Linux Servers

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Contents

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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.

More information and free .pdf available at https://hogenttin.github.io/linux-training-hogent/.

Part I.

web servers

1. apache web server

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Hans Roes, https://github.com/Blokker-1999/, Alex M. Schapelle, https://github.com/zero-pytagoras/)

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

To install `apache` on Debian:

```
root@linux:~# 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\
mon{a}  libapr1{a}  libaprutil1{a}  libaprutil1-dbd-sqlite3{a}  libaprutil1-
ldap{a}\
 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@linux:~# ls -l /var/www
total 4
-rw-r--r-- 1 root root 177 Apr 29 11:55 index.html
root@linux:~# 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\
readed 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:

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

To install apache on CentOS:

```
[root@linux ~]# yum install httpd
```

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

```
[root@linux ~]# rpm -q httpd
httpd-2.2.15-30.el6.centos.x86_64
[root@linux ~]# 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
[root@linux ~]#
```

1.1.3. running apache on Debian

This is how you start `apache2` on Debian.

```
root@linux:~# service apache2 status
Apache2 is NOT running.
root@linux:~# service apache2 start
Starting web server: apache2apache2: 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@linux:~# service apache2 status
Apache2 is running (pid 3680).
root@linux:~# 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@linux:~#
```

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

```
root@linux:~# wget 127.0.0.1
--2014-05-06 13:27:02--  http://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@linux:~# file index.html
index.html: HTML document, ASCII text
root@linux:~#
```

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@linux:~# echo ServerName debian10 >> /etc/apache2/apache2.conf
root@linux:~# service apache2 restart
Restarting web server: apache2 ... waiting .
root@linux:~#
```

1.1.4. running apache on CentOS

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

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

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

```
[root@linux ~]# service httpd status
httpd (pid  2410) is running...
[root@linux ~]# 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@linux ~]#
```

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

```
[root@linux ~]# echo ServerName Centos65 >> /etc/httpd/conf/httpd.conf
[root@linux ~]# service httpd restart
Stopping httpd:                                            [  OK  ]
Starting httpd:                                            [  OK  ]
[root@linux ~]#
```

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@linux ~]# 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
2014-05-06 15:10:22 ERROR 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@linux ~]# wget http://127.0.0.1/error/noindex.html
--2014-05-06 15:16:05--  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@linux ~]# file noindex.html
noindex.html: HTML document text
[root@linux ~]#
```

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

```
[root@linux ~]# echo 'Welcome to my website' > /var/www/html/index.html
[root@linux ~]# wget http://127.0.0.1
--2014-05-06 15:19:16--  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@linux ~]# 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@linux:~# grep DocumentRoot /etc/apache2/sites-available/default
        DocumentRoot /var/www
```

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

```
root@linux:~# 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>
root@linux:~#
```

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

```
[root@linux ~]# 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@linux ~]# echo '<html><head><title>Default website</title></head><body\
><p>A new web page</p></body></html>' > /var/www/html/index.html
[root@linux ~]# cat /var/www/html/index.html
<html><head><title>Default website</title></head><body><p>A new web page</p></b\
ody></html>
[root@linux ~]#
```

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@linux ~]# 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/modu\
les
lrwxrwxrwx. 1 root root   19 May  6 13:08 run -> ../../var/run/httpd
[root@linux ~]#
```

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

```
root@linux:~# 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@linux:~#
```

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

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

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

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

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

```
root@linux:~# echo 'Choo Choo model train Choo Choo' > /var/www/choochoo/inde\
x.html
root@linux:~# echo 'Welcome to chess club 42' > /var/www/chessclub42/index.ht\
ml
root@linux:~# 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...

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

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

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

```
root@linux:/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.

```
root@linux:/etc/apache2# ls sites-enabled/
000-default  chessclub42  choochoo  hunter2
root@linux:/etc/apache2# service apache2 reload
Reloading web server config: apache2.
root@linux:/etc/apache2#
```

1.2.6. testing the three websites

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

```
root@linux:/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@linux:/etc/apache2# cat index.html
Choo Choo model train Choo Choo
```

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

```
root@linux:/etc/apache2# wget 127.0.0.1:8000
--2014-05-06 21:16:20--  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

2014-05-06 21:16:20 (2.16 MB/s) - `index.html.1' saved [25/25]

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

Testing the hacker club named hunter2 on port 9000.

```
root@linux:/etc/apache2# wget 127.0.0.1:9000
--2014-05-06 21:16:30--  http://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@linux:/etc/apache2# cat index.html.2
HaCkInG iS fUn At HuNtEr2
```

Cleaning up the temporary files.

```
root@linux:/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 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`, `chess-club42.local` and `hunter2.local`.

We start by creating three new virtualhosts.

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

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@linux:/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@linux:/etc/apache2/sites-available# a2ensite choochoo.local
Enabling site choochoo.local.
To activate the new configuration, you need to run:
  service apache2 reload
root@linux:/etc/apache2/sites-available# a2ensite chessclub42.local
Enabling site chessclub42.local.
To activate the new configuration, you need to run:
  service apache2 reload
root@linux:/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@linux:/etc/apache2/sites-available# service apache2 reload
Reloading web server config: apache2.
root@linux:/etc/apache2/sites-available# wget chessclub42.local
--2014-05-06 21:37:13--  http://chessclub42.local/
Resolving chessclub42.local (chessclub42.local)... 192.168.42.50
Connecting to chessclub42.local (chessclub42.local)|192.168.42.50|:80... conne\
cted.
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@linux:/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@linux:~# htpasswd -c /var/www/.htpasswd cliff
New password:
Re-type new password:
Adding password for user cliff
root@linux:~# 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@linux:~# htpasswd /var/www/.htpasswd rob
New password:
Re-type new password:
Adding password for user rob
root@linux:~# cat /var/www/.htpasswd
cliff:$apr1$vujll0KL$./SZ4w9q0swhX93pQ0PVp.
rob:$apr1$HNln1FFt$nRlpF0H.IW11/1DRq4lQo0
```

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@linux:~# cd /var/www/hunter2/
root@linux:/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 `AllowOvveride` parameter in `/etc/apache2/sites-available/default` as this screenshot shows (with line numbers on debian10, 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@linux:~# 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/chooc\
hoo/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/ind\
ex.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
--2014-05-11 11:59:36--  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

2014-05-11 11:59:36 (4.47 MB/s) - `index.html' saved [32/32]

[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@linux:/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
--2014-05-11 12:02:37--  http://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@linux:/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.

```
[root@CentOS65 ~]# service httpd reload
Reloading httpd:
[root@CentOS65 ~]# wget chessclub42.local
--2014-05-25 16:59:14--  http://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: âindex.htmlâ

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

2014-05-25 16:59:15 (1014 KB/s) - `index.html' saved [25/25]

[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
[root@CentOS65 ~]#
```

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@linux:~# service apache2 restart
apache2: Syntax error on line 268 of /etc/apache2/apache2.conf: Syntax error o\
n  line  1  of  /etc/apache2/sites-enabled/chessclub42:  /etc/apache2/sites-
enabled\
/chessclub42:4: <VirtualHost> was not closed.\n/etc/apache2/sites-enabled/ches\
sclub42:1: <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@linux:~# 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@linux:~# mv /var/www/choochoo/ /var/www/chooshoo
root@linux:~# !ser
service apache2 restart
Restarting web server: apache2Warning: DocumentRoot [/var/www/choochoo] does n\
ot exist
Warning: DocumentRoot [/var/www/choochoo] does not exist
  ... waiting Warning: DocumentRoot [/var/www/choochoo] does not exist
Warning: DocumentRoot [/var/www/choochoo] does not exist
.
```

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>
ErrorDocument 404 http://www.cobbaut.be/cobbaut.php
</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.

```
student@linux:~/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]
student@linux:~/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@linux:~# 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@linux:~# mkdir /etc/ssl/localcerts
root@linux:~# openssl req -new -x509 -days 999 -nodes -out /etc/ssl/local\
certs/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@linux:~# 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@linux:~# chmod 600 /etc/ssl/localcerts/*
root@linux:~# 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@linux:~# 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@linux:~# vi /etc/apache2/sites-available/choochoos
root@linux:~# 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>
root@linux:~#
```

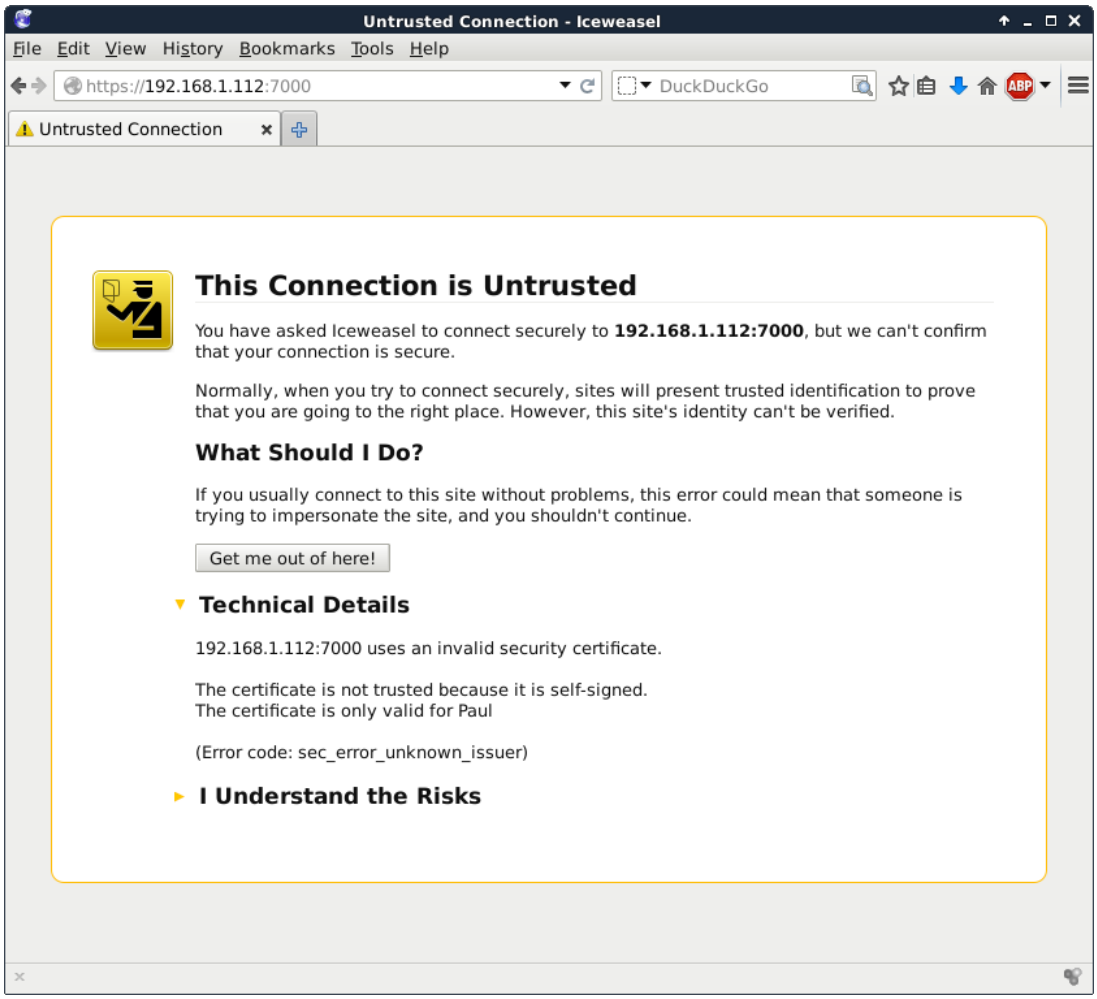
And create the website itself.

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

Enable the website and restart (or reload) apache2.

```
root@linux:/var/www/choochoos# a2ensite choochoos
Enabling site choochoos.
To activate the new configuration, you need to run:
  service apache2 reload
root@linux:/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 (0×10001)
[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.ke\
y -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
[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
```

Create a website configuration.

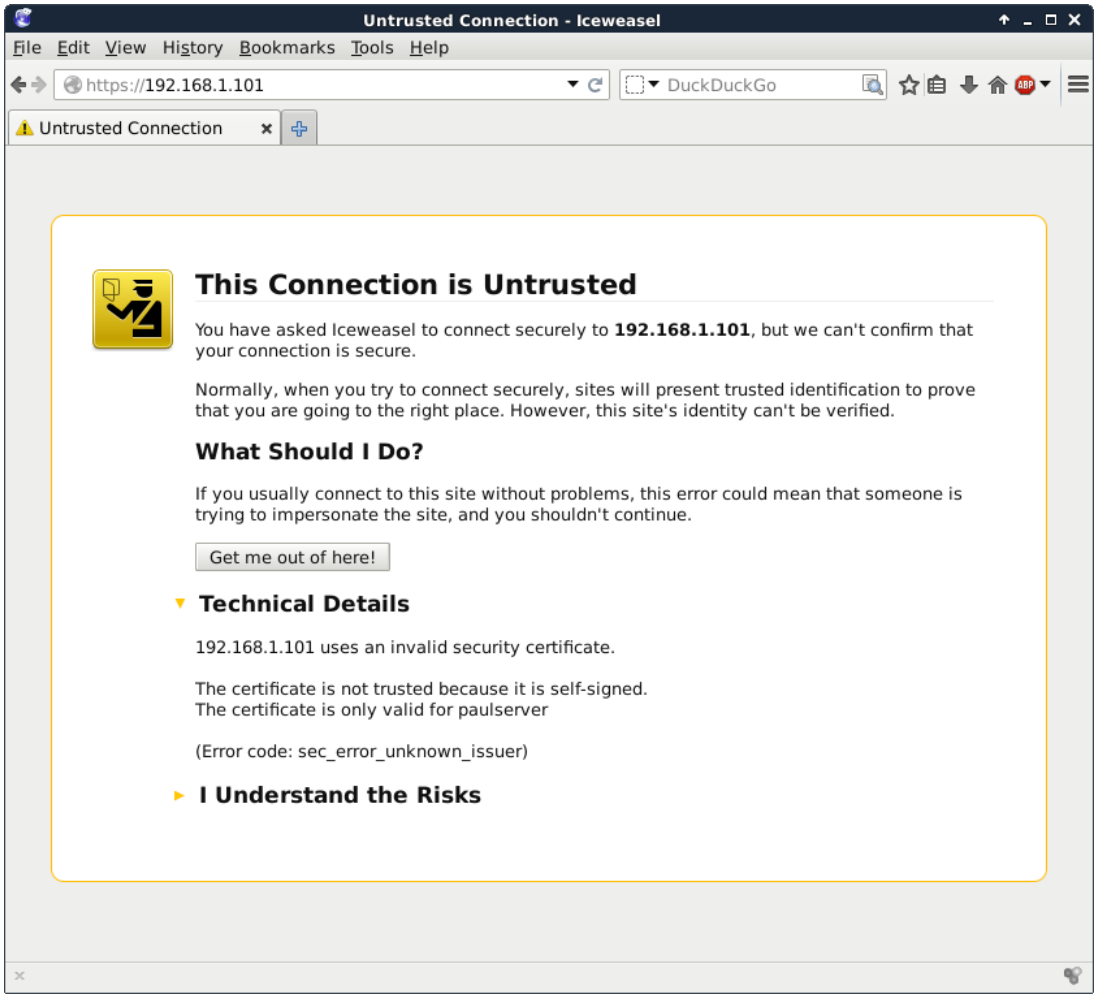
```
[root@paulserver certs]# vi /etc/httpd/conf.d/choochoos.conf
[root@paulserver certs]# cat /etc/httpd/conf.d/choochoos.conf
<VirtualHost *:443>
        SSLEngine on
        SSLCertificateFile /etc/pki/tls/certs/ca.crt
        SSLCertificateKeyFile /etc/pki/tls/private/ca.key
        DocumentRoot /var/www/choochoos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

Create a simple website and restart apache.

1. apache web server

```
[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.

2. apache web server

(Written by Alex M. Schapelle, https://github.com/zero-pytagoras/)

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).

2.1. introduction to apache

2.1.1. installing on Debian

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

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

To install `apache` on Debian:

```
root@linux:~# 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\
mon{a}  libapr1{a}  libaprutil1{a}  libaprutil1-dbd-sqlite3{a}  libaprutil1-
ldap{a}\
 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@linux:~# ls -l /var/www
total 4
-rw-r--r-- 1 root root 177 Apr 29 11:55 index.html
root@linux:~# 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\
readed 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
```

2.1.2. 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:

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

To install apache on CentOS:

```
[root@linux ~]# yum install httpd
```

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

```
[root@linux ~]# rpm -q httpd
httpd-2.2.15-30.el6.centos.x86_64
[root@linux ~]# 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
[root@linux ~]#
```

2.1.3. running apache on Debian

This is how you start `apache2` on Debian.

```
root@linux:~# service apache2 status
Apache2 is NOT running.
root@linux:~# service apache2 start
Starting web server: apache2apache2: 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@linux:~# service apache2 status
Apache2 is running (pid 3680).
root@linux:~# 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@linux:~#
```

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

```
root@linux:~# wget 127.0.0.1
--2014-05-06 13:27:02--  http://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@linux:~# file index.html
index.html: HTML document, ASCII text
root@linux:~#
```

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@linux:~# echo ServerName debian10 >> /etc/apache2/apache2.conf
root@linux:~# service apache2 restart
Restarting web server: apache2 ... waiting .
root@linux:~#
```

2.1.4. running apache on CentOS

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

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

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

```
[root@linux ~]# service httpd status
httpd (pid  2410) is running...
[root@linux ~]# 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@linux ~]#
```

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

```
[root@linux ~]# echo ServerName Centos65 >> /etc/httpd/conf/httpd.conf
[root@linux ~]# service httpd restart
Stopping httpd:                                            [  OK  ]
Starting httpd:                                            [  OK  ]
[root@linux ~]#
```

2.1.5. index file on CentOS

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

```
[root@linux ~]# 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
2014-05-06 15:10:22 ERROR 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@linux ~]# wget http://127.0.0.1/error/noindex.html
--2014-05-06 15:16:05--  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@linux ~]# file noindex.html
noindex.html: HTML document text
[root@linux ~]#
```

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

```
[root@linux ~]# echo 'Welcome to my website' > /var/www/html/index.html
[root@linux ~]# wget http://127.0.0.1
--2014-05-06 15:19:16--  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@linux ~]# cat index.html
Welcome to my website
```

2.1.6. 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@linux:~# grep DocumentRoot /etc/apache2/sites-available/default
        DocumentRoot /var/www
```

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

```
root@linux:~# 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>
root@linux:~#
```

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

```
[root@linux ~]# 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@linux ~]# echo '<html><head><title>Default website</title></head><body\
><p>A new web page</p></body></html>' > /var/www/html/index.html
[root@linux ~]# cat /var/www/html/index.html
<html><head><title>Default website</title></head><body><p>A new web page</p></b\
ody></html>
[root@linux ~]#
```

2.1.7. 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@linux ~]# 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/modu\
les
lrwxrwxrwx. 1 root root   19 May  6 13:08 run -> ../../var/run/httpd
[root@linux ~]#
```

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

```
root@linux:~# 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@linux:~#
```

2.2. port virtual hosts on Debian

2.2.1. default virtual host

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

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

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

2.2.3. 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@linux:~# vi /etc/apache2/ports.conf
```

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

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

2.2.4. three extra websites

Next we need to create three `DocumentRoot` directories.

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

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

```
root@linux:~# echo 'Choo Choo model train Choo Choo' > /var/www/choochoo/inde\
x.html
root@linux:~# echo 'Welcome to chess club 42' > /var/www/chessclub42/index.ht\
ml
root@linux:~# echo 'HaCkInG iS fUn At HuNtEr2' > /var/www/hunter2/index.html
```

2.2.5. 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...

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

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

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

```
root@linux:/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.

```
root@linux:/etc/apache2# ls sites-enabled/
000-default  chessclub42  choochoo  hunter2
root@linux:/etc/apache2# service apache2 reload
Reloading web server config: apache2.
root@linux:/etc/apache2#
```

2.2.6. testing the three websites

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

```
root@linux:/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@linux:/etc/apache2# cat index.html
Choo Choo model train Choo Choo
```

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

```
root@linux:/etc/apache2# wget 127.0.0.1:8000
--2014-05-06 21:16:20--  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

2014-05-06 21:16:20 (2.16 MB/s) - `index.html.1' saved [25/25]

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

Testing the hacker club named hunter2 on port 9000.

```
root@linux:/etc/apache2# wget 127.0.0.1:9000
--2014-05-06 21:16:30--  http://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@linux:/etc/apache2# cat index.html.2
HaCkInG iS fUn At HuNtEr2
```

Cleaning up the temporary files.

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

Try testing from another computer using the ip-address of your server.

2.3. named virtual hosts on Debian

2.3.1. 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`.

We start by creating three new virtualhosts.

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

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

2.3.2. 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@linux:/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...

2.3.3. enabling virtual hosts

Next we enable them with `a2ensite`.

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

2.3.4. reload and verify

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

```
root@linux:/etc/apache2/sites-available# service apache2 reload
Reloading web server config: apache2.
root@linux:/etc/apache2/sites-available# wget chessclub42.local
--2014-05-06 21:37:13--  http://chessclub42.local/
Resolving chessclub42.local (chessclub42.local)... 192.168.42.50
Connecting to chessclub42.local (chessclub42.local)|192.168.42.50|:80... conne\
cted.
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@linux:/etc/apache2/sites-available# cat index.html
Welcome to chess club 42
```

2.4. 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@linux:~# htpasswd -c /var/www/.htpasswd cliff
New password:
Re-type new password:
Adding password for user cliff
root@linux:~# 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@linux:~# htpasswd /var/www/.htpasswd rob
New password:
Re-type new password:
Adding password for user rob
root@linux:~# cat /var/www/.htpasswd
cliff:$apr1$vujll0KL$./SZ4w9q0swhX93pQ0PVp.
rob:$apr1$HNln1FFt$nRlpF0H.IW11/1DRq4lQo0
```

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@linux:~# cd /var/www/hunter2/
root@linux:/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 `AllowOvveride` parameter in `/etc/apache2/sites-available/default` as this screenshot shows (with line numbers on debian10, 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!

2.5. port virtual hosts on CentOS

2.5.1. 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).

2.5.2. 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.

2.5.3. 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@linux:~# grep ^Listen /etc/httpd/conf/httpd.conf
Listen 80
Listen 7000
Listen 8000
Listen 9000
```

2.5.4. 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  ]
```

2.5.5. 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/chooc\
hoo/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/ind\
ex.html
```

2.5.6. 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:
```

2.5.7. testing the three websites

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

```
[root@CentOS65 ~]# wget 127.0.0.1:7000
--2014-05-11 11:59:36--  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

2014-05-11 11:59:36 (4.47 MB/s) - `index.html' saved [32/32]

[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@linux:/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
--2014-05-11 12:02:37--  http://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@linux:/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
```

2.5.8. 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  ]
```

2.6. named virtual hosts on CentOS

2.6.1. 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.

2.6.2. 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...

2.6.3. reload and verify

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

```
[root@CentOS65 ~]# service httpd reload
Reloading httpd:
[root@CentOS65 ~]# wget chessclub42.local
--2014-05-25 16:59:14--  http://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: âindex.htmlâ

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

2014-05-25 16:59:15 (1014 KB/s) - `index.html' saved [25/25]

[root@CentOS65 ~]# cat index.html
Welcome to chess club 42
```

2.7. 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
[root@CentOS65 ~]#
```

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!

2.8. 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@linux:~# service apache2 restart
apache2: Syntax error on line 268 of /etc/apache2/apache2.conf: Syntax error o\
n  line  1  of  /etc/apache2/sites-enabled/chessclub42:  /etc/apache2/sites-
enabled\
/chessclub42:4: <VirtualHost> was not closed.\n/etc/apache2/sites-enabled/ches\
sclub42:1: <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@linux:~# 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@linux:~# mv /var/www/choochoo/ /var/www/chooshoo
root@linux:~# !ser
service apache2 restart
Restarting web server: apache2Warning: DocumentRoot [/var/www/choochoo] does n\
ot exist
Warning: DocumentRoot [/var/www/choochoo] does not exist
  ... waiting Warning: DocumentRoot [/var/www/choochoo] does not exist
Warning: DocumentRoot [/var/www/choochoo] does not exist
.
```

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`.

2.9. 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>
ErrorDocument 404 http://www.cobbaut.be/cobbaut.php
</VirtualHost>
```

2.10. 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
```

2.11. 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.

```
student@linux:~/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]
student@linux:~/cobbaut.be$
```

2.12. traffic

Apache keeps a log of all visitors. The `webalizer` is often used to parse this log into nice html statistics.

2.13. 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@linux:~# 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@linux:~# mkdir /etc/ssl/localcerts
root@linux:~# openssl req -new -x509 -days 999 -nodes -out /etc/ssl/local\
certs/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@linux:~# 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@linux:~# chmod 600 /etc/ssl/localcerts/*
root@linux:~# 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@linux:~# 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@linux:~# vi /etc/apache2/sites-available/choochoos
root@linux:~# 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>
root@linux:~#
```

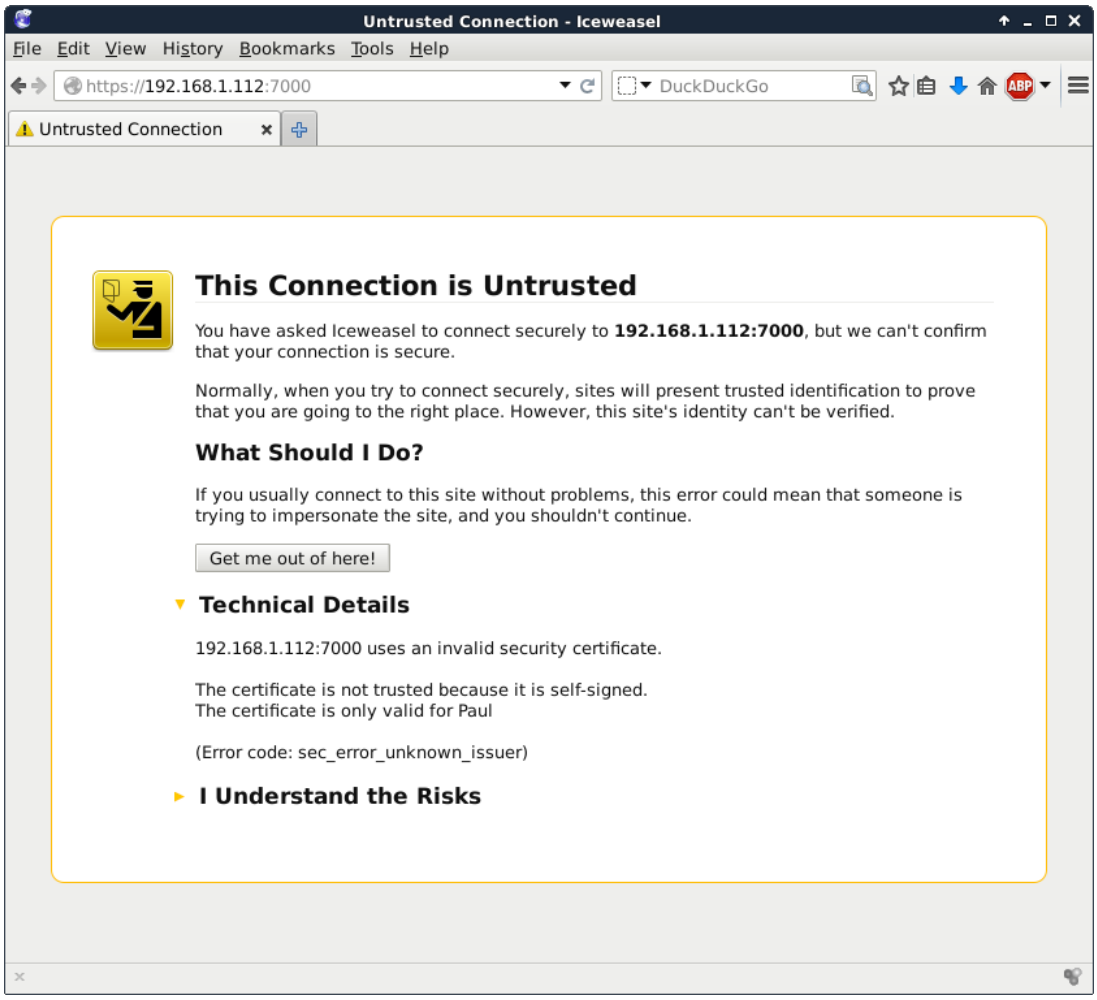
And create the website itself.

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

Enable the website and restart (or reload) apache2.

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

Chances are your browser will warn you about the self signed certificate.



2.14. 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 (0×10001)
[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.ke\
y -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
[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
```

Create a website configuration.

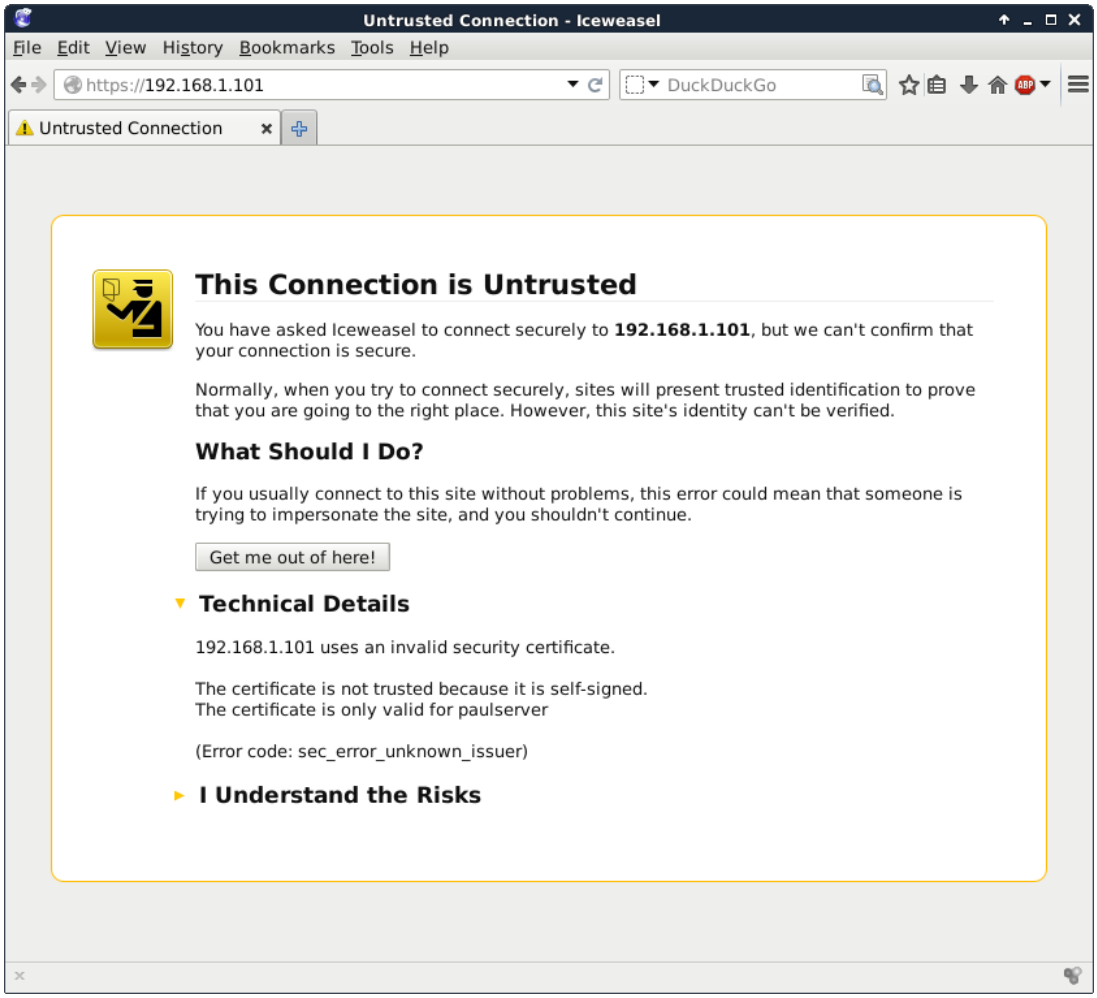
```
[root@paulserver certs]# vi /etc/httpd/conf.d/choochoos.conf
[root@paulserver certs]# cat /etc/httpd/conf.d/choochoos.conf
<VirtualHost *:443>
        SSLEngine on
        SSLCertificateFile /etc/pki/tls/certs/ca.crt
        SSLCertificateKeyFile /etc/pki/tls/private/ca.key
        DocumentRoot /var/www/choochoos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

Create a simple website and restart apache.

2. apache web server

```
[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.



2.15. 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.

3. introduction to squid

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Alex M. Schapelle, https://github.com/zero-pytagoras/)

4. about proxy servers

4.1. 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.

4.2. 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.

4.3. 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.

4.4. installing squid

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

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

4.5. port 3128

By default the squid proxy server will lsiten to port 3128.

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

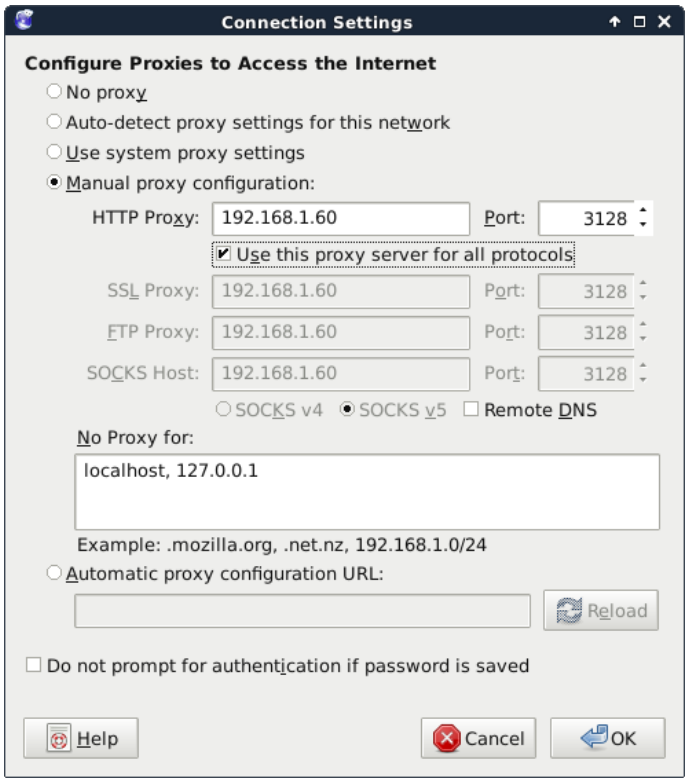
4.6. starting and stopping

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

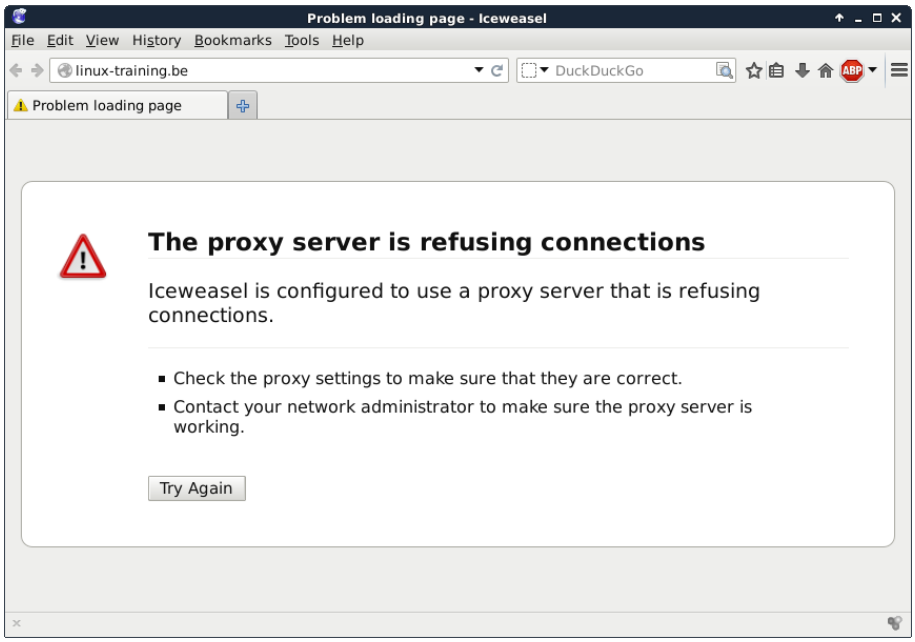
```
root@linux:~# service squid start
Starting Squid HTTP proxy: squid.
root@linux:~# service squid restart
Restarting Squid HTTP proxy: squid.
root@linux:~# service squid status
squid is running.
root@linux:~# service squid stop
Stopping Squid HTTP proxy: squid.
root@linux:~#
```

4.7. 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).



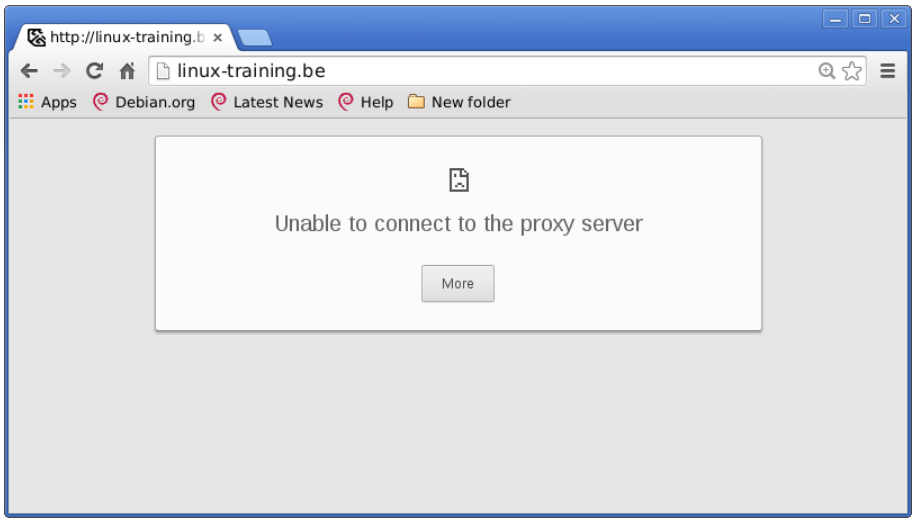
Test that your internet works with the proxy enabled. Also test that after a `service squid stop` command on your proxy server that you get a message similar to this schreenshot.



To enable a proxy server with Google Chrome (or Debian Chromium) start the program from the command line like this:

```
student@linux:~$ 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.



4.8. 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@linux:~# aptitude install imagemagick wget perl apache2
... output truncated ...
root@linux:~# dpkg -S $(readlink -f $(which mogrify))
imagemagick: /usr/bin/mogrify.im6
root@linux:~#
```

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@linux:~# 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++;
}
```

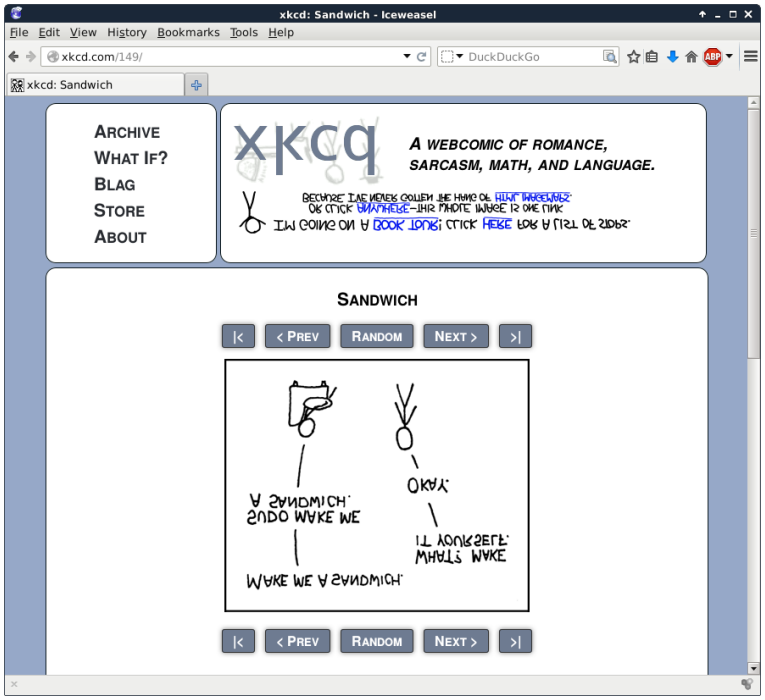
Change (or enable) also the following line in `/etc/squid/suiqd.conf`.

```
http_access allow localnet
http_port 3128 transparent
url_rwwrite_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@linux:~# mkdir /var/www/images
root@linux:~# chown www-data:www-data /var/www/images
root@linux:~# chmod 755 /var/www/images
root@linux:~# usermod -aG www-data proxy
root@linux:~# usermod -aG proxy www-data
```

Test that it works after restarting `squid` and `apache2`.



4.9. /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
```

4.10. 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
```

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

4.12. name resolution

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

```
[student@linux ~]$ wget http://grep.be
--14:35:44--  http://grep.be
Resolving grep.be... failed: Temporary failure in name resolution.
[student@linux ~]$ export http_proxy=http://192.168.1.39:8080
[student@linux ~]$ 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]

[student@linux ~]$
```

Part II.

mysql database

5. introduction to sql using mysql

(Written by Paul Cobbaut, https://github.com/paulcobbaut/)

`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.

5.1. installing mysql

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

```
root@linux~# 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@linux~# 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.

```
[student@linux ~]$ rpm -q mysql-server
mysql-server-5.0.45-7.el5
```

You will need at least version 5.0 to work with `triggers`.

5.2. accessing mysql

5.2.1. Linux users

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

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

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

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

5.2.2. 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.

```
root@linux~# 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)

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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> exit
Bye
```

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.

```
root@linux~# mysql -u root -phunter2
Welcome to the MySQL monitor.  Commands end with ; or \g.
...
```

5.2.3. ~/.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.

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

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

```
kevin@linux:~$ 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)
```

5.2.4. 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).

```
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.

5.3. mysql databases

5.3.1. 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@linux:~$ 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)

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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)
```

5.3.2. 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)
```

5.3.3. 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>
```

5.3.4. 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)
```

5.3.5. 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)
```

5.3.6. 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
```

5.4. mysql tables

5.4.1. 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)
```

5.4.2. 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)

mysql>
```

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), prim\
ary key (countrycode) );
Query OK, 0 rows affected (0.18 sec)
```

5.4.3. 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)
```

5.4.4. 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)
```

5.5. mysql records

5.5.1. 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'
```

5.5.2. 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        |   64000000 | 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)
```

5.5.3. updating records

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

```
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.

```
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.

```
mysql> select * from country;
+-------------+---------------+------------+----------------+
| countrycode | countryname   | population | countrycapital |
+-------------+---------------+------------+----------------+
| BE          | Belgium       |   11000000 | Brussels       |
| CN          | China         | 1400000000 | Beijing        |
| DE          | Germany       |   82000000 | Berlin         |
| ES          | Spain         |   48000000 | Madrid         |
| FR          | France        |   64000000 | Paris          |
| IN          | India         | 1300000000 | New Delhi      |
| JP          | Japan         |  128000000 | Tokyo          |
| MX          | Mexico        |  113000000 | Mexico City    |
| US          | United States |  313000000 | Washington     |
+-------------+---------------+------------+----------------+
9 rows in set (0.00 sec)
```

5.5.4. viewing selected records

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

```
mysql> SELECT * FROM country WHERE countrycode='ES';
+-------------+-------------+------------+----------------+
| countrycode | countryname | population | countrycapital |
+-------------+-------------+------------+----------------+
| ES          | Spain       |   48000000 | Madrid         |
+-------------+-------------+------------+----------------+
1 row in set (0.00 sec)
```

Another example of the `where` clause.

```
mysql> select * from country where countryname='Spain';
+-------------+-------------+------------+----------------+
| countrycode | countryname | population | countrycapital |
+-------------+-------------+------------+----------------+
| ES          | Spain       |   48000000 | Madrid         |
+-------------+-------------+------------+----------------+
1 row in set (0.00 sec)
```

5.5.5. 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.

```
mysql> insert into country values ('EG','Egypt','82000000','Cairo');
Query OK, 1 row affected (0.33 sec)

mysql> select * from country where population='82000000';
+-------------+-------------+------------+----------------+
| countrycode | countryname | population | countrycapital |
+-------------+-------------+------------+----------------+
| DE          | Germany     |   82000000 | Berlin         |
| EG          | Egypt       |   82000000 | Cairo          |
+-------------+-------------+------------+----------------+
2 rows in set (0.00 sec)
```

5.5.6. ordering records

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

```
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.

```
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)
```

5.5.7. grouping records

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

```
mysql> select * from people;
+-----------------+-----------+-----------+-------------+
| Name            | Field     | birthyear | countrycode |
+-----------------+-----------+-----------+-------------+
| Barack Obama    | politics  | 1961      | US          |
| Deng Xiaoping   | politics  | 1904      | CN          |
| 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          |
+-----------------+-----------+-----------+-------------+
9 rows in set (0.00 sec)

mysql> select Field,AVG(birthyear) from people;
+----------+-------------------+
| Field    | AVG(birthyear)    |
+----------+-------------------+
| politics | 1967.111111111111 |
+----------+-------------------+
1 row in set (0.00 sec)
```

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

```
mysql> select Field,AVG(birthyear) from people group by Field;
+-----------+-------------------+
| Field     | AVG(birthyear)    |
+-----------+-------------------+
| astronaut |              1978 |
| politics  | 1939.3333333333333 |
| tennis    |            1981.6 |
+-----------+-------------------+
3 rows in set (0.00 sec)
```

5.5.8. deleting records

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

```
mysql> delete from country where countryname='Spain';
Query OK, 1 row affected (0.06 sec)

mysql> select * from country where countryname='Spain';
Empty set (0.00 sec)
```

5.6. joining two tables

5.6.1. 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`.

```
mysql> select Name,Field,countryname
    -> from country
    -> inner join people on people.countrycode=country.countrycode;
+-----------------+-----------+---------------+
| 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         |
| Liu Yang        | astronaut | China         |
| Serena Williams | tennis    | United States |
| Venus Williams  | tennis    | United States |
+-----------------+-----------+---------------+
9 rows in set (0.00 sec)
```

This `inner join` will show only records with a match on `countrycode` in both tables.

5.6.2. 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.

```
mysql> select Name,Field,countryname from country left join people on people.countrycode=co
+-----------------+-----------+---------------+
| Name            | Field     | countryname   |
+-----------------+-----------+---------------+
| Guy Verhofstadt | politics  | Belgium       |
| Justine Henin   | tennis    | Belgium       |
| Kim Clijsters   | tennis    | Belgium       |
| Deng Xiaoping   | politics  | China         |
| Li Na           | tennis    | China         |
| Liu Yang        | astronaut | China         |
| NULL            | NULL      | Germany       |
| NULL            | NULL      | Egypt         |
| NULL            | NULL      | Spain         |
| NULL            | NULL      | France        |
| NULL            | NULL      | India         |
| NULL            | NULL      | Japan         |
| NULL            | NULL      | Mexico        |
| Barack Obama    | politics  | United States |
| Serena Williams | tennis    | United States |
| Venus Williams  | tennis    | United States |
+-----------------+-----------+---------------+
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.

5.7. mysql triggers

5.7.1. 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`.

```
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.

```
mysql> create trigger total_amount before INSERT on invoices
    -> for each row set new.amount = new.unitprice * new.unitcount ;
Query OK, 0 rows affected (0.02 sec)
```

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)
```

5.7.2. 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

6. introduction to DNS

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Alex M. Schapelle, https://github.com/zero-pytagoras/, Bert Van Vreckem https://github.com/bertvv/)

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.

For example, when you type https://linux-training.be in a browser address bar, a DNS query is sent to resolve *linux-training.be* to 188.40.26.208. The browser will set up a TCP connection with this IP-address and will use HTTP to obtain the website.

Should *DNS* fail on any level, then the whole network will grind to a halt (unless you hard-coded the network addresses, which is infeasible nowadays).

You will notice that even the largest of organizations benefit greatly from having a *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 interact with a DNS server on a Linux system.

Further reading:

- Wood, Robin. (n.d.) *ZoneTransfer.me*. Retrieved 2014-06-15 from https://digi.ninja/projects/zonetransferme.php
- Nadh, Kalaish. (2022) *DNS Toys*. Retrieved 2022-02-02 from https://www.dns.toys

6.1. about DNS

6.1.1. name to ip address resolution

The *domain name system* or *DNS* is a service on a TCP/IP network that enables clients to translate host 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.

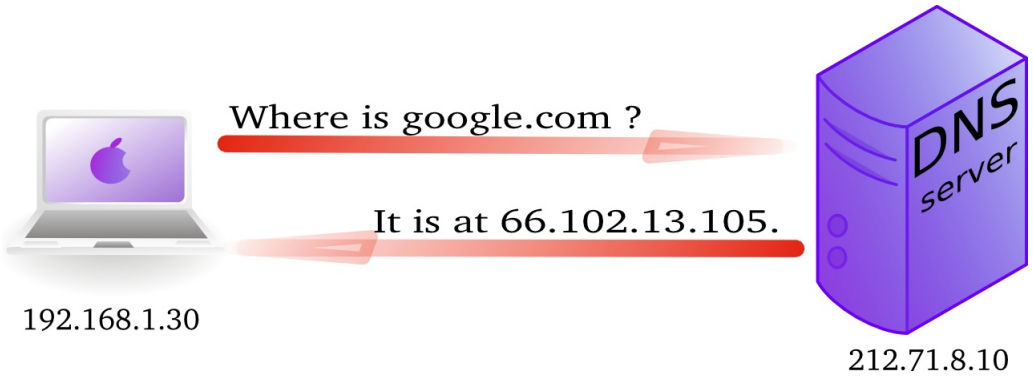


Figure 6.1.: Simplified depiction of a DNS query.

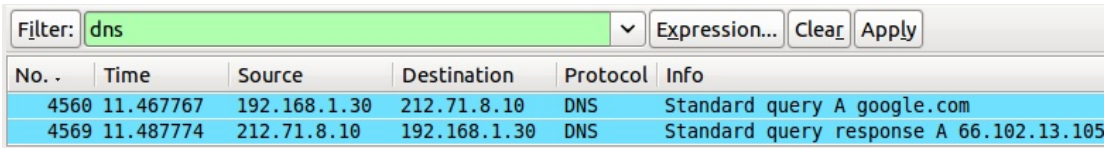


Figure 6.2.: Filtering DNS traffic in Wireshark. Enter `dns` in the Filter text field. The first line shows the request made by the client with IP address 192.168.1.30 and the second the response given by the DNS server at 212.71.8.10.

6.1.2. 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 below.

Today, *DNS* or *Domain Name System* is a worldwide distributed hierarchical database controlled by *ICANN* (the *Internet Corporation for Assigned Names and Numbers*). 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`). See the `hosts(5)` for details.

A hosts file may look like this:

```
# IP-address    hostname     aliases
127.0.0.1       localhost    localhost.localdomain
::1             localhost6   localhost6.localdomain6

172.22.255.254 router4038   gw gw.netlab.hogent.be
172.22.0.2     server4038   server4038.netlab.hogent.be
172.22.0.3     printer4038 printer4038.netlab.hogent.be
```

Each line contains a “record” with several fields, separated by whitespace. The first field is the IP (IPv4 or IPv6) address, following fields are hostnames and aliases.

You can use the hosts file to define shortcuts or aliases to websites or host names you use often. Contents of the hosts file will override all other means of name resolution.

Just enter the IP address and the chosen hostname in the hosts file and you can use that hostname in your browser, or when interacting with the host on the command line (e.g. `ping gw`, `ssh admin@server4038`, etc.).

A neat trick is to use the hosts file to block network traffic to unwanted hosts, e.g. ad servers or known malware domains. Just point the hostname to the IP address `127.0.0.1` and the website will not be reachable. You can find an example of an elaborate hosts file that blocks hundreds of ad servers at https://someonewhocares.org/hosts/.

6.1.3. DNS namespace

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.

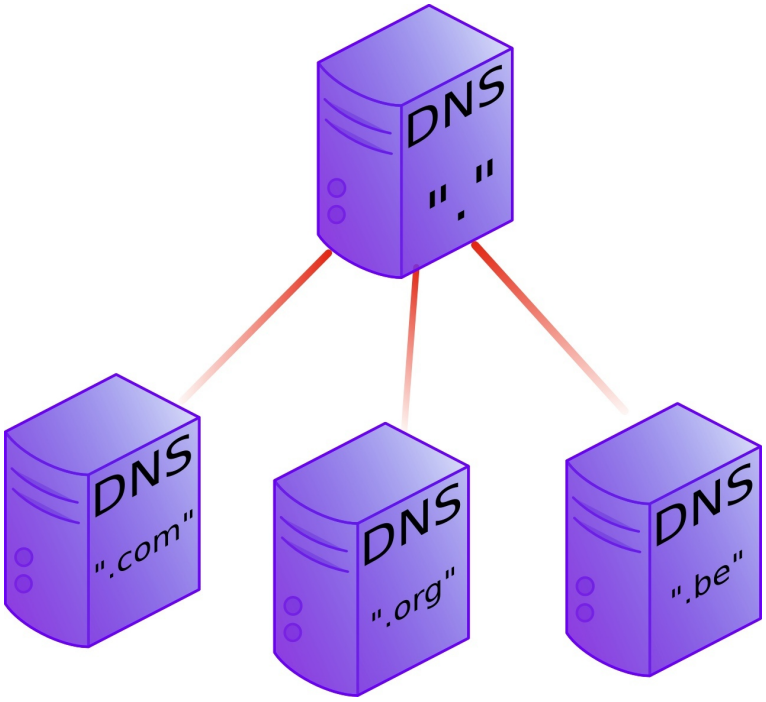


Figure 6.3.: Top-level hierarchy of the DNS namespace.

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*. (e.g. .be, .nl, .sh, etc.) And there are several general *TLD*'s like .com, .edu, .org, .gov, .net, .mil, .int and more recently also .aero, .info, .museum, ...

6.1.3.1. 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, there are many more. For example the *F* root server consists of 46 physical machines that all behave as one (using anycast).

For more information, see:

- http://root-servers.org
- http://en.wikipedia.org/wiki/Root_nameserver

6.1.3.2. top level domains

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

Year	TLD	Purpose
1985	.arpa	Reverse lookup via in-addr.arpa
1985	.com	Commercial Organizations
1985	.edu	US Educational Institutions
1985	.gov	US Government Institutions
1985	.mil	US Military
1985	.net	Internet Service Providers, Internet Infrastructure
1985	.org	Non profit Organizations
1988	.int	International Organizations like nato.int

Country *TLD*'s were defined for individual countries, like *.uk* in 1985 for the United Kingdom, *.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 where chosen, they became active in the 21st century.

Year	TLD	Purpose
2002	.aero	Aviation related
2001	.biz	Businesses
2001	.coop	For co-operatives
2001	.info	Informative internet resources
2001	.museum	For museums
2001	.name	For all kinds of names, pseudonyms and labels
2004	.pro	For professionals

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 *TLD*'s were create like *.travel* (for travel agents), *.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. The current list can be found at https://www.iana.org/domains/root/db.

6.1.3.3. domains

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

DNS domains are registered at the *TLD* servers, the *TLD* servers are registered at the *dot servers*.

6.1.3.4. 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.

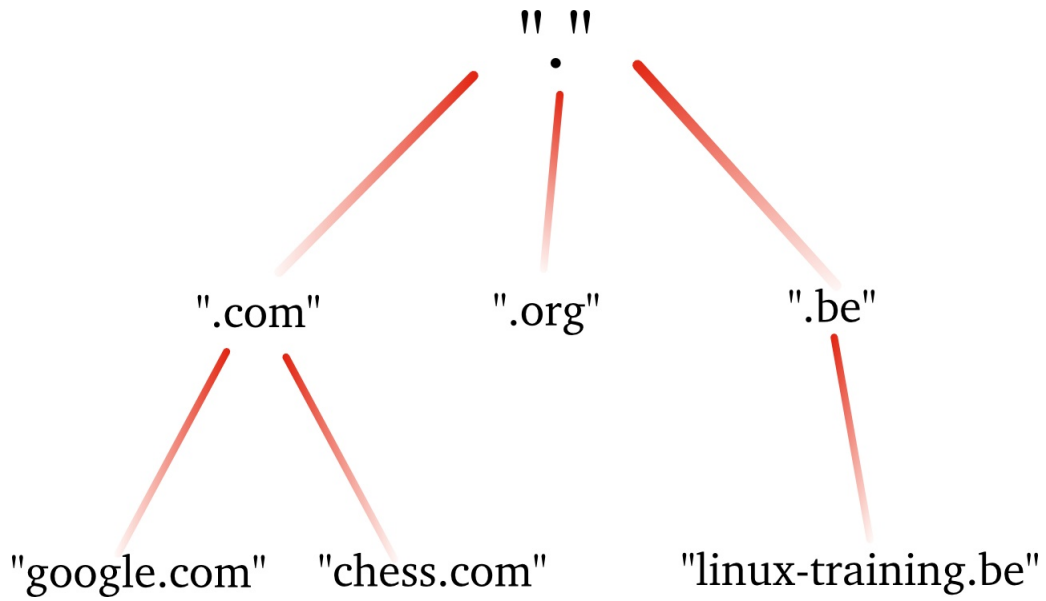


Figure 6.4.: This picture shows *dns domains* like google.com, chess.com, linux-training.be (there are millions more).

```
student@gwen:~$ hostname
gwen
student@gwen:~$ dnsdomainname
linux-training.be
student@gwen:~$ hostname --fqdn
gwen.linux-training.be
```

6.1.3.5. dns zones

A *zone* (aka a *zone of authority*) is a portion of the DNS tree that is covered 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 zero, one or more *dns zones*, which means that it is the source of truth for the mapping of names to IP addresses within that/those zone(s). We will see more details later on the relation between a *dns server* and a *dns zone*.

6.1.4. dns records

A *dns zone* is a collection of *records*, also called *resource records* (RRs). This section lists some of those *resource records*.

- 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 the specified ip address. An **AAAA record** is similar but contains an ipv6 address instead of ipv4.
- 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. This is called a *reverse lookup* or *reverse lookup query*
- A **NS record** or *nameserver record* is a record that points to an authoritative DNS name server (in this zone). You can list all your name servers for your DNS zone in distinct NS records.

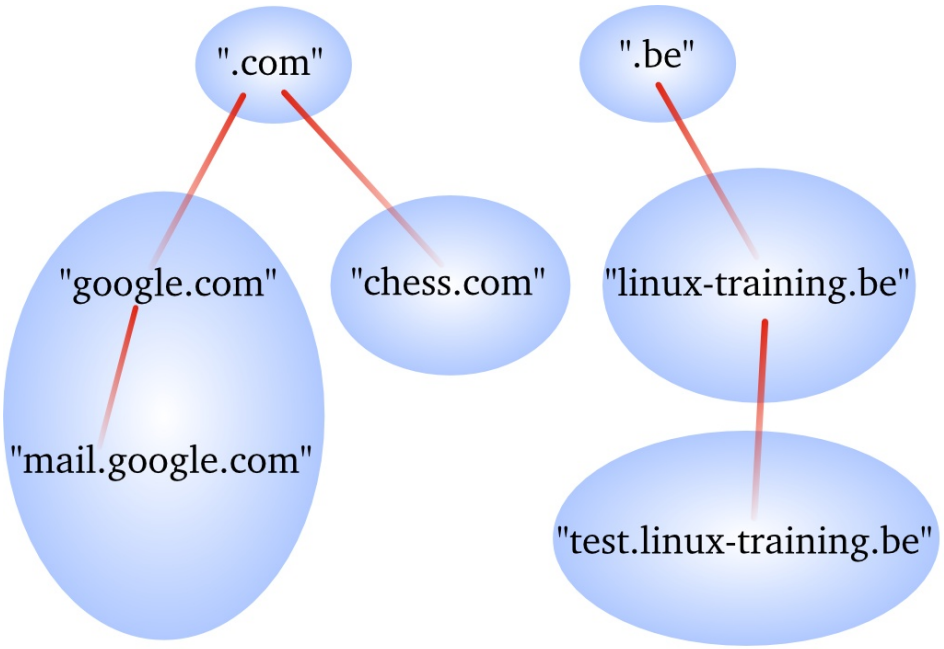


Figure 6.5.: DNS zones of authority.

- An *A record* that maps the name of an *NS record* to an ip address is said to be a **glue record**.
- The **SOA record** (*Start Of Authority*) 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 files. There is exactly one SOA record for each zone.
- 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*.
- 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 in order to deliver email to the recepient's mailbox.

6.2. DNS 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*.

We'll show in the following sections how to perform DNS queries with several command line tools.

This is what a reverse lookup looks like when sniffing with `tcpdump` (note the occurrecnes of PTR in the output):

```
student@linux:~$ sudo 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
11:01:29.357685 IP 192.168.1.103.42041 > 192.168.1.42.domain: 14763+ PT\
R? 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)
```

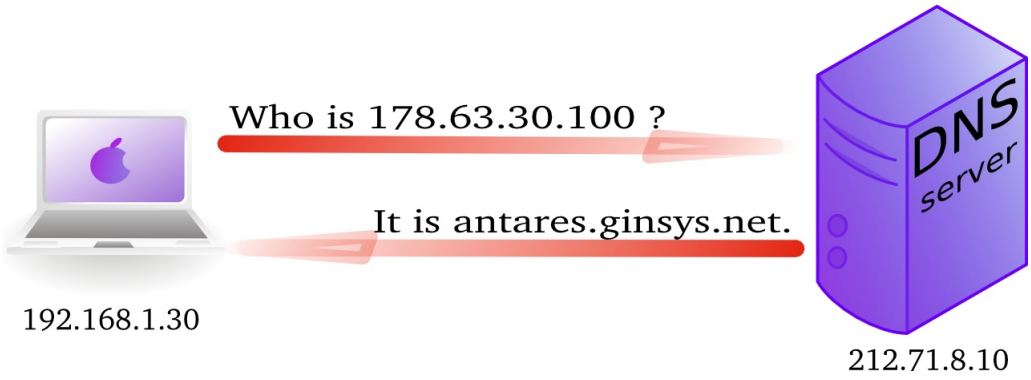


Figure 6.6.: Simplified depiction of a reverse DNS lookup query.

And here is what it looks like in `wireshark` (note this is an older screenshot).

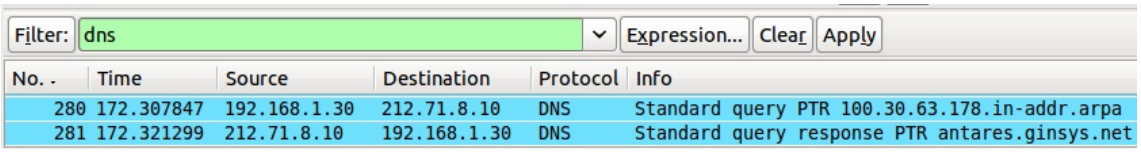


Figure 6.7.: Reverse lookup in Wireshark.

6.2.1. 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. Iterative queries usually take place between name servers, e.g. asking a root server for the authoritative name server of a top level domain. The root name servers do not respond to recursive queries.

6.3. interacting with DNS

There are several tools to interact with *DNS*. In this section, we'll discuss `host`, `nslookup`, `dig`, and `getent`.

The `ping` command could also be used to test whether DNS resolution is working, but it does additional things like sending ICMP echo requests. Therefore, we will avoid using it for the purpose of testing DNS.

On Enterprise Linux and derivatives, ensure the `bind-utils` package is installed in order to use `dig`, `host`, or `nslookup`. On Debian and derivatives, you'll need the `bind9-host` (for `host`) and `bind9-dnsutils` packages (for `dig` and `nslookup`).

When you're on a system that doesn't have these tools installed, and installing additional packages is not possible, `getent` can be used as a fallback, albeit with limited functionality. Getent is included in the `glibc` library, which is installed on all Linux systems (`glibc-common` on EL and `libc-bin` on Debian).

6.3.1. which DNS server is used?

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. See also the chapter on network configuration for more details.

The traditional location to keep this information on Linux systems is in the `/etc/resolv.conf` file.

```
student@linux:~$ cat /etc/resolv.conf
domain linux-training.be
search linux-training.be
nameserver 192.168.1.42
```

If the nameserver address points to 127.0.0.53, then the system is using *systemd-resolved* to resolve names. In this case, you can use the `resolvectl dns` command to see the current configuration, e.g.:

```
student@linux:~$ resolvectl dns
Global:
Link 2 (eth0): 10.0.2.3
Link 3 (eth1):
```

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.

```
student@linux:~$ sudo nano /etc/resolv.conf
[ ... edit the file ... ]
student@linux:~$ cat /etc/resolv.conf
nameserver 8.8.8.8
nameserver 8.8.4.4
```

If your system uses *systemd-resolved*, you should use the `resolvectl dns LINK SERVER` command to change the configuration.

```
student@linux:~$ resolvectl dns
Global:
Link 2 (eth0): 10.0.2.3
Link 3 (eth1):
vagrant@linux:~$ sudo resolvectl dns eth0 8.8.8.8
vagrant@linux:~$ resolvectl dns
Global:
Link 2 (eth0): 8.8.8.8
Link 3 (eth1):
```

Please note that on *dhcp clients* this configuration value can be overwritten when the *dhcp lease* is renewed. Permanent changes to the configuration are discussed in the chapter on network configuration.

6.3.2. getent ahosts

In case when you don't have `dig`, `host`, or `nslookup` available, and installing packages is not feasible, you can use `getent ahosts` to perform a DNS lookup. The `getent` command is used to get entries from the system databases (see the `getent(1)` man page), and `ahosts` is one of the databases it can query.

```
student@linux:~$ getent ahosts linux-training.be
188.40.26.208   STREAM linux-training.be
188.40.26.208   DGRAM
188.40.26.208   RAW
2a01:4f8:d0a:1044::2 STREAM
2a01:4f8:d0a:1044::2 DGRAM
2a01:4f8:d0a:1044::2 RAW
```

The command has no fancy options, but it can be used to perform a forward lookup to the default name server.

6.3.3. host

`host` is a simple utility for performing DNS lookups. It is normally used to convert names to IP addresses and vice versa.

```
student@linux:~$ host linux-training.be
linux-training.be has address 188.40.26.208
linux-training.be has IPv6 address 2a01:4f8:d0a:1044::2
linux-training.be mail is handled by 10 www115.your-server.de.
student@linux:~$ host linux-training.be 8.8.8.8
Using domain server:
Name: 8.8.8.8
Address: 8.8.8.8#53
Aliases:

linux-training.be has address 188.40.26.208
linux-training.be has IPv6 address 2a01:4f8:d0a:1044::2
linux-training.be mail is handled by 10 www115.your-server.de.
student@linux:~$ host 188.40.26.208
208.26.40.188.in-addr.arpa domain name pointer www115.your-server.de.
student@linux:~$ host 2a01:4f8:d0a:1044::2
2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.4.4.0.1.a.0.d.0.8.f.4.0.1.0.a.2.ip6.arpa domain name poin
server.de
```

The host command is quite limited in its functionality, `nslookup` and especially `dig` are much more useful to interact with DNS.

6.3.4. nslookup

Windows users are probably familiar with the `nslookup` command and will be happy to know that it is also available on Linux systems.

In the first example below, the default DNS server (mentioned in `/etc/resolv.conf` or by `resolvectl dns`) is queried.

```
student@linux:~$ nslookup linux-training.be
Server:         10.0.2.3
Address:        10.0.2.3#53

Non-authoritative answer:
Name:   linux-training.be
Address: 188.40.26.208
Name:   linux-training.be
Address: 2a01:4f8:d0a:1044::2
```

In the following example, we query a specific DNS server, in this case Google's public DNS server at 8.8.8.8. You will need this version of the command when you are troubleshooting issues with a DNS server you're configuring yourself (of course using its IP address instead of 8.8.8.8).

```
student@linux:~$ nslookup linux-training.be 8.8.8.8
Server:         8.8.8.8
Address:        8.8.8.8#53

Non-authoritative answer:
Name:   linux-training.be
Address: 188.40.26.208
Name:   linux-training.be
Address: 2a01:4f8:d0a:1044::2
```

Reverse lookups are also possible with `nslookup`.

```
student@linux:~$ nslookup 188.40.26.208
208.26.40.188.in-addr.arpa      name = www115.your-server.de.

Authoritative answers can be found from:

student@linux:~$ nslookup 2a01:4f8:d0a:1044::2
2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.4.4.0.1.a.0.d.0.8.f.4.0.1.0.a.2.ip6.arpa      name = www11
server.de.

Authoritative answers can be found from:
```

`nslookup` can also be used interactively:

```
nslookup
> server 8.8.8.8
Default server: 8.8.8.8
Address: 8.8.8.8#53
> linux-training.be
Server:         8.8.8.8
Address:        8.8.8.8#53

Non-authoritative answer:
Name:   linux-training.be
Address: 188.40.26.208
Name:   linux-training.be
Address: 2a01:4f8:d0a:1044::2
> set type=PTR
> 188.40.26.208
208.26.40.188.in-addr.arpa      name = www115.your-server.de.
```

```
Authoritative answers can be found from:
> 2a01:4f8:d0a:1044::2
Server:         8.8.8.8
Address:        8.8.8.8#53

Non-authoritative answer:
2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.4.4.0.1.a.0.d.0.8.f.4.0.1.0.a.2.ip6.arpa      name = www11
server.de.

Authoritative answers can be found from:
> set type=NS
> linux-training.be
Server:         8.8.8.8
Address:        8.8.8.8#53

Non-authoritative answer:
linux-training.be       nameserver = ns.second-ns.com.
linux-training.be       nameserver = ns1.your-server.de.
linux-training.be       nameserver = ns3.second-ns.de.

Authoritative answers can be found from:
> set type=MX
> linux-training.be
Server:         8.8.8.8
Address:        8.8.8.8#53

Non-authoritative answer:
linux-training.be       mail exchanger = 10 www115.your-server.de.

Authoritative answers can be found from:
> exit
```

6.3.5. dig

The `dig` command is a powerful tool for querying DNS servers. If you manage a DNS server, or need to troubleshoot DNS issues, it is a good idea to get familiar with `dig`, as it is much more versatile than `nslookup`.

```
student@linux:~$ dig linux-training.be
; <<>> DiG 9.18.18-0ubuntu0.22.04.1-Ubuntu <<>> linux-training.be
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 8729
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 65494
;; QUESTION SECTION:
;linux-training.be.             IN      A

;; ANSWER SECTION:
linux-training.be.      7200    IN      A       188.40.26.208

;; Query time: 44 msec
;; SERVER: 127.0.0.53#53(127.0.0.53) (UDP)
;; WHEN: Wed Mar 27 17:02:44 UTC 2024
;; MSG SIZE  rcvd: 62
```

The output of `dig` is quite verbose, but very informative, and follows the syntax of a BIND zone file (see below). The `;` character is used to indicate comments. In this example, it is indicated that there was one `QUERY` and one `ANSWER`. The `QUESTION SECTION` shows the query that was made, and the `ANSWER SECTION` shows the response. Sometimes, the `ADDITIONAL SECTION` contains glue records for the name servers that are authoritative for the queried domain. Finally, you also get information about the query time, the server that was queried, and the time the query was made.

The `+short` option can be used to get a more concise output.

```
student@linux:~$ dig +short linux-training.be
188.40.26.208
```

If you want to query a specific DNS server, you can specify it with the `@` symbol:

```
student@linux:~$ dig +short @1.1.1.1 linux-training.be
188.40.26.208
```

Another type of *Resource Record* can be specified by just mentioning the type in the query:

```
student@linux:~$ dig +short @1.1.1.1 AAAA linux-training.be
2a01:4f8:d0a:1044::2
student@linux:~$ dig +short NS hogent.be
ens1.hogent.be.
ns3.belnet.be.
ens2.hogent.be.
ns2.belnet.be.
ns1.belnet.be.
student@linux:~$ dig +short MX hogent.be
0 hogent-be.mail.protection.outlook.com.
```

A reverse lookup can be done with the -x option:

```
student@linux:~$ dig -x 188.40.26.208 +short
www115.your-server.de.
```

A useful query is the `ANY` query, which will return all records for a domain:

```
student@linux:~$ dig @ens1.hogent.be ANY hogent.be

; <<>> DiG 9.18.18-0ubuntu0.22.04.1-Ubuntu <<>> @ens1.hogent.be ANY hogent.be
; (2 servers found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 25886
;; flags: qr aa rd; QUERY: 1, ANSWER: 12, AUTHORITY: 0, ADDITIONAL: 5
;; WARNING: recursion requested but not available

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 1232
; COOKIE: 0d2f566a6341135d5ebd6167660452e7ffc6c1184db1c14a (good)
;; QUESTION SECTION:
;hogent.be.                     IN      ANY

;; ANSWER SECTION:
hogent.be.          3600    IN    SOA    ens1.hogent.be. hostmaster.hogent.be. 2024032506 43
```

```
hogent.be.              3600    IN      A       193.190.173.132
hogent.be.            3600    IN     TXT     "adobe-idp-site-verification= ... "
hogent.be.              3600    IN      TXT     "docusign= ... "
hogent.be.                  3600     IN        TXT      "v=spf1 a:spf-mail-
out.hogent.be include:spf.protection.outlook.com -all"
hogent.be.              3600    IN      TXT     "docusign= ... "
hogent.be.              3600    IN      NS      ens2.hogent.be.
hogent.be.              3600    IN      NS      ns1.belnet.be.
hogent.be.              3600    IN      NS      ns3.belnet.be.
hogent.be.              3600    IN      NS      ens1.hogent.be.
hogent.be.              3600    IN      NS      ns2.belnet.be.
hogent.be.                       3600       IN          MX          0  hogent-
be.mail.protection.outlook.com.

;; ADDITIONAL SECTION:
ens1.hogent.be.         3600    IN      A       193.190.172.1
ens2.hogent.be.         3600    IN      A       193.190.172.4
ens1.hogent.be.         3600    IN      AAAA    2001:6a8:1c60:d000::100
ens2.hogent.be.         3600    IN      AAAA    2001:6a8:1c60:d000::4

;; Query time: 24 msec
;; SERVER: 193.190.172.1#53(ens1.hogent.be) (TCP)
;; WHEN: Wed Mar 27 17:09:48 UTC 2024
;; MSG SIZE  rcvd: 674
```

You can request a zone transfer with the AXFR query type. Remark that this will usually not work for public DNS servers, as they are configured to deny zone transfers to the public. When you set up a primary and secondary nameserver yourself, the secondary nameserver will request a zone transfer from the primary nameserver.

The example below shows a zone transfer from `zonetransfer.me`, set up specifically for demonstration purposes. It contains examples for many different types of resource records. See https://zonetransfer.me/ for more information.

```
student@linux:~$ dig AXFR zonetransfer.me @nsztm1.digi.ninja

; <<>> DiG 9.18.18-0ubuntu0.22.04.1-Ubuntu <<>> AXFR zonetransfer.me @nsztm1.digi.ninja
;; global options: +cmd
zonetransfer.me.     7200   IN    SOA    nsztm1.digi.ninja. robin.digi.ninja. 2019100801 1
zonetransfer.me.        300     IN      HINFO   "Casio fx-700G" "Windows XP"

... more lines of output ...

zonetransfer.me.     7200   IN    SOA    nsztm1.digi.ninja. robin.digi.ninja. 2019100801 1
;; Query time: 24 msec
;; SERVER: 81.4.108.41#53(nsztm1.digi.ninja) (TCP)
;; WHEN: Wed Mar 27 17:16:22 UTC 2024
;; XFR size: 50 records (messages 1, bytes 2085)
```

If you don't specify an argument, `dig` will query the *dot domain* `.` and return a list with the names of the root DNS servers:

```
student@linux:~$ dig
; <<>> DiG 9.16.23-RH <<>>
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 25274
;; flags: qr rd ra ad; QUERY: 1, ANSWER: 13, AUTHORITY: 0, ADDITIONAL: 1
```

```
;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 512
;; QUESTION SECTION:
;.                  IN   NS

;; ANSWER SECTION:
.            20603   IN   NS   h.root-servers.net.
.            20603   IN   NS   b.root-servers.net.
.            20603   IN   NS   g.root-servers.net.
.            20603   IN   NS   l.root-servers.net.
.            20603   IN   NS   a.root-servers.net.
.            20603   IN   NS   k.root-servers.net.
.            20603   IN   NS   j.root-servers.net.
.            20603   IN   NS   e.root-servers.net.
.            20603   IN   NS   d.root-servers.net.
.            20603   IN   NS   i.root-servers.net.
.            20603   IN   NS   m.root-servers.net.
.            20603   IN   NS   c.root-servers.net.
.            20603   IN   NS   f.root-servers.net.

;; Query time: 19 msec
;; SERVER: 10.0.2.3#53(10.0.2.3)
;; WHEN: Wed Mar 27 21:23:11 UTC 2024
;; MSG SIZE  rcvd: 239
```

As mentioned before, each of the thirteen root servers has multiple instances located all over the world. You can ask a root name server to reveal its actual name that should contain an IATA three letter airport code.

```
student@linux:~$ dig +short +norec @f.root-servers.net hostname.bind chaos txt
"BRU.cf.f.root-servers.org"
```

6.4. practice: dns

Log in to a Linux system and try the following:

1. What's the IP address for the DNS server for this system? How did you find it? This may differ depending on your Linux distribution.
2. Try some DNS queries using `getent`, `host`, `nslookup` and `dig`. See how the output differs.
   - Try to resolve the IP address for `www.linux-training.be` or some well known websites.
   - Try reverse DNS lookups (PTR) and other types of queries (AAAA, MX, SOA, etc.).
3. Try to determine the authoritative DNS server for your Internet Service Provider, or for the DNS server of the organization you are affiliated with.
   - Try some forward (IPv4 and IPv6) and reverse DNS queries.
   - Try to find the mail server for this domain
   - The following exercise may yield different results depending whether you're inside the organization's network or not. Can you request a zone transfer? What happens? If you do get a zone transfer, what information do you get?
4. Go to https://www.dns.toys and try some of the tools there.
5. Go to https://digi.ninja/projects/zonetransferme.php and try the suggested exercises there.

6.5. solution: dns

TODO

7. the BIND DNS server

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Alex M. Schapelle, https://github.com/zero-pytagoras/, Bert Van Vreckem https://github.com/bertvv/)

In this module, we'll discuss how to set up ISC BIND, the most widely used implementation of DNS on a Linux system.

Learning goals:

- Install BIND
- Configure BIND as a caching or forwarding name server
- Configure BIND as an authoritative name server
- Configure BIND as a secondary name server

Further reading:

- Aitchison, Ron. *DNS for Rocket Scientists*. http://www.zytrax.com/books/dns/
- Mens, Jan-Piet. *Alternative DNS Servers*. UIT Cambridge, 2008.

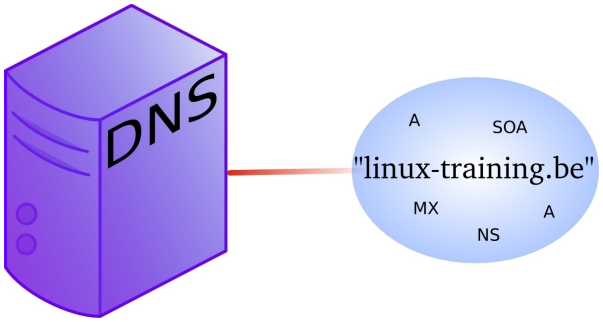
7.1. DNS server types

There are several types of DNS servers, each with its own purpose. The most common types are:

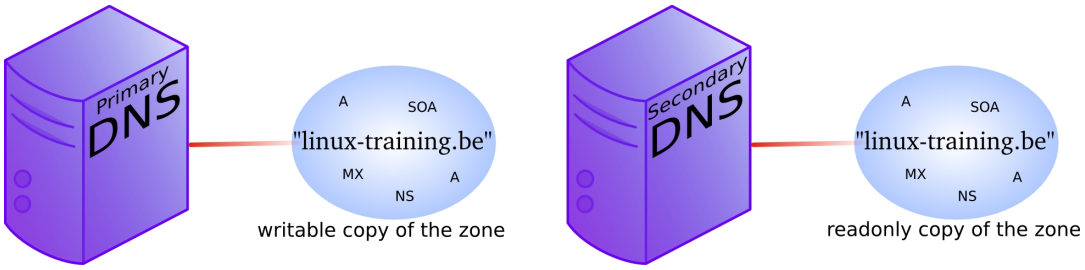
7.1.1. Authoritative name server

This type of server is the "source of truth" for a specific *DNS zone*. When a query is made for a record in the zone, the authoritative server returns the answer. **Authoritative** servers can be **primary** or **secondary**[1] **servers**. A *primary server* is the first authoritative DNS server for a domain, and it has a (human readable) *zone file* that contains all the resource records for the zone.

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. A *secondary server* replicates the zone data from the primary server through a *zone transfer* (and stores it in a binary format).



[1] The old nomenclature of *master* and *slave* servers is being phased out due to its negative connotations. The terms *primary* and *secondary* are now preferred.



7.1.2. Caching name server

This type of server is not authoritative, but passes on the query to another server and then caches responses to queries it receives.

When a query is made, the caching server first checks its cache to see if it has the answer. If it does, it returns the cached response. If not, it starts an **iterative query.** In an iterative query, the resolver will query a root server for the DNS server responsible for the top-level domain of the query. It will then query that server for the authoritative DNS server for the second-level domain, and so on, until it gets the answer to the original query. The caching server will cache the response to the original query for a certain amount of time (the *TTL* or *Time To Live* value of the record). Subsequent queries for the same record will be answered from the cache.

For example, a client queries for the A record on *www.linux-training.be* to its local server stored in `/etc/resolv.conf`. 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 send 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.

7.1.3. Forwarding name server

A **Forwarding name server** is not authoritative, but it forwards queries to other servers. The DNS server of a VirtualBox NAT interface is an example of a forwarding server that passes on queries of the VM to the DNS server of the physical machine.

7.1.4. Stealth name server

This type of server is hidden from the public and is used for internal purposes. It is not listed in the publicly visible NS records for a domain. **Stealth servers** are used for DNS resolution of network services for internal use and are not accessible from the internet.

For example, a company might have an intranet webserver with hostname `intranet.company.com` that is only accessible from within the company network. The RRs for this host would only be available from the internal stealth DNS server, but not from the public authoritative DNS server for `company.com`.

7.1.5. Split horizon server

This type of server provides different responses to queries based on the source of the query. For example, a **split horizon server** might return different IP addresses for a domain based on whether the query is coming from inside or outside the local network.

7.1.6. Best practices

A DNS server, depending on how it is configured, can have one or more properties from the above list. For example, a server can be both authoritative and caching, it can be caching and forwarding, or both primary and secondary (for different domains).

Some best practices for maintaining a DNS server in a production environment:

- *Don't configure your DNS server to support recursive queries for all clients*. This could lead to DDoS attacks. You can always limit the source IP addresses to trusted clients that are allowed to make recursive queries.
- *A secure DNS server should only perform a single function*. For example, a DNS server that is authoritative for a zone should not also be a caching server (this is called an **authoritative only server**). Unfortunately, this is not always feasible for smaller organizations and in practice, many DNS servers perform multiple functions.
- *A DNS server should be installed on a dedicated machine* because it is essential for the operation of a network. Combining a DNS server with other services on the same machine can lead to lower availability (if the services are under high load) or security issues (since it increases the attack surface).

7.1.7. 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*.

The default installation of BIND is a caching ony name server without a forwarder.

7.1.7.1. 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 determine the response through a series of *iterative queries* (as described earlier). 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 cas *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.

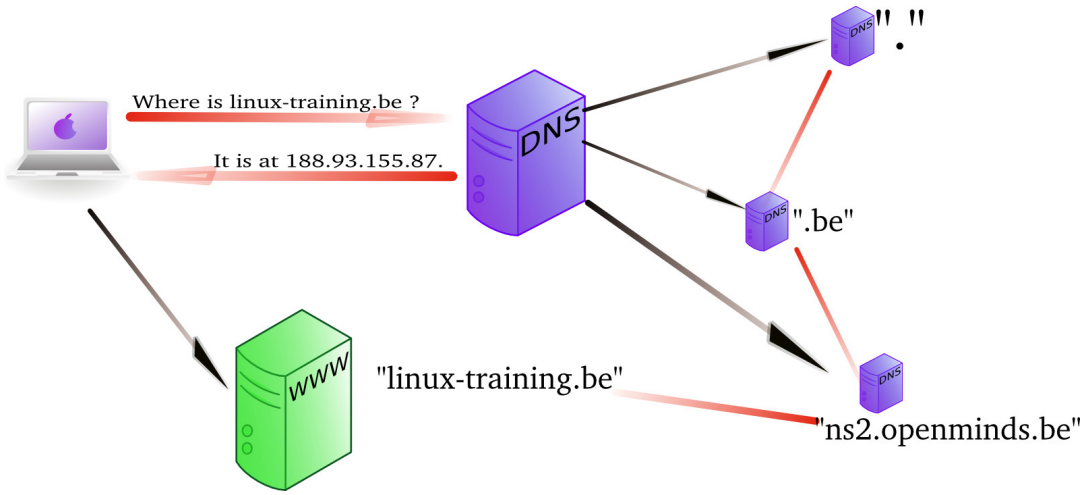


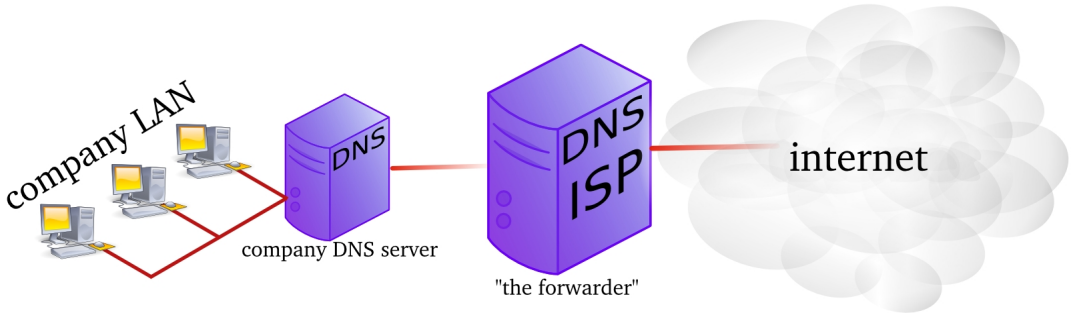
Figure 7.1.: Caching name server resolving *linux-training.be*.

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

```
192.168.1.103.41251 > M.ROOT-SERVERS.NET.domain: 37279% [1au] A? linux-tr\
aining.be. (46)
M.ROOT-SERVERS.NET.domain > 192.168.1.103.41251: 37279- 0/11/13 (740)
192.168.1.103.65268 > d.ns.dns.be.domain: 38555% [1au] A? linux-training.\
be. (46)
d.ns.dns.be.domain > 192.168.1.103.65268: 38555- 0/7/5 (737)
192.168.1.103.7514 > ns2.openminds.be.domain: 60888% [1au] A? linux-train\
ing.be. (46)
ns2.openminds.be.domain > 192.168.1.103.7514: 60888*- 1/0/1 A 188.93.155.\
87 (62)
```

7.1.7.2. 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*:

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

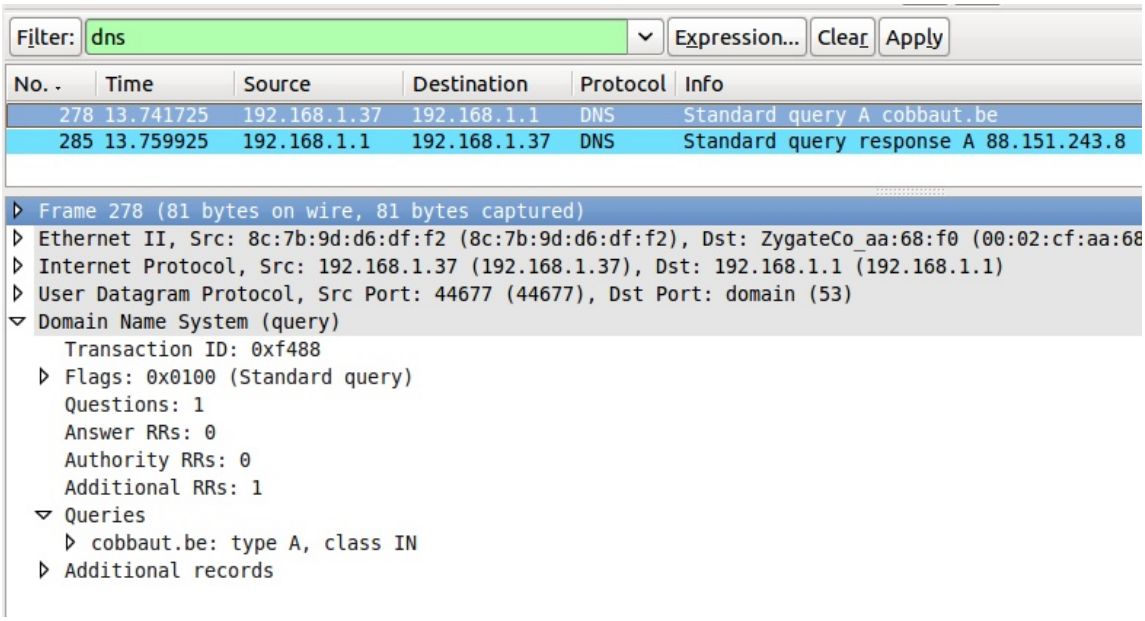


Figure 7.2.: Example of a forwarded DNS query, captured by Wireshark.

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

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

7.2. BIND installation

If you need to set up a DNS server, there are several open source solutions available. PowerDNS, MyDNS, MaraDNS, dnsmasq, Name Server Daemon (NSD), Unbound, etc. However, the most widely used DNS server on the internet is undoubtedly BIND (Berkeley Internet Name Domain). BIND is open source and maintained by the *Internet Systems Consortium* (ISC).

In this section, we'll discuss how to install and configure BIND on a Linux system.

7.2.1. installation on Debian

On **Debian-based systems**, install the `bind9` package:

```
student@debian:~$ sudo apt install bind9
```

The service will be started automatically after installation. You can check the status of the service with `systemctl status named`.

The main configuration files for BIND can be found in the `/etc/bind` directory and are named `named.conf*`. The `named.conf` file is the main configuration file for BIND, and it includes other configuration files. The `named.conf.options` file contains options that apply to the entire server, such as the listening interfaces and the forwarders. The `named.conf.local`

file contains the zone definitions for the server. The `named.conf.default-zones` file contains the *default zones* (e.g. the root, broadcast and localhost zones) that are included in the configuration.

Zone files are kept in the same directory and are named after the zone they represent. By default, you will find several files starting with `db.*` and `zones.rfc1918`.

7.2.2. installation on Enterprise Linux

On **Enterprise Linux**, install the `bind` package:

```
student@el:~$ sudo dnf install bind
```

The service will *not* be started automatically, so you will need to start it manually and enable it to start at boot:

```
student@el:~$ sudo systemctl enable --now named
```

For security, BIND configuration files and directories are only readable for the root user, so you will need to use `sudo` to view or edit them (or, optionally, become `root`). The main configuration file is `/etc/named.conf`, and the zone files are kept in the `/var/named` directory.

7.2.3. comparison between Debian and Enterprise Linux installation

Although BIND on EL and Debian are the same software, there are considerable differences in the way they are installed and configured. The config files are stored in a different location and are structured differently.

The main differences are:

	Debian	EL
Package name	`bind9`	`bind`
Service name	`named`	`named`
Configuration directory	`/etc/bind`	`/etc`, `/etc/named`
Main config file	`/etc/bind/named.conf`	`/etc/named.conf`
Server options	`/etc/bind/named.conf.options`	`/etc/named.conf`
Default zone definitions	`/etc/bind/named.conf.default-zones`	`/etc/named.conf`
Zone files directory	`/etc/bind`	`/var/named`
Root hints file	`/usr/share/dns/root.hints`	`/var/named/named.ca`
Default zone files	`/etc/bind/db.*`, `/etc/bind/zones.rfc1918`	`/var/named/named.*`

7.2.4. troubleshooting commands

Before we start configuring BIND, we'll first introduce some useful commands to observe how BIND works, that can be used for troubleshooting configuration issues. We'll show the commands on an EL system, but they work on Debian as well.

Checking the status of the BIND service:

```
[student@el ~]$ systemctl status named
● named.service - Berkeley Internet Name Domain (DNS)
    Loaded: loaded (/usr/lib/systemd/system/named.service; enabled; preset: disabled)
     Active: active (running) since Sat 2024-06-15 19:44:21 UTC; 3min 32s ago
   Process: 4812 ExecStartPre=/bin/bash -c if [ ! "$DISABLE_ZONE_CHECKING" == "yes" ]; then /
checkconf -z "$NAMEDCONF"; else echo "Checking of zone files is disabled"; fi (c>
   Process: 4815 ExecStart=/usr/sbin/named -u named -c ${NAMEDCONF} $OPTIONS (code=exited, s
   Main PID: 4816 (named)
      Tasks: 10 (limit: 11128)
     Memory: 25.2M
        CPU: 44ms
     CGroup: /system.slice/named.service
             └─4816 /usr/sbin/named -u named -c /etc/named.conf
```

Checking interfaces and network ports that BIND is listening on:

```
[student@el ~]$ sudo ss -tlnp | grep named
State   Recv-Q  Send-Q  Local Address:Port  Peer Address:Port  Process
LISTEN  0     10       127.0.0.1:53      0.0.0.0:*    users:(("named",pid=4816,fd=34))
LISTEN  0     10       127.0.0.1:53      0.0.0.0:*    users:(("named",pid=4816,fd=35))
LISTEN  0     4096      127.0.0.1:953     0.0.0.0:*    users:(("named",pid=4816,fd=31))
LISTEN  0     4096        [::1]:953       [::]:*    users:(("named",pid=4816,fd=42))
LISTEN  0     10          [::1]:53        [::]:*    users:(("named",pid=4816,fd=41))
LISTEN  0     10          [::1]:53        [::]:*    users:(("named",pid=4816,fd=40))
```

So immediately after installation, BIND is only listening on the loopback interface, on port 53 for DNS queries and on port 953 for `rndc` commands. Both IPv4 and IPv6, TCP and UDP are supported. UDP is typically used for simple DNS queries, while TCP is used for zone transfers and large responses.

Checking whether the configuration file is correct:

```
[student@el ~]$ sudo named-checkconf
```

If the syntax of the main configuration file is correct, the command will return without any output and exit status 0. If there are errors, they will be displayed on the screen and the process will exit with a non-zero exit status.

Checking the syntax of a zone file is done with `named-checkzone <zone> <zonefile>`. Later, we'll create our own zone files, but the following command can be run on a basic installation, and checks the root hints file. On Debian, you'll need to change the path to the root hints file.

```
[student@el ~]$ sudo named-checkzone . /var/named/named.ca
zone ./IN: has 0 SOA records
zone ./IN: not loaded due to errors.
```

You should check the syntax of the configuration and zone files after each change to ensure that the server will (re)start correctly.

Checking the logs of the BIND server with `journalctl`:

```
[student@el ~]$ sudo journalctl -u named.service
... output omitted ...
```

When troubleshooting a BIND server, it's useful to keep the logs open in a separate terminal. Add the `-f` option to the `journalctl` command to follow the logs in real-time and `-l` to wrap long lines:

```
[student@el ~]$ sudo journalctl -flu named.service
... output omitted ...
```

Finally, you can enable and disable logging of queries with `rndc`:

```
[student@el ~]$ sudo rndc querylog on
[student@el ~]$ sudo rndc querylog off
```

The command doesn't return any output, but you'll find the result in the logs. If you don't add the option `on` or `off`, the current status will be toggled.

7.3. main BIND configuration file

The main BIND configuration file `named.conf` usually consists of several sections. The most important sections are:

- `options`: configure interfaces, recursion, DNSSEC, etc.
- `logging`: configure logging
- `zone`: define zones
- include other configuration files

In the sections below, we show how to change basic configuration options for a BIND server. Remark that this is not a comprehensive guide to BIND configuration. BIND is a very powerful and flexible DNS server, and there are many more options available. For a more elaborate explanation, check e.g. DNS for Rocket Scientists or the BIND documentation.

7.3.1. control who can query the server

In a default installation, BIND can not be queried by other hosts, even though it is running. In order to make the service available over the network, you need to configure the *network interfaces* that BIND listens on, and determine which hosts are allowed to query the server.

To configure the interfaces that BIND listens on, you can use the `listen-on` directive. By default, BIND listens only on the loopback interface. Change this to the IP address(es) of the interface(s) you want BIND to listen on, or `any` to listen on all interfaces. Each IP address should be terminated with a semicolon.

The default configuration in the `options` section may look like:

```
    listen-on port 53 { 127.0.0.1; };
    listen-on-v6 port 53 { ::1; };
```

Change this to e.g.:

```
    listen-on port 53 { any; };
    listen-on-v6 port 53 { any; };
```

The hosts that can send queries to the server are configured with the `allow-query` directive. By default, BIND only allows queries from localhost. To allow queries from any host, change the directive to:

```
    allow-query { any; };
```

You can also specify a range of IP addresses (e.g. 192.168.56/24), a single IP address, special keywords like `localhost`, `localnets`, `any`, or a semicolon-separated list of these.

After making the change, check the syntax of the configuration file and restart the service:

```
[student@el ~]$ sudo named-checkconf
[student@el ~]$ sudo systemctl restart named
```

7.3.2. recursion

Whether your name server is allowed to perform recursive queries depends on the `recursion` directive in the `options` section.

```
    recursion yes;
```

If you set up an authoritative server, you should disable recursion:

```
    recursion no;
```

If recursion is allowed, it's best to limit this ability to specific clients. This is done with the `allow-recursion-on` and `allow-recursion` directives. The former specifies the network interfaces and the latter the clients that are allowed to perform recursive queries. Two examples:

```
    allow-recursion-on { any; };
    allow-recursion { localnets; };

    allow-recursion-on { eth1; };
    allow-recursion { 192.168.56/24; };
```

7.3.3. forwarders

If you want to configure a forwarder, set the `forward` and `forwarders` directives in the `options` section. The `forward` directive can be `only` (denoting it can only forward queries) or `first` (denoting it will try to resolve the query itself if the forwarder did not respond). The `forwarders` directive specifies the IP addresses of the forwarders. An example with the public Cloudflare DNS servers as forwarders:

```
    forward only;
    forwarders {
        1.1.1.1; 1.0.0.1;
        2606:4700:4700::1111; 2606:4700:4700::1001;
    };
```

7.4. DNS zones

In this section, we'll set up our DNS server to be authoritative for domain `example.com`. We'll create a *forward lookup zone* and a *reverse lookup zone*.

The forward lookup zone will typically contain A, AAAA, CNAME, MX, NS, and SOA records. The reverse lookup zone will contain PTR and SOA records.

A few zone files are already included in the default installation, a.o. the zone file for the *root zone* (see next section), and for the *local domain* (not discussed in this book).

7.4.1. the root hints file

The *root hints file* is a file that contains the addresses of the root servers of the internet. It is used by the DNS server to initiate recursive queries. The file is added during installation, but could -if necessary- be reproduced using the `dig` command. If you call `dig` without arguments, it will query the *dot*, `.` domain, i.e. the root servers. If you send this query to one of the root servers, you will additionally get the glue (A and AAAA) records for each root server:

```
[student@linux ~]$ dig @f.root-servers.net

; <<>> DiG 9.16.23-RH <<>> @f.root-servers.net
; (2 servers found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 6028
;; flags: qr aa rd; QUERY: 1, ANSWER: 13, AUTHORITY: 0, ADDITIONAL: 27
;; WARNING: recursion requested but not available

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 1472
;; QUESTION SECTION:
;.                              IN  NS

;; ANSWER SECTION:
.                       518400  IN  NS    i.root-servers.net.

[ ... more lines of output ... ]

.                       518400  IN  NS    m.root-servers.net.

;; ADDITIONAL SECTION:
i.root-servers.net.  518400  IN  A  192.36.148.17
i.root-servers.net.   518400  IN  AAAA  2001:7fe::53

[ ... more lines of output ... ]

m.root-servers.net.   518400  IN  A     202.12.27.33
m.root-servers.net.   518400  IN  AAAA  2001:dc3::35

;; Query time: 18 msec
;; SERVER: 192.5.5.241#53(192.5.5.241)
;; WHEN: Wed Mar 27 21:25:40 UTC 2024
;; MSG SIZE  rcvd: 811
```

This is exactly the information stored in the root hints file.

7.4.2. forward lookup zone

In order to set up a forward lookup zone, you first need to create a zone file, and then add a zone definition to the main configuration file.

Let's say we want to set up a forward lookup zone for the domain `example.com`. The zone file will have the same name as the zone (`example.com`) and will be stored in the `/var/named` directory (`/etc/bind` on Debian). We want to keep track of the following host names:

Host	Alias	IP	Function
ns1		192.0.2.1	Primary name server
ns2		192.0.2.2	Secondary name server
srv001	www	192.0.2.10	Web server
srv002	mail	192.0.2.20	Mail server

Additionally, we want that `https://example.com/` will also point to the web server.

A zone file for this domain could look like this:

```
;; Zone file for example.com
$ORIGIN example.com.
$TTL 1W

@ IN SOA ns1.example.com. hostmaster.example.com. (
         24061601  ; Serial
         1D        ; Refresh time
         1H        ; Retry time
         1W        ; Expiry time
         1D )      ; Negative cache TTL

; Name servers

       IN  NS     ns1
       IN  NS     ns2

; Mail server

       IN  MX     10 srv002

; Hosts

ns1    IN  A      192.0.2.1
ns2    IN  A      192.0.2.2

srv001 IN  A      192.0.2.10
@      IN  A      192.0.2.10
www    IN  CNAME  srv001

srv002 IN  A      192.0.2.20
smtp   IN  CNAME  srv002
imap   IN  CNAME  srv002
```

The `$ORIGIN` directive on line 1 sets the default domain name for the zone. Fully qualified domain names *must always* end with a dot. Names names *that do not end with a dot* are considered to be relative to this domain, and the value of `$ORIGIN` will be added. E.g. `ns1` will be interpreted as `ns1.example.com.` in this zone file. This is actually a common source of errors in zone files!

The `$TTL` directive on line 2 sets the default *time-to-live* value for the records in the zone. It determines how long a record can be cached by a resolver before it expires. The value `1W` stands for one week.

Line 4 and 5 define the *Start of Authority* record. The `@` symbol is a shorthand for the zone name (`example.com.`). The `IN` keyword stands for *Internet* and is the class of the record. The `SOA` record contains information about the zone:

- `ns.example.com.` is the primary name server for the zone.

- `hostmaster.example.com.` is the email address of the person responsible for the zone (to be interpreted as `hostmaster@example.com`, but the `@` is replaced with a dot because of the special meaning of the `@` symbol in the zone file).
- `24061601` is a serial number that is chosen by the system administrator. It is an integer, but commonly it contains an encoded timestamp, e.g. `YYMMDDHH`. The serial number is used to determine whether a zone transfer is necessary. If the serial number of the primary server is higher than the serial number of the secondary server, a zone transfer will occur. That means that you need to increment the serial number every time you make a change to the zone file.
- `1D` (one day) is the refresh time. It is the time that a secondary server waits before checking if the serial number of the primary server has changed. If it has, it requests a zone transfer.
- `1H` (one hour) is the retry time. It is the time that a secondary server waits before retrying a zone transfer if the previous attempt failed.
- `1W` (one week) is the expiry time. It is the time that a secondary server will keep the zone data if it can't contact the primary server. After this time has elapsed, the secondary server will stop answering queries for the zone.
- `1D` determines how long a NAME ERROR result can be cached.

The `NS` records on line 7 and 8 define the name servers for the zone, i.e. `ns1` and `ns2`.

On line 10, the `MX` record defines the mail server for the domain, i.e. `srv002`.

The `A` records on the following lines define the IP addresses of each host. The first "column" is the (unqualified) hostname and the last is the IP address. Remark that, because the names do not end with a dot, the value of `$ORIGIN` is appended to the names. The record on line 16 with the `@` symbol ensures that an A query for `example.com` points to the web server.

The `CNAME` records, finally, define aliases for the hosts. The `www` alias points to the web server `srv001`, and the `smtp` and `imap` aliases point to the mail server `srv002`

Save the file and test the syntax:

```
[student@el ~]$ sudo vi /var/named/example.com
... edit the file ...
[student@el ~]$ sudo named-checkzone example.com /var/named/example.com
zone example.com/IN: loaded serial 24061601
OK
```

Next, add a zone definition to the main configuration file. The zone definition could look like this:

```
zone "example.com" IN {
  type primary;
  file "example.com";
};
```

The first line defines the domain name of the zone. The `IN` keyword stands for *Internet* and is the class of the zone.

The `type` of this zone is `primary`, meaning that this server is the primary authoritative server for the zone.

The `file` directive specifies the location of the zone file, relative to the directory specified in the `directory` directive in the `options` section (`/var/named` on EL).

Check the syntax, restart the service and test:

```
[student@el ~]$ sudo named-checkconf
[student@el ~]$ sudo systemctl restart named
[student@el ~]$ dig @localhost example.com +short
192.0.2.10
```

Try to query the SOA record from the zone. This is a rare case where `nslookup` gives more information (specifically, the names of the timer fields) than `dig`:

```
[vagrant@el ~]$ dig @localhost SOA example.com +short
ns.example.com. hostmaster.example.com. 24061601 86400 3600 604800 86400
[vagrant@el ~]$ nslookup
> server localhost
Default server: localhost
Address: ::1#53
Default server: localhost
Address: 127.0.0.1#53
> set type=SOA
> example.com
Server:         localhost
Address:        ::1#53

example.com
        origin = ns.example.com
        mail addr = hostmaster.example.com
        serial = 24061601
        refresh = 86400
        retry = 3600
        expire = 604800
        minimum = 86400
```

7.4.3. reverse lookup zone

The example in the previous section is not sufficient to allow the DNS server to respond to *reverse lookup* queries, where the client provides the IP address and wants to know the associated host name. These are specified in a *reverse lookup zone*.

Some domains have IP addresses over several IP subnets. In this case, you will need to create a separate reverse lookup zone for each subnet!

The name of a reverse lookup zone has a special format. For the `example.com` domain, we used the 192.0.2.0/24 IP range. The reverse lookup zone name is constructed as follows:

- Start with the IP addres for the address range: 192.0.2.0/24
- Drop the host part, so only the network part remains: 192.0.2
- Reverse the order of the octets: 2.0.192
- Append `.in-addr.arpa.`: **2.0.192.in-addr.arpa.**

The zone file for this reverse lookup zone could look like this:

```
;; Zone file for reverse lookup zone 2.0.192.in-addr.arpa.
$ORIGIN 2.0.192.in-addr.arpa.
$TTL 1W

@ IN SOA ns1.example.com. hostmaster.example.com. (
         24061601  ; Serial
         1D        ; Refresh time
         1H        ; Retry time
         1W        ; Expiry time
         1D )      ; Negative cache TTL

; Name servers

       IN  NS     ns1.example.com.
```

```
       IN  NS     ns2.example.com.

; Reverse lookup records

1    IN  PTR    ns1.example.com.
2    IN  PTR    ns2.example.com.
10   IN  PTR    srv001.example.com.
20   IN  PTR    srv002.example.com.
```

In this file, we find the SOA record like in the forward lookup zone file. Next, the `NS` records define the name servers for the zone. Finally, the PTR records map an IP address to a host name.

Remark that for the IP addresses, we only need to specify the host part, in this case the last octet. The network part is already defined in the zone name.

Also remark that all host names are fully qualified and end with a dot. If we would only have specified the host name (e.g. `srv001`), the value of `$ORIGIN` would have been appended, resulting in the nonsensical `srv001.2.0.192.in-addr.arpa.`, which is not what we want!

Saving the zone definition to the appropriate file, and check its syntax:

```
[student@el ~]$ sudo vi /var/named/2.0.192.in-addr.arpa
... edit the file ...
[student@el ~]$ sudo named-checkzone 2.0.192.in-addr.arpa /var/named/2.0.192.in-
addr.arpa
zone 2.0.192.in-addr.arpa/IN: loaded serial 24061601
OK
```

Next, we add a zone definition to the main configuration file. The zone definition could look like this:

```
zone "2.0.192.in-addr.arpa" IN {
  type master;
  file "2.0.192.in-addr.arpa";
};
```

At this time, you set up a DNS server that is authoritative for the `example.com` domain, and can respond to forward and reverse lookup queries. If you want to follow best practices, turn off recursion and any forwarders that you might have set up previously.

After adding this section to the main configuration file, check the syntax, restart the service and test:

```
[student@el ~]$ sudo named-checkconf
[student@el ~]$ sudo systemctl restart named
[student@el ~]$ dig @localhost -x 192.0.2.10 +short
srv001.example.com.
```

7.5. secondary server and zone transfer

In this section, we'll set up a secondary server for the `example.com` domain. The secondary server will replicate the zone data from the primary server through a *zone transfer*.

Depending on expected network traffic and server load, a system administrator may want to set up multiple secondary name servers. Usually, the primary server sends notifications to all

Figure 7.3.: Zone transfer from a primary to a secondary name server

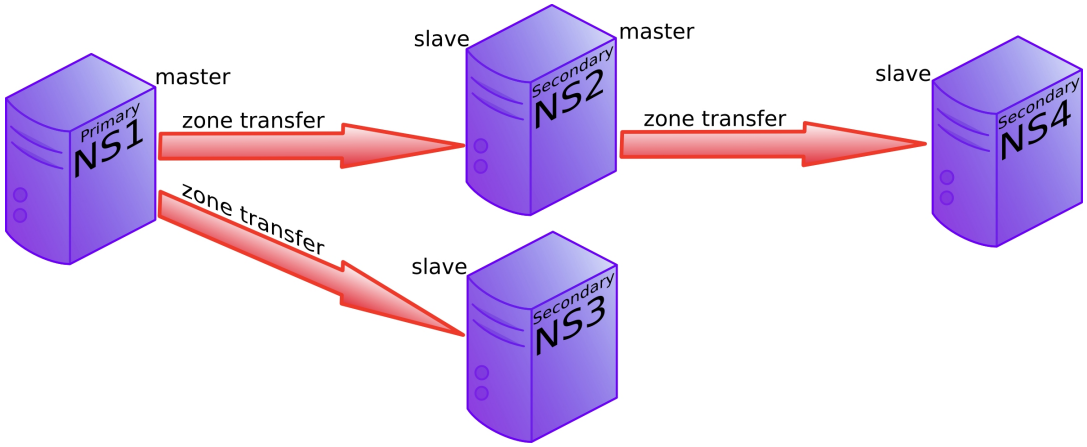


Figure 7.4.: More elaborate setup of primary and secondary name servers. `ns1` notifies `ns2` and `ns3`, but `ns4` is notified by `ns2`.

secondary servers, but sometimes a secondary server can be the primary server for another secondary server.

Zone transfers are requested by the secondary servers at regular intervals. Those intervals are defined in the *SOA record*.

- Set up a new VM (we'll give it host name `el2`), install BIND and start the service, as shown above.
- Ensure the service is listening on all network interfaces and is available for other hosts on the network. Ensure recursion is turned off.

```
[student@el2 ~]$ sudo dnf install -y bind
... output omitted ...
[student@el2 ~]$ sudo systemctl enable --now named
Created symlink /etc/systemd/system/multi-user.target.wants/named.service → /usr/lib/syste
[student@el2 ~]$ sudo vi /etc/named.conf
... edit the file ...
[student@el2 ~]$ sudo named-checkconf
[student@el2 ~]$ sudo systemctl restart named
```

Before we can set up `el2` as a secondary server, we need to allow zone transfers from the primary server. This is done with the `allow-transfer` directive in the zone definition. Add the IP address of the secondary server to the list of allowed hosts:

```
// Zone definitions on theprimary server

zone "example.com" IN {
  type primary;
```

```
  file "example.com";
  notify yes;
  allow-transfer { 192.168.56.111; };
};

zone "2.0.192.in-addr.arpa" IN {
  type primary;
  file "2.0.192.in-addr.arpa";
  notify yes;
  allow-transfer { 192.168.56.111; };
};
```

The `notify` directive tells the server to notify the secondary servers when the zone has changed (or, rather, when the zone's serial has increased).

The `allow-update` directive specifies which hosts are allowed to update the zone.

Remark that the IP address here is the one given to the VM `el2`. It does not correspond with the IP addresses in the zone file, but that is actually not necessary.

Save the file (on the primary server), check the syntax, and restart the service. Ensure query logging is turned on so you can observe the zone transfer in the logs. Follow the logs in real time:

```
[vagrant@el ~]$ sudo vi /etc/named.conf
[vagrant@el ~]$ sudo named-checkconf
[vagrant@el ~]$ sudo systemctl restart named
[vagrant@el ~]$ sudo rndc querylog on
[vagrant@el ~]$ sudo journalctl -flu named
```

Next, set up the secondary server:

```
// Zone definitions on the secondary server

zone "example.com" IN {
    type secondary;
    primaries { 192.168.56.11; };
    file "slaves/example.com";
};

zone "2.0.192.in-addr.arpa" IN {
    type secondary;
    primaries { 192.168.56.11; };
    file "slaves/2.0.192.in-addr.arpa";
};
```

Add these zone definitions for the forward and reverse lookup zones to the main configuration file. Change the IP address to the one of your primary server, if it differs. The secondary server will store the zone database in a file in binary format. On EL, the appropriate directory for these zone files is `/var/named/slaves`, on Debian it is `/var/cache/named`.

Check the syntax and restart. Observe the zone transfer in the primary server logs! Or, additionaly, you can set up a network sniffer to capture the zone transfer.

```
[student@el2 ~]$ sudo vi /etc/named.conf
[student@el2 ~]$ sudo named-checkconf
[student@el2 ~]$ sudo systemctl restart named
[student@el2 ~]$ dig @localhost example.com +short
192.0.2.10
```

The logs on the primary server should show something like this (for clarity, timestamps and other redundent information was removed):

```
query: 2.0.192.in-addr.arpa IN SOA -E(0) (192.168.56.11)
query: 2.0.192.in-addr.arpa IN AXFR -T (192.168.56.11)
transfer of '2.0.192.in-addr.arpa/IN': AXFR started (serial 24061601)
transfer of '2.0.192.in-addr.arpa/IN': AXFR ended: 1 messages, 8 records, 248 bytes, 0.001 s
query: example.com IN SOA -E(0) (192.168.56.11)
query: example.com IN AXFR -T (192.168.56.11)
transfer of 'example.com/IN': AXFR started (serial 24061601)
transfer of 'example.com/IN': AXFR ended: 1 messages, 13 records, 317 bytes, 0.001 secs (317
```

	Time	Source	Destination	Protocol	Info
1	0.000000	192.168.1.37	192.168.1.35	DNS	Standard query SOA cobbaut.paul
2	0.008502	192.168.1.35	192.168.1.37	DNS	Standard query response SOA ns.cobbaut.paul
3	0.014672	192.168.1.37	192.168.1.35	TCP	33713 > domain [SYN] Seq=0 Win=5840 Len=0 MS
4	0.015215	192.168.1.35	192.168.1.37	TCP	domain > 33713 [SYN, ACK] Seq=0 Ack=1 Win=57
5	0.015307	192.168.1.37	192.168.1.35	TCP	33713 > domain [ACK] Seq=1 Ack=1 Win=5856 Le
6	0.015954	192.168.1.37	192.168.1.35	TCP	[TCP segment of a reassembled PDU]
7	0.018359	192.168.1.35	192.168.1.37	TCP	domain > 33713 [ACK] Seq=1 Ack=3 Win=5792 Le
8	0.018411	192.168.1.37	192.168.1.35	DNS	Standard query IXFR cobbaut.paul
9	0.018823	192.168.1.35	192.168.1.37	TCP	domain > 33713 [ACK] Seq=1 Ack=77 Win=5792 L
10	0.019784	192.168.1.35	192.168.1.37	DNS	Standard query response SOA ns.cobbaut.paul
11	0.019821	192.168.1.37	192.168.1.35	TCP	33713 > domain [ACK] Seq=77 Ack=295 Win=6912
12	0.020618	192.168.1.37	192.168.1.35	TCP	33713 > domain [FIN, ACK] Seq=77 Ack=295 Win
13	0.021011	192.168.1.35	192.168.1.37	TCP	domain > 33713 [FIN, ACK] Seq=295 Ack=78 Win
14	0.021040	192.168.1.37	192.168.1.35	TCP	33713 > domain [ACK] Seq=78 Ack=296 Win=6912

Figure 7.5.: A zone transfer captured by Wireshark.

The transfer was performed using an AXFR query, requesting a *full zone transfer*. You can run this query yourself from the command line on the secondary server:

```
[student@el2 ~]$ dig @192.168.56.11 AXFR example.com

; <<>> DiG 9.16.23-RH <<>> @192.168.56.11 AXFR example.com
; (1 server found)
;; global options: +cmd
example.com.        604800  IN    SOA    ns.example.com. hostmaster.example.com. 24061601 8
example.com.            604800  IN      A       192.0.2.10
example.com.            604800  IN      NS      ns1.example.com.
example.com.            604800  IN      NS      ns2.example.com.
example.com.            604800  IN      MX      10 srv002.example.com.
imap.example.com.       604800  IN      CNAME   srv002.example.com.
ns1.example.com.        604800  IN      A       192.0.2.1
ns2.example.com.        604800  IN      A       192.0.2.2
smtp.example.com.       604800  IN      CNAME   srv002.example.com.
srv001.example.com.     604800  IN      A       192.0.2.10
srv002.example.com.     604800  IN      A       192.0.2.20
www.example.com.        604800  IN      CNAME   srv001.example.com.
example.com.        604800  IN    SOA    ns.example.com. hostmaster.example.com. 24061601 8
;; Query time: 2 msec
;; SERVER: 192.168.56.11#53(192.168.56.11)
;; WHEN: Sun Jun 16 09:21:32 UTC 2024
;; XFR size: 13 records (messages 1, bytes 356)
```

This returns all the records in the zone file for the `example.com` domain. We hope that this also illustrates the security risk of allowing zone transfers to any host! The AXFR query is quite

useful for an attacker who is trying to enumerate all the hosts in a domain. So be careful with this and only allow zone transfers to secondary name servers.

You can also force a refresh from a zone with `rndc`. The example below forces a transfer of the `example.com` zone:

```
[student@el2 ~]$ sudo rndc retransfer example.com
```

There also exists an *incremental zone transfer* (IXFR), which only transfers the changes since the last transfer. The decision on which of the two (AXFR/IXFR) depends on the size of the transfer that is needed to completely update the zone on the secondary server. An incremental zone transfer is prefered when the total size of changes is smaller than the size of the zone database.

7.6. practice: BIND

Use Vagrant and VirtualBox to set up the following scenario for DNS domain `linuxtrn.lan` with IP range 172.16.76.0/24. The scenario is illustrated in the following diagram:

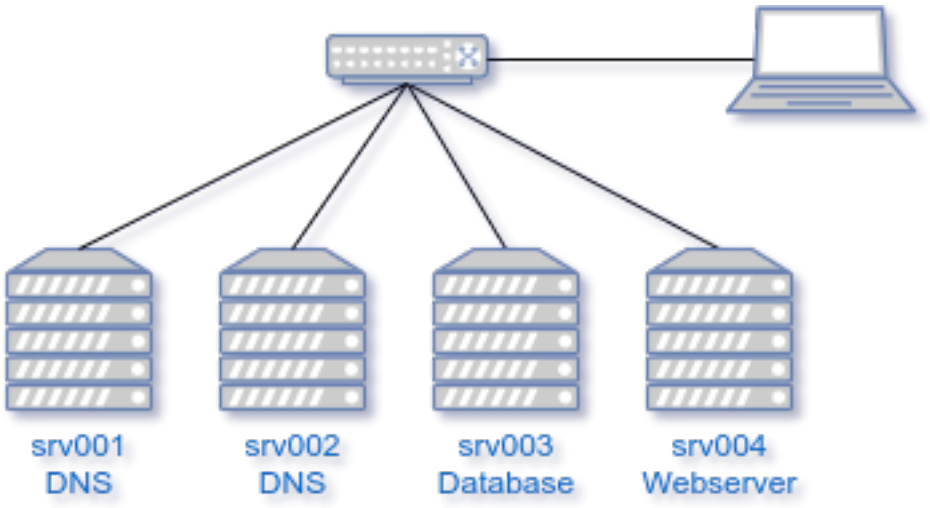


Figure 7.6.: BIND practice lab

Four VMs are attached to a common Host-Only or Internal network. The properties of the VMs are summarized in the following table:

Host	Alias	IP	Role
`srv001`	`ns1`	`172.16.76.251`	Primary DNS server
`srv002`	`ns2`	`172.16.76.252`	Secondary DNS server
`srv003`	`smtp`, `imap`	`172.16.76.3`	Mail server
`srv004`	`www`	`172.16.76.4`	Webserver

If you used a Host-Only network, the host machine can play the role of a client. In the case of an internal network, add another VM (e.g. a ready-made Linux Mint or Kali Linux VM) to the network as a client. In this scenario, routing is not considered. The VMs will have internet access through their NAT interfaces.

Remark that the VMS `srv003` and `srv004` should not necessarily exist in order to make te setup work. It could add to the realism of the scenario, though, since you can check whether entering `https://www.linuxtrn.lan` in a browser on a client will work.

1. Set up `srv001` (Debian or EL-based) and install BIND.

   - Discover the default configuration files. Can you define the purpose of each file?
   - Turn on the query log and start `tcpdump` to capture any traffic for port 53 (inbound and outbound).
   - Without changing the configuration, send a simple forward A query for any domain name from the VM itself. Do you expect this to work?
   - Try to determine from the logs or the `tcpdump` output whether the DNS server is configured as a *caching name server* with or without a *forwarder*.
   - Repeat the previous query. Do you see a difference in behavior? Can you explain why?

2. Ensure that the DNS server is available to all hosts on the local network. Don't forget to check firewall settings! Test whether you can resolve the domain name from another VM or a physical machine on the same network.

3. Add a *forwarder* and verify that it works. Try to use a public DNS server as a forwarder. Google's is well known, but there are others, too! Search for "free public dns servers" to get some suggestions.

   - Repeat the queries from the previous step. Do you see a difference in behavior?

4. Create a *primary forward lookup zone* named `linuxtrn.lan` with a variety of resource records, e.g. NS, MX, A, CNAME. Also add an A record for the `@` shorthand.

   - Use `dig` and `nslookup` to verify all resource records.
   - Optionally, write a test script that runs these queries automatically and compares the results with the expected values.

5. On the client machine, set the system DNS server to the IP address of `srv001` and test (from the terminal, or using your test script) whether you can:

   - Ping the VMs by their hostnames.
   - Resolve the domain name `linuxtrn.lan` to an IP address.
   - Query the name and mail servers for the domain `linuxtrn.lan`.
   - Perform a reverse lookup for any of the IP addresses in the domain.
   - Access the website on `srv004` by entering `https://www.linuxtrn.lan` in a browser (or alternatively use `curl` if your client VM does not have a graphical UI).

6. Set up `srv002`, install BIND and set up a *secondary* server for your primary zone.

   - Rewrite your test script so it can also run queries against the secondary server.
   - Ensure that you have the query logs on the primary server turned on and that you are watching its logs before you start the secondary server.
   - Observe the zone transfer process when you start the secondary server.
   - Check that the secondary server responds to the same queries as the primary.
   - Try an AXFR query from the secondary server to the primary server. Try the same from the client machine. Also try it from the primary server to the secondary server. Which work and which don't?
   - Make a change to one of the resource records on the primary server (e.g. change an IP address) and update your test script. Restart the primary server. Query both the primary and the secondary server to see if the change has been propagated.
   - It probably hasn't, unless you thought of incrementing the seral number in the zone file. Do that now and repeat the previous step. Check whether the zone transfer happens and that both primary and secondary server respond with the updated information.

7.7. solution: BIND

TODO: update to the new version of the exercises

1. Set up a Linux VM (Debian or EL-based) and install BIND. 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 van 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 new VM, install BIND and set up a *secondary* server of your primary zone. Verify the *zone transfer* in the logs.

   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)

8. advanced DNS

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Alex M. Schapelle, https://github.com/zero-pytagoras/)

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`.

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

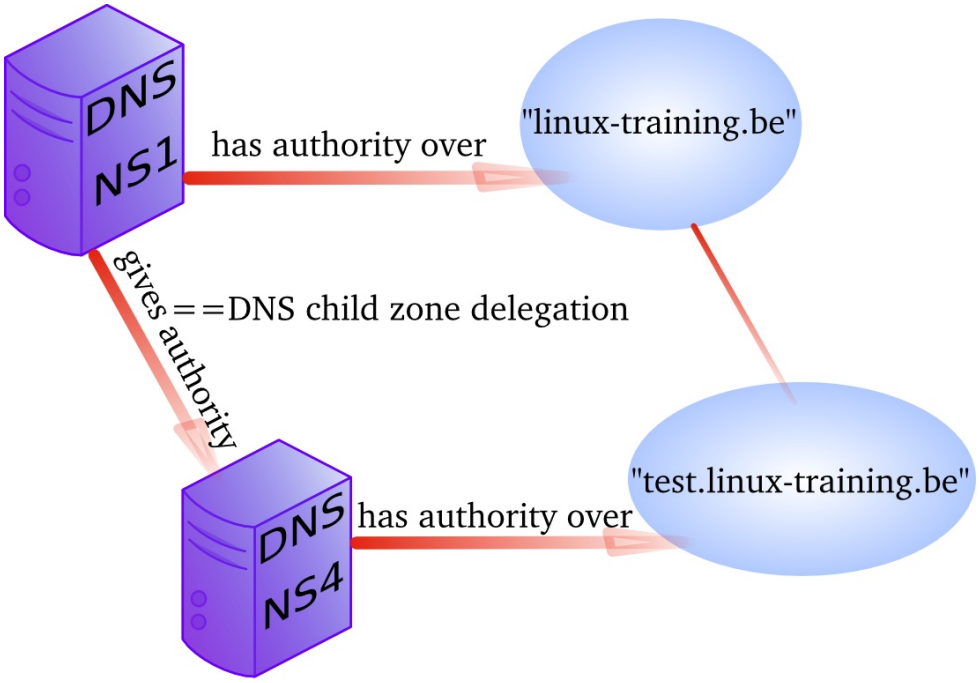
Below a screenshot of `nslookup` querying a load balanced A record. Notice the order of ip addresses returned.

```
root@linux:~# 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@linux:~# 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`.

8.2. 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.

8.3. example: DNS delegation

We have another `Linux server` named `debian10b` 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 `debian10` *(hosting the parent domain) or* `debian10b` *(hosting the child domain).*

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

```
root@linux:~# 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 { };
};
root@linux:~#
```

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@linux:~# 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
root@linux:~#
```

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

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

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:

```
root@linux:~# 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      debian10b.test42.paul.local.
;
; servers
;
ns2             IN      A       10.104.33.31
debian10b        IN      A       10.104.33.31
testsrv         IN      A       10.104.33.31
root@linux:~#
```

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

```
root@linux:~# 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; };
};
root@linux:~#
```

Testing on the parent server:

```
root@linux:~# dig ns1.paul.local +short
10.104.33.30
root@linux:~# dig ns2.test42.paul.local +short
10.104.33.31
root@linux:~# dig debian10b.test42.paul.local +short
10.104.33.31
```

8.4. 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@linux:/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@linux:/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
```

8.5. old dns topics

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

8.5.1. 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):

```
root@linux:/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.

```
root@linux:/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@linux:/etc/bind#
```

4. Test with nslookup or dig:

```
root@linux:/etc/bind# dig 1.168.192.in-addr.arpa AXFR
```

8.5.2. 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.

8.5.3. 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";
};
```

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

8.5.5. 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.

8.5.6. old reverse is forward in-addr.arpa

Reverse lookup is actually iomplemented 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.

8.5.7. 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.

8.5.8. 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.

8.5.9. 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.

8.5.10. 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.

8.5.11. 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.

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

};

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

};
```

Or allow only queries from the local network.

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

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

Or only allow recursive queries from internal clients.

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

8.5.12. old DNS security: chrooted bind

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

8.5.13. old DNS security: DNSSEC

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

8.5.14. old DNS security: root

Do not run bind as root. Do not run any application daemon as root.

Part IV.

dhcp server

9. introduction to dhcp

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Alex M. Schapelle, https://github.com/zero-pytagoras/)

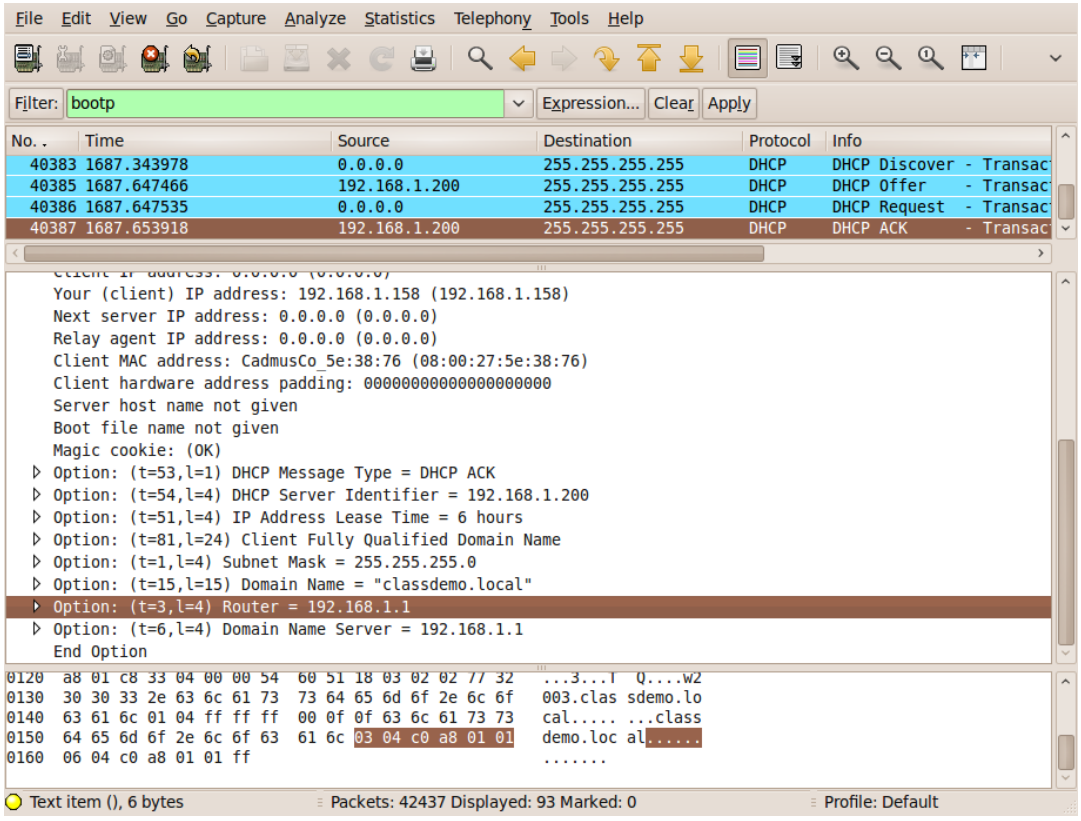
Dynamic Host Configuration Protocol (or short `dhcp`) is a standard tcp/ip protocol that distributes ip configurations to clients. `dhcp` is defined in `rfc 2131` (before that it was defined as an update to `bootp` in rfc 1531/1541.

The alternative to `dhcp` is manually entering the ip configuration on each client computer.

9.1. 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).

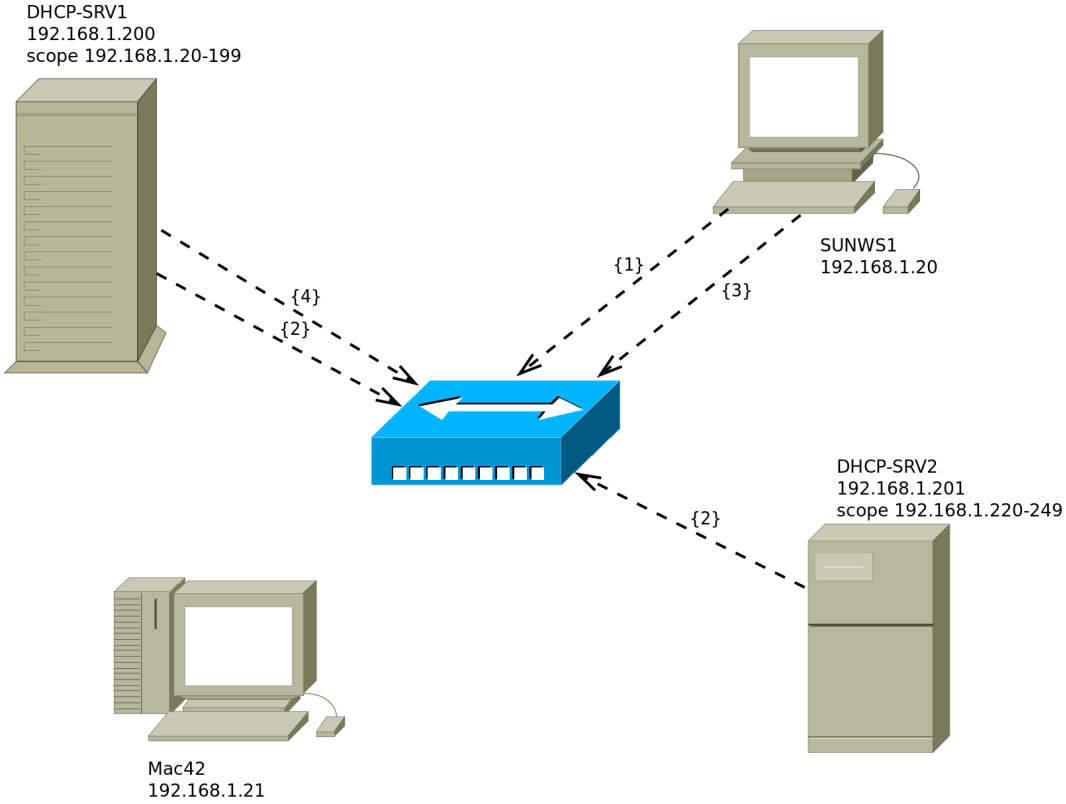
In wireshark it looks like this.



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

9.2. 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:ff` and a layer 3 ip broadcast to 255.255.255.255.

The same story can be read in `rfc 2131`.

9.3. installing a dhcp server

dhcp server for Debian/Mint

```
debian10:~# 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.

```
debian10:~# ls -l /etc/dhcp3/dhcpd.conf
-rw-r--r-- 1 root root 3551 2011-04-10 21:23 /etc/dhcp3/dhcpd.conf
```

9.4. dhcp server for RHEL/CentOS

Installing is easy with `yum`.

```
[root@linux ~]# 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@linux ~]#
```

After installing we get a `/etc/dhcp/dhcpd.conf` that points us to an example file named `dhcpd.conf.sample`.

```
[root@linux ~]# cat /etc/dhcp/dhcpd.conf
#
# DHCP Server Configuration file.
```

```
#   see /usr/share/doc/dhcp*/dhcpd.conf.example
#   see dhcpd.conf(5) man page
#
[root@linux ~]#
```

So we copy the sample and adjust it for our real situation. We name the copy `/etc/dhcp/dhcpd.conf`.

```
[root@linux ~]# cp /usr/share/doc/dhcp-4.2.5/dhcpd.conf.example /etc/dhcp/dhcp\
d.conf
[root@linux ~]# vi /etc/dhcp/dhcpd.conf
[root@linux ~]# cat /etc/dhcp/dhcpd.conf
option domain-name "linux-training.be";
option domain-name-servers 10.42.42.42;
default-lease-time 600;
max-lease-time 7200;
log-facility local7;

subnet 10.42.0.0 netmask 255.255.0.0 {
  range 10.42.200.11 10.42.200.120;
  option routers 10.42.200.1;
}
[root@linux ~]#
```

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/CentOS8 and `service dhcpd start` on previous versions of RHEL/CentOS.

```
[root@linux ~]# systemctl start dhcpd
[root@linux ~]#
```

9.5. client reservations

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

```
host pc42 {
hardware ethernet 11:22:33:44:55:66;
fixed-address 192.168.42.42;
}
```

You can add individual options to this reservation.

```
host pc42 {
hardware ethernet 11:22:33:44:55:66;
fixed-address 192.168.42.42;
option domain-name "linux-training.be";
option routers 192.168.42.1;
}
```

9.6. example config files

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

```
# NetSec Antwerp Network
subnet 192.168.1.0 netmask 255.255.255.0 {
 range 192.168.1.20 192.168.1.199;
 option domain-name-servers ns1.netsec.local;
 option domain-name "netsec.local";
 option routers 192.168.1.1;
 option broadcast-address 192.168.1.255;
 default-lease-time 7200;
 max-lease-time 7200;
}
```

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;
}
```

9.7. 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" {
    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)

```
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:

```
[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:

```
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.

9.8. advanced dhcp

9.8.1. 80/20 rule

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

9.8.2. relay agent

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

9.8.3. 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.

9.8.4. 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"
```

9.9. 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

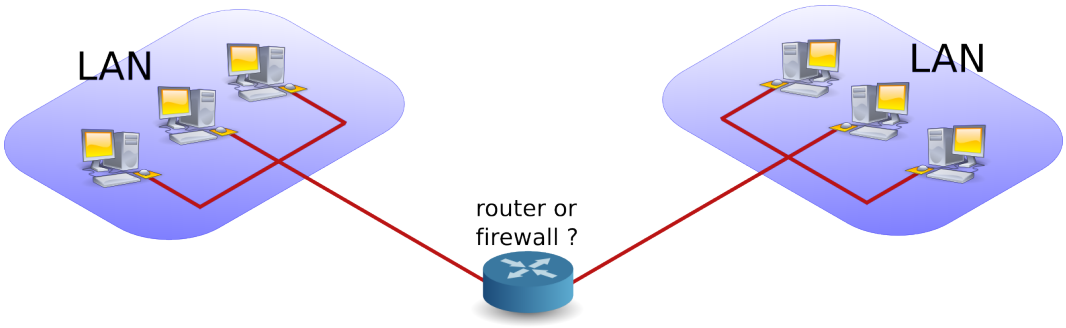
10. introduction to routers

(Written by Paul Cobbaut, https://github.com/paulcobbaut/)

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

10.1. 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.



10.2. 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`.

10.3. 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.

10.4. 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.

10.5. 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 distuinguish several types of nat.

10.6. 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.

10.7. 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.

10.8. 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.

10.9. dnat (destination nat)

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

10.10. 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.

10.11. /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.

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

The next command shows how to disable packet forwarding.

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

Use cat to check if packet forwarding is enabled.

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

10.12. /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.

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

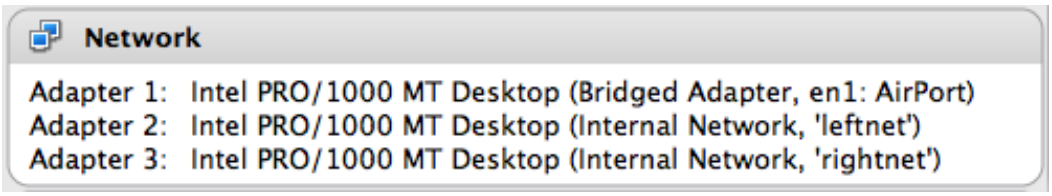
10.13. sysctl

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

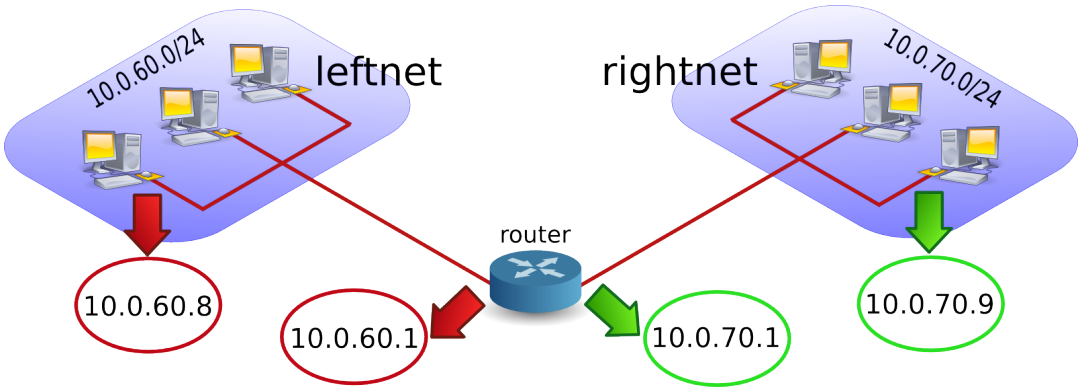
```
root@linux~# man sysctl
root@linux~# sysctl -a 2>/dev/null | grep ip_forward
net.ipv4.ip_forward = 0
```

10.14. practice: packet forwarding

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 10.1.: Packet Forwarding Exercise

	leftnet computer	the router	rightnet computer
MAC			
IP			

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`.

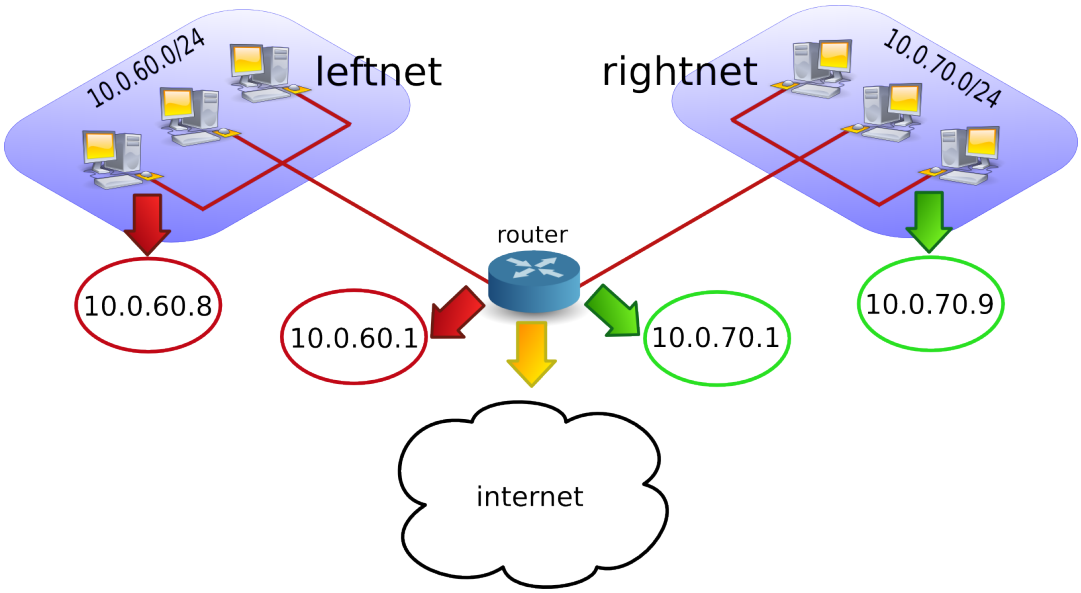
4. `Ping` from the leftnet computer to the rightnet computer. Enable and/or disable packet forwarding on the `router` and verify what happens to the ping between the two networks. If you do not succeed in pinging between the two networks (on different subnets), then use a sniffer like `wireshark` or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

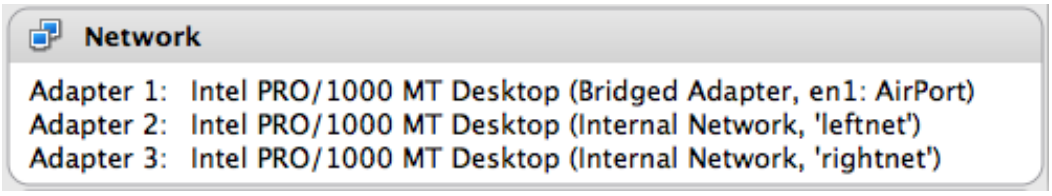
6. Remember the third network card on the router ? Connect this card to a LAN with internet connection. On many LAN's the command `dhclient eth0` just works (replace `eth0` with the correct interface).

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

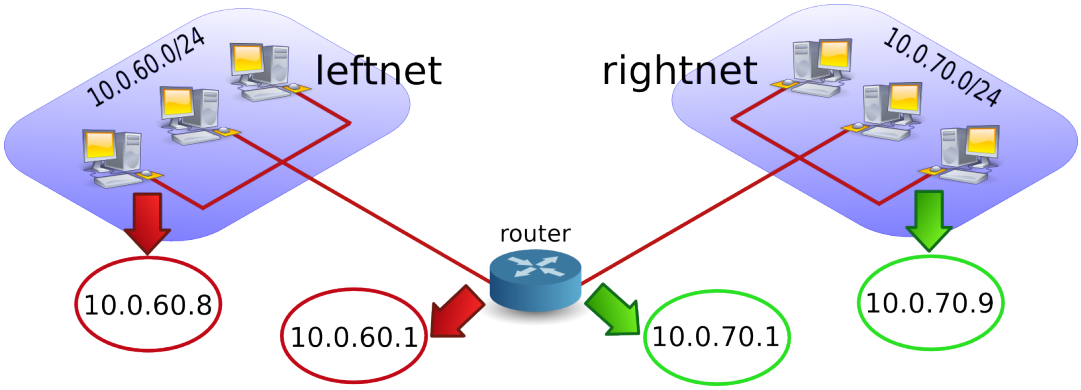
You now have a setup similar to this picture. What needs to be done to give internet access to `leftnet` and `rightnet`.



10.15. 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'.



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.

```
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.

```
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 10.2.: Packet Forwarding Solution

leftnet computer	the router		rightnet computer
08:00:27:f6:ab:b9 192.168.60.8	08:00:27:43:1f:5a 192.168.60.1	08:00:27:be:4a:6b 192.168.70.1	08:00:27:14:8b:17 192.168.70.9

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 ?

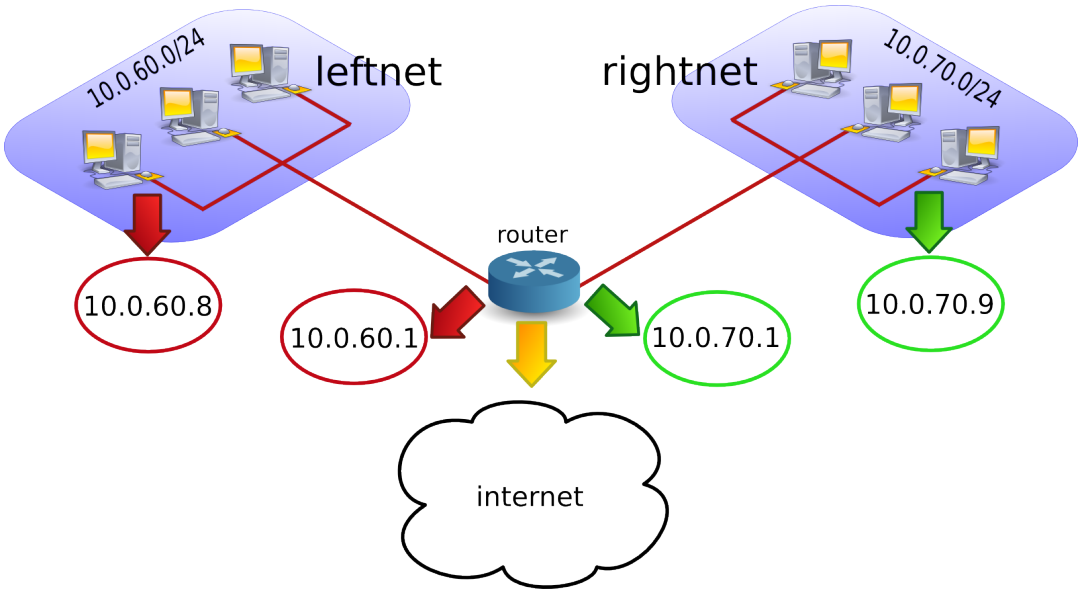
Both MAC addresses are changed when passing the router. Use `tcpdump -xx` like this:

```
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
```

11. iptables firewall

(Written by Paul Cobbaut, https://github.com/paulcobbaut/)

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.

11.1. 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@linux~# 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@linux~# 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.

11.2. 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
[root@centos6 ~]# service iptables start
iptables: Applying firewall rules                          [ ok ]
[root@centos6 ~]#
```

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

```
root@linux~# aptitude purge iptables
```

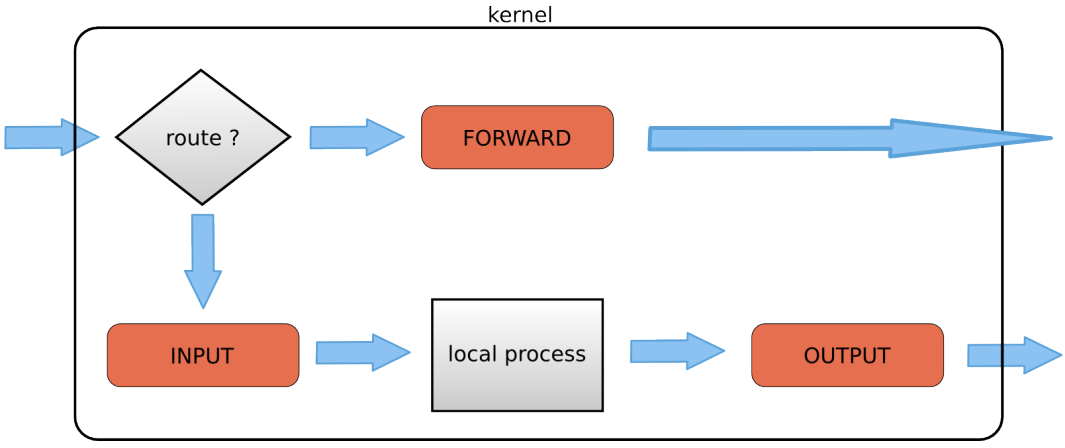
11.3. the filter table

11.3.1. 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.

11.3.2. 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.



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

```
[root@linux ~]# 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@linux ~]#
```

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

11.3.3. 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
```

11.3.4. 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@linux ~]# iptables -P INPUT DROP
[root@linux ~]# iptables -P FORWARD DROP
[root@linux ~]# 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@linux ~]# iptables -A INPUT -i lo -j ACCEPT
[root@linux ~]# iptables -A OUTPUT -o lo -j ACCEPT
```

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

```
[root@linux ~]# 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
```

11.3.5. Allowing ssh over eth0

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

```
[root@linux ~]# iptables -A INPUT -i eth0 -p tcp --dport 22 -j ACCEPT
[root@linux ~]# 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@linux ~]# 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
[root@linux ~]#
```

11.3.6. 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@linux ~]# iptables -A INPUT -i eth1 -s 10.1.1.0/24 -p tcp -j ACCEPT
[root@linux ~]# 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@linux ~]# 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  *     10.1.1.0/24 0.0.0.0/0

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
```

11.3.7. iptables save

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

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

11.3.8. 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
```

11.3.9. Allowing ICMP(ping)

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

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

11.4. 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.

11.5. solution: packet filtering

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

```
#!/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
```

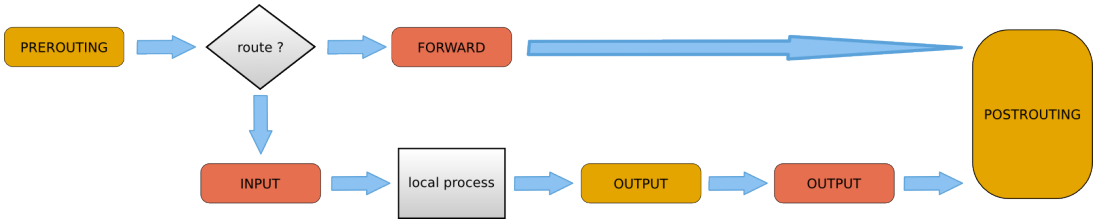
11.6. network address translation

11.6.1. 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@linux ~]# 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@linux ~]#
```

11.6.2. 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.

11.6.3. 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).

```
#!/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
```

11.6.4. 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
```

11.6.5. 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

12. introduction to samba

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Alex M. Schapelle, https://github.com/zero-pytagoras/)

This introduction to the Samba server simply explains how to install Samba 3 and briefly mentions the SMB protocol.

12.1. verify installed version

12.1.1. .rpm based distributions

To see the version of samba installed on Red Hat, Fedora or CentOS use `rpm -q samba`.

```
[root@linux ~]# 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@centos6 ~]# rpm -q samba
samba-3.5.10-116.el6_2.i686
```

12.1.2. .deb based distributions

Use `dpkg -l` or `aptitide 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@linux~# aptitude show samba | grep Version
Version: 2:3.6.3-1
```

Ubuntu 12.04 is currently at Samba version 3.6.3.

```
root@linux:~# dpkg -l samba | tail -1
ii samba 2:3.6.3-2ubuntu2.1 SMB/CIFS file, print, and login server for Unix
```

12.2. installing samba

12.2.1. .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.

```
[student@linux ~]$ 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.

```
[root@centos6 ~]# yum install samba
```

12.2.2. .deb based distributions

Ubuntu and Debian users can use the `aptitude` program (or use a graphical tool like Synaptic).

```
root@linux~# aptitude install samba
The following NEW packages will be installed:
  samba samba-common{a} samba-common-bin{a} tdb-tools{a}
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/?]
...
```

12.3. documentation

12.3.1. 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@linux:~# aptitude install samba-doc-pdf
The following NEW packages will be installed:
  samba-doc-pdf
...
```

12.3.2. 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).

12.4. 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.

```
root@linux:~# /etc/init.d/samba stop
 * Stopping Samba daemons                                    [ OK ]
root@linux:~# /etc/init.d/samba start
 * Starting Samba daemons                                    [ OK ]
root@linux:~# /etc/init.d/samba restart
 * Stopping Samba daemons                                    [ OK ]
 * Starting Samba daemons                                    [ OK ]
root@linux:~# /etc/init.d/samba status
 * SMBD is running                                           [ OK ]
```

Red Hat derived systems are happy with `service smb start`.

```
[root@linux ~]# /etc/init.d/smb start
Starting SMB services:                                     [  OK  ]
Starting NMB services:                                     [  OK  ]
[root@linux ~]# service smb restart
Shutting down SMB services:                                [  OK  ]
Shutting down NMB services:                                [  OK  ]
Starting SMB services:                                     [  OK  ]
Starting NMB services:                                     [  OK  ]
[root@linux ~]#
```

12.5. samba daemons

Samba 3 consists of three daemons, they are named `nmbd`, `smbd` and `winbindd`.

12.5.1. 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@linux ~]# ps -C nmbd
  PID TTY          TIME CMD
 5681 ?        00:00:00 nmbd
```

12.5.2. smbd

The `smbd` daemon manages file transfers and authentication.

```
[root@linux ~]# ps -C smbd
  PID TTY          TIME CMD
 5678 ?        00:00:00 smbd
 5683 ?        00:00:00 smbd
```

12.5.3. winbindd

The `winbind daemon` (winbindd) is only started to handle Microsoft Windows domain membership.

Note that `winbindd` is started by the `/etc/init.d/winbind` script (two dd's for the daemon and only one d for the script).

```
[root@linux ~]# /etc/init.d/winbind start
Starting Winbind services:                                 [  OK  ]
[root@linux ~]# 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`.

12.6. the SMB protocol

12.6.1. brief history

Development of this protocol was started by `IBM` in the early eighties. By the end of the eighties, most develpment 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.

12.6.2. 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.

12.6.3. 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.

12.6.4. 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).

12.7. 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.

13. getting started with samba

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Alex M. Schapelle, https://github.com/zero-pytagoras/)

13.1. /etc/samba/smb.conf

13.1.1. 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`.

```
[root@linux ~]# smbd -b | grep CONFIGFILE
CONFIGFILE: /etc/samba/smb.conf
```

13.1.2. the default smb.conf

The default smb.conf file contains a lot of examples with explanations.

```
[student@linux ~]$ 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.

```
student@linux:~$ ls -l /etc/samba/smb.conf
-rw-r--r-- 1 root root 10515 2007-05-24 00:21 /etc/samba/smb.conf
```

13.1.3. 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).

```
[student@linux ~]$ cat /etc/samba/smb.conf
[global]
workgroup = WORKGROUP
[firstshare]
path = /srv/samba/public
```

13.1.4. 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.
```

13.1.5. 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.

```
valid users = Serena, Venus, Lindsay \
              Kim, Justine, Sabine \
              Amelie, Marie, Suzanne
```

13.1.6. 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`.

13.1.7. man smb.conf

You can access a lot of documentation when typing `man smb.conf`.

```
[root@linux samba]# apropos samba
cupsaddsmb       (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@linux samba]#
```

13.2. /usr/bin/testparm

13.2.1. syntax check smb.conf

To verify the syntax of the smb.conf file, you can use `testparm`.

```
[student@linux ~]$ 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
```

13.2.2. testparm -v

An interesting option is `testparm -v`, which will output all the global options with their default value.

```
[root@linux ~]# 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.

13.2.3. 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@linux 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@linux 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@linux samba]# cat smb.conf
# Global parameters
[global]
server string = Public Test Server

[firstshare]
path = /srv/samba/public
[root@linux samba]#
```

13.3. /usr/bin/smbclient

13.3.1. 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@linux init.d]# smbclient -NL RHEL8b
Anonymous login successful
Domain=[WORKGROUP] OS=[Unix] Server=[Samba 3.0.10-1.4E.9]

Sharename       Type      Comment
---------       ----      -------
firstshare      Disk
IPC$            IPC       IPC Service (Public Test Server)
ADMIN$          IPC       IPC Service (Public Test Server)
Anonymous login successful
Domain=[WORKGROUP] OS=[Unix] Server=[Samba 3.0.10-1.4E.9]

Server               Comment
---------            -------
RHEL8b               Public Test Server
```

```
WINXP

Workgroup            Master
---------            -------
WORKGROUP            WINXP
```

13.3.2. 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@linux:/etc/samba# testparm smbclient -NL 127.0.0.1
Anonymous login successful
Domain=[LINUXTR] OS=[Unix] Server=[Samba 3.5.11]

    Sharename       Type      Comment
    ---------       ----      -------
    share1          Disk
    IPC$            IPC       IPC Service (Samba 3.5.11)
Anonymous login successful
Domain=[LINUXTR] OS=[Unix] Server=[Samba 3.5.11]

    Server               Comment
    ---------            -------

    Workgroup            Master
    ---------            -------
    LINUXTR              DEBIAN6
    WORKGROUP            UBU1110
```

13.3.3. 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`.

```
[student@linux ~]$ smbclient -L w2003 -U administrator%stargate
Domain=[W2003] OS=[Windows Server 2003 3790 Service Pack 2] Server= ...

    Sharename       Type      Comment
    ---------       ----      -------
    C$              Disk      Default share
    IPC$            IPC       Remote IPC
    ADMIN$          Disk      Remote Admin
 ...
```

13.4. /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).

```
[student@linux ~]$ smbtree
Password:
WORKGROUP
PEGASUS
    \\WINXP
    \\RHEL8b                        Pegasus Domain Member Server
Error connecting to 127.0.0.1 (Connection refused)
cli_full_connection: failed to connect to RHEL8b<20> (127.0.0.1)
    \\HM2003
[student@linux ~]$
```

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.

```
[student@linux ~]$ smbtree
Password:
WORKGROUP
    \\W2000
[student@linux ~]$
```

So we wait a while, and then run `smbtree` again, this time it looks a lot nicer.

```
[student@linux ~]$ smbtree
Password:
WORKGROUP
    \\W2000
PEGASUS
    \\WINXP
    \\RHEL8b                         Pegasus Domain Member Server
       \\RHEL8b\ADMIN$              IPC Service (Pegasus Domain Member Server)
       \\RHEL8b\IPC$                IPC Service (Pegasus Domain Member Server)
         \\RHEL8b\domaindata             Active Directory users only
    \\HM2003
[student@linux ~]$ smbtree --version
Version 3.0.10-1.4E.9
[student@linux ~]$
```

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.

```
student@linux:~$ smbtree --version
Version 3.0.24
student@linux:~$ 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
```

```
    \\RHEL8b                         Pegasus Domain Member Server
      \\RHEL8b\ADMIN$              IPC Service (Pegasus Domain Member Server)
      \\RHEL8b\IPC$                IPC Service (Pegasus Domain Member Server)
       \\RHEL8b\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
student@linux:~$
```

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).

```
[student@linux ~]$ smbtree -UAdministrator%Stargate1
WORKGROUP
     \\W2000
PEGASUS
     \\WINXP
        \\WINXP\C$              Default share
        \\WINXP\ADMIN$          Remote Admin
        \\WINXP\share55
        \\WINXP\IPC$            Remote IPC
     \\RHEL8b                   Pegasus Domain Member Server
        \\RHEL8b\ADMIN$         IPC Service (Pegasus Domain Member Server)
        \\RHEL8b\IPC$           IPC Service (Pegasus Domain Member Server)
        \\RHEL8b\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
[student@linux ~]$
```

As you can see, this gives a very nice overview of all SMB computers and their shares.

13.5. 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@linux 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.

```
C:\Documents and Settings\Administrator>net view
Server Name            Remark

------------------------------------------------------------------------
---
```

```
\\LAIKA                Ubuntu 9.04 server in Antwerp
\\RHEL53               Red Hat Server in Paris
\\W2003
```

13.6. 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@linux 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@linux samba]#
```

Then edit the `inetd.conf` or change the disable = yes line in `/etc/xinetd.d/swat` to disable = no.

```
[root@linux 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@linux samba]# /etc/init.d/xinetd restart
Stopping xinetd:                                           [  OK  ]
Starting xinetd:                                           [  OK  ]
[root@linux 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@linux 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.

13.7. 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 tesparm -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.
9. Browse the network with net view, smbtree and with Windows Explorer.
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.

13.8. 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 tesparm -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)
```

9. Browse the network with net view, smbtree and with Windows Explorer.

```
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
```

14. a read only file server

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Alex M. Schapelle, https://github.com/zero-pytagoras/)

14.1. 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@linux ~]# mkdir -p /srv/samba/readonly
[root@linux ~]# cd /srv/samba/readonly/
[root@linux readonly]# echo "It is cold today." > winter.txt
[root@linux readonly]# echo "It is hot today." > summer.txt
[root@linux 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
[root@linux readonly]#
```

14.2. configure the share

14.2.1. 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@linux 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.

14.2.2. 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@linux:~# 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@linux:~# cat /etc/samba/smb.conf
[global]
workgroup = LINUXTR
netbios name = DEBIAN6
security = share
[roshare1]
path = /srv/samba/readonly
read only = yes
guest ok = yes
```

14.3. restart the server

After testing with `testparm`, restart the samba server (so you don't have to wait).

```
[root@linux readonly]# service smb restart
Shutting down SMB services:                                [  OK  ]
Shutting down NMB services:                                [  OK  ]
Starting SMB services:                                     [  OK  ]
Starting NMB services:                                     [  OK  ]
```

14.4. verify the share

14.4.1. verify with smbclient

You can now verify the existence of the share with `smbclient`. Our `pubread` is listed as the fourth share.

```
[root@linux samba]# smbclient -NL 127.0.0.1
Domain=[WORKGROUP] OS=[Unix] Server=[Samba 3.0.33-3.7.el5]

    Sharename       Type      Comment
    ---------       ----      -------
    IPC$            IPC       IPC Service (Public Anonymous File Server)
    global$         Disk
    pub0            Disk
    pubread         Disk      files to read
Domain=[WORKGROUP] OS=[Unix] Server=[Samba 3.0.33-3.7.el5]

    Server               Comment
    ---------            -------
    TEACHER0             Samba 3.0.33-3.7.el5
    W2003EE

    Workgroup            Master
    ---------            -------
    WORKGROUP            W2003EE
```

14.4.2. 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.
```

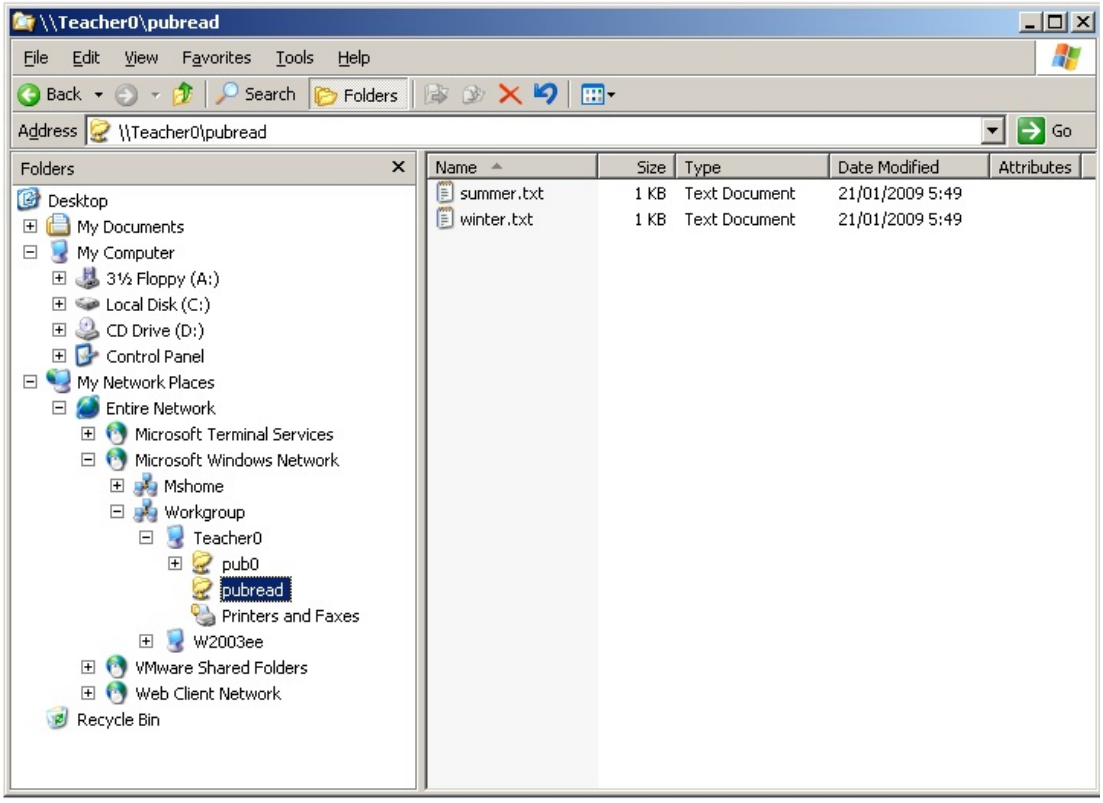
Then we test looking at the contents of the share, and reading the files.

```
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...



14.5. 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.

```
student@linux:~$ 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.
```

14.6. 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.

14.7. 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
```

15. a writable file server

(Written by Paul Cobbaut, https://github.com/paulcobbaut/)

15.1. 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@linux samba]# mkdir -p /srv/samba/writable
[root@linux samba]# chmod 777 /srv/samba/writable/
```

15.2. 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
```

15.3. 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@linux 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
```

15.4. 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.
```

15.5. 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
```

15.6. 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@linux samba]# ls -l /srv/samba/writable/
total 4
-rwxr--r-- 1 nobody nobody 6 Jan 21 06:16 hoi.txt
```

So this is not the cleanest solution. We will need to improve this.

15.7. 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.

15.8. solution: writable file server

1. Create a directory and share it with Samba.

```
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:

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.

```
ls -l /srv/samba/writable
```

16. samba first user account

(Written by Paul Cobbaut, https://github.com/paulcobbaut/)

16.1. 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@linux samba]# useradd -s /bin/false sambanobody
[root@linux samba]# usermod -c "Anonymous Samba Access" sambanobody
[root@linux samba]# passwd sambanobody
Changing password for user sambanobody.
New UNIX password:
Retype new UNIX password:
passwd: all authentication tokens updated successfully.
```

16.2. 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@linux samba]# chown -R sambanobody:sambanobody /srv/samba/
[root@linux 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
```

16.3. /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@linux samba]# smbpasswd -a sambanobody
New SMB password:
Retype new SMB password:
Added user sambanobody.
```

16.4. /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@linux samba]# smbd -b | grep PRIVATE
   PRIVATE_DIR: /etc/samba
[root@linux samba]# ls -l smbpasswd
-rw------- 1 root root 110 Jan 21 06:19 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@linux samba]# cat smbpasswd
sambanobody:503:AE9 ... 9DB309C528E540978:[U          ]:LCT-4976B05B:
```

16.5. passdb backend

Note that recent versions of Samba have `tdbsam` as default for the `passdb backend` paramater.

```
root@linux:~# testparm -v 2>/dev/null| grep 'passdb backend'

    passdb backend = tdbsam
```

16.6. 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).

16.7. 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.

16.8. 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)
```

17. samba authentication

(Written by Paul Cobbaut, https://github.com/paulcobbaut/)

17.1. 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@linux ~]# useradd -c "Serena Williams" serena
[root@linux ~]# useradd -c "Justine Henin" justine
[root@linux ~]# useradd -c "Martina Hingis" martina
[root@linux ~]# passwd serena
Changing password for user serena.
New UNIX password:
Retype new UNIX password:
passwd: all authentication tokens updated successfully.
[root@linux ~]# passwd justine
Changing password for user justine.
New UNIX password:
Retype new UNIX password:
passwd: all authentication tokens updated successfully.
[root@linux ~]# passwd martina
Changing password for user martina.
New UNIX password:
Retype new UNIX password:
passwd: all authentication tokens updated successfully.
```

17.2. creating the users on samba

Then we add them to the `smbpasswd` file, with the same password.

```
[root@linux ~]# smbpasswd -a serena
New SMB password:
Retype new SMB password:
Added user serena.
[root@linux ~]# smbpasswd -a justine
New SMB password:
Retype new SMB password:
Added user justine.
[root@linux ~]# smbpasswd -a martina
New SMB password:
Retype new SMB password:
Added user martina.
```

17.3. 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.

```
[global]
 workgroup = WORKGROUP
 netbios name = TEACHER0
 server string = Samba File Server
 security = user
```

17.4. 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
```

17.5. 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.
```

17.6. testing access with smbclient

You can also test connecting with authentication with `smbclient`. First we test with a wrong password.

```
[root@linux samba]# smbclient //teacher0/authwrite -U martina wrongpass
session setup failed: NT_STATUS_LOGON_FAILURE
```

Then we test with the correct password, and verify that we can access a file on the share.

```
[root@linux samba]# smbclient //teacher0/authwrite -U martina stargate
Domain=[TEACHER0] OS=[Unix] Server=[Samba 3.0.33-3.7.el5]
smb: \> more serena.txt
getting file \serena.txt of size 14 as /tmp/smbmore.QQfmSN (6.8 kb/s)
one
two
three
smb: \> q
```

17.7. 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@linux 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
```

17.8. common problems

17.8.1. NT_STATUS_BAD_NETWORK_NAME

You can get `NT_STATUS_BAD_NETWORK_NAME` when you forget to create the target directory.

```
[root@linux samba]# rm -rf /srv/samba/authwrite/
[root@linux 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
```

17.8.2. 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@linux samba]# smbclient //teacher0/authwrite -U martina STARGATE
session setup failed: NT_STATUS_LOGON_FAILURE
```

17.8.3. usernames are (not) case sensitive

Remember that usernames om Linux are case sensitive.

```
[root@linux samba]# su - MARTINA
su: user MARTINA does not exist
[root@linux samba]# su - martina
[martina@linux ~]$
```

But usernames on Microsoft computers are not case sensitive.

```
[root@linux samba]# smbclient //teacher0/authwrite -U martina stargate
Domain=[TEACHER0] OS=[Unix] Server=[Samba 3.0.33-3.7.el5]
smb: \> q
[root@linux samba]# smbclient //teacher0/authwrite -U MARTINA stargate
Domain=[TEACHER0] OS=[Unix] Server=[Samba 3.0.33-3.7.el5]
smb: \> q
```

17.9. 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.

17.10. solution: samba authentication

1. Create three users (on the Linux and on the samba), remember their passwords!

```
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:

[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.
```

18. samba securing shares

(Written by Paul Cobbaut, https://github.com/paulcobbaut/)

18.1. security based on user name

18.1.1. 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
```

18.1.2. invalid users

If you are paranoia, you can also use `invalid users` to explicitely 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
```

18.1.3. 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
```

18.1.4. 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
```

18.2. security based on ip-address

18.2.1. 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
```

18.2.2. 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
```

18.3. security through obscurity

18.3.1. hide unreadable

Setting `hide unreadable` to yes will prevent users from seeing files that cannot be read by them.

```
hide unreadable = yes
```

18.3.2. 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
```

18.4. file system security

18.4.1. 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
    guest ok = No
    create mask = 640
    directory mask = 750
```

18.4.2. 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
```

18.4.3. 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.

18.4.4. 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.

18.4.5. 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
```

18.5. 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 ?

18.6. 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.

18. samba securing shares

```
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 ?

19. samba domain member

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Alex M. Schapelle, https://github.com/zero-pytagoras/)

19.1. changes in smb.conf

19.1.1. workgroup

The `workgroup` option in the global section should match the netbios name of the Active Directory domain.

```
workgroup = STARGATE
```

19.1.2. 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
```

19.1.3. 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
```

19.1.4. 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
```

19.1.5. [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
```

19.1.6. 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
```

19.1.7. [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.

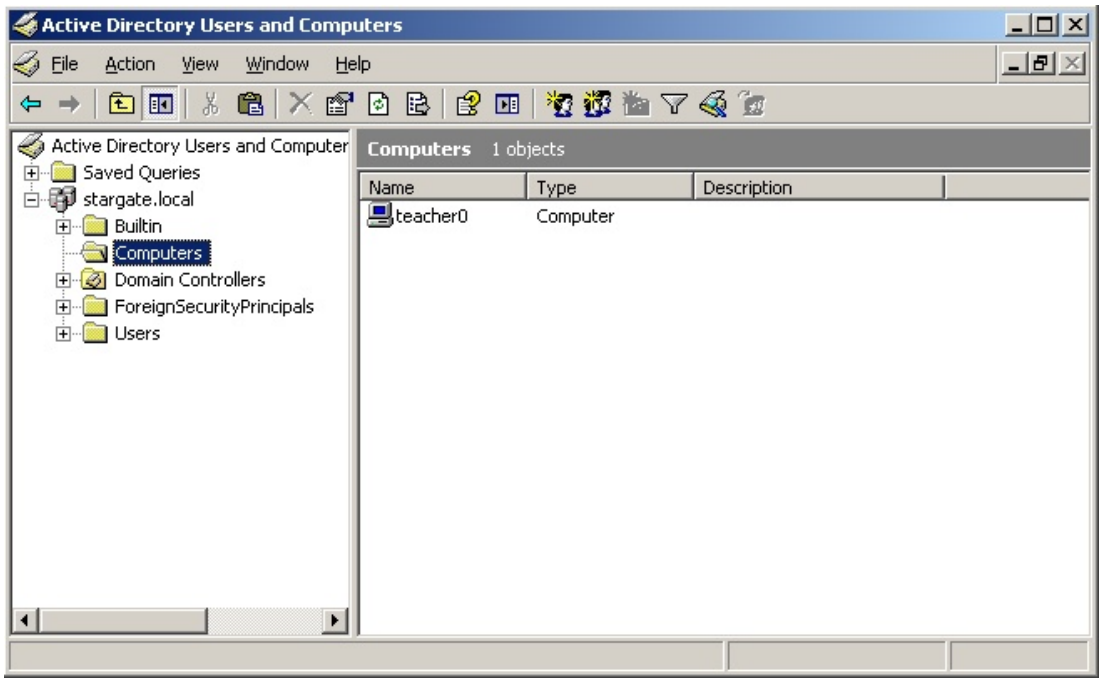
```
[domaindata]
 path = /srv/samba/domaindata
 comment = Active Directory users only
 read only = No
```

19.2. joining an Active Directory domain

While the Samba server is stopped, you can use `net rpc join` to join the Active Directory domain.

```
[root@linux samba]# service smb stop
Shutting down SMB services:                                [  OK  ]
Shutting down NMB services:                                [  OK  ]
[root@linux 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.



19.3. winbind

19.3.1. 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@linux samba]# vi /etc/nsswitch.conf
[root@linux samba]# grep winbind /etc/nsswitch.conf
passwd:     files winbind
group:      files winbind
hosts:      files dns winbind
```

19.3.2. starting samba and winbindd

Time to start Samba followed by `winbindd`.

```
[root@linux samba]# service smb start
Starting SMB services:                                     [  OK  ]
Starting NMB services:                                     [  OK  ]
[root@linux samba]# service winbind start
Starting winbindd services:                                [  OK  ]
[root@linux samba]#
```

19.4. wbinfo

19.4.1. verify the trust

You can use `wbinfo -t` to verify the trust between your samba server and Active Directory.

```
[root@linux ~]# wbinfo -t
checking the trust secret via RPC calls succeeded
```

19.4.2. 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@linux ~]# wbinfo -u
TEACHER0\serena
TEACHER0\justine
TEACHER0\martina
STARGATE\administrator
STARGATE\guest
STARGATE\support_388945a0
STARGATE\pol
STARGATE\krbtgt
STARGATE\arthur
STARGATE\harry
```

19.4.3. 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@linux ~]# 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
```

19.4.4. 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@linux ~]# wbinfo -a harry%stargate
plaintext password authentication succeeded
challenge/response password authentication succeeded
```

19.5. getent

We can use `getent` to verify that winbindd is working and actually adding the Active directory users to /etc/passwd.

```
[root@linux ~]# getent passwd harry
harry:*:20000:20008:harry potter:/home/BATMAN/harry:/bin/false
[root@linux ~]# getent passwd arthur
arthur:*:20001:20008:arthur dent:/home/BATMAN/arthur:/bin/false
[root@linux ~]# getent passwd bilbo
bilbo:*:20002:20008:bilbo baggins:/home/BATMAN/bilbo:/bin/false
```

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`.

```
[root@linux ~]# getent passwd paul
paul:x:500:500:Paul Cobbaut:/home/paul:/bin/bash
```

All the Active Directory users can now easily connect to the Samba share. Files created by them, belong to them.

19.6. file ownership

```
[root@linux 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
```

19.7. 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.

20. samba domain controller

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Alex M. Schapelle, https://github.com/zero-pytagoras/)

20.1. about Domain Controllers

20.1.1. 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.

20.1.2. 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).

20.1.3. 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.

20.1.4. 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!

20.2. About security modes

20.2.1. security = share

The 'Windows for Workgroups' way of working, a client requests connection to a share and provides a password for that connection. Aanyone 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.

20.2.2. 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.

20.2.3. 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.

20.2.4. security = ads

This mode will make samba use Kerberos to connect to the Active Directory domain.

20.2.5. security = server

This mode is obsolete, it can be used to forward authentication to another server.

20.3. 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.

20.4. [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.

20.4.1. 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
```

20.4.2. 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
```

20.4.3. passdb backend

The `passdb backend` parameter will determine whether samba uses `smbpasswd`, `tdbsam` or ldap.

```
passdb backend = tdbsam
```

20.4.4. preferred master

Setting the `preferred master` parameter to yes will make the nmbd daemon force an election on startup.

```
preferred master = yes
```

20.4.5. domain logons

Setting the `domain logons` parameter will make this samba server a domain controller.

```
domain logons = yes
```

20.4.6. 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
```

20.4.7. [global] section

The screenshot below shows a sample [global] section for a samba domain controller.

```
[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
```

20.5. 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.

```
[netlogon]
comment = Network Logon Service
path = /srv/samba/netlogon
admin users = root
guest ok = Yes
browseable = No
```

20.6. 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.

```
[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

[football]
comment = Information about football
path = /srv/samba/football
valid users = @ntfootball
read only = No
```

20.7. 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@linux samba]# groupadd ntadmins
[root@linux samba]# groupadd ntsports
[root@linux samba]# groupadd ntfootball
[root@linux 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@linux samba]# useradd -m -G ntadmins Administrator
[root@linux samba]# useradd -m -G ntsports,nttennis venus
[root@linux samba]# useradd -m -G ntsports,nttennis kim
[root@linux samba]# useradd -m -G ntsports,nttennis jelena
[root@linux samba]# useradd -m -G ntsports,ntfootball figo
[root@linux samba]# useradd -m -G ntsports,ntfootball ronaldo
[root@linux 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@linux 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:
```

20.8. tdbsam

Next we must make these users known to samba with the smbpasswd tool. When you add the first user to `tdbsam`, the file `/etc/samba/passdb.tdb` will be created.

```
[root@linux 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.

```
[root@linux samba]# smbpasswd -a root
New SMB password:
Retype new SMB password:
Added user root.
```

20.9. 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.

```
[root@linux samba]# tail -5 /etc/passwd
jelena:x:510:514::/home/jelena:/bin/bash
figo:x:511:515::/home/figo:/bin/bash
ronaldo:x:512:516::/home/ronaldo:/bin/bash
pfaff:x:513:517::/home/pfaff:/bin/bash
w2003ee$:x:514:518::/home/nobody:/bin/false
```

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.

```
add machine script = /usr/sbin/useradd -s /bin/false -d /home/nobody %u
```

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`.

20.10. 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.

```
logon home =
logon path =
```

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.

```
[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.

```
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.

```
[root@linux 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
-rw-r--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
```

20.11. Groups in NTFS acls

We have users on Unix, we have groups on Unix that contain those users.

```
[root@linux 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
[root@linux samba]#
```

We already added Venus to the tdbsam with smbpasswd.

```
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@linux samba]# net groupmap add ntgroup="tennis" unixgroup=nttennis type=d
No rid or sid specified, choosing algorithmic mapping
Successully added group tennis to the mapping db
[root@linux samba]# net groupmap add ntgroup="football" unixgroup=ntfootball type=d
No rid or sid specified, choosing algorithmic mapping
Successully added group football to the mapping db
[root@linux samba]# net groupmap add ntgroup="sports" unixgroup=ntsports type=d
No rid or sid specified, choosing algorithmic mapping
Successully added group sports to the mapping db
[root@linux samba]#
```

Now you can use the Samba groups on all NTFS volumes on members of the domain.

20.12. logon scripts

Before testing a logon script, make sure it has the proper carriage returns that DOS files have.

```
[root@linux netlogon]# cat start.bat
net use Z: \\DCSPORTS0\SPORTS
[root@linux netlogon]# unix2dos start.bat
unix2dos: converting file start.bat to DOS format ...
[root@linux netlogon]#
```

Then copy the scripts to the netlogon share, and add the following parameter to smb.conf.

```
logon script = start.bat
```

20.13. 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.

21. a brief look at samba 4

(Written by Paul Cobbaut, https://github.com/paulcobbaut/)

21.1. 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

```
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!)

```
[root@linux private]# dig _ldap._tcp.dc._msdcs.booi.schot SRV @localhost

; (1 server found)
;; global options:  printcmd
;; Got answer:
;; -HEADER- opcode: QUERY, status: NXDOMAIN, id: 58186
;; 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

[root@linux private]#
```

made sure /etc/resolv.conf points to himself

```
[root@linux 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

22. introduction to SELinux

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Alex M. Schapelle, https://github.com/zero-pytagoras/)

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..

22.1. 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`.

22.2. logging

Verify that `syslog` is running and activated on boot to enable logging of deny messages in `/var/log/messages`.

```
[root@linux ~]# 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@linux ~]# 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@linux ~]# service auditd status
auditd (pid  1660) is running...
[root@linux ~]# 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@linux:~# grep -i selinux /var/log/messages
Jun 25 15:59:34 deb106 kernel: [    0.084083] SELinux:  Disabled at boot.
```

Or that it is enabled.

```
root@linux:~# grep SELinux /var/log/messages | grep -i Init
Jun 25 15:09:52 deb106 kernel: [    0.084094] SELinux:  Initializing.
```

22.3. 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@linux:~# 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.
```

22.4. getenforce

Use getenforce to verify whether selinux is enforced, disabled or permissive.

```
[root@linux ~]# getenforce
Permissive
```

The /selinux/enforce file contains 1 when enforcing, and 0 when permissive mode is active.

```
root@fedora13 ~# cat /selinux/enforce
1root@fedora13 ~#
```

22.5. setenforce

You can use setenforce to switch between the Permissive or the Enforcing state once selinux is activated..

```
[root@linux ~]# setenforce Enforcing
[root@linux ~]# getenforce
Enforcing
[root@linux ~]# setenforce Permissive
[root@linux ~]# getenforce
Permissive
```

Or you could just use 0 and 1 as argument.

```
[root@linux ~]# setenforce 1
[root@linux ~]# getenforce
Enforcing
[root@linux ~]# setenforce 0
[root@linux ~]# getenforce
Permissive
[root@linux ~]#
```

22.6. sestatus

You can see the current `selinux` status and policy with the `sestatus` command.

```
[root@linux ~]# sestatus
SELinux status:                 enabled
SELinuxfs mount:                /selinux
Current mode:                   permissive
Mode from config file:          permissive
Policy version:                 21
Policy from config file:        targeted
```

22.7. policy

Most Red Hat server will have the `targeted` policy. Only NSA/FBI/CIA/DOD/HLS use the `mls` policy.

The targted policy will protect hundreds of processes, but lets other processes run 'unconfined' (= they can do anything).

22.8. /etc/selinux/config

The main configuration file for `selinux` is `/etc/selinux/config`. When in `permissive` mode, the file looks like this.

The targeted policy is selected in `/etc/selinux/config`.

```
[root@linux ~]# 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
```

22.9. 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.

22.10. 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@linux ~]# 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@linux ~]# useradd -m -s /bin/bash pol
[root@linux ~]# ls -Z /home/pol/.bashrc
-rw-r--r--. pol pol unconfined_u:object_r:user_home_t:s0 /home/pol/.bashrc
```

22.11. -Z

There are also some other tools with the -Z switch:

```
mkdir -Z
cp -Z
ps -Z
netstat -Z
...
```

22.12. /selinux

When selinux is active, there is a new virtual file system named `/selinux`. (You can compare it to /proc and /dev.)

```
[root@linux ~]# 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
--w-------.  1 root root    0 Apr 12 19:40 commit_pending_bools
-rw-rw-rw-.  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
--w-------.  1 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
-rw-------.  1 root root    0 Apr 12 19:40 load
-rw-rw-rw-.  1 root root    0 Apr 12 19:40 member
-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--.  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--.  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 wih size 0, they often contain a boolean value. Check `/selinux/enforce` to see if selinux is running in enforced mode.

```
[root@linux ~]# ls -l /selinux/enforce
-rw-r--r-- 1 root root 0 Apr 29 08:21 /selinux/enforce
[root@linux ~]# echo $(cat /selinux/enforce)
1
```

22.13. 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@linux ~]# id -Z
user_u:system_r:unconfined_t
```

22.14. role

The `selinux role` defines the domains that can be used. A `role` is denied to enter a domain, unless the `role` is explicitely authorized to do so.

22.15. 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@linux ~]# ps fax -Z | grep /sbin/init
system_u:system_r:init_t:s0         1 ?        Ss     0:00 /sbin/init
[root@linux ~]# 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@linux 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-xr-x. root root system_u:object_r:postfix_master_exec_t:s0 postfix
-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@linux 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@linux ~]# 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
```

22.16. 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.

```
[student@linux ~]$ 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.

```
[student@linux ~]$ 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@linux ~]# 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@linux ~]# 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.

22.17. 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@linux ~]$ touch test /tmp/test
[pol@linux ~]$ ls -Z test
-rw-rw-r--. pol pol unconfined_u:object_r:user_home_t:s0 test
[pol@linux ~]$ ls -Z /tmp/test
-rw-rw-r--. pol pol unconfined_u:object_r:user_tmp_t:s0 /tmp/test
```

22.18. extended attributes

Extended attributes are used by `selinux` to store security contexts. These attributes can be viewed with `ls` when `selinux` is running.

```
[root@linux 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@linux 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
[root@linux home]#
```

When selinux is not running, then `getfattr` is the tool to use.

```
[root@linux etc]# getfattr -m . -d hosts
# file: hosts
security.selinux="system_u:object_r:etc_t:s0\000"
```

22.19. process security context

A new option is added to `ps` to see the selinux security context of processes.

```
[root@linux 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
```

22.20. chcon

Use `chcon` to change the selinux security context.

This example shows how to use `chcon` to change the `type` of a file.

```
[root@linux ~]# ls -Z /var/www/html/test42.txt
-rw-r--r--  root root user_u:object_r:httpd_sys_content_t /var/www/html/test4\
2.txt
[root@linux ~]# chcon -t samba_share_t /var/www/html/test42.txt
[root@linux ~]# 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`.

22.21. 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@linux ~]# touch /var/www/html/test42.txt
[root@linux ~]# ls -Z /var/www/html/test42.txt
-rw-r--r--. root root unconfined_u:object_r:httpd_sys_content_t:s0 /var/www/h\
tml/test42.txt
```

Files created elsewhere do not get this type.

```
[root@linux ~]# touch /root/test42.txt
[root@linux ~]# 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@linux ~]# service httpd restart
Stopping httpd:                                            [  OK  ]
Starting httpd:                                            [  OK  ]
```

Will this work ? Yes it does.

```
[root@linux ~]# 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@linux ~]# ps -ZC 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
```

So let’s set SELinux to enforcing and change the type of this file.

```
[root@linux ~]# chcon -t samba_share_t /var/www/html/test42.txt
[root@linux ~]# ls -Z /var/www/html/test42.txt
-rw-r--r--. root root unconfined_u:object_r:samba_share_t:s0 /var/www/html/t\
est42.txt
[root@linux ~]# setenforce 1
[root@linux ~]# 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@linux ~]# 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
2014-04-12 21:05:02 ERROR 403: Forbidden.
```

The log file gives you a cryptic message...

```
[root@linux ~]# tail -3 /var/log/audit/audit.log
type=SYSCALL msg=audit(1398200702.803:64): arch=c000003e syscall=4 succ\
ess=no exit=-13 a0=7f5fbc334d70 a1=7fff553b4f10 a2=7fff553b4f10 a3=0 it\
ems=0 ppid=1666 pid=1673 auid=500 uid=48 gid=48 euid=48 suid=48 fsuid=4\
8 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=26324\
1 scontext=unconfined_u:system_r:httpd_t:s0 tcontext=unconfined_u:objec\
t_r:samba_share_t:s0 tclass=file
type=SYSCALL msg=audit(1398200702.804:65): arch=c000003e syscall=6 succ\
ess=no exit=-13 a0=7f5fbc334e40 a1=7fff553b4f10 a2=7fff553b4f10 a3=1 it\
ems=0 ppid=1666 pid=1673 auid=500 uid=48 gid=48 euid=48 suid=48 fsuid=4\
8 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.

22.22. setroubleshoot

The log file above was not very helpful, but these two packages can make your life much easier.

```
[root@linux ~]# 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@linux ~]# service httpd restart
Stopping httpd:                                            [FAILED]
Starting httpd:                                            [  OK  ]
[root@linux ~]# getenforce
Permissive
[root@linux ~]# setenforce  1
[root@linux ~]# getenforce
Enforcing
[root@linux ~]# 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
2014-04-12 21:44:13 ERROR 403: Forbidden.
```

The `/var/log/audit/` is still not out best friend, but take a look at `/var/log/messages`.

```
[root@linux ~]# tail -2 /var/log/messages
Apr 12 21:44:16  centos65  setroubleshoot: SELinux is preventing /usr/sbin/h\
ttpd 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/h\
ttpd 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@linux ~]# sealert -l b2a84386-54c1-4344-96fb-dcf969776696
SELinux is preventing /usr/sbin/httpd from getattr access on the file /va\
r/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@linux ~]# /sbin/restorecon -v /var/www/html/test42.txt
/sbin/restorecon reset /var/www/html/test42.txt context unconfined_u:objec\
t_r:samba_share_t:s0->unconfined_u:object_r:httpd_sys_content_t:s0
[root@linux ~]# 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!

22.23. booleans

Booleans are on/off switches

```
[root@linux ~]# 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.

```
[root@linux ~]# setsebool httpd_read_user_content=1
[root@linux ~]# getsebool httpd_read_user_content
httpd_read_user_content --> on
[root@linux ~]# setsebool httpd_enable_homedirs=1
[root@linux ~]# getsebool httpd_enable_homedirs
httpd_enable_homedirs --> on
```

You can set these booleans permanent.

```
[root@linux ~]# setsebool -P httpd_enable_homedirs=1
[root@linux ~]# setsebool -P httpd_read_user_content=1
```

The above commands regenerate the complete /etc/selinux/targeted directory!

```
[root@linux ~]# 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

23. git

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Alex M. Schapelle, https://github.com/zero-pytagoras/)

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:

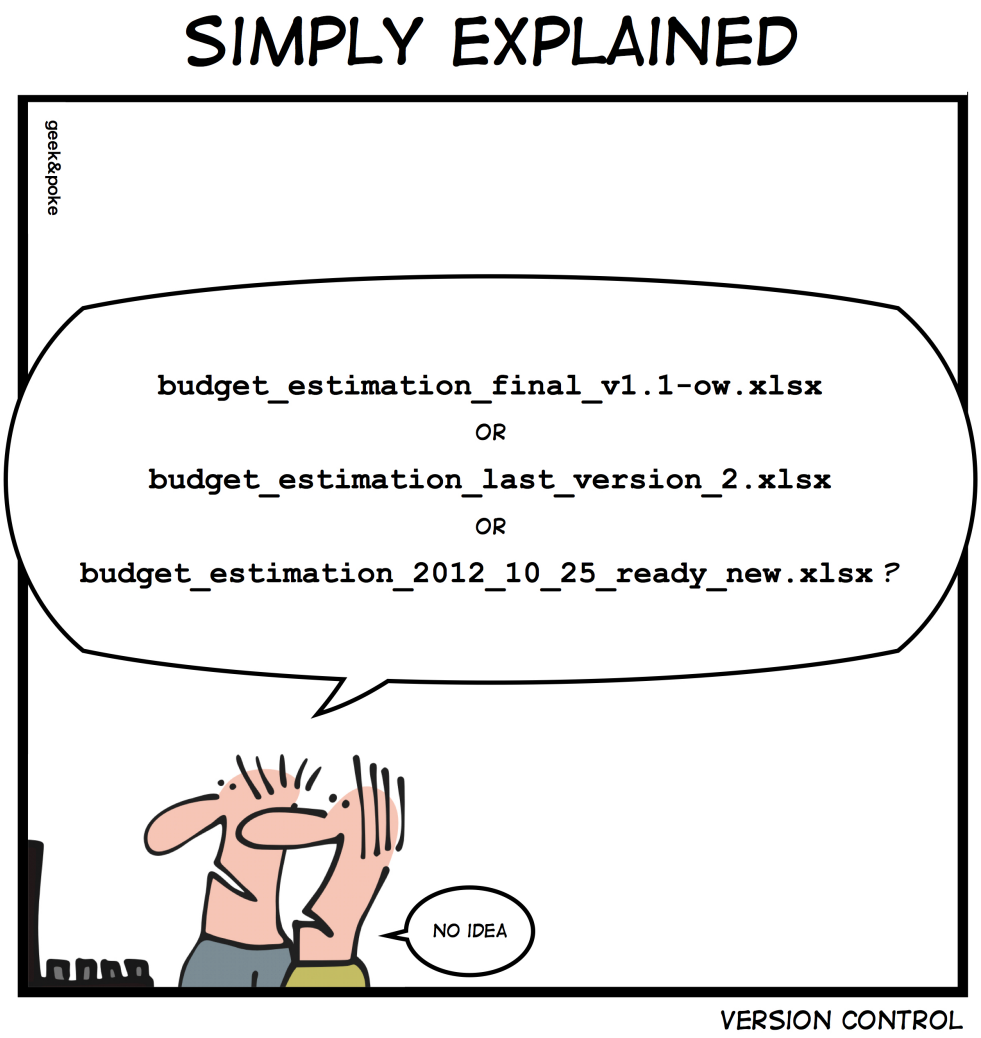
```
http://gitimmersion.com/
http://git-scm.com/book
```

23.1. git

Linus Torvalds created `git` back in 2005 when Bitkeeper changed its license and the Linux kernel developers where 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).



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).

23.2. installing git

We install `git` with `aptitude install git` as seen in this screenshot on Debian 6.

```
root@linux:~# 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) ...
```

23.3. starting a project

First we create a project directory, with a simple file in it.

```
student@linux~$ mkdir project42
student@linux~$ cd project42/
student@linux~/project42$ echo "echo The answer is 42." >> question.sh
```

23.3.1. git init

Then we tell `git` to create an empty git repository in this directory.

```
student@linux~/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
student@linux~/project42$ git init
Initialized empty Git repository in /home/paul/project42/.git/
student@linux~/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
```

23.3.2. git config

Next we use `git config` to set some global options.

```
student@linux$ git config --global user.name Paul
student@linux$ git config --global user.email "paul.cobbaut@gmail.com"
student@linux$ git config --global core.editor vi
```

We can verify this config in `~/.gitconfig`:

```
student@linux~/project42$ cat ~/.gitconfig
[user]
    name = Paul
    email = paul.cobbaut@gmail.com
[core]
    editor = vi
```

23.3.3. git add

Time now to add file to our project with `git add`, and verify that it is added with `git status`.

```
student@linux~/project42$ git add question.sh
student@linux~/project42$ git status
# On branch master
#
# Initial commit
#
# Changes to be committed:
#   (use "git rm --cached <file>..." to unstage)
#
#   new file:   question.sh
#
```

The `git status` tells us there is a new file ready to be committed.

23.3.4. git commit

With `git commit` you force git to record all added files (and all changes to those files) permanently.

```
student@linux~/project42$ git commit -m "starting a project"
[master (root-commit) 5c10768] starting a project
 1 file changed, 1 insertion(+)
 create mode 100644 question.sh
student@linux~/project42$ git status
# On branch master
nothing to commit (working directory clean)
```

23.3.5. changing a committed file

The screenshots below show several steps. First we change a file:

```
student@linux~/project42$ git status
# On branch master
nothing to commit (working directory clean)
student@linux~/project42$ vi question.sh
```

Then we verify the status and see that it is modified:

```
student@linux~/project42$ git status
# On branch master
# Changes not staged for commit:
#   (use "git add <file>..." to update what will be committed)
#   (use "git checkout -- <file>..." to discard changes in working directory)
#
#   modified:   question.sh
#
no changes added to commit (use "git add" and/or "git commit -a")
```

Next we add it to the git repository.

```
student@linux~/project42$ git add question.sh
student@linux~/project42$ git commit -m "adding a she-bang to the main script"
[master 86b8347] adding a she-bang to the main script
 1 file changed, 1 insertion(+)
student@linux~/project42$ git status
# On branch master
nothing to commit (working directory clean)
```

23.3.6. git log

We can see all our commits again using `git log`.

```
student@linux~/project42$ git log
commit 86b8347192ea025815df7a8e628d99474b41fb6c
Author: Paul <paul.cobbaut@gmail.com>
Date:   Sat Dec 8 17:12:24 2012 +0100

    adding a she-bang to the main script

commit 5c10768f29aecc16161fb197765e0f14383f7bca
Author: Paul <paul.cobbaut@gmail.com>
Date:   Sat Dec 8 17:09:29 2012 +0100

    starting a project
```

The log format can be changed.

```
student@linux~/project42$ git log --pretty=oneline
86b8347192ea025815df7a8e628d99474b41fb6c adding a she-bang to the main script
5c10768f29aecc16161fb197765e0f14383f7bca starting a project
```

The log format can be customized a lot.

```
student@linux~/project42$ git log --pretty=format:"%an: %ar :%s"
Paul: 8 minutes ago :adding a she-bang to the main script
Paul: 11 minutes ago :starting a project
```

23.3.7. 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`.

```
student@linux~/project42$ git mv question.sh thequestion.sh
student@linux~/project42$ git status
# On branch master
# Changes to be committed:
#   (use "git reset HEAD <file>..." to unstage)
#
#   renamed:    question.sh -> thequestion.sh
#
student@linux~/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%)
```

23.4. 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).

```
student@linux~/project42$ git branch
* master
student@linux~/project42$ git checkout -b newheader
Switched to a new branch 'newheader'
student@linux~/project42$ vi thequestion.sh
student@linux~/project42$ git add thequestion.sh
student@linux~/project42$ source thequestion.sh
The answer is 42.
```

It seems to work, so we commit in this branch.

```
student@linux~/project42$ git commit -m "adding a new company header"
[newheader 730a22b] adding a new company header
 1 file changed, 4 insertions(+)
student@linux~/project42$ git branch
  master
* newheader
student@linux~/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.

```
student@linux~/project42$ git checkout master
Switched to branch 'master'
student@linux~/project42$ cat thequestion.sh
#!/bin/bash
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.

```
student@linux~/project42$ cat thequestion.sh
#!/bin/bash
echo The answer is 42.
student@linux~/project42$ git merge newheader
Updating 69b2c8b..730a22b
Fast-forward
 thequestion.sh |    4 ++++
 1 file changed, 4 insertions(+)
student@linux~/project42$ cat thequestion.sh
#!/bin/bash
#
# copyright linux-training.be
#

echo The answer is 42.
```

The newheader branch can now be deleted.

```
student@linux~/project42$ git branch
* master
  newheader
student@linux~/project42$ git branch -d newheader
Deleted branch newheader (was 730a22b).
student@linux~/project42$ git branch
* master
```

23.5. to be continued...

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/
http://git-scm.com/book
```

23.6. 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.

23.7. 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`!

23.8. practice: git

1.Crate local project called `git_practice`.

2.Create a project on `gitlab.com` to host a local project that you have created.

3.The project should have `REAMDE.md` file as well as `TODO.md` file in it.

4.Write in `REAMDE.md` file description of the project and what you think it might be.

5.Initialize your project with `git` command, setup your username, mail and remote server.

6.Use `git push -u origin master` to send project saves to remote host.

7.Verify on `gitlab.com` that the project has been setup and is updated with `REAMDE.md` and `TODO.md`.

8.Add git_hello.sh script that prints hello to username from its current location.

9.Push the script to gitlab repository.

23.9. solution: git

1.Crate local project called `git_practice`.

```
aschapelle@vaio3:~$ mkdir git_practice; cd git_practice
```

2.Create a project on `gitlab.com` to host a local project that you have created.

3.The project should have `REAMDE.md` file as well as `TODO.md` file in it.

```
aschapelle@vaio3:~/git_practice$ touch REAMDE.md TODO.md
```

4.Write in `REAMDE.md` file description of the project and what you think it might be.

```
aschapelle@vaio3:~/git_practice$ echo "This is readme file for git_practice project" > READM
        aschapelle@vaio3:~/git_practice$echo "This is todo file for git_practice project" >
```

5.Initialize your project with `git` command, setup your username, mail and remote server.

```
aschapelle@vaio3:~/git_practice$ git init
        aschapelle@vaio3:~/git_practice$ git config user.name alex.schapelle
      aschapelle@vaio3:~/git_practice$ git config user.mail alex@vaiolabs.com
     aschapelle@vaio3:~/git_practice$ git remote add origin https://gitlab.com/url_to_you
```

6.Use `git push -u origin master` to send project saves to remote host.

```
        aschapelle@vaio3:~/git_practice$ git push -u origin master
```

7.Verify on `gitlab.com` that the project has been setup and is updated with `REAMDE.md` and `TODO.md`.

8.Add git_hello.sh script that prints hello to username from its current location.

```
aschapelle@vaio3:~/git_practice$ git push -u origin master
```

9.Push the script to gitlab repository.

```
        aschapelle@vaio3:~/git_practice$ git push -u origin master
```

Part IX.

ipv6

24. Introduction to ipv6

(Written by Paul Cobbaut, https://github.com/paulcobbaut/, with contributions by: Alex M. Schapelle, https://github.com/zero-pytagoras/)

24.1. 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 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:

```
fe80:0:0:0: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`.

```
student@linux:~/github/lt/images$ /sbin/ifconfig lo | grep inet6
          inet6 addr: ::1/128 Scope:Host
```

24.2. 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
```

24.3. host part generation

The host part of an automatically generated (stateless) ipv6 address contains part of the hosts mac address:

```
student@linux:~$ /sbin/ifconfig | head -3
eth3      Link encap:Ethernet  HWaddr 08:00:27:ab:67:30
          inet addr:192.168.1.29  Bcast:192.168.1.255  Mask:255.255.255.0
          inet6 addr: fe80::a00:27ff:feab:6730/64 Scope:Link
```

Some people are concerned about privacy here...

24.4. 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...

24.5. 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`.

```
student@linux:~$ /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.

24.6. 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..`.

24.7. 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.

24.8. 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:

```
2002:c0a8:12a:18::1
```

You can use the command below to convert any ipv4 address to this range.

```
student@linux:~$ printf "2002:%02x%02x:%02x%02x:%04x::1\n" `echo 192.168.1.42/24 \
|tr "./" "  "`
2002:c0a8:012a:0018::1
```

24.9. ISP

Should you be so lucky to get an ipv6 address from an `isp`, then it will start with `2001:`.

24.10. 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
```

24.11. 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
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 recieves replies from three ip6 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:fecd:7ffc: icmp_seq=1 ttl=64 time=1.87 ms (DUP!)
64 bytes from fe80::8e7b:9dff:fed6:dff2: 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::8e7b:9dff:fed6:dff2: icmp_seq=2 ttl=64 time=1.79 ms (DUP!)
64 bytes from fe80::a00:27ff:fecd:7ffc: icmp_seq=2 ttl=64 time=2.48 ms (DUP!)
```

24.12. 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).

24.13. other websites

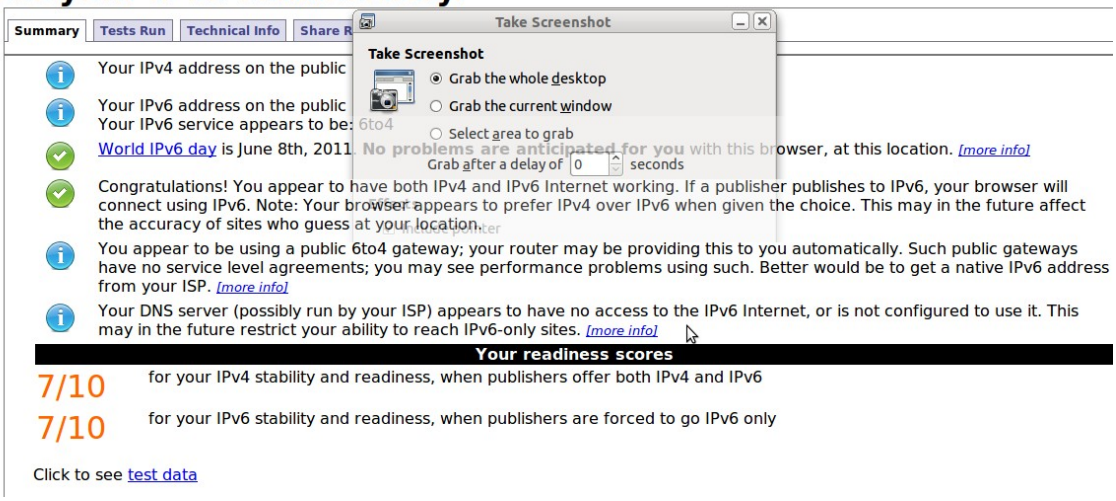
Other useful websites for testing ipv6 are:

```
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.



24.14. 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 gatway.

For example use http://www.slashdot.org.sixxs.org/ instead of http://slashdot.org

24.15. ping6 and dns

Below a screenshot of a `ping6` from behind a 6to4 connection.

```
81.165.101.125          195.130.131.4           DNS     Standard query AAAA ipv6-test.com
195.130.131.4           81.165.101.125          DNS     Standard query response AAAA 2001:41d0:2:67d1::7e57:1
2002:51a5:657d::1       2001:41d0:2:67d1::7e57:1 ICMPv6 Echo request
2001:41d0:2:67d1::7e57:1 2002:51a5:657d::1      ICMPv6  Echo reply
2002:51a5:657d::1       2001:41d0:2:67d1::7e57:1 ICMPv6 Echo request
2001:41d0:2:67d1::7e57:1 2002:51a5:657d::1      ICMPv6  Echo reply
```

24.16. ipv6 and tcp/http

Below a screenshot of a tcp handshake and http connection over ipv6.

Source	Destination	Protocol	Info
2002:51a5:657d::1	2001:41d0:2:67d1::7e57:1	TCP	38036 > http [SYN] Seq=0 Win=5648 L
2001:41d0:2:67d1::7e57:1	2002:51a5:657d::1	TCP	http > 38036 [SYN, ACK] Seq=0 Ack=1
2002:51a5:657d::1	2001:41d0:2:67d1::7e57:1	TCP	38036 > http [ACK] Seq=1 Ack=1 Win=
2002:51a5:657d::1	2001:41d0:2:67d1::7e57:1	HTTP	GET /json/addrinfo.php?PHPSESSID=19
2001:41d0:2:67d1::7e57:1	2002:51a5:657d::1	TCP	http > 38036 [ACK] Seq=1 Ack=708 Wi
2001:41d0:2:67d1::7e57:1	2002:51a5:657d::1	HTTP	HTTP/1.1 200 OK (text/javascript)

24.17. 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.

```
▷ Frame 46 (132 bytes on wire, 132 bytes captured)
▷ Ethernet II, Src: Apple_5d:2e:52 (00:26:bb:5d:2e:52), Dst: Riverdel_cf:6a:10 (00:30:b8:cf:6a:10)
▷ Internet Protocol, Src: 81.165.101.125 (81.165.101.125), Dst: 195.130.131.4 (195.130.131.4)
▷ User Datagram Protocol, Src Port: 34361 (34361), Dst Port: domain (53)
▽ Domain Name System (query)
    [Response In: 47]
    Transaction ID: 0xcfe3
  ▷ Flags: 0x0100 (Standard query)
    Questions: 1
    Answer RRs: 0
    Authority RRs: 0
    Additional RRs: 0
  ▽ Queries
    ▷ 1.0.0.0.7.5.e.7.0.0.0.0.0.0.0.0.1.d.7.6.2.0.0.0.0.d.1.4.1.0.0.2.ip6.arpa: type PTR, class IN
```

24.18. 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@linux:~# ifconfig
eth0      Link encap:Ethernet  HWaddr 00:26:bb:5d:2e:52
          inet addr:81.165.101.125  Bcast:255.255.255.255  Mask:255.255.248.0
          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:0×8000

lo        Link encap: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@linux:~# sysctl -w net.ipv6.conf.default.forwarding=1
net.ipv6.conf.default.forwarding = 1
root@linux:~# ip tunnel add tun6to4 mode sit remote any local 81.165.101.125
root@linux:~# ip link set dev tun6to4 mtu 1472 up
root@linux:~# 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@linux:~# ip -6 addr add dev tun6to4 2002:51a5:657d:0::1/64
root@linux:~# ip -6 addr add dev eth0 2002:51a5:657d:1::1/64
root@linux:~# ip -6 addr add dev eth0 fdcb:43c1:9c18:1::1/64
root@linux:~# ifconfig
eth0      Link encap:Ethernet  HWaddr 00:26:bb:5d:2e:52
          inet addr:81.165.101.125  Bcast:255.255.255.255  Mask:255.255.248.0
          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:0×8000

lo        Link encap: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 encap: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@linux:~# ip -6 route add 2002::/16 dev tun6to4
root@linux:~# ip -6 route add ::/0 via ::192.88.99.1 dev tun6to4 metric 1
root@linux:~# ip -6 route show
::/96 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
2002::/16 dev tun6to4  metric 1024  mtu 1472 advmss 1412 hoplimit 0
fdcb:43c1:9c18:1::/64 dev eth0  proto kernel  metric 256  mtu 1500 advmss 1440 hoplimit 0
fe80::/64 dev eth0  proto kernel  metric 256  mtu 1500 advmss 1440 hoplimit 0
fe80::/64 dev tun6to4  proto kernel  metric 256  mtu 1472 advmss 1412 hoplimit 0
default via ::192.88.99.1 dev tun6to4  metric 1  mtu 1472 advmss 1412 hoplimit 0
root@linux:~# 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
```

A. cloning

(Written by Paul Cobbaut, https://github.com/paulcobbaut/)

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@linux ~]# 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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