot

The log file above was not very helpful, but these two packages can make your life much easier.

[root@centos65 ~]# yum -y install setroubleshoot setroubleshoot-server

You need to **reboot** for this to work...

So we reboot, restart the httpd server, reactive SELinux Enforce, and do the wget again... and it fails (because of SELinux).

[root@centos65 ~]# service httpd restart
Stopping httpd:                                         [FAILED]
Starting httpd:                                         [  OK  ]
[root@centos65 ~]# getenforce
Permissive
[root@centos65 ~]# setenforce 1
[root@centos65 ~]# getenforce
Enforcing
[root@centos65 ~]# wget http://localhost/test42.txt
--2014-04-12 21:44:13--  http://localhost/test42.txt
Resolving localhost... ::1, 127.0.0.1
Connecting to localhost|::1|:80... connected.
HTTP request sent, awaiting response... 403 Forbidden

The **/var/log/audit/** is still not out best friend, but take a look at **/var/log/messages**.

[root@centos65 ~]# tail -2 /var/log/messages
Apr 12 21:44:16  centos65  setroubleshoot: SELinux is preventing /usr/sbin/httpd from getattr access on the file /var/www/html/test42.txt. For complete SELinux messages, run `sealert -l b2a84386-54c1-4344-96fb-dcf969776696`  
Apr 12 21:44:16  centos65  setroubleshoot: SELinux is preventing /usr/sbin/httpd from getattr access on the file /var/www/html/test42.txt. For complete SELinux messages, run `sealert -l b2a84386-54c1-4344-96fb-dcf969776696`

So we run the command it suggests...

[root@centos65 ~]# sealert -l b2a84386-54c1-4344-96fb-dcf969776696
SELinux is preventing /usr/sbin/httpd from getattr access on the file /var/www/html/test42.txt.

***** Plugin restorecon (92.2 confidence) suggests ***************

If you want to fix the label, 
/var/www/html/test42.txt default label should be httpd_sys_content_t. 
Then you can run restorecon. 
Do 
`#/sbin/restorecon -v /var/www/html/test42.txt`
...
We follow the friendly advice and try again to download our file:

```
[root@centos65 ~]# /sbin/restorecon -v /var/www/html/test42.txt
/sbin/restorecon reset /var/www/html/test42.txt context unconfined_u:object_r:samba_share_t:s0->unconfined_u:object_r:httpd_sys_content_t:s0
[root@centos65 ~]# wget http://localhost/test42.txt
--2014-04-12 21:54:03--  http://localhost/test42.txt
Resolving localhost... ::1, 127.0.0.1
Connecting to localhost|::1|:80... connected.
HTTP request sent, awaiting response... 200 OK
```

It works!
19.23. booleans

Booleans are on/off switches

```bash
[root@centos65 ~]# getsebool -a | head
abrt_anon_write --> off
abrt_handle_event --> off
allow_console_login --> on
allow_cvs_read_shadow --> off
allow_daemons_dump_core --> on
allow_daemons_use_tcp_wrapper --> off
allow_daemons_use_tty --> on
allow_domain_fd_use --> on
allow_execheap --> off
allow_execmem --> on
```

You can set and read individual booleans.

```bash
[root@centos65 ~]# setsebool httpd_read_user_content=1
[root@centos65 ~]# getsebool httpd_read_user_content
httpd_read_user_content --> on
[root@centos65 ~]# setsebool httpd_enable_homedirs=1
[root@centos65 ~]# getsebool httpd_enable_homedirs
httpd_enable_homedirs --> on
```

You can set these booleans permanent.

```bash
[root@centos65 ~]# setsebool -P httpd_enable_homedirs=1
[root@centos65 ~]# setsebool -P httpd_read_user_content=1
```

The above commands regenerate the complete /etc/selinux/targeted directory!

```bash
[root@centos65 ~]# cat /etc/selinux/targeted/modules/active/booleans.local
# This file is auto-generated by libsemanage
# Do not edit directly.

httpd_enable_homedirs=1
httpd_read_user_content=1
```
Part VIII. introducing git
Table of Contents

20. git ......................................................................................................................................................... 225
  20.1. git .................................................................................................................................................... 226
  20.2. installing git .................................................................................................................................... 227
  20.3. starting a project ............................................................................................................................. 227
  20.4. git branches ...................................................................................................................................... 230
  20.5. to be continued... ............................................................................................................................ 231
  20.6. github.com ....................................................................................................................................... 232
  20.7. add your public key to github ........................................................................................................ 232
  20.8. practice: git .................................................................................................................................... 233
Chapter 20. git

This chapter is an introduction to using git on the command line. The git repository is hosted by github, but you are free to choose another server (or create your own).

There are many excellent online tutorials for git. This list can save you one Google query:

http://gitimmersion.com/
20.1. git

Linus Torvalds created *git* back in 2005 when Bitkeeper changed its license and the Linux kernel developers were no longer able to use it for free.

*git* quickly became popular and is now the most widely used distributed version control system in the world.

Geek and Poke demonstrates why we need version control (image property of Geek and Poke CCA 3.0).

**SIMPLY EXPLAINED**

```
| budget_estimation_final_v1.1-ow.xlsx |
| OR                                       |
| budget_estimation_last_version_2.xlsx    |
| OR                                       |
| budget_estimation_2012_10_25_ready_new.xlsx |
```

Besides source code for software, you can also find German and Icelandic law on github (and probably much more by the time you are reading this).
20.2. installing git

We install git with aptitude install git as seen in this screenshot on Debian 6.

```
root@debian6:~# aptitude install git
The following NEW packages will be installed:
  git libcurl3-gnutls(a) liberror-perl(a)
0 packages upgraded, 3 newly installed, 0 to remove and 0 not upgraded.
... 
Processing triggers for man-db ...
Setting up libcurl3-gnutls (7.21.0-2.1+squeeze2) ...
Setting up liberror-perl (0.17-1) ...
Setting up git (1:1.7.2.5-3) ...
```

20.3. starting a project

First we create a project directory, with a simple file in it.

```
paul@debian6~$ mkdir project42
paul@debian6~$ cd project42/
paul@debian6~/project42$ echo "echo The answer is 42." >> question.sh
```

20.3.1. git init

Then we tell git to create an empty git repository in this directory.

```
paul@debian6~/project42$ ls -la
  total 12
  drwxrwxr-x  2 paul paul 4096 Dec  8 16:41 .
  drwxr-xr-x 46 paul paul 4096 Dec  8 16:41 ..
  -rw-rw-r--  1 paul paul   23 Dec  8 16:41 question.sh
paul@debian6~/project42$ git init
Initialized empty Git repository in /home/paul/project42/.git/
paul@debian6~/project42$ ls -la
  total 16
  drwxrwxr-x  3 paul paul 4096 Dec  8 16:44 .
  drwxr-xr-x 46 paul paul 4096 Dec  8 16:41 ..
  drwxrwxr-x  7 paul paul 4096 Dec  8 16:44 .git
  -rw-rw-r--  1 paul paul   23 Dec  8 16:41 question.sh
```

20.3.2. git config

Next we use git config to set some global options.

```
paul@debian6$ git config --global user.name Paul
paul@debian6$ git config --global user.email "paul.cobbaut@gmail.com"
paul@debian6$ git config --global core.editor vi
```

We can verify this config in ~/.gitconfig:

```
paul@debian6~/project42$ cat ~/.gitconfig
[user]
  name = Paul
  email = paul.cobbaut@gmail.com
[core]
  editor = vi
```

20.3.3. git add

Time now to add file to our project with git add, and verify that it is added with git status.
The git status tells us there is a new file ready to be committed.

20.3.4. git commit

With git commit you force git to record all added files (and all changes to those files) permanently.

20.3.5. changing a committed file

The screenshots below show several steps. First we change a file:

20.3.6. git log

We can see all our commits again using git log.
20.3.7. git mv

Renaming a file can be done with `mv` followed by a `git remove` and a `git add` of the new filename. But it can be done easier and in one command using `git mv`.

```
paul@debian6~/project42$ git mv question.sh thequestion.sh
paul@debian6~/project42$ git status
# On branch master
# Changes to be committed:
#   (use "git reset HEAD <file>..." to unstage)
#   renamed: question.sh => thequestion.sh

paul@debian6~/project42$ git commit -m "improved naming scheme"
[master 69b2c8b] improved naming scheme
 1 file changed, 0 insertions(+), 0 deletions(-)
  rename question.sh => thequestion.sh (100%)
```
20.4. git branches

Working on the project can be done in one or more git branches. Here we create a new branch that will make changes to the script. We will merge this branch with the master branch when we are sure the script works. (It can be useful to add git status commands when practicing).

```
paul@debian6~/project42$ git branch
* master
paul@debian6~/project42$ git checkout -b newheader
Switched to a new branch 'newheader'
paul@debian6~/project42$ vi thequestion.sh
paul@debian6~/project42$ git add thequestion.sh
paul@debian6~/project42$ source thequestion.sh
The answer is 42.
```

It seems to work, so we commit in this branch.

```
paul@debian6~/project42$ git commit -m "adding a new company header"
[newheader 730a22b] adding a new company header
  1 file changed, 4 insertions(+)
paul@debian6~/project42$ git branch
  master
  * newheader
paul@debian6~/project42$ cat thequestion.sh
#!/bin/bash
#
# copyright linux-training.be
#
echo The answer is 42.
```

Let us go back to the master branch and see what happened there.

```
paul@debian6~/project42$ git checkout master
Switched to branch 'master'
paul@debian6~/project42$ cat thequestion.sh
#!/bin/bash
#
# copyright linux-training.be
#
echo The answer is 42.
```

Nothing happened in the master branch, because we worked in another branch.

When we are sure the branch is ready for production, then we merge it into the master branch.

```
paul@debian6~/project42$ cat thequestion.sh
#!/bin/bash
echo The answer is 42.
paul@debian6~/project42$ git merge newheader
 Updating 69b2c8b..730a22b
 Fast-forward
 thequestion.sh | 4 ++++ 
 1 file changed, 4 insertions(+)
paul@debian6~/project42$ cat thequestion.sh
#!/bin/bash
#
# copyright linux-training.be
#
echo The answer is 42.
```

The newheader branch can now be deleted.
The **git** story is not finished.

There are many excellent online tutorials for **git**. This list can save you one Google query:

http://gitimmersion.com/
20.6. github.com

Create an account on github.com. This website is a frontend for an immense git server with over two and a half million users and almost five million projects (including Fedora, Linux kernel, Android, Ruby on Rails, Wine, X.org, VLC...)

https://github.com/signup/free

This account is free of charge, we will use it in the examples below.

20.7. add your public key to github

I prefer to use github with a public key, so it probably is a good idea that you also upload your public key to github.com.

You can upload your own key via the web interface:

https://github.com/settings/ssh

Please do not forget to protect your private key!
20.8. practice: git

1. Create a project on github to host a script that you wrote. Have at least two other people improve the script.
Part IX. ipv6
Table of Contents

21. Introduction to ipv6 ................................................................. 236
  21.1. about ipv6 ................................................................. 237
  21.2. network id and host id .................................................. 237
  21.3. host part generation ...................................................... 237
  21.4. ipv4 mapped ipv6 address ............................................... 238
  21.5. link local addresses ...................................................... 238
  21.6. unique local addresses .................................................. 238
  21.7. globally unique unicast addresses ................................... 238
  21.8. 6to4 ................................................................. 238
  21.9. ISP ................................................................. 239
  21.10. non routable addresses ................................................ 239
  21.11. ping6 ................................................................. 239
  21.12. Belgium and ipv6 ....................................................... 240
  21.13. other websites ........................................................ 240
  21.14. 6to4 gateways ........................................................ 242
  21.15. ping6 and dns ........................................................ 242
  21.16. ipv6 and tcp/http ...................................................... 242
  21.17. ipv6 PTR record ....................................................... 242
  21.18. 6to4 setup on Linux .................................................... 242
Chapter 21. Introduction to ipv6
21.1. about ipv6

The ipv6 protocol is designed to replace ipv4. Where ip version 4 supports a maximum of four billion unique addresses, ip version 6 expands this to four billion times four billion times four billion times four billion unique addresses. This is more than 100,000,000,000,000,000,000,000 ipv6 addresses per square cm on our planet. That should be enough, even if every cell phone, every coffee machine and every pair of socks gets an address.

Technically speaking ipv6 uses 128-bit addresses (instead of the 32-bit from ipv4). 128-bit addresses are huge numbers. In decimal it would amount up to 39 digits, in hexadecimal it looks like this:

```
fe80:0000:0000:0000:0a00:27ff:fe8e:8aa8
```

Luckily ipv6 allows us to omit leading zeroes. Our address from above then becomes:

```
fe80:0:0:a00:27ff:fe8e:8aa8
```

When a 16-bit block is zero, it can be written as ::. Consecutive 16-bit blocks that are zero can also be written as ::. So our address can from above can be shortened to:

```
fe80::a00:27ff:fe8e:8aa8
```

This :: can only occur once! The following is not a valid ipv6 address:

```
fe80::20:2e4f::39ac
```

The ipv6 localhost address is 0000:0000:0000:0000:0000:0000:0000:0001, which can be abbreviated to ::1.

```
paul@debian5:~/github/lt/images$ /sbin/ifconfig lo | grep inet6
inet6 addr: ::1/128 Scope:Host
```

21.2. network id and host id

One of the few similarities between ipv4 and ipv6 is that addresses have a host part and a network part determined by a subnet mask. Using the cidr notation this looks like this:

```
fe80::a00:27ff:fe8e:8aa8/64
```

The above address has 64 bits for the host id, theoretically allowing for 4 billion times four billion hosts.

The localhost address looks like this with cidr:

```
::1/128
```

21.3. host part generation

The host part of an automatically generated (stateless) ipv6 address contains part of the hosts mac address:

```
paul@debian5:~$ /sbin/ifconfig | head -3
```

237
Some people are concerned about privacy here...

## 21.4. ipv4 mapped ipv6 address

Some applications use ipv4 addresses embedded in an ipv6 address. (Yes there will be an era of migration with both ipv4 and ipv6 in use.) The ipv6 address then looks like this:

```
::ffff:192.168.1.42/96
```

Indeed a mix of decimal and hexadecimal characters...

## 21.5. link local addresses

ipv6 addresses starting with fe8, can only be used on the local segment (replace the dot with an hexadecimal digit). This is the reason you see Scope:Link behind the address in this screenshot. This address serves only the local link.

```
paul@deb503:~$ /sbin/ifconfig | grep inet6
  inet6 addr: fe80::a00:27ff:fe8e:8aa8/64 Scope:Link
  inet6 addr: ::1/128 Scope:Host
```

These link local addresses all begin with fe8.

Every ipv6 enabled nic will get an address in this range.

## 21.6. unique local addresses

The now obsolete system of site local addresses similar to ipv4 private ranges is replaced with a system of globally unique local ipv6 addresses. This to prevent duplicates when joining of networks within site local ranges.

All unique local addresses strat with fd...

## 21.7. globally unique unicast addresses

Since ipv6 was designed to have multiple ip addresses per interface, the global ipv6 address can be used next to the link local address.

These globally unique addresses all begin with 2... or 3... as the first 16-bits.

## 21.8. 6to4

6to4 is defined in rfc's 2893 and 3056 as one possible way to transition between ipv4 and ipv6 by creating an ipv6 tunnel.

It encodes an ipv4 address in an ipv6 address that starts with 2002. For example 192.168.1.42/24 will be encoded as:
You can use the command below to convert any IPv4 address to this range.

```
paul@ubu1010:$ printf "2002:%02x%02x:%02x%02x:%04x::1\n" `echo 192.168.1.42/24 | tr "." " `
2002:c0a8:012a:0018::1
```

## 21.9. ISP

Should you be so lucky to get an IPv6 address from an ISP, then it will start with **2001**.

## 21.10. non routable addresses

Comparable to example.com for DNS, the following IPv6 address ranges are reserved for examples, and not routable on the Internet:

- 3fff:ffff::/32
- 2001:0db8::/32

## 21.11. ping6

Use **ping6** to test connectivity between IPv6 hosts. You need to specify the interface (there is no routing table for 'random' generated IPv6 link local addresses).

```
[root@fedora14 ~]# ping6 -I eth0 fe80::a00:27ff:fecd:7ffc
PING fe80::a00:27ff:fecd:7ffc (fe80::a00:27ff:fecd:7ffc) from fe80::a00:27ff:fe3c:4346 eth0: 56 data bytes
64 bytes from fe80::a00:27ff:fecd:7ffc: icmp_seq=1 ttl=64 time=0.586 ms
64 bytes from fe80::a00:27ff:fecd:7ffc: icmp_seq=2 ttl=64 time=3.95 ms
64 bytes from fe80::a00:27ff:fecd:7ffc: icmp_seq=3 ttl=64 time=1.53 ms
```

Below a multicast ping6 that receives replies from three IPv6 hosts on the same network.

```
[root@fedora14 ~]# ping6 -I eth0 ff02::1
PING ff02::1 (ff02::1) from fe80::a00:27ff:fe3c:4346 eth0: 56 data bytes
64 bytes from fe80::a00:27ff:fe3c:4346: icmp_seq=1 ttl=64 time=0.598 ms
64 bytes from fe80::a00:27ff:fe3c:4346: icmp_seq=1 ttl=64 time=1.87 ms (DUP!)  
64 bytes from fe80::a00:27ff:fe3c:4346: icmp_seq=1 ttl=64 time=535 ms (DUP!)  
64 bytes from fe80::a00:27ff:fe3c:4346: icmp_seq=2 ttl=64 time=0.106 ms
64 bytes from fe80::a00:27ff:fe3c:4346: icmp_seq=2 ttl=64 time=1.79 ms (DUP!)  
64 bytes from fe80::a00:27ff:fe3c:4346: icmp_seq=2 ttl=64 time=2.48 ms (DUP!)  
```
21.12. Belgium and ipv6

A lot of information on ipv6 in Belgium can be found at www.ipv6council.be.

Sites like ipv6.belgium.be, www.bipt.be and www.bricozone.be are enabled for ipv6. Some Universities also: fundp.ac.be (Namur) and ulg.ac.be (Liege).

21.13. other websites

Other useful websites for testing ipv6 are:

- test-ipv6.com
- ipv6-test.com

Going to the ipv6-test.com website will test whether you have a valid accessible ipv6 address.

Going to the test-ipv6.com website will also test whether you have a valid accessible ipv6 address.
## Test your IPv6 connectivity

<table>
<thead>
<tr>
<th>Summary</th>
<th>Tests Run</th>
<th>Technical Info</th>
<th>Share</th>
<th>Screenshot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your IPv4 address on the public Internet</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Your IPv6 address on the public Internet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Your IPv6 service appears to be working</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### World IPv6 Day
June 8th, 2011

Congratulations! You appear to have both IPv4 and IPv6 Internet working. If a publisher publishes to IPv6, your browser will connect using IPv6. Note: Your browser appears to prefer IPv4 over IPv6 when given the choice. This may in the future affect the accuracy of sites who guess at your location.

You appear to be using a public IPv4 gateway; your router may be providing this to you automatically. Such public gateways have no service level agreements; you may see performance problems using such. Better would be to get a native IPv6 address from your ISP.

Your DNS server (possibly run by your ISP) appears to have no access to the IPv6 Internet, or is not configured to use it. This may in the future restrict your ability to reach IPv6-only sites.

### Your readiness scores

| 7/10 | for your IPv4 stability and readiness, when publishers offer both IPv4 and IPv6 |
| 7/10 | for your IPv6 stability and readiness, when publishers are forced to go IPv6 only |

Click to see test data
21.14. 6to4 gateways

To access ipv4 only websites when on ipv6 you can use sixxs.net (more specifically http://www.sixxs.net/tools/gateway/) as a gateway.

For example use http://www.slashdot.org.sixxs.org/ instead of http://slashdot.org

21.15. ping6 and dns

Below a screenshot of a ping6 from behind a 6to4 connection.

![Ping6 Screenshot]

21.16. ipv6 and tcp/http

Below a screenshot of a tcp handshake and http connection over ipv6.

![TCP Handshake and HTTP Connection]

21.17. ipv6 PTR record

As seen in the DNS chapter, ipv6 PTR records are in the ip6.net domain, and have 32 generations of child domains.

![DNS PTR Record]

21.18. 6to4 setup on Linux

Below a transcript of a 6to4 setup on Linux.

Thanks to http://www.anyweb.co.nz/tutorial/v6Linux6to4 and http://mirrors.bieringer.de/Linux+IPv6-HOWTO/ and tldp.org!

```
root@mac:~# ifconfig
eth0     Link encap:Ethernet   HWaddr 00:26:bb:5d:2e:52
inet addr:81.165.101.125  Bcast:255.255.255.255  Mask:255.255.255.248
```
Introduction to IPv6

inet6 addr: fe80::226:bbff:fe5d:2e52/64 Scope:Link
UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
RX packets:5926044 errors:0 dropped:0 overruns:0 frame:0
TX packets:2985892 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1000
RX bytes:4274849823 (4.2 GB)  TX bytes:237002019 (237.0 MB)
Interrupt:43 Base address:0x8000

lo    Link encapsulation: Local Loopback
inet addr:127.0.0.1  Mask:255.0.0.0
inet6 addr: ::1/128 Scope:Host
UP LOOPBACK RUNNING  MTU:16436  Metric:1
RX packets:598 errors:0 dropped:0 overruns:0 frame:0
TX packets:598 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:0
RX bytes:61737 (61.7 KB)  TX bytes:61737 (61.7 KB)

root@mac:~# sysctl -w net.ipv6.conf.default.forwarding=1
net.ipv6.conf.default.forwarding = 1
root@mac:~# ip tunnel add tun6to4 mode sit remote any local 81.165.101.125
root@mac:~# ip link set dev tun6to4 mtu 1472 up
root@mac:~# ip link show dev tun6to4
10: tun6to4: <NOARP,UP,LOWER_UP> mtu 1472 qdisc noqueue state UNKNOWN
    link/sit 81.165.101.125 brd 0.0.0.0
root@mac:~# ip -6 addr add dev tun6to4 2002:51a5:657d:0::1/64
root@mac:~# ip -6 addr add dev eth0 fdcb:43c1:9c18:1::1/64
root@mac:~# ifconfig
eth0    Link encapsulation: Ethernet  HWaddr 00:26:bb:5d:2e:52
inet addr:81.165.101.125  Bcast:255.255.255.255  Mask:255.255.248.0
inet6 addr: fe80::226:bbff:fe5d:2e52/64 Scope:Link
inet6 addr: fdcb:43c1:9c18:1::1/64 Scope:Global
inet6 addr: 2002:51a5:657d:1::1/64 Scope:Global
UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
RX packets:5927436 errors:0 dropped:0 overruns:0 frame:0
TX packets:2986025 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1000
RX bytes:4274948430 (4.2 GB)  TX bytes:237014619 (237.0 MB)
Interrupt:43 Base address:0x8000

lo    Link encapsulation: Local Loopback
inet addr:127.0.0.1  Mask:255.0.0.0
inet6 addr: ::1/128 Scope:Host
UP LOOPBACK RUNNING  MTU:16436  Metric:1
RX packets:598 errors:0 dropped:0 overruns:0 frame:0
TX packets:598 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:0
RX bytes:61737 (61.7 KB)  TX bytes:61737 (61.7 KB)

tun6to4    Link encapsulation: IPv6-in-IPv4
inet6 addr: ::81.165.101.125/128 Scope:Compat
inet6 addr: 2002:51a5:657d::1/64 Scope:Global
UP RUNNING NOARP  MTU:1472 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:0
RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

root@mac:~# ip -6 route add 2002::/16 dev tun6to4
root@mac:~# ip -6 route add ::/0 via ::192.88.99.1 dev tun6to4 metric 1
root@mac:~# ip -6 route show
::/64 via :: dev tun6to4 metric 256 mtu 1472 advmss 1412 hoplimit 0
2002:51a5:657d::/64 dev tun6to4 proto kernel metric 256 mtu 1472 advmss 1412 hoplimit 0
2002:51a5:657d:1::/64 dev eth0 proto kernel metric 256 mtu 1500 advmss 1440 hoplimit 0
Introduction to ipv6

2002::/16 dev tun6to4 metric 1024 mtu 1472 advmss 1412 hoplimit 0
dfdb:43c1:9c18:1::/64 dev eth0 proto kernel metric 256 mtu 1500 advmss 1440 hoplimit 0
dfe80::/64 dev eth0 proto kernel metric 256 mtu 1500 advmss 1440 hoplimit 0
default via ::192.88.99.1 dev tun6to4 metric 1 mtu 1472 advmss 1412 hoplimit 0

root@mac:~# ping6 ipv6-test.com
PING ipv6-test.com(ipv6-test.com) 56 data bytes
64 bytes from ipv6-test.com: icmp_seq=1 ttl=57 time=42.4 ms
64 bytes from ipv6-test.com: icmp_seq=2 ttl=57 time=43.0 ms
64 bytes from ipv6-test.com: icmp_seq=3 ttl=57 time=43.5 ms
64 bytes from ipv6-test.com: icmp_seq=4 ttl=57 time=43.9 ms
64 bytes from ipv6-test.com: icmp_seq=5 ttl=57 time=45.6 ms
^C
--- ipv6-test.com ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4006ms
rtt min/avg/max/mdev = 42.485/43.717/45.632/1.091 ms
Part X. Appendices
Table of Contents

A. cloning .................................................................................................................................................... 247
   A.1. About cloning ............................................................................................................................. 247
   A.2. About offline cloning ................................................................................................................. 247
   A.3. Offline cloning example ............................................................................................................ 247
B. License .................................................................................................................................................... 249
Appendix A. cloning

A.1. About cloning

You can have distinct goals for cloning a server. For instance a clone can be a cold iron backup system used for manual disaster recovery of a service. Or a clone can be created to serve in a test environment. Or you might want to make an almost identical server. Let's take a look at some offline and online ways to create a clone of a Linux server.

A.2. About offline cloning

The term offline cloning is used when you power off the running Linux server to create the clone. This method is easy since we don't have to consider open files and we don't have to skip virtual file systems like /dev or /sys. The offline cloning method can be broken down into these steps:

1. Boot source and target server with a bootable CD
2. Partition, format and mount volumes on the target server
3. Copy files/partitions from source to target over the network

The first step is trivial. The second step is explained in the Disk Management chapter. For the third step, you can use a combination of ssh or netcat with cp, dd, dump and restore, tar, cpio, rsync or even cat.

A.3. Offline cloning example

We have a working Red Hat Enterprise Linux 5 server, and we want a perfect copy of it on newer hardware. First thing to do is discover the disk layout.

```
[root@RHEL5 ~]# df -h
Filesystem           Size  Used Avail Use% Mounted on
/dev/sda2            15G   4.5G  9.3G  33% /  
/dev/sda1            99M    31M  64M  33% /boot
```

The /boot partition is small but big enough. If we create an identical partition, then dd should be a good cloning option. Suppose the / partition needs to be enlarged on the target system. The best option then is to use a combination of dump and restore. Remember that dd copies blocks, whereas dump/restore copies files.

The first step to do is to boot the target server with a live CD and partition the target disk. To do this we use the Red Hat Enterprise Linux 5 install CD. At the CD boot prompt we type "linux rescue". The cd boots into a root console where we can use fdisk to discover and prepare the attached disks.

When the partitions are created and have their filesystem, then we can use dd to copy the /boot partition.
ssh root@192.168.1.40 "dd if=/dev/sda1" | dd of=/dev/sda1

Then we use a dump and restore combo to copy the / partition.

mkdir /mnt/x
mount /dev/sda2 /mnt/x
cd /mnt/x
ssh root@192.168.1.40 "dump -0 -f - /" | restore -r -f -
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Index

Symbols
/etc/apache2, 10
/etc/bind/named.conf.local, 76
/etc/group, 45
/etc/httpd, 10
/etc/inetd.conf, 152
/etc/init.d/samba, 141
/etc/init.d/smb, 141
/etc/init.d/winbind, 142
/etc/passwd.config, 190, 192
/etc/passwd, 45, 199
/etc/resolv.conf, 62
/etc/samba/passdb.tdb, 198
/etc/samba/smb.conf, 146, 147, 148, 164, 188
/etc/samba/smbpasswd, 169, 196
/etc/selinux/config, 212
/etc/squid/squid.conf, 34
/etc/sysctl.conf, 116
/etc/xinetd.d/swat, 152
/proc/sys/net/ipv4/ip_forward, 116
/selinux, 214
/selinux/enforce, 214
/var/log/audit/audit.log, 210
/var/log/squid, 39
.htaccess, 27
.htpasswd, 17, 24
.my.cnf, 46

A
A (DNS record), 67
AAAA (DNS record), 67
allow hosts (Samba), 181
apache2, 6
aptitude, 138, 139, 227
aptitude(8), 44
auditd, 210
authoritative (dns), 71
authoritative zone, 66
axfr, 74

B
bind, 64
bind(DNS), 90
browseable (Samba), 182
browseable (Samba), 182
browser master, 196

C
cahing only name server, 68
chain (iptables), 123
char(mysql), 49
chcon(1), 216, 217
chkconfig, 210
chmod, 213
CIFS, 143
CNAME (DNS record), 67
context type(selinux), 215
create(mysql), 47, 49, 55
create mask (Samba), 182

d
delete(mysql), 54
deny hosts (Samba), 182
describe(mysql), 50
dhcclient, 118
dhcpp server, 62
directory mask (Samba), 182
directory security mask(samba), 183
DNAT, 115
dns, 60, 60
dnsdomainname, 66
dns namespace, 63
dns server, 62
domain (dns), 64
domain name system, 60, 60
dpkg, 138
dpkg(1), 44
drop(mysql), 48, 50, 56

F
filter table (iptables), 123
firewall, 114
force create mode(samba), 183
force directory mode(samba), 183
force directory security mode(samba), 183
force group(samba), 170
force security mode(samba), 183
force user(samba), 170
forwarder (dns), 70
forward lookup query, 61
fqdn, 66
fully qualified domain name, 66

G
getenforce, 211
getent(1), 191
getfattr(1), 217
git, 226
github, 232
glue record (dns), 67
group by(mysql), 54
guest ok (Samba), 157

H
hide unreadable (Samba), 182
host (DNS record), 67
hostname, 66, 143
hosts.txt, 60
hosts allow (Samba), 181
hosts deny (Samba), 182

256
Index

htpasswd(1), 17, 24
httpd, 7

I
IBM, 143
id(1), 216
identity(selinux), 214
idmap gid(samba), 188
idmap uid(samba), 188
inetd(8), 152
insert(mysql), 51
integer(mysql), 49
invalid users (Samba), 181
iptables, 122, 123
iptables save, 127
iterative query, 70
ixfr, 74

L
LAMP, 43
ls, 213
ls(1), 217

M
mac address, 117
mangle table (iptables), 123
masquerading, 115
master server (DNS), 73
MX (DNS record), 67
mysql, 43, 45, 46, 47
mysql(group), 45
mysql(user), 45
mysql-client, 44
mysqld, 45
mysql-server, 44

N
NAPT, 115
NAT, 115
nat table (iptables), 123
NetBIOS names, 143
netcat, 160
net groupmap, 201
net rpc join(samba), 189
net use(microsoft), 159, 164, 175
net view(microsoft), 146, 151
nmbd(8), 142
NS (DNS record), 67
nslookup, 61
NT_STATUS_BAD_NETWORK_NAME, 176
NT_STATUS_LOGON_FAILURE, 176

O
order by(mysql), 53

P
packet filtering, 114, 124

packet forwarding, 114
passdb backend (Samba), 170
PAT, 115
Paul Mockapetris, 60
php, 43
ping, 117, 118
port forwarding, 115
primary dns server, 71
primary server (DNS), 73
proxy server, 33
ps(1), 217
PTR (DNS record), 67
public key, 232

Q
query (dns), 61

R
read list (Samba), 181
read only (Samba), 164
recursive query, 70
reverse lookup query, 61
roaming profiles(samba), 200
role(selinux), 214
root(DNS), 63
root(mysql), 44
root hints, 64
root server (dns), 69
root servers (dns), 63
router, 114
rpm, 138
rpm(1), 44
rpm(8), 139

S
samba, 138
secondary dns server, 71
secondary server (DNS), 73
security(Samba), 157
security mask(samba), 183
security mode(samba), 174
select(mysql), 51, 52, 52
SELinux, 209
selinux, 212
selinux-activate, 210
service(8), 141
sestatus, 212
setenforce, 211
show(mysql), 47, 49
slave server (DNS), 73
SMB, 143
smbclient, 149, 158
smbclient(1), 148, 175
smbd(8), 142, 146, 169
smbpasswd(1), 201
smbpasswd(8), 169, 174
smbtree, 151
smbtree(1), 150
smtp, 67
SNAT, 115
soa (dns record), 71
SQL, 43, 51
squid, 33
stateful firewall, 114
swat(8), 152
sysctl, 116

tcpdump, 61, 118
tdbsam, 170, 196, 198
testparm(1), 147, 147, 148
tld, 65
TLD (dns), 65
top level domain, 65
transition(selinux), 216
trigger(mysql), 55
triggers(mysql), 44
type(selinux), 215

update(mysql), 52
use(mysql), 48

valid users (Samba), 181
varchar(mysql), 49
virtualbox, 117
vmware, 117

wbinfo(1), 190, 191
webalizer, 27
winbind(8), 190
winbind(samba), 188
winbindd(8), 142, 142, 190
wireshark, 118
workgroup, 157
writable (Samba), 164
write list (Samba), 181

xinetd(8), 152

yum, 139

zone (dns), 66, 71
zone transfer (dns), 71