Ubuntu Server Guide
Ubuntu Server Guide

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Abstract

Welcome to the Ubuntu Server Guide! It contains information on how to install and configure various server applications on your Ubuntu system to fit your needs. It is a step-by-step, task-oriented guide for configuring and customizing your system.

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1 https://launchpad.net/~ubuntu-core-doc
2 /usr/share/ubuntu-docs/libs/C/ccbysa.xml
3 https://launchpad.net/~ubuntu-core-doc/lib/C/ccbysa.xml


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Chapter 1. Introduction

Welcome to the Ubuntu Server Guide!

Here you can find information on how to install and configure various server applications. It is a step-by-step, task-oriented guide for configuring and customizing your system.

This guide assumes you have a basic understanding of your Ubuntu system. Some installation details are covered in Chapter 2, Installation [p. 3], but if you need detailed instructions installing Ubuntu please refer to the Ubuntu Installation Guide1.

A HTML version of the manual is available online at the Ubuntu Documentation website2. The HTML files are also available in the ubuntu-serverguide package. See Chapter 3, Package Management [p. 17] for details on installing packages.

If you choose to install the ubuntu-serverguide you can view this document from a console by:

```
w3m /usr/share/ubuntu-serverguide/html/en_GB/index.html
```

Replace en_GB with your language localization.

---

2 http://help.ubuntu.com
1. Support

There a couple of different ways that Ubuntu Server Edition is supported, commercial support and community support. The main commercial support (and development funding) is available from Canonical Ltd. They supply reasonably priced support contracts on a per desktop or per server basis. For more information see the Canonical Services\(^3\) page.

Community support is also provided by dedicated individuals, and companies, that wish to make Ubuntu the best distribution possible. Support is provided through multiple mailing lists, IRC channels, forums, blogs, wikis, etc. The large amount of information available can be overwhelming, but a good search engine query can usually provide an answer to your questions. See the Ubuntu Support\(^4\) page for more information.

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\(^3\) http://www.canonical.com/services/support
\(^4\) http://www.ubuntu.com/support
Chapter 2. Installation

This chapter provides a quick overview of installing Ubuntu 9.04 Server Edition. For more detailed instructions, please refer to the Ubuntu Installation Guide¹.

1. Preparing to Install

This section explains various aspects to consider before starting the installation.

1.1. System Requirements

Ubuntu 9.04 Server Edition supports two (2) major architectures: Intel x86 and AMD64. The table below lists recommended hardware specifications. Depending on your needs, you might manage with less than this. However, most users risk being frustrated if they ignore these suggestions.

Table 2.1. Recommended Minimum Requirements

<table>
<thead>
<tr>
<th>Install Type</th>
<th>RAM</th>
<th>Hard Drive Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server</td>
<td>128 megabytes</td>
<td>500 megabytes</td>
</tr>
</tbody>
</table>

The Server Edition provides a common base for all sorts of server applications. It is a minimalist design providing a platform for the desired services, such as file/print services, web hosting, email hosting, etc.

1.2. Server and Desktop Differences

There are a few differences between the Ubuntu Server Edition and the Ubuntu Desktop Edition. It should be noted that both editions use the same apt repositories. Making it just as easy to install a server application on the Desktop Edition as it is on the Server Edition.

The differences between the two editions are the lack of an X window environment in the Server Edition, the installation process, and different Kernel options.

1.2.1. Kernel Differences:

- Preemption is turned off in the Server Edition.
- The timer interrupt is 100 Hz in the Server Edition and 250 Hz in the Desktop Edition.

When running a 64-bit version of Ubuntu on 64-bit processors you are not limited by memory addressing space.

To see all kernel configuration options you can look through /boot/config-2.6.27-server. Also, Linux Kernel in a Nutshell² is a great resource on the options available.

² http://www.kroah.com/lkn/
1.3. Backing Up

- Before installing Ubuntu Server Edition you should make sure all data on the system is backed up. See Chapter 16, Backups [p. 213] for backup options.

If this is not the first time an operating system has been installed on your computer, it is likely you will need to re-partition your disk to make room for Ubuntu.

Any time you partition your disk, you should be prepared to lose everything on the disk should you make a mistake or something goes wrong during partitioning. The programs used in installation are quite reliable, most have seen years of use, but they also perform destructive actions.
2. Installing from CD

The basic steps to install Ubuntu Server Edition from CD are the same for installing any operating system from CD. Unlike the Desktop Edition the Server Edition does not include a graphical installation program. Instead the Server Edition uses a console menu based process.

• First, download and burn the appropriate ISO file from the Ubuntu website.
• Boot the system from the CD-ROM drive.
• At the boot prompt you will be asked to select the language. Afterwards the installation process begins by asking for your keyboard layout.
• The installer then discovers your hardware configuration, and configures the network settings using DHCP. If you do not wish to use DHCP at the next screen choose "Go Back", and you have the option to "Configure the network manually".
• Next, the installer asks for the system's hostname and Time Zone.
• You can then choose from several options to configure the hard drive layout. For advanced disk options see Section 4, "Advanced Installation" [p. 10].
• The Ubuntu base system is then installed.
• A new user is setup, this user will have root access through the sudo utility.
• After the user is setup, you will be asked to encrypt your home directory.
• The next step in the installation process is to decide how you want to update the system. There are three options:
  • No automatic updates: this requires an administrator to log into the machine and manually install updates.
  • Install security updates Automatically: will install the unattended-upgrades package, which will install security updates without the intervention of an administrator. For more details see Section 5, “Automatic Updates” [p. 24].
  • Manage the system with Landscape: Landscape is a paid service provided by Canonical to help manager your Ubuntu machines. See the Landscape site for details.
• You now have the option to install, or not install, several package tasks. See Section 2.1, “Package Tasks” [p. 7] for details. Also, there is an option to launch aptitude to choose specific packages to install. For more information see Section 4, “Aptitude” [p. 22].
• Finally, the last step before rebooting is to set the clock to UTC.

If at any point during installation you are not satisfied by the default setting, use the "Go Back" function at any prompt to be brought to a detailed installation menu that will allow you to modify the default settings.

At some point during the installation process you may want to read the help screen provided by the installation system. To do this, press F1.
Once again, for detailed instructions see the *Ubuntu Installation Guide*.

### 2.1. Package Tasks

During the Server Edition installation you have the option of installing additional packages from the CD. The packages are grouped by the type of service they provide.

- **DNS server**: Selects the BIND DNS server and its documentation.
- **LAMP server**: Selects a ready-made Linux/Apache/MySQL/PHP server.
- **Mail server**: This task selects a variety of package useful for a general purpose mail server system.
- **OpenSSH server**: Selects packages needed for an OpenSSH server.
- **PostgreSQL database**: This task selects client and server packages for the PostgreSQL database.
- **Print server**: This task sets up your system to be a print server.
- **Samba File server**: This task sets up your system to be a Samba file server, which is especially suitable in networks with both Windows and Linux systems.
- **Tomcat server**: Installs the Apache Tomcat and needed dependencies Java, gcj, etc.
- **Virtual machine host**: Includes packages needed to run KVM virtual machines.

Installing the package groups is accomplished using the `tasksel` utility. One of the important difference between Ubuntu (or Debian) and other GNU/Linux distribution is that, when installed, a package is also configured to reasonable defaults, eventually prompting you for additional required information. Likewise, when installing a task, the packages are not only installed, but also configured to provided a fully integrated service.

Once the installation process has finished you can view a list of available tasks by entering the following from a terminal prompt:

```
tasksel --list-tasks
```

The output will list tasks from other Ubuntu based distributions such as Kubuntu and Edubuntu. Note that you can also invoke the `tasksel` command by itself, which will bring up a menu of the different tasks available.

You can view a list of which packages are installed with each task using the `--task-packages` option. For example, to list the packages installed with the *DNS Server* task enter the following:

```
tasksel --task-packages dns-server
```

The output of the command should list:

```
bind9-doc
```

---

bind9

Also, if you did not install one of the tasks during the installation process, but for example you decide to make your new LAMP server a DNS server as well. Simply insert the installation CD and from a terminal:

```
sudo tasksel install dns-server
```
3. Upgrading

There are several ways to upgrade from one Ubuntu release to another. This section gives an overview of the recommended upgrade method.

3.1. do-release-upgrade

The recommended way to upgrade a Server Edition installation is to use the do-release-upgrade utility. Part of the update-manager-core package, it does not have any graphical dependencies and is installed by default.

Debian based systems can also be upgraded by using apt-get dist-upgrade. However, using do-release-upgrade is recommended because it has the ability to handle system configuration changes sometimes needed between releases.

To upgrade to a newer release, from a terminal prompt enter:

```
do-release-upgrade
```

It is also possible to use do-release-upgrade to upgrade to a development version of Ubuntu. To accomplish this use the `-d` switch:

```
do-release-upgrade -d
```

Upgrading to a development release is not recommended for production environments.
4. Advanced Installation

4.1. Software RAID

RAID is a method of configuring multiple hard drives to act as one, reducing the probability of catastrophic data loss in case of drive failure. RAID is implemented in either software (where the operating system knows about both drives and actively maintains both of them) or hardware (where a special controller makes the OS think there's only one drive and maintains the drives 'invisibly').

The RAID software included with current versions of Linux (and Ubuntu) is based on the 'mdadm' driver and works very well, better even than many so-called 'hardware' RAID controllers. This section will guide you through installing Ubuntu Server Edition using two RAID1 partitions on two physical hard drives, one for / and another for swap.

4.1.1. Partitioning

Follow the installation steps until you get to the Partition disks step, then:

1. Select Manual as the partition method.
2. Select the first hard drive, and agree to "Create a new empty partition table on this device?".

   Repeat this step for each drive you wish to be part of the RAID array.
3. Select the "FREE SPACE" on the first drive then select "Create a new partition".
4. Next, select the Size of the partition. This partition will be the swap partition, and a general rule for swap size is twice that of RAM. Enter the partition size, then choose Primary, then Beginning.
5. Select the "Use as:" line at the top. By default this is "Ext3 journaling file system", change that to "physical volume for RAID" then "Done setting up partition".
6. For the / partition once again select "Free Space" on the first drive then "Create a new partition".
7. Use the rest of the free space on the drive and choose Continue, then Primary.
8. As with the swap partition, select the "Use as:" line at the top, changing it to "physical volume for RAID" then choose "Done setting up partition".
9. Repeat steps three through eight for the other disk and partitions.

4.1.2. RAID Configuration

With the partitions setup the arrays are ready to be configured:

1. Back in the main "Partition Disks" page, select "Configure Software RAID" at the top.
2. Select "yes" to write the changes to disk.
3. Choose "Create MD drive".
4. For this example, select "RAID1", but if you are using a different setup choose the appropriate type (RAID0 RAID1 RAID5).

In order to use RAID5 you need at least three drives. Using RAID0 or RAID1 only two drives are required.

5. Enter the number of active devices “2”, or the amount of hard drives you have, for the array. Then select "Continue".

6. Next, enter the number of spare devices “0” by default, then choose "Continue".

7. Choose which partitions to use. Generally they will be sda1, sdb1, sdc1, etc. The numbers will usually match and the different letters correspond to different hard drives.

For the swap partition choose sda1 and sdb1. Select "Continue" to go to the next step.

8. Repeat steps three through seven for the / partition choosing sda2 and sdb2.

9. Once done select "Finish".

4.1.3. Formatting

There should now be a list of hard drives and RAID devices. The next step is to format and set the mount point for the RAID devices. Treat the RAID device as a local hard drive, format and mount accordingly.

1. Select the RAID1 device #0 partition.

2. Choose "Use as:”. Then select "swap area", then "Done setting up partition".

3. Next, select the RAID1 device #1 partition.

4. Choose "Use as:”. Then select "Ext3 journaling file system”.

5. Then select the "Mount point" and choose "/ - the root file system”. Change any of the other options as appropriate, then select "Done setting up partition".

6. Finally, select "Finish partitioning and write changes to disk".

If you choose to place the root partition on a RAID array, the installer will then ask if you would like to boot in a degraded state. See Section 4.1.4, “Degraded RAID” [p. 11] for further details.

The installation process will then continue normally.

4.1.4. Degraded RAID

At some point in the life of the computer a disk failure event may occur. When this happens, using Software RAID, the operating system will place the array into what is known as a degraded state.

If the array has become degraded, due to the chance of data corruption, by default Ubuntu Server Edition will boot to initramfs after thirty seconds. Once the initramfs has booted there is a fifteen second prompt giving you the option to go ahead and boot the system, or attempt manual recover.

Booting to the initramfs prompt may or may not be the desired behavior, especially if the machine is in a remote location. Booting to a degraded array can be configured several ways:
• The dpkg-reconfigure utility can be used to configure the default behavior, and during the process you will be queried about additional settings related to the array. Such as monitoring, email alerts, etc. To reconfigure mdadm enter the following:

```bash
sudo dpkg-reconfigure mdadm
```

• The `dpkg-reconfigure mdadm` process will change the `/etc/initramfs-tools/conf.d/mdadm` configuration file. The file has the advantage of being able to pre-configure the system's behavior, and can also be manually edited:

```bash
BOOT_DEGRADED=true
```

The configuration file can be overridden by using a Kernel argument.

• Using a Kernel argument will allow the system to boot to a degraded array as well:
  
  • When the server is booting press `ESC` to open the Grub menu.
  • Press "e" to edit your Kernel command options.
  • Press the `DOWN` arrow to highlight the kernel line.
  • Press the "e" key again to edit the kernel line.
  • Add "bootdegraded=true" (without the quotes) to the end of the line.
  • Press "ENTER".
  • Finally, press "b" to boot the system.

Once the system has booted you can either repair the array see Section 4.1.5, “RAID Maintenance” [p. 12] for details, or copy important data to another machine due to major hardware failure.

### 4.1.5. RAID Maintenance

The mdadm utility can be used to view the status of an array, add disks to an array, remove disks, etc:

• To view the status of an array, from a terminal prompt enter:

```bash
sudo mdadm -D /dev/md0
```

The `-D` tells mdadm to display detailed information about the `/dev/md0` device. Replace `/dev/md0` with the appropriate RAID device.

• To view the status of a disk in an array:

```bash
sudo mdadm -E /dev/sda1
```

The output if very similar to the `mdadm -D` command, adjust `/dev/sda1` for each disk.

• If a disk fails and needs to be removed from an array enter:
**Installation**

```
sudo mdadm --remove /dev/md0 /dev/sda1
```

Change `/dev/md0` and `/dev/sda1` to the appropriate RAID device and disk.

- Similarly, to add a new disk:

```
sudo mdadm --add /dev/md0 /dev/sda1
```

Sometimes a disk can change to a *faulty* state even though there is nothing physically wrong with the drive. It is usually worthwhile to remove the drive from the array then re-add it. This will cause the drive to re-sync with the array. If the drive will not sync with the array, it is a good indication of hardware failure.

The `/proc/mdstat` file also contains useful information about the system's RAID devices:

```
cat /proc/mdstat
```

```
Personalities : [linear] [multipath] [raid0] [raid1] [raid6] [raid5] [raid4] [raid10]
md0 : active raid1 sda1[0] sdb1[1]
     10016384 blocks [2/2] [UU]

unused devices: <none>
```

The following command is great for watching the status of a syncing drive:

```
watch -n1 cat /proc/mdstat
```

Press `Ctrl+c` to stop the watch command.

If you do need to replace a faulty drive, after the drive has been replaced and synced, `grub` will need to be installed. To install `grub` on the new drive, enter the following:

```
sudo grub-install /dev/md0
```

Replace `/dev/md0` with the appropriate array device name.

4.1.6. Resources

The topic of RAID arrays is a complex one due to the plethora of ways RAID can be configured. Please see the following links for more information:

- *Software RAID HOWTO*[^6]
- *Managing RAID on Linux*[^7]

4.2. Logical Volume Manager (LVM)

Logical Volume Manager, or *LVM*, allows administrators to create *logical* volumes out of one or multiple physical hard disks. LVM volumes can be created on both software RAID partitions and

[^6]: [Software RAID HOWTO](https://tldp.org/HOWTO/Software-RAID-HOWTO/)
[^7]: [Managing RAID on Linux](https://www.ibm.com/support/knowledgecenter/SSLTN_1.2.2/ls200/ls200_managing_RAID.html)
standard partitions residing on a single disk. Volumes can also be extended, giving greater flexibility to systems as requirements change.

4.2.1. Overview

A side effect of LVM’s power and flexibility is a greater degree of complication. Before diving into the LVM installation process, it is best to get familiar with some terms.

- **Volume Group (VG)**: contains one or several Logical Volumes (LV).
- **Logical Volume (LV)**: is similar to a partition in a non-LVM system. Multiple Physical Volumes (PV) can make up one LV, on top of which resides the actual EXT3, XFS, JFS, etc filesystem.
- **Physical Volume (PV)**: physical hard disk or software RAID partition. The Volume Group can be extended by adding more PVs.

4.2.2. Installation

As an example this section covers installing Ubuntu Server Edition with /srv mounted on a LVM volume. During the initial install only one Physical Volume (PV) will be part of the Volume Group (VG). Another PV will be added after install to demonstrate how a VG can be extended.

There are several installation options for LVM, "Guided - use the entire disk and setup LVM" which will also allow you to assign a portion of the available space to LVM, "Guided - use entire and setup encrypted LVM", or Manually setup the partitions and configure LVM. At this time the only way to configure a system with both LVM and standard partitions, during installation, is to use the Manual approach.

1. Follow the installation steps until you get to the Partition disks step, then:
2. At the "Partition Disks" screen choose "Manual".
3. Select the hard disk and on the next screen choose "yes" to "Create a new empty partition table on this device".
4. Next, create standard /boot, swap, and / partitions with whichever filesystem you prefer.
5. For the LVM /srv, create a new Logical partition. Then change "Use as" to "physical volume for LVM" then "Done setting up the partition".
6. Now select "Configure the Logical Volume Manager" at the top, and choose "Yes" to write the changes to disk.
7. For the "LVM configuration action" on the next screen, choose "Create volume group". Enter a name for the VG such as vg01, or something more descriptive. After entering a name, select the partition configured for LVM, and choose "Continue".
8. Back at the "LVM configuration action" screen, select "Create logical volume". Select the newly created volume group, and enter a name for the new LV, for example srv since that is the intended mount point. Then choose a size, which may be the full partition because it can always be extended later. Choose "Finish" and you should be back at the main "Partition Disks" screen.
9. Now add a filesystem to the new LVM. Select the partition under "LVM VG vg01, LV srv", or whatever name you have chosen, the choose Use as. Setup a file system as normal selecting /srv as the mount point. Once done, select "Done setting up the partition".

10. Finally, select "Finish partitioning and write changes to disk". Then confirm the changes and continue with the rest of the installation.

There are some useful utilities to view information about LVM:
- `vgdisplay`: shows information about Volume Groups.
- `lvdisplay`: has information about Logical Volumes.
- `pvdisplay`: similarly displays information about Physical Volumes.

### 4.2.3. Extending Volume Groups

Continuing with `srv` as an LVM volume example, this section covers adding a second hard disk, creating a Physical Volume (PV), adding it to the volume group (VG), extending the logical volume `srv` and finally extending the filesystem. This example assumes a second hard disk has been added to the system. This hard disk will be named `/dev/sdb` in our example. **Beware**: make sure you don't already have an existing `/dev/sdb` before issuing the commands below. You could lose some data if you issue those commands on a non-empty disk. In our example we will use the entire disk as a physical volume (you could choose to create partitions and use them as different physical volumes)

1. First, create the physical volume, in a terminal execute:

   ```bash
   sudo pvcreate /dev/sdb
   ```

2. Now extend the Volume Group (VG):

   ```bash
   sudo vgextend vg01 /dev/sdb
   ```

3. Use `vgdisplay` to find out the free physical extents - Free PE / size (the size you can allocate). We will assume a free size of 511 PE (equivalent to 2GB with a PE size of 4MB) and we will use the whole free space available. Use your own PE and/or free space.

   The Logical Volume (LV) can now be extended by different methods, we will only see how to use the PE to extend the LV:

   ```bash
   sudo lvextend /dev/vg01/srv -l +511
   ```

   The `-l` option allows the LV to be extended using PE. The `-L` option allows the LV to be extended using Meg, Gig, Tera, etc bytes.

4. Even though you are supposed to be able to `expand` an ext3 or ext4 filesystem without unmounting it first, it may be a good pratice to unmount it anyway and check the filesystem, so that you don't mess up the day you want to reduce a logical volume (in that case unmounting first is compulsory).
The following commands are for an *EXT3* or *EXT4* filesystem. If you are using another filesystem there may be other utilities available.

```
sudo umount /srv
sudo e2fsck -f /dev/vg01/srv
```

The `-f` option of `e2fsck` forces checking even if the system seems clean.

5. Finally, resize the filesystem:

```
sudo resize2fs /dev/vg01/srv
```

6. Now mount the partition and check its size.

```
mount /dev/vg01/srv /srv && df -h /srv
```

4.2.4. Resources

- See the [*LVM HOWTO*](#) for more information.
- Another good article is *Managing Disk Space with LVM* on O'Reilly's linuxdevcenter.com site.
- For more information on fdisk see the [*fdisk man page*](#).
Chapter 3. Package Management

Ubuntu features a comprehensive package management system for the installation, upgrade, configuration, and removal of software. In addition to providing access to an organized base of over 24,000 software packages for your Ubuntu computer, the package management facilities also feature dependency resolution capabilities and software update checking.

Several tools are available for interacting with Ubuntu's package management system, from simple command-line utilities which may be easily automated by system administrators, to a simple graphical interface which is easy to use by those new to Ubuntu.
1. Introduction

Ubuntu's package management system is derived from the same system used by the Debian GNU/Linux distribution. The package files contain all of the necessary files, meta-data, and instructions to implement a particular functionality or software application on your Ubuntu computer.

Debian package files typically have the extension '.deb', and typically exist in repositories which are collections of packages found on various media, such as CD-ROM discs, or online. Packages are normally of the pre-compiled binary format; thus installation is quick and requires no compiling of software.

Many complex packages use the concept of dependencies. Dependencies are additional packages required by the principal package in order to function properly. For example, the speech synthesis package Festival depends upon the package libasound2, which is a package supplying the ALSA sound library needed for audio playback. In order for Festival to function, it and all of its dependencies must be installed. The software management tools in Ubuntu will do this automatically.
2. dpkg

dpkg is a package manager for Debian based systems. It can install, remove, and build packages, but unlike other package management system's it can not automatically download and install packages and their dependencies. This section covers using dpkg to manage locally installed packages:

- To list all packages installed on the system, from a terminal prompt enter:

  ```
dpkg -l
  ```

  Depending on the amount of packages on your system, this can generate a large amount of output. Pipe the output through grep to see if a specific package is installed:

  ```
dpkg -l | grep apache2
  ```

  Replace `apache2` with any package name, part of a package name, or other regular expression.

- To list the files installed by a package, in this case the ufw package, enter:

  ```
dpkg -L ufw
  ```

- If you are not sure which package installed a file, dpkg -S may be able to tell you. For example:

  ```
dpkg -S /etc/host.conf
  ```

  The output shows that the `/etc/host.conf` belongs to the base-files package.

  Many files are automatically generated during the package install process, and even though they are on the filesystem dpkg -S may not know which package they belong to.

- You can install a local .deb file by entering:

  ```
sudo dpkg -i zip_2.32-1_i386.deb
  ```

  Change `zip_2.32-1_i386.deb` to the actual file name of the local .deb file.

- Uninstalling a package can be accomplished by:

  ```
sudo dpkg -r zip
  ```

  Uninstalling packages using dpkg, in most cases, is *NOT* recommended. It is better to use a package manager that handles dependencies, to ensure that the system is in a consistent state. For example using dpkg -r you can remove the zip package, but any packages that depend on it will still be installed and may no longer function correctly.

For more dpkg options see the man page: `man dpkg`. 
3. Apt-Get

The apt-get command is a powerful command-line tool used to work with Ubuntu's Advanced Packaging Tool (APT) performing such functions as installation of new software packages, upgrade of existing software packages, updating of the package list index, and even upgrading the entire Ubuntu system.

Being a simple command-line tool, apt-get has numerous advantages over other package management tools available in Ubuntu for server administrators. Some of these advantages include ease of use over simple terminal connections (SSH) and the ability to be used in system administration scripts, which can in turn be automated by the cron scheduling utility.

Some examples of popular uses for the apt-get utility:

- **Install a Package**: Installation of packages using the apt-get tool is quite simple. For example, to install the network scanner *nmap*, type the following:

  ```
  sudo apt-get install nmap
  ```

- **Remove a Package**: Removal of a package or packages is also a straightforward and simple process. To remove the nmap package installed in the previous example, type the following:

  ```
  sudo apt-get remove nmap
  ```

  **Multiple Packages**: You may specify multiple packages to be installed or removed, separated by spaces.

  Also, adding the `--purge` options to `apt-get remove` will remove the package configuration files as well. This may or may not be the desired effect so use with caution.

- **Update the Package Index**: The APT package index is essentially a database of available packages from the repositories defined in the `/etc/apt/sources.list` file. To update the local package index with the latest changes made in repositories, type the following:

  ```
  sudo apt-get update
  ```

- **Upgrade Packages**: Over time, updated versions of packages currently installed on your computer may become available from the package repositories (for example security updates). To upgrade your system, first update your package index as outlined above, and then type:

  ```
  sudo apt-get upgrade
  ```

  For information on upgrading to a new Ubuntu release see *Section 3, “Upgrading” [p. 9]*.

Actions of the apt-get command, such as installation and removal of packages, are logged in the /var/log/dpkg.log log file.
For further information about the use of APT, read the comprehensive *Debian APT User Manual*\(^1\) or type:

`apt-get help`

---

\(^1\) [http://www.debian.org/doc/user-manuals/apt-howto](http://www.debian.org/doc/user-manuals/apt-howto)
4. Aptitude

Aptitude is a menu-driven, text-based front-end to the Advanced Packaging Tool (APT) system. Many of the common package management functions, such as installation, removal, and upgrade, are performed in Aptitude with single-key commands, which are typically lowercase letters.

Aptitude is best suited for use in a non-graphical terminal environment to ensure proper functioning of the command keys. You may start Aptitude as a normal user with the following command at a terminal prompt:

```
sudo aptitude
```

When Aptitude starts, you will see a menu bar at the top of the screen and two panes below the menu bar. The top pane contains package categories, such as *New Packages* and *Not Installed Packages*. The bottom pane contains information related to the packages and package categories.

Using Aptitude for package management is relatively straightforward, and the user interface makes common tasks simple to perform. The following are examples of common package management functions as performed in Aptitude:

- **Install Packages**: To install a package, locate the package via the *Not Installed Packages* package category, for example, by using the keyboard arrow keys and the *ENTER* key, and highlight the package you wish to install. After highlighting the package you wish to install, press the *+* key, and the package entry should turn *green*, indicating it has been marked for installation. Now press *g* to be presented with a summary of package actions. Press *g* again, and you will be prompted to become root to complete the installation. Press *ENTER* which will result in a Password: prompt. Enter your user password to become root. Finally, press *g* once more and you'll be prompted to download the package. Press *ENTER* on the *Continue* prompt, and downloading and installation of the package will commence.

- **Remove Packages**: To remove a package, locate the package via the *Installed Packages* package category, for example, by using the keyboard arrow keys and the *ENTER* key, and highlight the package you wish to remove. After highlighting the package you wish to install, press the *-* key, and the package entry should turn *pink*, indicating it has been marked for removal. Now press *g* to be presented with a summary of package actions. Press *g* again, and you will be prompted to become root to complete the installation. Press *ENTER* which will result in a Password: prompt. Enter your user password to become root. Finally, press *g* once more, and you'll be prompted to download the package. Press *ENTER* on the *Continue* prompt, and removal of the package will commence.

- **Update Package Index**: To update the package index, simply press the *u* key and you will be prompted to become root to complete the update. Press *ENTER* which will result in a Password: prompt. Enter your user password to become root. Updating of the package index will commence. Press *ENTER* on the OK prompt when the download dialog is presented to complete the process.

- **Upgrade Packages**: To upgrade packages, perform the update of the package index as detailed above, and then press the *U* key to mark all packages with updates. Now press *g* whereby you'll be...
Presented with a summary of package actions. Press g again, and you will be prompted to become root to complete the installation. Press ENTER which will result in a Password: prompt. Enter your user password to become root. Finally, press g once more, and you'll be prompted to download the packages. Press ENTER on the Continue prompt, and upgrade of the packages will commence.

The first column of information displayed in the package list in the top pane, when actually viewing packages lists the current state of the package, and uses the following key to describe the state of the package:

- i: Installed package
- c: Package not installed, but package configuration remains on system
- p: Purged from system
- v: Virtual package
- B: Broken package
- u: Unpacked files, but package not yet configured
- C: Half-configured - Configuration failed and requires fix
- H: Half-installed - Removal failed and requires fix

To exit Aptitude, simply press the q key and confirm you wish to exit. Many other functions are available from the Aptitude menu by pressing the F10 key.
5. Automatic Updates

The unattended-upgrades package can be used to automatically install updated packages, and can be configured to update all packages or just install security updates. First, install the package by entering the following in a terminal:

```
sudo apt-get install unattended-upgrades
```

To configure unattended-upgrades, edit `/etc/apt/apt.conf.d/50unattended-upgrades` and adjust the following to fit your needs:

```
Unattended-Upgrade::Allowed-Origins {
    "Ubuntu jaunty-security";
    //      "Ubuntu jaunty-updates";
};
```

Certain packages can also be blacklisted and therefore will not be automatically updated. To blacklist a package, add it to the list:

```
Unattended-Upgrade::Package-Blacklist {
    //      "vim";
    //      "libc6";
    //      "libc6-dev";
    //      "libc6-i686";
};
```

The double “//” serve as comments, so whatever follows “//” will not be evaluated.

The results of unattended-upgrades will be logged to `/var/log/unattended-upgrades`.

5.1. Notifications

Configuring `Unattended-Upgrade::Mail` in `/etc/apt/apt.conf.d/50unattended-upgrades` will enable unattended-upgrades to email an administrator detailing any packages that need upgrading or have problems.

Another useful package is apticron. apticron will configure a cron job to email an administrator information about any packages on the system that need updated as well as a summary of changes in each package.

To install the apticron package, in a terminal enter:

```
sudo apt-get install apticron
```

Once the package is installed edit `/etc/apticron/apticron.conf`, to set the email address and other options:
EMAIL="root@example.com"
6. Configuration

Configuration of the Advanced Packaging Tool (APT) system repositories is stored in the /etc/apt/sources.list configuration file. An example of this file is referenced here, along with information on adding or removing repository references from the file.

Here is a simple example of a typical /etc/apt/sources.list file.

You may edit the file to enable repositories or disable them. For example, to disable the requirement of inserting the Ubuntu CD-ROM whenever package operations occur, simply comment out the appropriate line for the CD-ROM, which appears at the top of the file:

```bash
# no more prompting for CD-ROM please
# deb cdrom:[Ubuntu 9.04_Jaunty_Jackalope - Release i386 (20070419.1)] jaunty main restricted
```

6.1. Extra Repositories

In addition to the officially supported package repositories available for Ubuntu, there exist additional community-maintained repositories which add thousands more potential packages for installation. Two of the most popular are the Universe and Multiverse repositories. These repositories are not officially supported by Ubuntu, but because they are maintained by the community they generally provide packages which are safe for use with your Ubuntu computer.

Packages in the Multiverse repository often have licensing issues that prevent them from being distributed with a free operating system, and they may be illegal in your locality.

Be advised that neither the Universe or Multiverse repositories contain officially supported packages. In particular, there may not be security updates for these packages.

Many other package sources are available, sometimes even offering only one package, as in the case of package sources provided by the developer of a single application. You should always be very careful and cautious when using non-standard package sources, however. Research the source and packages carefully before performing any installation, as some package sources and their packages could render your system unstable or non-functional in some respects.

By default, the Universe and Multiverse repositories are enabled but if you would like to disable them edit /etc/apt/sources.list and comment the following lines:

```bash
deb http://archive.ubuntu.com/ubuntu jaunty universe multiverse
deb-src http://archive.ubuntu.com/ubuntu jaunty universe multiverse
deb http://us.archive.ubuntu.com/ubuntu/ jaunty universe
deb-src http://us.archive.ubuntu.com/ubuntu/ jaunty universe
```

2 ./sample/sources.list
7. References

Most of the material covered in this chapter is available in man pages, many of which are available online.

- For more dpkg details see the dpkg man page\(^3\).
- The APT HOWTO\(^4\) and apt-get man page\(^5\) contain useful information regarding apt-get usage.
- See the aptitude man page\(^6\) for more aptitude options.
- The Adding Repositories HOWTO (Ubuntu Wiki)\(^7\) page contains more details on adding repositories.
Chapter 4. Networking

Networks consist of two or more devices, such as computer systems, printers, and related equipment which are connected by either physical cabling or wireless links for the purpose of sharing and distributing information among the connected devices.

This section provides general and specific information pertaining to networking, including an overview of network concepts and detailed discussion of popular network protocols.
1. Network Configuration

Ubuntu ships with a number of graphical utilities to configure your network devices. This document is geared toward server administrators and will focus on managing your network on the command line.

1.1. Ethernet

Most Ethernet configuration is centralized in a single file, `/etc/network/interfaces`. If you have no Ethernet devices, only the loopback interface will appear in this file, and it will look something like this:

```
# This file describes the network interfaces available on your system
# and how to activate them. For more information, see interfaces(5).

# The loopback network interface
auto lo
iface lo inet loopback
address 127.0.0.1
netmask 255.0.0.0
```

If you have only one Ethernet device, `eth0`, and it gets its configuration from a DHCP server, and it should come up automatically at boot, only two additional lines are required:

```
auto eth0
iface eth0 inet dhcp
```

The first line specifies that the `eth0` device should come up automatically when you boot. The second line means that interface (“iface”) `eth0` should have an IPv4 address space (replace “inet” with “inet6” for an IPv6 device) and that it should get its configuration automatically from DHCP. Assuming your network and DHCP server are properly configured, this machine's network should need no further configuration to operate properly. The DHCP server will provide the default gateway (implemented via the `route` command), the device's IP address (implemented via the `ifconfig` command), and DNS servers used on the network (implemented in the `/etc/resolv.conf` file.)

To configure your Ethernet device with a static IP address and custom configuration, some more information will be required. Suppose you want to assign the IP address 192.168.0.2 to the device `eth1`, with the typical netmask of 255.255.255.0. Your default gateway's IP address is 192.168.0.1. You would enter something like this into `/etc/network/interfaces`:

```
iface eth1 inet static
   address 192.168.0.2
   netmask 255.255.255.0
   gateway 192.168.0.1
```

In this case, you will need to specify your DNS servers manually in `/etc/resolv.conf`, which should look something like this:
The `search` directive will append `mydomain.example` to hostname queries in an attempt to resolve names to your network. For example, if your network's domain is `mydomain.example` and you try to ping the host “mybox”, the DNS query will be modified to “mybox.mydomain.example” for resolution. The `nameserver` directives specify DNS servers to be used to resolve hostnames to IP addresses. If you use your own nameserver, enter it here. Otherwise, ask your Internet Service Provider for the primary and secondary DNS servers to use, and enter them into `/etc/resolv.conf` as shown above.

Many more configurations are possible, including dialup PPP interfaces, IPv6 networking, VPN devices, etc. Refer to man 5 interfaces for more information and supported options. Remember that `/etc/network/interfaces` is used by the `ifup/ifdown` scripts as a higher level configuration scheme than may be used in some other Linux distributions, and that the traditional, lower level utilities such as `ifconfig`, `route`, and `dhclient` are still available to you for ad hoc configurations.

### 1.2. Managing DNS Entries

This section explains how to configure which nameserver to use when resolving IP addresses to hostnames and vice versa. It does not explain how to configure the system as a name server.

To manage DNS entries, you can add, edit, or remove DNS names from the `/etc/resolv.conf` file. A sample file is given below:

```
search com
nameserver 204.11.126.131
nameserver 64.125.134.133
nameserver 64.125.134.132
nameserver 208.185.179.218
```

The search key specifies the string which will be appended to an incomplete hostname. Here, we have configured it to `com`. So, when we run `ping ubuntu` it would be interpreted as `ping ubuntu.com`.

The nameserver key specifies the nameserver IP address. It will be used to resolve a given IP address or hostname. This file can have multiple nameserver entries. The nameservers will be used by the network query in the same order.

If the DNS server names are retrieved dynamically from DHCP or PPPoE (retrieved from your ISP), do not add nameserver entries in this file. It will be overwritten.

### 1.3. Managing Hosts

To manage hosts, you can add, edit, or remove hosts from `/etc/hosts` file. The file contains IP addresses and their corresponding hostnames. When your system tries to resolve a hostname to an IP
Networking

address or determine the hostname for an IP address, it refers to the /etc/hosts file before using the name servers. If the IP address is listed in the /etc/hosts file, the name servers are not used. This behavior can be modified by editing /etc/nsswitch.conf at your peril.

If your network contains computers whose IP addresses are not listed in DNS, it is recommended that you add them to the /etc/hosts file.

1.4. Bridging

Bridging multiple interfaces is a more advanced configuration, but is very useful in multiple scenarios. One scenario is setting up a bridge with multiple network interfaces, then using a firewall to filter traffic between two network segments. Another scenario is using bridge on a system with one interface to allow virtual machines direct access to the outside network. The following example covers the latter scenario.

Before configuring a bridge you will need to install the bridge-utils package. To install the package, in a terminal enter:

```
sudo apt-get install bridge-utils
```

Next, configure the bridge by editing /etc/network/interfaces:

```
auto lo
iface lo inet loopback

auto br0
iface br0 inet static
     address 192.168.0.10
     network 192.168.0.0
     netmask 255.255.255.0
     broadcast 192.168.0.255
     gateway 192.168.0.1
     bridge_ports eth0
     bridge_fd 9
     bridge_hello 2
     bridge_maxage 12
     bridge_stp off
```

Enter the appropriate values for your physical interface and network.

Now restart networking to enable the bridge interface:

```
sudo /etc/init.d/networking restart
```

If setting up a bridge interface using Ubuntu Desktop Edition, or if dhcdbd is installed, the dhcdbd daemon will need to be stopped and disabled.
After configuring the bridge in `/etc/network/interfaces`, shutdown dhcddb by:

```
sudo /etc/init.d/dhcddb stop
```

Now to disable it from starting on boot enter:

```
sudo update-rc.d -f dhcddb remove
```

The new bridge interface should now be up and running. The brctl provides useful information about the state of the bridge, controls which interfaces are part of the bridge, etc. See `man brctl` for more information.

### 1.5. Resources

- The `interfaces man page`\(^1\) has details on more options for `/etc/network/interfaces`.
- For more information on DNS client configuration see the `resolver man page`\(^2\). Also, Chapter 6 of O'Reilly's `Linux Network Administrator's Guide`\(^3\) is a good source of resolver and name service configuration information.
- For more information on bridging see the `brctl man page`\(^4\) and the Linux Foundation's `Net:Bridge`\(^5\) page.
2. TCP/IP

The Transmission Control Protocol and Internet Protocol (TCP/IP) is a standard set of protocols developed in the late 1970s by the Defense Advanced Research Projects Agency (DARPA) as a means of communication between different types of computers and computer networks. TCP/IP is the driving force of the Internet, and thus it is the most popular set of network protocols on Earth.

2.1. TCP/IP Introduction

The two protocol components of TCP/IP deal with different aspects of computer networking. Internet Protocol, the "IP" of TCP/IP is a connectionless protocol which deals only with network packet routing using the IP Datagram as the basic unit of networking information. The IP Datagram consists of a header followed by a message. The Transmission Control Protocol is the "TCP" of TCP/IP and enables network hosts to establish connections which may be used to exchange data streams. TCP also guarantees that the data between connections is delivered and that it arrives at one network host in the same order as sent from another network host.

2.2. TCP/IP Configuration

The TCP/IP protocol configuration consists of several elements which must be set by editing the appropriate configuration files, or deploying solutions such as the Dynamic Host Configuration Protocol (DHCP) server which in turn, can be configured to provide the proper TCP/IP configuration settings to network clients automatically. These configuration values must be set correctly in order to facilitate the proper network operation of your Ubuntu system.

The common configuration elements of TCP/IP and their purposes are as follows:

- **IP address** The IP address is a unique identifying string expressed as four decimal numbers ranging from zero (0) to two-hundred and fifty-five (255), separated by periods, with each of the four numbers representing eight (8) bits of the address for a total length of thirty-two (32) bits for the whole address. This format is called dotted quad notation.

- **Netmask** The Subnet Mask (or simply, netmask) is a local bit mask, or set of flags which separate the portions of an IP address significant to the network from the bits significant to the subnetwork. For example, in a Class C network, the standard netmask is 255.255.255.0 which masks the first three bytes of the IP address and allows the last byte of the IP address to remain available for specifying hosts on the subnetwork.

- **Network Address** The Network Address represents the bytes comprising the network portion of an IP address. For example, the host 12.128.1.2 in a Class A network would use 12.0.0.0 as the network address, where twelve (12) represents the first byte of the IP address, (the network part) and zeroes (0) in all of the remaining three bytes to represent the potential host values. A network host using the private IP address 192.168.1.100 would in turn use a Network Address of 192.168.1.0, which specifies the first three bytes of the Class C 192.168.1 network and a zero (0) for all the possible hosts on the network.
• **Broadcast Address** The Broadcast Address is an IP address which allows network data to be sent simultaneously to all hosts on a given subnetwork rather than specifying a particular host. The standard general broadcast address for IP networks is 255.255.255.255, but this broadcast address cannot be used to send a broadcast message to every host on the Internet because routers block it. A more appropriate broadcast address is set to match a specific subnetwork. For example, on the private Class C IP network, 192.168.1.0, the broadcast address is 192.168.1.255. Broadcast messages are typically produced by network protocols such as the Address Resolution Protocol (ARP) and the Routing Information Protocol (RIP).

• **Gateway Address** A Gateway Address is the IP address through which a particular network, or host on a network, may be reached. If one network host wishes to communicate with another network host, and that host is not located on the same network, then a *gateway* must be used. In many cases, the Gateway Address will be that of a router on the same network, which will in turn pass traffic on to other networks or hosts, such as Internet hosts. The value of the Gateway Address setting must be correct, or your system will not be able to reach any hosts beyond those on the same network.

• **Nameserver Address** Nameserver Addresses represent the IP addresses of Domain Name Service (DNS) systems, which resolve network hostnames into IP addresses. There are three levels of Nameserver Addresses, which may be specified in order of precedence: The *Primary* Nameserver, the *Secondary* Nameserver, and the *Tertiary* Nameserver. In order for your system to be able to resolve network hostnames into their corresponding IP addresses, you must specify valid Nameserver Addresses which you are authorized to use in your system’s TCP/IP configuration. In many cases these addresses can and will be provided by your network service provider, but many free and publicly accessible nameservers are available for use, such as the Level3 (Verizon) servers with IP addresses from 4.2.2.1 to 4.2.2.6.

The IP address, Netmask, Network Address, Broadcast Address, and Gateway Address are typically specified via the appropriate directives in the file `/etc/network/interfaces`. The Nameserver Addresses are typically specified via `nameserver` directives in the file `/etc/resolv.conf`. For more information, view the system manual page for `interfaces` or `resolv.conf` respectively, with the following commands typed at a terminal prompt:

Access the system manual page for `interfaces` with the following command:

```
man interfaces
```

Access the system manual page for `resolv.conf` with the following command:

```
man resolv.conf
```
2.3. IP Routing

IP routing is a means of specifying and discovering paths in a TCP/IP network along which network data may be sent. Routing uses a set of *routing tables* to direct the forwarding of network data packets from their source to the destination, often via many intermediary network nodes known as *routers*. There are two primary forms of IP routing: *Static Routing* and *Dynamic Routing*.

Static routing involves manually adding IP routes to the system's routing table, and this is usually done by manipulating the routing table with the route command. Static routing enjoys many advantages over dynamic routing, such as simplicity of implementation on smaller networks, predictability (the routing table is always computed in advance, and thus the route is precisely the same each time it is used), and low overhead on other routers and network links due to the lack of a dynamic routing protocol. However, static routing does present some disadvantages as well. For example, static routing is limited to small networks and does not scale well. Static routing also fails completely to adapt to network outages and failures along the route due to the fixed nature of the route.

Dynamic routing depends on large networks with multiple possible IP routes from a source to a destination and makes use of special routing protocols, such as the Router Information Protocol (RIP), which handle the automatic adjustments in routing tables that make dynamic routing possible. Dynamic routing has several advantages over static routing, such as superior scalability and the ability to adapt to failures and outages along network routes. Additionally, there is less manual configuration of the routing tables, since routers learn from one another about their existence and available routes. This trait also eliminates the possibility of introducing mistakes in the routing tables via human error. Dynamic routing is not perfect, however, and presents disadvantages such as heightened complexity and additional network overhead from router communications, which does not immediately benefit the end users, but still consumes network bandwidth.

2.4. TCP and UDP

TCP is a connection-based protocol, offering error correction and guaranteed delivery of data via what is known as *flow control*. Flow control determines when the flow of a data stream needs to be stopped, and previously sent data packets should to be re-sent due to problems such as *collisions*, for example, thus ensuring complete and accurate delivery of the data. TCP is typically used in the exchange of important information such as database transactions.

The User Datagram Protocol (UDP), on the other hand, is a *connectionless* protocol which seldom deals with the transmission of important data because it lacks flow control or any other method to ensure reliable delivery of the data. UDP is commonly used in such applications as audio and video streaming, where it is considerably faster than TCP due to the lack of error correction and flow control, and where the loss of a few packets is not generally catastrophic.
2.5. ICMP

The Internet Control Messaging Protocol (ICMP) is an extension to the Internet Protocol (IP) as defined in the Request For Comments (RFC) #792 and supports network packets containing control, error, and informational messages. ICMP is used by such network applications as the ping utility, which can determine the availability of a network host or device. Examples of some error messages returned by ICMP which are useful to both network hosts and devices such as routers, include Destination Unreachable and Time Exceeded.

2.6. Daemons

Daemons are special system applications which typically execute continuously in the background and await requests for the functions they provide from other applications. Many daemons are network-centric; that is, a large number of daemons executing in the background on an Ubuntu system may provide network-related functionality. Some examples of such network daemons include the Hyper Text Transport Protocol Daemon (httpd), which provides web server functionality; the Secure SHell Daemon (sshd), which provides secure remote login shell and file transfer capabilities; and the Internet Message Access Protocol Daemon (imapd), which provides E-Mail services.

2.7. Resources

- There are man pages for TCP and IP that contain more useful information.
- Also, see the TCP/IP Tutorial and Technical Overview IBM Redbook.
- Another resource is O'Reilly's TCP/IP Network Administration.
3. Dynamic Host Configuration Protocol (DHCP)

The Dynamic Host Configuration Protocol (DHCP) is a network service that enables host computers to be automatically assigned settings from a server as opposed to manually configuring each network host. Computers configured to be DHCP clients have no control over the settings they receive from the DHCP server, and the configuration is transparent to the computer's user.

The most common settings provided by a DHCP server to DHCP clients include:
- IP-Address and Netmask
- DNS
- WINS

However, a DHCP server can also supply configuration properties such as:
- Host Name
- Domain Name
- Default Gateway
- Time Server
- Print Server

The advantage of using DHCP is that changes to the network, for example a change in the address of the DNS server, need only be changed at the DHCP server, and all network hosts will be reconfigured the next time their DHCP clients poll the DHCP server. As an added advantage, it is also easier to integrate new computers into the network, as there is no need to check for the availability of an IP address. Conflicts in IP address allocation are also reduced.

A DHCP server can provide configuration settings using two methods:

MAC Address
This method entails using DHCP to identify the unique hardware address of each network card connected to the network and then continually supplying a constant configuration each time the DHCP client makes a request to the DHCP server using that network device.

Address Pool
This method entails defining a pool (sometimes also called a range or scope) of IP addresses from which DHCP clients are supplied their configuration properties dynamically and on a "first come, first served" basis. When a DHCP client is no longer on the network for a specified period, the configuration is expired and released back to the address pool for use by other DHCP Clients.

Ubuntu is shipped with both DHCP server and client. The server is dhcpd (dynamic host configuration protocol daemon). The client provided with Ubuntu is dhclient and should be installed on all computers required to be automatically configured. Both programs are easy to install and configure and will be automatically started at system boot.

3.1. Installation

At a terminal prompt, enter the following command to install dhcpd:
`.sudo apt-get install dhcp3-server`

You will probably need to change the default configuration by editing `/etc/dhcp3/dhcpd.conf` to suit your needs and particular configuration.

You also need to edit `/etc/default/dhcp3-server` to specify the interfaces dhcpd should listen to. By default it listens to eth0.

NOTE: dhcpd's messages are being sent to syslog. Look there for diagnostics messages.

### 3.2. Configuration

The error message the installation ends with might be a little confusing, but the following steps will help you configure the service:

Most commonly, what you want to do is assign an IP address randomly. This can be done with settings as follows:

```
# Sample /etc/dhcpd.conf
# (add your comments here)
default-lease-time 600;
max-lease-time 7200;
option subnet-mask 255.255.255.0;
option broadcast-address 192.168.1.255;
option routers 192.168.1.254;
option domain-name-servers 192.168.1.1, 192.168.1.2;
option domain-name "mydomain.example";

subnet 192.168.1.0 netmask 255.255.255.0 {
    range 192.168.1.10 192.168.1.100;
    range 192.168.1.150 192.168.1.200;
}
```

This will result in the DHCP server giving a client an IP address from the range 192.168.1.10-192.168.1.100 or 192.168.1.150-192.168.1.200. It will lease an IP address for 600 seconds if the client doesn't ask for a specific time frame. Otherwise the maximum (allowed) lease will be 7200 seconds. The server will also "advise" the client that it should use 255.255.255.0 as its subnet mask, 192.168.1.255 as its broadcast address, 192.168.1.254 as the router/gateway and 192.168.1.1 and 192.168.1.2 as its DNS servers.

If you need to specify a WINS server for your Windows clients, you will need to include the netbios-name-servers option, e.g.

```
option netbios-name-servers 192.168.1.1;
```

Dhcpd configuration settings are taken from the DHCP mini-HOWTO, which can be found [here](http://www.tldp.org/HOWTO/DHCP/index.html).
3.3. References

- For more `/etc/dhcpc3/dchpd.conf` options see the `dhcpd.conf man page`\textsuperscript{11}.
- Also see the `DHCP FAQ`\textsuperscript{12}.
4. Time Synchronisation with NTP

This page describes methods for keeping your computer's time accurate. This is useful for servers, but is not necessary (or desirable) for desktop machines.

NTP is a TCP/IP protocol for synchronising time over a network. Basically a client requests the current time from a server, and uses it to set its own clock.

Behind this simple description, there is a lot of complexity - there are tiers of NTP servers, with the tier one NTP servers connected to atomic clocks (often via GPS), and tier two and three servers spreading the load of actually handling requests across the Internet. Also the client software is a lot more complex than you might think - it has to factor out communication delays, and adjust the time in a way that does not upset all the other processes that run on the server. But luckily all that complexity is hidden from you!

Ubuntu has two ways of automatically setting your time: ntpdate and ntpd.

4.1. ntpdate

Ubuntu comes with ntpdate as standard, and will run it once at boot time to set up your time according to Ubuntu's NTP server. However, a server's clock is likely to drift considerably between reboots, so it makes sense to correct the time occasionally. The easiest way to do this is to get cron to run ntpdate every day. With your favourite editor, as root, create a file `/etc/cron.daily/ntpdate` containing:

```
ntpdate ntp.ubuntu.com
```

The file `/etc/cron.daily/ntpdate` must also be executable.

```
sudo chmod 755 /etc/cron.daily/ntpdate
```

4.2. ntpd

ntpd is a bit of a blunt instrument - it can only adjust the time once a day, in one big correction. The ntp daemon ntpd is far more subtle. It calculates the drift of your system clock and continuously adjusts it, so there are no large corrections that could lead to inconsistent logs for instance. The cost is a little processing power and memory, but for a modern server this is negligible.

To set up ntpd:

```
sudo apt-get install ntp
```

4.3. Changing Time Servers

In both cases above, your system will use Ubuntu's NTP server at `ntp.ubuntu.com` by default. This is OK, but you might want to use several servers to increase accuracy and resilience, and you may want to use time servers that are geographically closer to you. To do this for ntpdate, change the contents of `/etc/cron.daily/ntpdate` to:
ntpdate ntp.ubuntu.com pool.ntp.org

And for ntpd edit /etc/ntp.conf to include additional server lines:

server ntp.ubuntu.com
server pool.ntp.org

You may notice pool.ntp.org in the examples above. This is a really good idea which uses round-robin DNS to return an NTP server from a pool, spreading the load between several different servers. Even better, they have pools for different regions - for instance, if you are in New Zealand, so you could use nz.pool.ntp.org instead of pool.ntp.org. Look at http://www.pool.ntp.org/ for more details.

You can also Google for NTP servers in your region, and add these to your configuration. To test that a server works, just type sudo ntpdate ntp.server.name and see what happens.

4.4. Related Pages

• NTP Support\textsuperscript{13}
• The NTP FAQ and HOWTO\textsuperscript{14}
Chapter 5. Remote Administration

There are many ways to remotely administer a Linux server. This chapter will cover one of the most popular SSH as well as eBox, a web based administration framework.
1. OpenSSH Server

1.1. Introduction

This section of the Ubuntu Server Guide introduces a powerful collection of tools for the remote control of networked computers and transfer of data between networked computers, called OpenSSH. You will also learn about some of the configuration settings possible with the OpenSSH server application and how to change them on your Ubuntu system.

OpenSSH is a freely available version of the Secure Shell (SSH) protocol family of tools for remotely controlling a computer or transferring files between computers. Traditional tools used to accomplish these functions, such as telnet or rcp, are insecure and transmit the user’s password in cleartext when used. OpenSSH provides a server daemon and client tools to facilitate secure, encrypted remote control and file transfer operations, effectively replacing the legacy tools.

The OpenSSH server component, sshd, listens continuously for client connections from any of the client tools. When a connection request occurs, sshd sets up the correct connection depending on the type of client tool connecting. For example, if the remote computer is connecting with the ssh client application, the OpenSSH server sets up a remote control session after authentication. If a remote user connects to an OpenSSH server with scp, the OpenSSH server daemon initiates a secure copy of files between the server and client after authentication. OpenSSH can use many authentication methods, including plain password, public key, and Kerberos tickets.

1.2. Installation

Installation of the OpenSSH client and server applications is simple. To install the OpenSSH client applications on your Ubuntu system, use this command at a terminal prompt:

```
sudo apt-get install openssh-client
```

To install the OpenSSH server application, and related support files, use this command at a terminal prompt:

```
sudo apt-get install openssh-server
```

The openssh-server package can also be selected to install during the Server Edition installation process.

1.3. Configuration

You may configure the default behavior of the OpenSSH server application, sshd, by editing the file `/etc/ssh/sshd_config`. For information about the configuration directives used in this file, you may view the appropriate manual page with the following command, issued at a terminal prompt:

```
man sshd_config
```
There are many directives in the sshd configuration file controlling such things as communication settings and authentication modes. The following are examples of configuration directives that can be changed by editing the `/etc/ssh/sshd_config` file.

Prior to editing the configuration file, you should make a copy of the original file and protect it from writing so you will have the original settings as a reference and to reuse as necessary.

Copy the `/etc/ssh/sshd_config` file and protect it from writing with the following commands, issued at a terminal prompt:

```
sudo cp /etc/ssh/sshd_config /etc/ssh/sshd_config.original
sudo chmod a-w /etc/ssh/sshd_config.original
```

The following are examples of configuration directives you may change:

- To set your OpenSSH to listen on TCP port 2222 instead of the default TCP port 22, change the `Port` directive as such:

  ```
  Port 2222
  ```

- To have sshd allow public key-based login credentials, simply add or modify the line:

  ```
  PubkeyAuthentication yes
  ```

In the `/etc/ssh/sshd_config` file, or if already present, ensure the line is not commented out.

- To make your OpenSSH server display the contents of the `/etc/issue.net` file as a pre-login banner, simply add or modify the line:

  ```
  Banner /etc/issue.net
  ```

In the `/etc/ssh/sshd_config` file.

After making changes to the `/etc/ssh/sshd_config` file, save the file, and restart the sshd server application to effect the changes using the following command at a terminal prompt:

```
sudo /etc/init.d/sshd restart
```

Many other configuration directives for sshd are available for changing the server application's behavior to fit your needs. Be advised, however, if your only method of access to a server is ssh, and you make a mistake in configuring sshd via the `/etc/ssh/sshd_config` file, you may find you are locked out of the server upon restarting it, or that the sshd server refuses to start due to an incorrect configuration directive, so be extra careful when editing this file on a remote server.

### 1.4. SSH Keys

SSH keys allow authentication between two hosts without the need of a password. SSH key authentication uses two keys a `private` key and a `public` key.
To generate the keys, from a terminal prompt enter:

```
ssh-keygen -t dsa
```

This will generate the keys using a DSA authentication identity of the user. During the process you will be prompted for a password. Simply hit Enter when prompted to create the key.

By default the public key is saved in the file `~/.ssh/id_dsa.pub`, while `~/.ssh/id_dsa` is the private key. Now copy the `id_dsa.pub` file to the remote host and append it to `~/.ssh/authorized_keys` by entering:

```
ssh-copy-id username@remotehost
```

Finally, double check the permissions on the `authorized_keys` file, only the authenticated user should have read and write permissions. If the permissions are not correct change them by:

```
chmod 644 .ssh/authorized_keys
```

You should now be able to SSH to the host without being prompted for a password.

### 1.5. References

*OpenSSH Website*¹

*Advanced OpenSSH Wiki Page*²

---

¹ http://www.openssh.org/
² https://wiki.ubuntu.com/AdvancedOpenSSH
2. eBox

eBox is a web framework used to manage server application configuration. The modular design of eBox allows you to pick and choose which services you want to configure using eBox.

2.1. Installation

The different eBox modules are split into different packages, allowing you to only install those necessary. One way to view the available packages is to enter the following from a terminal:

```
apt-cache rdepends ebox | uniq
```

To install the ebox package, which contains the default modules, enter the following:

```
sudo apt-get install ebox
```

During the installation you will be asked to supply a password for the ebox user. After installing eBox the web interface can be accessed from: `https://yourserver/ebox`.

2.2. Configuration

An important thing to remember when using eBox is that when configuring most modules there is a Change button that implements the new configuration. After clicking the Change button most, but not all, modules will then need to be Saved. To save the new configuration click on the “Save changes” link in the top right hand corner.

Once you make a change that requires a Save, the link will change from green to red.

2.3. eBox Modules

By default all eBox Modules are not enabled, and when a new module is installed it will not be automatically enabled.

To enable a disabled module click on the Module status link in the left hand menu. Then check which modules you would like to enable and click the “Save” link.

2.3.1. Default Modules

This section provides a quick summary of the default eBox modules.

- **System**: contains options allowing configuration of general eBox items.
- **General**: allows you to set the language, port number, and contains a change password form.
- **Disk Usage**: displays a graph detailing information about disk usage.
- **Backup**: is used to backup eBox configuration information, and the Full Backup option allows you to save all eBox information not included in the Configuration option such as log files.
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• **Halt/Reboot**: will shutdown the system or reboot it.

• **Bug Report**: creates a file containing details helpful when reporting bugs to the eBox developers.

• **Logs**: allows eBox logs to be queried depending on the purge time configured.

• **Events**: this module has the ability to send alerts through rss, jabber, and log file.

  • **Available Events**:
    
    • **Free Storage Space**: will send alert if free disk space drops below a configured percentage, 10% by default.
    
    • **Log Observer**: unfortunately this event does not work with the eBox version shipped with Ubuntu 7.10.
    
    • **RAID**: will monitor the RAID system and send alerts if any issues arise.
    
    • **Service**: sends alerts if a service restarts multiple times in a short time period.
    
    • **State**: alerts on the state of eBox, either up or down.

• **Dispatchers**:

  • **Log**: this dispatcher will send event messages to the eBox log file /var/log/ebox/ebox.log.
  
  • **Jabber**: before enabling this dispatcher you must first configure it by clicking on the “Configure” icon.
  
  • **RSS**: once this dispatcher is configured you can subscribe to the link in order to view event alerts.

2.4. Additional Modules

Here is a quick description of other available eBox modules:

• **Network**: allows configuration of the server's network options through eBox.

• **Firewall**: configures firewall options for the eBox host.

• **UsersandGroups**: this module will manage users and groups contained in an OpenLDAP LDAP directory.

• **DHCP**: provides an interface for configuring a DHCP server.

• **DNS**: provides BIND9 DNS server configuration options.

• **Objects**: allow configuration of eBox Network Objects, which allow you to assign a name to an IP address or group of IPs.

• **Services**: displays configuration information for services that are available to the network.

• **Squid**: configuration options for the Squid proxy server.

• **CA**: configures a Certificate Authority for the server.

• **NTP**: set Network Time Protocol options.

• **Printers**: allows the configuration of printers.

• **Samba**: configuration options for Samba.

• **OpenVPN**: setup options for OpenVPN Virtual Private Network application.
2.5. Resources

- For more information see the eBox Home Page³.
Chapter 6. Network Authentication

This section explains various Network Authentication protocols.
1. OpenLDAP Server

LDAP is an acronym for Lightweight Directory Access Protocol, it is a simplified version of the X.500 protocol. The directory setup in this section will be used for authentication. Nevertheless, LDAP can be used in numerous ways: authentication, shared directory (for mail clients), address book, etc.

To describe LDAP quickly, all information is stored in a tree structure. With OpenLDAP you have freedom to determine the directory arborescence (the Directory Information Tree: the DIT) yourself. We will begin with a basic tree containing two nodes below the root:

- "People" node where your users will be stored
- "Groups" node where your groups will be stored

Before beginning, you should determine what the root of your LDAP directory will be. By default, your tree will be determined by your Fully Qualified Domain Name (FQDN). If your domain is example.com (which we will use in this example), your root node will be dc=example,dc=com.

1.1. Installation

First, install the OpenLDAP server daemon slapd and ldap-utils, a package containing LDAP management utilities:

```
sudo apt-get install slapd ldap-utils
```

The installation process will prompt you for the LDAP directory admin password and confirmation.

By default the directory suffix will match the domain name of the server. For example, if the machine's Fully Qualified Domain Name (FQDN) is ldap.example.com, the default suffix will be dc=example,dc=com. If you require a different suffix, the directory can be reconfigured using dpkg-reconfigure. Enter the following in a terminal prompt:

```
sudo dpkg-reconfigure slapd
```

You will then be taken through a menu based configuration dialog, allowing you to configure various slapd options.

1.2. Configuration

OpenLDAP uses a separate database which contains the `cn=config` Directory Information Tree (DIT). The `cn=config` DIT is used to dynamically configure the slapd daemon, allowing the modification of schema definitions, indexes, ACLs, etc without stopping the service.

The `cn=config` tree can be manipulated using the utilities in the ldap-utils package. For example:

- Use ldapsearch to view the tree, entering the admin password set during installation or reconfiguration:
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```
ldapsearch -xLLL -b cn=config -D cn=admin,cn=config -W olcDatabase={1}hdb
```

Enter LDAP Password:

dn: olcDatabase={1}hdb,cn=config
objectClass: olcDatabaseConfig
objectClass: olcHdbConfig
olcDatabase: {1}hdb
olcDbDirectory: /var/lib/ldap
olcSuffix: dc=example,dc=com

```
olcAccess: (0)to attrs=userPassword,shadowLastChange by dn="cn=admin,dc=example,dc=com" write by anonymous auth by self write by * none
olcAccess: (1)to dn.base="*" by * read
olcAccess: (2)to * by dn="cn=admin,dc=example,dc=com" write by * read
olcLastMod: TRUE
olcDbCheckpoint: 512 30
olcDbConfig: (0)set_cachesize 0 2097152 0
olcDbConfig: (1)set lk_max_objects 1500
olcDbConfig: (2)set lk_max_locks 1500
olcDbConfig: (3)set lk_max_lockers 1500
olcDbIndex: objectClass eq
```

The output above is the current configuration options for the *hdb* backend database. Which in this case contains the *dc=example,dc=com* suffix.

- Refine the search by supplying a *filter*, in this case only show which attributes are indexed:

```
ldapsearch -xLLL -b cn=config -D cn=admin,cn=config -W olcDatabase={1}hdb olcDbIndex
```

Enter LDAP Password:

dn: olcDatabase={1}hdb,cn=config
olcDbIndex: objectClass eq

- As an example of modifying the *cn=config* tree, add another attribute to the index list using *ldapmodify*:

```
ldapmodify -x -D cn=admin,cn=config -W
```

Enter LDAP Password:

dn: olcDatabase={1}hdb,cn=config
add: olcDbIndex
olcDbIndex: entryUUID eq

```
modifying entry "olcDatabase={1}hdb,cn=config"
```

Once the modification has completed, press *Ctrl+D* to exit the utility.
• ldapmodify can also read the changes from a file. Copy and paste the following into a file named uid_index.ldif:

```
dn: olcDatabase={1}hdb,cn=config
add: olcDbIndex
olcDbIndex: uid eq,pres,sub
```

Then execute ldapmodify:

```
ldapmodify -x -D cn=admin,cn=config -W -f uid_index.ldif
```

Enter LDAP Password:
modifying entry "olcDatabase={1}hdb,cn=config"

The file method is very useful for large changes.

• Adding additional schemas to slapd requires the schema to be converted to LDIF format. Fortunately, the slapd program can be used to automate the conversion. The following example will add the misc.schema:

1. First, create a conversion schema_convert.conf file containing the following lines:

```
include /etc/ldap/schema/core.schema
include /etc/ldap/schema/collective.schema
include /etc/ldap/schema/corba.schema
include /etc/ldap/schema/cosine.schema
include /etc/ldap/schema/duaconf.schema
include /etc/ldap/schema/dyngroup.schema
include /etc/ldap/schema/inetorgperson.schema
include /etc/ldap/schema/java.schema
include /etc/ldap/schema/misc.schema
include /etc/ldap/schema/nis.schema
include /etc/ldap/schema/openldap.schema
include /etc/ldap/schema/ppolicy.schema
```

2. Next, create a temporary directory to hold the output:

```
mkdir /tmp/ldif_output
```

3. Now using slaptest convert the schema files to LDIF:

```
slaptest -f schema_convert.conf -F /tmp/ldif_output
```

Adjust the configuration file name and temporary directory names if yours are different. Also, it may be worthwhile to keep the ldif_output directory around in case you want to add additional schemas in the future.
4. Edit the /tmp/ldif_output/cn=config/cn=schema/cn={8}misc.ldif file, changing the following attributes:

```
        dn: cn=misc,cn=schema,cn=config
        ...
        cn: misc
```

And remove the following lines from the bottom of the file:

```
        structuralObjectClass: olcSchemaConfig
        entryUUID: 10dae0ea-0760-102d-80d3-f9366b7f7757
        creatorsName: cn=config
        createTimestamp: 20080826021140Z
        entryCSN: 20080826021140.791425Z#000000#000#000000
        modifiersName: cn=config
        modifyTimestamp: 20080826021140Z
```

The attribute values will vary, just be sure the attributes are removed.

5. Finally, using the ldapadd utility, add the new schema to the directory:

```
        ldapadd -x -D cn=admin,cn=config -W -f /tmp/ldif_output/cn\=config/cn\=schema/cn\={8}\=misc.ldif
```

There should now be a `dn: cn={4}misc,cn=schema,cn=config` entry in the `cn=config` tree.

### 1.3. Populating LDAP

The directory has been created during installation and reconfiguration, and now it is time to populate it. It will be populated with a "classical" scheme that will be compatible with address book applications and with Unix Posix accounts. Posix accounts will allow authentication to various applications, such as web applications, email Mail Transfer Agent (MTA) applications, etc.

For external applications to authenticate using LDAP they will each need to be specifically configured to do so. Refer to the individual application documentation for details.

LDAP directories can be populated with LDIF (LDAP Directory Interchange Format) files. Copy the following example LDIF file, naming it `example.com.ldif`, somewhere on your system:

```
        dn: ou=people,dc=example,dc=com
        objectClass: organizationalUnit
        ou: people

        dn: ou=groups,dc=example,dc=com
        objectClass: organizationalUnit
        ou: groups
```
In this example the directory structure, a user, and a group have been setup. In other examples you might see the objectClass: top added in every entry, but that is the default behaviour so you do not have to add it explicitly.

To add the entries to the LDAP directory use the ldapadd utility:

```
ldapadd -x -D cn=admin,dc=example,dc=com -W -f example.com.ldif
```

We can check that the content has been correctly added with the tools from the ldap-utils package. In order to execute a search of the LDAP directory:

```
ldapsearch -xLLL -b "dc=example,dc=com" uid=john sn givenName cn
```

```
cn: John Doe
sn: Doe
givenName: John

Just a quick explanation:

- `-x`: will not use SASL authentication method, which is the default.
- `-LLL`: disable printing LDIF schema information.

1.4. LDAP replication

LDAP often quickly becomes a highly critical service to the network. Multiple systems will come to depend on LDAP for authentication, authorization, configuration, etc. It is a good idea to setup a redundant system through replication.

Replication is achieved using the *Syncrepl* engine. Syncrepl allows the directory to be synced using either a *push* or *pull* based system. In a push based configuration a “primary” server will push directory updates to “secondary” servers, while a pull based approach allows replication servers to sync on a time based interval.

The following is an example of a *Multi-Master* configuration. In this configuration each OpenLDAP server is configured for both *push* and *pull* replication.

1. First, configure the server to sync the `cn=config` database. Copy the following to a file named `syncrepl_cn-config.ldif`:

    dn: cn=module{0},cn=config
    changetype: modify
    add: olcModuleLoad
    olcModuleLoad: syncprov

    dn: cn=config
    changetype: modify
    replace: olcServerID
    olcServerID: 1 ldap://ldap01.example.com
    olcServerID: 2 ldap://ldap02.example.com

    dn: olcOverlay=syncprov,olcDatabase={0}config,cn=config
    changetype: add
    objectClass: olcOverlayConfig
    objectClass: olcSyncProvConfig
    olcOverlay: syncprov

    dn: olcDatabase={0}config,cn=config
    changetype: modify
    add: olcSyncRepl
    olcSyncRepl: rid=001 provider=ldap://ldap01.example.com binddn="cn=admin,cn=config" bindmethod="simple"
2. Edit the file changing:

- `ldap://ldap01.example.com` and `ldap://ldap02.example.com` to the hostnames of your LDAP servers.

You can have more than two LDAP servers, and when a change is made to one of them it will by synced to the rest. Be sure to increment the `olcServerID` for each server, and the `rid` for each `olcSyncRepl` entry.

- And adjust `credentials=secret` to match your admin password.

3. Next, add the LDIF file using the ldapmodify utility:

```
ldapmodify -x -D cn=admin,cn=config -W -f syncrepl_cn-config.ldif
```

4. Copy the `syncrepl_cn-config.ldif` file to the next LDAP server and repeat the ldapmodify command above.

5. Because a new module has been added, the slapd daemon, on all replicated servers, needs to be restarted:

```sh
sudo /etc/init.d/slapd restart
```

6. Now that the configuration database is synced between servers, the `backend` database needs to be synced as well. Copy and paste the following into another LDIF file named `syncrepl_backend.ldif`:

```
dn: olcDatabase={1}hdb,cn=config
changetype: modify
add: olcRootDN
olcRootDN: cn=admin,dc=example,dc=com

add: olcSyncRepl
olcSyncRepl: rid=003 provider=ldap://ldap01.example.com binddn="cn=admin,dc=example,dc=com" bindmethod=simple credentials=secret searchbase="dc=example,dc=com" type=refreshOnly interval=00:00:00:10 retry="5 5 300 5" timeout=1
olcSyncRepl: rid=004 provider=ldap://ldap02.example.com binddn="cn=admin,dc=example,dc=com" bindmethod=simple credentials=secret searchbase="dc=example,dc=com" type=refreshOnly interval=00:00:00:10 retry="5 5 300 5" timeout=1

add: olcMirrorMode
olcMirrorMode: TRUE
```

```
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7. Like the previous LDIF file, edit this one changing:
   - searchbase="dc=example,dc=com" to your directory's searchbase.
   - If you use a different admin user, change binddn="cn=admin,dc=example,dc=com".
   - Also, replace credentials=secret with your admin password.

8. Add the LDIF file:

   `ldapmodify -x -D cn=admin,cn=config -W -f syncrepl_backend.ldif`

   Because the servers' configuration is already synced there is no need to copy this LDIF file to the other servers.

   The configuration and backend databases should now sync to the other servers. You can add additional servers using the ldapmodify utility as the need arises. See Section 1.2, “Configuration” [p. 51] for details.

   The slapd daemon will send log information to /var/log/syslog by default. So if all does not go well check there for errors and other troubleshooting information. Also, be sure that each server knows it's Fully Qualified Domain Name (FQDN). This is configured in /etc/hosts with a line similar to:

   127.0.0.1 ldap01.example.com ldap01

1.5. Setting up ACL

Authentication requires access to the password field, that should be not accessible by default. Also, in order for users to change their own password, using `passwd` or other utilities, `shadowLastChange` needs to be accessible once a user has authenticated.

To view the Access Control List (ACL), use the ldapsearch utility:

   `ldapsearch -xLLL -b cn=config -D cn=admin,cn=config -W olcDatabase=hdb olcAccess`

   Enter LDAP Password:
   
   dn: olcDatabase={1}hdb, cn=config
   olcAccess: {0}to attrs=userPassword,shadowLastChange by dn="cn=admin,dc=example,dc=com" write by anonymous auth by self write by * none
   olcAccess: {1}to dn.base="" by * read
   olcAccess: {2}to * by dn="cn=admin,dc=example,dc=com" write by * read
1.6. TLS and SSL

When authenticating to an OpenLDAP server it is best to do so using an encrypted session. This can be accomplished using Transport Layer Security (TLS) and/or Secure Sockets Layer (SSL).

The first step in the process is to obtain or create a certificate. See Section 5, “Certificates” [p. 115] and Section 5.5, “Certification Authority” [p. 117] for details.

Once you have a certificate, key, and CA cert installed, use ldapmodify to add the new configuration options:

```
ldapmodify -x -D cn=admin,cn=config -W
```

```
Enter LDAP Password:

do: cn=config
   add: olcTLSCACertificateFile
   olcTLSCACertificateFile: /etc/ssl/certs/cacert.pem
   -
   add: olcTLSCertificateFile
   olcTLSCertificateFile: /etc/ssl/certs/server.crt
   -
   add: olcTLSCertificateKeyFile
   olcTLSCertificateKeyFile: /etc/ssl/private/server.key

modifying entry "cn=config"
```

Adjust the server.crt, server.key, and cacert.pem names if yours are different.

Next, edit /etc/default/slapd uncomment the SLAPD_SERVICES option:

```
SLAPD_SERVICES="ldap:/// ldapi:/// ldaps:///
```

Now the openldap user needs access to the certificate:

```
sudo adduser openldap ssl-cert
sudo chgrp ssl-cert /etc/ssl/private/server.key
```

If the /etc/ssl/private and /etc/ssl/private/server.key have different permissions, adjust the commands appropriately.

Finally, restart slapd:

```
sudo /etc/init.d/slapd restart
```
The slapd daemon should now be listening for LDAPS connections and be able to use STARTTLS during authentication.

1.6.1. TLS Replication

If you have setup Syncrepl between servers, it is prudent to encrypt the replication traffic using Transport Layer Security (TLS). For details on setting up replication see Section 1.4, “LDAP replication” [p. 56].

After setting up replication, and following the instructions in Section 1.6, “TLS and SSL” [p. 59], there are a couple of consequences that should be kept in mind:

• The configuration only needs to be modified on one server.
• The path names for the certificate and key must be the same on all servers.

So on each replicated server: install a certificate, edit /etc/default/slapd, and restart slapd.

Once TLS has been setup on each server, modify the cn=config replication by entering the following in a terminal:

```
ldapmodify -x -D cn=admin,cn=config -W
```

Enter LDAP Password:

dn: olcDatabase={0}config,cn=config
replace: olcSyncRepl

```#
olcSyncRepl: (0)rid=001 provider=ldap://ldap01.example.com binddn="cn=admin,cn=config" bindmethod=simple credentials=secret searchbase="cn=config" type=refreshAndPersist retry="5 5 300 5" timeout=1 starttls=yes
olcSyncRepl: (1)rid=002 provider=ldap://ldap02.example.com binddn="cn=admin,cn=config" bindmethod=simple credentials=secret searchbase="cn=config" type=refreshAndPersist retry="5 5 300 5" timeout=1 starttls=yes
```

modifying entry "olcDatabase={0}config,cn=config"

Now adjust the backend database replication:

```
ldapmodify -x -D cn=admin,cn=config -W
```

Enter LDAP Password:

dn: olcDatabase={1}hdb,cn=config
replace: olcSyncRepl

```#
olcSyncRepl: (0)rid=003 provider=ldap://ldap01.example.com binddn="cn=admin,dc=example,dc=com" bindmethod=simple credentials=secret searchbase="dc=example,dc=com" type=refreshOnly interval=00:00:00:10 retry="5 5 300 5" timeout=1 starttls=yes
olcSyncRepl: (1)rid=004 provider=ldap://ldap02.example.com binddn="cn=admin,dc=example,dc=com" bindmethod=simple credentials=secret searchbase="dc=example,dc=com" type=refreshOnly interval=00:00:00:10 retry="5 5 300 5" timeout=1 starttls=yes
```

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modifying entry "olcDatabase={1}hdb,cn=config"

If the LDAP server hostname does not match the Fully Qualified Domain Name (FQDN) in the certificate, you may have to edit `/etc/ldap/ldap.conf` and add the following TLS options:

```
TLS_CERT /etc/ssl/certs/server.crt
TLS_KEY /etc/ssl/private/server.key
TLS_CACERT /etc/ssl/certs/cacert.pem
```

Finally, restart slapd on each of the servers:

```
sudo /etc/init.d/slapd restart
```

### 1.7. LDAP Authentication

Once you have a working LDAP server, the auth-client-config and libnss-ldap packages take the pain out of configuring an Ubuntu client to authenticate using LDAP. To install the packages from a terminal prompt enter:

```
sudo apt-get install libnss-ldap
```

During the install a menu dialog will ask you connection details about your LDAP server.

If you make a mistake when entering your information you can execute the dialog again using:

```
sudo dpkg-reconfigure ldap-auth-config
```

The results of the dialog can be seen in `/etc/ldap.conf`. If your server requires options not covered in the menu edit this file accordingly.

Now that libnss-ldap is configured enable the auth-client-config LDAP profile by entering:

```
sudo auth-client-config -t nss -p lac_ldap
```

- `-t`: only modifies `/etc/nsswitch.conf`.
- `-p`: name of the profile to enable, disable, etc.
- `lac_ldap`: the auth-client-config profile that is part of the ldap-auth-config package.

Using the `pam-auth-update` utility, configure the system to use LDAP for authentication:

```
sudo pam-auth-update
```

From the `pam-auth-update` menu, choose LDAP and any other authentication mechanisms you need.

You should now be able to login using user credentials stored in the LDAP directory.
If you are going to use LDAP to store Samba users you will need to configure the server to authenticate using LDAP. See Section 2, “Samba and LDAP” [p. 65] for details.

1.8. User and Group Management

The ldap-utils package comes with multiple utilities to manage the directory, but the long string of options needed, can make them a burden to use. The ldapscripts package contains configurable scripts to easily manage LDAP users and groups.

To install the package, from a terminal enter:

`sudo apt-get install ldapscripts`

Next, edit the config file `/etc/ldapscripts/ldapscripts.conf` uncommenting and changing the following to match your environment:

```
SERVER=localhost
BINDDN='cn=admin,dc=example,dc=com'
BINDPWDFILE="/etc/ldapscripts/ldapscripts.passwd"
SUFFIX='dc=example,dc=com'
GSUFFIX='ou=Groups'
USUFFIX='ou=People'
MSUFFIX='ou=Computers'
GIDSTART=10000
UIDSTART=10000
MIDSTART=10000
```

Now, create the `ldapscripts.passwd` file to allow authenticated access to the directory:

```
sudo sh -c "echo -n 'secret' > /etc/ldapscripts/ldapscripts.passwd"
sudo chmod 400 /etc/ldapscripts/ldapscripts.passwd
```

Replace “secret” with the actual password for your LDAP admin user.

The ldapscripts are now ready to help manage your directory. The following are some examples of how to use the scripts:

- Create a new user:

  ```
sudo ldapadduser george example
  ```

  This will create a user with uid `george` and set the user's primary group (gid) to `example`

- Change a user's password:

  ```
sudo ldapsetpasswd george
  ```

  Changing password for user uid=george,ou=People,dc=example,dc=com
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New Password:
New Password (verify):

• Delete a user:

    sudo ldapdeleteuser george

• Add a group:

    sudo ldapaddgroup qa

• Delete a group:

    sudo ldapdeletegroup qa

• Add a user to a group:

    sudo ldapaddusertogroup george qa

    You should now see a memberUid attribute for the qa group with a value of george.

• Remove a user from a group:

    sudo ldapdeleteuserfromgroup george qa

    The memberUid attribute should now be removed from the qa group.

• The ldapmodifyuser script allows you to add, remove, or replace a user's attributes. The script uses the same syntax as the ldapmodify utility. For example:

    sudo ldapmodifyuser george
    # About to modify the following entry :
    dn: uid=george,ou=People,dc=example,dc=com
    objectClass: account
    objectClass: posixAccount
    cn: george
    uid: george
    uidNumber: 1001
    gidNumber: 1001
    homeDirectory: /home/george
    loginShell: /bin/bash
    gecos: george
    description: User account
    userPassword:: e1NTSEF9eXFsTFcyWIhwKkFleGlybVdFWHZKRxJVMjFTSG9vcHk=

    # Enter your modifications here, end with CTRL-D.
    dn: uid=george,ou=People,dc=example,dc=com
    replace: gecos
    gecos: George Carlin

    The user's gecos should now be “George Carlin”.

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Network Authentication

• Another great feature of ldapscripts, is the template system. Templates allow you to customize the attributes of user, group, and machine objects. For example, to enable the user template edit /etc/ldapscripts/ldapscripts.conf changing:

UTEMPLATE="/etc/ldapscripts/ldapadduser.template"

There are sample templates in the /etc/ldapscripts directory. Copy or rename the ldapadduser.template.sample file to /etc/ldapscripts/ldapadduser.template:

```bash
sudo cp /etc/ldapscripts/ldapadduser.template.sample /etc/ldapscripts/ldapadduser.template
```

Edit the new template to add the desired attributes. The following will create new user's as with an objectClass of inetOrgPerson:

```text
dn: uid=<user>,<usuffix>,<suffix>
objectClass: inetOrgPerson
objectClass: posixAccount
cn: <user>
sn: <ask>
uid: <user>
uidNumber: <uid>
gidNumber: <gid>
homeDirectory: <home>
loginShell: <shell>
gecos: <user>
description: User account
title: Employee
```

Notice the <ask> option used for the cn value. Using <ask> will configure ldapadduser to prompt you for the attribute value during user creation.

There are more useful scripts in the package, to see a full list enter: `dpkg -L ldapscripts | grep bin`

1.9. Resources

• For more information see OpenLDAP Home Page

• Though starting to show it’s age, a great source for in depth LDAP information is O'Reilly’s LDAP System Administration

• Packt's Mastering OpenLDAP is a great reference covering newer versions of OpenLDAP.

• For more information on auth-client-config see the man page: `man auth-client-config`

• For more details regarding the ldapscripts package see the man pages: `man ldapscripts`, `man ldapadduser`, `man ldapaddgroup`, etc.
2. Samba and LDAP

This section covers configuring Samba to use LDAP for user, group, and machine account information and authentication. The assumption is, you already have a working OpenLDAP directory installed and the server is configured to use it for authentication. See Section 1, “OpenLDAP Server” [p. 51] and Section 1.7, “LDAP Authentication” [p. 61] for details on setting up OpenLDAP.

2.1. Installation

There are three packages needed when integrating Samba with LDAP. samba, samba-doc, and smbldap-tools packages. To install the packages, from a terminal enter:

```
sudo apt-get install samba samba-doc smbldap-tools
```

Strictly speaking the smbldap-tools package isn’t needed, but unless you have another package or custom scripts, a method of managing users, groups, and computer accounts is needed.

2.2. OpenLDAP Configuration

In order for Samba to use OpenLDAP as a passdb backend, the user objects in the directory will need additional attributes. This section assumes you want Samba to be configured as a Windows NT domain controller, and will add the necessary LDAP objects and attributes.

- The Samba attributes are defined in the `samba.schema` file which is part of the samba-doc package. The schema file needs to be unzipped and copied to `/etc/ldap/schema`. From a terminal prompt enter:

  ```
sudo cp /usr/share/doc/samba-doc/examples/LDAP/samba.schema.gz /etc/ldap/schema/
sudo gzip -d /etc/ldap/schema/samba.schema.gz
```

- The `samba` schema needs to be added to the `cn=config` tree. The procedure to add a new schema to `slapd` is also detailed in Section 1.2, “Configuration” [p. 51].

1. First, create a configuration file named `schema_convert.conf`, or a similar descriptive name, containing the following lines:

```ini
include /etc/ldap/schema/core.schema
include /etc/ldap/schema/collective.schema
include /etc/ldap/schema/corba.schema
include /etc/ldap/schema/cosine.schema
include /etc/ldap/schema/duaconf.schema
include /etc/ldap/schema/dyngroup.schema
include /etc/ldap/schema/inetorgperson.schema
include /etc/ldap/schema/java.schema
include /etc/ldap/schema/misc.schema
include /etc/ldap/schema/nis.schema
include /etc/ldap/schema/openldap.schema
```
include /etc/ldap/schema/ppolicy.schema
include /etc/ldap/schema/samba.schema

2. Next, create a temporary directory to hold the output:

mkdir /tmp/ldif_output

3. Now use slaptest to convert the schema files:

slaptest -f schema_convert.conf -F /tmp/ldif_output

Change the above file and path names to match your own if they are different.

4. Edit the generated /tmp/ldif_output/cn=config/cn=schema/cn={12}samba.ldif file, changing the following attributes:

dn: cn=samba,cn=schema,cn=config
...
  cn: samba

And remove the following lines from the bottom of the file:

structuralObjectClass: olcSchemaConfig
entryUUID: b53b75ca-083f-102d-9fff-2f64fd123c95
creatorsName: cn=config
createTimestamp: 20080827045234Z
entryCSN: 20080827045234.341425Z#000000#000#000000
modifiersName: cn=config
modifyTimestamp: 20080827045234Z

The attribute values will vary, just be sure the attributes are removed.

5. Finally, using the ldapadd utility, add the new schema to the directory:

ldapadd -x -D cn=admin,cn=config -W -f /tmp/ldif_output/cn=config/cn=schema/cn={12}samba.ldif

There should now be a dn: cn={X}misc,cn=schema,cn=config, where "X" is the next sequential schema, entry in the cn=config tree.

• Copy and paste the following into a file named samba_indexes.ldif:

dn: olcDatabase={1}hdb,cn=config
changetype: modify
add: olcDbIndex
  olcDbIndex: uidNumber eq
  olcDbIndex: gidNumber eq
  olcDbIndex: loginShell eq
  olcDbIndex: uid eq,pres,sub
  olcDbIndex: memberUid eq,pres,sub
Using the ldapmodify utility load the new indexes:

```
ldapmodify -x -D cn=admin,cn=config -W -f samba_indexes.ldif
```

If all went well you should see the new indexes using ldapsearch:

```
ldapsearch -xLLL -D cn=admin,cn=config -x -b cn=config -W olcDatabase={1}hdb
```

- Next, configure the smbldap-tools package to match your environment. The package comes with a configuration script that will ask questions about the needed options. To run the script enter:

```
sudo gzip -d /usr/share/doc/smbldap-tools/configure.pl.gz
sudo perl /usr/share/doc/smbldap-tools/configure.pl
```

Once you have answered the questions, there should be `/etc/smbldap-tools/smbldap.conf` and `/etc/smbldap-tools/smbldap_bind.conf` files. These files are generated by the configure script, so if you made any mistakes while executing the script it may be simpler to edit the file appropriately.

- The smbldap-populate script will add the necessary users, groups, and LDAP objects required for Samba. It is a good idea to make a backup LDAP Data Interchange Format (LDIF) file with slapcat before executing the command:

```
sudo slapcat -l backup.ldif
```

- Once you have a current backup execute smbldap-populate by entering:

```
sudo smbldap-populate
```

You can create an LDIF file containing the new Samba objects by executing `sudo smbldap-populate -e samba.ldif`. This allows you to look over the changes making sure everything is correct.

Your LDAP directory now has the necessary domain information to authenticate Samba users.

### 2.3. Samba Configuration

There a multiple ways to configure Samba for details on some common configurations see Chapter 15, Windows Networking [p. 194]. To configure Samba to use LDAP, edit the main Samba configuration file `/etc/samba/smb.conf` commenting the `passdb backend` option and adding the following:
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# passdb backend = tdbsam

# LDAP Settings
  passdb backend = ldapsam:ldap://hostname
  ldap suffix = dc=example,dc=com
  ldap user suffix = ou=People
  ldap group suffix = ou=Groups
  ldap machine suffix = ou=Computers
  ldap idmap suffix = ou=Idmap
  ldap admin dn = cn=admin,dc=example,dc=com
  ldap ssl = start tls
  ldap passwd sync = yes
...
  add machine script = sudo /usr/sbin/smbldap-useradd -t 0 -w "%u"

Restart samba to enable the new settings:

```
sudo /etc/init.d/samba restart
```

Now Samba needs to know the LDAP admin password. From a terminal prompt enter:

```
sudo smbpasswd -w secret
```
Replacing `secret` with your LDAP admin password.

If you currently have users in LDAP, and you want them to authenticate using Samba, they will need some Samba attributes defined in the `samba.schema` file. Add the Samba attributes to existing users using the `smbpasswd` utility, replacing `username` with an actual user:

```
sudo smbpasswd -a username
```
You will then be asked to enter the user's password.

To add new user, group, and machine accounts use the utilities from the `smbldap-tools` package. Here are some examples:
- To add a new user to LDAP with Samba attributes enter the following, replacing `username` with an actual username:

  ```
sudo smbldap-useradd -a -P username
  ```
  
The `-a` option adds the Samba attributes, and the `-P` options calls the `smbldap-passwd` utility after the user is created allowing you to enter a password for the user.

- To remove a user from the directory enter:
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```
sudo smbldap-userdel username
```

The smbldap-userdel utility also has a `-r` option to remove the user's home directory.

- Use smbldap-groupadd to add a group, replacing `groupname` with an appropriate group:

```
sudo smbldap-groupadd -a groupname
```

Similar to smbldap-useradd, the `-a` adds the Samba attributes.

- To add a user to a group use smbldap-groupmod:

```
sudo smbldap-groupmod -m username groupname
```

Be sure to replace `username` with a real user. Also, the `-m` option can add more than one user at a time by listing them in `comma separated` format.

- smbldap-groupmod can also be used to remove a user from a group:

```
sudo smbldap-groupmod -x username groupname
```

- Additionally, the smbldap-useradd utility can add Samba machine accounts:

```
sudo smbldap-useradd -t 0 -w username
```

Replace `username` with the name of the workstation. The `-t 0` option creates the machine account without a delay, while the `-w` option specifies the user as a machine account. Also, note the `add machine script` option in `/etc/samba/smb.conf` was changed to use smbldap-useradd.

There are more useful utilities and options in the smbldap-tools package. The man page for each utility provides more details.

### 2.4. Resources

- There are multiple places where LDAP and Samba is documented in the *Samba HOWTO Collection*.
- Specifically see the `passdb section`.
- Another good site is *Samba OpenLDAP HOWTO*.
- Again, for more information on smbldap-tools see the man pages: `man smbldap-useradd`, `man smbldap-groupadd`, `man smbldap-populate`, etc.
3. Kerberos

Kerberos is a network authentication system based on the principal of a trusted third party. The other two parties being the user and the service the user wishes to authenticate to. Not all services and applications can use Kerberos, but for those that can, it brings the network environment one step closer to being Single Sign On (SSO).

This section covers installation and configuration of a Kerberos server, and some example client configurations.

3.1. Overview

If you are new to Kerberos there are a few terms that are good to understand before setting up a Kerberos server. Most of the terms will relate to things you may be familiar with in other environments:

- **Principal**: any users, computers, and services provided by servers need to be defined as Kerberos Principals.
- **Instances**: are used for service principals and special administrative principals.
- **Realms**: the unique realm of control provided by the Kerberos installation. Usually the DNS domain converted to uppercase (EXAMPLE.COM).
- **Key Distribution Center**: (KDC) consist of three parts, a database of all principals, the authentication server, and the ticket granting server. For each realm there must be at least one KDC.
- **Ticket Granting Ticket**: issued by the Authentication Server (AS), the Ticket Granting Ticket (TGT) is encrypted in the user's password which is known only to the user and the KDC.
- **Ticket Granting Server**: (TGS) issues service tickets to clients upon request.
- **Tickets**: confirm the identity of the two principals. One principal being a user and the other a service requested by the user. Tickets establish an encryption key used for secure communication during the authenticated session.
- **Keytab Files**: are files extracted from the KDC principal database and contain the encryption key for a service or host.

To put the pieces together, a Realm has at least one KDC, preferably two for redundancy, which contains a database of Principals. When a user principal logs into a workstation, configured for Kerberos authentication, the KDC issues a Ticket Granting Ticket (TGT). If the user supplied credentials match, the user is authenticated and can then request tickets for Kerberized services from the Ticket Granting Server (TGS). The service tickets allow the user to authenticate to the service without entering another username and password.
3.2. Kerberos Server

3.2.1. Installation

Before installing the Kerberos server a properly configured DNS server is needed for your domain. Since the Kerberos Realm by convention matches the domain name, this section uses the example.com domain configured in Section 2.3, “Primary Master” [p. 86].

Also, Kerberos is a time sensitive protocol. So if the local system time between a client machine and the server differs by more than five minutes (by default), the workstation will not be able to authenticate. To correct the problem all hosts should have their time synchronized using the Network Time Protocol (NTP). For details on setting up NTP see Section 4, “Time Synchronisation with NTP” [p. 41].

The first step in installing a Kerberos Realm is to install the krb5-kdc and krb5-admin-server packages. From a terminal enter:

```
sudo apt-get install krb5-kdc krb5-admin-server
```

You will be asked at the end of the install to supply a name for the Kerberos and Admin servers, which may or may not be the same server, for the realm.

Next, create the new realm with the kdb5_newrealm utility:

```
sudo kdb5_newrealm
```

3.2.2. Configuration

The questions asked during installation are used to configure the `/etc/krb5.conf` file. If you need to adjust the Key Distribution Center (KDC) settings simply edit the file and restart the krb5-kdc daemon.

1. Now that the KDC running an admin user is needed. It is recommended to use a different username from your everyday username. Using the kadmin.local utility in a terminal prompt enter:

```
sudo kadmin.local
```

```
Authenticating as principal root/admin@EXAMPLE.COM with password.
kadmin.local: addprinc steve/admin
WARNING: no policy specified for steve/admin@EXAMPLE.COM; defaulting to no policy
Enter password for principal "steve/admin@EXAMPLE.COM":
Re-enter password for principal "steve/admin@EXAMPLE.COM":
Principal "steve/admin@EXAMPLE.COM" created.
kadmin.local: quit
```
In the above example steve is the Principal, /admin is an Instance, and @EXAMPLE.COM signifies the realm. The "every day" Principal would be steve@EXAMPLE.COM, and should have only normal user rights.

Replace EXAMPLE.COM and steve with your Realm and admin username.

2. Next, the new admin user needs to have the appropriate Access Control List (ACL) permissions. The permissions are configured in the /etc/krb5kdc/kadm5.acl file:

```
steve/admin@EXAMPLE.COM        *
```

This entry grants steve/admin the ability to perform any operation on all principals in the realm.

3. Now restart the krb5-admin-server for the new ACL to take affect:

```
sudo /etc/init.d/krb5-admin-server restart
```

4. The new user principal can be tested using the kinit utility:

```
kinit steve/admin
```

After entering the password, use the klist utility to view information about the Ticket Granting Ticket (TGT):

```
klist
```

You may need to add an entry into the /etc/hosts for the KDC. For example:

```
192.168.0.1   kdc01.example.com       kdc01
```

Replacing 192.168.0.1 with the IP address of your KDC.

5. In order for clients to determine the KDC for the Realm some DNS SRV records are needed. Add the following to /etc/named/db.example.com:

```
_kerberos._udp.EXAMPLE.COM. IN SRV 1 0 88 kdc01.example.com.
_kerberos._tcp.EXAMPLE.COM. IN SRV 1 0 88 kdc01.example.com.
_kerberos._udp.EXAMPLE.COM. IN SRV 10 0 88 kdc02.example.com.
_kerberos._tcp.EXAMPLE.COM. IN SRV 10 0 88 kdc02.example.com.
_kerberos-adm._tcp.EXAMPLE.COM. IN SRV 1 0 749 kdc01.example.com.
_kpasswd._udp.EXAMPLE.COM. IN SRV 1 0 464 kdc01.example.com.
```
Replace EXAMPLE.COM, kdc01, and kdc02 with your domain name, primary KDC, and secondary KDC.

See Chapter 7, Domain Name Service (DNS) [p. 83] for detailed instructions on setting up DNS.

Your new Kerberos Realm is now ready to authenticate clients.

### 3.3. Secondary KDC

Once you have one Key Distribution Center (KDC) on your network, it is good practice to have a Secondary KDC in case the primary becomes unavailable.

1. First, install the packages, and when asked for the Kerberos and Admin server names enter the name of the Primary KDC:

   ```bash
   sudo apt-get install krb5-kdc krb5-admin-server
   ```

2. Once you have the packages installed, create the Secondary KDC's host principal. From a terminal prompt, enter:

   ```bash
   kadmin -q "addprinc -randkey host/kdc02.example.com"
   ```

   After, issuing any kadmin commands you will be prompted for your username/admin@EXAMPLE.COM principal password.

3. Extract the keytab file:

   ```bash
   kadmin -q "ktadd -k keytab.kdc02 host/kdc02.example.com"
   ```

4. There should now be a keytab.kdc02 in the current directory, move the file to /etc/krb5.keytab:

   ```bash
   sudo mv keytab.kdc02 /etc/krb5.keytab
   ```

   If the path to the keytab.kdc02 file is different adjust accordingly.

   Also, you can list the principals in a Keytab file, which can be useful when troubleshooting, using the klist utility:

   ```bash
   sudo klist -k /etc/krb5.keytab
   ```

5. Next, there needs to be a kpropd.acl file on each KDC that lists all KDCs for the Realm. For example, on both primary and secondary KDC, create /etc/krb5kdc/kpropd.acl:
6. Create an empty database on the Secondary KDC:

```
sudo kdb5_util -s create
```

7. Now start the kpropd daemon, which listens for connections from the kprop utility. kprop is used to transfer dump files:

```
sudo kpropd -S
```

8. From a terminal on the Primary KDC, create a dump file of the principal database:

```
sudo kdb5_util dump /var/lib/krb5kdc/dump
```

9. Extract the Primary KDC’s keytab file and copy it to /etc/krb5.keytab:

```
kadmin -q "ktadd -k keytab.kdc01 host/kdc01.example.com"
sudo mv keytab.kdc01 /etc/krb5.keytab
```

Make sure there is a host for kdc01.example.com before extracting the Keytab.

10. Using the kprop utility push the database to the Secondary KDC:

```
sudo kprop -r EXAMPLE.COM -f /var/lib/krb5kdc/dump kdc02.example.com
```

There should be a SUCCEEDED message if the propagation worked. If there is an error message check /var/log/syslog on the secondary KDC for more information.

You may also want to create a cron job to periodically update the database on the Secondary KDC. For example, the following will push the database every hour:

```
# m h  dom mon dow   command
0 * * * * /usr/sbin/kdb5_util dump /var/lib/krb5kdc/dump && /usr/sbin/kprop -r EXAMPLE.COM -f /var/lib/krb5kdc/dump kdc02.example.com
```

11. Back on the Secondary KDC, create a stash file to hold the Kerberos master key:

```
sudo kdb5_util stash
```

12. Finally, start the krb5-kdc daemon on the Secondary KDC:

```
sudo /etc/init.d/krb5-kdc start
```

The Secondary KDC should now be able to issue tickets for the Realm. You can test this by stopping the krb5-kdc daemon on the Primary KDC, then use kinit to request a ticket. If all goes well you should receive a ticket from the Secondary KDC.
3.4. Kerberos Linux Client

This section covers configuring a Linux system as a Kerberos client. This will allow access to any kerberized services once a user has successfully logged into the system.

3.4.1. Installation

In order to authenticate to a Kerberos Realm, the krb5-user and libpam-krb5 packages are needed, along with a few others that are not strictly necessary but make life easier. To install the packages enter the following in a terminal prompt:

```
sudo apt-get install krb5-user libpam-krb5 libpam-ccreds auth-client-config
```

The auth-client-config package allows simple configuration of PAM for authentication from multiple sources, and the libpam-ccreds will cache authentication credentials allowing you to login in case the Key Distribution Center (KDC) is unavailable. This package is also useful for laptops that may authenticate using Kerberos while on the corporate network, but will need to be accessed off the network as well.

3.4.2. Configuration

To configure the client in a terminal enter:

```
sudo dpkg-reconfigure krb5-config
```

You will then be prompted to enter the name of the Kerberos Realm. Also, if you don’t have DNS configured with Kerberos SRV records, the menu will prompt you for the hostname of the Key Distribution Center (KDC) and Realm Administration server.

The dpkg-reconfigure adds entries to the `/etc/krb5.conf` file for your Realm. You should have entries similar to the following:

```
[libdefaults]
    default_realm = EXAMPLE.COM
...
[realms]
    EXAMPLE.COM = }
        kdc = 192.168.0.1
        admin_server = 192.168.0.1
    }
```

You can test the configuration by requesting a ticket using the kinit utility. For example:

```
kinit steve@EXAMPLE.COM
Password for steve@EXAMPLE.COM:
```

When a ticket has been granted, the details can be viewed using klist:
klist
Ticket cache: FILE:/tmp/krb5cc_1000
Default principal: steve@EXAMPLE.COM

Valid starting     Expires            Service principal
07/24/08 05:18:56  07/24/08 15:18:56  krbtgt/EXAMPLE.COM@EXAMPLE.COM
        renew until 07/25/08 05:18:57

Kerberos 4 ticket cache: /tmp/tkt1000
klist: You have no tickets cached

Next, use the auth-client-config to configure the libpam-krb5 module to request a ticket during login:

sudo auth-client-config -a -p kerberos_example

You will should now receive a ticket upon successful login authentication.

3.5. Resources

• For more information on Kerberos see the MIT Kerberos\textsuperscript{7} site.
• O'Reilly's Kerberos: The Definitive Guide\textsuperscript{8} is a great reference when setting up Kerberos.
• Also, feel free to stop by the \#ubuntu-server IRC channel on Freenode\textsuperscript{9} if you have Kerberos questions.
4. Kerberos and LDAP

Replicating a Kerberos principal database between two servers can be complicated, and adds an additional user database to your network. Fortunately, MIT Kerberos can be configured to use an LDAP directory as a principal database. This section covers configuring a primary and secondary kerberos server to use OpenLDAP for the principal database.

4.1. Configuring OpenLDAP

First, the necessary schema needs to be loaded on an OpenLDAP server that has network connectivity to the Primary and Secondary KDCs. The rest of this section assumes that you also have LDAP replication configured between at least two servers. For information on setting up OpenLDAP see Section 1, “OpenLDAP Server” [p. 51].

It is also required to configure OpenLDAP for TLS and SSL connections, so that traffic between the KDC and LDAP server is encrypted. See Section 1.6, “TLS and SSL” [p. 59] for details.

- To load the schema into LDAP, on the LDAP server install the krb5-kdc-ldap package. From a terminal enter:

  `sudo apt-get install krb5-kdc-ldap`

- Next, extract the `kerberos.schema.gz` file:

  `sudo gzip -d /usr/share/doc/krb5-kdc-ldap/kerberos.schema.gz`
  `sudo cp /usr/share/doc/krb5-kdc-ldap/kerberos.schema /etc/ldap/schema/`

- The `kerberos` schema needs to be added to the `cn=config` tree. The procedure to add a new schema to slapd is also detailed in Section 1.2, “Configuration” [p. 51].

1. First, create a configuration file named `schema_convert.conf`, or a similar descriptive name, containing the following lines:

   ```
   include /etc/ldap/schema/core.schema
   include /etc/ldap/schema/collective.schema
   include /etc/ldap/schema/corba.schema
   include /etc/ldap/schema/cosine.schema
   include /etc/ldap/schema/dyngroup.schema
   include /etc/ldap/schema/inetorgperson.schema
   include /etc/ldap/schema/java.schema
   include /etc/ldap/schema/misc.schema
   include /etc/ldap/schema/nis.schema
   include /etc/ldap/schema/openldap.schema
   include /etc/ldap/schema/ppolicy.schema
   include /etc/ldap/schema/kerberos.schema
   ```

2. Create a temporary directory to hold the LDIF files:
mkdir /tmp/ldif_output

3. Now use slaptest to convert the schema files:

    slaptest -f schema_convert.conf -F /tmp/ldif_output

Change the above file and path names to match your own if they are different.

4. Edit the generated /tmp/ldif_output/cn=config/cn=schema/cn={12}kerberos.ldif file, changing the following attributes:

    dn: cn=kerberos,cn=schema,cn=config
    ...
    cn: kerberos

And remove the following lines from the end of the file:

    structuralObjectClass: olcSchemaConfig
    entryUUID: 18ccd010-746b-102d-9fbe-3760cca765dc
    creatorsName: cn=config
    createTime: 20090111203515Z
    entryCSN: 20090111203515.326445Z#000000#000#000000
    modifiersName: cn=config
    modifyTime: 20090111203515Z

    \* The attribute values will vary, just be sure the attributes are removed.

5. Load the new schema with ldapadd:

    ldapadd -x -D cn=admin,cn=config -W -f /tmp/ldif_output/cn=config/cn=schema/cn={12}kerberos.ldif

6. Add an index for the krb5principalname attribute:

    ldapmodify -x -D cn=admin,cn=config -W

Enter LDAP Password:

    dn: olcDatabase={1}hdb,cn=config
    add: olcDbIndex
    olcDbIndex: krbPrincipalName eq,pres,sub

modifying entry "olcDatabase={1}hdb,cn=config"

7. Finally, update the Access Control Lists (ACL):

    ldapmodify -x -D cn=admin,cn=config -W

Enter LDAP Password:

    dn: olcDatabase={1}hdb,cn=config
    replace: olcAccess
That’s it, your LDAP directory is now ready to serve as a Kerberos principal database.

4.2. Primary KDC Configuration

With OpenLDAP configured it is time to configure the KDC.

• First, install the necessary packages, from a terminal enter:

  ```
  sudo apt-get install krb5-kdc krb5-admin-server krb5-kdc-ldap
  ```

• Now edit `/etc/krb5.conf` adding the following options to under the appropriate sections:

  ```
  [libdefaults]
  default_realm = EXAMPLE.COM

  ...

  [realms]
  EXAMPLE.COM = {
    kdc = kdc01.example.com
    kdc = kdc02.example.com
    admin_server = kdc01.example.com
    admin_server = kdc02.example.com
    default_domain = example.com
    database_module = openldap_ldapconf
  }

  ...

  [domain_realm]
  .example.com = EXAMPLE.COM

  ...

  [dbdefaults]
  ldap_kerberos_container_dn = dc=example,dc=com

  [dbmodules]
  openldap_ldapconf = {
  ```
Network Authentication

db_library = kldap
ldap_kdc_dn = "cn=admin,dc=example,dc=com"

# this object needs to have read rights on
# the realm container, principal container and realm sub-trees
ldap_kadmind_dn = "cn=admin,dc=example,dc=com"

# this object needs to have read and write rights on
# the realm container, principal container and realm sub-trees
ldap_service_password_file = /etc/krb5kdc/service.keyfile
ldap_servers = ldaps://ldap01.example.com ldaps://ldap02.example.com
ldap_conns_per_server = 5

}  

Change example.com, dc=example,dc=com, cn=admin,dc=example,dc=com, and ldap01.example.com to the appropriate domain, LDAP object, and LDAP server for your network.

• Next, use the kdb5_ldap_util utility to create the realm:

  sudo kdb5_ldap_util -D cn=admin,dc=example,dc=com create -subtrees dc=example,dc=com -r EXAMPLE.COM -H ldap://ldap01.example.com

• Create a stash of the password used to bind to the LDAP server. This password is used by the ldap_kdc_dn and ldap_kadmind_dn options in /etc/krb5.conf:

  sudo kdb5_ldap_util -D cn=admin,dc=example,dc=com stashsrvpw -f /etc/krb5kdc/service.keyfile cn=

• Copy the CA certificate from the LDAP server:

  scp ldap01:/etc/ssl/certs/cacert.pem .
  sudo cp cacert.pem /etc/ssl/certs

And edit /etc/ldap/ldap.conf to use the certificate:

  TLS_CACERT /etc/ssl/certs/cacert.pem

The certificate will also need to be copied to the Secondary KDC, to allow the connection to the LDAP servers using LDAPS.

You can now add Kerberos principals to the LDAP database, and they will be copied to any other LDAP servers configured for replication. To add a principal using the kadmin.local utility enter:

  sudo kadmin.local

  Authenticating as principal root/admin@EXAMPLE.COM with password.
  kadmin.local: addprinc -x dn="uid=steve,ou=people,dc=example,dc=com" steve
  WARNING: no policy specified for steve@EXAMPLE.COM; defaulting to no policy
  Enter password for principal "steve@EXAMPLE.COM":
  Re-enter password for principal "steve@EXAMPLE.COM":
  Principal "steve@EXAMPLE.COM" created.
There should now be krbPrincipalName, krbPrincipalKey, krbLastPwdChange, and krbExtraData attributes added to the \textit{uid=steve,ou=people,dc=example,dc=com} user object. Use the \textit{kinit} and \textit{klist} utilities to test that the user is indeed issued a ticket.

If the user object is already created the \textit{-x \text{dn}="..."} option is needed to add the Kerberos attributes. Otherwise a new \textit{principal} object will be created in the realm subtree.

4.3. Secondary KDC Configuration

Configuring a Secondary KDC using the LDAP backend is similar to configuring one using the normal Kerberos database.

- First, install the necessary packages. In a terminal enter:

\begin{verbatim}
sudo apt-get install krb5-kdc krb5-admin-server krb5-kdc-ldap
\end{verbatim}

- Next, edit \texttt{/etc/krb5.conf} to use the LDAP backend:

\begin{verbatim}
[libdefaults]
  default_realm = EXAMPLE.COM

...

[realms]
  EXAMPLE.COM = {
    kdc = kdc01.example.com
    kdc = kdc02.example.com
    admin_server = kdc01.example.com
    admin_server = kdc02.example.com
    default_domain = example.com
    database_module = openldap_ldapconf
  }

...

[domain_realm]
  .example.com = EXAMPLE.COM

...

[dbdefaults]
  ldap_kerberos_container_dn = dc=example,dc=com

[dbmodules]
  openldap_ldapconf = {
    db_library = kldap
    ldap_kdc_dn = "cn=admin,dc=example,dc=com"
    # this object needs to have read rights on
    # the realm container, principal container and realm sub-trees
    ldap_kadmind_dn = "cn=admin,dc=example,dc=com"
  }
\end{verbatim}
# this object needs to have read and write rights on
# the realm container, principal container and realm sub-trees
ldap_service_password_file = /etc/krb5kdc/service.keyfile
ldap_servers = ldaps://ldap01.example.com ldaps://ldap02.example.com
ldap_conns_per_server = 5
}

- Create the stash for the LDAP bind password:

```
sudo kdb5_ldap_util -D cn=admin,dc=example,dc=com stashsrvpw -f /etc/krb5kdc/service.keyfile cn=admin,dc=example,dc=com
```

- Now, on the Primary KDC copy the `/etc/krb5kdc/.k5.EXAMPLE.COM Master Key` stash to the Secondary KDC. Be sure to copy the file over an encrypted connection such as scp, or on physical media.

```
sudo scp /etc/krb5kdc/.k5.EXAMPLE.COM steve@kdc02.example.com:~
sudo mv .k5.EXAMPLE.COM /etc/krb5kdc/
```

Again, replace `EXAMPLE.COM` with your actual realm.

- Finally, start the `krb5-kdc` daemon:

```
sudo /etc/init.d/krb5-kdc start
```

You now have redundant KDCs on your network, and with redundant LDAP servers you should be able to continue to authenticate users if one LDAP server, one Kerberos server, or one LDAP and one Kerberos server become unavailable.

### 4.4. Resources

- The *Kerberos Admin Guide*\(^\text{10}\) has some additional details.
- For more information on kdb5_ldap_util see *Section 5.6*\(^\text{11}\) and the *kdb5_ldap_util man page*\(^\text{12}\).
- Another useful link is the *krb5.conf man page*\(^\text{13}\).
Chapter 7. Domain Name Service (DNS)

Domain Name Service (DNS) is an Internet service that maps IP addresses and fully qualified domain names (FQDN) to one another. In this way, DNS alleviates the need to remember IP addresses. Computers that run DNS are called name servers. Ubuntu ships with BIND (Berkley Internet Naming Daemon), the most common program used for maintaining a name server on Linux.
1. Installation

At a terminal prompt, enter the following command to install dns:

```
sudo apt-get install bind9
```

A very useful package for testing and troubleshooting DNS issues is the dnsutils package. To install dnsutils enter the following:

```
sudo apt-get install dnsutils
```
2. Configuration

There are many ways to configure BIND9. Some of the most common configurations are a caching nameserver, primary master, and as a secondary master.

- When configured as a caching nameserver BIND9 will find the answer to name queries and remember the answer when the domain is queried again.
- As a primary master server BIND9 reads the data for a zone from a file on its host and is authoritative for that zone.
- In a secondary master configuration BIND9 gets the zone data from another nameserver authoritative for the zone.

2.1. Overview

The DNS configuration files are stored in the `/etc/bind` directory. The primary configuration file is `/etc/bind/named.conf`.

The `include` line specifies the filename which contains the DNS options. The `directory` line in the `/etc/bind/named.conf.options` file tells DNS where to look for files. All files BIND uses will be relative to this directory.

The file named `/etc/bind/db.root` describes the root nameservers in the world. The servers change over time, so the `/etc/bind/db.root` file must be maintained now and then. This is usually done as updates to the bind9 package. The `zone` section defines a master server, and it is stored in a file mentioned in the `file` option.

It is possible to configure the same server to be a caching name server, primary master, and secondary master. A server can be the Start of Authority (SOA) for one zone, while providing secondary service for another zone. All the while providing caching services for hosts on the local LAN.

2.2. Caching Nameserver

The default configuration is setup to act as a caching server. All that is required is simply adding the IP Addresses of your ISP's DNS servers. Simply uncomment and edit the following in `/etc/bind/named.conf.options`:

```
forwarders {
    1.2.3.4;
    5.6.7.8;
};
```

Replace `1.2.3.4` and `5.6.7.8` with the IP Addresses of actual nameservers.

Now restart the DNS server, to enable the new configuration. From a terminal prompt:
sudo /etc/init.d/bind9 restart

See Section 3.1.2, “dig” [p. 90] for information on testing a caching DNS server.

2.3. Primary Master

In this section BIND9 will be configured as the Primary Master for the domain example.com. Simply replace example.com with your FQDN (Fully Qualified Domain Name).

2.3.1. Forward Zone File

To add a DNS zone to BIND9, turning BIND9 into a Primary Master server, the first step is to edit /etc/bind/named.conf.local:

```
zone "example.com" {
    type master;
    file "/etc/bind/db.example.com";
};
```

Now use an existing zone file as a template to create the /etc/bind/db.example.com file:

```
sudo cp /etc/bind/db.local /etc/bind/db.example.com
```

Edit the new zone file /etc/bind/db.example.com change localhost to the FQDN of your server, leaving the additional "." at the end. Change 127.0.0.1 to the nameserver's IP Address and root.localhost to a valid email address, but with a "." instead of the usual "@" symbol, again leaving the "." at the end.

Also, create an A record for ns.example.com. The name server in this example:

```
; ; BIND data file for local loopback interface
; $TTL 604800
@ IN SOA ns.example.com. root.example.com. ( 2 ; Serial
  604800 ; Refresh
  86400 ; Retry
  2419200 ; Expire
  604800 ) ; Negative Cache TTL

@ IN NS ns.example.com.
@ IN A 127.0.0.1
@ IN AAAA ::1
ns IN A 192.168.1.10
```

You must increment the Serial Number every time you make changes to the zone file. If you make multiple changes before restarting BIND9, simply increment the Serial once.

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Now, you can add DNS records to the bottom of the zone file. See Section 4.1, “Common Record Types” [p. 94] for details.

Many admins like to use the last date edited as the serial of a zone, such as 2007010100 which is yyyymmddss (where ss is the Serial Number)

Once you have made a change to the zone file BIND9 will need to be restarted for the changes to take effect:

```
sudo /etc/init.d/bind9 restart
```

### 2.3.2. Reverse Zone File

Now that the zone is setup and resolving names to IP Adresses a Reverse zone is also required. A Reverse zone allows DNS to resolve an address to a name.

Edit `/etc/bind/named.conf.local` and add the following:

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

Replace `1.168.192` with the first three octets of whatever network you are using. Also, name the zone file `/etc/bind/db.192` appropriately. It should match the first octet of your network.

Now create the `/etc/bind/db.192` file:

```
sudo cp /etc/bind/db.127 /etc/bind/db.192
```

Next edit `/etc/bind/db.192` changing the basically the same options as `/etc/bind/db.example.com`:

```plaintext
; ; BIND reverse data file for local loopback interface
;
$TTL 604800
@    IN    SOA    ns.example.com. root.example.com. ( 
                   2 ; Serial
                   604800 ; Refresh
                   86400  ; Retry
                  2419200 ; Expire
                  604800 ) ; Negative Cache TTL
;
@    IN    NS    ns.
10    IN    PTR    ns.example.com.
```
The *Serial Number* in the Reverse zone needs to be incremented on each changes as well. For each *A record* you configure in `/etc/bind/db.example.com` you need to create a *PTR record* in `/etc/bind/db.192`

After creating the reverse zone file restart BIND9:

```
sudo /etc/init.d/bind9 restart
```

### 2.4. Secondary Master

Once a *Primary Master* has been configured a *Secondary Master* is needed in order to maintain the availability of the domain should the Primary become unavailable.

First, on the Primary Master server, the zone transfer needs to be allowed. Add the `allow-transfer` option to the example Forward and Reverse zone definitions in `/etc/bind/named.conf.local`:

```conf
zone "example.com" {
    type master;
    file "/etc/bind/db.example.com";
    allow-transfer { 192.168.1.11; };
};
zone "1.168.192.in-addr.arpa" {
    type master;
    notify no;
    file "/etc/bind/db.192";
    allow-transfer { 192.168.1.11; };
};
```

Replace `192.168.1.11` with the IP Address of your Secondary nameserver.

Next, on the Secondary Master, install the bind9 package the same way as on the Primary. Then edit the `/etc/bind/named.conf.local` and add the following declarations for the Forward and Reverse zones:

```conf
zone "example.com" {
    type slave;
    file "/var/cache/bind/db.example.com";
    masters { 192.168.1.10; }
};
zone "1.168.192.in-addr.arpa" {
    type slave;
    file "/var/cache/bind/db.192";
    masters { 192.168.1.10; }
};
```
Replace 192.168.1.10 with the IP Address of your Primary nameserver.

Restart BIND9 on the Secondary Master:

```
sudo /etc/init.d/bind9 restart
```

In /var/log/syslog you should see something similar to:

```
slave zone "example.com" (IN) loaded (serial 6)
slave zone "100.18.172.in-addr.arpa" (IN) loaded (serial 3)
```

Note: A zone is only transferred if the **Serial Number** on the Primary is larger than the one on the Secondary.

The default directory for non-authoritative zone files is /var/cache/bind/. This directory is also configured in AppArmor to allow the named daemon to write to. For more information on AppArmor see **Section 4, “AppArmor” [p. 111]**.
3. Troubleshooting

This section covers ways to help determine the cause when problems happen with DNS and BIND9.

3.1. Testing

3.1.1. resolv.conf

The first step in testing BIND9 is to add the nameserver's IP Address to a hosts resolver. The Primary nameserver should be configured as well as another host to double check things. Simply edit `/etc/resolv.conf` and add the following:

```plaintext
nameserver 192.168.1.10
nameserver 192.168.1.11
```

You should also add the IP Address of the Secondary nameserver in case the Primary becomes unavailable.

3.1.2. dig

If you installed the dnsutils package you can test your setup using the DNS lookup utility dig:

- After installing BIND9 use dig against the loopback interface to make sure it is listening on port 53. From a terminal prompt:

  ```bash
dig -x 127.0.0.1
  ```

  You should see lines similar to the following in the command output:

  ```text
  ;; Query time: 1 msec
  ;; SERVER: 192.168.1.10#53(192.168.1.10)
  ```

- If you have configured BIND9 as a Caching nameserver "dig" an outside domain to check the query time:

  ```bash
dig ubuntu.com
  ```

  Note the query time toward the end of the command output:

  ```text
  ;; Query time: 49 msec
  ```

  After a second dig there should be improvement:

  ```text
  ;; Query time: 1 msec
  ```
3.1.3. ping

Now to demonstrate how applications make use of DNS to resolve a host name use the ping utility to send an ICMP echo request. From a terminal prompt enter:

```
ping example.com
```

This tests if the nameserver can resolve the name ns.example.com to an IP Address. The command output should resemble:

```
PING ns.example.com (192.168.1.10) 56(84) bytes of data.
64 bytes from 192.168.1.10: icmp_seq=1 ttl=64 time=0.800 ms
64 bytes from 192.168.1.10: icmp_seq=2 ttl=64 time=0.813 ms
```

3.1.4. named-checkzone

A great way to test your zone files is by using the named-checkzone utility installed with the bind9 package. This utility allows you to make sure the configuration is correct before restarting BIND9 and making the changes live.

- To test our example Forward zone file enter the following from a command prompt:

```
named-checkzone example.com /etc/bind/db.example.com
```

If everything is configured correctly you should see output similar to:

```
zone example.com/IN: loaded serial 6
OK
```

- Similarly, to test the Reverse zone file enter the following:

```
named-checkzone example.com /etc/bind/db.192
```

The output should be similar to:

```
zone example.com/IN: loaded serial 3
OK
```

The Serial Number of your zone file will probably be different.

3.2. Logging

BIND9 has a wide variety of logging configuration options available. There are two main options. The `channel` option configures where logs go, and the `category` option determines what information to log.
If no logging option is configured the default option is:

```plaintext
logging {
    category default { default_syslog; default_debug; };
    category unmatched { null; };
};
```

This section covers configuring BIND9 to send debug messages related to DNS queries to a separate file.

- First, we need to configure a channel to specify which file to send the messages to. Edit `/etc/bind/named.conf.local` and add the following:

```plaintext
logging {
    channel query.log {
        file "/var/log/query.log";
        severity debug 3;
    };
};
```

- Next, configure a category to send all DNS queries to the query file:

```plaintext
logging {
    channel query.log {
        file "/var/log/query.log";
        severity debug 3;
    };
    category queries { query.log; };
};
```

Note: the `debug` option can be set from 1 to 3. If a level isn’t specified level 1 is the default.

- Since the `named daemon` runs as the `bind` user the `/var/log/query.log` file must be created and the ownership changed:

```bash
sudo touch /var/log/query.log
sudo chown bind /var/log/query.log
```

- Before named daemon can write to the new log file the AppArmor profile must be updated. First, edit `/etc/apparmor.d/usr.sbin.named` and add:

```bash
/var/log/query.log w,
```

Next, reload the profile:

```bash
cat /etc/apparmor.d/usr.sbin.named | sudo apparmor_parser -r
```

For more information on AppArmor see Section 4, “AppArmor” [p. 111]
• Now restart BIND9 for the changes to take effect:

    sudo /etc/init.d/bind9 restart

You should see the file /var/log/query.log fill with query information. This is a simple example of the BIND9 logging options. For coverage of advanced options see Section 4.2, “More Information” [p. 94].
4. References

4.1. Common Record Types

This section covers some of the most common DNS record types.

- **A record**: This record maps an IP Address to a hostname.

  ```
  www      IN    A      192.168.1.12
  ```

- **CNAME record**: Used to create an alias to an existing A record. You cannot create a CNAME record pointing to another CNAME record.

  ```
  web     IN    CNAME  www
  ```

- **MX record**: Used to define where email should be sent to. Must point to an A record, not a CNAME.

  ```
  IN    MX      mail.example.com.
  mail    IN    A       192.168.1.13
  ```

- **NS record**: Used to define which servers serve copies of a zone. It must point to an A record, not a CNAME. This is where Primary and Secondary servers are defined.

  ```
  IN    NS     ns.example.com.
  IN    NS     ns2.example.com.
  ns     IN    A      192.168.1.10
  ns2    IN    A      192.168.1.11
  ```

4.2. More Information

The *DNS HOWTO*\(^1\) explains more advanced options for configuring BIND9.

For in depth coverage of DNS and BIND9 see *Bind9.net*\(^2\).

*DNS and BIND*\(^3\) is a popular book now in its fifth edition.

A great place to ask for BIND9 assistance, and get involved with the Ubuntu Server community, is the #ubuntu-server IRC channel on *freenode*\(^4\).

---

\(^1\) [http://www.tldp.org/HOWTO/DNS-HOWTO.html](http://www.tldp.org/HOWTO/DNS-HOWTO.html)
\(^4\) [http://freenode.net](http://freenode.net)
Chapter 8. Security

Security should always be considered when installing, deploying, and using any type of computer system. Although a fresh installation of Ubuntu is relatively safe for immediate use on the Internet, it is important to have a balanced understanding of your systems security posture based on how it will be used after deployment.

This chapter provides an overview of security related topics as they pertain to Ubuntu 9.04 Server Edition, and outlines simple measures you may use to protect your server and network from any number of potential security threats.
1. User Management

User management is a critical part of maintaining a secure system. Ineffective user and privilege management often lead many systems into being compromised. Therefore, it is important that you understand how you can protect your server through simple and effective user account management techniques.

1.1. Where is root?

Ubuntu developers made a conscientious decision to disable the administrative root account by default in all Ubuntu installations. This does not mean that the root account has been deleted or that it may not be accessed. It merely has been given a password which matches no possible encrypted value, therefore may not log in directly by itself.

Instead, users are encouraged to make use of a tool by the name of sudo to carry out system administrative duties. Sudo allows an authorized user to temporarily elevate their privileges using their own password instead of having to know the password belonging to the root account. This simple yet effective methodology provides accountability for all user actions, and gives the administrator granular control over which actions a user can perform with said privileges.

- If for some reason you wish to enable the root account, simply give it a password:

  
  sudo passwd

  Sudo will prompt you for your password, and then ask you to supply a new password for root as shown below:

  [sudo] password for username: (enter your own password)
  Enter new UNIX password: (enter a new password for root)
  Retype new UNIX password: (repeat new password for root)
  passwd: password updated successfully

- To disable the root account, use the following passwd syntax:

  
  sudo passwd -l root

- You should read more on Sudo by checking out it's man page:

  
  man sudo

By default, the initial user created by the Ubuntu installer is a member of the group "admin" which is added to the file /etc/sudoers as an authorized sudo user. If you wish to give any other account full root access through sudo, simply add them to the admin group.
1.2. Adding and Deleting Users

The process for managing local users and groups is straightforward and differs very little from most other GNU/Linux operating systems. Ubuntu and other Debian based distributions, encourage the use of the "adduser" package for account management.

- To add a user account, use the following syntax, and follow the prompts to give the account a password and identifiable characteristics such as a full name, phone number, etc.

  ```
  sudo adduser username
  ```

- To delete a user account and its primary group, use the following syntax:

  ```
  sudo deluser username
  ```

Deleting an account does not remove their respective home folder. It is up to you whether or not you wish to delete the folder manually or keep it according to your desired retention policies.

Remember, any user added later on with the same UID/GID as the previous owner will now have access to this folder if you have not taken the necessary precautions.

You may want to change these UID/GID values to something more appropriate, such as the root account, and perhaps even relocate the folder to avoid future conflicts:

  ```
  sudo chown -R root:root /home/username/
  sudo mkdir /home/archived_users/
  sudo mv /home/username /home/archived_users/
  ```

- To temporarily lock or unlock a user account, use the following syntax, respectively:

  ```
  sudo passwd -l username
  sudo passwd -u username
  ```

- To add or delete a personalized group, use the following syntax, respectively:

  ```
  sudo addgroup groupname
  sudo delgroup groupname
  ```

- To add a user to a group, use the following syntax:

  ```
  sudo adduser username groupname
  ```

1.3. User Profile Security

When a new user is created, the adduser utility creates a brand new home directory named `/home/username`, respectively. The default profile is modeled after the contents found in the directory of `/etc/skel`, which includes all profile basics.
If your server will be home to multiple users, you should pay close attention to the user home directory permissions to ensure confidentiality. By default, user home directories in Ubuntu are created with world read/execute permissions. This means that all users can browse and access the contents of other users home directories. This may not be suitable for your environment.

- To verify your current users home directory permissions, use the following syntax:

```
ls -ld /home/username
```

The following output shows that the directory `/home/username` has world readable permissions:

```
drwxr-xr-x  2 username username    4096 2007-10-02 20:03 username
```

- You can remove the world readable permissions using the following syntax:

```
sudo chmod 0750 /home/username
```

Some people tend to use the recursive option (-R) indiscriminately which modifies all child folders and files, but this is not necessary, and may yield other undesirable results. The parent directory alone is sufficient for preventing unauthorized access to anything below the parent.

A much more efficient approach to the matter would be to modify the adduser global default permissions when creating user home folders. Simply edit the file `/etc/adduser.conf` and modify the `DIR_MODE` variable to something appropriate, so that all new home directories will receive the correct permissions.

```
DIR_MODE=0750
```

- After correcting the directory permissions using any of the previously mentioned techniques, verify the results using the following syntax:

```
ls -ld /home/username
```

The results below show that world readable permissions have been removed:

```
drwxr-x---  2 username username    4096 2007-10-02 20:03 username
```

1.4. Password Policy

A strong password policy is one of the most important aspects of your security posture. Many successful security breaches involve simple brute force and dictionary attacks against weak passwords. If you intend to offer any form of remote access involving your local password system, make sure you adequately address minimum password complexity requirements, maximum password lifetimes, and frequent audits of your authentication systems.
1.4.1. Minimum Password Length

By default, Ubuntu requires a minimum password length of 4 characters, as well as some basic entropy checks. These values are controlled in the file `/etc/pam.d/common-password`, which is outlined below.

```
password required pam_unix.so nullok obscure min=4 max=8 md5
```

If you would like to adjust the minimum length to 6 characters, change the appropriate variable to min=6. The modification is outlined below.

```
password required pam_unix.so nullok obscure min=6 max=8 md5
```

The `max=8` variable does not represent the maximum length of a password. It only means that complexity requirements will not be checked on passwords over 8 characters. You may want to look at the libpam-cracklib package for additional password entropy assistance.

1.4.2. Password Expiration

When creating user accounts, you should make it a policy to have a minimum and maximum password age forcing users to change their passwords when they expire.

- To easily view the current status of a user account, use the following syntax:

  `sudo chage -l username`

  The output below shows interesting facts about the user account, namely that there are no policies applied:

<table>
<thead>
<tr>
<th>Last password change</th>
<th>: Jan 20, 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Password expires</td>
<td>: never</td>
</tr>
<tr>
<td>Password inactive</td>
<td>: never</td>
</tr>
<tr>
<td>Account expires</td>
<td>: never</td>
</tr>
<tr>
<td>Minimum number of days</td>
<td>: 0</td>
</tr>
<tr>
<td>Maximum number</td>
<td>: 99999</td>
</tr>
<tr>
<td>Number of days</td>
<td>: 7</td>
</tr>
</tbody>
</table>

- To set any of these values, simply use the following syntax, and follow the interactive prompts:

  `sudo chage username`

  The following is also an example of how you can manually change the explicit expiration date (`-E`) to 01/31/2008, minimum password age (`-m`) of 5 days, maximum password age (`-M`) of 90 days, inactivity period (`-I`) of 5 days after password expiration, and a warning time period (`-W`) of 14 days before password expiration.
sudo chage -E 01/31/2008 -m 5 -M 90 -I 30 -W 14 username

• To verify changes, use the same syntax as mentioned previously:

sudo chage -l username

The output below shows the new policies that have been established for the account:

<table>
<thead>
<tr>
<th>Policy</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last password change</td>
<td>Jan 20, 2008</td>
</tr>
<tr>
<td>Password expires</td>
<td>Apr 19, 2008</td>
</tr>
<tr>
<td>Password inactive</td>
<td>May 19, 2008</td>
</tr>
<tr>
<td>Account expires</td>
<td>Jan 31, 2008</td>
</tr>
<tr>
<td>Minimum number of days between password change</td>
<td>5</td>
</tr>
<tr>
<td>Maximum number of days between password change</td>
<td>90</td>
</tr>
<tr>
<td>Number of days of warning before password expires</td>
<td>14</td>
</tr>
</tbody>
</table>

1.5. Other Security Considerations

Many applications use alternate authentication mechanisms that can be easily overlooked by even experienced system administrators. Therefore, it is important to understand and control how users authenticate and gain access to services and applications on your server.

1.5.1. SSH Access by Disabled Users

Simply disabling/locking a user account will not prevent a user from logging into your server remotely if they have previously set up RSA public key authentication. They will still be able to gain shell access to the server, without the need for any password. Remember to check the users home directory for files that will allow for this type of authenticated SSH access. e.g. /home/username/.ssh/authorized_keys.

Remove or rename the directory .ssh/ in the user's home folder to prevent further SSH authentication capabilities.

Be sure to check for any established SSH connections by the disabled user, as it is possible they may have existing inbound or outbound connections. Kill any that are found.

Restrict SSH access to only user accounts that should have it. For example, you may create a group called "sshlogin" and add the group name as the value associated with the AllowGroups variable located in the file /etc/ssh/sshd_config.

AllowGroups sshlogin

Then add your permitted SSH users to the group "sshlogin", and restart the SSH service.

sudo adduser username sshlogin
sudo /etc/init.d/ssh restart
1.5.2. External User Database Authentication

Most enterprise networks require centralized authentication and access controls for all system resources. If you have configured your server to authenticate users against external databases, be sure to disable the user accounts both externally and locally, this way you ensure that local fallback authentication is not possible.
2. Console Security

As with any other security barrier you put in place to protect your server, it is pretty tough to defend against untold damage caused by someone with physical access to your environment, for example, theft of hard drives, power or service disruption and so on. Therefore, console security should be addressed merely as one component of your overall physical security strategy. A locked "screen door" may deter a casual criminal, or at the very least slow down a determined one, so it is still advisable to perform basic precautions with regard to console security.

The following instructions will help defend your server against issues that could otherwise yield very serious consequences.

2.1. Disable Ctrl+Alt+Delete

First and foremost, anyone that has physical access to the keyboard can simply use the Ctrl+Alt+Delete key combination to reboot the server without having to log on. Sure, someone could simply unplug the power source, but you should still prevent the use of this key combination on a production server. This forces an attacker to take more drastic measures to reboot the server, and will prevent accidental reboots at the same time.

- To disable the reboot action taken by pressing the Ctrl+Alt+Delete key combination, comment out the following line in the file /etc/event.d/control-alt-delete.  

  #exec /sbin/shutdown -r now "Control-Alt-Delete pressed"

2.2. GRUB Password Security

Ubuntu installs GNU GRUB as its default boot loader, which allows for great flexibility and recovery options. For example, when you install additional kernel images, these are automatically added as available boot options in the grub menu. Also, by default, alternate boot options are available for each kernel entry that may be used for system recovery, aptly labeled (recovery mode). Recovery mode simply boots the corresponding kernel image into single user mode (init 1), which lands the administrator at a root prompt without the need for any password.

Therefore, it is important to control who may edit the grub menu items which, would otherwise allow for someone to perform the following dangerous actions:

- Pass kernel options at boot up.
- Boot the server into single user mode.

You can prevent these actions by adding a password to GRUB's configuration file of /boot/grub/ menu.lst, which will be required to unlock GRUB's more advanced features prior to use.

- To add a password for use with grub, first you must generate an md5 password hash using the grub-md5-crypt utility:
grub-md5-crypt

The command will ask you to enter a password and offer a resulting hash value as shown below:

Password: (enter new password)
Retype password: (repeat password)
$1$s3YiK$M3lxAbqA6Jlm2FbdWnClQ0

• Add the resulting hash value to the file `/boot/grub/menu.lst` in the following format:

password --md5 $1$s3YiK$M3lxAbqA6Jlm2FbdWnClQ0

• To require use of the password for entering single user mode, change the value of the `lockalternative` variable in the file `/boot/grub/menu.lst` to `true`, as shown in the following example.

# lockalternative=true

This does not prevent someone from booting the server from alternate media. A determined attacker would simply boot into an alternate environment, overwrite your master boot record, mount or copy your physical volumes, destroy your data, or anything else they can imagine. Please explore other countermeasures that may help you with these types of attacks.
3. Firewall

3.1. Introduction

The Linux kernel includes the Netfilter subsystem, which is used to manipulate or decide the fate of network traffic headed into or through your server. All modern Linux firewall solutions use this system for packet filtering.

The kernel's packet filtering system would be of little use to administrators without a userspace interface to manage it. This is the purpose of iptables. When a packet reaches your server, it will be handed off to the Netfilter subsystem for acceptance, manipulation, or rejection based on the rules supplied to it from userspace via iptables. Thus, iptables is all you need to manage your firewall if you're familiar with it, but many frontends are available to simplify the task.

3.2. ufw - Uncomplicated Firewall

The default firewall configuration tool for Ubuntu is ufw. Developed to ease iptables firewall configuration, ufw provides a user friendly way to create an IPv4 or IPv6 host-based firewall.

ufw by default is initially disabled. From the ufw man page:

"ufw is not intended to provide complete firewall functionality via its command interface, but instead provides an easy way to add or remove simple rules. It is currently mainly used for host-based firewalls."

The following are some examples of how to use ufw:

- First, ufw needs to be enabled. From a terminal prompt enter:

  sudo ufw enable

- To open a port (ssh in this example):

  sudo ufw allow 22

- Rules can also be added using a numbered format:

  sudo ufw insert 1 allow 80

- Similarly, to close an opened port:

  sudo ufw deny 22

- To remove a rule, use delete followed by the rule:

  sudo ufw delete deny 22

- It is also possible to allow access from specific hosts or networks to a port. The following example allows ssh access from host 192.168.0.2 to any ip address on this host:
sudo ufw allow proto tcp from 192.168.0.2 to any port 22

Replace 192.168.0.2 with 192.168.0.0/24 to allow ssh access from the entire subnet.

- Adding the --dry-run option to a ufw command will output the resulting rules, but not apply them. For example, the following is what would be applied if opening the HTTP port:

  sudo ufw --dry-run allow http

  *filter
  :ufw-user-input - [0:0]
  :ufw-user-output - [0:0]
  :ufw-user-forward - [0:0]
  :ufw-user-limit - [0:0]
  :ufw-user-limit-accept - [0:0]
  ### RULES ###
  ### tuple ### allow tcp 80 0.0.0.0/0 any 0.0.0.0/0
  -A ufw-user-input -p tcp --dport 80 -j ACCEPT
  ### END RULES ###
  -A ufw-user-input -j RETURN
  -A ufw-user-output -j RETURN
  -A ufw-user-forward -j RETURN
  -A ufw-user-limit -m limit --limit 3/minute -j LOG --log-prefix "[UFW LIMIT]: "
  -A ufw-user-limit -j REJECT
  -A ufw-user-limit-accept -j ACCEPT
  COMMIT
  Rules updated

- ufw can be disabled by:

  sudo ufw disable

- To see the firewall status, enter:

  sudo ufw status

- And for more verbose status information use:

  sudo ufw status verbose

- To view the numbered format:

  sudo ufw status numbered

If the port you want to open or close is defined in /etc/services, you can use the port name instead of the number. In the above examples, replace 22 with ssh.
This is a quick introduction to using ufw. Please refer to the ufw man page for more information.

3.2.1. ufw Application Integration

Applications that open ports can include an ufw profile, which details the ports needed for the application to function properly. The profiles are kept in /etc/ufw/applications.d, and can be edited if the default ports have been changed.

- To view which applications have installed a profile, enter the following in a terminal:

  `sudo ufw app list`

- Similar to allowing traffic to a port, using an application profile is accomplished by entering:

  `sudo ufw allow Samba`

- An extended syntax is available as well:

  `ufw allow from 192.168.0.0/24 to any app Samba`

  Replace `Samba` and `192.168.0.0/24` with the application profile you are using and the IP range for your network.

  There is no need to specify the protocol for the application, because that information is detailed in the profile. Also, note that the app name replaces the port number.

- To view details about which ports, protocols, etc are defined for an application, enter:

  `sudo ufw app info Samba`

Not all applications that require opening a network port come with ufw profiles, but if you have profiled an application and want the file to be included with the package, please file a bug against the package in Launchpad¹.

3.3. IP Masquerading

The purpose of IP Masquerading is to allow machines with private, non-routable IP addresses on your network to access the Internet through the machine doing the masquerading. Traffic from your private network destined for the Internet must be manipulated for replies to be routable back to the machine that made the request. To do this, the kernel must modify the source IP address of each packet so that replies will be routed back to it, rather than to the private IP address that made the request, which is impossible over the Internet. Linux uses Connection Tracking (conntrack) to keep track of which connections belong to which machines and reroute each return packet accordingly. Traffic leaving your private network is thus "masqueraded" as having originated from your Ubuntu gateway machine. This process is referred to in Microsoft documentation as Internet Connection Sharing.

¹ https://launchpad.net/
3.3.1. ufw Masquerading

IP Masquerading can be achieved using custom ufw rules. This is possible because the current back-
end for ufw is iptables-restore with the rules files located in /etc/ufw/*.rules. These files are a
great place to add legacy iptables rules used without ufw, and rules that are more network gateway or
bridge related.

The rules are split into two different files, rules that should be executed before ufw command line
rules, and rules that are executed after ufw command line rules.

- First, packet forwarding needs to be enabled in ufw. Two configuration files will need to be
  adjusted, in /etc/default/ufw change the DEFAULT_FORWARD_POLICY to “ACCEPT”:

  ```
  DEFAULT_FORWARD_POLICY="ACCEPT"
  ```

  Then edit /etc/ufw/sysctl.conf and uncomment:

  ```
  net.ipv4.ip_forward=1
  ```

  Similarly, for IPv6 forwarding uncomment:

  ```
  net.ipv6.conf.default.forwarding=1
  ```

- Now we will add rules to the /etc/ufw/before.rules file. The default rules only configure the
  filter table, and to enable masquerading the nat table will need to be configured. Add the following
to the top of the file just after the header comments:

  ```
  # nat Table rules
  *nat
  :POSTROUTING ACCEPT [0:0]
  
  # Forward traffic from eth1 through eth0.
  -A POSTROUTING -s 192.168.0.0/24 -o eth0 -j MASQUERADE
  
  # don't delete the 'COMMIT' line or these nat table rules won't be processed
  COMMIT
  ```

  The comments are not strictly necessary, but it is considered good practice to document your
configuration. Also, when modifying any of the rules files in /etc/ufw, make sure these lines are
the last line for each table modified:

  ```
  # don't delete the 'COMMIT' line or these rules won't be processed
  COMMIT
  ```

  For each Table a corresponding COMMIT statement is required. In these examples only the nat and
filter tables are shown, but you can also add rules for the raw and mangle tables.
In the above example replace eth0, eth1, and 192.168.0.0/24 with the appropriate interfaces and IP range for your network.

- Finally, disable and re-enable ufw to apply the changes:

  ```
sudo ufw disable && sudo ufw enable
  ```

IP Masquerading should now be enabled. You can also add any additional FORWARD rules to the 
/etc/ufw/before.rules. It is recommended that these additional rules be added to the ufw-before-forward chain.

### 3.3.2. iptables Masquerading

iptables can also be used to enable masquerading.

- Similar to ufw, the first step is to enable IPv4 packet forwarding by editing /etc/sysctl.conf and uncomment the following line

  ```
  net.ipv4.ip_forward=1
  ```

  If you wish to enable IPv6 forwarding also uncomment:

  ```
  net.ipv6.conf.default.forwarding=1
  ```

- Next, execute the sysctl command to enable the new settings in the configuration file:

  ```
  sudo sysctl -p
  ```

- IP Masquerading can now be accomplished with a single iptables rule, which may differ slightly based on your network configuration:

  ```
  sudo iptables -t nat -A POSTROUTING -s 192.168.0.0/16 -o ppp0 -j MASQUERADE
  ```

  The above command assumes that your private address space is 192.168.0.0/16 and that your Internet-facing device is ppp0. The syntax is broken down as follows:

  - `-t nat` -- the rule is to go into the nat table
  - `-A POSTROUTING` -- the rule is to be appended (-A) to the POSTROUTING chain
  - `-s 192.168.0.0/16` -- the rule applies to traffic originating from the specified address space
  - `-o ppp0` -- the rule applies to traffic scheduled to be routed through the specified network device
  - `-j MASQUERADE` -- traffic matching this rule is to "jump" (-j) to the MASQUERADE target to be manipulated as described above

  Also, each chain in the filter table (the default table, and where most or all packet filtering occurs) has a default policy of ACCEPT, but if you are creating a firewall in addition to a gateway device, you may have set the policies to DROP or REJECT, in which case your masqueraded traffic needs to be allowed through the FORWARD chain for the above rule to work:
sudo iptables -A FORWARD -s 192.168.0.0/16 -o ppp0 -j ACCEPT
sudo iptables -A FORWARD -d 192.168.0.0/16 -m state --state ESTABLISHED,RELATED -i ppp0 -j ACCEPT

The above commands will allow all connections from your local network to the Internet and all traffic related to those connections to return to the machine that initiated them.

- If you want masquerading to be enabled on reboot, which you probably do, edit /etc/rc.local and add any commands used above. For example add the first command with no filtering:

  iptables -t nat -A POSTROUTING -s 192.168.0.0/16 -o ppp0 -j MASQUERADE

3.4. Logs

Firewall logs are essential for recognizing attacks, troubleshooting your firewall rules, and noticing unusual activity on your network. You must include logging rules in your firewall for them to be generated, though, and logging rules must come before any applicable terminating rule (a rule with a target that decides the fate of the packet, such as ACCEPT, DROP, or REJECT).

If you are using ufw, you can turn on logging by entering the following in a terminal:

  sudo ufw logging on

To turn logging off in ufw, simply replace on with off in the above command.

If using iptables instead of ufw, enter:

  sudo iptables -A INPUT -m state --state NEW -p tcp --dport 80 -j LOG --log-prefix "NEW_HTTP_CONN: "

A request on port 80 from the local machine, then, would generate a log in dmesg that looks like this:

  [4304885.870000] NEW_HTTP_CONN: IN=lo OUT= MAC=00:00:00:00:00:00:00:00:00:00:08:00 SRC=127.0.0.1 DST=127.0.0.1 LEN=60 TOS=0x00 PREC=0x00 TTL=64 ID=58288 DF PROTO=TCP SPT=53981 DPT=80 WINDOW=32767 RES=0x00 SYN URGP=0

The above log will also appear in /var/log/messages, /var/log/syslog, and /var/log/kern.log. This behavior can be modified by editing /etc/syslog.conf appropriately or by installing and configuring ulogd and using the ULOG target instead of LOG. The ulogd daemon is a userspace server that listens for logging instructions from the kernel specifically for firewalls, and can log to any file you like, or even to a PostgreSQL or MySQL database. Making sense of your firewall logs can be simplified by using a log analyzing tool such as fwanalog, fwlogwatch, or lire.

3.5. Other Tools

There are many tools available to help you construct a complete firewall without intimate knowledge of iptables. For the GUI-inclined:

- Firestarter is quite popular and easy to use.
• *fwbuilder* $^3$ is very powerful and will look familiar to an administrator who has used a commercial firewall utility such as Checkpoint FireWall-1.

If you prefer a command-line tool with plain-text configuration files:

• *Shorewall* $^4$ is a very powerful solution to help you configure an advanced firewall for any network.

• *ipkungfu* $^5$ should give you a working firewall “out of the box” with zero configuration, and will allow you to easily set up a more advanced firewall by editing simple, well-documented configuration files.

• *fireflier* $^6$ is designed to be a desktop firewall application. It is made up of a server (fireflier-server) and your choice of GUI clients (GTK or QT), and behaves like many popular interactive firewall applications for Windows.

### 3.6. References

• The *Ubuntu Firewall* $^7$ wiki page contains information on the development of ufw.

• Also, the ufw manual page contains some very useful information: **man ufw**.

• See the *packet-filtering-HOWTO* $^8$ for more information on using iptables.

• The *nat-HOWTO* $^9$ contains further details on masquerading.
4. AppArmor

AppArmor is a Linux Security Module implementation of name-based mandatory access controls. AppArmor confines individual programs to a set of listed files and posix 1003.1e draft capabilities.

AppArmor is installed and loaded by default. It uses profiles of an application to determine what files and permissions the application requires. Some packages will install their own profiles, and additional profiles can be found in the apparmor-profiles package.

To install the apparmor-profiles package from a terminal prompt:

```
sudo apt-get install apparmor-profiles
```

AppArmor profiles have two modes of execution:

- Complaining/Learning: profile violations are permitted and logged. Useful for testing and developing new profiles.
- Enforced/Confined: enforces profile policy as well as logging the violation.

4.1. Using AppArmor

The apparmor-utils package contains command line utilities that you can use to change the AppArmor execution mode, find the status of a profile, create new profiles, etc.

- `apparmor_status` is used to view the current status of AppArmor profiles.
  ```
sudo apparmor_status
  ```

- `aa-complain` places a profile into *complain* mode.
  ```
sudo aa-complain /path/to/bin
  ```

- `aa-enforce` places a profile into *enforce* mode.
  ```
sudo aa-enforce /path/to/bin
  ```

- The `/etc/apparmor.d` directory is where the AppArmor profiles are located. It can be used to manipulate the *mode* of all profiles.

Enter the following to place all profiles into complain mode:

```
sudo aa-complain /etc/apparmor.d/*
```

To place all profiles in enforce mode:

```
sudo aa-enforce /etc/apparmor.d/*
```
Security

- apparmor_parser is used to load a profile into the kernel. It can also be used to reload a currently loaded profile using the -r option. To load a profile:

  ```
  cat /etc/apparmor.d/profile.name | sudo apparmor_parser -a
  ```

  To reload a profile:

  ```
  cat /etc/apparmor.d/profile.name | sudo apparmor_parser -r
  ```

- /etc/init.d/apparmor can be used to reload all profiles:

  ```
  sudo /etc/init.d/apparmor reload
  ```

- The /etc/apparmor.d/disable directory can be used along with the apparmor_parser -R option to disable a profile.

  ```
  sudo ln -s /etc/apparmor.d/profile.name /etc/apparmor.d/disable/
  sudo apparmor_parser -R /etc/apparmor.d/profile.name
  ```

  To re-enable a disabled profile remove the symbolic link to the profile in /etc/apparmor.d/disable/. Then load the profile using the -a option.

  ```
  sudo rm /etc/apparmor.d/disable/profile.name
  cat /etc/apparmor.d/profile.name | sudo apparmor_parser -a
  ```

- AppArmor can be disabled, and the kernel module unloaded by entering the following:

  ```
  sudo /etc/init.d/apparmor stop
  sudo update-rc.d -f apparmor remove
  ```

- To re-enable AppArmor enter:

  ```
  sudo /etc/init.d/apparmor start
  sudo update-rc.d apparmor defaults
  ```

Replace profile.name with the name of the profile you want to manipulate. Also, replace /path/to/bin/ with the actual executable file path. For example for the ping command use /bin/ping

4.2. Profiles

AppArmor profiles are simple text files located in /etc/apparmor.d/. The files are named after the full path to the executable they profile replacing the "/" with ".". For example /etc/apparmor.d/bin.ping is the AppArmor profile for the /bin/ping command.

There are two main type of rules used in profiles:

- **Path entries:** which detail which files an application can access in the file system.
• *Capability entries:* determine what privileges a confined process is allowed to use.

As an example take a look at `/etc/apparmor.d/bin.ping`:

```plaintext
#include <tunables/global>
/bin/ping flags=(complain) {
    #include <abstractions/base>
    #include <abstractions/consoles>
    #include <abstractions/nameservice>
    
capability net_raw,
capability setuid,
network inet raw,

    /bin/ping mixr,
    /etc/modules.conf r,
}
```

• *#include <tunables/global>*: include statements from other files. This allows statements pertaining to multiple applications to be placed in a common file.

• */bin/ping flags=(complain)*: path to the profiled program, also setting the mode to *complain*.

• *capability net_raw*: allows the application access to the CAP_NET_RAW Posix.1e capability.

• */bin/ping mixr*: allows the application read and execute access to the file.

After editing a profile file the profile must be reloaded. See Section 4.1, “Using AppArmor” [p. 111] for details.

4.2.1. Creating a Profile

• *Design a test plan:* Try to think about how the application should be exercised. The test plan should be divided into small test cases. Each test case should have a small description and list the steps to follow.

Some standard test cases are:

• Starting the program.

• Stopping the program.

• Reloading the program.

• Testing all the commands supported by the init script.

• *Generate the new profile:* Use aa-genprof to generate a new profile. From a terminal:

```
sudo aa-genprof executable
```

For example:

```
sudo aa-genprof slapd
```
To get your new profile included in the apparmor-profiles package, file a bug in Launchpad against the AppArmor package:

- Include your test plan and test cases.
- Attach your new profile to the bug.

### 4.2.2. Updating Profiles

When the program is misbehaving, audit messages are sent to the log files. The program aa-logprof can be used to scan log files for AppArmor audit messages, review them and update the profiles. From a terminal:

```
sudo aa-logprof
```

### 4.3. References

- See the AppArmor Administration Guide for advanced configuration options.
- For details using AppArmor with other Ubuntu releases see the AppArmor Community Wiki page.
- The OpenSUSE AppArmor page is another introduction to AppArmor.
- A great place to ask for AppArmor assistance, and get involved with the Ubuntu Server community, is the #ubuntu-server IRC channel on freenode.
5. Certificates

One of the most common forms of cryptography today is public-key cryptography. Public-key cryptography utilizes a public key and a private key. The system works by encrypting information using the public key. The information can then only be decrypted using the private key.

A common use for public-key cryptography is encrypting application traffic using a Secure Socket Layer (SSL) or Transport Layer Security (TLS) connection. For example, configuring Apache to provide HTTPS, the HTTP protocol over SSL. This allows a way to encrypt traffic using a protocol that does not itself provide encryption.

A Certificate is a method used to distribute a public key and other information about a server and the organization who is responsible for it. Certificates can be digitally signed by a Certification Authority or CA. A CA is a trusted third party that has confirmed that the information contained in the certificate is accurate.

5.1. Types of Certificates

To set up a secure server using public-key cryptography, in most cases, you send your certificate request (including your public key), proof of your company's identity, and payment to a CA. The CA verifies the certificate request and your identity, and then sends back a certificate for your secure server. Alternatively, you can create your own self-signed certificate.

Note, that self-signed certificates should not be used in most production environments.

Continuing the HTTPS example, a CA-signed certificate provides two important capabilities that a self-signed certificate does not:

- Browsers (usually) automatically recognize the certificate and allow a secure connection to be made without prompting the user.
- When a CA issues a signed certificate, it is guaranteeing the identity of the organization that is providing the web pages to the browser.

Most Web browsers, and computers, that support SSL have a list of CAs whose certificates they automatically accept. If a browser encounters a certificate whose authorizing CA is not in the list, the browser asks the user to either accept or decline the connection. Also, other applications may generate an error message when using a self-signed certificate.

The process of getting a certificate from a CA is fairly easy. A quick overview is as follows:

1. Create a private and public encryption key pair.
2. Create a certificate request based on the public key. The certificate request contains information about your server and the company hosting it.
3. Send the certificate request, along with documents proving your identity, to a CA. We cannot tell you which certificate authority to choose. Your decision may be based on your past experiences, or on the experiences of your friends or colleagues, or purely on monetary factors.
Once you have decided upon a CA, you need to follow the instructions they provide on how to obtain a certificate from them.

4. When the CA is satisfied that you are indeed who you claim to be, they send you a digital certificate.

5. Install this certificate on your secure server, and configure the appropriate applications to use the certificate.

5.2. Generating a Certificate Signing Request (CSR)

Whether you are getting a certificate from a CA or generating your own self-signed certificate, the first step is to generate a key.

If the certificate will be used by service daemons, such as Apache, Postfix, Dovecot, etc, a key without a passphrase is often appropriate. Not having a passphrase allows the services to start without manual intervention, usually the preferred way to start a daemon.

This section will cover generating a key with a passphrase, and one without. The non-passphrase key will then be used to generate a certificate that can be used with various service daemons.

Running your secure service without a passphrase is convenient because you will not need to enter the passphrase every time you start your secure service. But it is insecure and a compromise of the key means a compromise of the server as well.

To generate the keys for the Certificate Signing Request (CSR) run the following command from a terminal prompt:

```
openssl genrsa -des3 -out server.key 1024
```

```
Generating RSA private key, 1024 bit long modulus
........................+++++
........................+++++
unable to write 'random state'
e is 65537 (0x10001)
Enter pass phrase for server.key:
```

You can now enter your passphrase. For best security, it should at least contain eight characters. The minimum length when specifying -des3 is four characters. It should include numbers and/or punctuation and not be a word in a dictionary. Also remember that your passphrase is case-sensitive.

Re-type the passphrase to verify. Once you have re-typed it correctly, the server key is generated and stored in the `server.key` file.

Now create the insecure key, the one without a passphrase, and shuffle the key names:
openssl rsa -in server.key -out server.key.insecure
mv server.key server.key.secure
mv server.key.insecure server.key

The insecure key is now named server.key, and you can use this file to generate the CSR without passphrase.

To create the CSR, run the following command at a terminal prompt:

openssl req -new -key server.key -out server.csr

It will prompt you to enter the passphrase. If you enter the correct passphrase, it will prompt you to enter Company Name, Once you enter all these details, your CSR will be created and it will be stored in the server.csr file. Site Name, Email Id, etc.

You can now submit this CSR file to a CA for processing. The CA will use this CSR file and issue the certificate. On the other hand, you can create self-signed certificate using this CSR.

### 5.3. Creating a Self-Signed Certificate

To create the self-signed certificate, run the following command at a terminal prompt:

openssl x509 -req -days 365 -in server.csr -signkey server.key -out server.crt

The above command will prompt you to enter the passphrase. Once you enter the correct passphrase, your certificate will be created and it will be stored in the server.crt file.

If your secure server is to be used in a production environment, you probably need a CA-signed certificate. It is not recommended to use self-signed certificate.

### 5.4. Installing the Certificate

You can install the key file server.key and certificate file server.crt, or the certificate file issued by your CA, by running following commands at a terminal prompt:

sudo cp server.crt /etc/ssl/certs
sudo cp server.key /etc/ssl/private

Now simply configure any applications, with the ability to use public-key cryptography, to use the certificate and key files. For example, Apache can provide HTTPS, Dovecot can provide IMAPS and POP3S, etc.

### 5.5. Certification Authority

If the services on your network require more than a few self-signed certificates it may be worth the additional effort to setup your own internal Certification Authority (CA). Using certificates signed
by your own CA, allows the various services using the certificates to easily trust other services using certificates issued from the same CA.

1. First, create the directories to hold the CA certificate and related files:

   ```
sudo mkdir /etc/ssl/CA
sudo mkdir /etc/ssl/newcerts
   ```

2. The CA needs a few additional files to operate, one to keep track of the last serial number used by the CA, each certificate must have a unique serial number, and another file to record which certificates have been issued:

   ```
sudo sh -c "echo '01' > /etc/ssl/CA/serial"
sudo touch /etc/ssl/CA/index.txt
   ```

3. The third file is a CA configuration file. Though not strictly necessary, it is very convenient when issuing multiple certificates. Edit `/etc/ssl/openssl.cnf`, and in the `[CA_default]` change:

   ```
dir             = /etc/ssl/             # Where everything is kept
database        = $dir/CA/index.txt     # database index file.
certificate     = $dir/certs/cacert.pem # The CA certificate
serial          = $dir/CA/serial        # The current serial number
private_key     = $dir/private/cakey.pem# The private key
   ```

4. Next, create the self-signed root certificate:

   ```
openssl req -new -x509 -extensions v3_ca -keyout cakey.pem -out cacert.pem -days 3650
   ```

   You will then be asked to enter the details about the certificate.

5. Now install the root certificate and key:

   ```
sudo mv cakey.pem /etc/ssl/private/
sudo mv cacert.pem /etc/ssl/certs/
   ```

6. You are now ready to start signing certificates. The first item needed is a Certificate Signing Request (CSR), see Section 5.2, “Generating a Certificate Signing Request (CSR)” [p. 116] for details. Once you have a CSR, enter the following to generate a certificate signed by the CA:

   ```
sudo openssl ca -in server.csr -config /etc/ssl/openssl.cnf
   ```

   After entering the password for the CA key, you will be prompted to sign the certificate, and again to commit the new certificate. You should then see a somewhat large amount of output related to the certificate creation.

7. There should now be a new file, `/etc/ssl/newcerts/01.pem`, containing the same output. Copy and paste everything between the `-----BEGIN CERTIFICATE-----` and `----END CERTIFICATE-----`
Secure lines to a file named after the hostname of the server where the certificate will be installed. For example `mail.example.com.crt` is a nice descriptive name.

Subsequent certificates will be named `02.pem`, `03.pem`, etc.

Replace `mail.example.com.crt` with your own descriptive name.

8. Finally, copy the new certificate to the host that needs it, and configure the appropriate applications to use it. The default location to install certificates is `/etc/ssl/certs`. This enables multiple services to use the same certificate without overly complicated file permissions.

For applications that can be configured to use a CA certificate, you should also copy the `/etc/ssl/certs/cacert.pem` file to the `/etc/ssl/certs/` directory on each server.

5.6. References

- For more detailed instructions on using cryptography see the SSL Certificates HOWTO by tlpd.org
- The PKI Page contains a list of Certificate Authorities.
- The Wikipedia HTTPS page has more information regarding HTTPS.
- For more information on OpenSSL see the OpenSSL Home Page.
- Also, O'Reilly's Network Security with OpenSSL is a good in depth reference.
6. eCryptfs

eCryptfs is a POSIX-compliant enterprise-class stacked cryptographic filesystem for Linux. Layering on top of the filesystem layer eCryptfs protects files no matter the underlying filesystem, partition type, etc.

During installation there is an option to encrypt the /home partition. This will automatically configure everything needed to encrypt and mount the partition.

As an example, this section will cover configuring /srv to be encrypted using eCryptfs.

6.1. Using eCryptfs

First, install the necessary packages. From a terminal prompt enter:

```bash
sudo apt-get install ecryptfs-utils
```

Now mount the partition to be encrypted:

```bash
sudo mount -t ecryptfs /srv /srv
```

You will then be prompted for some details on how ecryptfs should encrypt the data.

To test that files placed in /srv are indeed encrypted copy the /etc/default folder to /srv:

```bash
sudo cp -r /etc/default /srv
```

Now unmount /srv, and try to view a file:

```bash
sudo umount /srv
cat /srv/default/cron
```

Remounting /srv using ecryptfs will make the data viewable once again.

6.2. Automatically Mounting Encrypted Partitions

There are a couple of ways to automatically mount an ecryptfs encrypted filesystem at boot. This example will use a /root/.ecryptfsrc file containing mount options, along with a passphrase file residing on a USB key.

First, create /root/.ecryptfsrc containing:

```plaintext
key=passphrase:passphrase_passwd_file=/mnt/usb/passwd_file.txt
ecryptfs_sig=5826dd62cf81c615
ecryptfs_cipher=aes
ecryptfs_key_bytes=16
```
Security

ecryptfs_passthrough=n
ecryptfs_enable_filename_crypto=n

Adjust the `ecryptfs_sig` to the signature in `/root/.ecryptfs/sig-cache.txt`.

Next, create the `/mnt/usb/passwd_file.txt` passphrase file:

`passphrase_passwd=[secrets]`

Now add the necessary lines to `/etc/fstab`:

```
/dev/sdb1 /mnt/usb ext3 ro 0 0
/srv /srv ecryptfs defaults 0 0
```

Make sure the USB drive is mounted before the encrypted partition.

Finally, reboot and the `/srv` should be mounted using ecryptfs.

6.3. Other Utilities

The ecryptfs-utils package includes several other useful utilities:
- `ecryptfs-setup-private`: creates a `~/.Private` directory to contain encrypted information. This utility can be run by unprivileged users to keep data private from other users on the system.
- `ecryptfs-mount-private` and `ecryptfs-umount-private`: will mount and unmount respectively, a user's `~/.Private` directory.
- `ecryptfs-add-passphrase`: adds a new passphrase to the kernel keyring.
- `ecryptfs-manager`: manages eCryptfs objects such as keys.
- `ecryptfs-stat`: allows you to view the ecryptfs meta information for a file.

6.4. References

- For more information on eCryptfs see the [Launch Pad project page](#).
- There is also a [Linux Journal](#) article covering eCryptfs.
- Also, for more ecryptfs options see the `ecryptfs man page`.

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Chapter 9. Web Servers

A Web server is a software responsible for accepting HTTP requests from clients, which are known as Web browsers, and serving them HTTP responses along with optional data contents, which usually are Web pages such as HTML documents and linked objects (images, etc.).
### 1. HTTPD - Apache2 Web Server

Apache is the most commonly used Web Server on Linux systems. Web Servers are used to serve Web Pages requested by client computers. Clients typically request and view Web Pages using Web Browser applications such as Firefox, Opera, or Mozilla.

Users enter a Uniform Resource Locator (URL) to point to a Web server by means of its Fully Qualified Domain Name (FQDN) and a path to the required resource. For example, to view the home page of the [Ubuntu Web site](http://www.ubuntu.com) a user will enter only the FQDN. To request specific information about [paid support](http://www.ubuntu.com/support/paid), a user will enter the FQDN followed by a path.

The most common protocol used to transfer Web pages is the Hyper Text Transfer Protocol (HTTP). Protocols such as Hyper Text Transfer Protocol over Secure Sockets Layer (HTTPS), and File Transfer Protocol (FTP), a protocol for uploading and downloading files, are also supported.

Apache Web Servers are often used in combination with the MySQL database engine, the HyperText Preprocessor (PHP) scripting language, and other popular scripting languages such as Python and Perl. This configuration is termed LAMP (Linux, Apache, MySQL and Perl/Python/PHP) and forms a powerful and robust platform for the development and deployment of Web-based applications.

#### 1.1. Installation

The Apache2 web server is available in Ubuntu Linux. To install Apache2:

- At a terminal prompt enter the following command:

  ```
  sudo apt-get install apache2
  ```

#### 1.2. Configuration

Apache2 is configured by placing directives in plain text configuration files. The configuration files are separated between the following files and directories:

- `apache2.conf`: the main Apache2 configuration file. Contains settings that are global to Apache2.
- `conf.d`: contains configuration files which apply globally to Apache. Other packages that use Apache2 to serve content may add files, or symlinks, to this directory.
- `envvars`: file where Apache2 environment variables are set.
- `httpd.conf`: historically the main Apache2 configuration file, named after the httpd daemon. The file can be used for user specific configuration options that globally effect Apache2.
- `mods-available`: this directory contains configuration files to both load modules and configure them. Not all modules will have specific configuration files, however.

---

1 [http://www.ubuntu.com](http://www.ubuntu.com)
2 [http://www.ubuntu.com/support/paid](http://www.ubuntu.com/support/paid)
• **mods-enabled:** holds symlinks to the files in `/etc/apache2/mods-available`. When a module configuration file is symlinked it will be enabled the next time apache2 is restarted.

• **ports.conf:** houses the directives that determine which TCP ports Apache2 is listening on.

• **sites-available:** this directory has configuration files for Apache Virtual Hosts. Virtual Hosts allow Apache2 to be configured for multiple sites that have separate configurations.

• **sites-enabled:** like mods-enabled, sites-enabled contains symlinks to the `/etc/apache2/sites-available` directory. Similarly when a configuration file in sites-available is symlinked it will be active once Apache is restarted.

In addition, other configuration files may be added using the `Include` directive, and wildcards can be used to include many configuration files. Any directive may be placed in any of these configuration files. Changes to the main configuration files are only recognized by Apache2 when it is started or restarted.

The server also reads a file containing mime document types; the filename is set by the `TypesConfig` directive, and is `/etc/mime.types` by default.

### 1.2.1. Basic Settings

This section explains Apache2 server essential configuration parameters. Refer to the Apache2 Documentation\(^3\) for more details.

• Apache2 ships with a virtual-host-friendly default configuration. That is, it is configured with a single default virtual host (using the `VirtualHost` directive) which can modified or used as-is if you have a single site, or used as a template for additional virtual hosts if you have multiple sites. If left alone, the default virtual host will serve as your default site, or the site users will see if the URL they enter does not match the `ServerName` directive of any of your custom sites. To modify the default virtual host, edit the file `/etc/apache2/sites-available/default`.

The directives set for a virtual host only apply to that particular virtual host. If a directive is set server-wide and not defined within the virtual host settings, the default setting is used. For example, you can define a Webmaster email address and not define individual email addresses for each virtual host.

If you wish to configure a new virtual host or site, copy that file into the same directory with a name you choose. For example:

```
sudo cp /etc/apache2/sites-available/default /etc/apache2/sites-available/mynewsite
```

Edit the new file to configure the new site using some of the directives described below.

• The `ServerAdmin` directive specifies the email address to be advertised for the server's administrator. The default value is webmaster@localhost. This should be changed to an email address.

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\(^3\) [http://httpd.apache.org/docs/2.2/](http://httpd.apache.org/docs/2.2/)
address that is delivered to you (if you are the server’s administrator). If your website has a problem, Apache2 will display an error message containing this email address to report the problem to. Find this directive in your site’s configuration file in /etc/apache2/sites-available.

- The `Listen` directive specifies the port, and optionally the IP address, Apache2 should listen on. If the IP address is not specified, Apache2 will listen on all IP addresses assigned to the machine it runs on. The default value for the `Listen` directive is 80. Change this to 127.0.0.1:80 to cause Apache2 to listen only on your loopback interface so that it will not be available to the Internet, to (for example) 81 to change the port that it listens on, or leave it as is for normal operation. This directive can be found and changed in its own file, `/etc/apache2/ports.conf`.

- The `ServerName` directive is optional and specifies what FQDN your site should answer to. The default virtual host has no `ServerName` directive specified, so it will respond to all requests that do not match a `ServerName` directive in another virtual host. If you have just acquired the domain name ubunturocks.com and wish to host it on your Ubuntu server, the value of the `ServerName` directive in your virtual host configuration file should be ubunturocks.com. Add this directive to the new virtual host file you created earlier (`/etc/apache2/sites-available/mynewsite`).

You may also want your site to respond to www.ubunturocks.com, since many users will assume the www prefix is appropriate. Use the `ServerAlias` directive for this. You may also use wildcards in the `ServerAlias` directive.

For example, the following configuration will cause your site to respond to any domain request ending in `.ubunturocks.com`.

```
ServerAlias *.ubunturocks.com
```

- The `DocumentRoot` directive specifies where Apache should look for the files that make up the site. The default value is `/var/www`. No site is configured there, but if you uncomment the `RedirectMatch` directive in `/etc/apache2/apache2.conf` requests will be redirected to `/var/www/apache2-default` where the default Apache2 site awaits. Change this value in your site's virtual host file, and remember to create that directory if necessary!

The `/etc/apache2/sites-available` directory is **not** parsed by Apache2. Symbolic links in `/etc/apache2/sites-enabled` point to "available" sites.

Enable the new `VirtualHost` using the `a2ensite` utility and restart Apache:

```
sudo a2ensite mynewsite
sudo /etc/init.d/apache2 restart
```

Be sure to replace `mynewsite` with a more descriptive name for the `VirtualHost`. One method is to name the file after the `ServerName` directive of the `VirtualHost`.

Similarly, use the `a2dissite` utility to disable sites. This is can be useful when troubleshooting configuration problems with multiple `VirtualHosts`. 
1.2.2. Default Settings

This section explains configuration of the Apache2 server default settings. For example, if you add a virtual host, the settings you configure for the virtual host take precedence for that virtual host. For a directive not defined within the virtual host settings, the default value is used.

- The `DirectoryIndex` is the default page served by the server when a user requests an index of a directory by specifying a forward slash (/) at the end of the directory name. For example, when a user requests the page `http://www.example.com/this_directory/`, he or she will get either the `DirectoryIndex` page if it exists, a server-generated directory list if it does not and the Indexes option is specified, or a Permission Denied page if neither is true. The server will try to find one of the files listed in the `DirectoryIndex` directive and will return the first one it finds. If it does not find any of these files and if Options Indexes is set for that directory, the server will generate and return a list, in HTML format, of the subdirectories and files in the directory. The default value, found in `/etc/apache2/apache2.conf` is "index.html index.cgi index.pl index.php index.xhtml". Thus, if Apache2 finds a file in a requested directory matching any of these names, the first will be displayed.

- The `ErrorDocument` directive allows you to specify a file for Apache to use for specific error events. For example, if a user requests a resource that does not exist, a 404 error will occur, and per Apache2's default configuration, the file `/usr/share/apache2/error/HTTP_NOT_FOUND.html.var` will be displayed. That file is not in the server's DocumentRoot, but there is an Alias directive in `/etc/apache2/apache2.conf` that redirects requests to the `/error` directory to `/usr/share/apache2/error/`. To see a list of the default ErrorDocument directives, use this command:

```
grep ErrorDocument /etc/apache2/apache2.conf
```

- By default, the server writes the transfer log to the file `/var/log/apache2/access.log`. You can change this on a per-site basis in your virtual host configuration files with the `CustomLog` directive, or omit it to accept the default, specified in `/etc/apache2/apache2.conf`. You may also specify the file to which errors are logged, via the `ErrorLog` directive, whose default is `/var/log/apache2/error.log`. These are kept separate from the transfer logs to aid in troubleshooting problems with your Apache2 server. You may also specify the `LogLevel` (the default value is "warn") and the `LogFormat` (see `/etc/apache2/apache2.conf` for the default value).

- Some options are specified on a per-directory basis rather than per-server. `Options` is one of these directives. A Directory stanza is enclosed in XML-like tags, like so:

```
<Directory /var/www/mynewsite>
...
```
The *Options* directive within a Directory stanza accepts one or more of the following values (among others), separated by spaces:

- **ExecCGI** - Allow execution of CGI scripts. CGI scripts are not executed if this option is not chosen.
  
  Most files should not be executed as CGI scripts. This would be very dangerous. CGI scripts should kept in a directory separate from and outside your DocumentRoot, and only this directory should have the ExecCGI option set. This is the default, and the default location for CGI scripts is `/usr/lib/cgi-bin`.

- **Includes** - Allow server-side includes. Server-side includes allow an HTML file to *include* other files. This is not a common option. See the Apache2 SSI HOWTO for more information.

- **IncludesNOEXEC** - Allow server-side includes, but disable the `#exec` and `#include` commands in CGI scripts.

- **Indexes** - Display a formatted list of the directory's contents, if no `DirectoryIndex` (such as `index.html`) exists in the requested directory.
  
  For security reasons, this should usually not be set, and certainly should not be set on your DocumentRoot directory. Enable this option carefully on a per-directory basis only if you are certain you want users to see the entire contents of the directory.

- **Multiview** - Support content-negotiated multiviews; this option is disabled by default for security reasons. See the Apache2 documentation on this option.

- **SymLinksIfOwnerMatch** - Only follow symbolic links if the target file or directory has the same owner as the link.

### 1.2.3. httpd Settings

This section explains some basic httpd daemon configuration settings.

- **LockFile** - The LockFile directive sets the path to the lockfile used when the server is compiled with either `USE_FCNTL_SERIALIZED_ACCEPT` or `USE_FLOCK_SERIALIZED_ACCEPT`. It must be stored on the local disk. It should be left to the default value unless the logs directory is located on an NFS share. If this is the case, the default value should be changed to a location on the local disk and to a directory that is readable only by root.

- **PidFile** - The PidFile directive sets the file in which the server records its process ID (pid). This file should only be readable by root. In most cases, it should be left to the default value.

- **User** - The User directive sets the userid used by the server to answer requests. This setting determines the server's access. Any files inaccessible to this user will also be inaccessible to your website's visitors. The default value for User is `www-data`.

  Unless you know exactly what you are doing, do not set the User directive to root. Using root as the User will create large security holes for your Web server.
The Group directive is similar to the User directive. Group sets the group under which the server will answer requests. The default group is also www-data.

1.2.4. Apache Modules

Apache is a modular server. This implies that only the most basic functionality is included in the core server. Extended features are available through modules which can be loaded into Apache. By default, a base set of modules is included in the server at compile-time. If the server is compiled to use dynamically loaded modules, then modules can be compiled separately, and added at any time using the LoadModule directive. Otherwise, Apache must be recompiled to add or remove modules.

Ubuntu compiles Apache2 to allow the dynamic loading of modules. Configuration directives may be conditionally included on the presence of a particular module by enclosing them in an `<IfModule>` block.

You can install additional Apache2 modules and use them with your Web server. For example, run the following command from a terminal prompt to install the MySQL Authentication module:

```
sudo apt-get install libapache2-mod-auth-mysql
```

See the `/etc/apache2/mods-available` directory, for additional modules.

Use the `a2enmod` utility to enable a module:

```
sudo a2enmod auth_mysql
sudo /etc/init.d/apache2 restart
```

Similarly, `a2dismod` will disable a module:

```
sudo a2dismod auth_mysql
sudo /etc/init.d/apache2 restart
```

1.3. HTTPS Configuration

The mod_ssl module adds an important feature to the Apache2 server - the ability to encrypt communications. Thus, when your browser is communicating using SSL, the `https://` prefix is used at the beginning of the Uniform Resource Locator (URL) in the browser navigation bar.

The mod_ssl module is available in apache2-common package. Execute the following command from a terminal prompt to enable the mod_ssl module:

```
sudo a2enmod ssl
```

There is a default HTTPS configuration file in `/etc/apache2/sites-available/default-ssl`. In order for Apache to provide HTTPS, a certificate and key file are also needed. The default HTTPS configuration will use a certificate and key generated by the ssl-cert package. They are good for
testing, but the auto-generated certificate and key should be replaced by a certificate specific to the site or server. For information on generating a key and obtaining a certificate see Section 5, “Certificates” [p. 115]

To configure Apache for HTTPS, enter the following:

```
sudo a2ensite default-ssl
```

The directories `/etc/ssl/certs` and `/etc/ssl/private` are the default locations. If you install the certificate and key in another directory make sure to change `SSLCertificateFile` and `SSLCertificateKeyFile` appropriately.

With Apache now configured for HTTPS, restart the service to enable the new settings:

```
sudo /etc/init.d/apache2 restart
```

Depending on how you obtained your certificate you may need to enter a passphrase when Apache starts.

You can access the secure server pages by typing https://your_hostname/url/ in your browser address bar.

### 1.4. References

- *Apache2 Documentation* contains in depth information on Apache2 configuration directives. Also, see the apache2-doc package for the official Apache2 docs.
- See the *Mod SSL Documentation* site for more SSL related information.
- O’Reilly’s *Apache Cookbook* is a good resource for accomplishing specific Apache2 configurations.
- For Ubuntu specific Apache2 questions, ask in the #ubuntu-server IRC channel on freenode.net.
2. PHP5 - Scripting Language

PHP is a general-purpose scripting language suited for Web development. The PHP script can be embedded into HTML. This section explains how to install and configure PHP5 in Ubuntu System with Apache2 and MySQL.

This section assumes you have installed and configured Apache 2 Web Server and MySQL Database Server. You can refer to Apache 2 section and MySQL sections in this document to install and configure Apache 2 and MySQL respectively.

2.1. Installation

The PHP5 is available in Ubuntu Linux.

- To install PHP5 you can enter the following command in the terminal prompt:

  `sudo apt-get install php5 libapache2-mod-php5`

  You can run PHP5 scripts from command line. To run PHP5 scripts from command line you should install php5-cli package. To install php5-cli you can enter the following command in the terminal prompt:

  `sudo apt-get install php5-cli`

  You can also execute PHP5 scripts without installing PHP5 Apache module. To accomplish this, you should install php5-cgi package. You can run the following command in a terminal prompt to install php5-cgi package:

  `sudo apt-get install php5-cgi`

  To use MySQL with PHP5 you should install php5-mysql package. To install php5-mysql you can enter the following command in the terminal prompt:

  `sudo apt-get install php5-mysql`

  Similarly, to use PostgreSQL with PHP5 you should install php5-pgsql package. To install php5-pgsql you can enter the following command in the terminal prompt:

  `sudo apt-get install php5-pgsql`

2.2. Configuration

Once you install PHP5, you can run PHP5 scripts from your web browser. If you have installed php5-cli package, you can run PHP5 scripts from your command prompt.
By default, the Apache 2 Web server is configured to run PHP5 scripts. In other words, the PHP5 module is enabled in Apache2 Web server automatically when you install the module. Please verify if the files /etc/apache2/mods-enabled/php5.conf and /etc/apache2/mods-enabled/php5.load exist. If they do not exist, you can enable the module using a2enmod command.

Once you install PHP5 related packages and enabled PHP5 Apache 2 module, you should restart Apache2 Web server to run PHP5 scripts. You can run the following command at a terminal prompt to restart your web server:

```
sudo /etc/init.d/apache2 restart
```

### 2.3. Testing

To verify your installation, you can run following PHP5 phpinfo script:

```php
<?php
print_r (phpinfo());
?>
```

You can save the content in a file `phpinfo.php` and place it under DocumentRoot directory of Apache2 Web server. When point your browser to `http://hostname/phpinfo.php`, it would display values of various PHP5 configuration parameters.

### 2.4. References

- For more in depth information see `php.net`\(^{10}\) documentation.
- There are a plethora of books on PHP. Two good books from O'Reilly are *Learning PHP 5*\(^{11}\) and the *PHP Cook Book*\(^{12}\).
3. Squid - Proxy Server

Squid is a full-featured web proxy cache server application which provides proxy and cache services for Hyper Text Transport Protocol (HTTP), File Transfer Protocol (FTP), and other popular network protocols. Squid can implement caching and proxying of Secure Sockets Layer (SSL) requests and caching of Domain Name Server (DNS) lookups, and perform transparent caching. Squid also supports a wide variety of caching protocols, such as Internet Cache Protocol, (ICP) the Hyper Text Caching Protocol, (HTCP) the Cache Array Routing Protocol (CARP), and the Web Cache Coordination Protocol. (WCCP)

The Squid proxy cache server is an excellent solution to a variety of proxy and caching server needs, and scales from the branch office to enterprise level networks while providing extensive, granular access control mechanisms and monitoring of critical parameters via the Simple Network Management Protocol (SNMP). When selecting a computer system for use as a dedicated Squid proxy, or caching servers, ensure your system is configured with a large amount of physical memory, as Squid maintains an in-memory cache for increased performance.

3.1. Installation

At a terminal prompt, enter the following command to install the Squid server:

```
sudo apt-get install squid
```

3.2. Configuration

Squid is configured by editing the directives contained within the `/etc/squid/squid.conf` configuration file. The following examples illustrate some of the directives which may be modified to affect the behavior of the Squid server. For more in-depth configuration of Squid, see the References section.

Prior to editing the configuration file, you should make a copy of the original file and protect it from writing so you will have the original settings as a reference, and to re-use as necessary.

Copy the `/etc/squid/squid.conf` file and protect it from writing with the following commands entered at a terminal prompt:

```
sudo cp /etc/squid/squid.conf /etc/squid/squid.conf.original
sudo chmod a-w /etc/squid/squid.conf.original
```

- To set your Squid server to listen on TCP port 8888 instead of the default TCP port 3128, change the `http_port` directive as such:

```
http_port 8888
```
• Change the visible_hostname directive in order to give the Squid server a specific hostname. This hostname does not necessarily need to be the computer's hostname. In this example it is set to *weezie*

```
visible_hostname weezie
```

• Again, Using Squid's access control, you may configure use of Internet services proxied by Squid to be available only users with certain Internet Protocol (IP) addresses. For example, we will illustrate access by users of the 192.168.42.0/24 subnetwork only:

Add the following to the **bottom** of the ACL section of your `/etc/squid/squid.conf` file:

```
acl fortytwo_network src 192.168.42.0/24
```

Then, add the following to the **top** of the `http_access` section of your `/etc/squid/squid.conf` file:

```
http_access allow fortytwo_network
```

• Using the excellent access control features of Squid, you may configure use of Internet services proxied by Squid to be available only during normal business hours. For example, we'll illustrate access by employees of a business which is operating between 9:00AM and 5:00PM, Monday through Friday, and which uses the 10.1.42.0/24 subnetwork:

Add the following to the **bottom** of the ACL section of your `/etc/squid/squid.conf` file:

```
acl biz_network src 10.1.42.0/24
acl biz_hours time M T W T F 9:00-17:00
```

Then, add the following to the **top** of the `http_access` section of your `/etc/squid/squid.conf` file:

```
http_access allow biz_network biz_hours
```

After making changes to the `/etc/squid/squid.conf` file, save the file and restart the squid server application to effect the changes using the following command entered at a terminal prompt:

```
sudo /etc/init.d/squid restart
```

### 3.3. References

*Squid Website*[^13]

[^13]: http://www.squid-cache.org/
4. Ruby on Rails

Ruby on Rails is an open source web framework for developing database backed web applications. It is optimized for sustainable productivity of the programmer since it lets the programmer to write code by favouring convention over configuration.

4.1. Installation

Before installing Rails you should install Apache and MySQL. To install the Apache package, please refer to Section 1, “HTTPD - Apache2 Web Server” [p. 123]. For instructions on installing MySQL refer to Section 1, “MySQL” [p. 141].

Once you have Apache and MySQL packages installed, you are ready to install Ruby on Rails package.

To install the Ruby base packages and Ruby on Rails, you can enter the following command in the terminal prompt:

```
sudo apt-get install rails
```

4.2. Configuration

Modify the `/etc/apache2/sites-available/default` configuration file to setup your domains.

The first thing to change is the `DocumentRoot` directive:

```
DocumentRoot /path/to/rails/application/public
```

Next, change the `<Directory "/path/to/rails/application/public">` directive:

```
<Directory "/path/to/rails/application/public”>
  Options Indexes FollowSymLinks MultiViews ExecCGI
  AllowOverride All
  Order allow,deny
  allow from all
  AddHandler cgi-script .cgi
</Directory>
```

You should also enable the mod_rewrite module for Apache. To enable mod_rewrite module, please enter the following command in a terminal prompt:

```
sudo a2enmod rewrite
```

Finally you will need to change the ownership of the `/path/to/rails/application/public` and `/path/to/rails/application/tmp` directories to the user used to run the Apache process:
```bash
sudo chown -R www-data:www-data /path/to/rails/application/public
sudo chown -R www-data:www-data /path/to/rails/application/tmp
```

That's it! Now you have your Server ready for your Ruby on Rails applications.

### 4.3. References

- See the *Ruby on Rails*\textsuperscript{14} website for more information.
- Also *Agile Development with Rails*\textsuperscript{15} is a great resource.
5. **Apache Tomcat**

Apache Tomcat is a web container that allows you to serve Java Servlets and JSP (Java Server Pages) web applications.

The Tomcat 6.0 packages in Ubuntu support two different ways of running Tomcat. You can install them as a classic unique system-wide instance, that will be started at boot time and will run as the tomcat6 unprivileged user. But you can also deploy private instances that will run with your own user rights, and that you should start and stop by yourself. This second way is particularly useful in a development server context where multiple users need to test on their own private Tomcat instances.

5.1. **System-wide installation**

To install the Tomcat server, you can enter the following command in the terminal prompt:

```
sudo apt-get install tomcat6
```

This will install a Tomcat server with just a default ROOT webapp that displays a minimal "It works" page by default.

5.2. **Configuration**

Tomcat configuration files can be found in `/etc/tomcat6`. Only a few common configuration tweaks will be described here, please see [Tomcat 6.0 documentation](http://tomcat.apache.org/tomcat-6.0-doc/index.html) for more.

5.2.1. **Changing default ports**

By default Tomcat 6.0 runs a HTTP connector on port 8080 and an AJP connector on port 8009. You might want to change those default ports to avoid conflict with another server on the system. This is done by changing the following lines in `/etc/tomcat6/server.xml`:

```
<Connector port="8080" protocol="HTTP/1.1"
    connectionTimeout="20000"
    redirectPort="8443" />
...
<Connector port="8009" protocol="AJP/1.3" redirectPort="8443" />
```

5.2.2. **Changing JVM used**

By default Tomcat will run preferably with OpenJDK-6, then try Sun's JVM, then try some other JVMs. If you have various JVMs installed, you can set which should be used by setting `JAVA_HOME` in `/etc/default/tomcat6`:

```
JAVA_HOME=/usr/lib/jvm/java-6-sun
```

5.2.3. Declaring users and roles

Usernames, passwords and roles (groups) can be defined centrally in a Servlet container. In Tomcat 6.0 this is done in the /etc/tomcat6/tomcat-users.xml file:

```
<role rolename="admin"/>
<user username="tomcat" password="s3cret" roles="admin"/>
```

5.3. Using Tomcat standard webapps

Tomcat is shipped with webapps that you can install for documentation, administration or demo purposes.

5.3.1. Tomcat documentation

The tomcat6-docs package contains Tomcat 6.0 documentation, packaged as a webapp that you can access by default at http://yourserver:8080/docs. You can install it by entering the following command in the terminal prompt:

```
sudo apt-get install tomcat6-docs
```

5.3.2. Tomcat administration webapps

The tomcat6-admin package contains two webapps that can be used to administer the Tomcat server using a web interface. You can install them by entering the following command in the terminal prompt:

```
sudo apt-get install tomcat6-admin
```

The first one is the `manager` webapp, which you can access by default at http://yourserver:8080/manager/html. It is primarily used to get server status and restart webapps.

Access to the `manager` application is protected by default: you need to define a user with the role "manager" in /etc/tomcat6/tomcat-users.xml before you can access it.

The second one is the `host-manager` webapp, which you can access by default at http://yourserver:8080/host-manager/html. It can be used to create virtual hosts dynamically.

Access to the `host-manager` application is also protected by default: you need to define a user with the role "admin" in /etc/tomcat6/tomcat-users.xml before you can access it.

For security reasons, the tomcat6 user cannot write to the /etc/tomcat6 directory by default. Some features in these admin webapps (application deployment, virtual host creation) need write access to that directory. If you want to use these features execute the following, to give users in the tomcat6 group the necessary rights:
Web Servers

```
sudo chgrp -R tomcat6 /etc/tomcat6
sudo chmod -R g+w /etc/tomcat6
```

5.3.3. Tomcat examples webapps

The `tomcat6-examples` package contains two webapps that can be used to test or demonstrate Servlets and JSP features, which you can access them by default at `http://yourserver:8080/examples`. You can install them by entering the following command in the terminal prompt:

```
sudo apt-get install tomcat6-examples
```

5.4. Using private instances

Tomcat is heavily used in development and testing scenarios where using a single system-wide instance doesn’t meet the requirements of multiple users on a single system. The Tomcat 6.0 packages in Ubuntu come with tools to help deploy your own user-oriented instances, allowing every user on a system to run (without root rights) separate private instances while still using the system-installed libraries.

It is possible to run the system-wide instance and the private instances in parallel, as long as they do not use the same TCP ports.

5.4.1. Installing private instance support

You can install everything necessary to run private instances by entering the following command in the terminal prompt:

```
sudo apt-get install tomcat6-user
```

5.4.2. Creating a private instance

You can create a private instance directory by entering the following command in the terminal prompt:

```
tomcat6-instance-create my-instance
```

This will create a new `my-instance` directory with all the necessary subdirectories and scripts. You can for example install your common libraries in the `lib/` subdirectory and deploy your webapps in the `webapps/` subdirectory. No webapps are deployed by default.

5.4.3. Configuring your private instance

You will find the classic Tomcat configuration files for your private instance in the `conf/` subdirectory. You should for example certainly edit the `conf/server.xml` file to change the default ports used by your private Tomcat instance to avoid conflict with other instances that might be running.
5.4.4. Starting/stopping your private instance

You can start your private instance by entering the following command in the terminal prompt (supposing your instance is located in the `my-instance` directory):

```
my-instance/bin/startup.sh
```

You should check the `logs/` subdirectory for any error. If you have a `java.net.BindException: Address already in use <null>:8080` error, it means that the port you're using is already taken and that you should change it.

You can stop your instance by entering the following command in the terminal prompt (supposing your instance is located in the `my-instance` directory):

```
my-instance/bin/shutdown.sh
```

5.5. References

- See the *Apache Tomcat*\(^7\) website for more information.
- *Tomcat: The Definitive Guide*\(^8\) is a good resource for building web applications with Tomcat.
- For additional books see the *Tomcat Books*\(^9\) list page.
Chapter 10. Databases

Ubuntu provides two popular database servers. They are:

• MySQL™
• PostgreSQL

They are available in the main repository. This section explains how to install and configure these database servers.
1. MySQL

MySQL is a fast, multi-threaded, multi-user, and robust SQL database server. It is intended for mission-critical, heavy-load production systems as well as for embedding into mass-deployed software.

1.1. Installation

To install MySQL, run the following command from a terminal prompt:

```
sudo apt-get install mysql-server
```

During the installation process you will be prompted to enter a password for the MySQL root user.

Once the installation is complete, the MySQL server should be started automatically. You can run the following command from a terminal prompt to check whether the MySQL server is running:

```
sudo netstat -tap | grep mysql
```

When you run this command, you should see the following line or something similar:

```
tcp 0 0 localhost:mysql *:* LISTEN 2556/mysqld
```

If the server is not running correctly, you can type the following command to start it:

```
sudo /etc/init.d/mysql restart
```

1.2. Configuration

You can edit the `/etc/mysql/my.cnf` file to configure the basic settings -- log file, port number, etc. For example, to configure MySQL to listen for connections from network hosts, change the `bind_address` directive to the server’s IP address:

```
bind-address = 192.168.0.5
```

Replace 192.168.0.5 with the appropriate address.

After making a change to `/etc/mysql/my.cnf` the mysql daemon will need to be restarted:

```
sudo /etc/init.d/mysql restart
```

If you would like to change the MySQL root password, in a terminal enter:
sudo dpkg-reconfigure mysql-server-5.0

The mysql daemon will be stopped, and you will be prompted to enter a new password.

1.3. Resources

- See the MySQL Home Page\(^1\) for more information.
- The MySQL Handbook is also available in the mysql-doc-5.0 package. To install the package enter the following in a terminal:

  sudo apt-get install mysql-doc-5.0

  The documentation is in HTML format, to view them enter \texttt{file:///usr/share/doc/mysql-doc-5.0/refman-5.0-en.html-chapter/index.html} in your browser’s address bar.
- For general SQL information see Using SQL Special Edition\(^2\) by Rafe Colburn.
2. PostgreSQL

PostgreSQL is an object-relational database system that has the features of traditional commercial
database systems with enhancements to be found in next-generation DBMS systems.

2.1. Installation

To install PostgreSQL, run the following command in the command prompt:

```
sudo apt-get install postgresql
```

Once the installation is complete, you should configure the PostgreSQL server based on your needs,
although the default configuration is viable.

2.2. Configuration

By default, connection via TCP/IP is disabled. PostgreSQL supports multiple client authentication
methods. By default, IDENT authentication method is used for postgres and local users. Please refer
to the PostgreSQL Administrator's Guide\(^3\).

The following discussion assumes that you wish to enable TCP/IP connections and use the MD5
method for client authentication. PostgreSQL configuration files are stored in the `/etc/postgresql/
<version>/main` directory. For example, if you install PostgreSQL 8.3, the configuration files are
stored in the `/etc/postgresql/8.3/main` directory.

To configure `ident` authentication, add entries to the `/etc/postgresql/8.3/main/
pindent.conf` file.

To enable TCP/IP connections, edit the file `/etc/postgresql/8.3/main/postgresql.conf`

Locate the line `#listen_addresses = 'localhost'` and change it to:

```
listen_addresses = 'localhost'
```

To allow other computers to connect to your PostgreSQL server replace `localhost` with the
`IP Address` of your server.

You may also edit all other parameters, if you know what you are doing! For details, refer to the
configuration file or to the PostgreSQL documentation.

Now that we can connect to our PostgreSQL server, the next step is to set a password for the `postgres`
user. Run the following command at a terminal prompt to connect to the default PostgreSQL template
database:

```
```

\(^3\) http://www.postgresql.org/docs/8.3/static/admin.html
sudo -u postgres psql template1

The above command connects to PostgreSQL database `template1` as user `postgres`. Once you connect to the PostgreSQL server, you will be at a SQL prompt. You can run the following SQL command at the psql prompt to configure the password for the user `postgres`.

```sql
ALTER USER postgres with encrypted password 'your_password';
```

After configuring the password, edit the file `/etc/postgresql/8.3/main/pg_hba.conf` to use MD5 authentication with the `postgres` user:

```
local   all         postgres                          md5 sameuser
```

Finally, you should restart the PostgreSQL service to initialize the new configuration. From a terminal prompt enter the following to restart PostgreSQL:

```
sudo /etc/init.d/postgresql-8.3 restart
```

The above configuration is not complete by any means. Please refer the PostgreSQL Administrator's Guide to configure more parameters.

### 2.3. Resources

- As mentioned above the Administrator's Guide is an excellent resource. The guide is also available in the postgresql-doc-8.3 package. Execute the following in a terminal to install the package:

  ```
sudo apt-get install postgresql-doc-8.3
```

  To view the guide enter `file:///usr/share/doc/postgresql-doc-8.3/html/index.html` into the address bar of your browser.

- For general SQL information see Using SQL Special Edition by Rafe Colburn.
Chapter 11. LAMP Applications
1. Overview

LAMP installations (Linux + Apache + MySQL + PHP) are a popular setup for Ubuntu servers. There is a plethora of Open Source applications written using the LAMP application stack. Some popular LAMP applications are Wiki’s, Content Management Systems, and Management Software such as phpMyAdmin.

One advantage of LAMP is the substantial flexibility for different database, web server, and scripting languages. Popular substitutes for MySQL include Postgresql and SQLite. Python, Perl, and Ruby are also frequently used instead of PHP.

The traditional way to install most LAMP applications is:

- Download an archive containing the application source files.
- Unpack the archive, usually in a directory accessible to a web server.
- Depending on where the source was extracted, configure a web browser to serve the files.
- Configure the application to connect to the database.
- Run a script, or browse to a page of the application, to install the database needed by the application.
- Once the steps above, or similar steps, are completed you are ready to begin using the application.

A disadvantage of using this approach is that the application files are not placed in the file system in a standard way, which can cause confusion as to where the application is installed. Another larger disadvantage is updating the application. When a new version is released, the same process used to install the application is needed to apply updates.

Fortunately, a number of LAMP applications are already packaged for Ubuntu, and are available for installation in the same way as non-LAMP applications. Depending on the application some extra configuration and setup steps may be needed, however.

This section covers how to install and configure the Wiki applications MoinMoin, MediaWiki, and the MySQL management application phpMyAdmin.

A Wiki is a website that allows the visitors to easily add, remove and modify available content easily. The ease of interaction and operation makes Wiki an effective tool for mass collaborative authoring. The term Wiki is also referred to the collaborative software.
2. Moin Moin

MoinMoin is a Wiki engine implemented in Python, based on the PikiPiki Wiki engine, and licensed under the GNU GPL.

2.1. Installation

To install MoinMoin, run the following command in the command prompt:

```
sudo apt-get install python-moinmoin
```


2.2. Configuration

For configuring your first Wiki application, please run the following set of commands. Let us assume that you are creating a Wiki named `mywiki`:

```
cd /usr/share/moin
sudo mkdir mywiki
sudo cp -R data mywiki
sudo cp -R underlay mywiki
sudo cp server/moin.cgi mywiki
sudo chown -R www-data.www-data mywiki
sudo chmod -R ug+rwX mywiki
sudo chmod -R o-rwx mywiki
```

Now you should configure MoinMoin to find your new Wiki `mywiki`. To configure MoinMoin, open `/etc/moin/mywiki.py` file and change the following line:

```
data_dir = '/org/mywiki/data'
```

To

```
data_dir = '/usr/share/moin/mywiki/data'
```

Also, below the `data_dir` option add the `data_underlay_dir`:

```
data_underlay_dir='/usr/share/moin/mywiki/underlay'
```

If the `/etc/moin/mywiki.py` file does not exists, you should copy `/etc/moin/moinmaster.py` file to `/etc/moin/mywiki.py` file and do the above mentioned change.

If you have named your Wiki as `my_wiki_name` you should insert a line “("my_wiki_name", r".*")” in `/etc/moin/farmconfig.py` file after the line “("mywiki", r".*")”.

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Once you have configured MoinMoin to find your first Wiki application `mywiki`, you should configure apache2 and make it ready for your Wiki application.

You should add the following lines in `/etc/apache2/sites-available/default` file inside the “<VirtualHost *>” tag:

```apache
### moin
  ScriptAlias /mywiki "'/usr/share/moin/mywiki/moin.cgi"
  alias /moin_static181 "'/usr/share/moin/htdocs"
<Directory /usr/share/moin/htdocs>
  Order allow,deny
  allow from all
</Directory>
### end moin
```

Once you configure the apache2 web server and make it ready for your Wiki application, you should restart it. You can run the following command to restart the apache2 web server:

```
sudo /etc/init.d/apache2 restart
```

### 2.3. Verification

You can verify the Wiki application and see if it works by pointing your web browser to the following URL:

```
http://localhost/mywiki
```

You can also run the test command by pointing your web browser to the following URL:

```
http://localhost/mywiki?action=test
```

For more details, please refer to the `MoinMoin`¹ web site.

### 2.4. References

- For more information see the `moinmoin Wiki`².

¹ [http://moinmo.in/](http://moinmo.in/)
² [http://moinmo.in/](http://moinmo.in/)
3. MediaWiki

MediaWiki is an web based Wiki software written in the PHP language. It can either use MySQL or PostgreSQL Database Management System.

3.1. Installation

Before installing MediaWiki you should also install Apache2, the PHP5 scripting language and Database a Management System. MySQL or PostgreSQL are the most common, choose one depending on your need. Please refer to those sections in this manual for installation instructions.

To install MediaWiki, run the following command in the command prompt:

```
sudo apt-get install mediawiki php5-gd
```

For additional MediaWiki functionality see the mediawiki-extensions package.

3.2. Configuration

Run the following commands to configure MediaWiki:

```
sudo ln -s /var/lib/mediawiki /var/www/mediawiki
```

Point your web browser to the following URL for MediaWiki setup:

```
http://localhost/mediawiki/config/index.php
```

Please read the “Checking environment...” section in this page. You should be able to fix many issues by carefully reading this section.

3.3. References

- For more details, please refer to the MediaWiki web site.
4. phpMyAdmin

phpMyAdmin is a LAMP application specifically written for administering MySQL servers. Written in PHP, and accessed through a web browser, phpMyAdmin provides a graphical interface for database administration tasks.

4.1. Installation

Before installing phpMyAdmin you will need access to a MySQL database either on the same host as that phpMyAdmin is installed on, or on a host accessible over the network. For more information see Section 1, “MySQL” [p. 141]. From a terminal prompt enter:

```bash
sudo apt-get install phpmyadmin
```

At the prompt choose which web server to be configured for phpMyAdmin. The rest of this section will use Apache2 for the web server.

In a browser go to http://servername/phpmyadmin, replacing servername with the server's actual hostname. At the login, page enter root for the username, or another MySQL user if you any setup, and enter the MySQL user's password.

Once logged in you can reset the root password if needed, create users, create/destroy databases and tables, etc.

4.2. Configuration

The configuration files for phpMyAdmin are located in /etc/phpmyadmin. The main configuration file is /etc/phpmyadmin/config.inc.php. This file contains configuration options that apply globally to phpMyAdmin.

To use phpMyAdmin to administer a MySQL database hosted on another server, adjust the following in /etc/phpmyadmin/config.inc.php:

```php
$cfg['Servers'][$i]['host'] = 'db_server';
```

Replace db_server with the actual remote database server name or IP address. Also, be sure that the phpMyAdmin host has permissions to access the remote database.

Once configured, log out of phpMyAdmin and back in, and you should be accessing the new server.

The config.header.inc.php and config.footer.inc.php files are used to add a HTML header and footer to phpMyAdmin.

Another important configuration file is /etc/phpmyadmin/apache.conf, this file is symlinked to /etc/apache2/conf.d/phpmyadmin.conf, and is used to configure Apache2 to serve the phpMyAdmin
site. The file contains directives for loading PHP, directory permissions, etc. For more information on configuring Apache2 see Section 1, “HTTPD - Apache2 Web Server” [p. 123].

4.3. References

- The phpMyAdmin documentation comes installed with the package and can be accessed from the phpMyAdmin Documentation link (a question mark with a box around it) under the phpMyAdmin logo. The official docs can also be access on the phpMyAdmin site.
- Also, Mastering phpMyAdmin is a great resource.
Chapter 12. File Servers

If you have more than one computer on a single network. At some point you will probably need to share files between them. In this section we cover installing and configuring FTP, NFS, and CUPS.
1. FTP Server

File Transfer Protocol (FTP) is a TCP protocol for uploading and downloading files between computers. FTP works on a client/server model. The server component is called an FTP daemon. It continuously listens for FTP requests from remote clients. When a request is received, it manages the login and sets up the connection. For the duration of the session it executes any of commands sent by the FTP client.

Access to an FTP server can be managed in two ways:

• Anonymous
• Authenticated

In the Anonymous mode, remote clients can access the FTP server by using the default user account called "anonymous" or "ftp" and sending an email address as the password. In the Authenticated mode a user must have an account and a password. User access to the FTP server directories and files is dependent on the permissions defined for the account used at login. As a general rule, the FTP daemon will hide the root directory of the FTP server and change it to the FTP Home directory. This hides the rest of the file system from remote sessions.

1.1. vsftpd - FTP Server Installation

vsftpd is an FTP daemon available in Ubuntu. It is easy to install, set up, and maintain. To install vsftpd you can run the following command:

    sudo apt-get install vsftpd

1.2. Anonymous FTP Configuration

By default vsftpd is configured to only allow anonymous download. During installation a ftp user is created with a home directory of /home/ftp. This is the default FTP directory.

If you wish to change this location, to /srv/ftp for example, simply create a directory in another location and change the ftp user's home directory:

    sudo mkdir /srv/ftp
    sudo usermod -d /srv/ftp ftp

After making the change restart vsftpd:

    sudo /etc/init.d/vsftpd restart

Finally, copy any files and directories you would like to make available through anonymous FTP to /srv/ftp.
1.3. User Authenticated FTP Configuration

To configure vsftpd to authenticate system users and allow them to upload files edit /etc/vsftpd.conf:

```
local_enable=YES
write_enable=YES
```

Now restart vsftpd:

```
sudo /etc/init.d/vsftpd restart
```

Now when system users login to FTP they will start in their home directories where they can download, upload, create directories, etc.

Similarly, by default, the anonymous users are not allowed to upload files to FTP server. To change this setting, you should uncomment the following line, and restart vsftpd:

```
anon_upload_enable=YES
```

Enabling anonymous FTP upload can be an extreme security risk. It is best to not enable anonymous upload on servers accessed directly from the Internet.

The configuration file consists of many configuration parameters. The information about each parameter is available in the configuration file. Alternatively, you can refer to the man page, `man 5 vsftpd.conf` for details of each parameter.

1.4. Securing FTP

There are options in /etc/vsftpd.conf to help make vsftpd more secure. For example users can be limited to their home directories by uncommenting:

```
chroot_local_user=YES
```

You can also limit a specific list of users to just their home directories:

```
chroot_list_enable=YES
chroot_list_file=/etc/vsftpd.chroot_list
```

After uncommenting the above options, create a /etc/vsftpd.chroot_list containing a list of users one per line. Then restart vsftpd:

```
sudo /etc/init.d/vsftpd restart
```

Also, the /etc/ftpusers file is a list of users that are disallowed FTP access. The default list includes root, daemon, nobody, etc. To disable FTP access for additional users simply add them to the list.
FTP can also be encrypted using FTPS. Different from SFTP, FTPS is FTP over Secure Socket Layer (SSL). SFTP is a FTP like session over an encrypted SSH connection. A major difference is that users of SFTP need to have a shell account on the system, instead of a nologin shell. Providing all users with a shell may not be ideal for some environments, such as a shared web host.

To configure FTPS, edit /etc/vsftpd.conf and at the bottom add:

```bash
ssl_enable=Yes
```

Also, notice the certificate and key related options:

```bash
rsa_cert_file=/etc/ssl/certs/ssl-cert-snakeoil.pem
r rsa_private_key_file=/etc/ssl/private/ssl-cert-snakeoil.key
```

By default these options are set the the certificate and key provided by the ssl-cert package. In a production environment these should be replaced with a certificate and key generated for the specific host. For more information on certificates see Section 5, “Certificates” [p. 115].

Now restart vsftpd, and non-anonymous users will be forced to use FTPS:

```bash
sudo /etc/init.d/vsftpd restart
```

To allow users with a shell of /usr/sbin/nologin access to FTP, but have no shell access, edit /etc/shells adding the nologin shell:

```bash
# /etc/shells: valid login shells
/bin/csh
/bin/sh
/usr/bin/es
/usr/bin/ksh
/bin/ksh
/usr/bin/rc
/usr/bin/tcsh
/bin/tcsh
/usr/bin/esh
/bin/dash
/bin/bash
/bin/rbash
/usr/bin/screen
/usr/sbin/nologin
```

This is necessary because, by default vsftpd uses PAM for authentication, and the /etc/pam.d/vsftpd configuration file contains:

```bash
auth    required        pam_shells.so
```

The shells PAM module restricts access to shells listed in the /etc/shells file.
Most popular FTP clients can be configured connect using FTPS. The lftp command line FTP client has the ability to use FTPS as well.

1.5. References

• See the vsftpd website\(^1\) for more information.
• For detailed /etc/vsftpd.conf options see the vsftpd.conf man page\(^2\).
• The CodeGurus article *FTPS vs. SFTP: What to Choose*\(^3\) has useful information contrasting FTPS and SFTP.
2. Network File System (NFS)

NFS allows a system to share directories and files with others over a network. By using NFS, users and programs can access files on remote systems almost as if they were local files.

Some of the most notable benefits that NFS can provide are:

- Local workstations use less disk space because commonly used data can be stored on a single machine and still remain accessible to others over the network.
- There is no need for users to have separate home directories on every network machine. Home directories could be set up on the NFS server and made available throughout the network.
- Storage devices such as floppy disks, CDROM drives, and USB Thumb drives can be used by other machines on the network. This may reduce the number of removable media drives throughout the network.

2.1. Installation

At a terminal prompt enter the following command to install the NFS Server:

```
sudo apt-get install nfs-kernel-server
```

2.2. Configuration

You can configure the directories to be exported by adding them to the `/etc/exports` file. For example:

```
/ubuntu  *(ro,sync,no_root_squash)
/home    *(rw,sync,no_root_squash)
```

You can replace `*` with one of the hostname formats. Make the hostname declaration as specific as possible so unwanted systems cannot access the NFS mount.

To start the NFS server, you can run the following command at a terminal prompt:

```
sudo /etc/init.d/nfs-kernel-server start
```

2.3. NFS Client Configuration

Use the `mount` command to mount a shared NFS directory from another machine, by typing a command line similar to the following at a terminal prompt:

```
sudo mount example.hostname.com:/ubuntu /local/ubuntu
```

The mount point directory `/local/ubuntu` must exist. There should be no files or subdirectories in the `/local/ubuntu` directory.
An alternate way to mount an NFS share from another machine is to add a line to the `/etc/fstab` file. The line must state the hostname of the NFS server, the directory on the server being exported, and the directory on the local machine where the NFS share is to be mounted.

The general syntax for the line in `/etc/fstab` file is as follows:

```
example.hostname.com:/ubuntu /local/ubuntu nfs rsize=8192,wsize=8192,timeo=14,intr
```

If you have trouble mounting an NFS share, make sure the nfs-common package is installed on your client. To install nfs-common enter the following command at the terminal prompt:

```
sudo apt-get install nfs-common
```

### 2.4. References

*Linux NFS faq*[^1]

[^1]: http://nfs.sourceforge.net/
3. CUPS - Print Server

The primary mechanism for Ubuntu printing and print services is the Common UNIX Printing System (CUPS). This printing system is a freely available, portable printing layer which has become the new standard for printing in most Linux distributions.

CUPS manages print jobs and queues and provides network printing using the standard Internet Printing Protocol (IPP), while offering support for a very large range of printers, from dot-matrix to laser and many in between. CUPS also supports PostScript Printer Description (PPD) and auto-detection of network printers, and features a simple web-based configuration and administration tool.

3.1. Installation

To install CUPS on your Ubuntu computer, simply use sudo with the apt-get command and give the packages to install as the first parameter. A complete CUPS install has many package dependencies, but they may all be specified on the same command line. Enter the following at a terminal prompt to install CUPS:

```bash
sudo apt-get install cupsys
```

Upon authenticating with your user password, the packages should be downloaded and installed without error. Upon the conclusion of installation, the CUPS server will be started automatically.

For troubleshooting purposes, you can access CUPS server errors via the error log file at: /var/log/cups/error_log. If the error log does not show enough information to troubleshoot any problems you encounter, the verbosity of the CUPS log can be increased by changing the LogLevel directive in the configuration file (discussed below) to "debug" or even "debug2", which logs everything, from the default of "info". If you make this change, remember to change it back once you've solved your problem, to prevent the log file from becoming overly large.

3.2. Configuration

The Common UNIX Printing System server's behavior is configured through the directives contained in the file /etc/cups/cupsd.conf. The CUPS configuration file follows the same syntax as the primary configuration file for the Apache HTTP server, so users familiar with editing Apache's configuration file should feel at ease when editing the CUPS configuration file. Some examples of settings you may wish to change initially will be presented here.

Prior to editing the configuration file, you should make a copy of the original file and protect it from writing, so you will have the original settings as a reference, and to reuse as necessary.

Copy the /etc/cups/cupsd.conf file and protect it from writing with the following commands, issued at a terminal prompt:
sudo cp /etc/cups/cupsd.conf /etc/cups/cupsd.conf.original
sudo chmod a-w /etc/cups/cupsd.conf.original

• **ServerAdmin**: To configure the email address of the designated administrator of the CUPS server, simply edit the /etc/cups/cupsd.conf configuration file with your preferred text editor, and modify the ServerAdmin line accordingly. For example, if you are the Administrator for the CUPS server, and your e-mail address is 'bjoy@somebigco.com', then you would modify the ServerAdmin line to appear as such:

```plaintext
ServerAdmin bjoy@somebigco.com
```

For more examples of configuration directives in the CUPS server configuration file, view the associated system manual page by entering the following command at a terminal prompt:

```plaintext
man cupsd.conf
```

Whenever you make changes to the /etc/cups/cupsd.conf configuration file, you'll need to restart the CUPS server by typing the following command at a terminal prompt:

```plaintext
sudo /etc/init.d/cupsys restart
```

Some other configuration for the CUPS server is done in the file /etc/cups/cups.d/ports.conf:

• **Listen**: By default on Ubuntu, the CUPS server installation listens only on the loopback interface at IP address 127.0.0.1. In order to instruct the CUPS server to listen on an actual network adapter's IP address, you must specify either a hostname, the IP address, or optionally, an IP address/port pairing via the addition of a Listen directive. For example, if your CUPS server resides on a local network at the IP address 192.168.10.250 and you'd like to make it accessible to the other systems on this subnetwork, you would edit the /etc/cups/cupsd.conf and add a Listen directive, as such:

```plaintext
Listen 127.0.0.1:631           # existing loopback Listen
Listen /var/run/cups/cups.sock # existing socket Listen
Listen 192.168.10.250:631      # Listen on the LAN interface, Port 631 (IPP)
```

In the example above, you may comment out or remove the reference to the Loopback address (127.0.0.1) if you do not wish cupsd to listen on that interface, but would rather have it only listen on the Ethernet interfaces of the Local Area Network (LAN). To enable listening for all network interfaces for which a certain hostname is bound, including the Loopback, you could create a Listen entry for the hostname *socrates* as such:

```plaintext
Listen socrates:631  # Listen on all interfaces for the hostname 'socrates'
```

or by omitting the Listen directive and using *Port* instead, as in:
Port 631  # Listen on port 631 on all interfaces

3.3. References

CUPS Website\textsuperscript{5}

\textsuperscript{5}http://www.cups.org/
Chapter 13. Email Services

The process of getting an email from one person to another over a network or the Internet involves many systems working together. Each of these systems must be correctly configured for the process to work. The sender uses a Mail User Agent (MUA), or email client, to send the message through one or more Mail Transfer Agents (MTA), the last of which will hand it off to a Mail Delivery Agent (MDA) for delivery to the recipient's mailbox, from which it will be retrieved by the recipient's email client, usually via a POP3 or IMAP server.
1. Postfix

Postfix is the default Mail Transfer Agent (MTA) in Ubuntu. It attempts to be fast and easy to administer and secure. It is compatible with the MTA sendmail. This section explains how to install and configure postfix. It also explains how to set it up as an SMTP server using a secure connection (for sending emails securely).

1.1. Installation

To install postfix run the following command:

```
sudo apt-get install postfix
```

Simply press return when the installation process asks questions, the configuration will be done in greater detail in the next stage.

1.2. Basic Configuration

To configure postfix, run the following command:

```
sudo dpkg-reconfigure postfix
```

The user interface will be displayed. On each screen, select the following values:

- Internet Site
- mail.example.com
- steve
- mail.example.com, localhost, localdomain, localhost
- No
- 127.0.0.0/8 [:ffff:127.0.0.0]/104 [:1]/128 192.168.0/24
- 0
- +
- all

Replace mail.example.com with your mail server hostname, 192.168.0/24 with the actual network and class range of your mail server, and steve with the appropriate username.

1.3. SMTP Authentication

SMTP-AUTH allows a client to identify itself through an authentication mechanism (SASL). Transport Layer Security (TLS) should be used to encrypt the authentication process. Once authenticated the SMTP server will allow the client to relay mail.

Configuring Postfix for SMTP-AUTH is very simple using the dovecot-postfix package. This package will install Dovecot and configure Postfix to use it for both SASL authentication and as a Mail Delivery Agent (MDA). The package also configures Dovecot for IMAP, IMAPS, POP3, and POP3S.
To install the package, from a terminal prompt enter:

```bash
sudo apt-get install dovecot-postfix
```

You should now have a working mail server, but there are a few options that you may wish to further customize. For example, the package uses the certificate and key from the ssl-cert package, and in a production environment you should use a certificate and key generated for the host. See Section 5, “Certificates” [p. 115] for more details.

Once you have a customized certificate and key for the host, change the following options in `/etc/postfix/main.cf`:

```plaintext
smtpd_tls_cert_file = /etc/ssl/certs/ssl-mail.pem
smtpd_tls_key_file = /etc/ssl/private/ssl-mail.key
```

Then restart Postfix:

```bash
sudo /etc/init.d/postfix restart
```

### 1.4. Testing

SMTP-AUTH configuration is complete. Now it is time to test the setup.

To see if SMTP-AUTH and TLS work properly, run the following command:

```bash
telnet mail.example.com 25
```

After you have established the connection to the postfix mail server, type:

```plaintext
ehlo mail.example.com
```

If you see the following lines among others, then everything is working perfectly. Type `quit` to exit.

```
250-STARTTLS
250-AUTH LOGIN PLAIN
250-AUTH=LOGIN PLAIN
250 8BITMIME
```

### 1.5. Troubleshooting

This section introduces some common ways to determine the cause if problems arise.

#### 1.5.1. Escaping chroot

The Ubuntu postfix package will by default install into a `chroot` environment for security reasons. This can add greater complexity when troubleshooting problems.
To turn off the chroot operation locate for the following line in the `/etc/postfix/master.cf` configuration file:

```
smtp  inet  n       -       -       -       -       smtpd
```

and modify it as follows:

```
smtp  inet  n       n       -       -       -       smtpd
```

You will then need to restart Postfix to use the new configuration. From a terminal prompt enter:

```bash
sudo /etc/init.d/postfix restart
```

### 1.5.2 Log Files

Postfix sends all log messages to `/var/log/mail.log`. However error and warning messages can sometimes get lost in the normal log output so they are also logged to `/var/log/mail.err` and `/var/log/mail.warn` respectively.

To see messages entered into the logs in real time you can use the `tail -f` command:

```bash
tail -f /var/log/mail.err
```

The amount of detail that is recorded in the logs can be increased. Below are some configuration options for increasing the log level for some of the areas covered above.

- To increase TLS activity logging set the `smtpd_tls_loglevel` option to a value from 1 to 4.

  ```bash
  sudo postconf -e 'smtpd_tls_loglevel = 4'
  ```

- If you are having trouble sending or receiving mail from a specific domain you can add the domain to the `debug_peer_list` parameter.

  ```bash
  sudo postconf -e 'debug_peer_list = problem.domain'
  ```

- You can increase the verbosity of any Postfix daemon process by editing the `/etc/postfix/master.cf` and adding a `-v` after the entry. For example edit the `smtp` entry:

  ```
  smtp  unix  -       -       -       -       -       smtp -v
  ```

  It is important to note that after making one of the logging changes above the Postfix process will need to be reloaded in order to recognize the new configuration: `sudo /etc/init.d/postfix reload`

- To increase the amount of information logged when troubleshooting SASL issues you can set the following options in `/etc/dovecot/dovecot.conf`
auth_debug=yes
auth_debug_passwords=yes

Just like Postfix if you change a Dovecot configuration the process will need to be reloaded:

```
sudo /etc/init.d/dovecot reload.
```

Some of the options above can drastically increase the amount of information sent to the log files. Remember to return the log level back to normal after you have corrected the problem. Then reload the appropriate daemon for the new configuration to take affect.

1.5.3. References

Administering a Postfix server can be a very complicated task. At some point you may need to turn to the Ubuntu community for more experienced help.

A great place to ask for Postfix assistance, and get involved with the Ubuntu Server community, is the #ubuntu-server IRC channel on freenode\(^1\). You can also post a message to one of the Web Forums\(^2\).

For in depth Postfix information Ubuntu developers highly recommend: The Book of Postfix\(^3\).

Finally, the Postfix\(^4\) website also has great documentation on all the different configuration options available.

---

\(^1\) http://freenode.net
\(^2\) http://www.ubuntu.com/support/community/webforums
\(^3\) http://www.postfix-book.com/
\(^4\) http://www.postfix.org/documentation.html
2. Exim4

Exim4 is another Message Transfer Agent (MTA) developed at the University of Cambridge for use on Unix systems connected to the Internet. Exim can be installed in place of sendmail, although the configuration of exim is quite different to that of sendmail.

2.1. Installation

To install exim4, run the following command:

```
sudo apt-get install exim4
```

2.2. Configuration

To configure Exim4, run the following command:

```
sudo dpkg-reconfigure exim4-config
```

The user interface will be displayed. The user interface lets you configure many parameters. For example, In Exim4 the configuration files are split among multiple files. If you wish to have them in one file you can configure accordingly in this user interface.

All the parameters you configure in the user interface are stored in `/etc/exim4/update-exim4.conf.conf` file. If you wish to re-configure, either you re-run the configuration wizard or manually edit this file using your favourite editor. Once you configure, you can run the following command to generate the master configuration file:

```
sudo update-exim4.conf
```

The master configuration file, is generated and it is stored in `/var/lib/exim4/config.autogenerated`.

At any time, you should not edit the master configuration file, `/var/lib/exim4/config.autogenerated` manually. It is updated automatically every time you run `update-exim4.conf`

You can run the following command to start Exim4 daemon.

```
sudo /etc/init.d/exim4 start
```

2.3. SMTP Authentication

This section covers configuring Exim4 to use SMTP-AUTH with TLS and SASL.

The first step is to create a certificate for use with TLS. Enter the following into a terminal prompt:
Now Exim4 needs to be configured for TLS by editing `/etc/exim4/conf.d/main/03_exim4-config_tls_options` add the following:

```
MAIN_TLS_ENABLE = yes
```

Next you need to configure Exim4 to use the `saslauthd` for authentication. Edit `/etc/exim4/conf.d/auth/30_exim4-config_examples` and uncomment the `plain_saslauthd_server` and `login_saslauthd_server` sections:

```
plain_saslauthd_server:
driver = plaintext
    public_name = PLAIN
    server_condition = ${if saslauthd{{$auth2}{$auth3}}{1}{0}}
    server_set_id = $auth2
    server_prompts = :
 .ifndef AUTH_SERVER_ALLOW_NOTLS_PASSWORDS
    server_advertise_condition = ${if eq{$tls_cipher}{}{}{*}}
 .endif
#
login_saslauthd_server:
driver = plaintext
    public_name = LOGIN
    server_prompts = "Username:: : Password::"
 # don't send system passwords over unencrypted connections
    server_condition = ${if saslauthd{{$auth1}{$auth2}}{1}{0}}
    server_set_id = $auth1
 .ifndef AUTH_SERVER_ALLOW_NOTLS_PASSWORDS
    server_advertise_condition = ${if eq{$tls_cipher}{}{}{*}}
 .endif
```

Finally, update the Exim4 configuration and restart the service:

```
sudo update-exim4.conf
sudo /etc/init.d/exim4 restart
```

### 2.4. Configuring SASL

This section provides details on configuring the `saslauthd` to provide authentication for Exim4.

The first step is to install the `sasl2-bin` package. From a terminal prompt enter the following:

```
sudo apt-get install sasl2-bin
```

To configure `saslauthd` edit the `/etc/default/saslauthd` configuration file and set `START=no` to:
Next the \texttt{Debian-exim} user needs to be part of the \texttt{sasl} group in order for Exim4 to use the saslauthd service:

\begin{verbatim}
sudo adduser Debian-exim sasl
\end{verbatim}

Now start the saslauthd service:

\begin{verbatim}
sudo /etc/init.d/saslauthd start
\end{verbatim}

Exim4 is now configured with SMTP-AUTH using TLS and SASL authentication.

\subsection*{2.5. References}

\begin{itemize}
  \item See \texttt{exim.org}\textsuperscript{5} for more information.
  \item There is also an \textit{Exim4 Book}\textsuperscript{6} available.
\end{itemize}
3. Dovecot Server

Dovecot is a Mail Delivery Agent, written with security primarily in mind. It supports the major mailbox formats: mbox or Maildir. This section explain how to set it up as an imap or pop3 server.

3.1. Installation

To install dovecot, run the following command in the command prompt:

```
sudo apt-get install dovecot-imapd dovecot-pop3d
```

3.2. Configuration

To configure dovecot, you can edit the file `/etc/dovecot/dovecot.conf`. You can choose the protocol you use. It could be pop3, pop3s (pop3 secure), imap and imaps (imap secure). A description of these protocols is beyond the scope of this guide. For further information, refer to the Wikipedia articles on POP3\(^7\) and IMAP\(^8\).

IMAPS and POP3S are more secure that the simple IMAP and POP3 because they use SSL encryption to connect. Once you have chosen the protocol, amend the following line in the file `/etc/dovecot/dovecot.conf`:

```
protocols = pop3 pop3s imap imaps
```

Next, choose the mailbox you would like to use. Dovecot supports maildir and mbox formats. These are the most commonly used mailbox formats. They both have their own benefits and are discussed on the Dovecot web site\(^9\).

Once you have chosen your mailbox type, edit the file `/etc/dovecot/dovecot.conf` and change the following line:

```
mail_location = maildir:~/Maildir # (for maildir)
```

or

```
mail_location = mbox:~/mail:INBOX=/var/spool/mail/%u # (for mbox)
```

You should configure your Mail Transport Agent (MTA) to transfer the incoming mail to this type of mailbox if it is different from the one you have configured.

Once you have configured dovecot, restart the dovecot daemon in order to test your setup:

```
sudo /etc/init.d/dovecot restart
```

---


\(^9\) [http://wiki.dovecot.org/MailboxFormat](http://wiki.dovecot.org/MailboxFormat)
If you have enabled imap, or pop3, you can also try to log in with the commands `telnet localhost pop3` or `telnet localhost imap2`. If you see something like the following, the installation has been successful:

```
bhuvan@rainbow:~$ telnet localhost pop3
Trying 127.0.0.1...
Connected to localhost.localdomain.
Escape character is '^]'.
+OK Dovecot ready.
```

### 3.3. Dovecot SSL Configuration

To configure dovecot to use SSL, you can edit the file `/etc/dovecot/dovecot.conf` and amend following lines:

```
ssl_cert_file = /etc/ssl/certs/ssl-cert-snakeoil.pem
ssl_key_file = /etc/ssl/private/ssl-cert-snakeoil.key
ssl_disable = no
disable_plaintext_auth = no
```

You can get the SSL certificate from a Certificate Issuing Authority or you can create self signed SSL certificate. The latter is a good option for email, because SMTP clients rarely complain about "self-signed certificates". Please refer to Section 5, “Certificates” [p. 115] for details about how to create self signed SSL certificate. Once you create the certificate, you will have a key file and a certificate file. Please copy them to the location pointed in the `/etc/dovecot/dovecot.conf` configuration file.

### 3.4. Firewall Configuration for an Email Server

To access your mail server from another computer, you must configure your firewall to allow connections to the server on the necessary ports.

- IMAP - 143
- IMAPS - 993
- POP3 - 110
- POP3S - 995

### 3.5. References

- See the [Dovecot website](#) for more information.
4. Mailman

Mailman is an open source program for managing electronic mail discussions and e-newsletter lists. Many open source mailing lists (including all the Ubuntu mailing lists\(^{11}\)) use Mailman as their mailing list software. It is powerful and easy to install and maintain.

4.1. Installation

Mailman provides a web interface for the administrators and users, using an external mail server to send and receive emails. It works perfectly with the following mail servers:

- Postfix
- Exim
- Sendmail
- Qmail

We will see how to install and configure Mailman with, the Apache web server, and either the Postfix or Exim mail server. If you wish to install Mailman with a different mail server, please refer to the references section.

You only need to install one mail server and Postfix is the default Ubuntu Mail Transfer Agent.

4.1.1. Apache2

To install apache2 you refer to HTTPD Installation\(^{12}\) section for details.

4.1.2. Postfix

For instructions on installing and configuring Postfix refer to Section 1, “Postfix” [p. 163]

4.1.3. Exim4

To install Exim4 refer to Section 2, “Exim4” [p. 167].

Once exim4 is installed, the configuration files are stored in the /etc/exim4 directory. In Ubuntu, by default, the exim4 configuration files are split across different files. You can change this behavior by changing the following variable in the /etc/exim4/update-exim4.conf file:

- dc_use_split_config='true'

4.1.4. Mailman

To install Mailman, run following command at a terminal prompt:

\(^{11}\) http://lists.ubuntu.com
\(^{12}\) ./web-servers.xml#http-installation
sudo apt-get install mailman

It copies the installation files in /var/lib/mailman directory. It installs the CGI scripts in /usr/lib/cgi-bin/mailman directory. It creates list linux user. It creates the list linux group. The mailman process will be owned by this user.

4.2. Configuration

This section assumes you have successfully installed mailman, apache2, and postfix or exim4. Now you just need to configure them.

4.2.1. Apache2

An example Apache configuration file comes with Mailman and is placed in /etc/mailman/apache.conf. In order for Apache to use the config file it needs to be copied to /etc/apache2/sites-available:

sudo cp /etc/mailman/apache.conf /etc/apache2/sites-available/mailman.conf

This will setup a new Apache VirtualHost for the Mailman administration site. Now enable the new configuration and restart Apache:

sudo a2ensite mailman.conf
sudo /etc/init.d/apache2 restart

Mailman uses apache2 to render its CGI scripts. The mailman CGI scripts are installed in the /usr/lib/cgi-bin/mailman directory. So, the mailman url will be http://hostname/cgi-bin/mailman/. You can make changes to the /etc/apache2/sites-available/mailman.conf file if you wish to change this behavior.

4.2.2. Postfix

For Postfix integration, we will associate the domain lists.example.com with the mailing lists. Please replace lists.example.com with the domain of your choosing.

You can use the postconf command to add the necessary configuration to /etc/postfix/main.cf:

sudo postconf -e 'relay_domains = lists.example.com'
sudo postconf -e 'transport_maps = hash:/etc/postfix/transport'
sudo postconf -e 'mailman_destination_recipient_limit = 1'

In /etc/postfix/master.cf double check that you have the following transport:

mailman   unix   -    n    n    -    -    pipe
flags=FR user=list argv=/usr/lib/mailman/bin/postfix-to-mailman.py
Email Services

${nexthop} ${user}

It calls the `postfix-to-mailman.py` script when a mail is delivered to a list.

Associate the domain `lists.example.com` to the Mailman transport with the transport map. Edit the file `/etc/postfix/transport`:

```
lists.example.com      mailman:
```

Now have Postfix build the transport map by entering the following from a terminal prompt:

```
sudo postmap -v /etc/postfix/transport
```

Then restart Postfix to enable the new configurations:

```
sudo /etc/init.d/postfix restart
```

### 4.2.3. Exim4

Once Exim4 is installed, you can start the Exim server using the following command from a terminal prompt:

```
sudo /etc/init.d/exim4 start
```

In order to make mailman work with Exim4, you need to configure Exim4. As mentioned earlier, by default, Exim4 uses multiple configuration files of different types. For details, please refer to the [Exim](http://www.exim.org) website. To run mailman, we should add new a configuration file to the following configuration types:

- Main
- Transport
- Router

Exim creates a master configuration file by sorting all these mini configuration files. So, the order of these configuration files is very important.

### 4.2.4. Main

All the configuration files belonging to the main type are stored in the `/etc/exim4/conf.d/main/` directory. You can add the following content to a new file, named `04_exim4-config_mailman`:

```
# start
# Home dir for your Mailman installation -- aka Mailman's prefix
directory.
# On Ubuntu this should be "/var/lib/mailman"
```

13 [http://www.exim.org](http://www.exim.org)
# This is normally the same as ~mailman
MM_HOME=/var/lib/mailman
#
# User and group for Mailman, should match your --with-mail-gid
# switch to Mailman's configure script. Value is normally "mailman"
MM_UID=list
MM_GID=list
#
# Domains that your lists are in - colon separated list
# you may wish to add these into local_domains as well
domainlist mm_domains=hostname.com
#
# -=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=
#
# These values are derived from the ones above and should not need
# editing unless you have munged your mailman installation
#
# The path of the Mailman mail wrapper script
MM_WRAP=MM_HOME/mail/mailman
#
# The path of the list config file (used as a required file when
# verifying list addresses)
MM_LISTCHK=MM_HOME/lists/${lc::$local_part}/config.pck
# end

4.2.5. Transport

All the configuration files belonging to transport type are stored in the /etc/exim4/conf.d/transport/ directory. You can add the following content to a new file named 40_exim4-config_mailman:

```bash
mailman_transport:
  driver = pipe
  command = MM_WRAP
  \'$\{if def:local_part_suffix \n  \{\$sg{$local_part_suffix}={-\\W+}({\\.+}?){\\1}\}" \n  $local_part
  current_directory = MM_HOME
  home_directory = MM_HOME
  user = MM_UID
  group = MM_GID
```

4.2.6. Router

All the configuration files belonging to router type are stored in the /etc/exim4/conf.d/router/ directory. You can add the following content in to a new file named 101_exim4-config_mailman:

```bash
mailman_router:
  driver = accept
```
require_files = $MA_HOME/lists/$local_part/config.pck
local_part_suffix_optional
local_part_suffix = -bounces : -bounces+* : \
                   -confirm+* : -join : -leave : \
                   -owner : -request : -admin
transport = mailman_transport

The order of main and transport configuration files can be in any order. But, the order of router configuration files must be the same. This particular file must appear before the 200_exim4-config_primary file. These two configuration files contain same type of information. The first file takes the precedence. For more details, please refer to the references section.

4.2.7. Mailman

Once mailman is installed, you can run it using the following command:

    sudo /etc/init.d/mailman start

Once mailman is installed, you should create the default mailing list. Run the following command to create the mailing list:

    sudo /usr/sbin/newlist mailman

Enter the email address of the person running the list: bhuvan at ubuntu.com

Initial mailman password:

To finish creating your mailing list, you must edit your /etc/aliases (or equivalent) file by adding the following lines, and possibly running the `newaliases' program:

    ## mailman mailing list
    mailman:          "|/var/lib/mailman/mail/mailman post mailman"
    mailman-admin:    "|/var/lib/mailman/mail/mailman admin mailman"
    mailman-bounces:  "|/var/lib/mailman/mail/mailman bounces mailman"
    mailman-confirm:   "|/var/lib/mailman/mail/mailman confirm mailman"
    mailman-join:     "|/var/lib/mailman/mail/mailman join mailman"
    mailman-leave:    "|/var/lib/mailman/mail/mailman leave mailman"
    mailman-owner:    "|/var/lib/mailman/mail/mailman owner mailman"
    mailman-request:  "|/var/lib/mailman/mail/mailman request mailman"
    mailman-subscribe: "|/var/lib/mailman/mail/mailman subscribe mailman"
    mailman-unsubscribe: "|/var/lib/mailman/mail/mailman unsubscribe mailman"

Hit enter to notify mailman owner...

#

We have configured either Postfix or Exim4 to recognize all emails from mailman. So, it is not mandatory to make any new entries in /etc/aliases. If you have made any changes to the configuration files, please ensure that you restart those services before continuing to next section.
4.3. Administration

We assume you have a default installation. The mailman cgi scripts are still in the /usr/lib/cgi-bin/mailman/ directory. Mailman provides a web based administration facility. To access this page, point your browser to the following url:

http://hostname/cgi-bin/mailman/admin

The default mailing list, mailman, will appear in this screen. If you click the mailing list name, it will ask for your authentication password. If you enter the correct password, you will be able to change administrative settings of this mailing list. You can create a new mailing list using the command line utility (/usr/sbin/newlist). Alternatively, you can create a new mailing list using the web interface.

4.4. Users

Mailman provides a web based interface for users. To access this page, point your browser to the following url:

http://hostname/cgi-bin/mailman/listinfo

The default mailing list, mailman, will appear in this screen. If you click the mailing list name, it will display the subscription form. You can enter your email address, name (optional), and password to subscribe. An email invitation will be sent to you. You can follow the instructions in the email to subscribe.

4.5. References

GNU Mailman - Installation Manual\textsuperscript{14}

HOWTO - Using Exim 4 and Mailman 2.1 together\textsuperscript{15}

\textsuperscript{14} http://www.list.org/mailman-install/index.html
\textsuperscript{15} http://www.exim.org/howto/mailman21.html
5. Mail Filtering

One of the largest issues with email today is the problem of Unsolicited Bulk Email (UBE). Also known as SPAM, such messages may also carry viruses and other forms of malware. According to some reports these messages make up the bulk of all email traffic on the Internet.

This section will cover integrating Amavisd-new, Spamassassin, and ClamAV with the Postfix Mail Transport Agent (MTA). Postfix can also check email validity by passing it through external content filters. These filters can sometimes determine if a message is spam without needing to process it with more resource intensive applications. Two common filters are dkim-filter and python-policyd-spf.

- Amavisd-new is a wrapper program that can call any number of content filtering programs for spam detection, antivirus, etc.
- Spamassassin uses a variety of mechanisms to filter email based on the message content.
- ClamAV is an open source antivirus application.
- dkim-filter implements a Sendmail Mail Filter (Milter) for the DomainKeys Identified Mail (DKIM) standard.
- python-policyd-spf enables Sender Policy Framework (SPF) checking with Postfix.

This is how the pieces fit together:

- An email message is accepted by Postfix.
- The message is passed through any external filters dkim-filter and python-policyd-spf in this case.
- Amavisd-new then processes the message.
- ClamAV is used to scan the message. If the message contains a virus Postfix will reject the message.
- Clean messages will then be analyzed by Spamassassin to find out if the message is spam.
  Spamassassin will then add X-Header lines allowing Amavisd-new to further manipulate the message.

For example, if a message has a Spam score of over fifty the message could be automatically dropped from the queue without the recipient ever having to be bothered. Another, way to handle flagged messages is to deliver them to the Mail User Agent (MUA) allowing the user to deal with the message as they see fit.

5.1. Installation

See Section 1, “Postfix” [p. 163] for instructions on installing and configuring Postfix.

To install the rest of the applications enter the following from a terminal prompt:

```bash
sudo apt-get install amavisd-new spamassassin clamav-daemon
dkdfilter python-policyd-spf
```
There are some optional packages that integrate with Spamassassin for better spam detection:

```
sudo apt-get install pyzor razor
```

Along with the main filtering applications compression utilities are needed to process some email attachments:

```
sudo apt-get install arj cabextract cpio lha nomarch pax rar unrar unzip zip zoo
```

### 5.2. Configuration

Now configure everything to work together and filter email.

#### 5.2.1. ClamAV

The default behaviour of ClamAV will fit our needs. For more ClamAV configuration options, check the configuration files in `/etc/clamav`.

Add the `clamav` user to the `amavis` group in order for Amavisd-new to have the appropriate access to scan files:

```
sudo adduser clamav amavis
```

#### 5.2.2. Spamassassin

Spamassassin automatically detects optional components and will use them if they are present. This means that there is no need to configure pyzor and razor.

Edit `/etc/default/spamassassin` to activate the Spamassassin daemon. Change `ENABLED=0` to:

```
ENABLED=1
```

Now start the daemon:

```
sudo /etc/init.d/spamassassin start
```

#### 5.2.3. Amavisd-new

First activate spam and antivirus detection in Amavisd-new by editing `/etc/amavis/conf.d/15-content_filter_mode`:

```
use strict;

# You can modify this file to re-enable SPAM checking through spamassassin
# and to re-enable antivirus checking.
```

# Default antivirus checking mode
# Uncomment the two lines below to enable it
#
@bypass_virus_checks_maps = (
  \%bypass_virus_checks, \@bypass_virus_checks_acl, \$bypass_virus_checks_re);

#
# Default SPAM checking mode
# Uncomment the two lines below to enable it
#
@bypass_spam_checks_maps = (
  \%bypass_spam_checks, \@bypass_spam_checks_acl, \$bypass_spam_checks_re);

1;  # insure a defined return

Bouncing spam can be a bad idea as the return address is often faked. Consider editing `/etc/amavis/conf.d/20-debian_defaults` to set `$final_spam_destiny` to D_DISCARD rather than D_BOUNCE, as follows:

```
$final_spam_destiny       = D_DISCARD;
```

If the server's `hostname` is different from the domain's MX record you may need to manually set the `$myhostname` option. Also, if the server receives mail for multiple domains the `@local_domains_acl` option will need to be customized. Edit the `/etc/amavis/conf.d/50-user` file:

```
$myhostname = 'mail.example.com';
@local_domains_acl = ( "example.com", "example.org" );
```

After configuration Amavisd-new needs to be restarted:

```
sudo /etc/init.d/amavis restart
```

5.2.3.1. DKIM Whitelist

Amavisd-new can be configured to automatically Whitelist addresses from domains with valid Domain Keys. There are some pre-configured domains in the `/etc/amavis/conf.d/40-policy_banks`.

There are multiple ways to configure the Whitelist for a domain:

- `example.com' => 'WHITELIST'`: will whitelist any address from the "example.com" domain.
- `example.com' => 'WHITELIST'`: will whitelist any address from any subdomains of "example.com" that have a valid signature.
- `example.com/@example.com' => 'WHITELIST'`: will whitelist subdomains of "example.com" that use the signature of example.com the parent domain.
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- 

  '.*@example.com' => 'WHITELIST': adds addresses that have a valid signature from 'example.com'. This is usually used for discussion groups that sign their messages.

A domain can also have multiple Whitelist configurations. After editing the file, restart amaisd-new:

```
sudo /etc/init.d/amavis restart
```

In this context, once a domain has been added to the Whitelist, the message will not receive any anti-virus or spam filtering. This may or may not be the intended behavior you wish for a domain.

### 5.2.4. Postfix

For Postfix integration, enter the following from a terminal prompt:

```
sudo postconf -e 'content_filter = smtp-amavis:[127.0.0.1]:10024'
```

Next edit `/etc/postfix/master.cf` and add the following to the end of the file:

```
smtp-amavis    unix    -    -    -    -    2    smtp
  -o smtp_data_done_timeout=1200
  -o smtp_send_xforward_command=yes
  -o disable_dns_lookups=yes
  -o max_use=20

127.0.0.1:10025    inet    n    -    -    -    -    smtpd
  -o content_filter=
  -o local_recipient_maps=
  -o relay_recipient_maps=
  -o smtpd_restriction_classes=
  -o smtpd_delay_reject=no
  -o smtpd_client_restrictions=permit_mynetworks,reject
  -o smtpd_helo_restrictions=
  -o smtpd_sender_restrictions=
  -o smtpd_recipient_restrictions=permit_mynetworks,reject
  -o smtpd_data_restrictions-reject_unauth_pipeline
  -o smtpd_end_of_data_restrictions=
  -o mynetworks=127.0.0.0/8
  -o smtpd_error_sleep_time=0
  -o smtpd_soft_error_limit=1001
  -o smtpd_hard_error_limit=1000
  -o smtpd_client_connection_count_limit=0
  -o smtpd_client_connection_rate_limit=0
  -o receive_override_options=no_header_body_checks,no_unknown_recipient_checks
```

Also add the following two lines immediately below the "pickup" transport service:

```
  -o content_filter=
  -o receive_override_options=no_header_body_checks
```
This will prevent messages that are generated to report on spam from being classified as spam.

Now restart Postfix:

```
sudo /etc/init.d/postfix restart
```

Content filtering with spam and virus detection is now enabled.

### 5.3. Testing

First, test that the Amavisd-new SMTP is listening:

```
telnet localhost 10024
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
220 [127.0.0.1] ESMTP amavisd-new service ready
```

In the Header of messages that go through the content filter you should see:

```
X-Spam-Level:
X-Virus-Scanned: Debian amavisd-new at example.com
X-Spam-Status: No, hits=-2.3 tagged_above=-1000.0 required=5.0 tests=AWL, BAYES_00
X-Spam-Level:
```

Your output will vary, but the important thing is that there are `X-Virus-Scanned` and `X-Spam-Status` entries.

### 5.4. Troubleshooting

The best way to figure out why something is going wrong is to check the log files.

- For instructions on Postfix logging see the Section 1.5, “Troubleshooting” [p. 164] section.
- Amavisd-new uses Syslog to send messages to `/var/log/mail.log`. The amount of detail can be increased by adding the `$log_level` option to `/etc/amavis/conf.d/50-user`, and setting the value from 1 to 5.

```
$log_level = 2;
```

When the Amavisd-new log output is increased Spamassassin log output is also increased.

- The ClamAV log level can be increased by editing `/etc/clamav/clamd.conf` and setting the following option:

```
LogVerbose true
```
By default ClamAV will send log messages to /var/log/clamav/clamav.log.

After changing an applications log settings remember to restart the service for the new settings to take affect. Also, once the issue you are troubleshooting is resolved it is a good idea to change the log settings back to normal.

5.5. References

For more information on filtering mail see the following links:

- Amavisd-new Documentation\(^\text{16}\)
- ClamAV Documentation\(^\text{17}\) and ClamAV Wiki\(^\text{18}\)
- Spamassassin Wiki\(^\text{19}\)
- Pyzor Homepage\(^\text{20}\)
- Razor Homepage\(^\text{21}\)
- DKIM.org\(^\text{22}\)

Also, feel free to ask questions in the \#ubuntu-server IRC channel on freenode\(^\text{23}\).
Chapter 14. Version Control System

Version control is the art of managing changes to information. It has long been a critical tool for programmers, who typically spend their time making small changes to software and then undoing those changes the next day. But the usefulness of version control software extends far beyond the bounds of the software development world. Anywhere you can find people using computers to manage information that changes often, there is room for version control.
1. Bazaar

Bazaar is a new version control system sponsored by Canonical, the commercial company behind Ubuntu. Unlike Subversion and CVS that only support a central repository model, Bazaar also supports \textit{distributed version control}, giving people the ability to collaborate more efficiently. In particular, Bazaar is designed to maximize the level of community participation in open source projects.

1.1. Installation

At a terminal prompt, enter the following command to install bzr:

\texttt{sudo apt-get install bzr}

1.2. Configuration

To introduce yourself to bzr, use the \texttt{whoami} command like this:

\texttt{$ bzr whoami 'Joe Doe <joe.doe@gmail.com>''}

1.3. Learning Bazaar

Bazaar comes with bundled documentation installed into /usr/share/doc/bzr/html by default. The tutorial is a good place to start. The bzr command also comes with built-in help:

\texttt{$ bzr help}

To learn more about the \texttt{foo} command:

\texttt{$ bzr help foo}

1.4. Launchpad Integration

While highly useful as a stand-alone system, Bazaar has good, optional integration with \textit{Launchpad}, the collaborative development system used by Canonical and the broader open source community to manage and extend Ubuntu itself. For information on how Bazaar can be used with Launchpad to collaborate on open source projects, see \texttt{http://bazaar-vcs.org/LaunchpadIntegration}.

\textsuperscript{1} https://launchpad.net/
\textsuperscript{2} http://bazaar-vcs.org/LaunchpadIntegration/
2. Subversion

Subversion is an open source version control system. Using Subversion, you can record the history of source files and documents. It manages files and directories over time. A tree of files is placed into a central repository. The repository is much like an ordinary file server, except that it remembers every change ever made to files and directories.

2.1. Installation

To access Subversion repository using the HTTP protocol, you must install and configure a web server. Apache2 is proven to work with Subversion. Please refer to the HTTP subsection in the Apache2 section to install and configure Apache2. To access the Subversion repository using the HTTPS protocol, you must install and configure a digital certificate in your Apache 2 web server. Please refer to the HTTPS subsection in the Apache2 section to install and configure the digital certificate.

To install Subversion, run the following command from a terminal prompt:

```
sudo apt-get install subversion libapache2-svn
```

2.2. Server Configuration

This step assumes you have installed above mentioned packages on your system. This section explains how to create a Subversion repository and access the project.

2.2.1. Create Subversion Repository

The Subversion repository can be created using the following command from a terminal prompt:

```
svnadmin create /path/to/repos/project
```

2.2.2. Importing Files

Once you create the repository you can import files into the repository. To import a directory, enter the following from a terminal prompt:

```
svn import /path/to/import/directory file:///path/to/repos/project
```

2.3. Access Methods

Subversion repositories can be accessed (checked out) through many different methods --on local disk, or through various network protocols. A repository location, however, is always a URL. The table describes how different URL schemes map to the available access methods.
Table 14.1. Access Methods

<table>
<thead>
<tr>
<th>Schema</th>
<th>Access Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>file://</td>
<td>direct repository access (on local disk)</td>
</tr>
<tr>
<td>http://</td>
<td>Access via WebDAV protocol to Subversion-aware Apache2 web server</td>
</tr>
<tr>
<td>https://</td>
<td>Same as http://, but with SSL encryption</td>
</tr>
<tr>
<td>svn://</td>
<td>Access via custom protocol to an svnserve server</td>
</tr>
<tr>
<td>svn+ssh://</td>
<td>Same as svn://, but through an SSH tunnel</td>
</tr>
</tbody>
</table>

In this section, we will see how to configure Subversion for all these access methods. Here, we cover the basics. For more advanced usage details, refer to the *svn book*.

2.3.1. Direct repository access (file://)

This is the simplest of all access methods. It does not require any Subversion server process to be running. This access method is used to access Subversion from the same machine. The syntax of the command, entered at a terminal prompt, is as follows:

```
svn co file:///path/to/repos/project
```

or

```
svn co file://localhost/path/to/repos/project
```

If you do not specify the hostname, there are three forward slashes (///) -- two for the protocol (file, in this case) plus the leading slash in the path. If you specify the hostname, you must use two forward slashes (///).

The repository permissions depend on filesystem permissions. If the user has read/write permission, he can checkout from and commit to the repository.

2.3.2. Access via WebDAV protocol (http://)

To access the Subversion repository via WebDAV protocol, you must configure your Apache 2 web server. You must add the following snippet in your `/etc/apache2/apache2.conf` file:

```
<Location /svn>
  DAV svn
  SVNParentPath /home/svn
  AuthType Basic
  AuthName "Your repository name"
  AuthUserFile /etc/subversion/passwd
  <LimitExcept GET PROPFIND OPTIONS REPORT>
</Location>
```

1 http://svnbook.red-bean.com/
The above configuration snippet assumes that Subversion repositories are created under 
/home/svn/ directory using svnadmin command. They can be accessible using http://
hostname/svn/repos_name url.

To import or commit files to your Subversion repository over HTTP, the repository should be 
owned by the HTTP user. In Ubuntu systems, normally the HTTP user is www-data. To change the 
ownership of the repository files enter the following command from terminal prompt:

```
sudo chown -R www-data:www-data /path/to/repos
```

By changing the ownership of repository as www-data you will not be able to import or 
commit files into the repository by running svn import file:/// command as any user other 
than www-data.

Next, you must create the /etc/subversion/passwd file that will contain user authentication details. 
To create a file issue the following command at a command prompt (which will create the file and add 
the first user):

```
sudo htpasswd -c /etc/subversion/passwd user_name
```

To add additional users omit the "-c" option as this option replaces the old file. Instead use this form:

```
sudo htpasswd /etc/subversion/password user_name
```

This command will prompt you to enter the password. Once you enter the password, the user is added. 
Now, to access the repository you can run the following command:

```
svn co http://servername/svn
```

The password is transmitted as plain text. If you are worried about password snooping, you 
are advised to use SSL encryption. For details, please refer next section.

2.3.3. Access via WebDAV protocol with SSL encryption (https://)

Accessing Subversion repository via WebDAV protocol with SSL encryption (https://) is similar to 
http:// except that you must install and configure the digital certificate in your Apache2 web server.

You can install a digital certificate issued by a signing authority like Verisign. Alternatively, you can 
install your own self-signed certificate.

This step assumes you have installed and configured a digital certificate in your Apache 2 web server. 
Now, to access the Subversion repository, please refer to the above section! The access methods are 
exactly the same, except the protocol. You must use https:// to access the Subversion repository.
2.3.4. Access via custom protocol (svn://)

Once the Subversion repository is created, you can configure the access control. You can edit the `path/to/repos/project/conf/svnserve.conf` file to configure the access control. For example, to set up authentication, you can uncomment the following lines in the configuration file:

```
# [general]
# password-db = passwd
```

After uncommenting the above lines, you can maintain the user list in the `passwd` file. So, edit the file `passwd` in the same directory and add the new user. The syntax is as follows:

```
username = password
```

For more details, please refer to the file.

Now, to access Subversion via the svn:// custom protocol, either from the same machine or a different machine, you can run `svnserver` using `svnserve` command. The syntax is as follows:

```
$ svnserve -d --foreground -r /path/to/repos
# -d  -- daemon mode
# --foreground -- run in foreground (useful for debugging)
# -r -- root of directory to serve
```

For more usage details, please refer to:

```
$ svnserve --help
```

Once you run this command, Subversion starts listening on default port (3690). To access the project repository, you must run the following command from a terminal prompt:

```
svn co svn://hostname/project project --username user_name
```

Based on server configuration, it prompts for password. Once you are authenticated, it checks out the code from Subversion repository. To synchronize the project repository with the local copy, you can run the `update` sub-command. The syntax of the command, entered at a terminal prompt, is as follows:

```
cd project_dir ; svn update
```

For more details about using each Subversion sub-command, you can refer to the manual. For example, to learn more about the `co` (checkout) command, please run the following command from a terminal prompt:

```
svn co help
```

2.3.5. Access via custom protocol with SSL encryption (svn+ssh://)

The configuration and server process is same as in the `svn://` method. For details, please refer to the above section. This step assumes you have followed the above step and started the Subversion server using `svnserve` command.
It is also assumed that the ssh server is running on that machine and that it is allowing incoming connections. To confirm, please try to login to that machine using ssh. If you can login, everything is perfect. If you cannot login, please address it before continuing further.

The svn+ssh:// protocol is used to access the Subversion repository using SSL encryption. The data transfer is encrypted using this method. To access the project repository (for example with a checkout), you must use the following command syntax:

```
svn co svn+ssh://hostname/var/svn/repos/project
```

You must use the full path (/path/to/repos/project) to access the Subversion repository using this access method.

Based on server configuration, it prompts for password. You must enter the password you use to login via ssh. Once you are authenticated, it checks out the code from the Subversion repository.
3. CVS Server

CVS is a version control system. You can use it to record the history of source files.

3.1. Installation

To install CVS, run the following command from a terminal prompt:

```
sudo apt-get install cvs
```

After you install cvs, you should install xinetd to start/stop the cvs server. At the prompt, enter the following command to install xinetd:

```
sudo apt-get install xinetd
```

3.2. Configuration

Once you install cvs, the repository will be automatically initialized. By default, the repository resides under the /var/lib/cvs directory. You can change this path by running following command:

```
cvs -d /your/new/cvs/repo init
```

Once the initial repository is set up, you can configure xinetd to start the CVS server. You can copy the following lines to the `/etc/xinetd.d/cvspserver` file.

```bash
service cvspserver
{
    port = 2401
    socket_type = stream
    protocol = tcp
    user = root
    wait = no
    type = UNLISTED
    server = /usr/bin/cvs
    server_args = -f --allow-root /var/lib/cvs pserver
    disable = no
}
```

Be sure to edit the repository if you have changed the default repository (/var/lib/cvs) directory.

Once you have configured xinetd you can start the cvs server by running following command:

```
sudo /etc/init.d/xinetd restart
```

You can confirm that the CVS server is running by issuing the following command:
sudo netstat -tap | grep cvs

When you run this command, you should see the following line or something similar:

tcp 0 0 *:cvspserver *:* LISTEN

From here you can continue to add users, add new projects, and manage the CVS server.

CVS allows the user to add users independently of the underlying OS installation. Probably the easiest way is to use the Linux Users for CVS, although it has potential security issues. Please refer to the CVS manual for details.

3.3. Add Projects

This section explains how to add new project to the CVS repository. Create the directory and add necessary document and source files to the directory. Now, run the following command to add this project to CVS repository:

cd your/project
cvs -d :pserver:username@hostname.com:/var/lib/cvs import -m "Importing my project to CVS repository" new_project start

You can use the CVSROOT environment variable to store the CVS root directory. Once you export the CVSROOT environment variable, you can avoid using -d option in the above cvs command.

The string new_project is a vendor tag, and start is a release tag. They serve no purpose in this context, but since CVS requires them, they must be present.

When you add a new project, the CVS user you use must have write access to the CVS repository (/var/lib/cvs). By default, the src group has write access to the CVS repository. So, you can add the user to this group, and he can then add and manage projects in the CVS repository.
4. References

Bazaar Home Page

Launchpad

Subversion Home Page

Subversion Book

CVS Manual

http://bazaar-vcs.org/
http://launchpad.net/
http://subversion.tigris.org/
http://svnbook.red-bean.com/
http://ximbiot.com/cvs/manual/cvs-1.11.21/cvs_toc.html
Chapter 15. Windows Networking

Computer networks are often comprised of diverse systems, and while operating a network made up entirely of Ubuntu desktop and server computers would certainly be fun, some network environments must consist of both Ubuntu and Microsoft® Windows® systems working together in harmony. This section of the Ubuntu Server Guide introduces principles and tools used in configuring your Ubuntu Server for sharing network resources with Windows computers.
1. Introduction

Successfully networking your Ubuntu system with Windows clients involves providing and integrating with services common to Windows environments. Such services assist the sharing of data and information about the computers and users involved in the network, and may be classified under three major categories of functionality:

- **File and Printer Sharing Services.** Using the Server Message Block (SMB) protocol to facilitate the sharing of files, folders, volumes, and the sharing of printers throughout the network.

- **Directory Services.** Sharing vital information about the computers and users of the network with such technologies as the Lightweight Directory Access Protocol (LDAP) and Microsoft Active Directory®.

- **Authentication and Access.** Establishing the identity of a computer or user of the network and determining the information the computer or user is authorized to access using such principles and technologies as file permissions, group policies, and the Kerberos authentication service.

Fortunately, your Ubuntu system may provide all such facilities to Windows clients and share network resources among them. One of the principal pieces of software your Ubuntu system includes for Windows networking is the Samba suite of SMB server applications and tools.

This section of the Ubuntu Server Guide will introduce some of the common Samba use cases, and how to install and configure the necessary packages. Additional detailed documentation and information on Samba can be found on the *Samba website*\(^1\).

\(^1\) http://www.samba.org
2. Samba File Server

One of the most common ways to network Ubuntu and Windows computers is to configure Samba as a File Server. This section covers setting up a Samba server to share files with Windows clients.

The server will be configured to share files with any client on the network without prompting for a password. If your environment requires stricter Access Controls see Section 4, "Securing a Samba File and Print Server" [p. 199]

2.1. Installation

The first step is to install the samba package. From a terminal prompt enter:

```
sudo apt-get install samba
```

That's all there is to it; you are now ready to configure Samba to share files.

2.2. Configuration

The main Samba configuration file is located in `/etc/samba/smb.conf`. The default configuration file has a significant amount of comments in order to document various configuration directives.

Not all the available options are included in the default configuration file. See the `smb.conf` man page or the Samba HOWTO Collection for more details.

1. First, edit the following key/value pairs in the `[global]` section of `/etc/samba/smb.conf`:

   - `workgroup = EXAMPLE`
   - `security = user`

   The `security` parameter is farther down in the `[global]` section, and is commented by default. Also, change `EXAMPLE` to better match your environment.

2. Create a new section at the bottom of the file, or uncomment one of the examples, for the directory to be shared:

   ```
   [share]
   comment = Ubuntu File Server Share
   path = /srv/samba/share
   browsable = yes
   guest ok = yes
   read only = no
   create mask = 0755
   ```

   - `comment`: a short description of the share. Adjust to fit your needs.
   - `path`: the path to the directory to share.
This example uses `/srv/samba/sharename` because, according to the *Filesystem Hierarchy Standard (FHS)*, `/srv` is where site-specific data should be served. Technically Samba shares can be placed anywhere on the filesystem as long as the permissions are correct, but adhering to standards is recommended.

- **browseable**: enables Windows clients to browse the shared directory using Windows Explorer.
- **guest ok**: allows clients to connect to the share without supplying a password.
- **read only**: gives write access to the shared directory.
- **create mask**: determines the permissions new files will have when created.

3. Now that Samba is configured, the directory needs to be created and the permissions changed.

   From a terminal enter:

   ```
   sudo mkdir -p /srv/samba/share
   sudo chown nobody.nogroup /srv/samba/share/
   ```

   The `-p` switch tells `mkdir` to create the entire directory tree if it doesn't exist. Change the share name to fit your environment.

4. Finally, restart the samba services to enable the new configuration:

   ```
   sudo /etc/init.d/samba restart
   ```

   Once again, the above configuration gives all access to any client on the local network. For a more secure configuration see *Section 4. “Securing a Samba File and Print Server”* [p. 199].

   From a Windows client you should now be able to browse to the Ubuntu file server and see the shared directory. To check that everything is working try creating a directory from Windows.

   To create additional shares simply create new `[dir]` sections in `/etc/samba/smb.conf`, and restart Samba. Just make sure that the directory you want to share actually exists and the permissions are correct.

2.3. Resources

- For in depth Samba configurations see the *Samba HOWTO Collection*

- The guide is also available in *printed format*.

- O'Reilly's *Using Samba* is another good reference.
3. Samba Print Server

Another common use of Samba is to configure it to share printers installed, either locally or over the network, on an Ubuntu server. Similar to Section 2, “Samba File Server” [p. 196] this section will configure Samba to allow any client on the local network to use the installed printers without prompting for a username and password.

For a more secure configuration see Section 4, “Securing a Samba File and Print Server” [p. 199].

3.1. Installation

Before installing and configuring Samba it is best to already have a working CUPS installation. See Section 3, “CUPS - Print Server” [p. 159] for details.

To install the samba package, from a terminal enter:

```
sudo apt-get install samba
```

3.2. Configuration

After installing samba edit `/etc/samba/smb.conf`. Change the `workgroup` attribute to what is appropriate for your network, and change `security` to `share`:

```
workgroup = EXAMPLE
...
security = user
```

In the `[printers]` section change the `guest ok` option to `yes`:

```
browsable = yes
guest ok = yes
```

After editing `smb.conf` restart Samba:

```
sudo /etc/init.d/samba restart
```

The default Samba configuration will automatically share any printers installed. Simply install the printer locally on your Windows clients.

3.3. Resources

- For in depth Samba configurations see the Samba HOWTO Collection.
- The guide is also available in printed format.
- O'Reilly's Using Samba is another good reference.
- Also, see the CUPS Website for more information on configuring CUPS.
4. Securing a Samba File and Print Server

4.1. Samba Security Modes

There are two security levels available to the Common Internet Filesystem (CIFS) network protocol user-level and share-level. Samba's security mode implementation allows more flexibility, providing four ways of implementing user-level security and one way to implement share-level:

- **security = user**: requires clients to supply a username and password to connect to shares. Samba user accounts are separate from system accounts, but the libpam-smbpass package will sync system users and passwords with the Samba user database.

- **security = domain**: this mode allows the Samba server to appear to Windows clients as a Primary Domain Controller (PDC), Backup Domain Controller (BDC), or a Domain Member Server (DMS). See Section 5, “Samba as a Domain Controller” [p. 203] for further information.

- **security = ADS**: allows the Samba server to join an Active Directory domain as a native member. See Section 6, “Samba Active Directory Integration” [p. 207] for details.

- **security = server**: this mode is left over from before Samba could become a member server, and due to some security issues should not be used. See the Server Security section of the Samba guide for more details.

- **security = share**: allows clients to connect to shares without supplying a username and password.

The security mode you choose will depend on your environment and what you need the Samba server to accomplish.

4.2. Security = User

This section will reconfigure the Samba file and print server, from Section 2, “Samba File Server” [p. 196] and Section 3, “Samba Print Server” [p. 198], to require authentication.

First, install the libpam-smbpass package which will sync the system users to the Samba user database:

```
sudo apt-get install libpam-smbpass
```

If you chose the Samba Server task during installation libpam-smbpass is already installed.

Edit `/etc/samba/smb.conf`, and in the `[share]` section change:

```
guest ok = no
```

Finally, restart Samba for the new settings to take effect:

```
sudo /etc/init.d/samba restart
```
Now when connecting to the shared directories or printers you should be prompted for a username and password.

If you choose to map a network drive to the share you can check the “Reconnect at Logon” check box, which will require you to only enter the username and password once, at least until the password changes.

4.3. Share Security

There are several options available to increase the security for each individual shared directory. Using the `share` example, this section will cover some common options.

4.3.1. Groups

Groups define a collection of computers or users which have a common level of access to particular network resources and offer a level of granularity in controlling access to such resources. For example, if a group `qa` is defined and contains the users `freda`, `danika`, and `rob` and a second group `support` is defined and consists of users `danika`, `jeremy`, and `vincent` then certain network resources configured to allow access by the `qa` group will subsequently enable access by `freda`, `danika`, and `rob`, but not `jeremy` or `vincent`. Since the user `danika` belongs to both the `qa` and `support` groups, she will be able to access resources configured for access by both groups, whereas all other users will have only access to resources explicitly allowing the group they are part of.

By default Samba looks for the local system groups defined in `/etc/group` to determine which users belong to which groups. For more information on adding and removing users from groups see `Section 1.2, “Adding and Deleting Users” [p. 97].`

When defining groups in the Samba configuration file, `/etc/samba/smb.conf`, the recognized syntax is to preface the group name with an "@" symbol. For example, if you wished to define a group named `sysadmin` in a certain section of the `/etc/samba/smb.conf` file, you would do so by entering the group name as `@sysadmin`.

4.3.2. File Permissions

File Permissions define the explicit rights a computer or user has to a particular directory, file, or set of files. Such permissions may be defined by editing the `/etc/samba/smb.conf` file and specifying the explicit permissions of a defined file share.

For example, if you have defined a Samba share called `share` and wish to give read-only permissions to the group of users known as `qa`, but wanted to allow writing to the share by the group called `sysadmin` and the user named `vincent`, then you could edit the `/etc/samba/smb.conf` file, and add the following entries under the `[share]` entry:

```
read list = @qa
write list = @sysadmin, vincent
```
Another possible Samba permission is to declare *administrative* permissions to a particular shared resource. Users having administrative permissions may read, write, or modify any information contained in the resource the user has been given explicit administrative permissions to.

For example, if you wanted to give the user *melissa* administrative permissions to the *share* example, you would edit the `/etc/samba/smb.conf` file, and add the following line under the `[share]` entry:

```
admin users = melissa
```

After editing `/etc/samba/smb.conf`, restart Samba for the changes to take effect:

```
sudo /etc/init.d/samba restart
```

For the *read list* and *write list* to work the Samba security mode must *not* be set to *security = share*

Now that Samba has been configured to limit which groups have access to the shared directory, the filesystem permissions need to be updated.

Traditional Linux file permissions do not map well to Windows NT Access Control Lists (ACLs). Fortunately POSIX ACLs are available on Ubuntu servers providing more fine grained control. For example, to enable ACLs on `/srv` an EXT3 filesystem, edit `/etc/fstab` adding the *acl* option:

```
UUID=66bcdd2e-8861-4fb0-b7e4-e61c569fe17d /srv ext3 noatime,relatime,acl 0 1
```

Then remount the partition:

```
sudo mount -v -o remount /srv
```

The above example assumes `/srv` on a separate partition. If `/srv`, or wherever you have configured your share path, is part of the `/` partition a reboot may be required.

To match the Samba configuration above the *sysadmin* group will be given read, write, and execute permissions to `/srv/samba/share`, the *qa* group will be given read and execute permissions, and the files will be owned by the username *melissa*. Enter the following in a terminal:

```
sudo chown -R melissa /srv/samba/share/
sudo chgrp -R sysadmin /srv/samba/share/
sudo setfacl -R -m g:qa:rx /srv/samba/share/
```

The *setfacl* command above gives *execute* permissions to all files in the `/srv/samba/share` directory, which you may or may not want.

Now from a Windows client you should notice the new file permissions are implemented. See the *acl* and *setfacl* man pages for more information on POSIX ACLs.
4.4. Samba AppArmor Profile

Ubuntu comes with the AppArmor security module, which provides mandatory access controls. The default AppArmor profile for Samba will need to be adapted to your configuration. For more details on using AppArmor see Section 4, “AppArmor” [p. 111].

There are default AppArmor profiles for /usr/sbin/smbd and /usr/sbin/nmbd, the Samba daemon binaries, as part of the apparmor-profiles packages. To install the package, from a terminal prompt enter:

```
sudo apt-get install apparmor-profiles
```

This package contains profiles for several other binaries.

By default the profiles for smbd and nmbd are in `complain` mode allowing Samba to work without modifying the profile, and only logging errors. To place the smbd profile into `enforce` mode, and have Samba work as expected, the profile will need to be modified to reflect any directories that are shared.

Edit `/etc/apparmor.d/usr.sbin.smbd` adding information for `[share]` from the file server example:

```
/srv/samba/share/ r,
/srv/samba/share/** rwkix,
```

Now place the profile into `enforce` and reload it:

```
sudo aa-enforce /usr/sbin/smbd

cat /etc/apparmor.d/usr.sbin.smbd | sudo apparmor_parser -r
```

You should now be able to read, write, and execute files in the shared directory as normal, and the smbd binary will have access to only the configured files and directories. Be sure to add entries for each directory you configure Samba to share. Also, any errors will be logged to `/var/log/syslog`.

4.5. Resources

- For in depth Samba configurations see the *Samba HOWTO Collection*.
- The guide is also available in *printed format*.
- O'Reilly's *Using Samba* is also a good reference.
- *Chapter 18* of the Samba HOWTO Collection is devoted to security.
- For more information on Samba and ACLs see the *Samba ACLs page*. 

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5. Samba as a Domain Controller

Although it cannot act as an Active Directory Primary Domain Controller (PDC), a Samba server can be configured to appear as a Windows NT4-style domain controller. A major advantage of this configuration is the ability to centralize user and machine credentials. Samba can also use multiple backends to store the user information.

5.1. Primary Domain Controller

This section covers configuring Samba as a Primary Domain Controller (PDC) using the default smbpasswd backend.

1. First, install Samba, and libpam-smbpass to sync the user accounts, by entering the following in a terminal prompt:

```
sudo apt-get install samba libpam-smbpass
```

2. Next, configure Samba by editing `/etc/samba/smb.conf`. The `security` mode should be set to `user`, and the `workgroup` should relate to your organization:

   ```
   workgroup = EXAMPLE
   ...
   security = domain
   ```

3. In the commented “Domains” section add or uncomment the following:

   ```
   domain logons = yes
   logon path = \%N\%U\profile
   logon drive = H:
   logon home = \%N\%U
   logon script = logon.cmd
   add machine script = sudo /usr/sbin/useradd -n -g machines -c Machine -d /var/lib/samba -s / 
   ```

   - **domain logons**: provides the netlogon service causing Samba to act as a domain controller.
   - **logon path**: places the user’s Windows profile into their home directory. It is also possible to configure a [profiles] share placing all profiles under a single directory.
   - **logon drive**: specifies the home directory local path.
   - **logon home**: specifies the home directory location.
   - **logon script**: determines the script to be run locally once a user has logged in. The script needs to be placed in the [netlogon] share.
   - **add machine script**: a script that will automatically create the Machine Trust Account needed for a workstation to join the domain.

In this example the machines group will need to be created using the addgroup utility see Section 1.2, “Adding and Deleting Users” [p. 97] for details.
If you wish to not use Roaming Profiles leave the logon home and logon path options commented.

4. Uncomment the [homes] share to allow the logon home to be mapped:

```
[homes]
  comment = Home Directories
  browseable = no
  read only = no
  create mask = 0700
  directory mask = 0700
  valid users = %S
```

5. When configured as a domain controller a [netlogon] share needs to be configured. To enable the share, uncomment:

```
[netlogon]
  comment = Network Logon Service
  path = /srv/samba/netlogon
  guest ok = yes
  read only = yes
  share modes = no
```

The original netlogon share path is /home/samba/netlogon, but according to the Filesystem Hierarchy Standard (FHS), /srv is the correct location for site-specific data provided by the system.

6. Now create the netlogon directory, and an empty (for now) logon.cmd script file:

```
sudo mkdir -p /srv/samba/netlogon
sudo touch /srv/samba/netlogon/logon.cmd
```

You can enter any normal Windows logon script commands in logon.cmd to customize the client's environment.

7. With root being disabled by default, in order to join a workstation to the domain, a system group needs to be mapped to the Windows Domain Admins group. Using the net utility, from a terminal enter:

```
sudo net groupmap add ntgroup="Domain Admins" unixgroup=sysadmin rid=512 type=d
```

Change sysadmin to whichever group you prefer. Also, the user used to join the domain needs to be a member of the sysadmin group, as well as a member of the system admin group. The admin group allows sudo use.

8. Finally, restart Samba to enable the new domain controller:

```
sudo /etc/init.d/samba restart
```
9. You should now be able to join Windows clients to the Domain in the same manner as joining them to an NT4 domain running on a Windows server.

5.2. Backup Domain Controller

With a Primary Domain Controller (PDC) on the network it is best to have a Backup Domain Controller (BDC) as well. This will allow clients to authenticate in case the PDC becomes unavailable.

When configuring Samba as a BDC you need a way to sync account information with the PDC. There are multiple ways of accomplishing this scp, rsync, or by using LDAP as the passdb backend.

Using LDAP is the most robust way to sync account information, because both domain controllers can use the same information in real time. However, setting up a LDAP server may be overly complicated for a small number of user and computer accounts. See Section 2, “Samba and LDAP” [p. 65] for details.

1. First, install samba and libpam-smbpass. From a terminal enter:

   ```
   sudo apt-get install samba libpam-smbpass
   ```

2. Now, edit `/etc/samba/smb.conf` and uncomment the following in the `[global]`:

   ```
   workgroup = EXAMPLE
   ...
   security = user
   ```

3. In the commented `Domains` uncomment or add:

   ```
   domain logons = yes
   domain master = no
   ```

4. Make sure a user has rights to read the files in `/var/lib/samba`. For example, to allow users in the `admin` group to scp the files, enter:

   ```
   sudo chgrp -R admin /var/lib/samba
   ```

5. Next, sync the user accounts, using scp to copy the `/var/lib/samba` directory from the PDC:

   ```
   sudo scp -r username@pdc:/var/lib/samba /var/lib
   ```

   Replace `username` with a valid username and `pdc` with the hostname or IP Address of your actual PDC.

6. Finally, restart samba:

   ```
   sudo /etc/init.d/samba restart
   ```
You can test that your Backup Domain controller is working by stopping the Samba daemon on the PDC, then trying to login to a Windows client joined to the domain.

Another thing to keep in mind is if you have configured the logon home option as a directory on the PDC, and the PDC becomes unavailable, access to the user’s Home drive will also be unavailable. For this reason it is best to configure the logon home to reside on a separate file server from the PDC and BDC.

5.3. Resources

- For in depth Samba configurations see the Samba HOWTO Collection\textsuperscript{18}
- The guide is also available in printed format\textsuperscript{19}.
- O'Reilly's Using Samba\textsuperscript{20} is also a good reference.
- Chapter 4\textsuperscript{21} of the Samba HOWTO Collection explains setting up a Primary Domain Controller.
- Chapter 5\textsuperscript{22} of the Samba HOWTO Collection explains setting up a Backup Domain Controller.
6. Samba Active Directory Integration

6.1. Accessing a Samba Share

Another use for Samba is to integrate into an existing Windows network. Once part of an Active Directory domain, Samba can provide file and print services to AD users.

The simplest way to join an AD domain is to use Likewise-open. For detailed instructions see Section 7, “Likewise Open” [p. 209].

Once part of the domain, install the following packages:

```
sudo apt-get install samba smbfs smbclient
```

Since the likewise-open and samba packages use separate *secrets.tdb* files, a symlink will need to be created in */var/lib/samba*:

```
sudo mv /var/lib/samba/secrets.tdb /var/lib/samba/secrets.tdb.orig
sudo ln -s /etc/samba/secrets.tdb /var/lib/samba
```

Next, edit */etc/samba/smb.conf* changing:

```
workgroup = EXAMPLE
...
security = ads
realm = EXAMPLE.COM
...
idmap backend = lwopen
idmap uid = 50-9999999999
idmap gid = 50-9999999999
```

Restart samba for the new settings to take effect:

```
sudo /etc/init.d/samba restart
```

You should now be able to access any Samba shares from a Windows client. However, be sure to give the appropriate AD users or groups access to the share directory. See Section 4, “Securing a Samba File and Print Server” [p. 199] for more details.

6.2. Accessing a Windows Share

Now that the Samba server is part of the Active Directory domain you can access any Windows server shares:

- To mount a Windows file share enter the following in a terminal prompt:
mount.cifs //fs01.example.com/share mount_point

It is also possible to access shares on computers not part of an AD domain, but a username and
password will need to be provided.

- To mount the share during boot place an entry in /etc/fstab, for example:

  //192.168.0.5/share /mnt/windows cifs auto,username=steve,password=secret,rw 0 0

- Another way to copy files from a Windows server is to use the smbclient utility. To list the files in
  a Windows share:

  smbclient //fs01.example.com/share -k -c "ls"

- To copy a file from the share, enter:

  smbclient //fs01.example.com/share -k -c "get file.txt"

  This will copy the file.txt into the current directory.

- And to copy a file to the share:

  smbclient //fs01.example.com/share -k -c "put /etc/hosts hosts"

  This will copy the /etc/hosts to //fs01.example.com/share/hosts.

- The -c option used above allows you to execute the smbclient command all at once. This is useful
  for scripting and minor file operations. To enter the smb: \> prompt, a FTP like prompt where you
  can execute normal file and directory commands, simply execute:

  smbclient //fs01.example.com/share -k

  Replace all instances of fs01.example.com/share, //192.168.0.5/share,
  username=steve,password=secret, and file.txt with your server's IP, hostname, share name, 
  file name, and an actual username and password with rights to the share.

6.3. Resources

For more smbclient options see the man page: **man smbclient**, also available online\(^{23}\).

The mount.cifs *man page*\(^{24}\) is also useful for more detailed information.


7. Likewise Open

Likewise Open simplifies the necessary configuration needed to authenticate a Linux machine to an Active Directory domain. Based on winbind, the likewise-open package takes the pain out of integrating Ubuntu authentication into an existing Windows network.

7.1. Installation

There are two ways to use Likewise Open, likewise-open the command line utility and likewise-open-gui. This section focuses on the command line utility.

To install the likewise-open package, open a terminal prompt and enter:

```bash
sudo apt-get install likewise-open
```

With Ubuntu 9.04 Likewise Open 5.0 is available in the *Universe* repository. However, since upgrading from Likewise Open 4.1 currently requires the system to leave the domain and re-join, a separate package for version five was created.

To install Likewise Open 5.0 enter:

```bash
sudo apt-get install likewise-open5
```

Installing likewise-open5 over an existing likewise-open (4.1) installation will replace it. You will have to rejoin the domain after install.

The command line tools, and GUI interface, for likewise-open5 are the same as version four.

7.2. Joining a Domain

The main executable file of the likewise-open package is `/usr/bin/domainjoin-cli`, which is used to join your computer to the domain. Before you join a domain you will need to make sure you have:

- Access to an Active Directory user with appropriate rights to join the domain.
- The *Fully Qualified Domain Name* (FQDN) of the domain you want to join. If your AD domain does not match a valid domain such as `example.com`, it is likely that it has the form of `domainname.local`.
- DNS for the domain setup properly. In a production AD environment this should be the case. Proper Microsoft DNS is needed so that client workstations can determine the Active Directory domain is available.

If you don't have a Windows DNS server on your network, see *Section 7.5, “Microsoft DNS”* [p. 211] for details.

To join a domain, from a terminal prompt enter:
```
sudo domainjoin-cli join example.com Administrator
```

Replace `example.com` with your domain name, and `Administrator` with the appropriate user name.

You will then be prompted for the user's password. If all goes well a `SUCCESS` message should be printed to the console.

After successfully joining an Ubuntu machine to an Active Directory domain you can authenticate using any valid AD user. To login you will need to enter the user name as `domain\username`. For example to ssh to a server joined to the domain enter:

```
ssh 'example\steve'@hostname
```

If configuring a Desktop the user name will need to be prefixed with `domain\` in the graphical logon as well.

To make likewise-open use a default domain, you can add the following statement to `/etc/samba/lwiauthd.conf`:

```
winbind use default domain = yes
```

Then restart the likewise-open daemons:

```
sudo /etc/init.d/likewise-open restart
```

Once configured for a `default domain` the `domain\` is no longer required, users can login using only their username.

The domainjoin-cli utility can also be used to leave the domain. From a terminal:

```
sudo domainjoin-cli leave
```

### 7.3. Other Utilities

The likewise-open package comes with a few other utilities that may be useful for gathering information about the Active Directory environment. These utilities are used to join the machine to the domain, and are the same as those available in the samba-common and winbind packages:

- `lwinet`: Returns information about the network and the domain.
- `lwimsg`: Allows interaction with the likewise-winbindd daemon.
- `lwiinfo`: Displays information about various parts of the Domain.

Please refer to each utility's man page specific for details.
7.4. Troubleshooting

- If the client has trouble joining the domain, double check that the Microsoft DNS is listed first in `/etc/resolv.conf`. For example:

  nameserver 192.168.0.1

- For more information when joining a domain, use the `--loglevel verbose` or `--advanced` option of the domainjoin-cli utility:

  ```bash
  sudo domainjoin-cli --loglevel verbose join example.com Administrator
  ```

- If an Active Directory user has trouble logging in, check the `/var/log/auth.log` for details.

- When joining an Ubuntu Desktop workstation to a domain, you may need to edit `/etc/nsswitch.conf` if your AD domain uses the `.local` syntax. In order to join the domain the "mdns4" entry from the `hosts` option. For example:

  ```bash
  hosts: files mdns4_minimal [NOTFOUND=return] dns mdns4
  ```

  Change the above to:

  ```bash
  hosts: files dns [NOTFOUND=return]
  ```

  Then restart networking by entering:

  ```bash
  sudo /etc/init.d/networking restart
  ```

  You should now be able to join the Active Directory domain.

7.5. Microsoft DNS

The following are instructions for installing DNS on an Active Directory domain controller running Windows Server 2003, but the instructions should be similar for other versions:

- Click Start → Administrative Tools → Manager Your Server. This will open the Server Role Management utility.
  1. Click Add or remove a role
  2. Click Next
  3. Select "DNS Server"
  4. Click Next
  5. Next
  6. Select "Create a forward lookup zone" if it is not selected.
  7. Click Next
  8. Make sure "This server maintains the zone" is selected and click Next.
9. Enter your domain name and click Next
10. Click Next to "Allow only secure dynamic updates"
11. Click Next to "Allow only secure dynamic updates"
12. Enter the IP for DNS servers to forward queries to, or Select "No, it should not forward queries" and click Next.
13. Click Finish
14. Click Finish

DNS is now installed and can be further configured using the Microsoft Management Console DNS snap-in.

- Next, configure the Server to use itself for DNS queries:
  1. Click Start
  2. Control Panel
  3. Network Connections
  4. Right Click "Local Area Connection"
  5. Click Properties
  6. Double click "Internet Protocol (TCP/IP)"
  7. Enter the Server's IP Address as the "Preferred DNS server"
  8. Click Ok
  9. Click Ok again to save the settings

### 7.6. References

Please refer to the Likewise\textsuperscript{25} home page for further information.

For more domainjoin-cli options see the man page: man domainjoin-cli.

---

\textsuperscript{25} http://www.likewisesoftware.com/
Chapter 16. Backups

There are many ways to backup an Ubuntu installation. The most important thing about backups is to develop a backup plan consisting of what to backup, where to back it up to, and how to restore it.

The following sections discuss various ways of accomplishing these tasks.
1. Shell Scripts

One of the simplest ways to backup a system is using a *shell script*. For example, a script can be used to configure which directories to backup, and use those directories as arguments to the tar utility creating an archive file. The archive file can then be moved or copied to another location. The archive can also be created on a remote file system such as an *NFS* mount.

The tar utility creates one archive file out of many files or directories. tar can also filter the files through compression utilities reducing the size of the archive file.

1.1. Simple Shell Script

The following shell script uses tar to create an archive file on a remotely mounted NFS file system. The archive filename is determined using additional command line utilities.

```
#!/bin/sh
####################################
#
# Backup to NFS mount script.
#
####################################

# What to backup.
backup_files="/home /var/spool/mail /etc /root /boot /opt"

# Where to backup to.
dest="/mnt/backup"

da day=$(date +%A)
hostname=$(hostname -s)
archive_file="$hostname-$day.tgz"

# Print start status message.
echo "Backing up $backup_files to $dest/$archive_file"
date
echo

tar czf $dest/$archive_file $backup_files

# Print end status message.
echo
echo "Backup finished"
date

# Long listing of files in $dest to check file sizes.
ls -lh $dest
```
• $backup_files: a variable listing which directories you would like to backup. The list should be
customized to fit your needs.

• $day: a variable holding the day of the week (Monday, Tuesday, Wednesday, etc). This is used to
create an archive file for each day of the week, giving a backup history of seven days. There are
other ways to accomplish this including other ways using the date utility.

• $hostname: variable containing the short hostname of the system. Using the hostname in the
archive filename gives you the option of placing daily archive files from multiple systems in the
same directory.

• $archive_file: the full archive filename.

• $dest: destination of the archive file. The directory needs to be created and in this case mounted
before executing the backup script. See Section 2, “Network File System (NFS)” [p. 157] for
details using NFS.

• status messages: optional messages printed to the console using the echo utility.

• tar czf $dest/$archive_file $backup_files: the tar command used to create the archive file.
  • c: creates an archive.
  • z: filter the archive through the gzip utility compressing the archive.
  • f: use archive file. Otherwise the tar output will be sent to STDOUT.

• ls -lh $dest: optional statement prints a -l long listing in -h human readable format of the destination
directory. This is useful for a quick file size check of the archive file. This check should not replace
testing the archive file.

This is a simple example of a backup shell script. There are large amount of options that can be
included in a backup script. See Section 1.4, “References” [p. 217] for links to resources providing
more in depth shell scripting information.

1.2. Executing the Script

1.2.1. Executing from a Terminal

The simplest way of executing the above backup script is to copy and paste the contents into a file.
backup.sh for example. Then from a terminal prompt:

    sudo bash backup.sh

This is a great way to test the script to make sure everything works as expected.

1.2.2. Executing with cron

The cron utility can be used to automate the script execution. The cron daemon allows the execution
of scripts, or commands, at a specified time and date.

cron is configured through entries in a crontab file. crontab files are separated into fields:
# m h dom mon dow   command

- **m:** minute the command executes on between 0 and 59.
- **h:** hour the command executes on between 0 and 23.
- **dom:** day of month the command executes on.
- **mon:** the month the command executes on between 1 and 12.
- **dow:** the day of the week the command executes on between 0 and 7. Sunday may be specified by using 0 or 7, both values are valid.
- **command:** the command to execute.

To add or change entries in a **crontab** file the **crontab -e** command should be used. Also, the contents of a **crontab** file can be viewed using the **crontab -l** command.

To execute the backup.sh script listed above using cron. Enter the following from a terminal prompt:

```
sudo crontab -e
```

Using sudo with the **crontab -e** command edits the **root** user’s **crontab**. This is necessary if you are backing up directories only the root user has access to.

Add the following entry to the **crontab** file:

```
# m h dom mon dow   command
0 0 * * * bash /usr/local/bin/backup.sh
```

The backup.sh script will now be executed every day at 12:00 am.

The backup.sh script will need to be copied to the `/usr/local/bin/` directory in order for this entry to execute properly. The script can reside anywhere on the file system simply change the script path appropriately.

For more in depth crontab options see Section 1.4, “References” [p. 217].

## 1.3. Restoring from the Archive

Once an archive has been created it is important to test the archive. The archive can be tested by listing the files it contains, but the best test is to **restore** a file from the archive.

- To see a listing of the archive contents. From a terminal prompt:

  ```
tar -t zvf /mnt/backup/host-Monday.tgz
  ```

- To restore a file from the archive to a different directory enter:

  ```
tar -x zvf /mnt/backup/host-Monday.tgz -C /tmp etc/hosts
  ```
Backups

The -C option to tar redirects the extracted files to the specified directory. The above example will extract the `/etc/hosts` file to `/tmp/etc/hosts`. tar recreates the directory structure that it contains.

Also, notice the leading "/" is left off the path of the file to restore.

- To restore all files in the archive enter the following:

```
cd /
sudo tar -xzvf /mnt/backup/host-Monday.tgz
```

This will overwrite the files currently on the file system.

1.4. References

- For more information on shell scripting see the Advanced Bash-Scripting Guide.
- The book Teach Yourself Shell Programming in 24 Hours is available online and a great resource for shell scripting.
- The CronHowto Wiki Page contains details on advanced cron options.
- See the GNU tar Manual for more tar options.
- The Wikipedia Backup Rotation Scheme article contains information on other backup rotation schemes.
- The shell script uses tar to create the archive, but there many other command line utilities that can be used. For example:
  - `cpio`: used to copy files to and from archives.
  - `dd`: part of the coreutils package. A low level utility that can copy data from one format to another
  - `rsnapshot`: a file system snap shot utility used to create copies of an entire file system.
2. Archive Rotation

The shell script in section Section 1, “Shell Scripts” [p. 214] only allows for seven different archives. For a server whose data doesn’t change often this may be enough. If the server has a large amount of data a more robust rotation scheme should be used.

2.1. Rotating NFS Archives

In this section the shell script will be slightly modified to implement a grandfather-father-son rotation scheme (monthly-weekly-daily):

- The rotation will do a daily backup Sunday through Friday.
- On Saturday a weekly backup is done giving you four weekly backups a month.
- The monthly backup is done on the first of the month rotating two monthly backups based on if the month is odd or even.

Here is the new script:

```bash
#!/bin/bash

# Backup to NFS mount script with grandfather-father-son rotation.
# What to backup.
backup_files="/home /var/spool/mail /etc /root /boot /opt"

# Where to backup to.
dest="/mnt/backup"

# Setup variables for the archive filename.
day=$(date +%A)
hostname=$(hostname -s)

# Find which week of the month 1-4 it is.
day_num=$(date +%d)
if (( $day_num <= 7 )); then
    week_file="$hostname-week1.tgz"
elif (( $day_num > 7 && $day_num <= 14 )); then
    week_file="$hostname-week2.tgz"
elif (( $day_num > 14 && $day_num <= 21 )); then
    week_file="$hostname-week3.tgz"
elif (( $day_num > 21 && $day_num < 32 )); then
    week_file="$hostname-week4.tgz"
fi
```
# Find if the Month is odd or even.
month_num=$(date +%m)
month=$(expr $month_num % 2)
if [ $month -eq 0 ]; then
    month_file="$hostname-month2.tgz"
else
    month_file="$hostname-month1.tgz"
fi

# Create archive filename.
if [ $day_num == 1 ]; then
    archive_file=$month_file
elif [ $day != "Saturday" ]; then
    archive_file="$hostname-$day.tgz"
else
    archive_file=$week_file
fi

# Print start status message.
echo "Backing up $backup_files to $dest/$archive_file"
date
echo

# Backup the files using tar.
tar czf $dest/$archive_file $backup_files

# Print end status message.
echo
echo "Backup finished"
date

# Long listing of files in $dest to check file sizes.
ls -lh $dest/

The script can be executed using the same methods as in Section 1.2, "Executing the Script" [p. 215].

It is good practice to take backup media off site in case of a disaster. In the shell script example the backup media is another server providing an NFS share. In all likelihood taking the NFS server to another location would not be practical. Depending upon connection speeds it may be an option to copy the archive file over a WAN link to a server in another location.

Another option is to copy the archive file to an external hard drive which can then be taken off site. Since the price of external hard drives continue to decrease it may be cost affective to use two drives for each archive level. This would allow you to have one external drive attached to the backup server and one in another location.

2.2. Tape Drives

A tape drive attached to the server can be used instead of a NFS share. Using a tape drive simplifies archive rotation, and taking the media off site as well.
When using a tape drive the filename portions of the script aren't needed because the date is sent directly to the tape device. Some commands to manipulate the tape are needed. This is accomplished using mt, a magnetic tape control utility part of the cpio package.

Here is the shell script modified to use a tape drive:

```bash
#!/bin/bash
####################################
# Backup to tape drive script.
#
####################################
# What to backup.
backup_files="/home /var/spool/mail /etc /root /boot /opt"
# Where to backup to.
dest="/dev/st0"
# Print start status message.
echo "Backing up $backup_files to $dest"
date
echo
# Make sure the tape is rewound.
mt -f $dest rewind
# Backup the files using tar.
tar czf $dest $backup_files
# Rewind and eject the tape.
mt -f $dest rewoffl
# Print end status message.
echo
echo "Backup finished"
date
```

The default device name for a SCSI tape drive is `/dev/st0`. Use the appropriate device path for your system.

Restoring from a tape drive is basically the same as restoring from a file. Simply rewind the tape and use the device path instead of a file path. For example to restore the `/etc/hosts` file to `/tmp/etc/hosts`:

```bash
mt -f /dev/st0 rewind
tar -xzf /dev/st0 -C /tmp etc/hosts
```
3. Bacula

Bacula is a backup program enabling you to backup, restore, and verify data across your network. There are Bacula clients for Linux, Windows, and Mac OSX. Making it a cross platform network wide solution.

3.1. Overview

Bacula is made up of several components and services used to manage which files to backup and where to back them up to:

- Bacula Director: a service that controls all backup, restore, verify, and archive operations.
- Bacula Console: an application allowing communication with the Director. There are three versions of the Console:
  - Text based command line version.
  - Gnome based GTK+ Graphical User Interface (GUI) interface.
  - wxWidgets GUI interface.
- Bacula File: also known as the Bacula Client program. This application is installed on machines to be backed up, and is responsible for the data requested by the Director.
- Bacula Storage: the programs that perform the storage and recovery of data to the physical media.
- Bacula Catalog: is responsible for maintaining the file indexes and volume databases for all files backed up, enabling quick location and restoration of archived files. The Catalog supports three different databases MySQL, PostgreSQL, and SQLite.
- Bacula Monitor: allows the monitoring of the Director, File daemons, and Storage daemons. Currently the Monitor is only available as a GTK+ GUI application.

These services and applications can be run on multiple servers and clients, or they can be installed on one machine if backing up a single disk or volume.

3.2. Installation

There are multiple packages containing the different Bacula components. To install Bacula, from a terminal prompt enter:

```
sudo apt-get install bacula
```

By default installing the bacula package will use a MySQL database for the Catalog. If you want to use SQLite or PostgreSQL, for the Catalog, install bacula-director-sqlite3 or bacula-director-pgsql respectively.

During the install process you will be asked to supply credentials for the database administrator and the bacula database owner. The database administrator will need to have the appropriate rights to create a database, see Section 1, “MySQL” [p. 141] for more information.
3.3. Configuration

Bacula configuration files are formatted based on resources comprising of directives surrounded by “{}” braces. Each Bacula component has an individual file in the /etc/bacula directory.

The various Bacula components must authorize themselves to each other. This is accomplished using the password directive. For example, the Storage resource password in the /etc/bacula/bacula-dir.conf file must match the Director resource password in /etc/bacula/bacula-sd.conf.

By default the backup job named Client1 is configured to archive the Bacula Catalog. If you plan on using the server to backup more than one client you should change the name of this job to something more descriptive. To change the name edit /etc/bacula/bacula-dir.conf:

```bash
# # Define the main nightly save backup job # By default, this job will back up to disk in Job { Name = "BackupServer" JobDefs = "DefaultJob" Write Bootstrap = "/var/lib/bacula/Client1.bsr"
}
```

The example above changes the job name to BackupServer matching the machine's host name. Replace “BackupServer” with your appropriate hostname, or other descriptive name.

The Console can be used to query the Director about jobs, but to use the Console with a non-root user, the user needs to be in the bacula group. To add a user to the bacula group enter the following from a terminal:

```bash
sudo adduser $username bacula
```

Replace $username with the actual username. Also, if you are adding the current user to the group you should log out and back in for the new permissions to take effect.

3.4. Localhost Backup

This section describes how to backup specified directories on a single host to a local tape drive.

- First, the Storage device needs to be configured. Edit /etc/bacula/bacula-sd.conf add:

```bash
Device {
    Name = "Tape Drive"
    Device Type = tape
    Media Type = DDS-4
    Archive Device = /dev/st0
    Hardware end of medium = No;
    AutomaticMount = yes; # when device opened, read it
}
```
AlwaysOpen = Yes;
RemovableMedia = yes;
RandomAccess = no;
Alert Command = "sh -c 'tapeinfo -f %c | grep TapeAlert'"
}

The example is for a DDS-4 tape drive. Adjust the Media Type and Archive Device to match your hardware.

You could also uncomment one of the other examples in the file.

- After editing /etc/bacula/bacula-sd.conf the Storage daemon will need to be restarted:

```bash
sudo /etc/init.d/bacula-sd restart
```

- Now add a Storage resource in /etc/bacula/bacula-dir.conf to use the new Device:

```bash
# Definition of "Tape Drive" storage device
Storage {
    Name = TapeDrive
    # Do not use "localhost" here
    Address = backupserver               # N.B. Use a fully qualified name here
    SDPort = 9103
    Password = "Cv70F6pf1t6pBopT4vQOnigDrR0v3LT3Cgklyj"
    Device = "Tape Drive"
    Media Type = tape
}
```

The Address directive needs to be the Fully Qualified Domain Name (FQDN) of the server. Change backupserver to the actual host name.

Also, make sure the Password directive matches the password string in /etc/bacula/bacula-sd.conf.

- Create a new FileSet, which will determine what directories to backup, by adding:

```bash
# LocalhostBacup FileSet.
FileSet {
    Name = "LocalhostFiles"
    Include {
        Options {
            signature = MD5
            compression=GZIP
        }
        File = /etc
        File = /home
    }
}
```

This FileSet will backup the /etc and /home directories. The Options resource directives configure the FileSet to create a MD5 signature for each file backed up, and to compress the files using GZIP.
• Next, create a new Schedule for the backup job:

```bash
# LocalhostBackup Schedule -- Daily.
Schedule {
    Name = "LocalhostDaily"
    Run = Full daily at 00:01
}
```

The job will run every day at 00:01 or 12:01 am. There are many other scheduling options available.

• Finally create the Job:

```bash
# Localhost backup.
Job {
    Name = "LocalhostBackup"
    JobDefs = "DefaultJob"
    Enabled = yes
    Level = Full
    FileSet = "LocalhostFiles"
    Schedule = "LocalhostDaily"
    Storage = TapeDrive
    Write Bootstrap = "/var/lib/bacula/LocalhostBackup.bsr"
}
```

The job will do a Full backup every day to the tape drive.

• Each tape used will need to have a Label. If the current tape does not have a label Bacula will send an email letting you know. To label a tape using the Console enter the following from a terminal:

```
bconsole
```

• At the Bacula Console prompt enter:

```
label
```

• You will then be prompted for the Storage resource:

```
Automatically selected Catalog: MyCatalog
Using Catalog "MyCatalog"
The defined Storage resources are:
   1: File
   2: TapeDrive
Select Storage resource (1-2):2
```

• Enter the new Volume name:
Enter new Volume name: Sunday

Defined Pools:
  1: Default
  2: Scratch

Replace Sunday with the desired label.

• Now, select the Pool:

Select the Pool (1-2): 1

Connecting to Storage daemon TapeDrive at backupserver:9103 ...

Sending label command for Volume "Sunday" Slot 0 ...

Congratulations, you have now configured Bacula to backup the localhost to an attached tape drive.

3.5. Resources

• For more Bacula configuration options refer to the Bacula User's Manual
• The Bacula Home Page contains the latest Bacula news and developments.
Chapter 17. Virtualization

Virtualization is being adopted in many different environments and situations. If you are a developer, virtualization can provide you with a contained environment where you can safely do almost any sort of development safe from messing up your main working environment. If you are a systems administrator, you can use virtualization to more easily separate your services and move them around based on demand.

The default virtualization technology supported in Ubuntu is KVM, a technology that takes advantage of virtualization extensions built into Intel and AMD hardware. For hardware without virtualization extensions Xen and Qemu are popular solutions.
1. **libvirt**

The `libvirt` library is used to interface with different virtualization technologies. Before getting started with `libvirt` it is best to make sure your hardware supports the necessary virtualization extensions for KVM. Enter the following from a terminal prompt:

```
egrep '(vmx|svm)' /proc/cpuinfo
```

If nothing is printed, it means that your cpu does *not* support hardware virtualization.

On most computer whose processor supports virtualization, it is necessary to activate an option in the bios to enable it. The method described above does not show the status of it's activation.

### 1.1. Virtual Networking

There are a few different ways to allow a virtual machine access to the external network. The default virtual network configuration is *usermode* networking, which uses the SLIRP protocol and traffic is NATed through the host interface to the outside network.

To enable external hosts to directly access services on virtual machines a *bridge* needs to be configured. This allows the virtual interfaces to connect to the outside network through the physical interface, making them appear as normal hosts to the rest of the network. For information on setting up a bridge see Section 1.4, “Bridging” [p. 32].

### 1.2. Installation

To install the necessary packages, from a terminal prompt enter:

```
sudo apt-get install kvm libvirt-bin
```

After installing `libvirt-bin`, the user used to manage virtual machines will need to be added to the `libvirtd` group. Doing so will grant the user access to the advanced networking options.

In a terminal enter:

```
sudo adduser $USER libvirtd
```

If the user chosen is the current user, you will need to log out and back in for the new group membership to take effect.

You are now ready to install a *Guest* operating system. Installing a virtual machine follows the same process as installing the operating system directly on the hardware. You either need a way to automate the installation, or a keyboard and monitor will need to be attached to the physical machine.

In the case of virtual machines a Graphical User Interface (GUI) is analogous to using a physical keyboard and mouse. Instead of installing a GUI the `virt-viewer` application can be used to connect
Virtualization

to a virtual machine's console using VNC. See Section 1.6, “Virtual Machine Viewer” [p. 230] for more information.

There are several ways to automate the Ubuntu installation process, for example using preseeds, kickstart, etc. Refer to the Ubuntu Installation Guide¹ for details.

Yet another way to install an Ubuntu virtual machine is to use ubuntu-vm-builder. ubuntu-vm-builder allows you to setup advanced partitions, execute custom post-install scripts, etc. For details see Section 2, “JeOS and vmbuilder” [p. 232]

1.3. virt-install

virt-install is part of the python-virtinst package. To install it, from a terminal prompt enter:

```
sudo apt-get install python-virtinst
```

There are several options available when using virt-install. For example:

```
sudo virt-install -n web_devel -r 256 -f web_devel.img \ 
-s 4 -c jeos.iso --accelerate \ 
--connect=qemu:///system --vnc \ 
--noautoconsole -v
```

• -n web_devel: the name of the new virtual machine will be web_devel in this example.
• -r 256: specifies the amount of memory the virtual machine will use.
• -f web_devel.img: indicates the path to the virtual disk which can be a file, partition, or logical volume. In this example a file named web_devel.img.
• -s 4: the size of the virtual disk.
• -c jeos.iso: file to be used as a virtual CDROM. The file can be either an ISO file or the path to the host's CDROM device.
• --accelerate: enables the kernel's acceleration technologies.
• --vnc: exports the guest's virtual console using VNC.
• --noautoconsole: will not automatically connect to the virtual machine's console.
• -v: creates a fully virtualized guest.

After launching virt-install you can connect to the virtual machine's console either locally using a GUI or with the virt-viewer utility.

1.4. virt-clone

The virt-clone application can be used to copy one virtual machine to another. For example:

sudo virt-clone -o web_devel -n database_devel -f /path/to/database_devel.img --connect=qemu:///system

- `-o`: original virtual machine.
- `-n`: name of the new virtual machine.
- `-f`: path to the file, logical volume, or partition to be used by the new virtual machine.
- `--connect`: specifies which hypervisor to connect to.

Also, use `-d` or `--debug` option to help troubleshoot problems with virt-clone.

Replace `web_devel` and `database_devel` with appropriate virtual machine names.

### 1.5. Virtual Machine Management

#### 1.5.1. virsh

There are several utilities available to manage virtual machines and libvirt. The virsh utility can be used from the command line. Some examples:

- To list running virtual machines:

  ```bash
  virsh -c qemu:///system list
  ```

- To start a virtual machine:

  ```bash
  virsh -c qemu:///system start web_devel
  ```

- Similarly, to start a virtual machine at boot:

  ```bash
  virsh -c qemu:///system autostart web_devel
  ```

- Reboot a virtual machine with:

  ```bash
  virsh -c qemu:///system reboot web_devel
  ```

- The state of virtual machines can be saved to a file in order to be restored later. The following will save the virtual machine state into a file named according to the date:

  ```bash
  virsh -c qemu:///system save web_devel web_devel-022708.state
  ```

  Once saved the virtual machine will no longer be running.

- A saved virtual machine can be restored using:

  ```bash
  virsh -c qemu:///system restore web_devel-022708.state
  ```

- To shutdown a virtual machine do:
**Virtualization**

```
virsh -c qemu:///system shutdown web_devel
```

- A CDROM device can be mounted in a virtual machine by entering:

```
virsh -c qemu:///system attach-disk web_devel /dev/cdrom /media/cdrom
```

In the above examples replace `web_devel` with the appropriate virtual machine name, and `web_devel-022708.state` with a descriptive file name.

### 1.5.2. Virtual Machine Manager

The virt-manager package contains a graphical utility to manage local and remote virtual machines. To install virt-manager enter:

```
sudo apt-get install virt-manager
```

Since virt-manager requires a Graphical User Interface (GUI) environment it is recommended to be installed on a workstation or test machine instead of a production server. To connect to the local libvirt service enter:

```
virt-manager -c qemu:///system
```

You can connect to the libvirt service running on another host by entering the following in a terminal prompt:

```
virt-manager -c qemu+ssh://virtnode1.mydomain.com/system
```

The above example assumes that SSH connectivity between the management system and virtnode1.mydomain.com has already been configured, and uses SSH keys for authentication. SSH keys are needed because libvirt sends the password prompt to another process. For details on configuring SSH see Section 1, “OpenSSH Server” [p. 44]

### 1.6. Virtual Machine Viewer

The virt-viewer application allows you to connect to a virtual machine's console. virt-viewer does require a Graphical User Interface (GUI) to interface with the virtual machine.

To install virt-viewer from a terminal enter:

```
sudo apt-get install virt-viewer
```

Once a virtual machine is installed and running you can connect to the virtual machine's console by using:

```
virt-viewer -c qemu:///system web_devel
```
Similar to virt-manager, virt-viewer can connect to a remote host using SSH with key authentication, as well:

```
virt-viewer -c qemu+ssh://virtnode1.mydomain.com/system web_devel
```

Be sure to replace `web_devel` with the appropriate virtual machine name.

If configured to use a bridged network interface you can also setup SSH access to the virtual machine. See Section 1, “OpenSSH Server” [p. 44] and Section 1.4, “Bridging” [p. 32] for more details.

### 1.7. Resources

- See the KVM² home page for more details.
- For more information on libvirt see the [libvirt home page]³
- The [Virtual Machine Manager]⁴ site has more information on virt-manager development.
- Also, stop by the #ubuntu-virt IRC channel on [freenode]⁵ to discuss virtualization technology in Ubuntu.
2. JeOS and vmbuilder

2.1. Introduction

2.1.1. What is JeOS

Ubuntu JeOS (pronounced "Juice") is an efficient variant of the Ubuntu Server operating system, configured specifically for virtual appliances. No longer available as a CD-ROM ISO for download, but only as an option either:

• While installing from the Server Edition ISO (pressing F4 on the first screen will allow you to pick "Minimal installation", which is the package selection equivalent to JeOS).
• Or to be built using Ubuntu's vmbuilder, which is described here.

JeOS is a specialized installation of Ubuntu Server Edition with a tuned kernel that only contains the base elements needed to run within a virtualized environment.

Ubuntu JeOS has been tuned to take advantage of key performance technologies in the latest virtualization products from VMware. This combination of reduced size and optimized performance ensures that Ubuntu JeOS Edition delivers a highly efficient use of server resources in large virtual deployments.

Without unnecessary drivers, and only the minimal required packages, ISVs can configure their supporting OS exactly as they require. They have the peace of mind that updates, whether for security or enhancement reasons, will be limited to the bare minimum of what is required in their specific environment. In turn, users deploying virtual appliances built on top of JeOS will have to go through fewer updates and therefore less maintenance than they would have had to with a standard full installation of a server.

2.1.2. What is vmbuilder

With vmbuilder, there is no need to download a JeOS ISO anymore. vmbuilder will fetch the various package and build a virtual machine tailored for our need in about a minute for us. Vmbuilder is a Script that automates the process of creating a ready to use Linux based VM. The currently supported hypervisors are KVM and Xen.

You can pass command line options to add extra packages, remove packages, choose which version of Ubuntu, which mirror etc. On recent hardware with plenty of RAM, tmpdir in /dev/shm or using a tmpfs, and a local mirror, you can bootstrap a VM in less than a minute.

First introduced as a shell script in Ubuntu 8.04LTS, ubuntu-vm-builder started with little emphasis as a hack to help developers test their new code in a virtual machine without having to restart from scratch each time. As a few Ubuntu administrators started to notice this script, a few of them went on improving it and adapting it for so many use case that Soren Hansen (the author of the script and Ubuntu virtualization specialist, not the golf player) decided to rewrite it from scratch for Intrepid as a python script with a few new design goals:
Virtualization

• Develop it so that it can be reused by other distributions.
• Use a plugin mechanisms for all virtualization interactions so that others can easily add logic for other virtualization environments.
• Provide an easy to maintain web interface as an option to the command line interface.

But the general principles and commands remain the same.

2.2. Initial Setup

It is assumed that you have installed and configured libvirt and KVM locally on the machine you are using. For details on how to perform this, please refer to:

• Section 1, “libvirt” [p. 227]
• The KVM Wiki page.

We also assume that you know how to use a text based text editor such as nano or vi. If you have not used any of them before, you can get an overview of the various text editors available by reading the PowerUsersTextEditors page. This tutorial has been done on KVM, but the general principle should remain on other virtualization technologies.

2.2.1. Install vmbuilder

The name of the package that we need to install is python-vm-builder. In a terminal prompt enter:

```bash
sudo apt-get install python-vm-builder
```

If you are running Hardy, you can still perform most of this using the older version of the package named ubuntu-vm-builder, there are only a few changes to the syntax of the tool.

2.3. Defining Your Virtual Machine

Defining a virtual machine with Ubuntu's vmbuilder is quite simple, but here are a few thing to consider:

• If you plan on shipping a virtual appliance, do not assume that the end-user will know how to extend disk size to fit their need, so either plan for a large virtual disk to allow for your appliance to grow, or explain fairly well in your documentation how to allocate more space. It might actually be a good idea to store data on some separate external storage.

• Given that RAM is much easier to allocate in a VM, RAM size should be set to whatever you think is a safe minimum for your appliance.

The vmbuilder command has 2 main parameters: the virtualization technology (hypervisor) and the targeted distribution. Optional parameters are quite numerous and can be found using the following command:

```bash
vmbuilder --help
```

7 https://help.ubuntu.com/community/PowerUsersTextEditors
**2.3.1. Base Parameters**

As this example is based on KVM and Ubuntu 9.04 (Jaunty Jackalope), and we are likely to rebuild the same virtual machine multiple time, we'll invoke vmbuilder with the following first parameters:

```sh
dsudo vmbuilder kvm ubuntu --suite jaunty --flavour virtual --arch i386 -o --libvirt qemu:///system
```

The `--suite` defines the Ubuntu release, the `--flavour` specifies that we want to use the virtual kernel (that's the one used to build a JeOS image), the `--arch` tells that we want to use a 32 bit machine, the `-o` tells vmbuilder to overwrite the previous version of the VM and the `--libvirt` tells to inform the local virtualization environment to add the resulting VM to the list of available machines.

**Notes:**

- Because of the nature of operations performed by vmbuilder, it needs to have root privilege, hence the use of `sudo`.
- If your virtual machine needs to use more than 3Gb of ram, you should build a 64 bit machine (`--arch amd64`).
- Until Ubuntu 8.10, the virtual kernel was only built for 32 bit architecture, so if you want to define an amd64 machine on Hardy, you should use `--flavour server` instead.

**2.3.2. JeOS Installation Parameters**

**2.3.2.1. JeOS Networking**

**2.3.2.1.1. Assigning a fixed IP address**

As a virtual appliance that may be deployed on various very different networks, it is very difficult to know what the actual network will look like. In order to simplify configuration, it is a good idea to take an approach similar to what network hardware vendors usually do, namely assigning an initial fixed IP address to the appliance in a private class network that you will provide in your documentation. An address in the range 192.168.0.0/255 is usually a good choice.

To do this we'll use the following parameters:

- **--ip ADDRESS**: IP address in dotted form (defaults to dhcp if not specified)
- **--mask VALUE**: IP mask in dotted form (default: 255.255.255.0)
- **--net VALUE**: IP net address (default: X.X.X.0)
- **--bcast VALUE**: IP broadcast (default: X.X.X.255)
- **--gw ADDRESS**: Gateway address (default: X.X.X.1)
- **--dns ADDRESS**: Name server address (default: X.X.X.1)

We assume for now that default values are good enough, so the resulting invocation becomes:
sudo vmbuilder kvm ubuntu --suite jaunty --flavour virtual --arch i386 -- --libvirt qemu:///system --ip 192.168.0.100

2.3.2.1.2. Modifying the libvirt Template to use Bridging

Because our appliance will be likely to need to be accessed by remote hosts, we need to configure libvirt so that the appliance uses bridge networking. To do this we use vmbuilder template mechanism to modify the default one.

In our working directory we create the template hierarchy and copy the default template:

```bash
mkdir -p VMBuilder/plugins/libvirt/templates
cp /etc/vmbuilder/libvirt/* VMBuilder/plugins/libvirt/templates/
```

We can then edit `VMBuilder/plugins/libvirt/templates/libvirtxml.tmpl` to change:

```xml
<interface type='network'>
  <source network='default'/>
</interface>
```

To:

```xml
<interface type='bridge'>
  <source bridge='br0'/>
</interface>
```

2.3.2.2. Partitioning

Partitioning of the virtual appliance will have to take into consideration what you are planning to do with it. Because most appliances want to have a separate storage for data, having a separate `/var` would make sense.

In order to do this vmbuilder provides us with `--part`:

```bash
--part PATH
```

Allows to specify a partition table in partfile each line of partfile should specify (root first):

- mountpoint size

where `size` is in megabytes. You can have up to 4 virtual disks, a new disk starts on a line with `---`. ie:

```
root 1000
/opt 1000
swap 256
---
/var 2000
/log 1500
```

In our case we will define a text file name `vmbuilder.partition` which will contain the following:
Note that as we are using virtual disk images, the actual sizes that we put here are maximum sizes for these volumes.

Our command line now looks like:

```
sudo vmbuilder kvm ubuntu --suite jaunty --flavour virtual --arch i386 \
   -o --libvirt qemu:///system --ip 192.168.0.100 --part vmbuilder.partition
```

Using a "\" in a command will allow long command strings to wrap to the next line.

### 2.3.2.3. User and Password

Again setting up a virtual appliance, you will need to provide a default user and password that is generic so that you can include it in your documentation. We will see later on in this tutorial how we will provide some security by defining a script that will be run the first time a user actually logs in the appliance, that will, among other things, ask him to change his password. In this example I will use 'user' as my user name, and 'default' as the password.

To do this we use the following optional parameters:

- **--user USERNAME**: Sets the name of the user to be added. Default: ubuntu.
- **--name FULLNAME**: Sets the full name of the user to be added. Default: Ubuntu.
- **--pass PASSWORD**: Sets the password for the user. Default: ubuntu.

Our resulting command line becomes:

```
sudo vmbuilder kvm ubuntu --suite intrepid --flavour virtual --arch i386 \ 
   -o --libvirt qemu:///system --ip 192.168.0.100 --part vmbuilder.partition \ 
   --user user --name user --pass default
```

### 2.3.3. Installing Required Packages

In this example we will be installing a package (Limesurvey) that accesses a MySQL database and has a web interface. We will therefore require our OS to provide us with:

- Apache
- PHP
- MySQL
- OpenSSH Server
- Limesurvey (as an example application that we have packaged)
This is done using vmbuilder by specifying the --addpkg command multiple times:

```bash
--addpkg PKG
    Install PKG into the guest (can be specified multiple times)
```

However, due to the way vmbuilder operates, packages that have to ask questions to the user during the post install phase are not supported and should instead be installed while interactivity can occur. This is the case of Limesurvey, which we will have to install later, once the user logs in.

Other packages that ask simple debconf question, such as mysql-server asking to set a password, the package can be installed immediately, but we will have to reconfigure it the first time the user logs in.

If some packages that we need to install are not in main, we need to enable the additional repositories using --comp and --ppa:

```bash
--components COMP1,COMP2,...,COMPN
    A comma separated list of distro components to include (e.g. main,universe). This defaults to "main"
--ppa=PPA
    Add ppa belonging to PPA to the vm's sources.list.
```

Limesurvey not being part of the archive at the moment, we’ll specify it’s PPA (personal package archive) address so that it is added to the VM `/etc/apt/source.list`, so we add the following options to the command line:

```bash
--addpkg apache2 --addpkg apache2-mpm-prefork --addpkg apache2-utils --addpkg apache2.2-common \  
    --addpkg dbconfig-common --addpkg libapache2-mod-php5 --addpkg mysql-client --addpkg php5- \  
    --addpkg php5-gd --addpkg php5-ldap --addpkg php5-mysql --addpkg wwwconfig-common \  
    --addpkg mysql-server --ppa nijaba
```

### 2.3.1. OpenSSH

Another convenient tool that we want to have on our appliance is OpenSSH, as it will allow our admins to access the appliance remotely. However, pushing in the wild an appliance with a pre-installed OpenSSH server is a big security risk as all these servers will share the same secret key, making it very easy for hackers to target our appliance with all the tools they need to crack it open in a breeze. As for the user password, we will instead rely on a script that will install OpenSSH the first time a user logs in so that the key generated will be different for each appliance. For this we’ll use a --firstboot script, as it does not need any user interaction.

### 2.3.4. Speed Considerations

#### 2.3.4.1. Package Caching

When vmbuilder creates builds your system, it has to go fetch each one of the packages that composes it over the network to one of the official repositories, which, depending on your internet connection speed and the load of the mirror, can have a big impact on the actual build time. In order to reduce
this, it is recommended to either have a local repository (which can be created using apt-mirror) or
using a caching proxy such as apt-cache. The later option being much simpler to implement and
requiring less disk space, it is the one we will pick in this tutorial. To install it, simply type:

```
sudo apt-get install apt-proxy
```

Once this is complete, your (empty) proxy is ready for use on http://mirroraddress:9999 and will find
ubuntu repository under /ubuntu. For vmbuilder to use it, we'll have to use the `--mirror` option:

```
--mirror=URL  Use Ubuntu mirror at URL instead of the default, which
               is http://archive.ubuntu.com/ubuntu for official
               arches and http://ports.ubuntu.com/ubuntu-ports
               otherwise
```

So we add to the command line:

```
--mirror http://mirroraddress:9999/ubuntu
```

The mirror address specified here will also be used in the `/etc/apt/source.list` of the
newly created guest, so it is useful to specify here an address that can be resolved by the
guest or to plan on resetting this address later on, such as in a `--firstboot` script.

2.3.4.2. Install a Local Mirror

If we are in a larger environment, it may make sense to setup a local mirror of the Ubuntu
repositories. The package apt-mirror provides you with a script that will handle the mirroring for you.
You should plan on having about 20 gigabyte of free space per supported release and architecture.

By default, apt-mirror uses the configuration file in `/etc/apt/mirror.list`. As it is set up, it will
replicate only the architecture of the local machine. If you would like to support other architectures on
your mirror, simply duplicate the lines starting with “deb”, replacing the deb keyword by `/deb-{arch}`
where arch can be i386, amd64, etc... For example, on an amd64 machine, to have the i386 archives
as well, you will have:

```
deb  http://archive.ubuntu.com/ubuntu jaunty main restricted universe multiverse
/deb-i386 http://archive.ubuntu.com/ubuntu jaunty main restricted universe multiverse
```

```
deb http://archive.ubuntu.com/ubuntu/ jaunty-backports main restricted universe multiverse
/deb-i386 http://archive.ubuntu.com/ubuntu jaunty-backports main restricted universe multiverse
```

```
deb http://security.ubuntu.com/ubuntu jaunty-security main restricted universe multiverse
/deb-i386 http://security.ubuntu.com/ubuntu jaunty-security main restricted universe multiverse
```

```
```
Notice that the source packages are not mirrored as they are seldom used compared to the binaries and they do take a lot more space, but they can be easily added to the list.

Once the mirror has finished replicating (and this can be quite long), you need to configure Apache so that your mirror files (in /var/spool/apt-mirror if you did not change the default), are published by your Apache server. For more information on Apache see Section 1, “HTTPD - Apache2 Web Server” [p. 123].

2.3.5. Installing in a RAM Disk

As you can easily imagine, writing to RAM is a LOT faster than writing to disk. If you have some free memory, letting vmbuilder perform its operation in a RAMdisk will help a lot and the option --tmpfs will help you do just that:

```
--tmpfs OPTS  Use a tmpfs as the working directory, specifying its size or "-" to use tmpfs default (suid,dev,size=1G).
```

So adding --tmpfs - sounds like a very good idea if you have 1G of free ram.

2.4. Package the Application

Two option are available to us:

- The recommended method to do so is to make a Debian package. Since this is outside of the scope of this tutorial, we will not perform this here and invite the reader to read the documentation on how to do this in the Ubuntu Packaging Guide. In this case it is also a good idea to setup a repository for your package so that updates can be conveniently pulled from it. See the Debian Administration article for a tutorial on this.

- Manually install the application under /opt as recommended by the FHS guidelines.

In our case we’ll use Limesurvey as example web application for which we wish to provide a virtual appliance. As noted before, we’ve made a version of the package available in a PPA (Personal Package Archive).

2.5. Finishing Install

2.5.1. First Boot

As we mentioned earlier, the first time the machine boots we'll need to install openssh-server so that the key generated for it is unique for each machine. To do this, we’ll write a script called boot.sh as follows:

```bash
# This script will run the first time the virtual machine boots
# It is run as root.
```
apt-get update
apt-get install -qqy --force-yes openssh-server

And we add the --firstboot boot.sh option to our command line.

2.5.2. First Login

Mysql and Limesurvey needing some user interaction during their setup, we'll set them up the first time a user logs in using a script named login.sh. We'll also use this script to let the user specify:
- His own password
- Define the keyboard and other locale info he wants to use

So we'll define login.sh as follows:

```bash
# This script is ran the first time a user logs in

echo "Your appliance is about to be finished to be set up."
echo "In order to do it, we'll need to ask you a few questions,"
echo "starting by changing your user password."

passwd

give the opportunity to change the keyboard
sudo dpkg-reconfigure console-setup

#configure the mysql server root password
sudo dpkg-reconfigure mysql-server-5.0

#install limesurvey
sudo apt-get install -qqy --force-yes limesurvey

echo "Your appliance is now configured. To use it point your"
echo "browser to http://serverip/limesurvey/admin"

And we add the --firstlogin login.sh option to our command line.

2.6. Useful Additions

2.6.1. Configuring Automatic Updates

To have your system be configured to update itself on a regular basis, we will just install unattended-upgrades, so we add the following option to our command line:

--addpkg unattended-upgrades

As we have put our application package in a PPA, the process will update not only the system, but also the application each time we update the version in the PPA.
2.6.2. ACPI Event Handling

For your virtual machine to be able to handle restart and shutdown events it is being sent, it is a good idea to install the acpid package as well. To do this we just add the following option:

```
--addpkg acpid
```

2.7. Final Command

Here is what the command with all the options discussed above:

```
sudo vmbuilder kvm ubuntu --suite intrepid --flavour virtual --arch i386 -o /
    --libvirt qemu:///system --ip 192.168.0.100 --part vmbuilder.partition --user user /
    --name user --pass default --addpkg apache2 --addpkg apache2-mpm-prefork /
    --addpkg apache2-utils --addpkg apache2.2-common --addpkg dbconfig-common /
    --addpkg libapache2-mod-php5 --addpkg mysql-client --addpkg php5-cli /
    --addpkg php5-gd --addpkg php5-ldap --addpkg php5-mysql --addpkg wwwconfig-common /
    --addpkg mysql-server --addpkg unattended-upgrades --addpkg acpid --ppa nijaba /
    --mirror http://mirroraddress:9999/ubuntu --tmpfs - --firstboot boot.sh /
    --firstlogin login.sh es
```

2.8. Resources

If you are interested in learning more, have questions or suggestions, please contact the Ubuntu Server Team at:

- IRC: #ubuntu-server on freenode
- Mailing list: ubuntu-server at lists.ubuntu.com

11
3. Eucalyptus

3.1. Overview

Eucalyptus is an open-source software infrastructure for implementing "cloud computing" on your own clusters. Eucalyptus allows you to create your own cloud computing environment in order to maximize computing resources and provide a cloud computing environment to your users.

This section will cover setting up a Cloud Computing environment using Eucalyptus with KVM. For more information on KVM see Section 1, “libvirt” [p. 227].

The Cloud Computing environment will consist of three components, typically installed on at least two separate machines (termed the 'front-end' and 'node(s)' for the rest of this document):

- **One Front-End**: hosts one Cloud Controller, a Java based Web configuration interface, and a Cluster Controller, which determines where virtual machines (VMs) will be housed and manages cluster level VM networking.
- **One or more Compute Nodes**: runs the Node Controller component of Eucalyptus, which allows the machine to be part of the cloud as a host for VMs.

The simple *System* networking option will be used by default. This network method allows virtual machine instances, to obtain IP addresses from the local LAN, assuming that a DHCP server is properly configured on the LAN to hand out IPs dynamically to VMs that request them. Each node will be configured for bridge networking. For more details see Section 1.4, “Bridging” [p. 32].

3.2. Configuration

First, on the **Front-End** install the appropriate packages. In a terminal prompt on the Front-End enter:

```
sudo apt-get install eucalyptus-cloud eucalyptus-cc
```

Next, on the each **Compute Node** install the node controller package. In a terminal prompt on each Compute Node enter:

```
sudo apt-get install eucalyptus-nc
```

Once the installation is complete, and it may take a while, in a browser go to `https://front-end:8443` and login to the administration interface using the default username and password of *admin*. You will then be prompted to change the password, configure an email address for the admin user, and set the storage URL.

In the web interface’s "Configuration” tab, add a cluster under the "Clusters” heading (in this configuration, the cluster controller is on the same system as the cloud controller, so entering 'localhost' as the cluster hostname is correct). Once the form is filled out click the "Add Cluster” button.
Now, back on the *Front-End*, add the nodes to the cluster:

```
sudo euca_conf -addnode hostname_of_node
```

You will then be prompted to log into your Node, install the eucalyptus-nc package, and add the eucalyptus user's ssh key to the node's `authorized_keys` file, and confirm authenticity of the host's OpenSSH RSA key fingerprint. Finally, the command will complete by synchronizing the eucalyptus component keys and node registration is complete.

On the Node, the `/etc/eucalyptus/eucalyptus.conf` configuration file will need editing to use your node's bridge interface (assuming here that the interface is named `br0`):

```
VNET_INTERFACE="br0"
...
VNET_BRIDGE="br0"
```

Finally, restart eucalyptus-nc:

```
sudo /etc/init.d/eucalyptus-nc restart
```

Be sure to replace `nodecontroller`, `node01`, and `node02` with actual hostnames.

Eucalyptus is now ready to host images on the cloud.

### 3.3. References

- See the *Eucalyptus website*\(^{12}\) for more information.
- For information on loading instances see the *Eucalyptus Wiki*\(^{13}\) page.
- You can also find help in the `#ubuntu-virt`, `#eucalyptus`, and `#ubuntu-server` IRC channels on Freenode\(^{14}\).
4. OpenNebula

OpenNebula allows virtual machines to be placed and re-placed dynamically on a pool of physical resources. This allows a virtual machine to be hosted from any location available.

This section will detail configuring an OpenNebula cluster using three machines: one Front-End host, and two Compute Nodes used to run the virtual machines. The Compute Nodes will also need a bridge configured to allow the virtual machines access to the local network. For details see Section 1.4, “Bridging” [p. 32].

4.1. Installation

First, from a terminal on the Front-End enter:

```
sudo apt-get install opennebula
```

On each Compute Node install:

```
sudo apt-get install opennebula-node
```

In order to copy SSH keys, the oneadmin user will need to have a password. On each machine execute:

```
sudo passwd oneadmin
```

Next, copy the oneadmin user’s SSH key to the Compute Nodes, and to the Front-End’s authorized_keys file:

```
sudo scp /var/lib/one/.ssh/id_rsa.pub oneadmin@node01:/var/lib/one/.ssh/authorized_keys
sudo scp /var/lib/one/.ssh/id_rsa.pub oneadmin@node02:/var/lib/one/.ssh/authorized_keys
sudo sh -c "cat /var/lib/one/.ssh/id_rsa.pub >> /var/lib/one/.ssh/authorized_keys"
```

The SSH key for the Compute Nodes needs to be added to the /etc/ssh/ssh_known_hosts file on the Front-End host. To accomplish this ssh to each Compute Node as a user other than oneadmin. Then exit from the SSH session, and execute the following to copy the SSH key from ~/.ssh/known_hosts to /etc/ssh/ssh_known_hosts:

```
sudo sh -c "ssh-keygen -f .ssh/known_hosts -F node01 1>> /etc/ssh/ssh_known_hosts"
sudo sh -c "ssh-keygen -f .ssh/known_hosts -F node02 1>> /etc/ssh/ssh_known_hosts"
```

Replace node01 and node02 with the appropriate host names.

This allows the oneadmin to use scp, without a password or manual intervention, to deploy an image to the Compute Nodes.
On the Front-End create a directory to store the VM images, giving the `oneadmin` user access to the directory:

```
sudo mkdir /var/lib/one/images
sudo chown oneadmin /var/lib/one/images/
```

Finally, copy a virtual machine disk file into `/var/lib/one/images`. You can create an Ubuntu virtual machine using `vmbuilder`, see Section 2, “JeOS and `vmbuilder`” [p. 232] for details.

### 4.2. Configuration

The `OpenNebula Cluster` is now ready to be configured, and virtual machines added to the cluster.

From a terminal prompt enter:

```
onehost create node01 im_kvm vmm_kvm tm_ssh
onehost create node02 im_kvm vmm_kvm tm_ssh
```

Next, create a `Virtual Network` template file named `vnet01.template`:

```
NAME            = "LAN"
TYPE            = RANGED
BRIDGE          = br0
NETWORK_SIZE    = C
NETWORK_ADDRESS = 192.168.0.0
```

Be sure to change `192.168.0.0` to your local network.

Using the `onevnet` utility, add the virtual network to OpenNebula:

```
onevnet create vnet01.template
```

Now create a `VM Template` file named `vm01.template`:

```
NAME   = vm01
CPU    = 0.5
MEMORY = 512

OS     = [ BOOT = hd ]

DISK   = [ source = "/var/lib/one/images/vm01.qcow2", target = "hda", readonly = "no" ]

NIC    = [ NETWORK="LAN"]
```
GRAPHICS = [type="vnc",listen="127.0.0.1",port="-1"]

Start the virtual machine using onevm:

`onevm submit vm01.template`

Use the onevm list option to view information about virtual machines. Also, the onevm show vm01 option will display more details about a specific virtual machine.

4.3. References

- See the OpenNebula website\textsuperscript{15} for more information.
- You can also find help in the \texttt{#ubuntu-virt} and \texttt{#ubuntu-server} IRC channels on Freenode\textsuperscript{16}. 
Chapter 18. Clustering
1. DRBD

Distributed Replicated Block Device (DRBD) mirrors block devices between multiple hosts. The replication is transparent to other applications on the host systems. Any block device hard disks, partitions, RAID devices, logical volumes, etc can be mirrored.

To get started using drbd, first install the necessary packages. From a terminal enter:

```
sudo apt-get install drbd8-utils
```

This section covers setting up a drbd to replicate a separate /srv partition, with an ext3 filesystem between two hosts. The partition size is not particularly relevant, but both partitions need to be the same size.

1.1. Configuration

The two hosts in this example will be called `drbd01` and `drbd02`. They will need to have name resolution configured either through DNS or the `/etc/hosts` file. See Chapter 7, Domain Name Service (DNS) [p. 83] for details.

- To configure drbd, on the first host edit `/etc/drbd.conf`:

```
global { usage-count no; }
common { syncer { rate 100M; } }
resource r0 {
    protocol C;
    startup {
        wfc-timeout 15;
        degr-wfc-timeout 60;
    }
    net {
        cram-hmac-alg sha1;
        shared-secret "secret";
        allow-two-primaries;
    }
}
on drbd01 {
    device /dev/drbd0;
    disk /dev/sdb1;
    address 192.168.0.1:7788;
    meta-disk internal;
}
on drbd02 {
    device /dev/drbd0;
    disk /dev/sdb1;
    address 192.168.0.2:7788;
    meta-disk internal;
}
```
There are many other options in /etc/drbd.conf, but for this example their default values are fine.

- Now copy /etc/drbd.conf to the second host:

```
scp /etc/drbd.conf drbd02:~
```

- And, on drbd02 move the file to /etc:

```
sudo mv drbd.conf /etc/
```

- Next, on both hosts, start the drbd daemon:

```
sudo /etc/init.d/drbd start
```

- Now using the drbdadm utility initialize the meta data storage. On each server execute:

```
sudo drbdadm create-md r0
```

- On the drbd01, or whichever host you wish to be the primary, enter the following:

```
sudo drbdadm -- --overwrite-data-of-peer primary all
```

- After executing the above command, the data will start syncing with the secondary host. To watch the progress, on drbd02 enter the following:

```
watch -n1 cat /proc/drbd
```

To stop watching the output press Ctrl+c.

- Finally, add a filesystem to /dev/drbd0 and mount it:

```
sudo mkfs.ext3 /dev/drbd0
sudo mount /dev/drbd0 /srv
```

### 1.2. Testing

To test that the data is actually syncing between the hosts copy some files on the drbd01, the primary, to /srv:

```
sudo cp -r /etc/default /srv
```

Next, unmount /srv:

```
sudo umount /srv
```

*Demote* the primary server to the secondary role:
sudo drbdadm secondary r0

Now on the the secondary server promote it to the primary role:

sudo drbdadm primary r0

Lastly, mount the partition:

sudo mount /dev/drbd0 /srv

Using ls you should see /srv/default copied from the former primary host drbd01.

1.3. References

• For more information on DRBD see the DRBD web site.\(^1\)
• The drbd.conf man page\(^2\) contains details on the options not covered in this guide.
• Also, see the drbdadm man page\(^3\).
Chapter 19. Other Useful Applications

There are many very useful applications developed by the Ubuntu Server Team, and others that are well integrated with Ubuntu Server Edition, that might not be well known. This chapter will showcase some useful applications that can make administering an Ubuntu server, or many Ubuntu servers, that much easier.
1. Update MOTD

When logging into an Ubuntu server you may have noticed the informative Message Of The Day (MOTD). This information is obtained and displayed using a couple of packages:

- **landscape-common**: provides the core libraries of landscape-client, which can be used to manage systems using the web based Landscape application. The package includes the `/usr/bin/landscape-sysinfo` utility which is used to gather the information displayed in the MOTD.

- **update-motd**: is used to automatically update the MOTD via cron.

The update-motd utility has several options to further customize the MOTD:

- **--disable**: prevents automatic updates of the MOTD. Using this option creates the `/var/lib/update-motd/disabled` file, which if present stops update-motd from modifying `/etc/motd`.

- **--enable**: enables the automatic MOTD updates. If `/var/lib/update-motd` is present it will be removed.

- **--force**: does a one time update of `/etc/motd`, overriding update-motd if it has been disabled.

- **d, hourly, weekly, monthly**: option will run the scripts in `/etc/update-motd.d` (default), `/etc/update-motd.d/hourly`, `/etc/update-motd.d/weekly`, or `/etc/update-motd.d/monthly` respectively.

`update-motd` executes the scripts in `/etc/update-motd.d` in order based on the number prepended to the script. Separate cron scripts execute every ten minutes, hourly, weekly, and monthly running the corresponding scripts in `/etc/update-motd.d`. The output of the scripts is written to `/var/run/update-motd/`, keeping the numerical order, then concatenated with `/etc/motd.tail` and written to `/etc/motd`.

You can add your own dynamic information to the MOTD. For example, to add local weather information:

- First, install the weather-util package:

  ```bash
  sudo apt-get install weather-util
  ```

  The weather utility uses METAR data from the National Oceanic and Atmospheric Administration and forecasts from the National Weather Service. In order to find local information you will need the 4-character ICAO location indicator. This can be determined by browsing to the National Weather Service site.

  Although the National Weather Service is a United States government agency there are weather stations available world wide. However, local weather information for all locations outside the U.S. may not be available.

- Create `/usr/local/bin/local-weather`, a simple shell script to use weather with your local ICAO indicator:
#!/bin/sh

# Prints the local weather to /var/run/update-motd/60-local-weather
# for update-motd.
#
# Replace KINT with your local weather station.
# Local stations can be found here: http://www.weather.gov/tg/siteloc.shtml

echo "" > /var/run/update-motd/60-local-weather
weather -i KINT >> /var/run/update-motd/60-local-weather

• Make the script executable:

    sudo chmod 755 /usr/local/bin/local-weather

• Next, create a symlink to /etc/update-motd.d/60-local-weather:

    sudo ln -s /usr/local/bin/local-weather /etc/update-motd.d/60-local-weather

• Finally, update the MOTD:

    sudo update-motd

You should now be greeted with some useful information, and some information about the local weather that may not be quite so useful. Hopefully the local-weather example demonstrates the flexibility of update-motd.
2. etckeeper

etckeeper allows the contents of /etc be easily stored in Version Control System (VCS) repository. It hooks into apt to automatically commit changes to /etc when packages are installed or upgraded. Placing /etc under version control is considered an industry best practice, and the goal of etckeeper is to make this process as painless as possible.

Install etckeeper by entering the following in a terminal:

```bash
sudo apt-get install etckeeper
```

The main configuration file, /etc/etckeeper/etckeeper.conf, is fairly simple. The main options being which VCS and which package management system to use. By default etckeeper is configured to use bzr for version control, apt for high level package management, and dpkg for low level package management.

With the package installed, it is time to initialize the repository. In a terminal enter:

```bash
sudo etckeeper init
```

Next, commit the files to the repository:

```bash
sudo etckeeper commit "initial import"
```

Using the VCS commands you can view log information about files in /etc:

```bash
sudo bzr log /etc/passwd
```

To demonstrate the integration with the package management system, install postfix:

```bash
sudo apt-get install postfix
```

When the installation is finished, all the postfix configuration files should be committed to the repository:

```bash
Committing to: /etc/
added aliases.db
modified group
modified group-
modified gshadow
modified gshadow-
modified passwd
modified passwd-
added postfix
added resolvconf
added rsyslog.d
```
modified shadow
modified shadow-
added init.d/postfix
added network/if-down.d/postfix
added network/if-up.d/postfix
added postfix/dynamicmaps.cf
added postfix/main.cf
added postfix/master.cf
added postfix/post-install
added postfix/postfix-files
added postfix/postfix-script
added postfix/sasl
added ppp/ip-down.d
added ppp/ip-down.d/postfix
added ppp/ip-up.d/postfix
added rc0.d/K20postfix
added rc1.d/K20postfix
added rc2.d/S20postfix
added rc3.d/S20postfix
added rc4.d/S20postfix
added rc5.d/S20postfix
added rc6.d/K20postfix
added resolvconf/update-libc.d
added resolvconf/update-libc.d/postfix
added rsyslog.d/postfix.conf
added ufw/applications.d/postfix
Committed revision 2.

For an example of how etckeeper tracks manual changes, add new a host to /etc/hosts. Using bzr you can see which files have been modified:

    sudo bzr status /etc/
modified:
hosts

Now commit the changes:

    sudo etckeeper commit "new host"

For more information on bzr see Section 1, “Bazaar” [p. 185].
3. Screen Profiles

One of the most useful applications for any system administrator is screen. It allows the execution of multiple shells in one terminal. To make some of the advanced screen features more user friendly, and provide some useful information about the system, the screen-profiles package was created.

When executing screen for the first time you will be presented with the screen-profiles-helper menu. This menu will allow you to:

- View the Help menu
- Change the key binding set
- Change screen profiles
- Change the escape sequence
- Create new screen windows
- Manage the default windows
- Install screen by default at login

The key bindings determine such things as the escape sequence, new window, change window, etc. There are two key binding sets to choose from common and none. If you wish to use the original key bindings choose the none set.

The Ubuntu screen-profiles provide a menu which displays the Ubuntu release, processor information, memory information, and the time and date. The effect is similar to a desktop menu. When a profile is selected it will be symlinked to ~/.screenrc. The select-screen-profile utility can also be used to change profiles, in a terminal enter:

```
select-screen-profile -s ubuntu-light
```

The plain profile will change screen back to the defaults, which does not include the information menu at the bottom.

Using the "Install screen by default at login" option will cause screen to be executed any time a terminal is opened. Changes made to screen are on a per user basis, and will not affect other users on the system.

One difference when using screen is the scrollback mode. If you are using one of the Ubuntu profiles press the F7, or Ctrl+a+f if not, to enter scrollback mode. Scrollback mode allows you to navigate past output using vi like commands. Here is a quick list of movement commands:

- h - Move the cursor left by one character
- j - Move the cursor down by one line
- k - Move the cursor up by one line
- l - Move the cursor right by one character
- 0 - Move to the beginning of the current line
• $ - Move to the end of the current line
• G - Moves to the specified line (defaults to the end of the buffer)
• C-u - Scrolls a half page up
• C-b - Scrolls a full page up
• C-d - Scrolls a half page down
• C-f - Scrolls the full page down
• / - Search forward
• ? - Search backward
• n - Moves to the next match, either forward or backward
4. References

- See the `update-motd man page` for more options available to update-motd.
- The Debian Package of the Day `weather` article has more details about using the weatherutility.
- See the `etckeeper` site for more details on using etckeeper.
- For the latest news and information about bzr see the `bzr` web site.
- For more information on screen see the `screen web site`.
- Also, see the screen-profiles `project page` for more information.