Linux 102 Examination

Modular Training Notes

Leading Edge Business Solutions

This manual was written for Leading Edge Business Solutions
http://www.ledge.co.za/ as part of their Linux training programme.

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LPIC topics

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1 Foreword

> See the amazing new paradoxical Linux powered vacuum cleaner! It's Linux, but it sucks!
>
> *(I made it up)*

This course material relates to the Linux Professionals Institute's LPI 102 examination (release 2). This course is intended to provide you with the basic skills required for operating and administering Linux systems. This document is a set of training notes for the course.

At every good training course the student should come away with some paper in his hand, to file in the company filing cabinet. A really excellent course will include some knowledge and practical ability in the student's head as well. We hope to achieve at least the first with these notes. The second is up to the instructor.

Goal of this course

This course aims to equip you with the knowledge to be able to pass the LPI 102 examination (release 2). We hope that in the course of doing this course you will acquire the skills that go with an understanding of how Linux works.

Target audience

This course is aimed at ...

- People who have already written the LPIC 101 exam, as part of the LPIC Level 1 certification.
- People who wish to write the LPIC 102 exam, as part of the LPIC Level 1 certification.
- People who are familiar with Linux and wish to acquire more advanced skills and fill the gaps in their understanding.
- People who want to run network servers on Linux.

Prerequisites for taking this course

People wishing to take this course will probably fit the following profile

- You should have a firm understanding of Linux. Writing and passing the LPIC 101 examination or an equivalent qualification is recommended.
- You are a system administrator or hold a similar technical position (or you would like a job like that).
- You are interested in technical things and the fascinating little details that make your computer behave strangely.
- You want to know how things work – specifically how Linux works, and be willing to spend some time finding out.
- You have practical administrative experience with computer systems.
- You already have some practical familiarity with using Linux. You have probably installed Linux and have used it without gaining a complete understanding of many functions.

We recommend that this course be followed by professional people who have completed their secondary education, and possibly an additional qualification. It is preferable that you already hold a position in which you can use Linux on a day to day basis.

What you need for this course

You will need the following in order to complete this course.

- A dedicated computer to work on outside of course contact time. As part of the course, the existing data on this computer will most likely be destroyed. If you do not have an appropriate computer, you should consider buying a laptop, or at least a new hard disk for an existing computer.
- Committed time for six working weeks:
  - Lecture, tutorial and review time: 2 hours per week (excluding travel time).
  - Self-study and practice time: minimum of 2 hours per day, Monday to Friday.

Flow of instruction

Each section in the notes is structured as an independent entity. Each section covers a single LPIC topic. Each section is structured as follows:

- LPIC objectives (with the weighting noted)
- Introductory material
- Detailed material
- Review material (quiz questions and assignments).

Some of the sections are more demanding than others, and the certification does not weight all of the sections equally.

Typographic conventions

Command names and example of command are printed in **boldface**. So for example, **ls -la** is used for printing a list of files in the current directory, and **pwd** prints the current working directory.

Syntax explanations are shown like this.

```
ls [directory-name]
```

In this particular case, it means that you can tell **ls** to list a particular directory.

Interactive command sessions are shown in a block like this

```
# This is an interactive session
# What was typed is shown in boldface.
foo:~ $ su - jack
Password:
[jack@foo jack]$ ls
[jack@foo jack]$ ls -a
.  ..  .bash_logout  .bash_profile  .bashrc  .emacs  .gtkrc  .kde
[jack@foo jack]$ pwd
/home/jack
```

The student is encouraged to try these example commands on her[1] computer, as the results

1 And when we say “her”, we mean “his” if the student happens to be male.

may differ from one system to the next. Often the output shown is incomplete, and a valuable learning experience awaits the person bold enough to retype the bold text.

1.1 About these notes

These notes have been written with the LPI's objectives and criteria for approved training materials in mind. We have designed them to be modular, so that a course following LPI objectives can easily be built up from a selection of topics.

Printed copies of this and other manuals can be purchased from Leading Edge Business Solutions (Pty) Ltd – see www.ledge.co.za. We offer training courses based on this material. The contact address for queries related to these notes is lpinotes@ledge.co.za.

1.2 Revisions and bugs

Gentle reader, we hope that these notes provide a wonderful learning experience for you. In this process we trust that you will be kind enough to point out to us the typos, stylistic faults and gross errors in the text. If you make changes to these notes, or produce them in an alternative format, we would appreciate it if you would send us a copy of your revisions.

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2 Kernel modules

> Basically, I want people to know that when they use binary-only modules, it's THEIR problem. I want people to know that in their bones, and I want it shouted out from the rooftops. I want people to wake up in a cold sweat every once in a while if they use binary-only modules.
>
> *– Linus Torvalds on linux-kernel*

LPIC topic 1.105.1 — Manage/Query kernel and kernel modules at runtime [4]

Weight: 4

Objectives

Candidates should be able to manage and/or query a kernel and kernel loadable modules. This objective includes using command-line utilities to get information about the currently running kernel and kernel modules. It also includes manually loading and unloading modules as appropriate. It also includes being able to determine when modules can be unloaded and what parameters a module accepts. Candidates should be able to configure the system to load modules by names other than their file name.

Key files, terms and utilities include

/lib/modules/kernel-version/modules.dep	Kernel module inter-dependencies
/etc/modules.conf & /etc/conf.modules	modprobe configuration file (new and old)
depmod	Determine module dependencies
insmod	Insert a module into the kernel
lsmod	List kernel modules
rmmod	Remove an installed kernel module
modinfo	Show information about a kernel module
modprobe	Install modules and their dependencies (or remove)
uname	Unix name, and kernel version number.

2.1 Kernel modules

The Linux kernel started out as a big monolithic thing that did all of the necessary kernel functions. The wise academics said that this was the wrong way to do things, since it made it more or less impossible to add functionality while the system was running, unless you resort to ugly hacks. So, in the course of time, the loadable kernel module was introduced. It's an ugly hack, and it works very well.

There are now modules that support the following types of thing (and a whole lot more than this too):

- Filesystems (e.g. ext3, reiserfs, vfat, jfs, xfs)
- Character and block devices (tapes, mice, serial ports, hardware sensors)
- Network adapters from various manufacturers and of various sorts

- Bus protocols (USB, Firewire, ISA PnP)

There are a couple of consequences to the Linux approach to modules:

- Kernel modules are "object files", exactly like what is produced when compiling a C program. The linking part of compiling a C program is what happens when a module is loaded. Somehow, the kernel manages to support unlinking of these linked-in objects too.
- Modules must be compiled with the same options as the kernel they are part of, since they are simply pluggable parts of the same monolithic program.
- Modules from one kernel version will *not* work with other kernel versions.
- Modules will rely on other parts of the kernel to be present – possibly on other modules (introducing dependencies).

2.2 Module information

The command **lsmod** displays a list of loaded kernel modules. From the list below you can probably work out what kind of system **lsmod** was run on.

```
foo:~ # lsmod
Module                  Size  Used by    Not tainted
via82cxxx_audio        21304   1  (autoclean)
uart401                 8068   0  (autoclean) [via82cxxx_audio]
ac97_codec             12136   0  (autoclean) [via82cxxx_audio]
sound                  70196   0  (autoclean) [via82cxxx_audio
      uart401]
soundcore               6180   4  (autoclean) [via82cxxx_audio
      sound]
tulip                  42304   1  (autoclean)
ds                      8136   2
yenta_socket           12320   2
pcmcia_core            51168   0  [ds yenta_socket]
mousedev                5236   1
input                   5696   0  [mousedev]
usbcore                71680   1
ext3                   64160   3
jbd                    48180   3  [ext3]
```

The columns have the following meanings

- The module name (without its **.o** extension)
- The number of bytes of kernel memory occupied by the module
- The number of devices or processes that are using the module.
- The list of modules that rely on the particular module being present.

2.3 Inserting modules

To load a single module into the kernel, you use the command **insmod**. To remove a single module from the running kernel, the command is **rmmod**.

modinfo displays information about a module. The module information for the 3COM 3c501 Ethernet adapter looks something like this.

```
foo:~ # modinfo 3c501
filename:    /lib/modules/2.4.18-19.8.0/kernel/drivers/net/3c501.o
```

```
description: <none>
author:      <none>
license:     "GPL"
parm:        io int, description "EtherLink I/O base address"
parm:        irq int, description "EtherLink IRQ number"
```

In the unlikely event that you happen to have a 3c501 ethernet adapter connected to your computer, you can load the module something like this – presuming you know what the settings of the card are. If you get them wrong, of course it doesn't work.

```
foo:~ # insmod 3c501 io=0x200 irq=3
Using /lib/modules/2.4.18-19.8.0/kernel/drivers/net/3c501.o
/lib/modules/2.4.18-19.8.0/kernel/drivers/net/3c501.o: init_module:
      Input/output error
Hint: insmod errors can be caused by incorrect module parameters,
      including invalid IO or IRQ parameters.  You may find more
      information in syslog or the output from dmesg
```

Here is some **modinfo** for some journalling filesystems.

```
foo:~ # modinfo reiserfs
filename:    /lib/modules/2.4.18-
      19.8.0/kernel/fs/reiserfs/reiserfs.o
description: "ReiserFS journaled filesystem"
author:      "Hans Reiser <reiser@namesys.com>"
license:     "GPL"
foo:~ # modinfo ext3
filename:    /lib/modules/2.4.18-19.8.0/kernel/fs/ext3/ext3.o
description: "Second Extended Filesystem with journaling extensions"
author:      "Remy Card, Stephen Tweedie, Andrew Morton, Andreas
      Dilger, Theodore Ts'o and others"
license:     "GPL"
```

Filesystem modules are quite easy to load. Since the list of available filesystems is displayed in **/proc/filesystems** it is quite easy to see whether loading the module had any effect. Here we load and unload the **reiserfs** module.

```
foo:~ # egrep 'ext|reiser' /proc/filesystems
        ext2
        ext3
foo:~ # insmod reiserfs
foo:~ # insmod /lib/modules/2.4.18/kernel/fs/reiserfs/reiserfs.o
insmod: a module named reiserfs already exists
Using /lib/modules/2.4.18/kernel/fs/reiserfs/reiserfs.o
foo:~ # egrep 'ext|reiser' /proc/filesystems
        ext2
        ext3
        reiserfs
foo:~ # rmmod reiserfs.o
rmmod: module reiserfs.o is not loaded
foo:~ # rmmod reiserfs
foo:~ # egrep 'ext|reiser' /proc/filesystems
        ext2
        ext3
```

insmod accepts a filename (usually ending in **.o**) or a module name as its argument. **rmmod** will only accept the name of the particular module as its argument.

insmod is limited in that it does not handle module dependencies. If a module requires another module in order to be loaded, **insmod** will simply refuse to load it. In order to automatically load the required modules you require **modprobe** together with **depmod** and **modules.conf**.

2.4 modprobe, modules.conf and depmod

It's like this:

- **depmod -a** examines the modules forming part of the kernel, and generates **/lib/modules/*/modules.dep**, which lists the full paths of the modules, and also which modules are required to be loaded before a particular module.
- **/etc/modules.conf** (or **/etc/conf.modules** in older versions) lists the parameters for modules (e.g. io=0x220 and irq=7)
- **modprobe** loads a module with the parameters specified in **/etc/modules.conf**, and also loads all the modules required by that module.
- You can specify aliases for modules in **/etc/modules.conf**. So instead of saying **modprobe 3c509x**, you can say **modprobe eth0** to load the module.

modules.conf

The most popular entries in **/etc/modules.conf** are shown below.

```
alias parport_lowlevel parport_pc
alias usb-controller usb-uhci
alias eth0 tulip
options tulip full_duplex=1
```

An "alias" defines an alternative name for a module. The USB line above exists because there are two USB controllers available – usb-ohci and usb-uhci. This system uses usb-uhci, but the startup script simply says **modprobe usb-controller**, without worrying about which particular USB controller will be loaded. Similarly the networking scripts run **modprobe eth0**, without worrying about which particular ethernet device is to be used. What actually happens is the command **insmod tulip full_duplex=1**.

An "options" line defines the default options with which a module is supplied when it is loaded.

modprobe

To load a module (and all the modules it depends on), the syntax for **modprobe** is one of these

```
modprobe modulename
modprobe aliasname
```

To remove a module (and quite often its dependencies as well), the syntax is

```
modprobe -r modulename
modprobe -r aliasname
```

depmod

Whenever modules change, you need to run **depmod -a**. The dependencies between modules are determined and written to a file, **/lib/modules/*/modules.dep**. Which particular directory gets used depends on which kernel you are running, as reported by **uname -a**.

```
foo:~ # uname
foo:~ # uname -a
foo:~ # uname -a | cut -f 3 -d ' '
```

Most distributions run **depmod -a** during startup (although it is not usually necessary).

2.5 Unloading modules

A module can only be unloaded when it is not in use. If you wish to unload the module, you must terminate the process or resource that is accessing it.

Here we try to remove the **tulip** module which runs the eth0 network interface.

```
foo:~ # ifconfig eth0 192.168.12.3
foo:~ # rmmod tulip
tulip: Device or resource busy
foo:~ # ifconfig eth0 down
foo:~ # rmmod tulip
foo:~ # lsmod | grep tulip
```

Of course, when we try to look at the eth0 interface to see what happened, we discover that **ifconfig** does an implicit **modprobe eth0** when you run **ifconfig eth0**.

```
foo:~ # ifconfig eth0
eth0      Link encap:Ethernet  HWaddr 00:E0:98:99:70:91
          BROADCAST MULTICAST  MTU:1500  Metric:1
          Interrupt:10 Base address:0xe000

foo:~ # lsmod | grep tulip
tulip                  42304   0  (autoclean) (unused)
```

2.6 Review

Quiz questions

1. Why are kernel modules necessary?
2. What are the commands to insert and remove a single module?
3. Which command tells you which parameters a module accepts?
4. Which command reads modules.conf, and what does it do?
5. What condition will prevent a module from being unloaded?
6. What is necessary for the command **modprobe eth0** to load the appropriate module for an installed ethernet card?

Assignment

1. Make a list of modules which are loaded, and note how much free memory is reported by **free**. Load the **ip_conntrack_ftp** module. Which other modules are loaded in order to do

this? Make a list of the configurable parameters that these modules accept. Remove the **ip_conntrack_ftp** module and all the other modules you loaded. How much memory is now reported free?

2. Make a list of all the kernel modules which can be loaded on your system (not those available for loading, but those which *can* be loaded). How does loading these modules affect the free memory on your system as reported by **free**?

Answers to quiz questions

1. Expanding the capabilities of the kernel once it is already running.
2. **inmod** and **rmmod**. **modprobe** and **modprobe -r** may affect multiple modules.
3. **modinfo**
4. **modprobe** and **depmod**. **depmod -a** creates **modules.dep** in the modules directory.
5. Modules which are in use cannot be unloaded.
6. An entry in **modules.conf** saying "**alias eth0 e100**" (specifying the appropriate module). You may have to run **depmod -a** as well,.

3 Rebuilding the kernel

> "I tell you the truth, unless a kernel of wheat falls to the ground and dies, it remains only a single seed. But if it dies, it produces many seeds."
>
> *– Jesus, John 12:24*

LPIC topic 1.105.2 — Reconfigure, build, and install a custom kernel and kernel modules [3]

Weight: 3

Objectives

Candidates should be able to customize, build, and install a kernel and kernel loadable modules from source This objective includes customizing the current kernel configuration, building a new kernel, and building kernel modules as appropriate. It also includes installing the new kernel as well as any modules, and ensuring that the boot manager can locate the new kernel and associated files (generally located under /boot, see objective 1.102.2 for more details about boot manager configuration).

Key files, terms and utilities include

/usr/src/linux/*	The Linux kernel source directory
/usr/src/linux/.config	Your options for compiling the kernel (modules and features)
/lib/modules/kernel-version/*	Where modules get installed
/boot/*	Where the kernel gets installed
make	Make output files up to date with source files
make targets:	Things that you use as arguments to **make**
• config	Console mode configuration editing .config
• menuconfig	ncurses mode configuration editing .config
• xconfig	Graphical configuration editing .config
• oldconfig	Like make config, but ask only about new features
• modules	Compile binary modules
• install	Install the kernel image in /boot for booting
• modules_install	Install kernel modules in /lib/modules/*/
• depmod	(not a make target, but needed after installing modules)

3.1 The kernel

The kernel is the core of the operating system. It is the first "process" to start and provides many of the services required by other software "user land" applications.

The kernel facilitates four basic types of services:

1. creation and management of processes,
2. the filesystem/s,
3. communication with hardware, and

4. a means to start the system

The kernel provides these facilities in two broad functional groups, these are the *autonomous* and *responsive* functions. Examples of autonomous functions are the allocation of memory and CPU time to processes, undertaken without any special request being directed at the kernel.

The allocation of other system resources, such as the use of hardware, is usual responsive and the the requesting process never have final control over this resource. All requests against this resource are still directed through the kernel and the kernel may deny any request from a user land process. For example, a process has obtained read access to a file does not read data directly from the disk, but rather *requests* the kernel to read the file though a suitable function call. The kernel only complies with the request after it has determined the validity of the request. Requests directed to the kernel from processes are often called *system calls* and the set of *services* exposed by the kernel forms the kernel's application program interface (API).

Here are some examples of system calls.

- fork – fork creates a copy of the parent process that differs only in process ID and parent process ID. An example of the use of this system call is a web server where the server forks a copy of itself to deal with each new request.
- exec – exec request the kernel to replace the present process with a new process loaded from a file. The regular method of starting new processes on Linux is for the parent to fork and exec.
- kill – The kill system call requests the kernel to send a signal to another process. This is the system call implemented by the **kill** command line program.
- open – convert a file name into a file descriptor for reading and writing. Before any file is read or written, it is "opened".
- read – read data from a file descriptor.
- write – write data to a file descriptor.
- close – close an open file descriptor.
- exit – terminates the current process.

The system call interface acts as an abstraction of the hardware, such that, a process does not need to know the specifics of the hardware on which it is running or how that hardware has been configured. An example of this is that all network devices look the same to a process irrespective of the underlying hardware. Similarly, all files look the same to processes, irrespective of the underlying filesystem.

The kernel configures the CPU to provide insulation between processes, so that processes do not interfere with each other. It is expected of a well designed and implemented kernel that even delinquent processes will not excessively interfere with the correct functioning of other processes.

3.2 Obtaining the kernel

The Linux source code is distributed from The Linux Kernel Archives at http://www.kernel.org/ Either the complete source can be downloaded, or depending on how

adventurous and experienced a user is a pre-existing source tree can be patched or “rsync”ed. The later two methods, while quicker, are more difficult and frustrating for a beginner.

This section outlines the basic procedure to patch the kernel, but for first time users either download or install the complete source tree from your distribution[2]. Be warned that the complete download is fairly sizeable and to obtain experience in compiling the kernel it is not necessary to compile the latest release.

If you plan to download the complete source look for a file named something like **linux-2.4.18.tar.gz**. Files with names like **patch-2.4.18.gz** are the kernel patch file and are not what you want as a beginner.

```
joe@dwarf:~> rpm -qpi /cdrom/suse/d3/linux.rpm
Name        : linux                    Relocations: (not relocateable)
Version     : 2.4.9                    Vendor: SuSE GmbH, Nuernberg,
      Ge
Release     : 4                        Build Date: Thu 20 Sep 2001
      06:38:42
Install date: (not installed)          Build Host: lhospital.suse.de
Group       : System Environment/Kernel Source RPM: linux-2.4.9-
      4.src.rpm
Size        : 113747460                License: GPL
Packager    : feedback@suse.de
Summary     : Rest of the kernel source code
Description :
This package contains the Linux Kernel source files.

Authors:
--------
    Linus Torvalds <torvalds@transmeta.com>

    see /usr/src/linux/CREDITS for more details.

SuSE series: d
joe@dwarf:~ > su
Password:
dwarf:/home/joe # rpm -i /cdrom/suse/d3/linux.rpm
```

If you install the kernel source tree from a distribution package (e.g. an rpm), it will generally be installed in a directory such as **/usr/src/linux-2.4.9/** (where the numerical part reflects the version of the kernel source). Your distribution may create a symbolic link **/usr/src/linux** pointing to the directory. Because each kernel version gets its own directory with its own version number, it is possible to have multiple kernel sources under the directory **/usr/src/**.

If you download the kernel source, simply change to the **/usr/src** directory, and uncompress the tar ball. The kernel source will create the directory with the correct version number (although the soft link must be manually created, if you want it).

The kernel version number is significant (i.e. not meaningless, and not a marketing exercise). Kernels where the minor version number is even are considered to be stable when they are released. For example **kernel-2.4.9** has a minor version number of 4 and is therefore a

2 On the SuSE distribution the kernel source tree is contained in the linux.rpm or the kernel-source.rpm package. The examples in the text were done using a SuSE supplied kernel tree.

member of a stable series of kernel releases. The 9 indicates that it is the ninth member of the series, because bugs are found in the stable kernels and features are often back ported to stable kernels requiring an additional new release in the series. Kernels with odd minor version numbers, for example **2.5.xx**, are the unstable or development kernel. Experimenting with almost any kernel is fairly safe, but on a production system you should use only the latest stable release of the kernel.

3.3 Kernel patches

If you have a copy of the kernel source, you can install a series of patches to bring the source code up to date with the latest release. It is bad idea™ to patch non-standard kernels – the patches may already be installed, or may be in conflict with other code. Some distributions (e.g. SuSE and Mandrake) routinely ship non-standard kernels that have non-standard features included. If the kernel is not the standard "Linus" kernel, patches to update you to the next release are likely to fail.

To patch the source do the following:

1. Visit http://www.kernel.org/ and obtain the latest stable patch.
2. Clean the source and backup your present source tree. If the patch fails or requires some manual intervention, having a copy of your source tree is always nice.

   ```
   dwarf:/usr/src/linux # make clean
   dwarf:/usr/src/linux # cd ..
   dwarf:/usr/src # tar czf linux-2.4.9.tar.gz linux-2.4.9
   ```

   Don't be tempted to use **make backup** in **/usr/src/linux –** this might not really do what you want. In particular it will destroy your configuration files.
3. To patch the kernel to the next version, you install the patch something like this (assuming that the patch is in your home directory):

   ```
   dwarf:/usr/src # zcat ~/patch-2.4.10.gz | patch -p0 -s
   ```
4. If there are errors, it is now your job to fix all the places that patch program failed to correctly patch a file. This is done by searching for ***.rej** files (rejected patches), examining their content, fixing the problem and then attempting to re-apply the the rejected file as follows:

   ```
   dwarf:/usr/src/linux/fs # patch -p0 < rejectedFile.rej
   ```

3.4 Compiling a kernel

Once you have an installed kernel source tree, you can build it by following the following steps:

1. Log in as root[3] and switch to the root directory of the kernel source that compile. This is usually cd /usr/src/linux.
2. If you have previously compiled a kernel in this same directory, you need to clear out the intermediate files to ensure that you get what you are expecting. To clean out the files, you can do one of the following.

3 Strictly, you do not have to compile the kernel as root – if you change the ownership of the kernel files, you can compile as a regular user, although **make install** and **make modules_install** will fail if you are not root.

- **make distclean** – This target returns the source tree to it original state, removing all intermediate files. All files generated by any of the other targets are removed, including the configuration file **.config**.
- **make mrproper** – This is almost a complete distclean except that files named ***.rej**, ***.orig** or ***.bak** which may have been generated by faulty patches are left untouched. If the source tree has been badly damaged as the result of the application of an inappropriate patch, then delete the source tree and re-install it from the backup or an original.

3. Run one of the following commands to interactively choose which kernel options and modules should be compiled, and which should be omitted.

```
dwarf:/usr/src/linux # make config
dwarf:/usr/src/linux # make xconfig
dwarf:/usr/src/linux # make menuconfig
```

   Probably the easiest one to use is **make menuconfig**, which works in a console, and does not require X windows. All of the above commands generate a file named **.config** in the kernel source directory. **.config** is a text file which you can also edit manually.

4. Once you have configured your options, you must determine the dependencies between the various components you have enabled.

```
dwarf:/usr/src/linux # make dep
```

   The **dep** target relies on the presence of the **.config** file generated by **make config**.

5. If you skipped the last step for some reason, or if you have previously compiled a kernel with different options, you will want to remove the intermediate files:

```
dwarf:/usr/src/linux # make clean
```

6. Build the kernel image that gets loaded into memory at boot time using one of the following.

```
dwarf:/usr/src/linux # make bzImage
dwarf:/usr/src/linux # make zImage
dwarf:/usr/src/linux # make zlilo
```

   The most often used one of these is **bzImage**.

7. At this point, you have a bootable kernel image, which you could install. However, your system would probably not work, since most systems rely heavily on loadable module support. To compile the modules and install them in **/lib/modules/2.4.9** (or your particular kernel version).

```
dwarf:/usr/src/linux # make modules
dwarf:/usr/src/linux # make modules_install
```

   Newer versions of the kernel Makefile will automatically run **depmod** to compute inter-module dependencies. If your modules don't work when you reboot, it's because you didn't run **depmod**, and you were supposed to.

8. Lastly, the new kernel image must be copied into place and lilo configured.

```
dwarf:/usr/src/linux # cp arch/i386/boot/bzImage /boot/vmlinuz
dwarf:/usr/src/linux # cp arch/i386/boot/System.map /boot/vmlinuz
dwarf:/usr/src/linux # mk_initrd
dwarf:/usr/src/linux # lilo
```

The **mk_initrd** step is to ensure that your *initial root disk* which loads modules essential to your systems operation does exactly that.

If your system is sufficiently similar to the kernel maintainer's system, the following may install a bootable kernel.

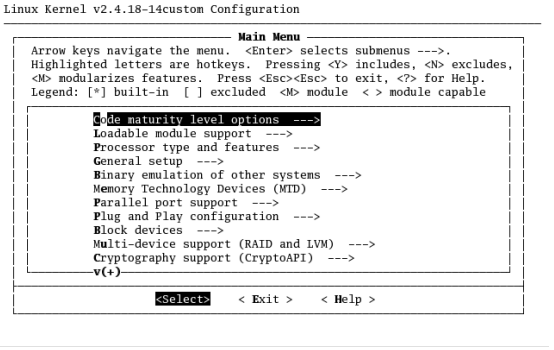
```
dwarf:/usr/src/linux # make install
```

The following section contains suggestions on how you can determine which kernel options are necessary.

General guidelines

- Keep a copy of the standard kernel which was installed with your system.
- Keep a copy of a clean source tree.
- Keep a copy of a working **.config** or you will have to going through all those menu options again. Most distributions install a copy of the default **.config** in **/proc/config.gz**, or in **/boot/config**.
- After copying your **.config** file from its backup location, always run one of the **make config** commands. If you don't execute **make menuconfig** (or similar) then certain of the targets required for rebuilding the kernel will not be available.

3.5 Choosing options for your kernel



The number of options available when compiling the kernel is mind boggling and is also constantly changing (upwards). The best we can do in terms of describing the options is to offer suggestions as to how you can build your first kernel.

Execute **make menuconfig** after preparing as described above.

1. The selections in **menuconfig** are arranged by category, and to make good selections, you require some knowledge of the hardware you are running. Use the **lsmod** command to see which modules are installed on your running system, use the command **lspci** to see what is installed on the PCI bus, find the documentation that came with the computer or open the computer and look at the numbers on the chips on your hardware.
2. Configure only what you really need. The biggest advantage to compiling the kernel yourself is that you can remove all that bloat included with your distribution's standard kernel – things that are included just in case. Although it does not affect performance to build every kernel module available, it will increase the amount of time it takes to get the modules built.
3. When in doubt, accept the defaults if in doubt and read the help text if you suspect the option may be necessary. You could also search at your favourite search engine for more information on the particular option, e.g. CONFIG_EXPERIMENTAL.

3.6 Review

Quiz questions

1. What is the order in which the following commands should be issued:
   make modules
   make modules_install
   make config
   make install
   make bzImage
   make dep
2. What is the difference between a modular kernel and a static kernel?
3. If you are using the lilo boot loader, what steps are necessary to ensure that the system boots up with a newly compiled kernel?
4. What is the effect in terms of performance and kernel size when you include an an unnecessary module when compiling the kernel?

Assignment

Your company has appointed you to install their new mail and web server. It is required the a custom system be configured to perform this task where attention must be paid to removing all unnecessary options. Consider the computer that you are using to be the new company computer. To achieve better performance and security you must compile a customised kernel without using loadable modules.

Download and extract the latest stable kernel source. This is a clean source tree, so just run **make menuconfig**.

The following configuration settings are suggested. Change the configuration as needed to reflect the hardware that you have installed. Whatever you do, you should have a working bootable system at the end. The computer used is considered to be a entry level computer – IDE disks, PCI cards, ethernet networking. In the example below the kernel with be compiled with module support but it is recommend that you compile everything into the kernel on your first attempt. As an exercise later you can compile the kernel with some components as modules.

Initial options

- Code maturity level options – should be set to not prompt for experimental code.
- Loadable module support – should be enabled.
- Select the correct processor family (compare to **/proc/cpuinfo**). This will enable the optimal use of that processor's command set. Turn off *Symmetric multi-processor* support (unless you really have one).

In the "General Setup" section turn everything off except for the following:

- Networking support
- PCI support – chances are you actually do have PCI hardware. Even if your computer has it, supporting older ISA hardware is not necessary for your mail server.

- ELF executables – most programs are ELF executables on Linux.
- System V IPC – chances are your mail server needs it
- Sysctl support – chances are that something will fail without this.

Disable the following sections entirely:

- Binary emulation of other systems
- Memory Technology Devices
- Parallel port supporting

Under “Plug and Play configuration”, disable ISA Plug and Play support.

Disable all block devices except the floppy disk and the loopback device.

Disable RAID and LVM

Disable Cryptography if it is included in your kernel (it’s a mail server!)

Under networking enable only the following options

- Packet socket – this option may not appear to be entirely necessary but it makes it possible to run a network sniffer and debug situations where people have trouble communicating with the server.
- Unix domain sockets
- TCP/IP networking

Disable telephony support.

Under ATA/IDE/MFM/RLL support, enable the following options:

- Enhanced IDE/MFM/RLL disk/cdrom/tape/floppy support
- Include IDE/ATA-2 DISK support}
- Use multi-mode by default
- Include IDE/ATAPI CDROM support – provided you have an CDROM installed.
- SCSI emulation support – actually, don’t enable this – but you would if you had an IDE CD writer on your mail server.
- Generic PCI IDE chipset
- Generic PCI bus-master DMA
- Use PCI DMA by default when available

Also determine the chipset installed on your motherboard and build it into the kernel, if it is treated specially. Deselect support for all the other chipsets that you are not using.

Turn off support for the following:

- SCSI support
- Fusion MPT device support
- IEEE 1394 (FireWire) support
- I2O device support

Under “Network Device Support” enable only the network card that is actually installed in your computer. Generally this device will be found under Ethernet 10/100.

Turn off support for all of these:

- Amateur Radio
- IrDA
- ISDN

- Old CD-ROM
- Input core

Under Character devices select these options.

- Virtual terminal – this is a must – don't consider not setting this or else you will not be using your system at all.
- Console on virtual terminal – enable this, or else kernel messages will not be visible at bootup.
- Standard/generic serial support – even if you don't think that you will ever need to use the serial ports. Serial ports on mail servers tend to attract modems and mice, and can be quite useful.
- Mice – turn on PS/2 support. This will make it possible to use **gpm** in console mode, which is always nice.

Turn Multimedia devices off, unless you are setting up a musical mail server.

In the Filesystem support options turn the following options on:

- /proc
- Second extended fs support
- If you have a CDROM installed also turn on ISO 9660 support and Microsoft Joliet CDROM extensions.
- Support for the filesystem which is running on your root and boot partitions.
- Enable Native Language Support for the default only.

In the console drivers section enable VGA text console, but no other drivers. The VGA text driver is entirely necessary if you are planning to connect a monitor to your mail server.

Turn off support for –

- Sound cards
- USB
- Kernel hacking

Now that you have completely specified all the kernel options that you want exit making sure that you save your configuration. It is also a very good idea to copy the file **.config** to a safe place as this contains the configuration you just generated.

Complete the kernel and module build. (If your kernel is compiled without modules, the last two steps are entirely redundant, of course.)

```
dwarf:/usr/src/linux # make dep
dwarf:/usr/src/linux # make clean
dwarf:/usr/src/linux # make bzImage
dwarf:/usr/src/linux # make modules
dwarf:/usr/src/linux # make modules_install
```

Finally copy the new image from **arch/i386/boot/bzImage** to **/boot** and configure lilo appropriately. As this image is one of our own it can be renamed in the copy to anything that you like which also help to make sure that you don't destroy your present working kernel.

```
dwarf:/usr/src/linux # cp i386/boot/bzImage /boot/viper
```

Edit **/etc/lilo.conf** (or **/etc/grub.conf** if your boot loader is GRUB) and add adding the lines required to provide the option to boot your new kernel.

Your **/etc/lilo.conf** may look something like this. (If it's GRUB, you're on your own.)

```
boot=/dev/hda
read-only
prompt
timeout=100
# End LILO global Section
image = /boot/viper
  root = /dev/hda6
  label = Viper
image = /boot/vmlinuz
  root = /dev/hda6
  label = linux
```

Remember to run lilo (or if it's GRUB, remember to do nothing at all).

```
dwarf:~ # lilo -v
```

Test whether all functions necessary for your mail server work correctly – you should be able to start the mail program (sendmail or postfix or similar) and connect to it from outside your own computer.

If you completed the assignment without difficulty you can repeat it, but with loadable module support. Alternatively, you can experiment with configuring as many functions as possible in modules. You will discover an interesting and valuable truth if you make your root filesystem's filesystem type a module. Once you have discovered this truth, make an appropriate initial root disk using **mkinitrd**.

Answers to quiz questions

1. This order

   make config
   make dep
   make bzImage
   make modules
   make modules_install
   make install

2. A modular kernel allows you to load additional capabilities into the running kernel. A static kernel has only the capabilities included at compile-time.
3. If there is an entry in **lilo.conf** pointing to your new kernel, you must also run **lilo**.
4. Compiling additional modules takes time, but does not affect the performance of the running kernel. The kernel size is unaffected, unless you choose to load the additional modules.

4 Booting Linux

"Repeated reboots of the system failed to solve the problem..."

– /usr/share/games/fortune/bofh-excuses

LPIC topic 1.106.1 — Boot the system [3]

Weight: 3

Objective

Candidates should be able to guide the system through the booting process. This includes giving commands to the boot loader and giving options to the kernel at boot time, and checking the events in the log files.

Key files, terms, and utilities include

dmesg	Show kernel message buffer
/var/log/messages	All messages
/etc/conf.modules or /etc/modules.conf	Aliases and configuration for modprobe
LILO	Linux loader
GRUB	Grand Unified Boot Loader

4.1 Kernel boot parameters

LILO and GRUB both allow you to edit the command line that is passed to the kernel when it boots. Kernel boot parameters are used to override the hardware configuration parameters that would be detected by the kernel.

The parameters supplied to the kernel as it boots are a single word, or in the format **name=value**, or **name=value1,value2,value3**. Each name identifies which part of the kernel receives the option. The default kernel command line specifies the **root** filesystem, and often specifies **ro**, meaning that the root filesystem should be mounted read-only.

```
foo:~ $ cat /proc/cmdline
ro root=/dev/hda1 apm=off
```

The **bootparam(7)** man page discusses the boot parameters in some detail, and the file **/usr/src/linux/Documentation/kernel-parameters.txt** is the more complete reference.

```
% man bootparam
% less /usr/src/linux/Documentation/kernel-parameters.txt
```

Kernel command line parameters which are not used by the kernel are passed to the **init** process (usually **/sbin/init**). The following parameters can be used:

- **single** – boot into single user mode (usually requiring the root password)
- **emergency** – boot into a shell (but newer versions of **init** require the root password)
- **1**, **2**, **3**, **4**, **5**, **6** – boot into a specific run-level.

that were not picked up by the kernel and were

not interpreted as environment variables are then passed onto process

one, which is usually the init program. The most common argument that

is passed to the init process is the word `single' which instructs init to boot the computer in single user mode, and not launch all the usual daemons. Check the manual page for the version of init installed on your system to see what arguments it accepts.

The following boot parameters are quite useful.

- **root=/dev/hda1** – change the root filesystem during boot-up.
- **init=/sbin/init** – by default, after the kernel boots up, it will run **/sbin/init**. If you want to run something different, you can. A common troubleshooting parameter is **init=/bin/bash** which runs an interactive shell instead of **/sbin/init**.
- **mem=32M** – limit the amount of memory to the amount specified. The kernel does not attempt to check if this corresponds with the amount of memory actually present in the machine. You will use the **mem** parameter when the kernel. **mem=nopentium** specifies that the kernel should not use 4Mb page tables for allocating memory
- **noinitrd** – don't execute **/linuxrc** on the initial root disk image supplied by the boot loader. The initial root disk will usually load modules required for booting (e.g. filesystem support). There will be times when you want to avoid this behaviour.

Various devices can be configured with IO and IRQ settings if they are compiled into the kernel. The most common format is

```
device=irq,iobase
```

so if you have a AHA152x SCSI controller (in your ISA bus), you may specify its settings like this

```
aha152x=0x340,11
```

The **vga=value** parameter changes the display mode of a VGA adapter – usually to a higher resolution graphics mode. This parameter is actually handled by the boot loader, rather than by the kernel. Here is a table of the VESA graphics modes that will enable you to experiment with your BIOS's graphics support.

Color depth	*640x480*	*800x600*	*1024x768*	*1280x1024*
8 bits – 256 colours	769	771	773	775
15 bits – 32768 colours	784	787	790	793
16 bits – 65535 colours	785	788	791	794
24 bits – 16.7 Million colours	786	789	792	795

The **rdev** command (and the commands related to it) can be used to *modify* a kernel image so that it does not require boot time options for any of these –

- root device (**rdev /boot/vmlinuz "/dev/hda7 "**)
- VGA video mode (**vidmode /boot/vmlinuz "788"**)
- Read only vs. read-write root filesystem (**rootflags** ...)

4.2 LILO

LILO (**LI**nux **LO**ader) is a basic system program which boots your Linux system. LILO loads the Linux kernel from a floppy or a hard drive, boots the kernel and passes control of the system to the kernel. LILO can also boot other operating systems. The installation of LILO is covered in the LPIC 101 course.

To control booting using LILO, you have to interrupt the boot up process using one or all of the following techniques.

- Press **Shift** – to obtain a prompt, you have to press **Shift** before LILO begins booting if there is no timeout specified in **lilo.conf**.
- Enter a password – **lilo.conf** can specify that a password must be entered in order to change the boot parameters.

LILO allows you to configure the boot sequence in the following ways:

- Select a kernel to boot or a boot image to load – either by typing it's name (press **Tab** to see a list), or by selecting it from a menu.
- Add options to the kernel command line (you can't remove option that are already there)

LILO can look like this at times.

```
LILO: linux root=/dev/fd0 rw init=/bin/bash
```

4.3 GRUB

GRUB (**G**rand **U**nified **B**oot **L**oader) is a boot loader capable of booting into most free operating systems – Linux, FreeBSD, NetBSD, GNU Mach, and others as well as most commercial operating systems. With GRUB it is possible to boot a system provided you know the parameters you want to pass to the kernel and the location of the kernel image (and, of course the initrd image).

Because of GRUB's emphasis on being cross platform, it does not follow the Linux convention on hard disk and partition naming. GRUB disks and partitions are numbered according to the BIOS –

- **(fd0)** – /dev/fd0
- **(hd0)** – /dev/hda (usually, otherwise the first SCSI disk)
- **(hd0,1)** – /dev/hda2 (the second partition of the first disk)

To boot Linux, it is required that GRUB know where its files are (**root**), where the kernel is found (**kernel**), and (usually) where the initial root disk is (**initrd**), containing vital system modules (e.g. for a filesystem or a SCSI controller). The **boot** command tells GRUB to boot.

```
root (hd0,0)                          # source of grub files is
     /dev/hda1
kernel /boot/vmlinuz root=/dev/hda1  # load a kernel
initrd /boot/initrd                   # load an initial root disk
boot                                  # boot up
```

These commands usually appear in **/etc/grub.conf**, but they can be typed in when the system boots. Newer versions of GRUB print helpful menus, but you may need to know the following keypresses:

- p – enter a password
- c – start the GRUB command line (type GRUB configuration yourself)
- e – edit a GRUB configuration line line
- a – modify kernel arguments before booting
- o – open a new line for configuration commands
- d – remove the selected line from the configuration
- b – boot the system
- Escape – return to the menu

The commands to boot another operating system (e.g. DOS) which has its boot loader at the start of a partition are these (although this is not part of the LPIC requirements).

```
rootnoverify (hd0,0)                # /dev/hda1
makeactive                          # modify the partition tables
chainloader +1                      # use the chain loader
boot                                # boot now
```

4.4 Boot messages

When the Linux kernel boots, each subsystem is initialised in a predetermined order. The messages generated by each subsystem are generally displayed on the console. The messages are recorded in two places in addition to this.

- The kernel message buffer – the kernel keeps 16k of messages, which can be displayed by the **dmesg** command.
- The **syslogd** records kernel messages to **/var/log/messages**. These are also timestamped.

```
% dmesg
% less /var/log/messages
% tail -f /var/log/messages
```

4.5 Review

Quiz questions

1. How does one select the kernel to load in LILO?
2. How does one modify the kernel boot parameters in LILO?
3. How does one select the kernel to load in GRUB?
4. How does one modify the kernel boot parameters in GRUB?
5. What is the difference between LILO and GRUB?
6. What resources allow you to debug the booting process?
7. Which log file is relevant to the booting process?
8. Which kernel parameter allows you to boot with an interactive shell?

Assignments

1. Boot your system with **/bin/bash** instead of **/sbin/init**. Change your root password using **passwd**.

```
mount / -o remount,rw     # make root disk writeable
```

```
mount -a                    # mount other partitions, like /proc
passwd                      # change the root password
umount -a                   # unmount other partitions
mount / -o remount,ro       # mount again read-only, as expected by
      init
echo $$                     # B.T.W. what's the PID of /sbin/init?
exec /sbin/init # boot the system
```

2. See how syslog is configured on your system by examining **/etc/syslog.conf**. Make a list of the log files that may contain information generated during the boot process.
3. Read the log files generated during booting and find out what the first logged message is when you boot up.
4. Install GRUB on a floppy, but without a configuration file.

   ```
   mv /etc/grub.conf /etc/grub.conf.crashmysystem
   grub-install /dev/fd0
   ```

   Now boot your system using the floppy disk, and pass the appropriate **root**, **kernel**, **initrd** parameters to GRUB. Make notes on how you did this.

Answers to quiz questions

1. Either the first kernel is loaded, or the one marked as default, or the one entered on the command line during booting.
2. Choose an image and type any *additional* kernel parameters after the image name.
3. The **default** keyword selects the entry that is used. You can select the entry name, or modify the "kernel" line when booting.
4. You edit the commands which will be run, or manually enter the commands as they would appear in the configuration file.
5. LILO relies on the position of files on the disk, while GRUB understands various filesystems, and dynamically locates the kernel.
6. Kernel boot messages (**dmesg**) and **syslog** boot messages. You can also press Shift+PgUp.
7. **/var/log/messages**
8. "init=/bin/bash" or "single" or "1".

5 Change runlevels

Wee Willie Winkie runs through the town,
Upstairs and downstairs in his nightgown,
Rapping at the window, crying through the lock,
"Are the children in their beds, for now it's eight o'clock?"

– Mother Goose, on runlevels

LPIC topic 1.106.2 — Change runlevels and shutdown or reboot system [3]

Weight: 3

Objective

Candidates should be able to manage the runlevel of the system. This objective includes changing to single user mode, shutdown or rebooting the system. Candidates should be able to alert users before switching runlevel, and properly terminate processes. This objective also includes setting the default runlevel.

Key files, terms, and utilities include

shutdown	Schedule a shutdown (maybe reboot too)
init	**init** initialised everything
/etc/inittab	**inittab** configures **init**

5.1 init and telinit

init runs all the processes that run on your Linux system. The collection of processes started by **init** is the runlevel, and each runlevel corresponds to the scripts **/etc/rc.d/rc?.d/S*** (with the **?** replaced by a number from **0** to **6**).

When you *change* the runlevel, **init** runs a script which stops all the extra processes in the current runlevel, and starts the required processes from the new runlevel. To see the current and previous runlevel, the command is **runlevel**.

```
linux:~ # runlevel
N 5
linux:~ # init 3
linux:~ # tail -1 /var/log/messages
Jun  2 09:55:08 linux init: Switching to runlevel: 3
linux:~ # runlevel
5 3
linux:~ # ps -C kdm
  PID TTY          TIME CMD
```

The effect of changing to runlevel 3, was to stop **kdm** (which was running). When we change back to runlevel 5, **kdm** is started.

```
linux:~ # init 5
linux:~ # ps -C kdm
  PID TTY          TIME CMD
 2991 ?        00:00:00 kdm
 2995 ?        00:00:00 kdm
```

5.2 shutdown

shutdown is for shutting down your system.

```
linux:~ # shutdown
Usage:    shutdown [-akrhfnc] [-t secs] time [warning message]
              -a:      use /etc/shutdown.allow
              -k:      don't really shutdown, only warn.
              -r:      reboot after shutdown.
              -h:      halt after shutdown.
              -z:      shutdown using software suspend.
              -f:      do a 'fast' reboot (skip fsck).
              -F:      Force fsck on reboot.
              -n:      do not go through "init" but go down real
     fast.
              -c:      cancel a running shutdown.
              -t secs: delay between warning and kill signal.
              ** the "time" argument is mandatory! (try "now") **
```

The reason to use shutdown, rather than **init 6** to reboot or **init 0** is so that the shutdown can happen at a time determined by the administrator.

```
linux:~ # date
Mon Jun  2 10:12:49 SAST 2003
linux:~ # shutdown -r -t 10 10:14    # reboot at 10:14 AM
Broadcast message from root (pts/0) (Mon Jun  2 10:13:02 2003):
The system is going DOWN for reboot in 1 minute!

<Press Ctrl+C to kill shutdown
Shutdown cancelled.
linux:~ # shutdown -r -t 10 10:14
Broadcast message from root (pts/0) (Mon Jun  2 10:13:11 2003):
The system is going DOWN for reboot in 1 minute!
                                                  A little bit later...
Broadcast message from root (pts/0) (Mon Jun  2 10:14:11 2003):
The system is going down for reboot NOW!
```

At this point, **shutdown** exits, but the current runlevel has changed to 6, as if **telinit -t 10 6** had been run (which is more or less what happened). At this point, the system is busy shutting down. (Hey, you can reboot a system when logged in remotely!)

```
linux:~ # runlevel
5 6
linux:~ # Read from remote host 192.168.1.191: Connection reset by
     peer
Connection to 192.168.1.191 closed.
```

5.3 inittab

When **/sbin/init** is started by the kernel, it reads **/etc/inittab** to determine the start-up sequence. These are the lines that determine the startup behaviour of your system.

The **initdefault** specification specifies the default runlevel at startup (unless overridden by kernel parameters). Remember that the meaning of runlevels is not uniform between distributions.

```
#   0 - halt
```

```
#   1 - Single user mode (for maintenance, e.g. reiserfsck)
#   2 - Multiuser, without NFS
#   3 - Full multiuser mode
#   4 - unused
#   5 - X11
#   6 - reboot (Do NOT set initdefault to this)
id:5:initdefault:
```

Before thinking about runlevels, **init** runs the **sysinit** script.

```
# System initialization.
si::sysinit:/etc/rc.d/rc.sysinit
```

For the actual runlevel which is chosen, a script is run – in this case **/etc/rc.d/rc 5**.

```
l0:0:wait:/etc/rc.d/rc 0
l1:1:wait:/etc/rc.d/rc 1
l2:2:wait:/etc/rc.d/rc 2
l3:3:wait:/etc/rc.d/rc 3
l4:4:wait:/etc/rc.d/rc 4
l5:5:wait:/etc/rc.d/rc 5
l6:6:wait:/etc/rc.d/rc 6
```

And when you are in runlevel **2** ,**3** , **4** and **5**, **init** makes sure that the following programs are always running (**mingetty** handles terminal login, and **mgetty** handles modem dial-in access.)

```
1:2345:respawn:/sbin/mingetty --noclear tty1
2:2345:respawn:/sbin/mingetty tty2
3:2345:respawn:/sbin/mingetty tty3
4:2345:respawn:/sbin/mingetty tty4
5:2345:respawn:/sbin/mingetty tty5
6:2345:respawn:/sbin/mingetty tty6
s0:2345:respawn:/sbin/mgetty -x 3 ttyS0
```

5.4 Review

Quiz questions

1. How do you schedule a reboot in one hour from now?
2. Which parameter in which file changes the default runlevel of your system?
3. What is the purpose of single user mode?
4. What mechanism is used to alert users of an impending shutdown?
5. How does **init** terminate processes (i.e. which signals)?

Assignments

1. Switch to single user mode and modify your root password. Check which processes are running in single user mode. After this switch to multi-user mode again.
2. Schedule a shutdown which will occur in 1 minute. Once the shutdown has started, cancel it. Observe the effect that this has on
   a) a user who is logged in at a console
   b) a user who is logged in using X

c) a user who is logged in using **ssh** or **telnet**

3. Configure your system with a different default runlevel (e.g. boot multi-user without X). Document the steps you took to do this.

Answers to quiz questions

1. Using **shutdown** (or **at** if you care to).
2. **initdefault** in **/etc/inittab**
3. System maintenance without interference by other users and programs
4. Console broadcast
5. First TERM (polite) then KILL (forced)

6 Print queues

Line printer paper is strongest at the perforations.

LPIC topic 1.107.2 — Manage printers and print queues [1]

Weight: 1

Objective

The candidate should be able to manage print queues and user print jobs. This objective includes monitoring print server and user print queues and troubleshooting general printing problems.

Key files, terms, and utilities include

lpc	line printer control
lpq	show the line printer queue
lprm	remove jobs from the line printer queue
lpr	line printer submit a job
/etc/printcap	**lpd** configuration file

6.1 lpd, lpr, lpq and lprm

Originally, most printing on Unix systems was done with line printers. The “lp” of “line printer”' has survived into the new millennium, even though it is now rather difficult to get access to a genuine line printer.

The unix printing system consists of a few components:

lpd – **lpd** is the queue manager. It sits patiently in the background waiting for someone to want something printed. Print jobs that are submitted to **lpd** are queued, and printed in more or less the order in which they were requested. **lpd** is configured by the file **/etc/printcap**, which names the printers connected to the machine, and describes the filters and parameters for each printer.

lpr – **lpr** is used to add jobs to the printer queue. The standard method of printing a postscript file is the command **lpr**. If you have a second printer named **lp1**, you can print to it with **lpr -P lp1**.

```
lpr filename.ps
lpr -P lp1 filename.ps
```

lpq, **lprm** – these commands are used to control the print queue. **lpq** displays a list of jobs for the default printer, and **lpq -P lp1** will display the list for a printer named jerry. **lprm** will remove a print job from the queue. It is possible to remove a job based on its job id, or alternatively, to remove all jobs for a user.

```
foo:~ $ lpq -P lp1
lp1 is ready
no entries
foo:~ $ lpr -P lp1 < /etc/passwd
foo:~ $ lpq -P lp1
```

```
lp1 is ready and printing
Rank    Owner   Job     File(s)                         Total Size
active  donaldd 1214    (stdin)                         2048 bytes
foo:~ $ lpr -P lp1 < /etc/passwd
foo:~ $ lpr -P lp1 < /etc/passwd
foo:~ $ lpq -P lp1
lp1 is ready and printing
Rank    Owner   Job     File(s)                         Total Size
active  donaldd 1214    (stdin)                         2048 bytes
1st     donaldd 1215    (stdin)                         2048 bytes
2nd     donaldd 1216    (stdin)                         2048 bytes
foo:~ $ lprm -P lp1 1216 1215
foo:~ $ lpq -P lp1
lp1 is ready and printing
Rank    Owner   Job     File(s)                         Total Size
active  donaldd 1214    (stdin)                         2048 bytes
foo:~ $ lprm -P lp1 1214
foo:~ $ lpq -P lp1
lp1 is ready
no entries
```

lpc – the **lpc** command provides a mechanism to talk the **lpd** process while it is running. In some implementations, **lpc** can be used to adjust the priority of messages, and to restart the print system. The most common use of **lpc** is to show the status of all printers.

```
# lpc help                                      # your lpc may have
      more
Commands may be abbreviated.  Commands are:

exit    help    quit    status  ?
# lpc status
lp0:
        printer is on device 'parallel' speed -1
        queuing is enabled
        printing is enabled
        no entries
        daemon present
lp1:
        printer is on device 'lpd' speed -1
        queuing is enabled
        printing is enabled
        no entries
        daemon present
# lpc restart             # hit lpd with a big hammer
# lpc topq                # make a job jump the queue
```

6.2 Troubleshooting

My job does not print –

- Check if it is in the print queue at all using **lpq -a**. It may be in the wrong printer queue.
- Check for additional information on the status of the printer using **lpc status**
- The most common cause of printing problems is that printer is not accepting data (e.g. it is turned off, or it has no paper, or its buffer is full.)

The printer is spewing gobbledegook –

- Remove the offending job from the queue using **lprm**.
- You generally cannot interrupt a job for which printing has already begun without repercussions. Since the computer does not know that the printer has lost power or that the data in its buffer has been reset, it continues to send the job to the printer. To see if any process is sending stuff to the printer use **lsof /dev/lp0**. Usually this will be **cat**, or a process named **parallel** for CUPS.

And if you get a problem not described here, then read the system log files.

6.3 Review

Quiz questions

1. Which command line parameter to **lpr**, **lpq** and **lprm** specifies the printer to be used?
2. How do you determine which printers are attached to a system?
3. Which command shows a list of print jobs to be printed?
4. When can a print job be stopped with **lprm**?

Assignments

1. Unplug your printer cable, and then print **/etc/passwd** multiple times using **a2ps** (you may print something else if you choose). List the jobs in the print queue. Remove all the jobs from the queue, and then plug in the printer cable again.

   What processes are running and which are accessing the parallel port? How does your implementation of **lpd** spool jobs to the printer? What happens if you power off the printer during printing or data transfer and later power it up again? How do you handle the problem?

   Hint: lsof /dev/lp0 lists programs accessing the printer.
2. Install two different **lpr** implementations and compare their behaviour when printing to a locally connected printer. Choose from the classic **lpr**, **lprng** (LPR next generation) and CUPS (Common Unix Printing System).

Answers to quiz questions

1. **-P**printername (without a space for some versions of **lpr**)
2. **lpc status**
3. **lpq -P**printername
4. A print job can be removed if printing has not already started.

7 Postscript

> Someone's tie is caught in the printer, and if anything else gets printed, he'll be in it too.
>
> */usr/share/games/fortune/bofh-excuses*

LPIC topic 1.107.3 — Print files [1]

Weight: 1

Objective

Candidates should be able to manage print queues and manipulate print jobs. This objective includes adding and removing jobs from configured printer queues and converting text files to postscript for printing.

Key files, terms, and utilities include

lpr	submit a print job
lpq	show the printer queue
mpage	text to postscript conversion (and more)

7.1 What is postscript

PostScript is a programming language that communicates a document description to a printing system in a device-independent way. Postscript was was used as a page description language by the Apple LaserWriter. Its primary application is to describe the appearance of text, graphical shapes, and sampled images on printed pages. PostScript is an unusually powerful printer language because it is a full programming language, rather than a series of low-level escape sequences, such as is used by terminals.

Postscript is the standardised format for printing in Linux. Every program that wants to print something converts it to postscript. Every printer that needs to print on Linux converts postscript to its own printing format, such as PCL (for a postscript printer no conversion may be necessary).

To submit a job to a printer, use **lpr**. To view the printer queue, use **lpq**. (For good measure, **lprm** removes print jobs). Notice that the output of **lpq** shows the filename submitted to the print system.

```
foo:~ $ ls -la *.ps
-rw-rw-r--    1 donaldd  donaldd    164531 Jan 31 14:35 blah.ps
foo:~ $ lpr -P lp1 blah.ps
foo:~ $ lpq -P lp1
lp1 is ready and printing
Rank    Owner   Job     File(s)                         Total Size
active  donaldd 1260    blah.ps                         164864 bytes
foo:~ $ lprm -P lp1 1260
foo:~ $ lpq -P lp1
lp1 is ready
no entries
```

7.2 mpage

If you send ASCII text straight to your printer, it will probably print, but will use a lot of paper. It will also print the text against the left margin, in the default font. **mpage** converts ASCII text to **m**ultiple **page**s of postscript, organising it into columns and fitting many pages onto a single sheet (in smaller type). You can also change the font and other important details.

mpage -x shows the default values for the various settings in brackets. In the example below, **mpage** generates 4 pages per sheet, in the up-down layout, and formats the output for "Letter" size paper (rather than A4 or something similar).

```
foo:~ $ mpage -x
 mpage - print multiple pages on postscript, version 2.5.2pre August
      1999

 mpage [-1248acEfHlkoOrRStvxX] [-b papersize] [-Btextboxmargin]
       [-C [encodingfile]] [-da|p] [-D dateformat] [-F fontname]
       [-h header] [-I indent] [-j pagespec] [-L lines]
       [-msheetmargin] [-Mpagemargin] [-p[prprog]] [-P[printer]]
       [-s tabstop] [-W width] [-X [header]] [-z printcmd] [-Z
      quearg]
       [file...]]

 -1, -2, -4, -8  Pages per sheet (4)    -D strftime format for date
      specs
 -da Force ascii input format           -dp Force postscript input
      format
 -a Toggle across/updown layout (u)     -l Toggle portrait/landscape
      (p)
 -f Toggle folding long lines (off)     -o Toggle printing outlines
      (on)
 -r Reverse printing, last->first sheet -v Toggle verbose output,
      (on)
 -F Text font to be used (Courier)      -C Character encoding
      filename
 -E Print every second and third page   -O Print every 1st and 4th
      page
 -s Define tabstop width (8)            -k kill on %TRailer is PS
      file
 -b papersize (Letter), use l of ? to get a list of sizes
```

mpage can print **-1**, **-2**, **-4** or -**8** pages per sheet.

```
% mpage /etc/services                              # default behaviour
% mpage /etc/services > services.ps
% gv services.ps                                   # default is ...
% cat /etc/profile | mpage -1 | gv -
```

The output of **mpage** is postscript, which can be sent to **lpr** for printing. **mpage** accepts the **-P** option like **lpr** for specifying the printer. If **-P** is given, the output is automatically printed.

```
% mpage -8 /etc/protocols | lpr
% mpage -8 -Plp0 /etc/protocols
% lpq -Plp0
```

Formatting options allow you to change the font (**-F**). The font name must be the

name of a PostScript font.

```
% mpage -1 -F Helvetica /etc/inittab  | gv -
% mpage -1 -F Times /etc/inittab  | gv -
```

To send the output to particular printer, you use the **-P** option. The first example here is incorrect – **mpage** undestands that you wish to print to the default printer, in particular the files **lp1** and **/etc/protocols**.

```
foo:~ $ mpage -8 -P lp1 /etc/protocols
mpage: cannot open lp1
mpage: No such file or directory
```

Here's the right way to do it ...

```
foo:~ $ mpage -8 -Plp1 /etc/protocols
foo:~ $ lpq -P lp1
lp1 is ready and printing
Rank    Owner   Job     File(s)                         Total Size
active  donaldd 1259    (stdin)                         26624 bytes
```

mpage -H prints headers for each file printed. These examples also illustrate the use of the **-c** option to concatenate multiple files onto a single sheet.

```
foo:~ $ mpage -H /etc/p* - | gv -
foo:~ $ mpage -c -H /etc/p* - | gv -
```

mpage -b is used to print to a specific type of paper. Here are just a few of the paper sizes that **mpage** supports.

```
foo:~ $ mpage -bl
Mpage knows about the following paper types:
Type           Points Wide Points High
-------------- ----------- -----------
Letter                 612         792
Legal                  612        1008
A4                     596         842
A4Small                595         842
foo:~ $ mpage -b A4 -H -2 -c /etc/h* | gv -
foo:~ $ mpage -b A5 -H -2 -c /etc/h* | gv -
```

While **mpage** is most often used for formatting text output, it can also be used to format postscript output, and reduce the amount of paper used in printing. Here we generate two postscript files using **mpage** – but we could have used two arbitrary postscript files.

```
foo:~ $ mpage -1 -H /etc/hosts.allow  > hosts.allow.ps
foo:~ $ mpage -1 -H /etc/hosts > hosts.ps
foo:~ $ mpage -2c hosts*.ps | gv -
```

7.3 Review

Quiz questions

1. What is postscript?
2. Which command removes a print job from the queue?
3. How does one specify that **mpage** or **lpr** must print to a specific printer?
4. When printing to a specific printer with **mpage**, the error message “cannot open lp2” is

displayed. What is wrong?

5. What is the command to print a text file using 4 pages per sheet on A4 paper, with headings?

Assignments

1. If you have access to a Windows system, set up an Apple LaserWriter printer driver which writes to a file. To what extent are files generated by Windows compatible with the Linux printing system, e.g. with **gv** (for viewing), **pstopdf** (for converting to PDF) and **lpr** for your printer?
2. Generate a document from another application (not **mpage**) and print it two pages per sheet using **mpage**. What are the options to **mpage** that you had to use?
3. Investigate the **a2ps** utility and compare it to **mpage**. Why would you use **a2ps** rather than **mpage** to print **/etc/profile**?
4. How does **enscript** compare to **a2ps**? What additional functionality does it offer?

Answers to quiz questions

1. A document formatting language with backward syntax (commands after parameters).
2. lprm
3. -Pprinter
4. If you run **mpage -P lp2** then you have specified the printer as "" and the file to print as **lp2**.
5. **mpage -4 -H filename** (although the heading is not going to be that useful in this context).

8 Printer setup

> Snow White has become a camera buff. She spends hours and hours shooting pictures of the seven dwarfs and their antics. Then she mails the exposed film to a cut rate photo service. It takes weeks for the developed film to arrive in the mail, but that is all right with Snow White. She clears the table, washes the dishes and sweeps the floor, all the while singing "Someday my prints will come."
>
> */usr/share/games/fortune/art*

LPIC topic 1.107.4 — Install and configure local and remote printers [1]

Weight: 1
Objective

Candidate should be able to install a printer daemon, install and configure a print filter (e.g.: apsfilter, magicfilter). This objective includes making local and remote printers accessible for a Linux system, including postscript, non-postscript, and Samba printers.

Key files, terms, and utilities include

lpd	Line printer daemon
/etc/printcap	Configuration for **lpd** and **lpr**
/etc/apsfilter/*	Configuration for apsfilter
/var/lib/apsfilter/*/	apsfilter per-printer filters
/etc/magicfilter/*/	Configuration for magicfilter
/var/spool/lpd/*/	Printer output spool directories

8.1 lpd and printcap

Printing under Linux is usually handled by **lpd** – the line printer daemon. Jobs are submitted to **lpd** via the **lpr** command. Of course, if **lpd** is not running, your printing does not happen. There are a number of competing implementations for Linux printing:

- The original BSD **lpr** – the objectives of this chapter are focused on this software. Not all distributions use the original **lpr** – many have now migrated to LPRng and CUPS.
- LPRng (LPR next generation) – this is largely compatible with the original **lpr** implementation, but adds some extra functionality, such as its own filtering and format conversion.
- CUPS (Common Unix Printing System) – CUPS does away with **lpd** and replaces it with **cupsd**. Printing to remote CUPS printers from a CUPS client does not require configuration, except perhaps to specify the CUPS server. CUPS provides a web based interface for configuration and control of printers, in addition to the command line interface via **lpq**, **lprm** and **lpc**.

The standard method of installing a printer under Linux is to modify **/etc/printcap**. Each printer connected to your system and each network printer has an entry in **/etc/printcap**. Each

printer is described by a single line, but usually the lines end in a backslash and continue over multiple lines.

The format of the lines in **/etc/printcap** is

```
printername:setting1=value1:setting2=value2:setting3=value3
```

The first field is the name of the printer. Quite often multiple names are given, separated by a pipe (e.g. **lp0|hplj4**).

Here are the common entries for printing

- **lp=device-name** – the name of the output device – often something like **lp=/dev/lp0**
- **sd=/spool/directory** – the directory for temporary files queued for printing.
- **af=accounting-file** – the name of the file containing printer accounting data for the printer.
- **if=input-filter-command** – the name of the file which is the input filter for this printer. This is usually related to **apsfilter** or **magicfilter**.
- **lf=log-file** – the name of the error log file
- **mx#maximum-print-kb** – the maximum size of a printed file, e.g. **mx#2048** or **mx#0** (no limit)
- **sh** – suppress header – don't print a banner page about who printed the job and what they were printing it for.

Remote printing

- **rm=hostname** – connect to a remote unix print server.
- **rp=printername** – print to a specific printer on the remote machine, e.g. **rp=lp**
- **of=output-filter-command** – the name of the file which is the output filter for this printer. The output filter will usually convert from postscript to an appropriate format (if the input filter didn't), or connect to a network device (e.g. for Windows printing).

Local printers

A fairly minimal **printcap** entry for a local printer could look like this. There is no input filter or output filter, so output jobs submitted to this printer *must* be in the correct format (e.g. PCL for a HP LaserJet). **apsfilter** and **magicfilter** translate various formats to the printer's own local format.

```
lp|hplj4:\
       :lp=/dev/lp0:\
       :sd=/var/spool/lp:\
       :mx#0:\
       :lf=/var/spool/lp/hp-log:
```

Remote printers

A minimal configuration for a remote printer, connected at **192.168.0.175** with the name **lp**. There is no limit on job sizes, and no banners are shown.

```
lp1|remote printer:\
       :sd=/var/spool/lp1:\
       :rm=192.168.0.175:\
       :rp=lp:\
       :sh:mx#0:
```

Here is a printer entry for a remote printer used by **LPRng**. The **cm** entry is a comment, which determines which filtering is applied by the input filter "/usr/lib/lpdfilter/bin/if".

```
hplaserjet:\
        :cm=lpdfilter drv=upp method=auto color=yes:\
        :lp=/dev/lp0:\
        :sd=/var/spool/lpd/hplaserjet:\
        :lf=/var/spool/lpd/hplaserjet/log:\
        :af=/var/spool/lpd/hplaserjet/acct:\
        :if=/usr/lib/lpdfilter/bin/if:\
        :la@:\
        :tr=:cl:lk:sh:
```

Windows printers via samba

If you have a printer shared by a Windows server via SMB networking, you connect to it using **smbclient** and print using the **-P** option.

```
% smbclient -h
Usage: smbclient service <password> [options]
Version 2.2.7
        -N                    don't ask for a password
        -n netbios name.      Use this name as my netbios name
        -P                    connect to service as a printer
        -I dest IP            use this IP to connect to
        -E                    write messages to stderr instead of
      stdout
        -U username           set the network username
        -W workgroup          set the workgroup name
% smbclient //server/epson password -U guest -N -P < data.dat
```

To print to this printer via the **lpr** printing system we require an entry in **printcap** and a script. The **printcap** entry runs the script as the output filter[4].

```
lp2|smb-remote:\
    :lp=/dev/null:sh:\
    :sd=/var/spool/lp2:\
    :of=/usr/local/bin/smbprint-epson:
```

The corresponding contents of the script would be this.

```
#! /bin/bash
# /usr/local/bin/smbprint-epson
# Print to the epson printer on the server ...
smbclient //server/epson/ password -U guest -N -P
```

This arrangement assumes that you will configure an input filter ("**if**" in **printcap**) which will transform the data you want to print into something suitable for the printer.

8.2 apsfilter

apsfilter makes it possible to print various data formats without having to manually convert to the particular printer's print format. **apsfilter** first converts the input data to postscript, and then converts postscript to the printer's own print language, usually using the **ghostscript**

4 You do not have to run the script as the output filter – you could run it as the input filter, provided you also make sure you handle the input format conversion correctly.

program. As a result, **apsfilter** supports all the printers for which **ghostscript** can produce output.

To configure **apsfilter**, the program **apsfilterconfig** is used. The directory **/var/lib/apsfilter** contains the settings configured by **apsfilterconfig**. Once the filter has been configured with **apsfilterconfig** the **printcap** entry for the printer is modified so that **apsfilter** is called as part of the printing sequence.

```
lp|PS;r=300x300;q=high;c=gray;p=a4;m=auto:\
    :if=/etc/apsfilter/basedir/bin/apsfilter:\
    :lp=/dev/lp0:\
    :sd=/var/spool/lpd/lp:\
    :lf=/var/spool/lpd/lp/log:\
    :af=/var/spool/lpd/lp/acct:\
    :mx#0:sh:
```

The program **apsfilter** is configured as the input filter ("**if**"). It relies on the name of the printer to configure some of its settings. It is possible to pass further configuration settings to **apsfilter** via parameters to **lpr**.

This is the example from **apsfilter.org** on how submit options to **apsfilter** (and also demonstrating how **apsfilter** can convert a number of formats to printable output).

```
% lpr -C high:duplex:32bpp:present:glossy ascii-file.gz \
     LaTeX.dvi.bz2 picture.gif xfig-file.fig.Z
```

8.3 magicfilter

magicfilter is a customisable and extendable printer filter. It examines the provided input files to determine what their format is, and handles them appropriately. **magicfilter** is intended to be used as an input filter for LPD – configured as "if" in **printcap**. Because the input filter parameter for printcap cannot be given with arguments, a separate script is used for each printer.

By convention, the scripts for **magicfilter** are in the directory **/etc/magicfilter**, and are named after the printer.

printcap entries may look like this –

```
  pencil|lp|PostScript|ljet4|HP LaserJet 4:\
        :lp=/dev/lp1:sd=/var/spool/lpd/pencil:sh:mx#0:\
        :if=/usr/sbin/printers/ljet4:
  crayon|dj550c|color|HP DeskJet 550C:\
        :lp=/dev/lp2:sd=/var/spool/lpd/crayon:sh:mx#0:\
        :if=/usr/sbin/printers/dj550c:
```

Depending on the version and configuration of your installation of **magicfilter**, **/usr/sbin/printers** may be **/etc/magicfilter** or some other location. A magicfilter printcap entry may look something like this too

```
lp|hplj4l|HP Laserjet 4L:\
        :lp=/dev/lp1:sd=/var/spool/lpd/hplj4l:\
        :sh:pw#80:pl#72:px#1440:mx#0:\
        :if=/etc/magicfilter/ljet4l-filter:\
        :af=/var/log/lp-acct:lf=/var/log/lp-errs:
```

Whatever their location, the actual script files are interpreted by the **magicfilter** program, as shown by the "#!" at the top of the file.

```
#!/usr/sbin/magicfilter
```

Quiz questions

1. What must appear in /etc/printcap for a postscript printer connected at /dev/lp0?
2. In what format are files which are submitted to lpr?
3. What does apsfilter do?
4. What does magicfilter do?
5. How does one print to a windows printer from the command line?
6. What is /etc/magicfilter, and what would you expect to find there?

Assignments

1. If you are running LPRng or CUPS, install the original BSD printing system, and set up your printer using either **apsfilter** or **magicfilter**.

Answers to quiz questions

1. If the printer is named **hplj**, then something like **hplj:lp=/dev/lp0:sd=/var/spool/hplj:**
2. Usually postscript, but other formats may be converted to postscript.
3. apsfilter converts various input formats to the printer's native format.
4. magicfilter is a script language to convert various input formats to a printer's native format.
5. **cat raw-print-data | smbclient //server/hplj bigsecret -U guest -P**
6. It's the conventional configuration directory for magicfilter, and contains a magicfilter script for each printer that requires one.

9 Documentation

Arnold's Laws of Documentation:

(1) If it should exist, it doesn't.
(2) If it does exist, it's out of date.
(3) Only documentation for useless programs transcends the first two laws.

– /usr/share/games/fortune/definitions

LPIC topic 1.108.1 — Use and manage local system documentation [4]

Weight: 4

Objective

Candidates should be able to use and administer man and the material in /usr/share/doc/. This objective includes finding relevant man pages, searching man page sections, finding commands and man pages related to them, and configuring access to man sources and the man system. It also includes using system documentation stored in /usr/share/doc/ and determining what documentation to keep in /usr/share/doc/.

Key files, terms, and utilities include

man	system manual pages
apropos	search for manual page keywords
whatis	show available man pages and their titles
MANPATH	path for man pages

9.1 man pages

For most commands that you can type on a Linux system there is a man page. Man pages are useful if you need detailed information about a command. A man page is an electronic document with a number of sections:

- NAME – the name of the command, and a very short description
- SYNOPSIS – command line usage
- DESCRIPTION – all about the command
- OPTIONS – detailed information about each option the command accepts
- FILES – which files are relevant to this program
- SEE ALSO – other sources of information, including other man pages
- BUGS – things that byte
- AUTHOR – who was responsible for the man page, or alternatively, for the program

In practice, few man pages have all these sections.

The syntax for **man** is one of these.

```
man [section] pagename
```

If you don't specify the section number, then the first man page found is used. Here are some examples of using **man**:

```
$ man man
$ man cd
```

```
$ man ls
$ man passwd
$ man 1 passwd
$ man 5 passwd
```

MANPATH

man searches the subdirectories of the directories listed in the **MANPATH** environment variables.

```
foo:~ # echo $MANPATH
/usr/share/man:/usr/local/man:/usr/X11R6/man:/usr/man:/usr/openwin/m
      an
foo:~ # ls /usr/share/man/
.   de     es     it  man1  man3  man5  man7  man9  pt_BR
..  de_DE  fr_FR  ja  man2  man4  man6  man8  mann
stop:~ # ls -C /usr/share/man/man1 | head -5
.                   ldappasswd.1.gz       perlvar.1.gz
..                  ldapsearch.1.gz       perlvmesa.1.gz
a2p.1.gz            ldd.1.gz              perlvms.1.gz
addftinfo.1.gz      less.1.gz             perlvos.1.gz
addr2line.1.gz      lesskey.1.gz          perlwin32.1.gz
```

If you have man pages in other locations, you can modify the value of MANPATH in **/etc/profile** (or a related script). Of course, it's not quite so simple. The contents of MANPATH is usually set to the output of the command **manpath**.

manpath is configured by the file **/etc/manpath.config**

```
foo:~ $ manpath
manpath: warning: $MANPATH set, ignoring /etc/manpath.config
/usr/local/man:/usr/share/man:/usr/X11R6/man:/opt/gnome/man
```

So the configuration for man is actually contained in one of these files (depending on the version of man) – but the simplest way to change things is to modify the MANPATH environment variable in the user's profile.

- **/etc/manpath.config** (version 2.x)
- **/etc/man.config** (version 1.x)

```
foo:~ $ ls /etc/man*
```

whatis

When a name of a man page is used in a number of sections, **whatis** lists the man pages available. The database used by **whatis** which contains the contents of all the "**NAME**" sections of manual pages is updated by **makewhatis**.

```
foo:~ # whatis
whatis what?
foo:~ # whatis whatis
whatis (1)           - display manual page descriptions
foo:~ # whatis passwd
passwd (1ssl)        - compute password hashes
passwd (1)           - change user password
passwd (5)           - The password file
reception:~ # man 1ssl passwd
```

```
Reformatting passwd(1ssl), please wait...
foo:~ # man 1 passwd
Reformatting passwd(1), please wait...
foo:~ # man 5 passwd
Reformatting passwd(5), please wait...
foo:~ # whatis thematrix
thematrix: nothing appropriate.
```

apropos

You can search the "**NAME**" sections of man pages for text of your choice using **apropos**. **apropos** searches for text in a similar way to **grep -i pattern** (case insensitive, word boundaries don't matter).

```
foo:~ $ apropos
apropos what?
foo:~ $ apropos apropos
apropos (1)          - search the manual page names and descriptions
foo:~ $ apropos printer
foo:~ $ apropos profile
foo:~ $ apropos passwd
foo:~ $ apropos cd
foo:~ $ apropos motd
foo:~ $ man -k motd
foo:~ $ apropos .
```

When you are searching for specific documentation, it can be quite useful to filter the output of apropos through **grep** to clarify what you meant.

```
foo:~ $ apropos cd | grep -w cd
foo:~ $ apropos scanner | grep -i USB
```

9.2 /usr/share/doc

This directory is contains all manner of documentation for your system, including:

- Package documentation – each installed package installs its documentation in its own directory, either under **/usr/share/doc** or under **/usr/share/doc/packages** (SuSE). Generally distributions package the original README, ChangeLog and COPYING files, and quite often the "contrib" directory (scripts and extensions which can be useful with a given program).
- HOWTOs – how to do various things – **/usr/share/doc/howto** – but not always installed.
- FAQs – frequently asked questions can also appear, but these are generally not the ones you want.
- Books – when you install the NAG (network administrator guide) and SAG (System Administration Guide) and other books from the Linux Documentation Project, they may be installed at **/usr/share/doc/books**.

Here is what **/usr/share/doc** looks like on a SuSE system.

```
fred@suse:~> ls /usr/share/doc
RELEASE_NOTES.de.html  howto     selfhtml    susetour
RELEASE_NOTES.en.html  packages  support-db  vnc-3.3.3r2
RELEASE_NOTES.hu.html  sdb       susehilf
fred@suse:~> ls -C /usr/share/doc/packages/ | head -5
```

```
3ddiag              kdebase3           samba
DirectFB            kdegames3          samba-vscan
ImageMagick         kdegraphics3       sane
MPlayer             kdegraphics3-scan  sash
NVIDIA_GLX          kdelibs3           sax
fred@suse:~ $ less /usr/share/doc/packages/*/README
```

On a Debian system, we see documentation for each installed package –

```
fred@debian:~$ ls -C /usr/share/doc | head -5
adduser             info                    makedev       syslinux
apt                 ipchains                man-db        sysvinit
apt-utils           iptables                manpages      tar
at                  klogd                   mawk          tasksel
base-config         lbxproxy                mbr           tcpd
fred@debian:~ $ less /usr/share/doc/*/README
```

/usr/share/doc on RedHat systems looks quite similar, but contains the version number of each package.

```
desktop@redhat:~ $ ls -C /usr/share/doc/ | head -5
4Suite-0.11.1                   libgnomeui-2.0.3
GConf-1.0.9                     libgtop2-2.0.0
GConf2-1.2.1                    libjpeg-6b
HTML                            libmrproject-0.6
ImageMagick-5.4.7               libogg-1.0
desktop@redhat:~ $ less /usr/share/doc/*/README
```

9.3 Review

Quiz questions

1. What type of documentation is found in **/usr/share/doc**?
2. What is the difference between **apropos** and **whatis**?
3. What is **MANPATH**, and what is its function?
4. How and why would a system administrator make changes to **MANPATH**?

Assignments

1. Read the man pages for **man**, **apropos** and **whatis**. Which of these refer to MANPATH?
2. Find and read the documentation on the fileutils project. How recent are the changes included in your installation, and what were they? Are there any outstanding problems with fileutils? How many contributors are there to the fileutils project?
3. Read all the documentation in **/usr/share/doc** :) , or alternatively find the Coffee HOWTO, and make notes on its contents.
4. Run the command **info info**, and then browse the **info** pages using the command **info**.

Answers to quiz questions

1. The documentation for installed software that is not part of the man page system.
2. **whatis** searches for man page names, and **apropos** searches the man page descriptions for

keywords.

3. **MANPATH** is an environment variable which specifies where to search for man pages.
4. The administrator would make changes to include man pages stored in non-default locations. This is a matter of editing **/etc/man.config** or **manpath.config**.

10 Internet Documentation

> The Internet? Yes, I've heard of it. I intend to finish reading it some day.
>
> *– things nobody ever said*

LPIC topic 1.108.1 — Use and manage local system documentation [3]

Weight: 3

Objective

Candidates should be able to find and use Linux documentation. This objective includes using Linux documentation at sources such as the Linux Documentation Project (LDP), vendor and third-party websites, newsgroups, newsgroup archives, and mailing lists.

Key files, terms, and utilities include

not applicable

10.1 Linux documentation project

The Linux Documentation Project (LDP) is a loosely knit team of volunteers who provide documentation for Linux. The LDP only has documents which are licences under a open source license.

On the Linux documentation project site (www.tldp.org or www.linuxdoc.org), you will find the following types of document:

- HOWTOs – a HOWTO is a step by step explanation of how to perform a specific task, such as installing Linux or making Coffee.
- Guides – a longish book with broad coverage of a subject, e.g. the Network Administration Guide. Guides aim to cover the entire subject, rather than just how to perform a specific task.
- man pages – man pages for the components you install are probably included in your system, but the Linux Documentation Project has man pages for all manner of components, including those you do not have installed.
- FAQs – a FAQ (Frequently Asked Questions) is a list of questions which are frequently asked in mailing list postings – along with the answers to these questions. The idea is that you shouldn't ask them.

Most of the material on the Linux Documentation project is widely available. Most Linux distributions include the Linux Documentation Project's material, but it is not necessarily installed by default.

10.2 Mailing lists

A number of different types of mailing lists are available for Linux.

- Project mailing lists (e.g. the Linux kernel, Gnome, KDE, textutils ...)
- Distribution-specific mailing lists

- Linux User Groups (LUGs) often run a mailing list for discussion of Linux related issues.

A list of Linux lists can be found at http://www.linux.org/docs/lists.html, with a large number administered by majordomo@vger.kernel.org – however this material is not entirely up to date – distribution vendors tend to rearrange their sites frequently.

- Debian – http://www.debian.org/MailingLists/subscribe
- Mandrake – http://www.linux-mandrake.com/en/flists.php3
- Redhat – http://www.redhat.com/mailman/listinfo/
- SuSE – http://www.suse.de/us/private/support/mailinglists/index.html

The name of the list usually indicates the topic which it deals with. It is helpful to understand the meaning of a list name, since posting off-topic questions is generally not helpful.

10.3 Newsgroups

The original development of Linux was done via newsgroups, rather than mailing lists. Currently many newsgroups are overrun by lesser mortals, and all the good stuff is on the mailing lists. Well, almost. Here are a couple of Linux newsgroups which have played a role in the development of Linux.

- comp.os.linux.advocacy – general discussion (heated argument) about Linux versus other operating systems.
- comp.os.linux.announce – Linux announcements – but you can do better on http://slashdot.org/
- comp.os.linux.answers – distribution of FAQs HOWTOs and READMEs (not very active)
- comp.os.linux.apps – linux applications discussion
- comp.os.linux.development.apps – programming and porting
- comp.os.linux.development.system – Linux kernel and device drivers and modules
- comp.os.linux.hardware – hardware compatibility, support, etc.
- comp.os.linux.networking – networking and communication
- comp.os.linux.setup – installation and configuration
- comp.os.linux.x – using X windows with Linux – see also http://www.xfree86.org/
- comp.os.linux.misc – everything else
- alt.os.linux – Linux flames

Google Groups http://groups.google.com has a complete archive of newsgroup postings (formerly managed by dejanews.com).

Since the LPIC only covers Linux on 80386 architecture, you will probably not want to know about these groups.

- comp.os.linux.m68k – Linux on the m68k architecture
- comp.os.linux.alpha – Linux on the alpha platform
- comp.os.linux.powerpc – Linux on the Power PC

10.4 Vendor web sites

These are the web sites of the major Linux distributions.

- http://www.redhat.com/ – Red Hat Linux

- http://www.suse.com/ – SuSE Linux
- http://www.linux-mandrake.com/ – Mandrake Linux
- http://www.slackware.com/ – Slackware
- http://www.debian.org/ – Debian
- http://www.connectiva.com/ – Connectiva Linux
- http://www.turbolinux.com/ – TurboLinux

10.5 Third party web sites

You can find interesting information on Linux at the following sites. These are not strictly tied to any particular distribution or software package.

- http://www.lwn.net/ (Linux Weekly News)
- http://www.linuxtoday.com/
- http://www.linuxplanet.com/
- http://www.linuxcentral.com/
- http://www.theregister.co.uk/

And of course there's always

- http://www.google.com/ – Search engine

10.6 Review

Quiz questions

1. Name three Linux distributions and their web sites
2. Name three Linux newsgroups.

Assignments

1. Join a LUG mailing list and see what kind of discussion takes place.
2. Browse the websites mentioned in the text, and make notes about their contents.

Answers to quiz questions

1. Refer to text. Here are a few that are quite interesting as well:
   http://www.openwrt.org, http://www.ubuntulinux.org, http://www.knoppix.net.
2. Refer to text.

11 System Notification

LPIC topic 1.108.5 — Notify users on system-related issues [1]

Weight: 1

Objective

Candidates should be able to notify the users about current issues related to the system. This objective includes automating the communication process, e.g. through logon messages.

Key files, terms and utilities include

/etc/issue	Logon banner
/etc/issue.net	Telnet logon banner
/etc/motd	Message of the day

11.1 Login Messages

When a user is presented with a shell login, it appears something like the following:

```
Welcome to SuSE Linux 8.2 (i586) - Kernel 2.4.20-4GB-athlon (tty1)

bar login:
```

The message above bar login: is generated from a file called **/etc/issue**. After successfully logging in a second message is displayed:

```
Last login: Mon May 10 1900 01:00:30 from console
One cheer for Linux!
```

The message “One cheer for Linux!” is the contents of the file **/etc/motd**, which stands for message of the day.

11.1.1 /etc/issue

/etc/issue is a plain text file presented before the login prompt. It can be used as a means of identification or to give users an instruction regarding logging in. If the console program (in our case **mingetty**) supports it \char sequences can be used.

Example:

```
foo@bar:~> cat /etc/issue

Welcome to SuSE Linux 8.2 (i586) - Kernel \r (\l).
```

The \r is translated into the kernel version, and the \l to the terminal line.

The following characters can be used:

\d	current day
\l	line on which mingetty is running
\m	machine architecture (uname -m)
\n	machine's network node hostname (uname -n)

\o	domain name
\r	operating system release (uname -r)
\t	current time
\s	operating system name
\u	the number of users which are currently logged in
\U	the number of users which are currently logged in followed by “users”
\v	operating system version (uname -v)

For network logins there is a separate file called **/etc/issue.net**. In fact, it is only used by **telnet** when a new connection is established. You can leave out sensitive information such as the system kernel version in the network logon banner.

11.1.2 /etc/motd

The message of the day file appears immediately after login whether remote or local. This file, as its name implies was intended as a means of communication between the system administrator and the users. The file is a plain text file and can be easily edited. Some system administrators like to have a joke or a quote of some sort in the message of the day. A popular source of quotes is the fortune database.

```
bar:~ $ cat /etc/motd
The message of the day service has been discontinued
```

11.2 Instant messaging

The **wall** command[5] can be used to send an instant message to all the consoles on the system. The **shutdown** command also sends a warning to all the consoles.

wall can be used as follows:

```
bar:/ # echo "scheduled maintenance at 15:00 today" | wall

Broadcast Message from root@bar
        (/dev/pts/5) at 03:03 ...

scheduled maintenance at 15:00 today
```

11.3 Review

Quiz questions

1. Who can view the message of the day?
2. Under what circumstances is the file **/etc/issue.net** displayed?

5 **wall** is not part of the LPI objectives.

Assignment

1. Change the login banner **/etc/issue** to show the number of the tty being used and the time of day, e.g. “You are logging in at terminal 1 at 16:00”.
2. Install the **fortune** program. Write a script to set the message of the day to the output of the fortune program. Set up a cron job to run this script every 5 minutes. Is there a better way of doing this?

Answers to quiz questions

1. Anyone who logs in successfully.
2. Before a telnet login.

12 Bash customisation

H@ppy, Sn33zy, D0p3y, D0c, 6rumpy, 5l33py and /bin/bashful

– The 31337 dwarves

LPIC topic 1.109.1 — Customize and use the shell environment [5]

Weight: 5

Objective

Candidate should be able to customize shell environments to meet users' needs. This objective includes setting environment variables (e.g. PATH) at login or when spawning a new shell. It also includes writing bash functions for frequently used sequences of commands.

Key files, terms, and utilities include

~/.bash_profile	The preferred user profile for bash
~/.bash_login	Another name for the same thing
~/.profile	Profile for any shell (including bash)
~/.bashrc	Bash rc file
~/.bash_logout	When you exit a login shell
~/.inputrc	User's readline configuration file
function (Bash built-in command)	Declare a command
export	Add an environment variable to the export list
env	Show exported variables
set (Bash built-in command)	Show environment and settings
unset (Bash built-in command)	Remove an environment variable

12.1 Bash profile(s)

When bash is running an interactive shell, there are two modes in which it can operate

- A login shell (as when bash gets started by a /bin/login)
- A regular shell (default)

The scripts run during startup and shutdown sequence for a login shell are as follows:

1. **/etc/profile**
2. **~/.bash_profile**, or **~/.bash_login** or **~/.profile** (in that order)
3. Interactive session
4. **~/.bash_logout** (if it exists)

For a regular session (e.g. a bash session in an xterm, or simply running bash from the command line) the startup and shutdown sequence is more straightforward:

1. **~/.bashrc** (user's bash configuration)
2. Interactive session

In the bash profile, you have the opportunity to do pretty much anything you can do at the command line, including.

- Set environment variables (e.g. **PATH**, **WINDOWMANAGER**)
- Define aliases
- Define functions
- Read include files. You may want your **~/.bash_profile** to read your **~/.bashrc** to yield a consistent environment.

Each of these topics is discussed in its own section below.

12.2 Variables

The following environment variables are commonly modified in profile scripts.

- **PS1** – the level 1 prompt.

```
foo:~ $ echo $PS1
\h:\w \$
[jack@foo jack]$ echo $PS1
[\u@\h \W]\$
```

The backslash receives special treatment in the **PS1** prompt:

\W – working directory (only the last part)
\w – working directory
\u – user name
\h – host name

- **HISTSIZE** – the number of history command lines that bash keeps in **$HISTFILE**.
- **MAILCHECK** – how often bash checks whether the mail file **$MAIL** has changed. When the mail file changes, bash prints a message "you have new mail".

The following variables, which are exported to other applications also appear in profile scripts.

- **PATH** – the directories which bash and other applications search when you run a new program.

```
foo:~ $ echo $PATH
/home/jack/bin:/bin:/usr/bin:/usr/X11R6/bin:/usr/local/bin
```

- **DISPLAY** – the X display on which output is displayed. This is generally set automatically by the X initialisation scripts, but it must be in the export list.
- **PAGER** – some applications default to using **more** rather than **less** as the pager if the **PAGER** environment variable is unset.
- **LANG** – the language to use for multi-lingual applications.

```
[jack@foo jack]$ echo $LANG
en_GB.UTF-8
```

To modify an environment variable, the syntax is

```
VARIABLENAME="value"
```

Note that you must quote the value assigned to the variable if it contains spaces. To add a variable to the export list so that it is available to applications, the command is **export** which can be used on its own, or together with an assignment to the variable:

```
export VARIABLENAME
export VARIABLENAME="value"
```

To remove an environment variable, the command is **unset**, as in

```
unset VARIABLENAME
```

Setting and clearing a variable:

```
[jack@foo jack]$ set | grep AA
[jack@foo jack]$ AAVARIABLE="A value, not exported"
[jack@foo jack]$ set | grep AA
AAVARIABLE='A value, not exported'
[jack@foo jack]$ env | grep AA
[jack@foo jack]$ export AAVARIABLE
[jack@foo jack]$ env | grep AA
AAVARIABLE=A value, not exported
[jack@foo jack]$ AAVARIABLE="A new value"
[jack@foo jack]$ env | grep AA
AAVARIABLE=A new value
[jack@foo jack]$ unset AAVARIABLE
[jack@foo jack]$ env | grep AA
[jack@foo jack]$ set | grep AA
[jack@foo jack]$ AAVARIABLE=
[jack@foo jack]$ set | grep AA
AAVARIABLE=
[jack@foo jack]$ env | grep AA
```

12.3 Functions (and aliases)

Aliases and functions enable you to customise the behaviour of commands, without modifying the commands themselves. You can also create new commands.

Aliases

It is not unusual for distributions (and administrators) to try to protect their users from problems by presenting them with custom commands – aliases. An alias allows you to change what the user actually runs when the command is entered.

```
alias dir='ls -l'
alias cp='cp -i'
alias mv='mv -i'
alias rm='rm -i'
alias cd..='cd ..'
alias ppp='/usr/sbin/pppd -detach'
```

Functions

Functions can do things that external scripts cannot do:

- Modify shell environment variables
- Refer to environment variables which are in the export list
- Change the working directory

To define a bash function, the syntax is:

```
function functionname()
{
      whatever the function does, using $1 $2 $3, etc as supplied as
      command line arguments
}
```

If that's too much, you can leave out the word **function**.

```
functionname()
{
      whatever the function does, using $1 $2 $3, etc
}
```

To use a function, you call it as if it is a regular command. A function allows you to do more than change the command name itself. The parameters passed to the function can be used inside the function itself.

Here is a function that changes directory and lists the files in the directory.

```
# Change directory and list files
function cdls()
{
      cd "$1"
      ls
}
```

A really good place to define a function is in a user's **~/.bash_profile**. Put this function in your **~/.bashrc** and test how it works.

12.4 Keyboard handling and inputrc

The bash shell uses the GNU readline library for obtaining user input of the commands to run. The behaviour of GNU readline is customised by modifying either the global configuration file **/etc/inputrc** or the user's **~/.inputrc**.

The **inputrc** file contains a list of key codes, and the interpretation that should be put on them. A number of keywords can be used to set configuration values. The interpretation is either a specific function (e.g. backward-delete-char), or a macro of keys in quotes

```
# Don't beep for funny keypresses
set bell-style none
# Map back space on the keyboard to trigger the
# backward-delete-char function
"\C-?":         backward-delete-char
"\C-H":         backward-delete-char
# Map F1 on an xterm to write the word "telnet "
"\eOP":         "telnet "
```

inputrc files can also contain macros to ensure that configuration values only take effect for certain terminal types.

```
$if term=linux
# On console the first five function keys
"\e[[A":        "support "
"\e[[B":        ""
"\e[[C":        ""
"\e[[D":        ""
"\e[[E":        ""
$else
# The first five standard function keys
"\e[11~":       ""
"\e[12~":       ""
"\e[13~":       ""
"\e[14~":       ""
```

```
"\e[15~":       ""
$endif
```

12.5 Review

Quiz questions

1. How do you access function parameters within a function?
2. At which point are the files **.bashrc**, **.bash_profile** and **.bash_login** read?
3. What must you do to set an environment variable so that it is available to the shell when the login session is active, but not to applications run from the shell?
4. What form does the contents of **~/.inputrc** take?
5. What is the purpose of the **set** bash built-in, and how does it differ from **env**?
6. How would you go about adding the directory **/usr/local/sbin** to the **PATH** environment variable for root?

Assignments

1. Edit your own **.inputrc** and assign useful macro values to F1 to F4 for both the Linux console and for xterm. If you don't have any ideas of your own, you can use these values for network diagnosis:

   F1 – "telnet "
   F2 – "ping "
   F3 – "traceroute "
   F4 – "nslookup "

   You can quite easily find out the key code generated by a certain key stroke by typing **Ctrl+V** (quote), followed by the key. The initial escape character is then quoted, and the remaining part of the escape sequence can be seen.
2. Modify your own profile script to include the directory ~/bin in your path specification. Check that it works.
3. Write a function named nettest which will traceroute, nslookup and ping a named machine, and make this available to both login shells and regular shells.
4. Investigate the use of the CDPATH environment variable (start by finding it in the bash man page).
5. Write a bash function for your **.bashrc** which will write the name of the file you are editing to a log file every time your run **vi**. Here's a tip – name the function "vi", and use the full pathname of "vi" when you run it, or use the **command** builtin.

Answers to quiz questions

1. $1, $2, $3 ... or $@ $* (and $#, if you care to know how many there were)
2. .bash_login is read for login sessions. .bash_profile is read if .bash_login doesn't exist. .basrc is read for non-login interactive sessions.
3. If the variable is called VAR, what you must *not* do is **export VAR**. (You can remove it

from the list with **export -n VAR**, if you really need to.)

4. It's text – most lines are of the form **keypress: action**. Conditional lines start with **$**, and the keyword **set** may be used to set options.
5. **set** shows all environment variables, including those not in the export list. For good measure, it shows function definitions. **env** is a stand-alone program which shows only variables from the export list.
6. Add **PATH=$PATH:/usr/local/sbin** to **/root/.bashrc** and **/root/.bash_profile**.

13 Scripting

Q. How many Unix hacks does it take to change a light bulb?
A. Let's see, can you use a shell script for that or does it need a C program?

/usr/share/games/fortune/cookie

This chapter is about simple scripting. Some extra material not suggested in the LPIC topic is included in this chapter. If you are studying this material exclusively for the purpose of LPIC certification, you may want to ignore the extra material, since the weighting of the topic is not that heavy.

LPIC topic 1.109.2 — Customize or write simple scripts [3]

Weight: 3

Objectives

Candidate should be able to customize existing scripts, or write simple new (ba)sh scripts. This objective includes using standard sh syntax (loops, tests), using command substitution, testing command return values, testing of file status, and conditional mailing to the superuser. This objective also includes making sure the correct interpreter is called on the first (#!) line of scripts. This objective also includes managing location, ownership, execution and suid-rights of scripts.

Key files, terms and utilities include

while	do something while a condition exists
for	do something for each value given on the command line
test	check whether a condition is true
chmod	change permissions (+x to execute)

13.1 Introduction

A clear understanding of shell scripting and in particular bash scripting is required to effectively maintain and extend a Linux installation. The system boot process is entirely based on scripts – see the directories **/etc/init.d**. Shell scripting is the core to the Unix philosophy of breaking tasks into may smaller specialized tasks. Scripts forming the glue that joins these specialized tasks into a greater functional whole. The boot process is an excellent example of this.

Bash scripts are useful for the following applications:

- Tools exist which do a part of the job you require but need to be combined with other executables to complete a task.
- A task is repetitive. Especially if consistency in the way the task is to be done is required.
- Only simple logic decisions need be made in the script. Complex or heavily mathematic logic is performed in executables called by the script.
- To provide “memory” to systems that have no mechanism of maintaining state on a persistent media storage device (e.g. **iptables** firewall configuration script).

Shells scripts are not suited to:

- Resource-intensive tasks – where speed or I/O performance are critical. Consider using a compiled language such.
- Systems requiring complex data structures and/or mathematics. This means anything beyond 32 bit signed integers and basic strings. Don't even consider shell scripts where computation may need to be performed on real numbers. Rather use Perl, Python or another high level scripting language.
- Cross-platform platform portability. For this you need patience or a portable language, perhaps Python, or ANSI C.
- Any large-scale mission critical application. A script of more than 1000 lines will be very difficult to maintain. Bash is the glue between systems and should not be used to engineer an entire system.
- Situations where the source must remain hidden (proprietary systems).

13.2 Permissions and executables

For a file to be executable it must have the execute mode set for the user that wishes to execute the script. The execute mode can be set with the **chmod** command.

```
foo@bar:~> ls -l param
-rw-r--r--    1 foo     users         125 2003-05-17 11:17 param
foo@bar:~> chmod u+x param  #allow the user to execute
foo@bar:~> ls -l param
-rwxr--r--    1 foo     users         125 2003-05-17 11:17 param
foo@bar:~> chmod g+x param  #allow the group to execute
foo@bar:~> ls -l param
-rwxr-xr--    1 foo     users         125 2003-05-17 11:17 param
foo@bar:~> chmod o+x param  #allow the anyone to execute
foo@bar:~> ls -l param
-rwxr-xr-x    1 foo     users         125 2003-05-17 11:17 param
```

The set-uid executable mode is represented by the symbol **s** in the output of **ls**. Suid executables allow a program to change user while it is executing. There are many executables on a Linux system which necessarily have **suid** permission. As an example, a non root user would not be able to use the **passwd** command to change his/her password in **/etc/shadow** if the **passed** command were not able to set its UID to root.

```
foo@bar:~> ls -l `which passwd`
-rwsr-xr-x    3 root     shadow    73680 2003-03-17 17:39
      /usr/bin/passwd
```

13.3 Basic syntax of a shell script

A shell script is a series of shell commands placed in a file. bash includes a number of control structures which make shell scripting quite powerful.

This “Hello World” script uses the **built-in** command **echo** to send a number of messages to standard output:

```
#!/bin/bash
```

```
#*****************************************************************
     ****#
#
# Program:      hello.sh
# Written by:   A N Onymous
# Date:         1 January 2002
#
# Displays a rather unhelpful message on the screen.  Program
     developed
# to provide an introduction to bash scripting.
#
#*****************************************************************
     ****#
echo 'A command is terminated at the end of a line.'
echo 'A ; also terminates commands.' ; echo 'Another echo on this
     line.'
echo 'Unnecessary ; are harmless.' ;
exit 0
```

Note:

- Lines beginning with a "#" are comments and are not executed.
- The first line, which is a comment to bash instructs the kernel to use **/bin/bash** as the command interpreter for this script. **#!/usr/bin/perl** would cause the script to be interpreted by **perl**. This line is affectionately known as the "shebang" and is not always necessary for bash scripts, but it is by far a good idea.
- Note than one command can be used on a line if a semicolon ";" separates them. That is a new line and a semicolon are equivalent.
- **exit 0**, this causes the script to exit with a return code of zero. We will discuss return code under conditional execution.

13.4 Script communication

There are a number of ways for scripts to send and receive information.

- Positional parameters (command line arguments).
- Environment variables.
- Return code. An integer returned by a script to indicate the result of its execution. Will be discussed under control structures.
- File descriptors. Every bash script has a number of "pseudo files" (streams) open. The three default streams are: standard input (stdin), standard output (stdout) and standard error (stderr). Scripts commonly redirect the default streams to read and write files.

13.4.1 Positional parameters

The positional parameters **$1**, **$2** etc are passed to the script simply by typing arguments after the scripts name on the command line. For example:

```
foo@bar:~> cat param
#!/bin/bash
#this is param
```

```
echo The script name $0
echo First parameter $1
echo Second parameter $2
echo Third parameter $3
foo@bar:~> ./param 1111 2222 3333
The script name ./param
First parameter 1111
Second parameter 2222
Third parameter 3333
```

The parameters are accessed as the variables **$1, $2, $3 ...** depending on the number of arguments given to the script and the path used to call the script is represented by **$0**.

13.4.2 Redirection review

Output can be directed in the following ways

```
echo message > file                    #redirects output to a filename
echo error message >&2                 #directs the message to stderr
```

Standard input can be read from using the **read** command. The **read** command will read one line from the standard input and the first word is assigned to the first variable supplied, the second word to the second variable, and so on, with leftover words and the white space between to the last variable.

Example:

```
foo@bar:~> cat useread
#!/bin/bash
read A B C
echo "First word:  $A"
echo "Second word: $B"
echo "Third word:  $C"

foo@bar:~> echo "This is a short sentence for useread" | ./useread
First word:  This
Second word: is
Third word:  a short sentence for useread
```

13.5 Quoting in bash

Bash applies a number of **shell expansions** to certain special characters. The most commonly used shell expansion is the asterisk "*" which the shell expands to match all possible file names.

It is not always desirable to expand special characters so bash allows for special characters to be quoted (also called "escaped"). Quoting has an additional side effect of causing a string containing spaces to be treated as a single parameter to a command.

Two forms of quoting are available, namely **partial quoting** (**" ... "**) and **full quoting** (**' ... '**), the difference being the set of special characters protected.

13.5.1 Full quoting '...'

The following example demonstrates full quoting:

```
foo@bar:~> echo '* usually lists all files in a directory.  '
* usually lists all files in a directory.
foo@bar:~> echo '$100.00 * 5 = $500.00'  # Loans sharks are
     expensive.
$100.00 * 5 = $500.00
foo@bar:~> echo # This is a comment.

foo@bar:~> echo '# This is not a comment.  '
# This is not a comment.
```

In the above examples bash makes no attempt to interpret anything enclosed within quotes. Everything within the full quotes is protected from bash shell expansion.

Full quoting protects a string from being manipulated by bash. The command that receives the quoted argument from bash (with quotes removed) and is free to interpret the string according to its own rules.

```
foo@bar:~> echo 'caaaaat' | grep 'a*'
caaaaat
foo@bar:~> echo 'ct' | grep 'a*'
ct
```

Bash sees a fully quoted string and passed **a*** to **grep** which in turn interprets the **a*** as implying match **a** zero or more times.

13.5.2 Partial quoting "..."

Partial quoting does not provide complete protection from shell expansion. In particular the **$**, ` and \ characters are still treated with special interpretation.

```
a=1
echo $a                  # prints 1
echo # $a                # prints a blank line
echo "# $a"               # prints # 1
echo "$a"                # prints 1
echo '$a'                # prints $a
echo *                   # doesn't print *
echo "*"                 # prints *
```

It should be clear that the shell still expands **$a** when it is enclosed in double quotes, but ignores the comment special **#** and the file expansion ***.

Note that:

- Single quotes protect enclosed double quotes from being interpreted by the shell.
- Double quotes protect enclosed single quotes from being interpreted by the shell.

13.5.3 Command substitution and backticks

In command substitution bash evaluates a command and substitutes its output in the place of the command, and then evaluates the new command generated as a result of this substitution.

For example,

```
foo@bar:~> echo 'cat /etc/passwd'    # Just prints to stdout.
cat /etc/passwd
foo@bar:~> echo `cat /etc/passwd`    # Actually runs cat
     /etc/passwd.
```

```
root:x:0:0:root:/root:/bin/bash bin:x:1:1:bin:/bin:/bin/bash
daemon:x:2:2:daemon:/sbin:/bin/bash
...
```

The first command is simply an example of full quoting. In the second example **cat /etc/passwd** is firstly evaluated before its resultant output is passed to the **echo** command.

The backticks are the traditional bash mechanism for command substitution, however command substitution is also performed by the following syntax.

```
foo@bar:~> echo $(cat /etc/passwd)              # Same as previously.
root:x:0:0:root:/root:/bin/bash bin:x:1:1:bin:/bin:/bin/bash
daemon:x:2:2:daemon:/sbin:/bin/bash ...
```

The second form of command substitution can be nested as follows.

```
$(echo "$(echo 'ls')")                          # Same as `ls`
```

Command substitution finds particular utility in creating variables which contain the value of a command.

```
foo@bar:~> B=`which cat`
foo@bar:~> echo $B
/bin/cat
```

13.6 Keywords and built-in commands*

A keyword is a reserved word, token or operator. Keywords are used to form the syntax of the shell but do not of their own right form commands. For example, **if** is a keyword forming the part of the larger syntax of the shell.

A builtin on the other hand is a command built into the shell (i.e. not an executable file). Builtins are transparent to the user but provide useful improvements in performance. It is possible to distinguish between keywords, builtins and external commands using the **type** command. In essence **type** is the shell builtin form of **which** with the added advantage that it can identify bash shell specific entities. The following screen fragment clarifies all these different concepts.

```
foo@bar:~> type if
if is a shell keyword
foo@bar:~> type test
test is a shell builtin
foo@bar:~> type [
[ is a shell builtin
foo@bar:~> type ls
ls is aliased to `ls $LS_OPTIONS'
foo@bar:~> type chmod
chmod is /bin/chmod
foo@bar:~> which chmod
/bin/chmod
```

Commands executed by bash are subdivided into external and internal commands. A list of commonly used and important builtin commands are documented below. A description of each builtin command can be obtained with the **help** builtin, and they are described in the man page for bash.

13.7 Arithmetic expansion and evaluation

Bash is capable of doing integer arithmetic, that is all variables and constants must be integer and the results produced are also only integer. There are a number of alternative means for doing arithmetic. These are:

- expr
- let
- $(( ))

13.7.1 expr

Evaluate expression **expr** preforms both arithmetic and some string evaluations on any given set of arguments. The command **expr** considers each of it parameters as either a number, operator or string. Operations may be arithmetic, comparisons, strings or logical.

The following examples should clarify the use of **expr**.

```
answer=`expr 1 + 2`        # answer is 3, as expected.
answer=`expr 2 \* 3`       # answer is now 3.  REMEMBER TO ESCAPE *.
answer=`expr "1 + 2"`      # echo $answer produces 1 + 2.
answer=`expr 1+2`          # echo $answer produces 1+2.
```

The use of **expr** in this manner is an example of arithmetic expansion.

As an aside to arithmetic expansion the following string operations may also be performed using **expr**. The **substr** operator extracts a part of a message.

```
foo@bar:~> message="The cat sat on the mat."
foo@bar:~> expr substr "$message" 5 3
cat
foo@bar:~> expr substr "$message" 5 6
cat sa
```

The **match** operator prints out the number of characters that match the string.

```
foo@bar:~> expr match $message "The"
3
foo@bar:~> expr match "$message" '.*cat"
7
foo@bar:~> expr match "$message ".*"
23
foo@bar:~> expr match "$message "cat"
0
```

13.7.2 let*

The shell builtin **let** provides a means to perform variable evaluation. As the **let** is a bash builtin the process of calcuating the resut of an expression is consider **evalutation**. In effect, and unlike **expr**,

let takes only a single argument as the following code fragment demonstrates.

```
let a=1+2  ; echo $a                          # echo $a produces
     3.
let a=$a+1 ; echo $a                          # echo $a produces
     4.
```

```
let a=11/2 ; echo $a                                # echo $a produces
      5.
let a=11*5 ; echo $a                                # echo $a produces
      55.
```

Note that unlike **expr**, **let** does not provide any string manipulation functionality. This has the considerable advantage that **let** with try to evaluate everything as arithmetic expression, not concerned about any unnecessary spaces. Remember however that let must receive only one argument to function as expected so the use of quotes is required.

```
let "a=1 + 2" ; echo $a                            # echo $a produces 3.
b='1+2 + 3 * 8'
let "a=$b" ; echo $a                               # Produces 27.
let "a = 1" ; echo $a                              # Also works.
# For let spaces are not a problem on either side of "="
```

13.7.3 Arithmetic expansion using $((...))

The final method of doing arithmetic expansion is to use the double parenthesis operator. As with **let** there is no string manipulation provided. White space inside the brackets is ignored by bash. However unlike **let** assignment can occur both within and outside the parenthesis.

```
a=$((b=1+ 2)); echo "a = $a" ; echo "b = $b"  # echo $a produces 3.
                                               # echo $b produces 3.
echo $((1+(b=2+2))) ; echo $b                  # produces 5 and 4.
b=$(($b+$b)) ; echo $b                         # produces 8.
```

Note that in the last example the brackets enclosing **(b=2+2)** are required such that the bracketed expression evaluates to 4 that is then added with the 1.

13.8 Control structures

Shell commands always produce a return code on termination. The return code is an integer:

- 0 means the command executed without errors, or achieved its purpose
- Any other number indicates an error condition, and may indicate the specific error.

The commands **true** and **false** do nothing, but they do generate a return code. The return code can be accessed in the shell using **$?** as the substitution.

```
foo:~ $ true
foo:~ $ echo $?
0
foo:~ $ false
foo:~ $ echo $?
1
foo:~ $ grep root /etc/passwd
root:x:0:0:root:/root:/bin/bash
foo:~ $ echo $?
0
foo:~ $ grep ro331ot /etc/passwd
foo:~ $ echo $?
1
```

13.8.1 test

In the shell, conditional testing of variables is handled by an external program, or at least a shell built-in. The command **test** (see man test) and the equivalent built-in **[...]** provide a number of tests which are used for conditional execution in scripts.

test implements three basic classes of test, namely

1. String comparisons

```
test "$STRING1" = "$STRING2"          # ok if two strings are equal
[ "$STRING1" = "$STRING2" ]           # ok if two strings are equal
[ "$STRING1" != "$STRING2" ]          # ok if two strings are not
      equal
[ -z "$STRING1" ]                     # ok if $STRING1 is empty
[ "$STRING1" ]                        # ok if $STRING1 is non-empty
[ $STRING1 = $STRING2 ]               # syntax error (sometimes)
```

2. Numeric comparisons

```
test integer1 -eq integer2 # ok if numbers are equal
[ $A -eq $B ]                         # ok if A=B
[ $A -gt $B ]                         # ok if A>B
[ $A -lt $B ]                         # ok if A<B
[ $A -ge $B ]                         # ok if A>=B
[ $A -le $B ]                         # ok if A<=B
[ $A -ne $B ]                         # ok if A not equal to B
```

3. File tests

```
test -e $FILE              # ok if file exists
[ -e $FILE ]               # ok if file exists
[ -d $FILE ]               # ok if file is a directory
[ -f $FILE ]               # ok if file is a regular filenames
[ -r $FILE ]               # ok if file is a readable
[ -s $FILE ]               # ok if file size greater than 0
```

   There are a number of file tests not listed here for examining the type, size, permissions and ownership of files.

13.8.2 &&, ||

The **&&** (and) and || (or) operators work in the sense of:

- Do this right **&&** I'll give you a lollipop

```
cp money wallet && echo Give him a lollipop
```

- Do this right || else

```
cp lollipop customer || echo Sorry, lollipop failure
```

Most commands return sensible values, so you can do things like this in a script. If tar returns an error code (non zero), then a mail is sent to the administrator

```
tar -cvzf etcbackup.tar /etc >& etcbackup.log ||
      cat etcbackup.log | mail -s "Backup failed" root
```

13.8.3 if ... then ... fi

A **if/then** construct in bash is formed as follows, where command can be any valid list of bash

commands. The return code of the final instruction in the list is used to make the branching decision where a return code of **zero** equals true.

```
if command1 ; then
   echo 'command1 succeeded ... do something ... '
elif command2
   then
   echo 'command1 didn't, but command2 did ...'
else
   echo 'Nothing works! I am not sure what to do.  '
fi
```

In the above code

- the semi-colon (;) is equivalent to the end of line
- **elif** combines **else** and **if**

13.8.4 case ... esac

The case statement is used to choose one of a number of blocks of code, depending on the supplied value. The case statement behaves like a series of **if**, **elif** and **else** commands. Bash evaluates each condition in turn until one of the conditions is satisfied.

The case statement is structure a follows:

```
case "$variable_to_test" in
something)
  echo "The first condition matched.  "
  ;;
"whatever")
  echo "The second condition matched.  "
  ;;
*)
  echo "None of the conditions matched.  "
  ;;
esac
```

The **case** statement is used in scripts in **/etc/init.d** to detect which option was supplied on the command line.

```
case "$1" in
    start)
        echo "Starting FOO "
        foo &
        ;;
    stop)
        echo "Shutting down FOO "
        killall -TERM foo
        ;;
    restart)
        $0 stop ; $0 start
        ;;
    *)
        echo "Usage: $0 [start|stop|restart]"
        ;;
esac
```

Another use for the case statement is to treat files differently based on their extensions:

```
#! /bin/bash
case "$1" in
    *.gz) zcat "$1" ;;
    *.bz2) bzcat "$1" ;;
    *) cat "$1" ;;
esac
```

13.8.5 The for ... do loop

The **for** loop occurs in two basic forms. The first form is:

```
for arg in list ; do
  ....
done
```

In this form the list is a white space separated list of elements. The variable **arg** is set to each element in the list in turn until the list is exhausted. The argument list may either be specified explicitly, be expanded from a variable or be generated dynamically though command substitution.

The following code segment should demonstrate the use of **for** in this manner.

```
for n in A B CDE FGH ; do
    echo $n
done
for n in `ls *` ; do
    echo $n
done
```

The C style loop supported by bash is demonstrated below (it is not part of the LPIC objectives).

```
for (( n=0 ; n<10 ; n++ )) ; do
    echo "$n"
done
```

In this form the variable **n** is initially set to zero. For each iteration of the loop the value of **n** is incremented by one. The loop will continue while the middle argument **n<10** is true.

```
for (( IP=0 ; IP<10 ; IP++ )) ; do
    ping -c 1 10.0.0.$IP
done
```

13.8.6 while ... do

This construct tests for a condition at the top of a loop, and keeps looping as long as the condition is true (returns a 0 exit status). A **while** loop is used in situations where the number of loop repetitions is not known beforehand. A **while ... do** loop is structure as follows:

```
while [condition] ; do
    ...
done
```

A common use for this is to read a file into bash:

```
while read LINE; do echo "blah: $LINE" ; done < /etc/passwd
while sleep 1; do echo -ne '\a' ; done
while true; do echo "Hello"; done
```

The **until ... do** loop (not part of LPIC objectives) is very similar except that the condition

must be false for the loop to execute.

```
until [condition-is-true] ; do
    ...
done
```

An example of this...

```
until ls | grep godot; do echo "Waiting for godot..." ; sleep 1 ;
      done
```

13.8.7 Loop control commands*

The **break** and **continue** loop control commands affect the execution of **for**, **while** and **until** loops.

- The **break** command terminates the loop (breaks out of it),
- The **continue** causes a jump to the next iteration of the loop, skipping all the remaining commands in that particular loop cycle.

Here is an example of using the **break** command.

```
echo "Enter something"
while read LINE ; do
  if [ "$LINE" = "EOF" ] ; then break; fi
  echo "You entered: $LINE. Enter EOF to end."
done
```

13.9 Review

Quiz questions

1. What is the purpose of the first line of the script?
2. In the command **while _____ ; do echo something; done** ... what type of value can appear after **while**?
3. In the command **for _____ in 1 2 3 ; do echo $something; done** ... what should appear after **for**?
4. What is the meaning of the error “bash: script-name: Permission denied” when running a script?
5. What will the command **echo $(1+2)** do, and what will be displayed?
6. How does bash treat set-uid scripts?
7. What does the command **[-e /etc/passwd] || echo whatever** do on most Linux installations?
8. What does the command **test -f /dev/zero && echo whatever** do on most Linux installations?
9. The script snippet below is intended to test whether the user ID is under 500. What is wrong with this script, if anything?

```
if $( id -u ) -lt 500 ; echo UID is under 500 ; done
```

Assignment

1. What will the following script do?

```
#! /bin/bash
while sleep 600; do
  netstat -ant | grep '0\.0\.0\.0:25.*LISTEN' ||
    echo "Oops" | mail -s "Oops" root
done
```

   Find a better way of doing the same thing.

2. Write a script to test multiplication tables. Generate two random numbers A and B, and calculate the product of the numbers (A*B). Ask the user what A / B is, and test whether the answer supplied is correct. You can use **B=$((RANDOM % 20 + 1))** to generate the random numbers.
3. Write a script to manipulate users' **.forward** files. The script is to be run by root and must accept two parameters – a user name, and an e-mail address. The script must create a file named **.forward** in the user's home directory, and enter the e-mail address in the file. If no e-mail address is given, the script must remove the **.forward** file from the user's home directory. For bonus points, have the script show the previous contents of the **.forward** file if it existed, and explain each step it takes.

Answers to quiz questions

1. To tell the kernel which interpreter to use for a script.
2. A command or a number of commands.
3. A variable name, without a $.
4. The script is not executable.
5. Same as echo `1+2` - attempt to run the command “1+2”, and print “bash: 1+2: command not found” and a blank line.
6. set-uid scripts are run as regular scripts. Bash does not set its UID.
7. Nothing (it exists)
8. Nothing (it's not a file)
9. Missing **[** ... **]**, missing **then**, **done** instead of **fi**.

14 Users and Groups

users, n. pl. idiot
group, n. many users

– system administrator's dictionary

LPIC topic 1.111.1 — Manage users and group accounts and related system files [4]

Weight: 4

Objective

Candidate should be able to add, remove, suspend and change user accounts. Tasks include to add and remove groups, to change user/group info in passwd/group databases. The objective also includes creating special purpose and limited accounts.

Key files, terms, and utilities include

chage	Change password aging and expiry information for a user
gpasswd	Set a group password
groupadd	Create a new group
groupdel	Delete a group
groupmod	Change group details
grpconv	Create gshadow from group file containing passwords
grpunconv	Convert gshadow to group file with passwords
passwd	Change a user's password
pwconv	Convert from regular passwords to shadow passwords
pwunconv	Convert from shadow passwords to regular passwords
useradd	Add a user
userdel	Delete a user, and maybe his files too
usermod	Change a user's details
/etc/passwd	The user and password database
/etc/shadow	The actual password part of the password database
/etc/group	User groups database
/etc/gshadow	Passwords for groups when using shadow passwords

14.1 Users

The term "user" refers to an account on the machine which allows access to some specific services. As far as Linux is concerned, each user is a number – the user ID. The name is used to establish the user's identity at login. Some users on the system represent real people who will log onto the machine in some way or another. Other users are system accounts which allow certain programs (normally daemons) to run with limited permissions on the machine.

The password database provides some basic properties to users such as a home directory and a shell. What you set these properties to determines the services that the user may use, as well as affecting the overall security of the machine.

As far as the kernel is concerned, a user is simply a number assigned to processes and files. Groups are also numbers assigned to processes and files. When you log in, your user ID is determined, and then associated with all the processes you start.

In the regular course of events[6], the login process reads the file **/etc/passwd** to translate your login name into the appropriate user ID, and **/etc/shadow** to check whether the password you enter is correct. The login process also notes the group given in **/etc/passwd** and the supplementary groups listed in **/etc/group**. It then starts the configured shell with the correct UID, GID and supplementary groups. After logging in, various other programs refer to **/etc/passwd** and **/etc/group**. For example **ls** uses the files to display the appropriate names for file owners and file groups, and **su** and **sg** work similarly to **login**.

So, a user is then:

- An entry in **/etc/passwd** (name, home directory, shell)
- An entry in **/etc/shadow** (password and expiry information)
- A home directory owned by the user (usually under **/home**). A user will also accumulate files in other places, such as mail in **/var/mail** and files in **/tmp**.

14.2 The passwd file

The file **/etc/passwd** is the default database of Unix users on the system. The file has the following format:

```
name:X:UID:GID:Comment:home:shell
```

Field	*Description*
Login name	The users name, case sensitive, usually lowercase, must be unique
X	Encrypted password. Most systems store passwords in in **/etc/shadow** and "**x**" is used to indicate this.
UID	A user identification number. Normally UIDs for non system users are 500 and above. If the UID is duplicated the two users are effectively duplicate logins for the same account.
GID	Group identification number. This is set to the ID of a valid group in **/etc/group**. Files created by the user are assigned to the group named here (by default).
Comment	The comment field can contain any information, usually the user's full name. There is a standard for inserting other information separated by commas, such as the user's room number.
Home	The user's home directory, normally **/home/username**. In the case of a system account this will normally be where certain of the daemon's files are installed like **/usr/local/daemon-name**.
Shell	User command interpreter. When you log in, this is the

6 With the advent of PAM (pluggable authentication modules), the regular course of events can change, and the source of authentication data may be anything from a LDAP database to a Windows domain controller.

Field	*Description*
	command that runs – to do anything useful your shell must be a valid command interpreter. Some programs like **ftp** check that the user attempting to log in has a valid shell (i.e. one listed in **/etc/shells**).

Your password file will contain entries that look something like this:

```
root:x:0:0:root:/root:/bin/bash
bin:x:1:1:bin:/bin:/sbin/nologin
daemon:x:2:2:daemon:/sbin:/sbin/nologin
adm:x:3:4:adm:/var/adm:/sbin/nologin
lp:x:4:7:lp:/var/spool/lpd:/sbin/nologin
sync:x:5:0:sync:/sbin:/bin/sync
shutdown:x:6:0:shutdown:/sbin:/sbin/shutdown
halt:x:7:0:halt:/sbin:/sbin/halt
vcsa:x:69:69:virtual console memory owner:/dev:/sbin/nologin
nscd:x:28:28:NSCD Daemon:/:/sbin/nologin
sshd:x:74:74:Privilege-separated SSH:/var/empty/sshd:/sbin/nologin
rpm:x:37:37::/var/lib/rpm:/bin/bash
jack:x:513:514::/home/jack:/bin/bash
joe:x:514:515::/home/joe:/bin/bash
```

The following points are worth noticing:

- The program **/sbin/nologin** is used by some distributions to display a message like “This account is currently not available” when someone actually manages to login to a system account.
- UID's under 1000 or under 500 are system users which are used for running particular programs. Every process on Linux needs a UID to run as, and processes belonging to different UID's cannot generally interfere with each other. Having special a special UID for each program (e.g. sshd above) largely prevents system processes from interference problems, and contributes to security.
- The comment field is optional, and can be left blank. Usually this is the full name of the user.
- In the example above, shadow passwords are in use, and the password field says simply “x”.

14.2.1 PAM[7]

The **passwd** file defines users that are often referred to as **Unix** users. Other user databases like LDAP and Berkeley db files, can be used for a number of services including shell login.

Authentication in Linux is actually carried out using PAM, the pluggable authentication module. PAM enables the administrator to plug in different types of authentication for different services without altering the programs that either perform the authentication or update the authentication tokens. So it is possible to authenticate mail logins against one database, and ftp logins against another database (although this is not often done in practice).

PAM is configured using a file called **pam.conf** or alternatively a set of files in the directory

7 Not required by the LPIC

/etc/pam.d. The existence of **/etc/pam.d** disables the use of **/etc/pam.conf**.

The following format is used in PAM files

Field	*Description*
Service	The name of the service e.g.~Login,su,ftp. This field is not present in files in **/etc/pam.d** where the file name determines the service.
Type	Which part of the authentication process this module is used for. Valid values are "account" (deciding whether the user has an account) , "auth" (evaluating the authentication credentials presented by the user), "password" (changing the user's password) and "session" (creating a session for the user).
Control	Determines the effect of the module. Valid values include: requisite, required, sufficient, optional.
Module-path	Path to module location. This can be an absolute path, or relative to **/lib/security.**
Module-arguments	Arguments that modify the behaviour of the module.

Try the following:

```
$ ls -l /etc/pam.d/
$ less /etc/pam.d/login
$ diff /etc/pam.d/login /etc/pam.d/su
```

14.2.2 User commands

These are the commands related to controlling user accounts.

- **useradd –** Add a user. Usage: **useradd -[option] username**. A value for each field required in **/etc/passwd** can be specified overriding the defaults. Commonly used options to use are these:
  - **useradd -m** – copy **/etc/skel** to home directory (this is very useful)
  - **useradd -c** – comment field (i.e. the full name of the user)
- **usermod –** Modify user. **usermod** is capable of changing all fields in **/etc/passwd** as well as group membership and account ageing information (see **/etc/shadow**).
- **userdel –** Delete user. The **-r** option will remove the home directory and mail spool as well.
- **chfn –** Changes user information in the comment field. **chfn** assumes that the comment filed contains the following information in a comma delimited format: full name, room no., work phone, home phone, other. An ordinary user can use the command to change their own information (depending on the settings in **/etc/login.defs**).
- **su –** Substitute user. As root, it is possible to run commands as any user, without providing a password to **su**. If the user does not have a useful shell, you can specify one on the command line with the **-s** option. Regular users can also use **su**, but must supply the correct password before proceeding.
- **vipw –** Edit password file or group file, with appropriate locking. The switch **-s** opens up

the shadow file rather than the regular file.

Try the following:

```
# useradd -m bob -c "Bob Cratchit"
# passwd bob
# ls -a /home/bob/
# ls -a /etc/skel
# vipw
# su - bob
$ chfn
$ exit
```

Now change Bob's shell to **/bin/true**

```
# vipw
# su - bob
# su -s /bin/bash - bob
```

Change the shell back to **/bin/bash** and experiment with locking and unlocking bob's account

```
# passwd -s /bin/bash bob
# passwd -l bob
# passwd -u bob
```

14.3 Passwords and the shadow password file

The original Unix password file contained an encrypted version of each plain text password. Authentication was possible, because the same encrypted text would be obtained when encrypting the password supplied in a login attempt. However, with faster computers it became possible to guess the correct password for a user by brute force, so the encrypted passwords were moved from **passwd** and **group** to **shadow** and **gshadow**.

14.3.1 The shadow password file

The **/etc/shadow** password file is not only the location of the user's encrypted password, but also contains password aging information. With this file the administrator can control how often a user must change passwords as well as being able to suspend accounts.

Like **passwd** the **shadow** file is an ascii text file containing colon ":" separated fields.

```
Name:Password:Last-changed:May-change:Must-change-
      warn:Expire:Disabled:Reserved
```

The details of the fields are these.

- **Name –** Login name. This must be a login name listed in **/etc/passwd**
- **Password –** Encrypted password, or * for no password. If there is no password, it is not possible to login as this user. This is not the same as a blank password field, which means that the password is an empty string.
- **Last changed –** Days since Jan 1, 1970 that the password was last changed. This value is set by the **passwd** command.
- **May Change –** Days that must elapse since last password change before the password may be changed. The default value is 0.

- **Must Change Warn –** Days since last password update after which the password must be changed. Default is 99999 days.
- **Warning –** Days before password is to expire that user is warned The default is 7 days.
- **Expire –** Days after password expires that account is disabled. Normally blank i.e. passwords never expire.
- **Disabled –** Days since Jan 1, 1970 that account is disabled. Normally blank i.e. never.
- **Reserved –** A reserved field (not used) (there must always be a reserved field, just in case though).

Note that the password is stored in encrypted format. The encrypted password is generated using the **crypt** routine (see man crypt). The crypt routine is a one way encryption algorithm and therefore it is not analytically possible to derive the password from the encrypted password.

The PAM system when authenticating a user will encrypt the password and then compare the crypt with that in **/etc/shadow**.

PAM can be configured to encrypt passwords using MD5 hashing instead of the **crypt** function. This allows users to usefully specify longer passwords than 8 characters, although the encrypted passwords may not work on another Unix system.

Here is what the shadow password file looks like in real life.

```
foo:~# cat /etc/shadow
root:$1$RBAjCEM7$/P85Bvo1ZzHx/aa9gjJTz.:12083:0:99999:7:::
daemon:*:12083:0:99999:7:::
bin:*:12083:0:99999:7:::
sys:*:12083:0:99999:7:::
sync:*:12083:0:99999:7:::
nobody:*:12083:0:99999:7:::
sshd:!:12084:0:99999:7:::
fred:$1$Rf5XafZU$wpNEtTRGMlLQNKljX3P7D1:12084:0:99999:7:::
george:$1$SjzIzZHa$8qKKn/sW1kXzxWtY7JSo51:12137:0:99999:7:::
```

You may wonder when did george's password change?

```
foo:~# date -d "1 jan 1970 + 12137 days"
Wed Mar 26 00:00:00 SAST 2003
```

Notes about this system:

- The shadow file does not list the UID's of users, but only the names
- There is no valid password for system users which will encrypt to “*” or “!” – this makes it rather difficult for them to log in, which is the point.
- The system shown is using MD5 passwords – the “1” gives that away.
- The passwords can be changed, have not expired, and if they did, the users would receive 7 days notice of it when they log in.

14.3.2 Password commands

These are the commands for changing passwords.

- **passwd –** The **passwd** command edits **/etc/shadow**. The primary use of **passwd** is to

change passwords – either by the user, or by root.

root can use **passwd** change the password of a specified user. All other users can run **passwd** without any arguments to change their own password. **passwd** can also be used to change the account aging information in the shadow file (see **man 1 passwd**)

- **pwconv, pwunconv – pwconv** creates an **/etc/shadow** from **/etc/passwd** and an optionally existing **/etc/shadow**. **pwunconv** creates **passwd** from **passwd** and **shadow** and then removes **shadow**.

Try the following

```
# useradd -m bob
# passwd bob
# su - bob
$ passwd
$ vipw
$ man passwd
```

Force Bob to change his password in 5 days.

```
# vi /etc/shadow
```

Here is an example of using **pwconv** and **pwunconv**. In the process of doing this, the account expiry information may be lost.

```
foo:~# cd /etc
foo:/etc# cat passwd
foo:/etc# ls -la shadow* passwd* group* gshadow*
foo:/etc# pwunconv
foo:/etc# grpunconv
foo:/etc# cat passwd
foo:/etc# ls -la shadow* passwd* group* gshadow*
foo:/etc# pwconv
foo:/etc# grpunconv
foo:/etc# cat passwd
foo:/etc# ls -la shadow* passwd* group* gshadow*
```

14.4 Groups

Each Unix user belongs to at least one group. This is known as the initial group or default group. Membership of this group is indicated by the GID field in **/etc/passwd**. User can belong to other groups as well, these are known as supplemental groups. A group is defined by the **/etc/group** file, which lists the members of the group by name.

14.4.1 /etc/group

The file has the following format:

```
name:X:GID:users
```

The fields are

Field	*Description*	*Comment*
Name	Group name	
X	Optional encrypted	Normally an X when shadow group

Field	*Description*	*Comment*
	password	passwords are used.
GID	Numerical group ID	The unique ID for this group.
Users	Users belonging to the group.	A comma separated list of users. The users who have the group as their initial group are not listed.

The password is used when a user runs the **sg** command to set his group. Any user that provides the correct password to **sg** can become a member of the group.

14.4.2 /etc/gshadow

The **/etc/gshadow** file contains group password and group administrators. The file has the following format:

```
name:crypt:admin:users
```

Field	**Description**	**Comment**
Name	Group name	
crypt	The group's encrypted password	Normally an * which means no password used, if there is no group password the sg command cannot be used.
admin	List of admin users	Admin users can be defined for a group, these users are allowed to add users to the group and to remove users from the group, and also to change the group password.
Users	Users belonging to the group	A comma separated list of users.

The group file looks something like this most of the time. Just as there are system users, there are also system groups.

```
foo@bar:~$ cat /etc/group
root:x:0:root
bin:x:1:root,bin,daemon
daemon:x:2:
sys:x:3:
tty:x:5:
disk:x:6:
lp:x:7:
wwwadmin:x:8:
kmem:x:9:
wheel:x:10:
uucp:x:14:uucp,fax,root,fnet,joe
dialout:x:16:root,joe,tom,dick,harry,fred,mary,elizabeth,beth
users:x:100:
boneheads:x:102:fred,joe
```

14.4.3 Group commands

These are the commands used for group administration.

- **groupadd – groupadd** creates a new group. The group ID's 0-99 are used for system accounts, 100 upwards for groups of human users.
- **groupmod –** Modify group i.e. can change the name or GID of a group. To change the membership of the group you use **gpasswd**.
- **groupdel –** Delete a group.
- **grpck –** Checks the integrity of the **/etc/group** file.
- **newgrp** and **sg –** Can be used to change your group permissions, a kind of group version of **su**. This is of course only possible if the target group has a password, or is one of your supplemental groups.
- **gpasswd –** This command allows you to administer **/etc/group** and **/etc/gshadow**. In general use:

  ```
  gpasswd group
  ```

  to change a group password, or

  ```
  gpasswd -A admin1,admin2 -M member1, member2 group
  ```

  to add administrators or members to a group. Users defined as group administrators can use **gpasswd** to set the password.
- **grpconv, grpunconv – grpconv** creates **/etc/gshadow** from group and an optionally existing **/etc/gshadow**. **grpunconv** creates **/etc/group** from **/etc/group** and **/etc/gshadow** and then removes **/etc/gshadow**.
- **vigr –** Opens the **/etc/group** file in the **vi** editor. **vigr** creates a lock file so that other commands that modify **/etc/group** cannot make conflicting changes. **vigr -s** modifies **/etc/gshadow.**

Commands to manipulate groups ...

```
# groupadd myusers
# vigr                                  # protected vi /etc/group
# grep myusers /etc/gshadow
# gpasswd -A bob myusers
# su - bob
$ gpasswd myusers
$ gpasswd -a student myusers
# vigr
# less /etc/gshadow
```

14.5 Review

Quiz questions

1. What are shadow passwords?
2. What are group passwords used for?
3. What happens to the user's session if you delete a user who is logged in from the password

file?

4. Under what circumstances would you create a group with a password?
5. What steps are necessary to create a user manually?
6. Which directory contains a template for a new user's home directory?
7. Which switch to **useradd** sets the user's shell?
8. What is the difference between **/etc/shadow** and **/etc/gshadow**?
9. How do you suspend a user account?
10. What are accounts with a UID of under 500 used for? How does one create one of these?
11. From left to right, what are the fields in **/etc/passwd** and **/etc/shadow**?
12. When would you use the grpconv command?

Assignment

1. Convert your system from using shadow passwords to using clear hashed passwords in **group** and **passwd**. Is it possible to delete the **shadow** and **gshadow** files at this point? What happens about suspended accounts if you do this?
2. Reverse the process from the previous assignment.
3. Create a new user named **jkrqf** with a shell of **/dev/null**, together with a default home directory. Change all of the user's details using **usermod**, namely his name, UID, comment, home directory and password, being sure to move the files. Check that your changes took effect.
4. Create a 3 new users named **hewey**, **dewey** and **lewey** and a group named **ducks**, by manually editing the relevant files, and manually copying the skeleton directory. (This is more practice with **cp** and **chown** than anything else.) Log in as each of these users and check the group membership using the **id** command.

Answers to quiz questions

1. Encrypted password readable only by root in **shadow** and **gshadow**.
2. You can become a member of the group on the fly if you know the password.
3. Nothing, except that **ls** begins to display UIDs rather than the name of the user.
4. For a group project.
5. Edit **passwd** and **shadow**, and set the password using **passwd**. Create the home directory (e.g. from **skel**), and change its ownership.
6. **/etc/skel**
7. **-s**
8. Users vs. groups.
9. **passwd -l user**
10. System accounts. Use **useradd -u 480** or similar.
11. See man (5) passwd and man (5) shadow.

12. When you have readable encrypted passwords in **/etc/group**, or when you want to use the extended group administration features.

15 The Environment

> "She sells sea shells on the sea shore..."
> "He bashes key slashes on the key board..."
>
> – *Unix environmentalism*

LPIC topic 1.111.2 — Tune the user environment and system environment variables [3]

Weight: 3

Objectives

Candidate should be able to modify global and user profiles. This includes setting environment variables, maintaining skel directories for new user accounts and setting command search path with the proper directory.

Key files, terms and utilities include

env	Show exported environment variables
export	Add an environment variable to the export list
set	Show settings
unset	Remove an environment variable
/etc/profile	Global profile
/etc/skel	Skeleton for new users' home directories

15.1 /etc/skel

When you create a new user using **useradd -m** or **adduser**, the home directory that the user receives is a copy of the files in **/etc/skel**. The files are, however, owned by the user, and can be further customised as necessary.

```
bar:~ $ ls -a /etc/skel
```

If you change the contents of a file in **/etc/skel**, all *new* users will receive a copy of the changed file.

```
bar:~ $ ls -a /etc/skel
.  ..  .bash_logout  .bash_profile  .bashrc  .emacs  .gtkrc  .kde
bar:~ $ cp /etc/inputrc /etc/skel/.inputrc
bar:~ $ vi /etc/skel/.inputrc
```

15.2 Profiles

The global profile is stored in **/etc/profile**. This script is always executed, in addition to the profile scripts in the user's home directory when a new login session is created. Changes to this file therefore affect all users.

The profile set the initial conditions for shell sessions, and may execute scripts. Initial conditions include the values of aliases, shell functions and environment variables.

```
foo@bar:~> less ~/.profile
foo@bar:~> less /etc/profile
```

```
foo@bar:~> less ~/etc/.profile
```

15.3 Environment variables

Environment variables play a major role in the initial conditions of the shell. When a new process is started, it receives a copy of all the **export**ed environment variables. Many processes are customised by the contents of environment variables.

A list of environment variables can be displayed using the **env** command[8].

```
foo@bar:~> env
PWD=/home/foo
PS1=\u@\h:\w\$
USER=foo
MAIL=/var/mail/foo
LOGNAME=foo
SHLVL=1
SHELL=/bin/bash
HOME=/home/foo
TERM=xterm
PATH=/usr/local/bin:/usr/bin:/bin:/usr/bin/X11:/usr/games
_=/usr/bin/env
```

The **export** builtin shows a list of variables which are exported. The output is similar to **env**, but the format is different[9].

```
foo@bar:~> export
declare -x HOME="/home/foo"
declare -x LOGNAME="foo"
declare -x MAIL="/var/mail/foo"
declare -x OLDPWD
declare -x
      PATH="/usr/local/bin:/usr/bin:/bin:/usr/bin/X11:/usr/games"
declare -x PS1="\\u@\\h:\\w\\\$ "
declare -x PWD="/home/foo"
declare -x SHELL="/bin/bash"
declare -x SHLVL="1"
declare -x TERM="xterm"
declare -x USER="foo"
```

Variables in bash can be created by using an assignment statement, e.g. **NAME=VALUE**. The environment variables you create can be accessed in the shell using the syntax **$NAME** – also in double quotes.

Once a variable exists, it can be added to the export list with the **export** builtin – either after assigning a value to it (**export NAME**), or as part of the assignment (**export NAME=VALUE**).

```
foo@bar:~> VAR="30 people did a course"
foo@bar:~> echo $VAR
30 people did a course
foo@bar:~> set | grep ^VAR
```

8 The stated purpose of the **env** command is to run a command in a modified environment i.e. with some or all of the environment variables set to a different value. You can do this directly in bash, e.g. "**A=B command**". **env** is however quite useful for displaying environment variables.

9 The example here is cooked – how can you tell?

```
VAR='30 people did a course'
foo@bar:~> bash           # start a new session
foo@bar:~> echo $VAR      # show the value

foo@bar:~> exit           # end that session
foo@bar:~> export VAR
foo@bar:~> bash           # start a new session to see what export
      did
foo@bar:~> echo $VAR
VAR='30 people did a course'
foo@bar:~> unset VAR      # remove the variable
foo@bar:~> echo $VAR

foo@bar:~> set | grep ^VAR

foo@bar:~> exit           # end that session
foo@bar:~> echo $VAR      # why was it not unset?
VAR='30 people did a course'
```

Notice that the set command can be used to show the value of existing variables, also when the bash command is executed a new shell is entered and the variable **VAR** no longer has a value. The **export** command can be used to expand the scope of a variable to sub shells, as demonstrated above. The command **unset** can be used to remove an environment variable.

PATH

One of the most significant environment variables is the **PATH** environment variable. Often the profile scripts will set the **PATH** environment variable to an appropriate value for local conditions.

```
PATH="$PATH:/opt/oracle/bin"
export PATH
```

HOSTNAME, USER

Some shell scripts rely on the environment variable **HOSTNAME** being set to the host name of the computer. Similarly, some scripts require **USER** to be set to the current user name.

```
USER=`whoami`
HOSTNAME=`hostname`
```

Applications

Various applications are customised by changing environment variables (provided these are exported). Here are some interesting or common examples, which you may find in a user's profile script.

```
# ls
LS_COLORS='no=00:fi=00:di=00;34:ln=00;36:pi=40;33:so=00;35:bd=40;33;
      01:cd=40;33;01:or=01;05;37;41:mi=01;05;37;41:ex=00;32:*.cmd=00
      ;32:*.exe=00;32:*.com=00;32:*.btm=00;32:*.bat=00;32:*.sh=00;32
      :*.csh=00;32:*.tar=00;31:*.tgz=00;31:*.arj=00;31:*.taz=00;31:*
      .lzh=00;31:*.zip=00;31:*.z=00;31:*.Z=00;31:*.gz=00;31:*.bz2=00
      ;31:*.bz=00;31:*.tz=00;31:*.rpm=00;31:*.cpio=00;31:*.jpg=00;35
      :*.gif=00;35:*.bmp=00;35:*.xbm=00;35:*.xpm=00;35:*.png=00;35:*
```

```
      .tif=00;35:
# less
LESS='-M -S'
LESSOPEN='|/usr/bin/lesspipe.sh %s'
# CVS
CVS_RSH=ssh
CVSROOT=cvsserver:/var/cvsroot
# grep
export GREP_OPTIONS='--colour=auto'
export GREP_COLOR='1;31;44'
# Oracle-Client-Access
export ORACLE_BASE=/opt/oracle
export ORACLE_VERSION=8.1.7.
export ORACLE_HOME=${ORACLE_BASE}/products/${ORACLE_VERSION}
export NLS_LANG=german_germany.WE8ISO8859P1
export PATH=${PATH}:${ORACLE_HOME}/bin
export LD_LIBRARY_PATH=${LD_LIBRARY_PATH}:${ORACLE_HOME}/lib
```

15.4 Review

Quiz questions

1. What is the effect on existing users of changing **/etc/skel**?
2. How would you go about adding the directory **/usr/local/sbin** to the **PATH** environment variable for root?
3. Which country is the major exporter of high quality environment variables?

Assignment

Write a bash function for your **.bashrc** which will write the name of the file you are editing to a log file every time your run **vi**. Here's a tip – name the function "vi", and use the full pathname of "vi" when you run it.

Add the following environment variable settings for all users:

- CVS_RSH=ssh
- PS1='\h:\w \$ '
- WHOISSERVER=whois.arin.net

Make sure that the values WHOISSERVER and CVS_RSH are exported to the **whois** application and the **cvs** command. How do you test this?

Answers to quiz questions

1. Nothing.
2. Add **PATH=/usr/local/sbin:$PATH** to **/root/.profile**
3. By international treaty, environment variables do not cross process boundaries, except in the case of parent-child relationships.

16 System logs

LPIC topic 1.111.3 — Configure and use system log files to meet administrative and security needs [3]

Weight: 3

Objectives

Candidate should be able to configure system logs. This objective includes managing the type and level of information logged, manually scanning log files for notable activity, monitoring log files, arranging for automatic rotation and archiving of logs and tracking down problems noted in logs.

Key files, terms and utilities include

logrotate	Move current logs to historical archives
tail -f	Show the end of a file, and watch for changes
/etc/syslog.conf	Configuration file for syslogd
/var/log/*	Logging directory for syslogd and other daemons

16.1 Syslog

System logs are managed by a daemon called **syslogd**. **syslogd** is configured by means of the file **/etc/syslog.conf**. Many applications log to syslog via its API, and a shell command **logger** is provided as an interface to **syslogd**. Experimenting with the **logger** command will give insight into the capabilities of **syslogd**.

16.1.1 syslogd

syslogd is the system logger that is is used to log both userspace programs and kernel messages. The kernel messages are provided to **syslogd** by another daemon called **klogd**.

Programs access **syslogd** via the **syslog** library calls, normally the following information is supplied to be recorded in the configured log files:

A hostname[10], program name, and a message.

syslog timestamps the message and records it in a file. The following messages from **/var/log/messages** illustrate the logging format.

```
Jan  5 23:59:00 bobo  /USR/SBIN/CRON[10896]: (root) CMD ( rm -f
      cron.hourly)
Jan  6 19:06:56 bobo  PAM-unix2[7489]: session started for user root,
      service su
Jan  7 13:30:32 bobo kernel: floppy0: disk absent or changed during
      operation
Jan  8 13:30:32 bobo kernel: end\_request: I/O error, dev 02:00
      (floppy),sector19
```

10 A single **syslogd** can receive log message from remote hosts via a UDP socket, so the host name is relevant.

16.1.2 syslog.conf

In the **syslogd** configuration file, **syslog.conf**, each line represents a separate entry and a "#" indicates a comment until the end of the line.

An entry in a the file has the following format:

```
subsystem.priority, ...   action
```

An asterisk in any of the fields meaning all, or any. If a message matches more than one entry it will be logged in all of the matched locations.

Subsystem

The subsystem from which the log came, this parameter is specified by the source of the logging program. Subsystem has one of the following values:

- **authpriv/security** security/authorization messages (private) (**auth** should not be used, but means the same thing).
- **cron** clock daemon (**cron** and **atd**).
- **daemon** system daemons without predefined subsystem.
- **ftp** ftp daemon.
- **kern** kernel messages
- **lpr** line printer subsystem.
- **mail** mail subsystem.
- **mark** for internal use only.
- **news** USENET news subsystem.
- **syslog** messages generated internally by **syslogd**.
- **user** generic user-level messages.
- **uucp** UUCP subsystem
- **local0-local7** reserved for local use.

Priority

The priority field is used to define the severity of the message and can have one of the following values:

debug, info, notice, warning, warn (same as warning), err, error (same as err), crit, alert, emerg, panic (which is the same as emerg).

- **debug** – A message from debug mode.
- **info** – An informational message.
- **notice** – A normal, but significant, condition.
- **warn** – A warning condition.
- **err** – An error condition.
- **crit** – Critical condition.
- **alert** – An action must be taken immediately.
- **emerg** – The system is unusable.

Action

This field specifies where the message must be logged. This field can be of the following types:

Plain file, Named Pipe, Terminal, Remote machine, List of users.

- **Plain file** – The absolute path to a plain file which will be used as a log. **syslogd** normally sync's the file to disk after a message is written to it in order to prevent loss of data in a system crash. The sync can be omitted if the filename is prefixed with a "-". This can improve system performance and is desirable for low priority messages, particularly if there are a lot of them.
- **Named Pipe** – A named pipe is specified by prepending the file name with a pipe symbol. This feature can be useful for debugging purposes.
- **Terminal** – syslog uses special techniques for handling terminals, if **/dev/tty*** or **/dev/console** is specified as the file name.
- **Remote machine** – A remote machine is specified using @hostname. **syslogd** is capable of sending messages to remote machines. **syslogd -r** causes **syslogd** listen for message from remote machines.
- **List of users** – user names can be specified, in which case the message will appear on their terminal, an "*" in the action field means that all logged-in users receive the message.

Example

A sample of **/etc/syslog.conf**

```
#send messages from the kernal of warning priority to
#the conole on line 10 try alt+F10 to see them
kern.warn;*.err;authpriv.none         /dev/tty10

*.emerg                                          *
#send all messages of emergency priority to all users (like wall)

# enable this, if you want that root is informed
# immediately, e.g. of logins
#*.alert                               root

# all email-messages in one file
mail.*                                -/var/log/mail
mail.info                             -/var/log/mail.info
mail.warn                             -/var/log/mail.warn
mail.err                               /var/log/mail.err
# !! note the use of - for all but error messages

# Warnings in one file
*.=warn;*.=err                        -/var/log/warn
*.crit                                 /var/log/warn

# save the rest in one file
*.*;mail.none;news.none               -/var/log/messages

# enable this, if you want to keep all messages
```

```
# in one file
#*.*                                -/var/log/allmessages

# Some foreign boot scripts require local7
local0,local1.*                     -/var/log/localmessages
local2,local3.*                     -/var/log/localmessages
local4,local5.*                     -/var/log/localmessages
local6,local7.*                     -/var/log/localmessages
```

16.2 Related tools

16.2.1 logger[11]

logger is a shell command which makes use of the **syslog** system calls. **logger** is intended to make it possible to use **syslogd** shell scripts.

The syntax of the logger command is one of these

```
logger The message that is logged
logger -p subsystem.priority The message that is logged
```

It looks a lot like this when you use it.

```
[root@bobo root]# logger A strange message appeared in the logs
[root@bobo root]# logger -p kern.panic "The logger caused a kernel
     panic"
[root@bobo root]#
Message from syslogd@bobo at Sat May 17 11:03:58 2003 ...
bobo root: The logger caused a kernel panic

[root@bobo root]# tail /var/log/messages
May 17 11:03:48 bobo root: A strange message appeared in the logs
May 17 11:03:58 bobo root: The logger caused a kernel panic
[root@bobo root]#
```

Review the system configuration and experiment with the **logger** command.

```
# less /etc/syslog.conf
# less /var/log/messages
# less /var/log/warn
# less /var/log/mail
# grep kernel /var/log/messages | tail
$ logger -p daemon.warn "hello there"
# tail /var/log/warn
$ logger -p daemon.notice "hello there"
# tail -f /var/log/messages
```

Edit **/etc/syslog.conf** such that debug messages go to **/var/log/debug**

```
$ logger -p daemon.debug "hello there"
```

Check that the message arrives where you expect it.

16.2.2 tail

The tail command is useful for viewing log files. **tail** by default shows the last 10 lines of a file. This behaviour can be altered with switches.

11 Not part of the LPIC objectives

```
tail filename
tail -20 filename
```

The first will display the last 10 lines, and the second displays the last 20 lines of the file.

```
tail -f filename
```

tail will initially display the last 10 lines of the file, however **tail -f** does not exit and will display lines added to the file after the command is run. To interrupt **tail -f** use **Ctrl+C**.

```
tail -f /var/log/messages
tail -f /var/log/messages | grep kernel
```

The key **F** in **less** selects the "follow" mode similar to **tail -f**.

16.2.3 Log rotation

Log rotation involves removing the current contents of log files and storing them as archives. This has to be done carefully, since new messages are being logged all the time. There are two ways to do this:

- To make a copy of the log file, and then remove the contents of the file. Programs which are appending to the file are not affected.
- Stop the program which is logging to the file, rearrange the logs, and then restart the program so that it starts writing to a new, clean file.

On most systems logs are rotated regularly to avoid unwieldy files or disk space being eaten away. There is normally a script in **cron.daily** that rotate is a tool to manage the size of log files. The configuration file is **/etc/logrotate.conf** which tells the script which log files to monitor and how large they should be. Log rotation configuration is also stored in **/etc/logrotate.d**.

When a log is found to have exceeded its maximum size it is compressed, given a new name, and a fresh log file is started. The daemon responsible for the logging is also reloaded to ensure logging to the new file proceeds smoothly.

The compressed logfile is normally logfilename-date.gz, e.g. messages is compressed to messages-19910201.gz

16.3 Review

Quiz questions

1. Which file configures the system logger?
2. Which file controls archiving of older logs.
3. How do you monitor a log file for activity?
4. What programs can be used to view a log file?
5. Which program produced the following log message?

```
May 17 10:04:43 bobo rc.sysinit: Initializing USB keyboard:
      succeeded
```

6. Which command line option to **syslogd** configures it to listen to remote log messages?
7. What are the security risks of logging to log files?

Assignment

Configure **syslogd** to log all debug messages to **/var/log/debug**. Edit **/etc/logrotate.conf** or a file in **/etc/logrotate.d** and add **/var/log/debug** as a log file to be rotated if it grows beyond 5Mb.

Answers to quiz questions

1. **/etc/syslog.conf**
2. **/etc/logrotate.conf**
3. **tail -f /var/log/logfile**
4. **less**. You can also use **cat**, **vi**, **head**, **tail**, **grep**, **more**.
5. **rc.sysinit**
6. **-r** – if the capability is compiled in.
7. If a machine is compromised, log files it can write to may be altered or removed. Log files that can be read may contain information useful to an attacker.

17 Scheduling jobs

"We always run on schedule"

– British Rail

LPIC topic 1.111.4 — Automate system administration tasks by scheduling jobs to run in the future [4]

Weight: 4

Objective

The candidate should be able to use **cron** or **anacron** to run jobs at regular intervals and to use **at** to run jobs at a specific time. Tasks include managing **cron** and **at** jobs and configuring user access to **cron** and **at** services.

Key files, terms, and utilities include

at	Run a task at a specific time
atq	Show the queued jobs
atrm	Remove a queued job
crontab	Edit cron jobs
/etc/anacrontab	Jobs run every so many days
/etc/at.deny	Who can't use **at**
/etc/at.allow	Who can use **at**
/etc/crontab	System cron jobs
/etc/cron.allow	Who can use **cron**
/etc/cron.deny	Who can't use **cron**
/var/spool/cron/*	User cron jobs

17.1 The cron daemon

Cron is a daemon which wakes up once every minute to execute tasks that have been scheduled. Jobs can be scheduled to run on the minute, hour, day of month, or month. Each job is a one-line shell script, and runs as specific user.

17.1.1 Crontab

The file **/etc/crontab** is the main configuration file for **cron**.

Each line in crontab specifies a schedule for a certain task to be executed.

A crontab entry has the following format:

```
min hour day-of-month month day-of-week user command
```

Where:

- **min** is the minute(s) to execute the command. A numerical value between 0-59.
- **hour** is the hour(s) to execute the command. A numerical value between 0-23.
- **day-of-month** is the day(s) of the month to execute the command. A numerical value

between 1-31.

- **month** is the month(s)of the year to execute the command. A numerical value between 0-12 or names such as Jan, Feb, etc.
- **day-of-week** is the days(s) of the week to execute the command. A numerical value between 0-7 (Sunday is 0 and 7) or names such as Mon, Tue, Wed, etc.
- **user** is the user the command must be executed as.
- **command** is the command line to execute.

Each of the time fields above can have the these values:

- * meaning every minute, hour, day etc.
- */x where "x" is a number meaning every "x" minutes, hours, or days etc.
- a comma separated list eg 8,10,12
- a range as in Mon-Fri

Example crontab entries:

```
0 0 * * * root /usr/bin/updatedb          #run updatedb at midnight every
      day
*/15 8-16 * * mon-fri mail fetchmail      # run fetchmail as user mail
      every
                                          # 15 min weekdays 8am to 4pm
0 3 1,10,20 * * root dump -5uf /dev/st0 / # Do a dump on the 1st 10th and
      20th
```

Each user has their own crontab in **/var/spool/cron/tab/username**. This can be edited using **crontab -e** which brings up the file in the vi editor. User crontabs have the same format as the **/etc/crontab** file, except the username field is not present.

17.1.2 Cron directories

Scripts contained in these directories are executed by **cron** on an hourly, daily and monthly basis respectively. These scripts are triggered by entries in **/etc/crontab**.

- /etc/cron.hourly/*
- /etc/cron.daily/*
- /etc/cron.monthly/*

17.1.3 Permissions

The following files control access for crontab:

- The allow file – **/var/spool/cron/allow** or **/etc/cron.allow**
- The deny file – **/var/spool/cron/deny** or **/etc/cron.deny**

If the allow file exists your user name must appear in it to use the **crontab** command. If the deny file exists, your user name must not appear in it. If neither file is present, either everyone or nobody will be able to use **crontab** (depending on compile time options).

17.2 at

at is a command that queues jobs to be done at a specified time. The **at** command relies on the **atd** daemon to perform the task.

at is used in this manner:

```
at [ -f script ] HH:MM
```

The **-f** option indicates that the commands are to be read from a file instead of stdin. The time can be specifed in the extended posix format.

Other commands in the **at** suite include:

- **atq** lists the user's pending jobs, unless the user is the superuser: in that case, everybody's jobs are listed. The format of the output lines (one for each job) is: Job number, date, hour, job class.
- **atrm** deletes jobs, identified by their job number.
- **batch** executes commands when system load levels permit; in other words, when the load average drops below 0.8, or the value specified in the invocation of **atrun**.

Here are a list of the files used by **at**:

- **/var/spool/atjobs** – currently queued jobs.
- **/var/spool/atspool** – jobs in process.
- **/proc/loadavg** – when the machine is busy, **at** jobs may be postponed (see also the output of **uptime**).
- **/var/run/utmp** – who is logged in (or who is running at jobs).
- **/etc/at.allow** – who can use **at**.
- **/etc/at.deny** – who can't use **at**.

17.3 Review

Quiz questions

1. What is the key difference between **cron** and **anacron**?
2. How does **at** differ from **cron**?
3. What are the fields in **/etc/crontab** from left to right?
4. When are the following cron jobs run?

```
*   *  *  *  *       /usr/local/bin/cronjob1
0   *  *  *  *       /usr/local/bin/cronjob2
*   0  *  *  *       /usr/local/bin/cronjob3
15 14  1  *  *       /usr/local/bin/cronjob4
```

5. Under what circumstances would the text in the previous question appear?
6. How does one specify the command to be run by **at**, and how does one specify the time at which it is run?
7. Which files control access to the **cron** and **at** services?

cron exercise

1. Investigate the **cron** files:

```
# /etc/init.d/cron status
# vi /etc/crontab
$ crontab -e
```

2. Create an entry using **crontab** to run **updatedb** as root every 2 minutes, and then try the following:

```
$ top
# ls -l /var/spool/cron
```

at exercise

1. Install **at** and ensure **atd** is running
2. Run the following commands

```
$ echo "mail -s hello root" | at 11:30
$ atq
$ atrm 1
$ echo "mail -s hello root" | at 11:32
$ atq
```

Answers to quiz questions

1. **cron** works on regular times, **anacron** on the interval between jobs.
2. **at** runs jobs once, **cron** repetitively.
3. minute, hour, day of month, month, day of week, user, command, arguments ...
4. Every minute, on the hour, every minute from 00h00 to 00h59, at 14h15 on the first day of each month.
5. **crontab -l** or **crontab -e** for a user – there is no user name.
6. Command as standard input. Time on command line.
7. /etc/cron.{allow,deny} or /var/spool/cron/{allow,deny}, and /etc/at.{allow,deny}, but dependant on compile-time options.

18 Backup strategy

"He who does not plan for failure, plans to fail...."

– Itold Yaso[12]

LPIC topic 1.111.5 — Maintain an effective data backup strategy [3]

Weight: 3

Objective

Candidate should be able to plan a backup strategy and backup filesystems automatically to various media. Tasks include dumping a raw device to a file or vice versa, performing partial and manual backups, verifying the integrity of backup files and partially or fully restoring backups.

Key files, terms and utilities include

cpio	archiver with list of files on standard input
dd	direct dump
dump	backup a filesystem (ext2)
restore	restore from a "dump" backup
tar	tape archive program

18.1 Backup and system recovery

18.1.1 Backup definitions

There are a few terms used to describe different types of backup in this document.

- Full backup – by this we mean a backup of the entire filesystem of the machine or set of machines in question is backed up.
- Partial backup – a backup of a part of the file system.
- Incremental backup – a backup of files that have changed since some specified previous backup.

18.1.2 Backup policy and disaster recovery

Every system needs a backup policy which would form part of a disaster recovery plan. Most corporations have some sort of disaster recovery policy – particularly with systems that form part of their financial system.

A simple backup policy addresses four issues:

- **what** to backup
- **how often** to backup
- the backup **type**
- how to **store** the backup (including the issue of **where**).

12 Bu'tcha dinnae wanna listen

What to backup

There are a number of approaches to deciding what to backup. Simplistically speaking, you need to backup anything that can change after installation and that contains information that you need. Whether or not you need to backup the *entire* system as is (a full backup) or just the *data* that changed since installation (partial backup), would depend upon the difficulty and time involved in: reinstalling, applying any patches needed and loading all incremental and/or all partial backups.

It boils down to a cost vs risk debate:

1. Calculate how the long will it take to reinstall using each method.
2. Calculate the cost of reinstallation considering labour and down-time costs.
3. Compare this to the cost of the backup technique over the mean time to failure.

Here we go:

	Monthly baseline + incremental backups	***Full backup every time***
1. Time to reinstall – based on number of tapes that must be read, plus some initial time.	1 hour setup, 3 tapes at 2 hours each 7 hours	1 hour setup, 1 tape at 2 hours 3 hours
2. Cost of reinstallation. Labour at R500 per hour, lost production at R5000 per hour.	7 * R5500.00 R38500.00	3 * R5500.00 R16500.00
3. Cost of backups during this time.		
Number of tapes per month	3 tapes	10 tapes
Number of months	120 months	120 months
Cost of tapes	R100.00 per tape	R100.00 per tape
Total cost over period	R36 000.00	R120 000.00

In this case, it is preferable to make a baseline backup and incremental backups, as the cost of the media far outweighs the benefit of being able to recover from failure faster. Factoring in the re-use of tapes is left as an exercise to the reader.

How often to backup

This decision needs to be made for every type of backup that you make. Here again the cost issue plays a role. The relevant comparison is the cost of one days lost production vs the cost of additional backups and the risk of failure.

How and where to store the data

Various media are available to us. The factors which determine which media should be used are cost of media, capacity, and reliability. The storage location of the media also needs to be considered, one would want to minimise the risks of storing all backups in one place.

18.1.3 Backup tools

A few backup tools have been selected here. Some fullfill different services to the others. The type of tool you will use may depend on the size of the system involved, the backup media and the skill of the user performing the backup (or the ability of the automated backup).

mt

mt controls a magnetic tape. By default, it will use the device **/dev/tape**, although you should make this a link to **/dev/st0** or similar. **mt** provides a mechanism to rewind, retension, eject and erase a tape.

```
mt rewind                  # rewind /dev/tape
mt -f /dev/ht0 eject       # eject /dev/ht0
mt erase                   # erase the tape
```

mt also provides a number of positioning and tape control commands.

tar and cpio

Tar stands for tape archiver. Tar is a well known and widely used archiving tool, orginally designed for tapes. The tool is quite often used to send compressed files over the internet.

Review of tar command

tar has three main functions:

Create	Create a new archive	**tar -c** or **tar --create**
Extract	Extract files from an archive	**tar -x** or **tar --extract**
List	List contents of archive or test the archive	**tar -t** or **tar --list**

The following supplementary options that are commonly used together with the main options.

File	Use a file name instead of stdin or stdout	**tar -**[c or x]**f filename** or **tar** --create **--file=filename**
Verbose	Display information while processing archive	**tar -v** or **tar --verbose**
Use gzip	Use gzip compression while either extracting, listing or creating an archive	**tar -z** or **tar --gzip**
Use bzip2	Use bzip2 compression while either extracting, listing or creating an archive	**tar -j** or **tar –bzip2** (**tar -I** in some versions of **tar**)

Example[13]

```
tar -zcvf tarfile.tar.gz /usr/local/
```

This command will create a gzipped tar archive called tarfile.tar.gz of all the files in **/usr/local**

13 What do you think happens if you run the command **tar -czf tarfile.tar.gz**? What is included in the archive?

Backups with tar

When doing backups with tar it is useful to use some of the following features:

Multi Volume **-M** or **--multi-volume**	This allows you to make backups to multi-volume media like multiple tapes of zip drives etc.
Volume Length **-L --tape-length=N**	Not all tape drives report an end of tape correctly. It is often necessary to specify the size of the media. The tape lenght will be 1024xN.
New Volume Script **-F**, **--info-script=F**, **--new-volume-script=F**	You can run a script every time the tape changes. This script could be used to interact with an automated tape changer, or simply to ask the user to change the tape.
Verify Backup **-W**, **--verify**	This option causes tar to attempt to verify the archive after writing it. Not all media support this option.
Apend to Archive -r --apend	This option works like the \cmd{-c}, except that the file is not overwriten, it is merely appended to.
Update Archive **-u --update**	Updating an archive is similar to append except that newer files will overwrite files by the same name.
Incremental using list **-g**, **--listed-incremental=F**	This option uses a list file to determine what files where last backed up and what their time stamp was. This method is very useful in a structured backup scenario.

Here we create archives using the file **inc.status** to store dates and times of files as we go.

```
% tar -c -l -g inc.status -f baseline.tar /etc
% touch /etc/motd
% tar -c -l -g inc.status -f inc1.tar /etc
% touch /etc/issue
% tar -c -l -g inc.status -f inc2.tar /etc
```

You will notice that the second incremental backup does not contain **/etc/motd**. Both backups contain all the directories however.

tarfix

The tarfix package contains tools that can handle corrupted tar files:

- **tarl** is a tool to list the contents of of a corrupted tar file.
- **targ** attempts to extract specified files from a damaged tar file.

cpio

cpio is similar to **tar** in the kind of functionality it provides, **cpio** is in fact used in the RPM package manager. **cpio** can work with a number of file formats, including **tar**.

cpio differs from **tar** in the following ways:

- The file list is passed to **cpio** on standard input.

- **cpio** handles a number of different backup formats.
- **cpio** does *not* remove leading slashes from file names as **tar** does (this can be very surprising).
- **cpio** does not offer tape changing and incremental backups (although you can specify a list of files that is effectively an incremental backup).
- The **cpio** format stores filesystem information like inode numbers.

cpio -o creates an archive on standard output consisting of the files listed on standard input.

```
find /etc | cpio -o -H crc > backup.cpio
find /etc | cpio -o -H ustar > backup.tar
```

cpio -i reads an archive from standard input and creates the files.

```
cpio -i  < backup.cpio
cpio -i < backup.tar
```

dd

dd does a direct dump of data. It is intended for reading a block device, and writing to a block device, or a file. **dd** is not generally used as a backup tool, because it is likely that the data will change while it is being read, and that the backup will be inconsistent.

The syntax for **dd** is a little different from other command line tools, in that it does not use switches, but named parameters:

```
dd if=input-file of=output-file bs=block-size count=how-many-blocks
```

The "input file" defaults to standard input, the output file defaults to standard output[14], and the block size defaults to 512 bytes. By default **dd** will dump as many blocks as are available on the media.

To create a backup of a floppy disk, you can do this.

```
dd if=/dev/fd0 of=floppydiskimage bs=18k
dd < /dev/fd >floppydisk
```

If you boot a rescue system, **dd** can clone a partition from a faulty hard drive like this – assuming that the target and destination are the same size.

```
dd if=/dev/hda1 of=/dev/hdc1 bs=4096k conv=noerror
```

dump

Dump is a fully featured backup tool intended specifically to backup e2fs file systems to tapes (although it is conceivable that it may be implemented for other filesystems).

Dump works with levels 0-9 where 0 is a baseline back up. Any level greater than 0 is an incremental backup, where all files are backed up that have been modified since the last dump of a lower level. The default dump level is 9. Dump records the time stamp and level of backup in a file called **/etc/dumpdate**. Dump also looks at the fifth field in **/etc/fstab** to determine which partitions should be included in a dump.

A typical **dump** command line:

```
dump -0uf /dev/st0 /home
```

14 Some older versions of **bash** will fail if you attempt to dump more than 2Gbytes of data to standard output or from standard input.

This will perform a baseline dump on the first SCSI tape of the **/home** partition.

Some useful options to **dump** include:

-B	No. of 1k blocks per volume. Useful on tapes that don't correctly report end-of-media.
-F	Script to execute when changing tapes.

Restore

Restore is used to extract a dump backup.

```
restore -xf /dev/st0 /home/student
```

This will only extract from the dump on **/dev/st0** the named home directory. When restoring from a full backup onto a pristine system, the **-r** (rebuild file system) option can be used.

18.1.4 Backup solutions

Apart from taper (**taper -T file -f backupfile.tar**), a number of packaged backup solutions exist. More than simply making a copy of your data, these tools may provide management of the backup process as well as tracking tapes with a database to make it easy to determine which tape has the latest version of a certain file.

Amanda

The Advanced Maryland Automatic Network Disk Archiver is a sophisticated backup management tool. Amanda is free software and makes use of the **dump** command to perform the actual backups.

Arkeia

Arkeia is a commercial backup solution from Knox software. Arkeia has a pleasant easy to use Java client to manage the server which actually performs the tape-backups. Arkeia is designed to work with tapes in a large system environment.

mkcdrec

This tool creates a complete image of your filesystem onto CDs. This is useful for a full backup, especially if it can be contained on a single CD. The image that **mkcdrec** creates is a bootable system that can reinstall the system as it was.

18.1.5 Partition and filesystem recovery tools

If you have a corrupted system, it is not always necessary to resort to backups (although it is by far preferable to have a backup available).

badblocks

badblocks finds bad (unreliable) blocks on a specified partition. It is normally used like this:

```
badblocks /dev/sda3 > badblocklist
```

The "badblocklist" file is then passed to an appropriate filesystem tool (e.g. **mkfs**). Usually, however, **badblocks** is not run directly, but is invoked with the correct block size by the **-c** option to **fsck**.

fsck – file system check

fsck is a file system integrity scanner and repair tool. There is a version of **fsck** for each disk filesystem that Linux supports. **fsck** is run on every file system that has a non-zero entry in the sixth field of **/etc/fstab** at boot time. If the filesystem was not unmounted cleanly or a certain time period has passed since the last time **fsck** will check the filesystem thoroughly. If a fault is detected which requires intervention, the file system will be mounted read-only[15] and the user forced to login as root and run **fsck** manually.

fsck is normally used as follows:

```
fsck /dev/hda1
```

Useful options include

-a	Check all filesystems, and automatically repair without asking questions.	This option is used at boot time. Note some errors cannot be repaired automatically, since they involve questions about what to do with apparently corrupted data.
-A	Use **/etc/fstab** to determine what to check.	This option is used at startup.
-s	Serialise	This option is used when you wish to run fsck manually on a number of file systems.

dumpe2fs – display "valuable" information

dumpe2fs displays information about the structure of the e2fs file system. This information is useful if the superblock is overwritten or corrupted.

```
foo:~ # dumpe2fs /dev/hda3 | head
dumpe2fs 1.27 (8-Mar-2002)
Filesystem volume name:   HOME
Last mounted on:          <not available>
Filesystem UUID:          ad6b0e85-3d19-4162-a078-8e40856e4e5a
Filesystem magic number:  0xEF53
Filesystem revision #:    1 (dynamic)
Filesystem features:      has_journal filetype needs_recovery
     sparse_super
Filesystem state:         clean
Errors behavior:          Continue
Filesystem OS type:       Linux
Inode count:              515072
```

There's more information than that – including the location of alternative superblocks.

15 It is a Bad Idea™ to **fsck** a filesystem which is mounted read-write.

Using a rescue disk

If a file system or disk boot record is somehow damaged such that the system will not boot, a rescue disk is needed. This disk will boot up a minimal file system with the root partition being a RAM disk. You will then be able to perform whatever maintenance tasks are needed on the file system, if it is still there.

Most distributions have a rescue disk image available on the installation media.

sfdisk – partition table manipulator

sfdisk is similar to **fdisk**, but can act in an automated way. **sfdisk** provides method of saving and restoring partition table information. The option that does this is **-d** (dump the partitions of a device in a format useful as input to **sfdisk**).

For example, the following commands will write and read the partition table from a file on a floppy disk.

```
sfdisk -d /dev/hda > /media/floppy/hda.out
sfdisk /dev/hda < /media/floppy/hda.out
```

Of course, using **sfdisk** on a system which has already been partitioned can be fatal.

gpart – guess partitions

gpart is a tool to try and restore a damaged partition table. It does this by making fake partitions and then attempting to mount these partitions as filesystems. If you overwrote your partition table with **sfdisk** by following the text above, you will need to use **gpart** to recover your original partition table.

```
# gpart /dev/hda
```

18.2 Review

Quiz questions

1. What are the differences between **cpio**, **dd**, **dump/restore** and **tar**?
2. What is the syntax for the **dd** command?
3. Under what circumstance should you use **cpio** in preference to **tar**?
4. Which files configure the behaviour of **dump**?
5. Which commands are capable of backing up a filesystem to tape.
6. What will the following command do?

```
tar cjvf file /
```

Assignment

Make a minimal backup of your system. Test whether this backup works by wiping your system clean and then restoring from the backup. Is your backup practical? How can it be improved?

Answers to quiz questions

1. **cpio** takes a list of files from standard input, while **tar** takes its list of files as command line parameters. **dd** reads any form of data, while **dump** reads only a filesystem. You can also compare the number of letters in each command (2 for **dd**, 3 for **tar**, 4 for **cpio** and **dump** and 7 for **restore**).
2. **dd if=input-file of=output-file** (and more)
3. You would use **cpio** to read a **cpio** archive (duh). **cpio** has a copy-pass function that you may like to use for copying. For certain types of media errors, **cpio** can be more robust.
4. **/etc/fstab** (and **/etc/dumpdate**, to a small extent)
5. tar, cpio, dd, dump
6. Create a bzip2 compressed tar archive named './file' containing all files in the filesystem (including **/proc**). It will print file names as it proceeds.

19 System time

time flies you cannot they pass by at such irregular intervals

– a punctuation puzzle

LPIC topic 1.111.6 — Maintain system time [4]

Weight: 4

Objective

Candidate should be able to properly maintain the system time and synchronize the clock over NTP. Tasks include setting the system date and time, setting the BIOS clock to the correct time in UTC, configuring the correct timezone for the system and configuring the system to correct clock drift to match NTP clock.

Key files, terms, and utilities include

date	Show or set the system software clock
hwclock	Manipulate the hardware clock
ntpd	Network Time Protocol Daemon
ntpdate	Set clock via NTP protocol
/usr/share/zoneinfo	Time zone definition files
/etc/timezone	Text version of current timezone on some distributions
/etc/localtime	Local time zone selection
/etc/ntp.conf	**ntpd** configuration file
/etc/ntp.drift	The rate at which your clock drifts from the real time

19.1 Setting the clock

When Linux boots up, it obtains the current system time from the battery backed-up hardware clock, and sets the system clock, which is maintained by the CPU. The system clock is used as the time reference for all applications.

date

The program **date** is used to access the system clock, and it can also be used to set it.

```
bar:~ $ date
Wed Jun 18 15:51:09 SAST 2003
```

The **date** command will also display the date in a particular format – the format is described in a parameter starting "+".

```
bar:~ $ date '+%D %T'
06/18/03 15:51:20
bar:~ $ date '+%H:%M:%S %Y/%m/%d'
15:51:44 2003/06/18
```

You can display a different date to the current date

```
foo:~ $ date -d 'yesterday'
Tue Jun 17 15:53:47 SAST 2003
```

```
foo:~ $ date -d '2 months ago'
Fri Apr 18 15:53:52 SAST 2003
foo:~ $ date -d '16 jun 2001'
Sat Jun 16 00:00:00 SAST 2001
foo:~ $ date -d '16 jun 2001 12:55:01'
Sat Jun 16 12:55:01 SAST 2001
foo:~ $ date -d '16 jun 1965 12:55:01'
date: invalid date `16 jun 1965 12:55:1'
foo:~ $ date -u -d '1 jan 2039'
date: invalid date `1 jan 2039'
```

You may wonder why **date** can't display dates before 1960, or much after 18 January 2038 or so (your implementation's limits may vary). The reason for this is that the beginning of time, according to many Linux applications, was 00h00, 1 January 1970 (GMT). The internal representation of time in these applications is the number of seconds that have passed since then (since Unix time began), and only 32 significant bits are allowed.

date can display the date of a particular file too.

```
foo:~ $ date -r /lib/ld.so
Mon Oct 30 13:52:51 SAST 2000
```

hwclock

The **hwclock** command manipulates the hardware clock – the same clock that the BIOS setup program will allow you to adjust. When you change the system clock using **date** the hardware clock is not affected.

```
foo:~ # hwclock
Fri 27 Jun 2003 14:01:24 SAST  -0.462635 seconds
foo:~ # hwclock --help
hwclock - query and set the hardware clock (RTC)

Usage: hwclock [function] [options...]

Functions:
  --set         set the rtc to the time given with --date
  --hctosys     set the system time from the hardware clock
  --systohc     set the hardware clock to the current system time
  --adjust      adjust the rtc to account for systematic drift since
                the clock was last set or adjusted

Options:
  --utc         the hardware clock is kept in coordinated universal
      time
  --localtime   the hardware clock is kept in local time
  --directisa   access the ISA bus directly instead of /dev/rtc
  --date        specifies the time to which to set the hardware
      clock
  --noadjfile   do not access /etc/adjtime. Requires the use of
                either --utc or -localtime
```

There are two ways to use the hardware clock. The hardware clock can either be set to local time in your current time zone, or it can be set to UTC. It is preferable to set the hardware clock to UTC, since this means that when you visit another timezone, you only configure your

time zone, and not your system clock too.

When you boot your system, the value of the hardware clock is copied to the system clock using one of the following commands:

```
hwclock --hctosys --utc              # BIOS clock is UTC
hwclock --hctosys --localtime        # BIOS clock is local time
```

To configure your distribution to use the correct one of these you will need to modify one of the following files to set the system time with the appropriate offset (depending on which distribution it is)

```
/etc/sysconfig/clock      # Redhat, newer SuSE - HWCLOCK value
/etc/rc.config            # SuSE - GMT value
/etc/defaults/rcS         # Debian - UTC value
```

19.2 Time zones

Commands that need to manipulate the time on Linux refer to the file **/etc/localtime** to find out the time zone the machine is in.

```
foo:~ $ strace -e open date
...
open("/etc/localtime", O_RDONLY)        = 3
Tue Jul  8 14:44:35 SAST 2003
```

/etc/localtime is either a symbolic link, or a copy of a file in **/usr/share/zoneinfo**. This is usually set during installation.

```
foo:~ $ ls -F /usr/share/zoneinfo/
Africa/      Cuba     GMT+0      Kwajalein  Pacific/   W-SU
America/     EET      GMT-0      Libya      Poland     WET
Antarctica/  EST      GMT0       MET        Portugal   Zulu
Arctic/      EST5EDT  Greenwich  MST        ROC        iso3166.tab
Asia/        Egypt    HST        MST7MDT    ROK        posix/
Atlantic/    Eire     Hongkong   Mexico/    Singapore  posixrules
Australia/   Etc/     Iceland    Mideast/   SystemV/   right/
Brazil/      Europe/  Indian/    NZ         Turkey     zone.tab
CET          Factory  Iran       NZ-CHAT    UCT
CST6CDT      GB       Israel     Navajo     US/
Canada/      GB-Eire  Jamaica    PRC        UTC
Chile/       GMT      Japan      PST8PDT    Universal
```

If your timezone is SAST (South African Standard Time), the contents of **/etc/localtime** will have been set by the timezone compiler **zic** something like the following.

```
% zic -l "Africa/Johannesburg"
```

19.3 Network time protocol (NTP)

The hardware and software clocks used in computers are not entirely accurate. Either the clock runs too fast or too slow, or it is just a little unpredictable because of changes in temperature and other operating conditions. Without adjustment, a PC's clock will drift from the real time by around 1 second per day. The network time protocol allows you to synchronise your computer's clock to UTC (Universal coordinated time) using a reliable time source.

ntpdate

The simplest way to use NTP is to query a time server using **ntpdate**. **ntpdate** queries the time server and adjusts the local clock before exiting.

```
bar:~ # ntpdate -?
usage: ntpdate [-bBdqsuv] [-a key#] [-e delay] [-k file] [-p
      samples] [-o version#] [-r rate] [-t timeo] [-U username]
      server ...
bar:~ # ntpdate tick.mikom.csir.co.za
 8 Jul 13:10:08 ntpdate[3946]: step time server 146.64.58.41 offset
      38.278329 sec
bar:~ # ntpdate tick.mikom.csir.co.za
 8 Jul 13:10:11 ntpdate[3947]: adjust time server 146.64.58.41
      offset 0.020943 sec
```

Notice that the first time, the clock was stepped (a big jump). The second time the time was it was simply adjusted (a small jump)[16].

```
bar:~ # ntpdate tick.mikom.csir.co.za
 8 Jul 13:16:20 ntpdate[4048]: adjust time server 146.64.58.41
      offset 0.024110 sec
```

To see the value on the remote clock, **ntpdate -q** (query) can be used:

```
bar:~ # ntpdate -q tick.mikom.csir.co.za
server 146.64.58.41, stratum 1, offset -13.503067, delay 0.07750
 8 Jul 14:06:29 ntpdate[23340]: step time server 146.64.58.41 offset
      -13.503067 sec
```

(x)ntpd[17]

Time is a continuous and steady stream so **xntpd** updates the clock in small quantities.

To configure **xntpd**, the following is sufficient for **/etc/ntpd.conf**:

```
server 132.199.176.10     # some NTP server's IP address
driftfile /etc/ntp.drift  # remember the drift of the local clock
```

The **server** line tells **xntpd** which server it should consult as a reference of the time. The **driftfile** line tells **xntpd** to record the drift of your system clock every hour. When **xntpd** is started (e.g. after a power failure), the drift file is used to determine the initial adjustment for the clock.

```
user@foo:~ > cat /etc/ntp.drift
-112.950
```

19.4 Review

Quiz questions

1. What is the command to set the system time to 15h55.
2. What command would you use to set the system clock to 6:44 pm 23 January 2004?

16 The ntpdate documentation explains that the adjustment is actually 50% larger than the measured difference in time. This will tend to keep a badly drifting clock more accurate. This is noted as a *bug*.

17 **xntpd** is "extended" **ntpd**. However, **xntpd** is the only implementation of the latest edition of the time protocol.

3. If the BIOS clock is stored in UTC format, how does one set it?
4. Does **ntpd** adjust the hardware or not?
5. Which file sets the system's time zone, and how does one change to another time zone?
6. How are changes written to **/etc/ntp.drift**, and under what circumstances are the contents of this file used?
7. What information appears in the directory **/usr/share/zoneinfo**?

Assignment

1. Set up your computer to use UTC rather than local time for the hardware clock. Reboot and see whether the change has taken effect as you expected. (If your computer is already set up for UTC, change to local time instead.)
2. Change your system's timezone. Does the change survive rebooting?
3. Use **ntpdate -q** to measure the difference between your system's time and the real time. Record this value. Set up a NTP daemon to keep your clock synchronised with the real time and ensure that it is in the startup sequence. After running NTP for a few hours, use **ntpdate -q** again to measure the difference between your time and the real time again.

Answers to quiz questions

1. date --set 15:55
2. date --set '20040123 06:44'
3. hwclock --systohc
4. ntp only adjusts the system clock
5. /etc/localtime – link to or copy a file from /usr/share/zoneinfo
6. The ntp server writes to the drift file hourly. In the case of a reboot, the drift file is used to determine the initial adjustment for the clock.
7. Definitions for timezones across the world.

20 TCP/IP

```
/*
 * [...] Note that 120 sec is defined in the protocol as the maximum
 * possible RTT.  I guess we'll have to use something other than TCP
 * to talk to the University of Mars.
  * PAWS allows us longer timeouts and large windows, so once
implemented
 * ftp to mars will work nicely.
 */
```

– from /usr/src/linux/net/inet/tcp.c, concerning RTT [retransmission timeout]

LPIC topic 1.112.1 — Fundamentals of TCP/IP [4]

Weight: 4

Objective

Candidates should demonstrate a proper understanding of network fundamentals. This objective includes the understanding of IP-addresses, network masks and what they mean (i.e. determine a network and broadcast address for a host based on its subnet mask in "dotted quad" or abbreviated notation or determine the network address, broadcast address and netmask when given an IP-address and number of bits). It also covers the understanding of the network classes and classless subnets (CIDR) and the reserved addresses for private network use. It includes the understanding of the function and application of a default route. It also includes the understanding of basic Internet protocols (IP, ICMP, TCP, UDP) and the more common TCP and UDP ports (20, 21, 23, 25, 53, 80, 110, 119, 139, 143, 161).

Key files, terms, and utilities include

/etc/services	TCP and UDP service numbers
ftp	File transfer protocol
telnet	Connect to a TCP service
host	DNS query program
ping	Network table tennis program
dig	DNS query program (verbose)
traceroute	Network routing path discovery
whois	Query IP and DNS allocations

20.1 IP and other animals

Networks connect computers. Connected networks form an *internet*, or in the case of the worldwide network, the Internet. The Internet Protocol (IP) provides a way for computers on the Internet to communicate with each other.

IP capabilities

Any machine connected to the Internet can send an IP packet to any other machine on the Internet[18]. To communicate with any given machine, all that is required is the IP address of the destination, and a common understanding of the protocol to be used.

The most commonly used IP protocols are these:

- ICMP – Internet control message protocol. ICMP packets transmit information about network problems and adjustments. As an example, when TCP or UDP packets are dropped, an ICMP packet is sent to the sender which explains the reason (if it gets through).
- UDP – User datagram protocol[19]. A UDP packet which is transmitted is simply sent into the network towards its destination address. If it arrives, the other side may choose to respond, or not respond, depending on the contents of the packet that was sent.
- TCP – Transmission Control Protocol. TCP provides a "reliable" network connection stream. **telnet** and **ftp** both rely on TCP.

Other IP protocols do exist, but are not as commonly used as TCP, UDP and ICMP. An example of another IP protocol is GRE, Generic Routing Encapsulation, which is used for tunnelling other protocols via IP routers.

20.2 IP addressing

Dotted quad

An IP address is 4 bytes long, or 32 bits. The four bytes of the IP address are usually written in dotted quad notation, ie. four numbers (in the range 0 to 255, inclusive) separated by dots –

```
192.168.33.12
```

Network mask

The network mask is associated with IP addresses, and indicates how many bits of the IP address is shared with the rest of the local network (subnet). A very common subnet is that the first 24 bits are the same in the subnet:

```
255.255.255.0
```

If you were to write that in binary, it would look something like this

```
11111111.11111111.11111111.00000000
```

To indicate the number of bits in the network mask, the following format is used:

```
network.address/bits
```

So the following are equivalent representations for the network 192.168.44.0-255:

```
192.168.44.0/255.255.255.0
192.168.44.0/24
```

Broadcast address and network address

The first numerical address in the subnet is the network address, and the last address in the

18 Well, that's the big idea, anyhow.

19 Sometimes incorrectly called Unreliable Delivery Protocol.

subnet is (usually) the broadcast address. The network address is intended for use by unconfigured devices (but is seldom used). All machines on the network receive traffic sent to the broadcast address. Broadcasting is used by some LAN networking protocols (e.g. Netbios and lisa).

CIDR – Classless Inter-Domain Routing

When IP routing was originally designed, it was intended that only class A, B and C networks would be used. The netmask would be either 8 (class A), 16 (class B) or 24 bits (class C). Classless Inter-Domain Routing (CIDR) uses any netmask from 13 to 27 bits. This makes it possible to simplify routing rules.

Here is a table of netmasks:

Netmask	*/xx*	*Binary netmask*	*Addresses*	*Comment*
255.0.0.0	/8	11111111.00000000.00000000.00000000	16777216	Class A subnet (seldom used)
255.255.0.0	/16	11111111.11111111.00000000.00000000	65536	Class B subnet
255.255.255.0	/24	11111111.11111111.11111111.00000000	256	Class C subnet
255.255.255.128	/25	11111111.11111111.11111111.10000000	128	
255.255.255.192	/26	11111111.11111111.11111111.11000000	64	
255.255.255.224	/27	11111111.11111111.11111111.11100000	32	
255.255.255.240	/28	11111111.11111111.11111111.11110000	16	
255.255.255.248	/29	11111111.11111111.11111111.11111000	8	
255.255.255.252	/30	11111111.11111111.11111111.11111100	4	Router to router

There are always two “unused” address in an IP subnet – the network address and the broadcast address. As a result, the maximum number of hosts that can be connected to a subnet is two less than the number of addresses. There must also be at least one machine which acts as the route out of the network.

In a Class C network (24 bit netmask, 255.255.255.0), there are 256 addresses, 254 hosts and at least one of the 254 will have to act as a router.

Reserved network addresses

A number of network addresses are reserved for special purposes. Of the special addresses

listed in RFC 3330, the following are used quite commonly.

```
Address Block           Present Use
   Reference
----------------------------------------------------------------
   --
0.0.0.0/8          "This" Network                 [RFC1700, page
   4]
10.0.0.0/8         Private-Use Networks
   [RFC1918]
127.0.0.0/8        Loopback                       [RFC1700, page
   5]
169.254.0.0/16     Link Local
   --
172.16.0.0/12      Private-Use Networks
   [RFC1918]
192.168.0.0/16     Private-Use Networks
   [RFC1918]
224.0.0.0/4        Multicast
   [RFC3171]
```

Example IP's and netmasks

The table shows the IP addresses and netmasks, together with the expected network and broadcast addresses.

Example IP address	*Example netmask*	*Network address*	*Network and bits in mask*	*Broadcast address*	*Number of machines*
The following three netmasks represent Class C (/24), class B(/16) and class A(/8) networks.					
192.168.6.12	255.255.255.0	192.168.6.0	192.168.6.0/24	192.168.6.255	253
172.16.24.12	255.255.0.0	172.16.0.0	172.16.0.0/16	172.16.255.255	65534
10.251.22.33	255.0.0.0	10.0.0.0	10.0.0.0/8	10.255.255.255	16777214
The following two machines are alone on a small subnet. This arrangement is commonly used by routers.					
192.168.44.1	255.255.255.252	192.168.44.0	192.168.44.0/30	192.168.44.3	2
192.168.44.2	255.255.255.252	192.168.44.0	192.168.44.0/30	192.168.44.3	2
192.168.44.61	255.255.255.252	192.168.44.60	192.168.44.0/30	192.168.44.63	2
192.168.44.62	255.255.255.252	192.168.44.60	192.168.44.0/30	192.168.44.63	2

Routing and the default gateway

If the destination a machine is talking to is not on the local subnet, the IP packet is sent to a chosen machine on the local subnet. This machine acts as a router, and is responsible for delivering the packet to it's destination, or at least to the next hop.

The kernel maintains a routing table, which contains routing information for each network that requires special treatment. An entry in the routing table specifies the following elements:

- The destination network and netmask

- The gateway which handles traffic for this network
- The device to which the traffic should be sent (e.g. **eth0** or **ppp0**)

A machine which is not acting as a router usually specifies two routing entries:

- A route for the local network
- A default gateway which handles all other traffic

```
foobar:~ $ route -n
Kernel IP routing table
Destination   Gateway       Genmask         Flags Metric Ref   Use
      Iface
10.0.0.0      0.0.0.0       255.255.255.0   U     0      0        0
      eth0
0.0.0.0       10.0.0.1      0.0.0.0         UG    0      0        0
      eth0
```

The first entry above specifies that the subnet 10.0.0.0/24 is local on the ethernet interface **eth0**. The second entry specifies that the default gateway is 10.0.0.1 (reachable via **eth0**).

20.3 ICMP – Internet Control Message Protocol

ICMP facilitates communication of other protocols. ICMP messages have the following specific functions:

- Flow control – ICMP messages are sent to tell the sender of data that it is sending faster than the data can be processed. When these are received, the sender should slow down.
- Unreachable networks and computers – Computers and networks may be disconnected, or there may be no route to reach them (they are unreachable). When packets cannot be delivered, ICMP messages are sent that indicate the error.
- Host and network redirection – ICMP messages are sent to modify routing tables on hosts when better routes exist (e.g. another router on the same subnet).

20.4 TCP – Transmission Control Protocol

A TCP connection is similar to a telephone call between to two machines. The data transmitted by each machine is relayed to the other in the order it is sent.

A TCP connection works something like this:

1. A server listens *on a chosen port* for an incoming TCP request.
2. The client requests a connection to the server. If the server is listening on the port, the connection is accepted.
3. The client and the server now send data to each other, peer to peer, until one of them closes the connection.

The file **/etc/services** contains a list of standard services and their associated port numbers.

```
$ egrep '\b(20|21|23|25|53|80|110|119|139|143)/tcp' /etc/services
ftp-data        20/tcp          # File Transfer [Default Data]
ftp             21/tcp          # File Transfer [Control]
telnet          23/tcp          # Telnet
smtp            25/tcp  mail    # Simple Mail Transfer
domain          53/tcp          # Domain Name Server
```

```
http            80/tcp          # World Wide Web HTTP
www             80/tcp          # World Wide Web HTTP
www-http        80/tcp          # World Wide Web HTTP
pop3            110/tcp         # Post Office Protocol - Version 3
nntp            119/tcp         # Network News Transfer Protocol
netbios-ssn     139/tcp         # NETBIOS Session Service
imap            143/tcp imap2   # Internet Message Access Protocol
```

The **telnet** application is designed for remote control via a TCP connection. You can, however, connect to any TCP service using the **telnet** application.

20.5 UDP – User datagram protocol

UDP provides an unreliable message delivery service – if your packet gets lost in the network, that's too bad. It is used for services which require either a fast response, where the overhead of setting up a connection cannot be justified.

A UDP session works something like this:

1. A server listens *on a chosen port* for an incoming UDP request.
2. The client sends a UDP packet to the server. If the server is listening on the port, the packet is passed to the appropriate application. If the server is not listening, an ICMP message is returned.
3. Usually the server sends back a response to the UDP packet it received, but this is not necessary.

The entries in **/etc/services** list entries for both UDP and TCP.

```
$ egrep '\b(53|161)/udp' /etc/services
domain          53/udp          # Domain Name Server
sunrpc          111/udp rpcbind # SUN Remote Procedure Call
snmp            161/udp         # SNMP
```

Some of the more famous protocols that use UDP are these:

- 53/UDP – DNS – Domain name service. A DNS server translates network names into IP addresses.
- 111/UDP – Sun RPC, including NFS. Port 111 is used by the RPC portmapper, which allocates TCP and UDP ports for RPC services as required.
- 161/UDP – SNMP – Simple Network Management Protocol. SNMP is commonly used for administering and monitoring routers.

20.6 Client applications

The applications discussed in this subsection are standard equipment on TCP/IP networks.

20.6.1 ping

A ping[20] is a quantum of happiness. The **ping** application sends pings (ICMP echo request) to remote IP based hosts, and reports how long it takes for them to respond with a pong (ICMP echo reply). In its default mode of operation, **ping** transmits ping packets until it is interrupted

20 It don't mean a thing if it 'aint got that ping.

with **Ctrl+C**, at which point it prints out vital statistics.

```
foobar:~ $ ping localhost
PING localhost (127.0.0.1) 56(84) bytes of data.
64 bytes from localhost (127.0.0.1): icmp_seq=1 ttl=64 time=0.149 ms
64 bytes from localhost (127.0.0.1): icmp_seq=2 ttl=64 time=0.143 ms
64 bytes from localhost (127.0.0.1): icmp_seq=3 ttl=64 time=0.144 ms
64 bytes from localhost (127.0.0.1): icmp_seq=4 ttl=64 time=0.141 ms
64 bytes from localhost (127.0.0.1): icmp_seq=5 ttl=64 time=0.146 ms

--- localhost ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4003ms
rtt min/avg/max/mdev = 0.141/0.144/0.149/0.013 ms
```

20.6.2 traceroute

traceroute prints the route packets take to a network host.

IP packets are forwarded by a number of routers between their source and their ultimate destination. Each IP packet is stamped with a TTL value (time to live). Each router decreases the TTL. If the TTL hits zero, an ICMP time-exceeded message is returned to the source. **traceroute** uses this behaviour to list the gateways which handle a packet between the source and destination.

Here's how traceroute goes when the network cable is unplugged.

```
foo:~ $ traceroute 172.16.0.1
traceroute to 172.16.0.1 (172.16.0.1), 30 hops max, 40 byte packets
 1  * * *
 2  * * *
 3  foo.bar (10.0.0.9)(H!) 59.919 ms (H!) 38.830 ms (H!) 19.878 ms
```

20.6.3 DNS query tools

The DNS system converts human readable names (like www.linux.org) into the IP addresses. DNS makes it possible to move servers around the world and around the office and change IP addresses without having to reconfigure all the client applications.

DNS queries are generally made when a name is used in the place of an IP address. On Linux, DNS name resolution is configured by the contents of **/etc/resolv.conf**. This file must contain at least a single **nameserver** entry.

```
foo:~ $ cat /etc/resolv.conf
nameserver 196.25.1.1
search example.com
```

dig

dig (domain information groper) is a tool that performs DNS lookups and displays the answers returned by the DNS servers that were queried. **dig** is used primarily for troubleshooting DNS problems because of the completeness of the output it produces.

The syntax for **dig** is

```
dig @server name type
```

but **dig** graciously accepts its parameters in any order. **type** indicates what type of DNS record is to be searched for (and may be in lower case, and the default type is A). If you don't specify **@server**, then the servers listed in **/etc/resolv.conf** are used.

DNS records include these:

- A – Address record (e.g. **dig www.google.com a**). These are used for machines on the internet.
- NS – name server records (e.g. **dig ns microsoft.com**). Name servers answer DNS queries for a DNS zone. There is are multiple DNS servers for a single domain so that name resolution works even if one DNS server fails.
- MX – Mail exchanger record (e.g. **dig iana.org mx**). Mail exchangers accept mail for the domain.
- PTR – Pointer record (e.g. dig **ptr 1.0.0.127.in-addr.arpa** or **dig -x 127.0.0.1**). DNS does backwards lookups as well as forward lookups. It's a bit messy when you look at the details.
- SOA – start of authority record (**dig soa ledge.co.za**) The SOA record contains interesting information about how secondary DNS servers should synchronise with their primary DNS server, and also the hostname on which the authoritative information for the domain is found, along with the email address of the person who administers the DNS server.

Here are some things to do with **dig**:

```
% dig soa ledge.co.za
% dig ns ledge.co.za
% dig ns ledge.co.za @ns2.ledge.co.za
% dig a www.ledge.co.za @ns2.ledge.co.za
% dig mx ledge.co.za
% dig a ledge.co.za
% dig any ledge.co.za
```

host

host is a simple DNS lookup utility It displays less detail than dig, which can be good, because dig displays everything. The syntax for using **host** is

```
host [-t type] name server
```

You can try these commands to get a feel for the **host** command.

```
foobar:~ $ host
Usage: host [-aCdlrTwv] [-c class] [-n] [-N ndots] [-t type] [-W
      time]
            [-R number] hostname [server]
foobar:~ $ host www.ledge.co.za
foobar:~ $ host www.ledge.co.za ns2.ledge.co.za
foobar:~ $ host -t soa ledge.co.za
foobar:~ $ host -t ns ledge.co.za
foobar:~ $ host -t ns ledge.co.za ns2.ledge.co.za
foobar:~ $ host -t mx ledge.co.za
foobar:~ $ host ledge.co.za
foobar:~ $ host -t any ledge.co.za
foobar:~ $ host www.microsoft.com
```

```
www.microsoft.com is an alias for www.microsoft.akadns.net.
www.microsoft.akadns.net has address 207.46.249.190
www.microsoft.akadns.net has address 207.46.249.222
www.microsoft.akadns.net has address 207.46.134.155
www.microsoft.akadns.net has address 207.46.134.190
www.microsoft.akadns.net has address 207.46.249.27
foobar:~ $ host 207.46.134.155
155.134.46.207.in-addr.arpa domain name pointer microsoft.com.
155.134.46.207.in-addr.arpa domain name pointer microsoft.net.
```

nslookup

nslookup is the original DNS query tool which has been largely displaced by **dig** and **host**. In fact, so much so that newer versions display the following message

```
Note:  nslookup is deprecated and may be removed from future
     releases.
Consider using the `dig' or `host' programs instead.  Run nslookup
     with
the `-sil[ent]' option to prevent this message from appearing.
```

nslookup displays additional information about the DNS server it queries (as specified in **/etc/resolv.conf**).

```
foobar:~ $ nslookup www.linux.org
Server:         192.168.4.2
Address:        192.168.4.2#53

Non-authoritative answer:
Name:   www.linux.org
Address: 198.182.196.56
```

In the query below, **nslookup** decides that you may want an authoritative answer, and suggests two name servers which you could query.

```
foobar:~ $ nslookup 198.182.196.56
Server:         192.168.4.2
Address:        192.168.4.2#53

Non-authoritative answer:
56.196.182.198.in-addr.arpa     name = www.linux.org.

Authoritative answers can be found from:
196.182.198.in-addr.arpa        nameserver = ns0.aitcom.net.
196.182.198.in-addr.arpa        nameserver = ns.invlogic.com.
ns.invlogic.com internet address = 207.245.34.122
ns0.aitcom.net  internet address = 208.234.1.34
```

nslookup has an interactive mode as well.

```
foobar:~ $ nslookup
> www.linux.org
Server:         192.168.4.2
Address:        192.168.4.2#53

Non-authoritative answer:
Name:   www.linux.org
Address: 198.182.196.56
```

```
> 198.182.196.56
Server:         192.168.4.2
Address:        192.168.4.2#53

Non-authoritative answer:
56.196.182.198.in-addr.arpa     name = www.linux.org.

Authoritative answers can be found from:
196.182.198.in-addr.arpa        nameserver = ns.invlogic.com.
196.182.198.in-addr.arpa        nameserver = ns0.aitcom.net.
ns.invlogic.com internet address = 207.245.34.122
ns0.aitcom.net  internet address = 208.234.1.34
> server 207.245.34.122
Default server: 207.245.34.122
Address: 207.245.34.122#53
> set type=MX
> linux.org
Server:         207.245.34.122
Address:        207.245.34.122#53

linux.org       mail exchanger = 10 mail.linux.org.
> exit
```

20.6.4 telnet

telnet allows remote control of computers by enabling you to log in over the network. Computers running telnet servers generally behave in the same way whether you log in at the console, or via the telnet protocol.

```
foobar:~ $ telnet sunny
Trying 172.18.18.16...
Connected to sunny.
Escape character is '^]'.
Debian GNU/Linux 3.0 sunny.ledge.co.za
sunny login: george
Password:
Last login: Mon Jul 28 20:05:56 2003 from foobar.ledge.co.za on
     pts/1
Linux sunny 2.4.18 #1 Sat May 31 16:43:45 SAST 2003 sparc unknown
You have new mail.
george@sunny:~$ whoami
george
george@sunny:~$ exit
Connection closed by foreign host.
foobar:~ $ whoami
joesoap
```

Because the **telnet** application simply establishes a TCP connection[21], it is quite useful for general TCP debugging and fault finding. When using **telnet** for this purpose, it is often necessary to use the escape character – Ctrl+] – to reach the telnet prompt, followed by **q** for **quit**.

21 The telnet client sends information like the TERM environment variable to the server using the “Out of band” feature of TCP. This information is ignored by most applications except telnet servers.

To tell **telnet** to connect to a specific TCP port, we specify the port after the host name. In this example we connect to the SMTP port (port 25) on a machine "sunny", and discover which mail software it is running.

```
foobar:~ $ telnet sunny 25
Trying 172.18.18.16...
Connected to sunny.
Escape character is '^]'.
220 sunny.ledge.co.za ESMTP Exim 3.35 #1 Tue, 12 Aug 2003 21:37:22
     +0200
^]
telnet> q
Connection closed.
```

If there is no application running on the port that **telnet** connects to, it prints the appropriate message. Here we try to connect to the pop3 port (port 110) on the machine "sunny".

```
foobar:~ $ telnet sunny 110
Trying 172.18.18.16...
telnet: connect to address 172.18.18.16: Connection refused
```

Here's an example session where the client application (**telnet**) is talking to a server (an SMTP mail server).

```
foobar:~ $ telnet smtprelay 25
Trying 192.168.3.2...
Connected to smtprelay.
Escape character is '^]'.
220 smtprelay.ledge.co.za ESMTP
HELO i.am.innocent.com
250 smtprelay.ledge.co.za
MAIL FROM: <bill@gates.com>
250 Ok
RCPT TO: <bogususer@example.com>
250 Ok
DATA
354 End data with <CR><LF>.<CR><LF>
Subject: Mail for you

But it's bogus
.
250 Ok: queued as E8614394019
QUIT
221 Bye
```

20.6.5 whois

IP addresses are not chosen randomly, but are administered by various regional and local address registries. The database about who administers what is stored in a RFC 812 database, and can be queried with the **whois** command. Specifically, you can query –

- who a specific network address (range) is registered to
- who a specific DNS domain name is registered to

Because there are a number of regional whois servers, it is not always possible to query the

correct whois server the first time round. Some versions of **whois** automatically select which whois server is to be queried. If yours does not, you will have to specify which server to query on the command line for many queries.

```
whois google.com
whois -h whois.arin.net 192.168.1.1
whois -h whois.internic.net example.com
whois -h whois.crsnic.net microsoft.com
```

20.6.6 ftp

The file transfer protocol is used to transfer files between machines on the internet – one running a FTP server, and the other running the FTP client program, **ftp**. It is not the only file transfer protocol, but it is the only one which is standard equipment on machines with TCP/IP.

To use FTP you supply a user name and password for the FTP server. The user name "anonymous" is given special treatment – any password is valid. With many FTP servers you can use "ftp" instead of "anonymous".

```
ftp
> open ftp.linux.org
> user anonymous
> pass nobody@example.com
> cd pub
> pwd
> cd linux
> pwd
> ls
> get README
> bye
```

Here we do more or less the same thing, using a couple of **ftp** features:

- Commands can be abbreviated to the shortest unique prefix – i.e. instead of **mget**, we can use the first two letters, **mg**.
- If we send a password ending in an @ sign, the FTP client sends our host name.
- FTP operates in a number of modes, most notably **binary** and **ascii** (selected by the commands of the same name). In **binary** mode, no translation is done on data. In **ascii** mode the ftp server translates the text into the character set of the client (this is only sometimes desirable).
- **prompt** turns off prompting "Are you sure?" for each file. **hash** prints a hash mark for each 4kb downloaded (this varies between FTP clients).

```
ftp ftp.linux.org
> user ftp
> pass me@
> cd pub/linux
> bin
> prompt
> hash
> mg READ*
> bye
```

Here's a list of the more commonly used FTP commands.

```
help            help on using ftp (a list of commands)
open            connect to remote ftp
ls              list contents of remote directory
cd              change remote working directory
pwd             print working directory on remote machine
cdup            change remote working directory to parent directory
lcd             change local working directory (on client side)
ascii           set ASCII transfer type
binary          set binary transfer type
get             receive file
mget            get multiple files
delete          delete remote file
mdelete         delete multiple files
mkdir           make directory on the remote machine
put             send one file
mput            send multiple files
prompt          force interactive prompting on (m)ultiple commands
rename          rename file
rmdir           remove directory on the remote machine
close           terminate ftp session
bye             terminate ftp session and exit
```

20.7 Review

Quiz questions

1. What is a Class B subnet?
2. What does 192.168.44.2/24 signify?
3. In the network 172.16.0.128/25, what are the network and broadcast addresses?
4. How many bits are in the subnet mask 255.255.255.240?
5. Name three ranges of IP address reserved for private use.
6. Explain the purpose of ICMP, UDP and TCP, and how they relate to IP.
7. What does the file **/etc/services** contain?
8. Explain the operation of **ping**, **telnet**, **traceroute** and **dig**.
9. Which protocols use TCP ports 25, 80 and 110?

Assignment

1. Set up your computer's IP address using DHCP.
2. Investigate the following IP addresses using **ping**, **whois**, **traceroute** and **dig**

   207.46.249.27 (one of the servers for www.microsoft.com)

   216.239.57.99 (www.google.com)

   192.0.34.166 (www.example.com)

   192.0.34.162 (www.iana.org)
3. Log on to a server using **telnet**. Read the man page for login, and see if you can find out why it is not possible to log in as root via **telnet**.

4. Find and download a copy of the latest Linux kernel source at **ftp.kernel.org** using the command line FTP client. Time how long this takes.

Answers to quiz questions

1. One with a netmask of 255.255.0.0 -- /16.
2. An IP address in 192.168.44.2 with a netmask of 255.255.255.0.
3. Network is 172.16.0.128, broadcast is 172.16.0.255.
4. 8 + 8 + 8 + 4 = 28
5. 10.0.0.0/8, 172.16.0.0/12, 192.168.0.0/16
6. All are sub-protocols of IP. ICMP is a helper protocol for control messages. UDP is for unassured transmissions, and TCP is for two-way streams.
7. A list of TCP and UDP port numbers, and the names of the protocols which use them.
8. Ping sends packets to test a network. Telnet makes TCP connections. Traceroute tests network routing. Dig queries DNS servers.
9. 25 is SMTP, 80 is HTTP, 110 is POP3.

21 TCP/IP configuration

How much work would a network net if a network could net work?

(a 21st century woodchuck)

LPIC topic 1.112.3 — TCP/IP configuration and troubleshooting [7]

Weight: 7

Objective

Candidates should be able to view, change and verify configuration settings and operational status for various network interfaces. This objective includes manual and automatic configuration of interfaces and routing tables. This especially means to add, start, stop, restart, delete or reconfigure network interfaces. It also means to change, view or configure the routing table and to correct an improperly set default route manually. Candidates should be able to configure Linux as a DHCP client and a TCP/IP host and to debug problems associated with the network configuration.

Key files, terms, and utilities include

/etc/HOSTNAME or /etc/hostname	System network name
/etc/hosts	Names for other hosts on the network (substitute for DNS)
/etc/networks	Network names
/etc/host.conf	Overall resolver configuration
/etc/resolv.conf	Resolver settings (e.g. DNS server and domain suffix)
/etc/nsswitch.conf	Name services switch (in which order are names resolved)
ifconfig	Network interface configuration and display
route	Network routes configuration and display
dhcpcd, dhcpclient, pump	DHCP clients (Dynamic Host Configuration Protocol)
host	DNS query tool
hostname (domainname, dnsdomainname)	Set or query the host name
netstat	Show network status
ping	Network connectivity testing
traceroute	Network routing testing
tcpdump	Network packet sniffer (show all network traffic)
the network scripts run during system initialization.	Somewhere in /etc ...

21.1 System start up scripts

Each distribution uses slightly different configuration scripts for configuring networking. In all cases, the following can be configured:

- The host name (usually **/etc/hostname** or **/etc/HOSTNAME**)
- For each network interface, the IP address, network mask and broadcast address
- The default gateway and additional routing

Redhat

For Redhat machines, the authoritative source of the host name and other network settings is **/etc/sysconfig/network**.

```
[root@foobary root]# cat /etc/sysconfig/network
NETWORKING=yes
GATEWAYDEV=""
HOSTNAME=foobar.example.com
GATEWAY="192.168.1.1"
```

The interface configuration is in the directory for network scripts, **/etc/sysconfig/network-scripts/**. Each interface is configured by a script **ifcfg-interfacename**. For example, **eth0** is configured by **/etc/sysconfig/network-scripts/ifcfg-eth0** and **ppp0** is configured by **/etc/sysconfig/network-scripts/ifcfg-ppp0**.

Configuration of fixed parameters on Redhat.

```
[root@foobar root]# cd /etc/sysconfig/network-scripts
[root@foobar network-scripts]# cat ifcfg-eth0
DEVICE=eth0
BROADCAST=192.168.1.255
IPADDR=192.168.1.100
NETMASK=255.255.255.0
NETWORK=192.168.1.0
ONBOOT=no
```

If **eth0** is configured by DHCP, then the configuration file is simpler.

```
[root@foobar tmp]# cd /etc/sysconfig/network-scripts
[root@foobar network-scripts]# cat ifcfg-eth0
DEVICE=eth0
BOOTPROTO=dhcp
ONBOOT=yes
```

Redhat supplies **ifup** to configure network interfaces, and **ifdown** to deactivate them.

```
[root@foobar network-scripts]# ifdown eth0
[root@foobar network-scripts]# ifup eth0
```

Network parameters are mostly read by **/etc/init.d/network** (i.e. when you run **service network restart**).

SuSE 7.x and before

Older versions of SuSE store network configuration parameters in the global configuration file **/etc/rc.config**. Some editions of SuSE stored additional information in **/etc/rc.config.d**. Routing information is stored in **/etc/routes.conf**

The configuration for a static IP address looks like this.

```
suseold:/etc # grep ^IFCONFIG
suseold:/etc # egrep '^(IFCONFIG|NETDEV)' /etc/rc.config
NETDEV_0="eth0"
NETDEV_1=""
NETDEV_2=""
NETDEV_3=""
IFCONFIG_0="192.168.0.100 broadcast 192.168.0.255 netmask
      255.255.255.0 up"
```

```
IFCONFIG_1=""
IFCONFIG_2=""
IFCONFIG_3=""
```

For dhcp, the settings are

```
IFCONFIG_0="dhcpclient"
```

Routing is specified in **/etc/route.conf**.

```
suseold:/etc # cat route.conf
0.0.0.0          192.168.0.1        0.0.0.0          eth0
```

The host name is set from the contents of **/etc/rc.config**.

```
suseold:/etc # grep HOSTNAME /etc/rc.config
FQHOSTNAME="suseold.example.com"
```

SuSE 8.0+

From version 8.0, SuSE stores network configuration parameters in a very similar way to redhat. **/etc/sysconfig/network/**

The configuration for a static IP address looks like this.

```
suse8:~ # cd /etc/sysconfig/network/
suse8:/etc/sysconfig/network # cat ifcfg-eth0
BOOTPROTO='static'
BROADCAST='192.168.0.255'
IPADDR='192.168.0.100'
MTU=''
NETMASK='255.255.255.0'
NETWORK='192.168.0.0'
REMOTE_IPADDR=''
STARTMODE='onboot'
UNIQUE=''
WIRELESS='no'
```

Routing is specified in **/etc/sysconfig/network/routes**.

```
suse8:/etc/sysconfig/network # cat routes
default 192.168.0.1 - -
```

The host name is set from the contents of **/etc/HOSTNAME**.

```
suse8:/etc/sysconfig/network # cat /etc/HOSTNAME
suse8.example.com
```

Debian – /etc/network

Debian stores networking parameters in the directory **/etc/network**. The most significant file in this directory is **/etc/network/interfaces**, which specifies the parameters for the available network interfaces.

Configuration of fixed parameters on Debian.

```
debian:~# cd /etc/network/
debian:/etc/network# cat interfaces
auto lo
iface lo inet loopback

auto eth0
```

```
iface eth0 inet static
        address 192.168.0.100
        broadcast 192.168.0.255
        netmask 255.255.255.0

gateway 192.168.0.1
```

If **eth0** is configured by DHCP, then the interfaces file contains less detail:

```
debian:/etc/network# cat interfaces
```

Like Redhat, Debian supplies an **ifup** and **ifdown** command to activate and deactivate network interfaces.

```
debian:~# ifdown eth0
debian:~# ifup eth0
```

hostname and HOSTNAME

The name of the computer is usually stored in the file **/etc/hostname** (or **/etc/HOSTNAME**). This is set as the system host name during the boot sequence and it determines the contents of the **HOSTNAME** environment variable.

The host name of a machine does not include the domain part (e.g. example.com). The fully qualified host name is determined by the resolver library. Usually this means that an entry in **/etc/hosts** determines the fully qualified host name (depending on **hosts.conf** or **nsswitch.conf**, as described later).

```
foobar:~ $ cd /etc/
foobar:/etc $ cat HOSTNAME
foobar.example.com
foobar:/etc $ cat hostname
cat: hostname: No such file or directory
foobar:/etc $ hostname
foobar
foobar:/etc $ hostname -f
foobar.example.com
foobar:/etc $ grep `hostname` /etc/hosts
10.0.0.3        foobar.example.com       foobar
foobar:/etc $ hostname barfoo
foobar:/etc $ hostname
barfoo
```

21.2 Configuring IP

ifconfig

ifconfig is used to configure the network interfaces controlled by the kernel. The boot-up sequence will call **ifconfig** to set up the initial configuration. After this **ifconfig** is only used for debugging and system tuning.

ifconfig without any further parameters displays the current interfaces and their settings. If you have a network card configured, you will two interfaces. **eth0** is the first ethernet interface. **lo** is the loopback interface, which is used for when the machine needs to talk to

itself.

```
foobar:~ $ /sbin/ifconfig                              #abbreviated
     output
eth0      Link encap:Ethernet  HWaddr 00:E9:98:99:70:91
          inet addr:192.168.0.100  Bcast:192.168.0.255
     Mask:255.255.0.0
...
lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
...
```

To change settings using **ifconfig**, the following syntax is used. The changes take effect immediately. If you do not supply a netmask or a broadcast address, the kernel will guess values for you (sometimes better than at other times).

```
foobar:~ # ifconfig eth0 192.168.0.100 netmask 255.255.255.0
     broadcast 192.168.0.255
foobar:~ # ifconfig eth0
eth0      Link encap:Ethernet  HWaddr 00:E9:98:99:70:91
          inet addr:192.168.0.100 Bcast:192.168.0.255
     Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:135 dropped:0 overruns:0 carrier:270
          collisions:0 txqueuelen:100
          RX bytes:0 (0.0 b)  TX bytes:0 (0.0 b)
          Interrupt:10 Base address:0x4000
```

ifconfig can also take down a running interface. When you do this, it will disapear from the output of **ifconfig**.

```
foobar:~ # ifconfig eth0 down
foobar:~ # ifconfig
...
foobar:~ # ifconfig eth0 up
foobar:~ # ifconfig
...
```

route

When an interface is configured by **ifconfig**, the kernel automatically adds a route to the local network, based on the netmask value supplied. It remains only to configure routes to networks that are not local. In the case of a workstation, this generally means adding a single routing entry for the default gateway. All traffic not destined for the local network is forwarded to that machine.

route with no options the active routes on the system[22].

```
foobar:~ # route
Kernel IP routing table
Destination   Gateway       Genmask         Flags Metric Ref  Use
     Iface
192.168.0.0   *             255.255.255.0   U     0      0      0
     eth0
```

22 So does **netstat -rn**, and that even works on all or most versions of Windows.

route add

To add a route the command is **route add**, with the following syntax:

```
route add [-net | -host] DEST [gw GATEWAY] [netmask MASK] [dev DEVICE]
```

The kernel adds a route to the destination host or the network with the given netmask, via the specific gateway, which is directly reachable on the device. The usage of **route add** is one of the following:

- **route add default** ... – set the default route
- **route add -host** ... – set up a route to a specific host
- **route add -net** ... – set up a route to a network

This changes the route for outgoing packets. Whether packets will return to you or not depends on the routing tables on the remote machine and intermediate routers.

Here we say that the route to the world is via the gateway 192.168.0.1, connected to **eth0**.

```
foobar:~ # route add default gw 192.168.0.1 dev eth0
foobar:~ # route
Kernel IP routing table
Destination   Gateway       Genmask         Flags Metric Ref  Use
      Iface
192.168.0.0   *             255.255.255.0   U     0      0      0
      eth0
default       192.168.0.1   0.0.0.0         UG    0      0      0
      eth0
```

To add a route to a single host, you use the **-host** switch.

Here we adjust our routing table so that packets destined for the host 192.168.0.62 will be submitted to the gateway 192.168.0.4 for further processing.

```
foobar:~ # route add -host 192.168.0.62 gw 192.168.0.4 dev eth0
foobar:~ # route -n
Kernel IP routing table
Destination   Gateway       Genmask         Flags Metric Ref  Use
      Iface
192.168.0.62  192.168.0.4   255.255.255.255 UGH   0      0      0
      eth0
192.168.0.0   0.0.0.0       255.255.255.0   U     0      0      0
      eth0
0.0.0.0       192.168.0.1   0.0.0.0         UG    0      0      0
      eth0
```

To add a route to a network the **-net** switch is used.

```
foobar:~ # route add -net 172.16.88.0 netmask 255.255.255.0 gw
      192.168.0.5 dev eth0
foobar:~ # route -n
Kernel IP routing table
Destination   Gateway       Genmask         Flags Metric Ref  Use
      Iface
192.168.0.62  192.168.0.4   255.255.255.255 UGH   0      0      0
      eth0
192.168.0.0   0.0.0.0       255.255.255.0   U     0      0      0
      eth0
```

```
172.16.88.0   192.168.0.5   255.255.255.0   UG    0      0      0
      eth0
0.0.0.0       192.168.0.1   0.0.0.0         UG    0      0      0
      eth0
```

route del

Routes can be deleted in the same way they were added, except that **route del** is used in the place of **route add**.

In this example, we realise that the gateway for the network 172.16.88.0/24 was incorrect. The way to fix this is to remove the route, and add a correct route.

```
foobar:~ # route del -net 172.16.88.0 netmask 255.255.255.0
foobar:~ # route add -net 172.16.88.0 netmask 255.255.255.0 gw
      192.168.0.6
foobar:~ # route -n
Kernel IP routing table
Destination   Gateway       Genmask         Flags Metric Ref  Use
      Iface
192.168.0.62  192.168.0.4   255.255.255.255 UGH   0      0      0
      eth0
192.168.0.0   0.0.0.0       255.255.255.0   U     0      0      0
      eth0
172.16.88.0   192.168.0.6   255.255.255.0   UG    0      0      0
      eth0
0.0.0.0       192.168.0.1   0.0.0.0         UG    0      0      0
      eth0
```

In the last example, the **route add** and **route del** commands did not entirely specify the route (leaving out **gw** and **dev** or both). The version of **route** that was used was smart enough to figure out what was intended. The **route** man page contains a number of examples of how the command is used.

Here we change the default gateway from 192.168.0.1 to 192.168.0.10. We remove the original default route, and add the new default route.

```
foobar:~ # route del default gw 192.168.0.1
foobar:~ # route add default gw 192.168.0.10
foobar:~ # route -n
Kernel IP routing table
Destination   Gateway       Genmask         Flags Metric Ref  Use
      Iface
192.168.0.62  192.168.0.4   255.255.255.255 UGH   0      0      0
      eth0
192.168.0.0   0.0.0.0       255.255.255.0   U     0      0      0
      eth0
172.16.88.0   192.168.0.6   255.255.255.0   UG    0      0      0
      eth0
0.0.0.0       192.168.0.10  0.0.0.0         UG    0      0      0
      eth0
```

21.3 Configuring name resolution

Name resolution involves translating names (such as www.w3c.org) into network addresses

(such as 172.31.98.251). Linux supports a number of name resolution methods, but the most commonly used ones are:

- files – look up names in **/etc/hosts**
- dns – look up names by querying the DNS server(s) listed in **/etc/resolv.conf**.

The full list varies between systems.

```
foobar:/lib $ cd /lib/
foobar:/lib $ ls libnss*
libnss_compat.so.2  libnss_hesiod.so.2   libnss_winbind.so
libnss_dns.so.2     libnss_nis.so.2      libnss_winbind.so.2
libnss_files.so.2   libnss_nisplus.so.2  libnss_wins.so.2
```

The file that configures which name resolution mechanism is to be used is **/etc/nsswitch.conf**. Older applications (based on libc5) use **/etc/host.conf**. It is good practice to have the same information in both files to avoid surprises.

```
foobar:~ $ cat /etc/host.conf
order hosts, bind
multi on
```

"hosts, bind" in the above text means that first **/etc/hosts** is checked, then the DNS servers are tried, as configured in **/etc/resolv.conf**. The "multi on" causes the resolver to return all the names of hosts, rather than just the first one found.

Of the many entries in **nsswitch.conf**, the **hosts** entry is the one that configures the resolving of host names.

```
foobar:~ $ cat /etc/nsswitch.conf
passwd:         compat
group:          compat
hosts:          files dns
networks:       files dns
services:       files
//snip
```

/etc/hosts

For each IP address, **/etc/hosts** lists the IP address, the name, and optionally a number of aliases.

```
foobar:~ $ cat /etc/hosts
# IP-Address    Full-Qualified-Hostname  Short-Hostname
127.0.0.1       localhost
192.168.0.100   foobar.example.com       foobar
```

In the usual case, the **hosts** file contains a **localhost** entry for the loop-back address and an entry for the local machine (sometimes using the IP address 127.0.0.2 if there is no fixed IP address). The entry for the local machine determines the fully-qualified host name (in the above case "foobar" maps to "foobar.example.com").

/etc/resolv.conf

resolv.conf determines how DNS resolution proceeds. There are only two entries.

```
foobar:~ $ cat /etc/resolv.conf
search example.com
```

```
# domain example.com                # an alternative to "search"
nameserver 192.168.0.2
nameserver 196.25.1.1
```

The **search** entry specifies that a query for a name like **foomatic** will actually generate queries for **foomatic.example.com**. The DNS query will be sent to each of the DNS servers until an answer is received.

/etc/networks

/etc/networks is similar to **/etc/hosts**, but lists names for networks. This information can be used by the output of **route** to display descriptions of network names. It is not unusual for this file to be empty.

```
foobar:~ # route -n
Kernel IP routing table
Destination   Gateway       Genmask         Flags Metric Ref  Use
      Iface
10.0.0.0      0.0.0.0       255.255.255.0   U     0      0      0
      eth0
172.19.18.0   0.0.0.0       255.255.255.0   U     0      0      0
      eth0
192.168.0.0   0.0.0.0       255.255.0.0     U     0      0      0
      eth0
0.0.0.0       10.0.0.20     0.0.0.0         UG    0      0      0
      eth0
foobar:~ # cat /etc/networks
loopback        127.0.0.0
worknet         10.0.0.0
homenet         172.19.18.0
sparenet        192.168.0.0
foobar:~ # route
Kernel IP routing table
Destination   Gateway       Genmask         Flags Metric Ref  Use
      Iface
worknet       *             255.255.255.0   U     0      0      0
      eth0
homenet       *             255.255.255.0   U     0      0      0
      eth0
sparenet      *             255.255.0.0     U     0      0      0
      eth0
default       10.0.0.20     0.0.0.0         UG    0      0      0
      eth0
```

The method used for network name lookups is actually determined by the “networks” entry in **/etc/nsswitch.conf**.

```
foobar:~ # grep networks /etc/nsswitch.conf
networks:       files dns
```

21.4 DHCP client

Running any DHCP client will do the following:

- Broadcast a DHCP configuration request on the network, and listen for the response from a DHCP server.

- Set up the interface address and network mask (**ifconfig**), routing (**route add default gw**) and DNS resolution (**/etc/resolv.conf**) according to the information received from the DHCP server.

In order to test these, you will require a DHCP server. Generally only one of the three programs will be included in any given distribution.

dhcpcd – DHCP client daemon

This program runs in the background, and keeps the DHCP server informed about the fact that you are still using the IP address assigned to you.

By default, **dhcpcd** sends out a query on **eth0**.

```
foobar:~ # dhcpcd
foobar:~ # cat /var/lib/dhcpcd/dhcpcd-eth0.info
IPADDR=10.10.1.25
NETMASK=255.255.255.0
NETWORK=10.10.1.0
BROADCAST=10.10.1.255
GATEWAY=10.10.1.3
DNS=10.10.1.3
DHCPSID=10.10.1.5
DHCPGIADDR=0.0.0.0
DHCPSIADDR=0.0.0.0
DHCPCHADDR=00:E0:98:99:70:91
DHCPSHADDR=00:D0:B7:A8:49:AE
DHCPSNAME=''
LEASETIME=864060
RENEWALTIME=432030
REBINDTIME=756052
INTERFACE='eth0'
CLASSID='Linux 2.4.18-4GB i586'
CLIENTID=00:E0:98:99:70:91
```

You can shut down the running **dhcpcd** with the **-k** switch. When you do this, the interface configured by DHCP will be shut down.

```
foobar:~ # dhcpcd -k
```

dhclient

dhclient runs as a daemon (similar to dhcpcd). The list of interfaces which are controlled by DHCP is configured by the file **/etc/dhclient.conf**.

pump

pump also runs as a daemon, and can configure network interfaces using DHCP or BOOTP (on which DHCP is based). It is configured by **/etc/pump.conf**.

21.5 Network troubleshooting

When there is trouble with the network, you can use the diagnosis and configuration commands to see which parts of the network are configured correctly, and how the network is

responding.

21.5.1 netstat

netstat (network status) shows the active network connections. Here are a couple of examples of how it can be used.

```
netstat --help      # Show complete usage information
netstat -t          # What TCP connections are active
netstat -tl         # Show listening TCP servers
netstat -ta         # Show all TCP sockets (connections and
      listening)
netstat -tan        # Show numbers, rather than names for TCP ports
netstat -pant       # Show process ID's as well
netstat -u          # What UDP "connections" are active
netstat -ua         # Show listening UCP servers too
netstat -uan        # Show numbers, rather than names for UCP ports
netstat -utan       # Show UDP and TCP information
netstat -peanut     # Show a lot of information (-e means extended)
```

netstat does some other interesting things too, which we mention for completeness.

```
netstat -s          # Networking statistics (add -t, or -u for
      TCP/UDP)
netstat -r          # Same as "route"
netstat -rC         # Kernel routing cache
netstat -i          # Kernel interface table
```

21.5.2 Troubleshooting with ping

ping tests whether a networked host is alive. When using ping for diagnostics, you will generally work outwards from the local machine.

1. ping the loopback interface. If things are horribly strange, this test will fail (e.g. if TCP/IP is not available in the current kernel).

   ```
   ping 127.0.0.1
   ```

2. ping the local ethernet interface. If the interface is not configured, this test will fail.

   ```
   ping 192.168.0.100
   ```

3. ping the default gateway. If you are not connected to the network, this will fail.

   ```
   route -n                  # first see what the default gateway is
   ping 192.168.0.1
   ```

4. ping beyond the default gateway. If the gateway is not routing for you, then this will fail. A reasonable choice of what to test is your DNS server, if it is outside of your network.

   ```
   cat /etc/resolv.conf      # look what the name server is set to
   ping 172.16.77.88
   ```

5. ping using a name. This tests whether the DNS server is . DNS can fail if the DNS server is not reachable, so it is best to use numeric addresses up to this point.

   ```
   ping www.google.com
   ```

21.5.3 Troubleshooting with traceroute

The output of **traceroute** can be helpful in diagnosing problems –

- Identifying the source of the problem when remote routers and links that are not working.
- Identifying the delay introduced by each link in the routing chain (e.g. link congestion, or asymmetric routing.)
- Determining who is providing IP connectivity to a specific network (e.g. when abuse reports are unattended).
- Reading the reverse DNS names of the links on the routing chain.

21.5.4 Troubleshooting with tcpdump

tcpdump is a network sniffer.

- The network interface card is switched to promiscuous mode. In this mode, it reads traffic not only for its own media address, but also packets for other hosts.
- Each packet that is displayed is checked according to the command line filter. The sniffer ignores packets that do not match the filter.
- The network packet that was received is disassembled, and information is displayed.

The syntax for **tcpdump** can include fairly complex packet selection. For troubleshooting it is sufficient to be able to use it to monitor a host, or a specific protocol.

Monitor the network

```
tcpdump
```

Monitor packets from a specific machine, listening on a specific interface.

```
tcpdump -i eth0 host 192.168.0.110
```

Monitor POP3 traffic (port 110)

```
tcpdump -i eth0 port 110                          # monitor pop3
      traffic
```

Filter expressions can be combined with "**and**". To monitor all **smtp** traffic from a host, the command will be.

```
tcpdump host 192.168.0.110 and port 25
```

21.5.5 Troubleshooting with "host"

The **host** program can diagnose DNS errors. If a server is not responding, this may be caused by a DNS failure – the host name cannot be converted to a network address, so the machine cannot be located.

```
host -t a www.example.com
host -t ns example.com
host -t a www.example.com a.iana.org
host -t a www.example.com b.iana.org
host -t soa example.com a.iana.org
host -t soa example.com b.iana.org
```

As illustrated, a procedure for diagnosing DNS errors is to start by querying your name server configured in **/etc/resolv.conf**. This should be able to tell what the name servers for a particular domain are. Each of these name servers should give you identical results when you query them directly.

21.6 Review

Quiz questions

1. What are the names of network interfaces under Linux for Ethernet, Point to point protocol and the loopback connection?
2. If your default route is set to 192.168.0.1, which commands would you use to set it to 192.168.0.55?
3. Which command is used to show the current routing table on your computer?
4. How do you view the interface settings for the first Ethernet card?
5. What is the host name of a Linux machine used for, and how is it set? How do you set the fully-qualified host name?
6. What is the format of **/etc/networks**, and when is the information in this file used?
7. Under what circumstances would the data in **/etc/hosts** have no effect on network name resolution?
8. What does the DHCP protocol do?
9. What does the switch **-n** do when used with **traceroute**, **netstat** and **tcpdump**?
10. What does the file **/etc/resolv.conf** contain?
11. Which files configure the network settings on Linux machines?

Assignment

1. Write a script to reset your computer's interface configuration, routing and DNS resolution to their current values by using the commands **hostname**, **ifconfig** and **route** and modifying **/etc/resolv.conf** (and **/etc/hosts** if necessary). Now reconfigure your system using DHCP and then reset your system to its original configuration using your script.

Answers to quiz questions

1. eth, ppp, lo
2. route del default gw 192.168.0.1
   route add default gw 192.168.0.55
3. route -n
4. ifconfig eth0
5. The hostname identifies the machine. It is set by the **hostname** command. The fully qualified host name is determined by the entry for the host name in the **/etc/hosts** file.
6. The file contains network name, and network addresses on multiple lines. The information is used to specify networks and for formatting output, such as the output of the **route** command.
7. If **nsswitch.conf** does not contain “files” as part of the “hosts” entry, or if **host.conf** does not contain “files” as part of the “order” list.
8. DHCP is the protocol used for assigning IP addresses and other parameters from a central

cerver.

9. It prevents network numbers from being converted to names.
10. Parameters controlling the usage of DNS servers.
11. Depending on distribution, the files include: **/etc/sysconfig/network**, **/etc/sysconfig/network-scripts/*** (Redhat), **/etc/network/*** (Debian)

22 PPP client

It's a long way to Ti-p-p-p-erary, it's a long way to go
It's a long way to Ti-p-p-p-erary when the modem is so slow ...

LPIC topic 1.112.4 — Configure Linux as a PPP client [3]

Weight: 3

Objective

Candidates should understand the basics of the PPP protocol and be able to configure and use PPP for outbound connections. This objective includes the definition of the chat sequence to connect (given a login example) and the setup commands to be run automatically when a PPP connection is made. It also includes initialization and termination of a PPP connection, with a modem, ISDN or ADSL and setting PPP to automatically reconnect if disconnected.

Key files, terms, and utilities include

/etc/ppp/options.*	ppp options for a particular serial line
/etc/ppp/peers/*	ppp options for **pppd call ***
/etc/wvdial.conf	configuration file for **wvdial**
/etc/ppp/ip-up	script run after IP is set up on a ppp link
/etc/ppp/ip-down	script run after IP is shut down on a ppp link
wvdial	Worldvisions WvDial ppp dialer
pppd	Point to Point Protocol daemon

22.1 Point to point protocol

The point to point protocol is used for network connections between two points, such as a modem connection, or a WAN link.

When establishing a point to point link, the following events happen:

1. The computer initialises the modem.
2. The computer tells the modem to dial the configured phone number.
3. The remote modem answers the data connection is set up.
4. A login sequence may be negotiated (e.g. a user name and a password entered at a prompt). Often this step is skipped.
5. **pppd** is started on both sides, and the two **pppd** processes talk to each other.
6. **pppd** sets up IP networking, and runs the script **/etc/ppp/ip-up**.

The really vital part is that the two **pppd** processes must talk to each other via a terminal. They do not particularly care how the link was established, as long as a serial terminal is used (e.g. **/dev/ttyS0**).

Manual PPP

Because a pseudo terminal can be used instead of a serial terminal you can run **pppd** manually.

```
bar:~ $ tty                 # find out which terminal we are
      currently on
/dev/pts/0                  # so later we can connect pppd to here
bar:~ $ cu -l /dev/modem
Connected.                  # that's cu saying it's connected to the
      modem
ATZ                         # the computer resets the modem
OK                          # the modem says it has completed the
      reset
ATDT5555555                 # the computer tell the modem to dial
CONNECT 56000               # the two modems set up a link
dialin login: joesoap       # the remote computer presents a login
      prompt
password: bigsecret         # and probably requires a password
Welcome to dialin.example.com /usr/sbin/pppd starts ppp.
dialin:~ $ /usr/sbin/pppd  # and the user starts pppd
```

Once **pppd** is running on the remote machine, you can run it on your own machine and they can talk via the terminal.

```
bar:~ $ tty
/dev/pts/1
bar:~ $ pppd tty /dev/pts/0
```

The general way that **pppd** is used is like this:

- **pppd** is started, and opens up the modem.
- **pppd** runs **chat** to chat to the modem, and get through the dialing and login sequence.
- When **chat** exits, **pppd** speaks PPP to the remote **pppd**.

There is considerable flexibility, of course. Instead of **pppd** running **chat**, it can be run by **wvdial** after **wvdial** has done the chatting.

- **wvdial** starts, and opens the modem.
- **wvdial** chats to the modem and negotiates through the dialing and login sequences.
- **wvdial** runs **pppd** and passes control of the modem.
- **pppd** speaks PPP to the remote **pppd**.

Chat scripts

The program **chat** talks to the modem. A chat script consists of text to listen for, and responses to send. **chat** does not worry about responses that it is not expecting – it simply listens for the response it is waiting for.

```
# "Wait for this"           "then send this in response"
''                          ATZ
OK                          ATDT55555555
CONNECT                     ''
ogin:                       joesoap
ssword:                     bigsecret
```

Although the prompt is actually something like “dialin login: ”, **chat** is happy to receive the “ogin:” part of that. This avoid problem with machines that insist on using “Login” instead of “login” and strange links that scramble the first few characters received.

chat scripts usually have instructions on how to handle failure in the conversation.

```
# These are generally at the top of the chat script
ABORT BUSY
ABORT 'NO CARRIER'
TIMEOUT 60
```

It is quite popular for systems to initiate PPP without a login sequence[23]. When running like this, sending of authentication information is handled by the **pppd** processes. The chat script ends as soon as the modems are connected.

```
ABORT BUSY ABORT 'NO CARRIER' TIMEOUT 60
''              ATZ
OK              ATDT55555555
CONNECT         ''
```

(You will also notice that **chat** allows flexibility in its script formatting).

To start **pppd** with a specific chat script, you may invoke it something like this.

```
/usr/sbin/pppd connect 'chat -f /etc/ppp/chat-script' /dev/ttyS0
      115200
```

You will have to read about **pppd** configuration to understand this, which is the topic of the next section.

wvdial --chat can be used in the place of **chat -f /etc/ppp/chat-script**.

22.2 pppd configuration

pppd options are used in the following order

- **/etc/ppp/options** – global options
- **~/.pppрc** – each user can have his own options when running **pppd**.
- **/etc/ppp/options.ttyS0** – options for the particular serial line is use (e.g. ttyS0). If the device is **/dev/pts/0**, the options file is **/etc/ppp/options.pts.0**.
- Command line options – you can pass options on the command line to **pppd**.
- **/etc/ppp/peers/peername** – this is used if you start **pppd** with **pppd call peername**

The following PPP options are useful when dialing an ISP.

- **noipdefault** – this prevents **pppd** from suggesting the local IP address to the server.
- **noauth** – PPP is a peer to peer system, and this tells **pppd** that the ISP does not have to provide authentication credentials to you when you dial up.
- **crtscts** – use hardware flow control for the modem.
- **lock** – create lock files when using the modem. This prevents interference from other programs.
- **modem** – when this option is present, **pppd** plays with the DTR signal to the modem and listens to the Carrier Detect signal from the modem. For modems without serious bugs this is the correct behaviour.

23 This is known as AutoPPP.

- **defaultroute** – once the connection has been established, the remote peer is set as the default gateway.
- **persist** – if this option is present, **pppd** will automatically reconnect if the connection is broken. The default for the related option that sets the number of reconnection attempts is **maxfail 10**.
- **idle 180** – if no IP packets are sent or received for 180 seconds, the connection is terminated. You still pay for the last 180 seconds of the call, of course.

PPP authentication

The peer that you are connecting to will generally require PPP authentication, even if you provided a correct user name and password at a login prompt. The authentication files for **pppd** are **/etc/ppp/chap-secrets** (for CHAP authentication) and **/etc/ppp/pap-secrets** (for PAP authentication).

You must identify which line in the secrets file is to be used, either by using the **name** option or the **user** option. If you don't supply any details, it is equivalent to using "**pppd name $HOSTNAME**".

If you start **pppd** with the **name** option ...

```
pppd name "wvdial"
```

You will need an entry in your secrets file like this ... (which is what **wvdial** actually uses)

```
"user@isp.example.com"    wvdial    "bigsecret"
```

Alternatively you can use the **user** option:

```
pppd user "user@isp.example.com"
```

And have the following secrets file ...

```
"user@isp.example.com"    *    "bigsecret"
```

Disconnecting a dialup

Disconnecting a PPP connection is as simple as killing the **pppd** process with a signal of your choice. Most of the following approaches will work:

```
kill -INT `cat /var/run/ppp0.pid`
killall pppd
killall -HUP pppd
ifconfig ppp0 down
ifdown ppp0                              # redhat and clones only ...
```

You can also disconnect the modem's power, telephone or data connection (provided it is not an internal modem).

ip-up and ip-down

When **pppd** has established an IP connection, it runs the script **/etc/ppp/ip-up** with details of the configuration. Similarly, when the connection has been disconnected **/etc/ppp/ip-down** runs with the same details.

```
INTERFACE=$1
```

```
DEVICE=$2
SPEED=$3
LOCALIP=$4
REMOTEIP=$5
IPPARAM=$6
```

In addition, **pppd** sets environment variables which allow automatic configuration of DNS, namely **$USEPEERDNS**, **$DNS1** and **$DNS2**.

The script supplied by most distributions sets up your ISP's DNS servers in your **/etc/resolv.conf**. The scripts can be modified, although they usually contain a great deal of code and call **/etc/ppp/ip-up.local** for any site-specific actions (**ip-down.local** can also be used).

A common use for this script is to notify somebody on a remote network that the system has dialled up (e.g. to set up dynamic DNS records) ...

```
#! /bin/bash
LOCALIP=$4
IPFILE=/var/run/lastip
LASTIP=`cat $IPFILE`
[ "$IP" = "$LASTIP" ] && exit
USER=anotherdialupuser ; PASS=bigsecret
URL="https://$USER:$PASS@members.dyndns.org/nic/update?system=dyndns
     "
URL="$URL&hostname=$USER.dyndns.org&myip=$LOCALIP&backmx=NO&offline=
     NO"
wget -q -O - "$URL" && echo $IP > $IPFILE
```

22.3 wvdial

wvdial is a PPP dialer which has a little bit of intelligence. The two most helpful things that **wvdial** does for you is that it automates the chat script, and correctly handles the setting up of authentication parameters in **/etc/ppp/chap-secrets** and **/etc/ppp/pap-secrets**.

/etc/wvdial.conf specifies the details about which device to use, the telephone number to dial, the user name and password to present, and miscellaneous init strings and options.

```
bar:~ # cat /etc/wvdial.conf
[Dialer Defaults]
Modem = /dev/modem
Baud = 57600
Init1 = ATZ
Init2 = ATQ0 V1 E1 S0=0 &C1 &D2 +FCLASS=0
Dial Command = ATDT
Idle Seconds = 180
Phone = 5550000
Username = ispuser533
Password = guessme
Stupid mode = 1
Idle Seconds = 180

[Dialer work]
Phone = 5552345
Username = gerald
Password = i81apple
```

```
[Dialer home]
Phone = 5554567
Username = mom
Password = mhallifwwas
```

With the above **wvdial.conf** it is possible to dial any of the three providers by the commands shown.

```
wvdial
wvdial home
wvdial work
```

This is what it looks like when it dials (or something quite similar)

```
bar:~ # wvdial
--> WvDial: Internet dialer version 1.42
--> Initializing modem.
--> Sending: ATZ
ATZ
OK
--> Sending: ATQ0 V1 E1 S0=0 &C1 &D2 +FCLASS=0
ATQ0 V1 E1 S0=0 &C1 &D2 +FCLASS=0
OK
OK
--> Modem initialized.
--> Idle Seconds = 180, disabling automatic reconnect.
--> Sending: ATDT5550000
--> Waiting for carrier.
ATDT5550000
CONNECT 50666/ARQ/V90/LAPM/V42BIS
--> Carrier detected.  Starting PPP immediately.
--> Starting pppd at Mon Jul  1 13:19:44 2002
--> pid of pppd: 2231
--> pppd: Using interface ppp0
```

wvdial --chat is able to replace the chat script usually required by **pppd**.

22.4 ADSL and ISDN

ISDN is a little different from analogue connections, in that it's not analogue. External ISDN terminal adapters function in the same way as external modems, and require no special treatment except providing the correct initialisation strings.

For ISDN links with an internal ISDN adapter, the following differences are relevant:

- The program that controls PPP is **ipppd**, not **pppd**.
- The configuration files are **/etc/ppp/ioptions**, in the place of **/etc/ppp/options**, and **/etc/ppp/ioptions.ttyH0** (or some other device), in the place of **/etc/ppp/options.ttyS0**

ADSL connections are also point to point connections. The ADSL modem[24] is generally connected to a PC via an Ethernet or USB connection. The program **pppoe** (PPP over ethernet) translates Ethernet signals into output on a pseudo terminal.

24 Most ADSL equipment is capable of acting in a bridge mode, in which they retransmit PPP packets that they receive via ethernet (that is, PPP over Ethernet). It is common to have this capability handled by the ADSL equipment itself, in which case it behaves like any other router.

```
adslclient:~# cat /etc/ppp/peers/dsl-provider
pty "/usr/sbin/pppoe -I eth0 -T 80 -m 1452"    # pppd uses pppoe
noipdefault               # doesn't insist on default IP addresses
defaultroute              # adds the peer as its default route
hide-password             # don't show the password if debug is
      used
connect /bin/true         # no chat sequence - just run /bin/true
noauth                    # don't ask for authentication from
      remote
persist                   # keep it up if possible
mtu 1492                  # pppoe likes little frames if possible
user "username"           # use this as our user name
adslclient:~# cat /etc/ppp/pap-secrets
"username" * "password"
```

And when we use the connection, it connects. The **nodetach** option is used here so that we can see what happens.

```
adslclient:~# pppd call dsl-provider nodetach
Serial connection established.
Using interface ppp0
Connect: ppp0 <--> /dev/pts/0
not replacing existing default route to eth0 [10.0.0.10]
found interface eth0 for proxy arp
local  IP address 10.67.15.6
remote IP address 10.0.0.1
```

22.5 Review

Quiz questions

1. Which program is capable of communicating via the Point to Point Protocol?
2. What will happen in a **chat** sequence which must simply dial an ISP before starting PPP?
3. What is the purpose of the modem initialisation string?
4. Which **pppd** keyword causes **pppd** to reconnect if the connection is dropped?
5. How are configuration options passed to **pppd**?
6. What command is used to connect using the configuration **/etc/ppp/peers/anytime**.
7. What is a minimal configuration for **/etc/wvdial.conf**?
8. What is the purpose of **/etc/ppp/ip-up and /etc/ppp/ip-down**?
9. How do ADSL and ISDN connections differ from modem based analogue connections?

Assignment

1. Set up a connection to an Internet service provider using **wvdial**. Test whether it works by pinging your point to point partner (as shown in the output of **ifconfig ppp0**), and an IP address on the internet.
2. Set up the same connection to the Internet, so that it can be dialed by running **pppd call isp**. Use **chat** rather than **wvdial** to set up the modem.
3. If you have access to a second computer, set it up to act as a PPP over ethernet server, and

then connect to it from another computer. Here are some configuration samples for the server:

```
pppoeserver:~# cat /etc/ppp/pppoe-server-options
lcp-echo-interval 20
lcp-echo-failure 3
connect /bin/true
noauth
mtu 1492
pppoeserver:~# pppoe-server -F
```

4. Network two Linux computers using PPP over a null-modem cable. A null modem cable connects the two computers to each other by their serial ports. You can start with the tip below

```
alpha:~# pppd ttyS0 noauth nodetach debug 10.4.4.4:
beta:~# pppd ttyS0 noauth nodetach debug 10.4.4.5:
```

Answers to quiz questions

1. **pppd** is the central component used to create the links, and any network-capable program can use the link after it is running.
2. The modem will be initialised (ATZ), and instructed to dial (ATD5551234). The modem must connect to the remote side (CONNECT), and it may be necessary to issue a login sequence for certain ISPs (wait for “ogin:”, send a user name; wait for “assword:”, send a password).
3. To set the modem options before dialing.
4. persist
5. In the **/etc/ppp/options** file; in the **/etc/ppp/options.tty*** file for the specific device used; in the **/etc/ppp/peers/peername** file if “pppd call peername” was used; and on the command line of **pppd**.
6. **pppd call anytime**
7. This looks quite minimal, and might even work (with some adjustments):

```
[Dialer Defaults]
Modem = /dev/ttyS0
Phone = 5551234
Username = myusername@myisp.blag.blag
Password = yeahyeah
```

8. The scripts are run when a PPP interface becomes available, and when it shuts down. It enables one to make routing adjustments, set up dynamic DNS, restart services, adjust firewalls and the like.
9. They are faster, and the underlying technology is digital (although ADSL is actually not so very digital).

23 inetd and xinetd

> "Ashley was talking about daemons forking children – it really didn't sound very healthy to me!"
>
> *– Jeanine*

LPIC topic 1.113.1 — Configure and manage inetd, xinetd, and related services [4]

Weight: 4

Objective

Candidates should be able to configure which services are available through inetd, use tcpwrappers to allow or deny services on a host-by-host basis, manually start, stop, and restart Internet services, configure basic network services including telnet and ftp. Set a service to run as another user instead of the default in inetd.conf.

Key files, terms, and utilities include

/etc/inetd.conf	inetd configuration file
/etc/hosts.allow	tcp wrappers access control (allowed hosts)
/etc/hosts.deny	tcp wrappers access control (denied hosts)
/etc/services	services list
/etc/xinetd.conf	xinetd configuration file
/etc/xinetd.log	xinetd configuration file (2)

23.1 inetd – the internet super server

A program can listen on a chosen TCP or UDP port. When a service request can come in, it can respond appropriately. Traditionally, Linux servers offer many services, and it would be wasteful to load a number of servers into memory which are not going to be used most of the time. To solve this problem, a single server, **inetd** listens for connections for a number of server. After accepting the connection, **inetd** starts the appropriate server.

The configuration file for **inetd** is **/etc/inetd.conf**. This file lists all the ports on which **inetd** listens, and the programs which are started when a connection is received.

```
foobar:~# cat /etc/inetd.conf
#port  type  protocol wait user   program        program arguments
ftp    stream tcp  nowait  root   /usr/sbin/tcpd /usr/sbin/proftpd
pop3   stream tcp  nowait  root   /usr/sbin/tcpd /usr/sbin/ipop3d
pop3s  stream tcp  nowait  root   /usr/sbin/tcpd /usr/sbin/ipop3d
imap2  stream tcp  nowait  root   /usr/sbin/tcpd /usr/sbin/imapd
imap3  stream tcp  nowait  root   /usr/sbin/tcpd /usr/sbin/imapd
tftp   dgram  udp  wait   nobody /usr/sbin/tcpd /usr/sbin/in.tftpd
      /boot
```

In detail, the fields from left to right are:

- **service_name** – the name of the service which is being offered. **inetd** determines which port it will open by consulting **/etc.services**.
- **sock_type** – the type of socket that will be used. For TCP, this must be "stream", and for

UDP the value should be “dgram” (datagram).

- **proto** – the protocol (either “tcp”, “udp”, or “rpc”).
- **flags** – either “wait” or “nowait”, depending on whether **inetd** should wait while the program runs. This is necessary for UDP servers. Each UDP server should be configured as documented.
- **user** – before running the server, **inetd** sets its UID to the user given. This means that the service does not necessarily run with root privileges.
- **server_path** – the program which is run by inetd. Usually this is **/usr/sbin/tcpd**, which checks the originating network address against **/etc/hosts.allow** and **/etc/hosts.deny** before running the program on its command line.
- **args** – the arguments listed are passed to t he server which **inetd** starts.

Common tasks with **inetd** include:

- Editing **/etc/inetd.conf** and removing a hash mark in front of a service name.

```
# This entry is disabled:
# ftp    stream tcp  nowait  root   /usr/sbin/tcpd /usr/sbin/proftpd
# And this is not:
pop3     stream tcp  nowait  root   /usr/sbin/tcpd /usr/sbin/ipop3d
```

- After changing the configuration file, you must instruct **inetd** to re-read its configuration file.

```
killall -HUP inetd
kill -HUP `cat /var/run/inetd.pid`
/etc/init.d/inetd reload
```

- Choose a specific server to handle a service:

```
# pop3     stream tcp  nowait  root   /usr/sbin/tcpd
      /usr/sbin/ipop3d
pop3       stream tcp  nowait  root   /usr/sbin/tcpd
      /usr/sbin/popper
```

- Set up a service to run as a particular user

```
# sslwrap does not need privileges, apart from being able to read
      the
# certificate file ... note that the lines below should not be
      wrapped
telnets stream tcp nowait nobody /usr/sbin/tcpd /usr/sbin/sslwrap
      -cert /etc/ssl/certs/telnets.pem -port 23
pop3s stream tcp nowait nobody /usr/sbin/tcpd /usr/sbin/sslwrap
      -cert /etc/ssl/certs/pop3.pem -port 110 -addr 192.168.33.145
```

- See which services are being offered by the currently running **inetd** process

```
foobar:~ # netstat -antup | grep inetd
tcp     0   0 0.0.0.0:110       0.0.0.0:*         LISTEN
      2340/inetd
tcp     0   0 0.0.0.0:21        0.0.0.0:*         LISTEN
      2340/inetd
udp     0   0 0.0.0.0:69        0.0.0.0:*         LISTEN
      2340/inetd
```

- Connect to a running service using **telnet** ...

```
foobar:~ # telnet localhost 21
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
220- Welkom by ons FTP server.  Net mense met skriftelike
     toestemming
220- mag hierdie diens gebruik.  Ons sal jou kry.
220 foobar.example.com FTP server ready.
^]
telnet> q
Connection closed.
```

Occasionally, you will have set up **tcpwrappers** so that access is denied. In this case, you get the following response

```
foobar:~ # telnet localhost 23
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.                    # ~ 3 second delay
     ...
Connection closed by foreign host.
foobar:~ #
```

23.2 xinetd – extended inetd

xinetd is an extended version of **inetd**, which differs primarily in its configuration. In **inetd** each service is configured by a single line. In **xinetd** each service is configured by a long description. The main configuration file for **xinetd** is **/etc/xinetd.conf** which includes every file in the directory **/etc/xinetd.d/**.

```
bar:~ # cat /etc/xinetd.conf
# /etc/xinetd.conf
defaults
{
        log_type        = FILE /var/log/xinetd.log
        log_on_success  = HOST EXIT DURATION
        log_on_failure  = HOST ATTEMPT RECORD
        instances       = 30
        cps             = 50 10
}
includedir /etc/xinetd.d
```

The entry shown above defines the default parameters for each host. The **log_** parameters configure what is logged for each connection, as described in the **xinetd.log** man page. Unlike **inetd**, **xinetd** allows you to configure the number of concurrent instances of a server ("instances"), and configure the rate of connections which will cause a service to be disabled temporarily ("cps").

In the directory **/etc/xinetd.d** there is a separate configuration file for each service (although these may be included in the main configuration file if preferred).

```
bar:~ $ ls /etc/xinetd.d/
chargen      cvs          echo      netstat  services  telnet  time-
     udp
chargen-udp  daytime      echo-udp  rsync    ssh       tftp    uucp
```

```
cups-lpd     daytime-udp  imap      servers  systat    time    vnc
```

This is the configuration file for the telnet service.

```
bar:~ $ cat /etc/xinetd.d/telnet
# description: Telnet is the old login server
service telnet
{
        disable         = yes
        socket_type     = stream
        protocol        = tcp
        wait            = no
        user            = root
        server          = /usr/sbin/in.telnetd
        server_args     =
}
```

- The telnet service in the above configuration file is disabled. The line **disable = yes** is the equivalent of a **#** comment in **inetd.conf**. If this line is not present, the service is enabled.
- The default behaviour of **xinetd** is to run everything through **tcpwrappers** unless specified, so it is not necessary to use **/sbin/tcpd** to handle connections as **inetd** does. There are man pages for **xinetd** and for **xinetd.conf**.
- The **server** and **server_args** (server command line arguments) are separate configuration entries.

23.3 tcpwrappers – host based access control

tcpwrappers is an add-on used by many programs that provides access control based on the network address of the originating machine. Programs using **tcpwrappers** either use **/usr/sbin/tcpd** (e.g. **inetd**) or are linked against the **libwrap** library (this is part of **libc** on many distributions).

The configuration files for **tcpwrappers** are **/etc/hosts.allow** and **/etc/hosts.deny**. These list the IP addresses that are denied access, and the addresses that are allowed access for each program using **tcpwrappers**. To restrict access to those that actually require access, enter the name of the program in **/etc/hosts.deny** like this.

```
# /etc/hosts.deny
sshd: ALL
proftpd: 212.0.0.0/255.0.0.0.0
```

Now allow access for those hosts that require access in **/etc/hosts.allow**:

```
# /etc/hosts.allow
# 160.201.23.33 and the network 192.168.55.0/24 are allowed access
sshd: 160.201.23.33 192.168.55.
```

In the above example, **sshd** may only be used from 160.201.23.33, 192.168.55.anything. **proftpd** can be used from anywhere, except the network 212.0.0.0/24. The man page for **tcpwrappers** and **hosts.allow** and **hosts.deny** is **man 5 hosts_access**.

23.4 Simple services

23.4.1 telnet

The server that provides the **telnet** service is called **in.telnetd**. Although there are a number of useful options it is generally invoked from **inetd** without any options.

```
bar:~ $ grep telnetd /etc/inetd.conf
# If you want telnetd not to "keep-alives" (e.g. if it runs over a
      ISDN
# uplink), add "-n".  See 'man telnetd' for more details.
telnet    stream  tcp  nowait  root    /usr/sbin/tcpd  in.telnetd
```

And for **xinetd** ...

```
bar:~ $ cat /etc/xinetd.d/telnet
service telnet
{
        disable         = no
        socket_type     = stream
        protocol        = tcp
        wait            = no
        user            = root
        server          = /usr/sbin/in.telnetd
}
```

Testing **telnet** ...

```
bar:~ $ telnet localhost
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
Go away - /etc/issue.net says so

bar login: george
Password:
You have new mail in /var/mail/george.
Last login: Thu Jun 2 19:39:42 on tty1
The message of the day service is no longer in operation.
bar:~ $ exit
logout
Connection closed by foreign host.
```

23.4.2 ftp – File transfer protocol

The BSD ftp server **in.ftpd** is quite widely deployed (**/usr/sbin/in.ftpd**). Other FTP servers are quite popular too – **wu_ftpd**, **proftpd** (**/usr/sbin/proftpd**) and **vsftpd** (**/usr/sbin/vsftpd**). In all of these, the server is invoked without arguments from **inetd**. The primary detail that is different between servers is the path to the executable.

```
bar:~ $ grep ^ftp /etc/inetd.conf
ftp     stream  tcp     nowait  root    /usr/sbin/tcpd  in.ftpd
bar:~ $ cat /etc/xinetd.d/ftpd
service ftp
{
        disable = no
```

```
        socket_type             = stream
        wait                    = no
        user                    = root
        server                  = /usr/sbin/in.ftpd
        nice                    = 10
}
```

The configuration files for the BSD FTP server are:

- **/etc/ftpusers** – a list of users who cannot log in via FTP (e.g. **root**)
- **/etc/shells** – if the user's shell is not listed here, they cannot log in via FTP.
- **/etc/ftpchroot** – if the user's name is listed here, they cannot change directory out of their home directory.

To add a user for FTP you can do something like this:

```
# You can make sure that /bin/true is in /etc/shells some other way
grep true /etc/shells || echo /bin/true >> /etc/shells
# Let's create a user named username
USER=username
useradd -s /bin/true $USER
mkdir /home/$USER
chown $USER /home/$USER
```

Some distributions include a program named **nologin** which displays a friendly message when a console login is attempted with FTP credentials.

23.4.3 pop3 – Post office protocol version 3

A POP3 server which authenticates against the Linux password database is very straightforward to set up. Popular POP3 servers include **qpopper** (by Qualcomm), and **ipop3d**.

```
george@example:~> cat /etc/xinetd.d/qpopper
# qpopper - pop3 mail daemon
service pop3
{
        disable         = yes
        socket_type     = stream
        protocol        = tcp
        wait            = no
        user            = root
        server          = /usr/sbin/popper
        server_args     = -s
        flags           = IPv4
}
george@example:~> grep ^pop3 /etc/inetd.conf
pop3s   stream  tcp     nowait  root    /usr/sbin/tcpd
      /usr/sbin/popper
```

The executable for ipop3d is generally **/usr/sbin/ipop3d**.

23.5 Review

Quiz questions

1. How does disable an **inetd** service?
2. How does one disable an **xinetd** service?
3. How would you deny access to your ssh server from all hosts except 192.168.3.3?
4. How do you make changes to **inetd.conf** or **xinetd.conf** take effect?
5. How does the **/etc/services** file relate to the **inetd.conf** and **xinetd.conf** files?
6. How is logging configured for **xinetd**?

Assignment

1. Set up a telnet server, an FTP server and a POP3 server. Use the appropriate client software to test access to each of these.
2. Set up a user account that can only use telnet and POP3. Set up a user account that can only use FTP and POP3.

Answers to quiz questions

1. Traditionally, you place a **#** on the line which defines the service in **inetd.conf**, and then **killall -HUP inetd**
2. You add “disable = yes” to the “service” section for the service in **/etc/xinetd.d/***.
3. Add “sshd: ALL” to **/etc/hosts.deny**, and add “sshd: 192.168.3.3” to **/etc/hosts.allow**.
4. **killall -HUP xinetd inetd**
5. The **services** file defines the port numbers that (x)inetd services use.
6. Using the log_ parameters in **xinetd.conf**.

24 Sendmail

> "A most convincing proof that computer software has evolved by random chance is the Sendmail configuration file. In fact, any random change is likely to improve the readability of this file ..."
>
> *– http://lunch.za.net/evolution*

LPIC topic 1.113.2 — Operate and perform basic configuration of sendmail [4]

Weight: 4

Objective

Candidate should be able to modify simple parameters in sendmail configuration files (including the "Smart Host" parameter, if necessary), create mail aliases, manage the mail queue, start and stop sendmail, configure mail forwarding and perform basic troubleshooting of sendmail. The objective includes checking for and closing open relay on the mail server. It does not include advanced custom configuration of Sendmail.

Key files, terms, and utilities include

/etc/sendmail.cf	Sendmail configuration file
/etc/aliases or /etc/mail/aliases	e-mail aliases and forwarding
/etc/mail/*	Sendmail configuration database files
~/.forward	Forwarding for a user account
mailq	Mail queue display
sendmail	The sendmail command, for sending mail
newaliases	Update the aliases database

24.1 How Sendmail works

Sendmail is the default means of transporting mail in many Linux distributions. Sendmail is a mail transfer agent (MTA). This means that Sendmail is capable receiving mail and passing it to another mail server, or local delivery agent. BSD was developed at The University of California at Berkley to facilitate inter-operability between a number of different mail formats and between network layouts (many of which are now no longer in use). Despite its antiquity Sendmail is still one of the most popular MTAs on the internet.

1. As its name implies, Sendmail is used from the client's point of view for sending mail, not receiving mail. A mail client does not collect mail from a Sendmail server but only transmits mail via a Sendmail server. (Collection is often handled by a POP3 server or an IMAP server).
2. Sendmail acts as a stand-alone server using TCP/IP and listens for connections on port 25. The protocol used is SMTP, simple mail transport protocol.
3. Sendmail will wake up periodically and transmit any mail which is waiting to be sent on the local machine (in the **/var/spool/mqueue** directory).

24.2 Sendmail configuration

The main configuration file for Sendmail is **/etc/sendmail.cf** (or sometimes **/etc/mail/sendmail.cf**). This file contains all sorts of rewriting rules for mail, which are seldom edited directly, and a few configuration parameters which can be edited manually.

The configuration files in **/etc/mail** are loaded by Sendmail when it starts up. Some of the files are used in-place, and modifications to the files take effect immediately.

Files that Sendmail loads on startup and on **killall -HUP sendmail**:

- **sendmail.cw** or **local-host-names** – the list of domains for which Sendmail does local delivery (i.e. this machine is the final resting place for mail to those domains).
- **relay-domains** – the list of domains which which Sendmail will accept the mail and transmit it to the destination.

Sendmail reads the following files as database files. These are not directly edited by humans.

- **/etc/mail/access.db** – access control – who may and may not send mail; who will Sendmail relay mail for.
- **/etc/mail/virtusertable.db** – virtual users – users whose e-mail address does not correspond directly with their user name.
- **/etc/mail/mailertable.db** – special delivery instructions for certain domains
- The files **/etc/mail/genericstable.db** (map outgoing local e-mail addresses to external e-mail addresses) and **/etc/mail/userdb.db** (incoming and outgoing address rewriting) are beyond the scope of this course.
- **/etc/aliases.db** configures alternative names for various accounts (and mail forwarding).

The command **makemap** is used to update the database files listed above from regular text files. **makemap** requires the text file to contain data separated by tabs.

```
#  key           data
10.33.33.12      RELAY
#  ^^^^^^^^^^^^ those are tab spaces - spaces are not good enough!
```

Here's how the update from text files can be done:

```
bar:~# cd /etc/mail
bar:/etc/mail# newaliases
/etc/aliases: 138 aliases, longest 163 bytes, 5748 bytes total
bar:/etc/mail# makemap hash -f access.db < access
bar:/etc/mail# makemap hash -f virtusertable.db < virtusertable
bar:/etc/mail# makemap hash -f mailertable.db < mailertable
bar:/etc/mail# makemap hash -f genericstable.db < genericstable
```

Most distribution include a **Makefile** which does these commands when changes are made to the configuration files.

```
bar:~# cd /etc/mail
bar:/etc/mail# newaliases
bar:/etc/mail# make
```

DNS MX records

Mail Exchanger (MX) records specify where mail for a domain is to be delivered to. Each

MX record specifies a priority where the lowest number is the best server to use.

```
foo:~ $ host -t mx google.com
google.com mail is handled by 40 smtp3.google.com.
google.com mail is handled by 10 smtp1.google.com.
google.com mail is handled by 20 smtp2.google.com.
```

Mail to **user@google.com** will be sent to **smtp1.google.com**, or one of the others if **smtp1** is not available.

sendmail.cw / local-host-names and local delivery

```
bar:/etc/mail# cat local-host-names
example.com
example.org
foo.bar.net
```

When mail is received for **username@example.com**, or **username@example.org** or **username@foo.bar.net**, it is handled by the local delivery system. If the user has a **.forward** file in **/home/username/.forward**, the mail is forwarded to the address given instead. Sendmail runs **procmail** as the user, which results in the received mail being appended to the user's mailbox, **/var/spool/mail/username** (or **/var/mail/username** in newer distributions).

Once the mail has been submitted to the local delivery system, Sendmail is finished with it. From the file **/var/mail/username**, the mail may be picked up by a local process, such as **pine**, **mutt** or **kmail**, or it may be delivered over the network by a POP3 or IMAP server.

relay-domains

When Sendmail receives a mail that is not addressed to a user at one of its local host names, it will by default reject it. If the mail is addressed to a domain listed in **relay-domains**, it will be relayed. Adding a domain to **/etc/mail/relay-domains** causes Sendmail to act as a backup mail server for that domain.

To act as a backup mail server, you would do it something like this:

1. The MX records for the domain **example.com** point to the main SMTP server (e.g. **smtp.example.com**) and your server (**smtp2.example.com**).
2. You add **example.com** to **/etc/mail/relay-domains**.
3. You restart sendmail (**killall -HUP sendmail**).
4. Your server now accepts mail for **example.com** and redirects it according to the MX records.

access – access control

The **access** file is used for the following purposes:

1. Specify who can relay mail via your Sendmail server

```
192.168         RELAY
10              RELAY
172.16          RELAY
127.0.0.1       RELAY
#      ^^^^^^^^^ those are tab spaces - spaces are not good enough!
```

This means that anyone with a network address beginning with the prefixes given can relay mail via the Sendmail server.

2. Specify source network addresses and e-mail addresses from which mail will be rejected.

```
192.168.0.55          550 You have a virus
61.56.224             550 AME-NET blocked for spam +27 11 555 5555
marketing@biz.info    550 We don't like your newsletter thank you
#                 ^^^^ those are tab spaces!
```

3. Specify source network addresses and e-mail addresses which are accepted without further checks (e.g. to override a DNS blacklisting...)

```
# juta.co.za was running an open relay ...
196.35.178.165  OK
#             ^^ that's a tab space - spaces are not good enough!
```

aliases – mail forwarding and alternative names

/etc/aliases gives the names of user accounts that are forwarded to other users. It is common to have an alias for **postmaster** and other accounts that are used for particular purposes.

```
postmaster: root
abuse: root
root: gerald
```

With the above aliases, mail for postmaster@ any domain and abuse@ any domain is forwarded to the local user **gerald**.

After editing the aliases file, the command **newaliases** must be run.

virtusertable – virtual users

The **virtusertable** specifies users that do not necessarily have a user account on your machine, and is commonly used for hosting multiple mail domains on a single machine.

```
fred@example.com          user001
joe@example.com           user002
catchall@example.com      user003
info@example.com          fred@example.com
@example.com              catchall@example.com
#          ^^^^^^^^^^^^^^^ those are tab spaces!
```

Mail for **fred** and **info** are delivered to the user account **user001**. Mail for **joe** is delivered to **user002**. The last line causes mail for any other user at **example.com** to be delivered to **user003** (this overrides aliases).

mailertable – domain specific delivery rules

The **mailertable** contains rules for how delivery to particular domains is handled. Entries in the **mailertable.db** file override MX records that Sendmail uses by default.

```
# forward all mail for example.org to internal SMTP server
     192.168.3.3
example.org               smtp:[192.168.3.3]
# send all smtp mail via our ISP's name server
.                         smtp:[smtp.isp.example.net]
# ^^^^^^^^^^^^^^^^^^^^^^^^^them there thangs are tab spaces
```

The first entry would usually be used along with an entry in **relay-domains** for **example.org**.

m4 sendmail.mc > sendmail.cf

Various configuration settings can be made by editing **sendmail.cf**. This is the recommended approach on a few distributions. On other distributions, it is recommended that you edit a macro-based configuration file, and generate the **sendmail.cf** with the **m4** macro processor. On SuSE a sample configuration file is installed as **/etc/mail/linux.mc**. On RedHat, the sample file is called **/etc/mail/sendmail.mc**.

```
bar:~ $ cd /etc/mail
bar:/etc/mail $ vi linux.mc                    # hey! what's this
      file?
bar:/etc/mail $ m4 linux.mc > ../sendmail.cf
```

sendmail.cf

You can edit **sendmail.cf** yourself if you are not planning to overwrite it with the output of **m4**. Much of **sendmail.cf** consists of address rewriting rules, which cannot be changed by a beginner (and which cause headaches to all that try to understand them).

The "DS" prefix in **sendmail.cf** sets the smart host for sending outgoing mail (by default none is used). This achieves the same effect as a "**.**" entry in **/etc/mail/mailertable.**

```
# "Smart" relay host (may be null)
DSsmtp.isp.example.net
```

The "Cw" prefix sets the list of host names for which mail is accepted (same as **/etc/mail/sendmail.cw** does). You can add as many "Cw" lines as you have domains for which you receive mail.

```
foo:~ $ grep ^.w /etc/sendmail.cf
Cwlocalhost
Fw-o /etc/mail/sendmail.cw %[^\#]
```

In **sendmail.cf** "O" lines are used to set various Sendmail options. One of the options you will need to set on most current distributions of Sendmail is the **DaemonPortOptions** option. This is often set as follows to indicate that Sendmail should only listen on the local interface address 127.0.0.1:

```
O DaemonPortOptions=Port=smtp, Name=MTA, Addr=127.0.0.1
```

Removing the "Addr=" option sets Sendmail to listen on the SMTP port (port 25), without binding to a particular interface:

```
O DaemonPortOptions=Port=smtp, Name=MTA
```

24.3 Sendmail queue control

Sendmail maintains a queue of mail which is waiting to be sent out. Every 30 minutes (by default) Sendmail tries to deliver each unsent mail. Generally the Sendmail rc script starts Sendmail with the following options so that Sendmail runs the queue every 30 minutes.

```
sendmail -bd -q30m
```

The files for the mail queue are stored in **/var/spool/mqueue**. The command **mailq** shows the

files which have not been sent yet, and often enough also the reason that they have not been sent.

```
matic:~ # mailq
/var/spool/mqueue is empty
                Total requests: 0
```

Sometimes it looks more like this, showing reasons that mail has not been delivered:

```
matic:~ # mailq
                /var/spool/mqueue (3 requests)
----Q-ID--- -Size-- -----Q-Time----- ------------
     Sender/Recipient-------
h0K7tss01519  47983 Mon Jan 20 09:55 <hugh@red.co.za>
               (Deferred: Connection reset by
     mail.leoburnett.co.za.)
                                     <lesmit@rednail.co.za>
h0H4inp24498  78260 Fri Jan 17 06:44 <joanne@red.co.za>
               (Deferred: Connection refused by bsh.com.)
                                     <murray@bsh.com>
h0GEKjp21158   5472 Thu Jan 16 16:20 <tracey@imak.co.za>
               (Deferred: Connection reset by nts02.mccann.co.za.)
                                     <andalkson@mccann.co.za>
```

Messages which are being delivered are marked with an asterisk *[25]:

```
-Queue ID- --Size-- ----Arrival Time---- -Sender/Recipient-------
05C24634097*   55473 Wed Aug 27 16:28:25  nithasha@dlr.org.za
                                         mzuma@sda1.org.za
```

To delete a specific mail from the queue, you can simply delete the files for the particular message from the **mqueue** directory.

```
matic:~ # rm /var/spool/mqueue/{df,qf}h0GEKjp21158
```

sendmail -q runs through the mail queue and considers delivering each mail again. Using **-v** does the delivery in verbose mode, showing the SMTP protocol steps as they happen.

```
sendmail -q
sendmail -v -q
```

24.4 Troubleshooting

Log files

Sendmail records log entries using the **syslog** "mail" log. The messages are deposited in **/var/log/mail**, or **maillog**, or **mail.info** depending on the **syslog** configuration. Each message is recorded at least twice:

- When the mail is received, a log entry is made
- For each delivery attempt, a log entry is made.

Here is a message which is received and relayed to another server:

When the message is received the first log entry is made. It is assigned a message ID, and its size and details about the sender and the sending machine are noted.

25 Actually, that's the output of **mailq** from a machine running **postfix**, a Sendmail replacement. The fact that seconds are displayed the time column gives the secret away.

```
Aug 25 00:22:56 matic sendmail[3605]: h70MMsi03605:
      from=<cavitamin@dailywebdeals.com>, size=2264, class=0,
      nrcpts=1,
      msgid=<20030824222744.BE653B48026@mail2.dailywebdeals.com>,
      proto=ESMTP, daemon=MTA, relay=mail2.dailywebdeals.com
      [206.251.239.177]
```

When the message is delivered (or delivery is attempted), another log entry is made. This records the details of the recipient and the server which accepted the mail. In this case, the mail was delivered to a machine 196.2.12.146.

```
Aug 25 00:22:57 matic sendmail[3607]: h70MMsi03605:
      to=<bongani@example.co.za>, delay=00:00:01, xdelay=00:00:01,
      mailer=smtp, pri=122264, relay=[196.2.12.146] [196.2.12.146],
      dsn=2.0.0, stat=Sent (Ok: queued as 00081634066)
```

Promiscuous relay

An all-too-common problem when configuring a mail server is to inadvertently allow any person anywhere to send mail from anybody to anybody via your server. Evil people then use this configuration feature to send spam messages about pornography, scams and useless products to innocent victims.

To avoid this problem with Sendmail, there are a few things you need to do:

1. Never use “FEATURE(promiscuous_relay)” in the **m4** macro configuration file.
2. Never configure your system to relay based on the sender name.
3. Always test whether your system does in fact deny relaying after setting it up.

A fair way to test this is to modify **/etc/mail/access** to permit relaying from only the loopback address 127.0.0.1, rather than all IP addresses starting with “127”.

```
127.0.0.1       RELAY
```

Now that 127.0.0.2 (which is also local) is untrusted, you should then be able to test whether the system trusts untrustworthy addresses like this.

```
georgem@smtp:~ > telnet 127.0.0.2 25
Trying 127.0.0.2...
Connected to 127.0.0.2.
Escape character is '^]'.
220 Sendmail ESMTP 8.12
HELO evil.spammer
250 smtp.ledge.co.za Hello [127.0.0.2], pleased to meet you
MAIL FROM: <fake@fake.example.net>
250 2.1.0 <fake@fake.example.net>... Sender ok
RCPT TO: <victim@example.com>
550 5.7.1 <victim@example.com>... Relaying denied.
QUIT
221 2.0.0 smtp.ledge.co.za closing connection
Connection closed by foreign host.
```

Instead of using 127.0.0.2, you can connect from an external untrusted host. Alternatively you can ask one of the automated testing systems such as **ordb.org** to test your server (and blacklist it in the friendliest possible way if it fails the test).

24.5 Review

Quiz questions

1. What is Sendmail, and what does it do?
2. What steps will you take to to cause all mail addressed to the address **sales** to be delivered to **george**?
3. How do you restart Sendmail after configuration changes? Which configuration changes require that Sendmail be restarted?
4. How do you view the contents of the mail queue?
5. How do you remove a message from the queue if you do not wish to send it?
6. Which parameter controls where outgoing mail is sent, and in what ways can it be set?

Assignment

1. Install Sendmail, and configure it to accept mail for a domain such as **fake.example.net**. Use the command **sendmail -bv user@fake.example.net** to verify how mail will be delivered.
2. Configure your Sendmail to listen to connections on its real network interface, rather than only the loopback interface. Verify that you have done this correctly with **netstat -lt**.
3. Send a mail manually using SMTP.

```
telnet localhost 25
HELO fraudulent.com
MAIL FROM: <bill@www.example.com>
RCPT TO: <victim@fake.example.com>
DATA
From: bill@www.example.com
To: victim@fake.example.com
X-Bogus-Mail-Header: Bogusly typed by me
Subject: LPIC is easy

I told you it was.
.
QUIT
```

4. Check that your mail server does not relay mail from the local network. Now modify the **access** table so that it does accept and relay for the local network.
5. Add a mailbox user using **useradd** with a shell of **/dev/null**. Send a test mail to this user. Set up a mail client to send mail via SMTP and receive mail via POP3 (e.g. **kmail**, **evolution** or **balsa**). Test whether you can send mail from the user to the user.
6. Send a mail to **anyuser@example.com** and document the effect that this has on the mail queue, and the mail logs.
7. Configure your server to be a backup mail server for the domain **other.example.com**. Attempt to deliver this mail another SMTP server on your network.

Answers to quiz questions

1. A mail server – MTA – message transfer agent. It transfers electronic mail it receives to the recipient.
2. Add “sales: george” to **/etc/aliases**, and run **newaliases**.
3. killall -HUP sendmail will work, as should /etc/init.d/sendmail reload. Restarting sendmail is only necessary for changes to text files, and not for changes to database files.
4. mailq
5. rm /var/spool/mqueue/{q,d}f$MESSAGEID
6. The “smarthost” parameter. It can be set by editing **sendmail.cf** (search for “^DS”). One can achieve the same effect with an entry in **/etc/mailertable**.

25 Apache

> apache **n. 1:** any member of Athapaskan tribes that migrated to the SW desert (from Arizona to Texas and south into Mexico); fought a losing battle from 1861 to 1886 with the US and were resettled in Oklahoma **2:** a Parisian gangster **3:** the language of the Apache people.
>
> *Wordnet* ™

LPIC topic 1.113.3 — Operate and perform basic configuration of Apache [4]

Weight: 4

Objective

Candidates should be able to modify simple parameters in Apache configuration files, start, stop, and restart httpd, arrange for automatic restarting of httpd upon boot. Does not include advanced custom configuration of Apache.

Key files, terms, and utilities include

apachectl	Apache stopper starter
httpd	Apache executable
httpd.conf	Configuration file for Apache

25.1 Running Apache

The Apache web server is a HTTP/1.1 (RFC 2616) compliant web server that runs on a variety of platforms including Windows, Netware, OS2 and most flavours of UNIX. Apache was derived from the NCSA HTTP server with patches applied (hence the name).

A configured Apache installation will consist of the following:

- The Apache executable, **httpd**. Current versions of Apache implement many of the server's features using dynamically loaded modules from **/usr/lib/modules**.
- The configuration file **httpd.conf**[26] (in a subdirectory of **/etc**, typically **apache** or **httpd** or **httpd/conf**).
- Documents which can be downloaded from the Apache server via HTTP. Typically a number of HTML documents and images are stored in a directory named the DocumentRoot. The exact directory varies across distributions. Redhat uses **/var/www/htdocs**, SuSE uses **/svr/www/htdocs** or **/usr/local/httpd/htdocs**, and Debian woody uses **/var/www**.

Starting and stopping

The startup script for Apache starts it as follows:

```
httpd -f /etc/httpd/httpd.conf
```

26 For Apache versions older than 1.3 the files **srm.conf** (namespace management) and **access.conf** (directory based access control) are included by **httpd.conf**. See http://httpd.apache.org/info/three-config-files.html

That's true, except sometimes the executable is not called **httpd** (like NCSA httpd) but **apache**.

```
apache -f /etc/httpd/httpd.conf
```

The **apachectl** program is used to start and stop Apache.

```
banana:~# apachectl help
usage: /usr/sbin/apachectl (start|stop|restart|fullstatus|status|
      graceful|configtest|help)

start      - start httpd
stop       - stop httpd
restart    - restart httpd if running by sending a SIGHUP or start
      if
             not running
fullstatus - dump a full status screen; requires lynx and mod_status
status     - dump a short status screen; requires lynx and
      mod_status
graceful   - do a graceful restart by sending a SIGUSR1 or start
configtest - do a configuration syntax test
help       - this screen
```

If you modify **httpd.conf**, the correct thing to do is **apachectl restart**. If you made errors in the configuration, it is possible that Apache will fail to start, so **apachectl configtest** is a wise check.

To make Apache start when the system starts, you use your distribution-specific procedure to make the link in the correct runlevel script (**/etc/init.d/apache** or **httpd**):

```
chkconfig --add apache                                  # Redhat,
      SuSE
update-rc.d apache start                                # Debian
insserv apache                                          # SuSE <
      8.0
cd /etc/rc2.d ; ln -s ../init.d/apache S80apache        # anything
```

Log files

Each time a URL is requested from the HTTP server, an entry is made in the access log file (e.g. **/var/log/apache/access.log**).

```
165.165.134.47 - - [28/Aug/2003:14:55:17 +0200] "GET
      /software/squint/ HTTP/1.0" 200 15166
      "http://freshmeat.net/search/?q=squid+log+analyze&section=proj
      ects" "Mozilla/4.0 (compatible; MSIE 5.5; Windows NT 5.0)"
165.165.134.47 - - [28/Aug/2003:14:55:17 +0200] "GET
      /software/squint/images/spacer.gif HTTP/1.0" 404 227
      "http://ledge.co.za/software/squint/" "Mozilla/4.0
      (compatible; MSIE 5.5; Windows NT 5.0)"
```

These log entries mean that 165.165.134.47 loaded the page "/software/squint/" (15166 bytes) after being referred there by freshmeat.net (as the result of a search for a squid log analyser). The user is using Microsoft Internet Explorer version 5.5 on Windows 2000. A subsequent request for "spacer.gif" failed (404 result code).

Errors are logged to a separate file, usually named **error.log** (e.g. **/var/log/httpd/error.log**)

```
[Fri Aug 15 06:37:00 2003] [error] [client 196.25.228.122] File does
     not exist: /usr/local/httpd/htdocs/default.ida
[Fri Aug 15 06:44:46 2003] [error] [client 66.196.65.40] File does
     not exist: /usr/local/httpd/htdocs/robots.txt
```

The first error was generated by a request from a Windows server infected with the Code red or Nimda worm, and the second was generated by a web crawler.

25.2 Configuration

The general form of configuration directives in **httpd.conf** is ...

```
<DirectiveName>
     ConfigurationItem
     AnotherConfigItem   Value
     SomethingElse       Value1 Value2 Value3 Value4
</DirectiveName>
```

Global options

The first part of **httpd.conf** contains configuration items for the entire server.

- **Listen 80** – listen on TCP port 80 (www service) for incoming HTTP requests.

```
#Listen 192.168.0.3:80
Listen 80
```

- **ServerRoot** – the current directory when the server runs. All configuration files are relative to this directory.
- **LoadModule ...** – a number of dynamic modules can be loaded.

```
LoadModule access_module modules/mod_access.so
LoadModule auth_module modules/mod_auth.so
LoadModule auth_anon_module modules/mod_auth_anon.so
...
```

- **AddModule ...** – each of the modules which is loaded is initialised in a preset order:

```
AddModule mod_access.c
AddModule mod_auth.c
# AddModule mod_auth_anon.c
...
```

- **User** and **Group** – after starting to listen on port 80, **httpd** changes its privileges to a user and group.

```
User www
Group nogroup
```

- **Servername** sets the name which your server identifies itself as. This name is used in error reports and when the server sends a redirection.

```
ServerName www.example.com
```

If the server's IP address is 172.18.45.231 then URLs like http://172.18.45.231/subdir will be redirected to http://www.example.com/subdir/ (note the extra slash).

Main server configuration

The second part of **httpd.conf** contains configuration items for server itself.

- **DocumentRoot** sets the directory from which the server looks for documents. Symbolic links and aliases can be used to reach files outside this directory.

```
# DocumentRoot "/var/www"          # debian
# DocumentRoot "/var/www/htdocs"   # redhat
DocumentRoot "/usr/local/httpd/htdocs"
```

- **Directory** specific access control. The **Directory** scope indicates whether the server should read files in a particular directory when they are requested. The directory given is relative to the root directory of the operating system (e.g. /). There are usually a number of **Directory** scopes.

  This **Directory** scope specifies that authentication is required for the root directory and all its subdirectories.

```
<Directory />
    AuthUserFile  /etc/httpd/passwd
    AuthGroupFile /etc/httpd/group
    Options -FollowSymLinks +Multiviews
    AllowOverride None
```

  This is generally followed by a **Directory** specification for the **DocumentRoot** directory. This particular one allows the generation of index pages for directories, forbids the server to follow symbolic links, allows SHTML include files and enables MultiViews (whatever those are). The **AllowOverride** line allows **.htaccess** files to contain Apache configuration directives.

```
<Directory "/usr/local/httpd/htdocs">
    Options Indexes -FollowSymLinks +Includes MultiViews
    AllowOverride All
</Directory>
```

- **Userdir** allows you to name the subdirectory for a user's personal files. This is often **public_html**.

```
UserDir public_html

<Directory /home/*/public_html>
    AllowOverride FileInfo AuthConfig Limit
    Options MultiViews Indexes SymLinksIfOwnerMatch IncludesNoExec
</Directory>
```

  The URL http://server/~user/page.html corresponds to the file /home/user/public_html/page.html

- **DirectoryIndex** sets the name of files which the server looks for instead of showing a directory listing.

```
DirectoryIndex index.php index.html index.htm default.htm
```

- **ErrorLog** sets the name of the log file for errors. This includes missing pages, permission problems and errors generated by scripts.

```
ErrorLog /var/log/httpd/error_log
```

- **CustomLog** sets the name of the file to which access logs are written. This example logs to **access_log** in the "combined" format.

```
CustomLog /var/log/httpd/access_log combined
```

- **ScriptAlias** sets the directory of the cgi-bin scripts. Executables in this directory are run when the corresponding URL is accessed.

```
ScriptAlias /cgi-bin/ "/usr/local/httpd/cgi-bin/"
```

  The URL **http://server/cgi-bin/script.pl** runs **/usr/local/httpd/cgi-bin/script.pl** and displays the output.

Virtual hosts

An optional third part of **httpd.conf** can contain configuration for virtual hosts.

It is common for a single Apache server to operate a number of separate web sites. HTTP requests include the name of the site that was requested, so the server can serve different configured sites based on the given name.

The **NameVirtualHost** directive less Apache that a particular IP address and port are used for virtual hosts.

```
# NameVirtualHost 172.19.122.2:80
NameVirtualHost *
```

Each virtual host is then defined in a **VirtualHost** section. The configuration is inherited from the main server configuration, except where an item changed.

```
<VirtualHost *>
    DocumentRoot /home/www/dummy-host.example.com
    ServerName dummy-host.example.com
    ServerAlias www.dummy-host.example.com
    ErrorLog /var/log/httpd/dummy-host.example.com-error_log
    CustomLog /var/log/httpd/dummy-host.example.com-access_log
      common
</VirtualHost>
<VirtualHost *>
    DocumentRoot /home/www/secure.example.com
    ServerName secure.example.com
</VirtualHost>
```

Apache can also serve different sites based on the destination IP address. In this case, you simply omit the **NameVirtualHost** directive.

Authentication

The directives below instruct Apache to consult the file in a particular directory, and allow the authentication configuration and the **Limit** directive to appear in the file.

```
<Directory /usr/local/httpd/htdocs/secretfiles/>
    AllowOverride AuthConfig Limit
</Directory>
```

The **.htaccess** file looks like this.

```
# /usr/local/httpd/htdocs/secretfiles/.htaccess
AuthUserFile /usr/local/httpd/htdocs/secretfiles/.htpasswd
AuthGroupFile /dev/null
AuthName "Secret files"
AuthType Basic
<Limit GET POST>
    require valid-user
```

```
</Limit>
```

Notice that everywhere full path names are used. This is necessary since path names are not relative to the file in which they appear, but are relative to the **ServerRoot**. The actual **.htpasswd** file is generated using the **htpasswd** utility.

25.3 Review

Quiz questions

1. What is the purpose of a web server?
2. Why is **apachectl configtest** necessary?
3. What does the **DocumentRoot** configuration parameter specify?
4. When you change **DocumentRoot**, what else in the configuration file will you change simultaneously?
5. What is the **ServerName** directive set to?

Assignment

1. On your server configure the server name and the document root to custom values (e.g. **example.net** and **/home/example**). What is the effect of the change? Which parameters do you have to change to make it work as a web site?
2. Set up two name based virtual hosts with different web pages for **www.example.com** and **www.example.org**. Test the behaviour of the web server using fake entries in **/etc/hosts**.
3. Set up authentication for a subdirectory on your web server. Allow read access to a user named **guest** with a password of **823kk**, and to a user named **admin** with a password of **513aj**.
4. Create a web site for yourself, and find a way to make it publicly accessible (preferably on your own Apache server, or someone else's).

Answers to quiz questions

1. To answer HTTP requests.
2. Apache will not start or restart if there are errors in the configuration file.
3. The directory at which the server begins to look for files requested by the client.
4. The “Directory” permissions.
5. The name by which your web server wishes to be known.

26 File servers

The steady state of disks is full.

– *Ken Thompson, quoted in /usr/share/games/fortunes/computers*

LPIC topic 1.113.4 — Properly manage the NFS, smb, and nmb daemons [4]

Weight: 4

Objective

Candidate should know how to mount remote filesystems using NFS, configure NFS for exporting local filesystems, start, stop, and restart the NFS server. Install and configure Samba using the included GUI tools or direct edit of the /etc/smb.conf file (Note: this deliberately excludes advanced NT domain issues but includes simple sharing of home directories and printers, as well as correctly setting the nmbd as a WINS client).

Key files, terms, and utilities include

/etc/exports	NFS server configuration file
/etc/fstab	File system table (network file systems too)
/etc/smb.conf	Samba configuration file
mount	Mount a file system (network file systems too)
umount	Unmount a file system (network file systems too)

26.1 NFS server

NFS, the Network File System, was originally developed by Sun Microsystems and is considered to be the UNIX native file sharing protocol. NFS provides a way to integrate disks on physically separate servers into a single file system.

The NFS protocol connects machines, rather than users. The NFS server shares files together with their ownership and permission information. The NFS client machine is trusted to implement access controls[27].

NFS can work together with a name service, known as NIS or Network Information Service. NIS distributes a central user database across the network. The alternative is to manually synchronise password files between computers.

NFS uses Sun RPC (Remote Procedure Call). Sun RPC negotiates procedure calls via the port mapper (**portmap**, port 111), and so does NFS.

rpc.nfsd and rpc.mountd

The NFS server is implemented in two parts[28]:

- **rpc.nfsd** – the NFS server process
- **rpc.mountd –** the process which handles NFS mount requests.

For a working NFS server the two servers and also **portmap** must be started by the init scripts.

27 Actually, NFS clients are not fully trusted. An NFS client can do whatever the server permits if it chooses to.
28 So that if it breaks you can keep both ...

/etc/exports – configuration file for NFS server

The **exports** file lists the directories which the NFS server shares, the machines which may use those directories, and the options for each machine.

Each line in **/etc/exports** has the syntax:

```
/share/path        host(option,option)
```

The host machines which may access the share may be given as IP addresses or host names (e.g. DNS entries or hosts files entries). For host names, asterisks may be used (e.g. ***.example.com**). For IP addresses you can append a netmask or the number of bits (e.g. **172.16.0.0/12** or **172.16.0.0/255.240.0.0**).

The options determine how the client connection is handled:

- **ro** – read only. **rw** – read/write. When a NFS share is read-only, the client can not write changes to the NFS share.
- **secure**, **insecure** – "secure" in this case means that the NFS server checks that the process on the client is running with root privileges. This prevents regular users on the client machine from bypassing file system permissions.
- **root_squash**, **no_root_squash**, **all_squash** – by default, root on the client system is root on the server system. **root_squash** tells the server to treat root on the client as if it were nobody. **all_squash** maps all users to nobody.

```
foobar:~ $ cat /etc/exports
# Directory     Exported to which clients ...
/               trusted(rw,no_root_squash)
/projects       proj*.example.com(rw)
/usr            *.example.com(ro) 192.168.5.0/24(rw)
/cdrom          (ro,insecure,all_squash)
```

After making changes to **/etc/exports**, you should signal **rpc.mountd** and **rpc.nfsd** to take note of the changes. Either of these will do the trick:

```
killall -HUP rpc.mountd rpc.nfsd
exportfs -r
```

26.2 NFS client

The **mount** command connects a NFS client to an NFS server. The syntax for mounting NFS is:

```
mount server:/share/dir /where/to/mount/it -o option,option
```

It is not generally necessarily to specify **mount -t nfs** (file system type).

```
mount nfsserver.example.com:/projects /mnt
```

Commonly used options when mounting a share from an NFS server are ...

- **soft** – by default, the kernel will lock up hard and put a process into disk wait state (**D**) when the NFS server reports errors. With **soft** the kernel reports NFS errors to the program after no response for the number of seconds indicated by the timeout parameter, e.g. **timeo=60**.
- **hard** – when the NFS server does not respond, the process using it is in disk wait state, and

can only by interrupted if the file system was mounted with the **intr** option.

- **async** – changes are written to the NFS server in the background.
- **nolock** – don't start the NFS lock daemon.

Here we mount the directory **/data** from a NFS server named "**baa**":

```
foo:~ # mount baa:/data /mnt/ -o intr,rw
foo:~ # mount
baa:/data on /mnt type nfs (rw,intr,addr=10.0.0.10)
```

/etc/fstab – filesystem table

Entries in **/etc/fstab** follow the pattern given to the mount command. The first column contains the source of the data (server:directory), the second column the mount point, the third column "nfs" and the option column contains the mount options required.

```
foo:~ # grep : /etc/fstab
# what            where     type options  ...
nfs:/suse/suse8.2 /distrib  nfs  defaults                          0
      0
nfs2:/home/stuff  /stuff    nfs  soft,intr,timeo=15,rw             0
      0
server:/home/foo  /var/foo  nfs  soft,intr,timeo=15,noauto,rw,user 0
      0
baa:/data         /mnt/data nfs  soft,intr,timeo=30,noauto,rw,user 0
      0
10.7.3.44:/home   /mnt/topaz nfs soft,intr,rw,noauto               0
      0
```

All the regular **fstab** mount options apply. The "user" option for example indicates that any user can mount the share.

26.3 Samba server

Computers running Microsoft operating systems support file and printer sharing using the SMB protocol (server message block). This protocol has grown into something of a standard over time. Samba is a suite of programs for UNIX that implement the SMB protocol.

SMB file sharing has been implemented on a number of Microsoft operating systems:

- Windows for Workgroups – SMB server and client software were included with Windows for Workgroups for peer to peer file sharing. TCP/IP networking required Trumpet Winsock (Windows sockets).
- Windows 95/98/ME – These operating systems are similar to Windows for Workgroups in functionality, but have native support for TCP/IP. Some new features were introduced into the SMB protocol – encrypted passwords and domain logon authentication (requiring a Windows NT server).
- Windows NT/2000 – Windows NT introduced the concept of a machine login to support multi-user functionality. Windows 2000 added a number of additional complexities that are not discussed in this text.

SMB protocol

The SMB protocol was originally run on Netbeui, but can be run on TCP/IP or SPX/IPX. The SAMBA implementation runs on TCP/IP only. The SMB protocol relies on the Nebios protocol to translate host names into network addresses, and this protocol is implemented by the SAMBA suite.

SMB is a client-driven protocol – the client makes a request and the server responds. SMB shares are accessed by supplying a user name and password.

SMB servers support one of two different file sharing modes – share level access control and user level access control. In share level access control, authentication to access a share is via a password only. In user level access control the client supplies a user name and a password when accessing a machine. Directories can individually be shared with either read-only or read-write permissions. The client requests to login to a share and supplies a user name and password.

When connected to the server, it behaves in a similar way to file systems on the local machine. Files can be copied, renamed, opened, deleted and transmogrified at will.

Netbios name resolution and WINS

Windows machines send broadcast queries to the network broadcast address to determine which machines are connected to the network. A machine appointed as the “browse master” responds to these queries and provides a list of machines (and users) on the network. Periodically the machines have an election to determine the master browser which caches the list of machines on the network.

Using subnet broadcasts is impractical in large networks, because of traffic considerations, and because network broadcasts are limited to a single subnet. In addition, the machine that wins the election is not always the most capable machine on the network. To solve these problems, a Windows Internet Name Server (WINS) is used to translate Netbios names into IP addresses. This feature enables widows machines to “find” each other fairly reliably.

Name resolution for SMB, either via WINS or via network broadcasts is implemented by **nmbd**.

For Netbios name resolution to work, one of the following must be true:

- Your Samba server is on the same subnet as your Windows client. The Windows client must have WINS disabled, and the Samba server must be configured with **wins support = no** and **wins server = ""**.
- The Samba server must act as a WINS server (**wins support = yes**), and the Windows client must specify the Samba server as its WINS server.
- The Windows clients must have the same setting for WINS server as the Samba server (**wins server = x.x.x.x**).

smb.conf – Samba configuration file

The configuration file for samba is **smb.conf** (usually in **/etc/samba**, or **/etc** in older versions). This file is documented by a comprehensive man page. After changing this file, Samba must

be reloaded for the changes to take effect (usually **killall -HUP smbd** is sufficient).

In the configuration file, the settings for each share are listed after the share name, in the format shown. The **[global]** section defines options that are applicable to the server. **[homes]** defines the settings for the sharing of each user's home directory. The **[printers]** section defines the settings for print sharing by **smbd**.

Samba shares each user's home directory as a share of the same name as the user. The actual configuration for these shares is set in the **[homes]** section. In this configuration, only user himself can connect to his home directory, and new files and directories are created with the given permissions.

```
[homes]
        comment = Home Directories
        valid users = %S
        browseable = No
        read only = No
        create mask = 0640
        directory mask = 0750
```

Unix permissions and ownership for the files in the share still apply. If there are problems accessing files in the user's home directory, these may be files to which the user does not have access to under his Unix user ID.

If the **[printers]** share is present, it sets the details for the use of the printers configured on your Samba server. Using a printer share is quite similar to using a file share, except that after uploading a file, the file is printed (usually via **lpr**).

```
[printers]
        comment = All Printers
        path = /var/tmp
        printable = Yes
        create mask = 0600
        browseable = No
```

Samba users

If **encrypt passwords = no** in the **[global]** configuration section, then Samba checks that the user anme and password supplied by clients matches the user authentication data. Samba expects the client computers to pass passwords unencrypted over the network. Although Windows machines *can* be configured to do this by changing a registry entry, it is far more common for Samba to store an unencrypted version of the password in **/etc/samba/smbpasswd**. The more commonly used setting is **encrypt passwords = yes**.

There are two steps in setting up a user account to access a Samba server.

1. The Unix user must exist (e.g. created with **useradd**). Samba does not require that the user have an executable shell (i.e. **/dev/null** is okay).
2. The user's password must be set with **smbpasswd**. For Samba to work, you do not have to set the password for this user using **passwd**[29].

The command **smbpasswd** updates the file **smbpasswd** with the user name and password that

29 Samba may modify the Unix password for you if the “unix password sync” option is enabled.

will be used.

```
foo:~ # smbpasswd -h
When run by root:
    smbpasswd [options] [username] [password]
otherwise:
    smbpasswd [options] [password]
options:
  -h                   print this usage message
  -a                   add user
  -d                   disable user
  -e                   enable user
  -m                   machine trust account
  -n                   set no password
  -x                   delete user
foo:~ # useradd bernadette
foo:~ # mkdir ~bernadette; chown bernadette ~bernadette
foo:~ # smbpasswd -a bernadette
New SMB password:
Retype new SMB password:
Added user bernadette.
foo:~ # cat /etc/samba/smbpasswd
bernadette:502:C187B8085FE1D9DFAAD3B435B51404EE:A9F0DD57E1EDAB5BB55A
      9AC0A99C15EC:[UX         ]:LCT-3F539773:
```

Windows GUI configuration

To connect to a share on a Samba server, you can enter **\\server\sharename** in the path of Windows Explorer, or after **net use** on the command line, or in the "Run" box. A Samba server can also be accessed via the Network Neighbourhood browser in Windows 95 and higher.

There are a few prerequisites to making this work.

- The Windows client must be set up to support Windows File Sharing over TCP ("Client for Microsoft Windows"). Networking between the two systems must be correctly configured, with particular reference to the broadcast address if no WINS server is used.
- The configuration of WINS or the lack thereof must correspond on the client and server.
- The log on user name on the Windows client must be set. Windows NT and derivatives allow you to set the user name which will be used to connect to the server. Earlier versions of Windows use the logon user name in all cases. If you do not know what it is, the connection will not succeed.
- The user must exist as a Unix user on the Samba server.
- The user must exist in **smbpasswd** on the Samba server.

Once the connection is established, the user must be able to access the files contained in the share according to the Unix permissions (i.e. **su username -s /bin/sh -c 'ls -la /home/sharename'** succeeds, and reading and writing of files as the user is possible).

26.4 Review

Quiz questions

1. What command would you use to mount a the directory **/home/myself** on a NFS server named **nfsserver** at the directory **/mnt/nfs**?
2. Which NFS mount option will ensure that you can kill a process using the NFS server if you are disconnected from the NFS server?
3. What is the syntax of the **exports** file?
4. Who will be able to use the NFS share, and what will they be able to do?
```
/etc          192.168.3.0/28(ro,insecure,all_squash)
```
5. What can one do to make changes to the NFS server configuration take effect?
6. How does one create a new share on a Samba server?
7. How does one configure **nmbd** to act as a WINS client?
8. What entry in **fstab** would cause the share **//pcpool/games** to be mounted automatically at boot time on the directory **/games** using the user name **fred** with the password **flint**?
9. How do you unmount a SMB filesystem?

Assignment

1. Set up a NFS server sharing its **/home** directory, with a number of users (**hewey**, **dewey** and **lewey** if you can't think of any names). Set up a NFS client machine which mounts its home directory from the NFS server. Manually synchronise **/etc/passwd** and **/etc/shadow** from the server to the client and log in on the client and the server simultaneously as one of the users.
2. Set up a Samba server on the NFS client that shares the home directories you set up previously. Test whether you can connect to the Samba server first using **smbclient** and then using Windows.
3. Create a folder which has read and write access for all users. Save a file in this share as one user, and then try to alter it as another user. If this does not succeed, correct your configuration so that it does.
4. Create a unix group on the Samba server named **accounts**. Make **hewey** and **dewey** (or two other users) members of this group. Create a shared directory to which only these users can connect.

Answers to quiz questions

1. **mount nfsserver:/home/myself /mnt/nfs**
2. soft
3. Exported directory-name, then a list of the machines that may mount it.
4. A machine in the subnet 192.168.3.0 – 192.168.3.15 can mount it. They will be able to read (but not write) files in **/etc** which can be read by the user **nobody**.

5. exportfs -r
6. Modify **smb.conf**, adding a new section, specifying (at a minimum) the directory name to share.
7. If the WINS server is 192.168.43.22, then with the parameter "wins server = 192.168.43.22" in **smb.conf**.
8. One like this:

```
# what          where   type   options
//pcpool/games  /games  smbfs username=fred,password=flint 0 0
```

9. umount /mountpoint

27 Caching DNS server

DNS is a bind.

LPIC topic 1.113.5 — Setup and configure basic DNS services [4]

Weight: 4

Objective

Candidate should be able to configure hostname lookups and troubleshoot problems with local caching-only name server. Requires an understanding of the domain registration and DNS translation process. Requires understanding key differences in configuration files for bind 4 and bind 8.

Key files, terms, and utilities include

/etc/hosts	Static name resolution file
/etc/resolv.conf	DNS name resolution configuration
/etc/nsswitch.conf	Name resolution selection
/etc/named.boot (v.4) or /etc/named.conf (v.8)	Configuration files for BIND.

27.1 Name resolution in brief

Name resolution involves translating a name like www.example.com into a network address like 172.31.52.222. In Linux systems the process works like this:

1. Look at the "hosts" entry in **/etc/nsswitch.conf**. Look up the name using each of the methods listed, and return the first set of results found. The usual entry is "hosts: files dns".
2. "Files": Look up the name in **/etc/hosts**. If it is found, we're done, otherwise go on to DNS.
3. "DNS": Open up the DNS configuration file **/etc/resolv.conf**.

```
bar:~ $ cat /etc/resolv.conf
search example.co.za
nameserver 196.25.1.1
```

The system sends a DNS query for the name to the configured DNS server. If the name is not found, it may be changed (possibly adding the search path, or the domain).

If the local machine is running a caching DNS server, you would configure the resolver to query the local DNS server.

```
bar:~ $ cat /etc/resolv.conf
search example.co.za
nameserver 127.0.0.1
```

27.2 BIND

The Berkeley Internet Name Daemon is standard equipment for much of the Internet, although alternative DNS servers do exist. DNS servers operate in two roles – providing authoritative information for domains which are delegated to them, and answering queries which require querying other DNS servers. A DNS server which has no DNS domains delegated to it is called a caching DNS server. DNS information is cached, and queries are performed

relatively quickly.

In order for BIND to act as a caching DNS server, the following are necessary:

- The server must be running (usually called **named**)
- The server must be able to locate the root servers. BIND ships with a list of the root servers – a file called **root.hint** or **named.boot** (the root servers may inform BIND that it its hints are not quite right).

27.2.1 BIND version 4

The configuration file for this version of BIND is **/etc/named.boot**. A simple configuration file would specify the root server hints (**named.root**) and provide forward and reverse lookups for localhost and 127.0.0.1.

```
directory /var/named
cache   .                       named.root
primary localhost               named.localhost
primary 0.0.127.IN-ADDR.ARPA    named.localhost.rev
primary example.com.            named.example.com
primary 0.168.192.IN-ADDR.ARPA  named.example.com.rev
```

This configuration file specifies that DNS request for localhost and example.com are handled by the server (by refering to the named file). Reverse lookup for 127.0.0.0/24 and 192.168.0.0/24 are handled by the server as well. All other DNS queries are handled by working from the root servers to the name requested.

BIND version 4 is not widely deployed, primarily due to security problems.

27.2.2 BIND version 8

The configuration file for BIND version 8 and 9 is **/etc/named.conf**. DNS zone files are stored in a directory such as **/var/named** (or **/var/lib/named**).

```
zone "0.0.127.IN-ADDR.ARPA" {
        type master;
        file "localhost.rev";
};
zone "example.com" {
        type master;
        file "named.example.com";
};
zone "0.192.168.in-addr.arpa" {
        type master;
        file "example.com.rev";
};
zone "." {
        type hint;
        file "db.root";
};
```

27.2.3 Domain registration

In order for you to run a domain name like **example.com**, the previous level of name servers

(e.g. those for **.com**) must know where your name servers are. The name servers for each top level domain is administered by an organisation. Some samples are shown here.

Domain	***Purpose***	***Administered by***
.	The root servers	iana.org – don't ask for chages
.com	Commercial entities	internic.net
.net	Network stuff	
.edu	US educational institutions	
.mil	US military	
.org	Non-profit organisations	
.gov	US government	The US government
.za	South Africa	SA govt? Mike Lawrie? Randy Bush?
.au	Australia	
.fi	Finland	
.uk	United Kingdom	
.de	Germany (Deutschland)	
.ru	Russia	

You can apply to the administrator to register a sub-domain. Each top level domain has its own standards and criteria. Some will not register a sub-domain, but will direct you to an existing sub-domain. Usually they will require some form of payment before delegating a sub-domain to you.

The top level domain for South Africa is za and a number of sub-domains exist which may register sub-domains in turn. These are a few sub-domains used in South Africa, and the organisations that administer them.

Domain	***Purpose***	***Administered by***
.co.za	Commercial and general	Uniforum, see www.co.za
.org.za	Non commercial organisations	Internet Solutions, see www.org.za
.za.org	Free for all	plig.net, see www.za.org
.za.net	Free for all	plig.net, see www.za.net
.alt.za	Alternative	Alan Barrett
.ac.za	Academic institutions	TENET
.gov.za	Government	SITA
.lunch.za.net	Not quite the leading edge	Leading Edge Business Solutions

27.2.4 Zone files*

DNS zone files as used by BIND zone are standardised in RFC 1035. A zone file specifies details which apply under a particular zone.

A number of abbreviations and syntax conventions are followed in a zone file:

- Each line is in the form

  ```
  name class time-to-live type details
  ```

  "name" is the name of the record (e.g. **mail**, **www** or **benedict**). "class" is almost always the Internet class "IN". If the class is left blank, "IN" is assumed. "time-to-live" is the number of seconds for which the record should be remembered by DNS servers (or hours "H", days "D" or weeks "W"). "type" is SOA, NS, A, TXT, CNAME, MX and similar. "details" differs from one record type to the next.
- A semicolon is used as the comment character (";")
- Lines can be continued using parentheses (...).
- From BIND version 9, the zone file must start with "$TTL ...", setting the default time to live for records that do not have one, e.g. "$TTL 1D" for 1 day.
- The domain name is automatically appended to each name in the zone file, except for "A" records and where the name ends with a dot. So for example, "mail" may become "mail.example.com", but "mail.example.com." is left unchanged[30].
- The "@" sign is replaced with the full name of the domain where it occurs. The DNS administrator's e-mail address is therefore written with a dot (.) in the place of an "@".
- If the name is omitted, the previous name is used.

The most often used types of Internet records that appear in a zone file are these:

- SOA – Start of authority – every zone file starts with a SOA record. In this record you can read which is the primary name server for the domain, the e-mail address of the DNS administrator, and the time at which the record was last changed.

  ```
  $TTL 1D
  google.com.   IN SOA ns1.google.com. dns-admin.google.com. (
        2003090402
                  7200
                  1800
                  1038800
                  60 )
  ```
- NS – Name server – The names of name server for the zone is listed in the zone file. Every zone must have name servers.

  ```
  google.com.             4D      IN      NS      ns1.google.com.
  google.com.             4D      IN      NS      ns2.google.com.
  google.com.             4D      IN      NS      ns3.google.com.
  google.com.             4D      IN      NS      ns4.google.com.
  ```
- A – Address record – Each of the hosts in the domain is listed (e.g. **www**, **ftp**, **zachary**, **mail**)

  ```
  google.com.             300     IN      A       216.239.51.100
  ```

30 As a side effect of this feature "mail.example.com" becomes "mail.example.com.example.com" in the example.com zone file.

```
google.com.             300     IN      A       216.239.53.100
www.google.com.         300     IN      A       216.239.37.99
smtp1.google.com.       3600    IN      A       216.239.33.25
```

- MX – Mail exchanger – A mail exchanger record determines where mail is delivered for a particular domain. The DNS name of a server which can handle mail for a domain is given. MX records have a priority. Mail is delivered to the mail server with the lowest priority or the backup mail servers are tried.

```
google.com.             300     IN      MX      10 smtp1.google.com.
google.com.             300     IN      MX      20 smtp2.google.com.
google.com.             300     IN      MX      40 smtp3.google.com.
```

- CNAME – Canonical name (alias) – A CNAME record points to an A record, similarly to MX records and NS records. A CNAME is treated as a regular host.

```
smtp.google.com.        600     IN      CNAME   smtp8.google.com.
```

- PTR – Pointer record (for reverse lookups) – these records occur only in **in-addr.arpa** zone files. For example, the zone file for the zone **233.22.196.in-addr.arpa** zone contains the following reverse entries for 196.22.233.34 and above:

```
34.233.22.196.in-addr.arpa.  8H  IN    PTR     pe.ledge.co.za.
35.233.22.196.in-addr.arpa.  8H  IN    PTR     jhb.ledge.co.za.
36.233.22.196.in-addr.arpa.  8H  IN    PTR     dbn.ledge.co.za.
37.233.22.196.in-addr.arpa.  8H  IN    PTR     pta.ledge.co.za.
38.233.22.196.in-addr.arpa.  8H  IN    PTR     pmb.ledge.co.za.
39.233.22.196.in-addr.arpa.  8H  IN    PTR     ct.ledge.co.za.
```

So the zone file for "google.com" looks something like this:

```
$TTL 4D
@            1D      SOA     ns1 dns-admin (
                     2003090402 ; Last modified (twice) on 2003-09-
      04
                     7200       ; Refresh interval
                     1800       ; Retry interval
                     1038800    ; Expiry interval
                     60 )       ; Minimum TTL
                     NS      ns1
                     NS      ns2
                     NS      ns3
                     NS      ns4
             300     MX 10   smtp1
             300     MX 20   smtp2
             300     MX 40   smtp3
             300     A       216.239.51.100
             300     A       216.239.53.100
www          300     A       216.239.37.99
smtp1        1H      A       216.239.33.25
smtp         600     CNAME   smtp8
ns1          4D      A       216.239.32.10
ns4          4D      A       216.239.38.10
... and so forth ...
```

To make **named** reload its zone files, you need to signal it with a **HUP** signal, or use **ndc reload** (or **rndc reload** for BIND 9).

27.3 Review

Quiz questions

1. If you see the error "ping: unknown host www.example.com", what does this mean? Which files will you consult to see if name resolution is working correctly?
2. What is the format of a line in the hosts file?
3. If you are running a DNS on your own machine, which file will you set up to indicate this?
4. What are the configuration files for BIND 4 and BIND 8? How do these files differ?
5. What is the purpose of a DNS zone file?
6. After setting up DNS servers for "random5138.com" serving "A" records for a web site "www.random5138.com", what step is necessary to make the rest of the world be able to connect to your site?

Assignment

1. Set up a caching DNS server using BIND. Test whether it works by using it as the name server from another machine.
2. Make your DNS server authoritative for the domain random1882.com. Add A records and MX records pointing to an SMTP server. Create a CNAME record for www.random1882.com pointing to www.google.com.

Answers to quiz questions

1. The resolver could not determine an IP address for the name given. **/etc/resolv.conf** should list the correct DNS servers. Configuring **hosts.conf** and **nsswitch.conf** can cause DNS resolution not to be used.
2. ip-address real-name alias1 alias2 (etc)
3. **/etc/resolv.conf** should say "nameserver 127.0.0.1"
4. named.boot and named.conf. They differ a lot. **named.boot** contains only zone definitions, while **named.conf** contains zone definitions and more advanced options.
5. The file lists the contents of the DNS zone.
6. You need to request the registrars of the .com domain to add NS records for "random5138.com" pointing to your DNS servers. This generally involves paying money.

28 Secure shell

SSH, abbr. Sharm El Sheikh, Egypt – Ophira

(Airport code)

LPIC topic 1.113.7 — Set up secure shell (OpenSSH) [4]

Weight: 4

Objective

The candidate should be able to obtain and configure OpenSSH. This objective includes basic OpenSSH installation and troubleshooting, as well as configuring sshd to start at system boot.

Key files, terms, and utilities include

/etc/hosts.allow	tcpwrappers configuration used by sshd
/etc/hosts.deny	tcpwrappers configuration used by sshd
/etc/nologin	if this is here, there's no login
/etc/ssh/sshd_config	**sshd** configuration file
/etc/ssh_known_hosts	identities of people we know
/etc/sshrc	login auto-run command
sshd	ssh server
ssh-keygen	generate keys for authentication

28.1 All about SSH

28.1.1 Alice and Bob

In stories about encryption, Alice (A) and Bob (B) need to communicate with each other in public. Alice and Bob's relationship suffers interference from the malevolent Eve (E), who is intent on monitoring and manipulating communication between them.

Encryption with private and public keys can be understood as a padlock and key. Anyone with a padlock can lock a message (encryption), but the lock can only be opened with the key (decryption). Having the key enables unlocking, and having the padlock enables locking.

Private and public keys are done using a number of mechanisms:

- RSA – RSA is named after Ronald **R**ivest, Adi **S**hamir, and Leonard **A**dleman who invented RSA encryption in 1977. RSA encryption and authentication take place without sharing of private keys. A person uses only their own private key or the peer's public key. Using RSA anyone can send an encrypted message or verify a signed message, and only someone with the correct private key can decrypt or sign a message.
- DSA – Digital Signature Algorithm – fast key generation, slower key verification.

28.1.2 SSH protocol

A regular TCP connection as used by **telnet** and **rsh** is functional and useful, but it has a

number of security problems. **ssh** guards against the following threats:

- **Network sniffing** – A regular telnet session can be observed down to the user names and passwords using a sniffer like **tcpdump** or **ngrep**. This applies even if you are on a switched network.
- **Man-in-the-middle attacks** – On the Internet, you do not know for sure who is responding to your packets. A machine between the client and the server can impersonate both the client and the server, and modify and observe traffic at will.

The SSH protocol incorporates a number of techniques to guard against the attacks that are possible for **telnet** and **rsh**.

1. **Encryption** – the traffic between the SSH client and server is encrypted. It is not possible to decrypt the traffic without knowledge of the encryption key.
2. **Identity checks** – the server must prove its identity to the client by demonstrating that it has the private key corresponding to its public key. Client authentication can also be via public and private keys.
3. **Diffie-Hellman key exchange** – key exchange is done in such a way that the encryption keys cannot be intercepted by a man in the middle.

ssh has a number of weaknesses in its operation.

- **Identity** – Confirming the identity of the machine that you are connected to is problematic. **ssh** addresses the problem by storing the public key of each machine that it has talked to in the past. If the cryptographic fingerprint changes, then it produces a large and significant warning ... although users may ignore it. The problem also remains that when the initial session is established, it may be with the man-in-the-middle.
- **Key changes** – There is no legitimate way for a server to change its public key.
- **Security problems** – **ssh** is a complex application. OpenSSH versions prior to version 2.9 suffered from a number of errors in their implementation of the SSH version 1 protocol. Remote root exploits exist for these versions (some of which were incorporated into internet worms)[31].

28.2 SSH server

The SSH server, **sshd** is standard equipment on most installations.

sshd_config

Common default configurations of **sshd** in **/etc/ssh/sshd_config** can be made more secure by editing the configuration file:

Protocol version – OpenSSH has the distinction of being able to support all versions of the ssh protocol. You should not support the SSH version 1 protocol. The protocol itself suffers from a number of flaws, and can be used as the vector for a network based attack. (Client software for protocol version 2 is available for most operating systems.)

Password authentication – Password based authentication increases your vulnerability to

31 Around the same time a remote root exploit for most telnet servers was discovered.

network based attacks where an attacker masquerades as the host and intercepts the password. It is better to use key-based authentication only.

Subsystems – Disable all the ssh subsystems that you do not actively use. There have been problems with the **sftp** subsystem. If you are not using it today, turn it off.

AllowGroups – You should not permit anyone outside the select few to log into the server. Create a group for this purpose if a suitable one does not exist.

PermitRootLogin – You should not permit direct root login. The security advantage is that for access to the machine, a valid password and user name is required. Once connected to the machine, gaining root privileges is not automatic either (although this is seldom an insurmountable problem).

AllowTcpForwarding – You should not allow TCP forwarding, since this enables a person who logs in to make outgoing connections from and incoming connections to the machine. This is a potential problem with POP3 and FTP accounts, where the shell may not be useful, but may still be permitted for SSH login.

SSH login procedure

When a user connects to the remote SSH server the steps below are followed.

1. Authentication is checked.
2. For terminal based logins **/etc/motd** from the server is printed out.
3. If **/etc/nologin** exists, it is printed and the connection is closed.
4. If **~/.ssh/environment** exists the environment is modified accordingly.
5. A command is run to set up the session. If it exists **~/.ssh/rc** is run, or **/etc/ssh/sshrc** or **xauth**. **ssh -X** forwards X11 protocol data over the encrypted session. Running **xauth** on the **sshd** server enables processes there to submit authentication credentials to the X server on the client.
6. The shell for the user is started, or the command or subsystem is started.

tcpwrappers

tcpwrappers – You should create an entry in **hosts.deny** that denies access to **sshd** for all addresses. Only allow access from a trusted machine, network or country by specifying these addresses in **hosts.allow**.

```
foot@bar:~ > cat /etc/hosts.allow
sshd: 16.130.13.33 211.125. 196.21.243.3
foot@bar:~ > cat /etc/hosts.deny
# See tcpd(8) and hosts_access(5) for a description.
sshd: ALL
```

Note that the key for **tcpwrappers** is not “ssh” but the name of the executable, “sshd”.

28.3 SSH client

The SSH client is superficially similar to **telnet**, with the exception that you must specify the remote user name in advance (by default the local user name is assumed).

Modes of operation

ssh can be used in a number of modes:

- Interactive session – this is quite similar to **telnet**

```
ssh user@remote
```

```
foo@bar:~ $ ssh server
foo@server's password: *****
Last login: Tue Sep  1 09:52:35 2002 from
Always sit ACROSS the table from any wise guy.
foo@server:~> hostname -f
server.example.com
foo@server:~> exit
logout
Connection to server closed.
foo@bar:~ $
```

- Non-interactive session

```
pipe-command | ssh user@remote "command" | pipe-command
```

Here we are logging into a server named “server” and running the command there.

```
foo@bar:~ $ uptime
 12:36pm  up   3:56,  4 users,  load average: 0.15, 0.23, 0.20
foo@bar:~ $ ssh server 'uptime'
foo@server's password: *****
 12:36pm  up 4 days  1:10,  6 users,  load average: 0.23, 0.26, 0.38
foo@bar:~ $ ssh server 'vmstat 1 5'
foo@server's password: *****
procs -------memory---------- --swap- ----io---- --system-- ----
      cpu----
 r b   swpd  free  buff  cache  si  so   bi    bo   in    cs us sy id
      wa
 0 0 15340 11608 24596 163708   0   0   22    19   34    51 82  1 17
      0
 0 0 15340 11596 24596 163716   0   0    0     0  658  1465 43  6 52
      0
 0 0 15340 11588 24600 163720   0   0    0   304  665  1343 19  8 73
      0
 0 0 15340 11584 24600 163724   0   0    0     0  898  1819 24  9 67
      0
 0 0 15340 11584 24600 163724   0   0    0     0  640  1009 21  3 76
      0
```

Here we send the SSH server data for processing:

```
foo@server:~ $ ls | ssh server wc -l
foo@server's password: *****
    270
foo@bar:~ $ tar -cz /etc | ssh reception 'cat > backup.tar.gz'
foo@server's password: *****
```

- Copying files. The program **scp** works like **cp**, except that you add the machine name and a colon (:) in front of the file name.

```
scp user@remote:remote/file/name local-file-name
```

```
foo@bar:~ $ scp .bashrc server:
foo@server's password: *****
```

```
.bashrc              100% |**********************|   415
      00:00
foo@bar:~ $ scp server:/etc/services .
foo@server's password: *****
services             100% |**********************|   297 KB
      00:00
foo@bar:~ $ scp server:/etc/services .
foo@server's password: *****
services             100% |**********************|   297 KB
      00:00
foo@bar:~ $ tar -czf backup.tar.gz /etc 2>/dev/null
foo@bar:~ $ scp backup.tar.gz server:
foo@server's password: *****
backup.tar.gz        100% |**********************|  2989 KB
      00:01
```

- SSH extensions – The most commonly used ssh subsystem is the **sftp** system, which can be used as a replacement for **ftp**.

`sftp user@remote`

```
foo@bar:~ $ sftp server
Connecting to server...
sftp> get .bashrc remote-bashrc.orig
Fetching /home/foo/.bashrc to remote-bashrc.orig
sftp> put .bashrc
Uploading .bashrc to /home/foo/.bashrc
sftp> rm backup.tar.gz
Removing /home/foo/backup.tar.gz
sftp> exit
```

A complete list of **sftp** commands is shown by typing **help** at the **sftp** prompt.

Identity checks

The first time **ssh** connects to an SSH server, it checks whether the identity is known or not. If the identity is not known, then it is possible that you are connected to a man in the middle rather than the true server. SSH does not try to solve this problem, and leaves the question to you.

```
foo@bar:~ $ ssh server
The authenticity of host 'server (10.0.0.2)' can't be established.
RSA key fingerprint is
      52:bb:d6:a9:71:74:a1:64:68:40:89:64:51:c8:77:c0.
Are you sure you want to continue connecting (yes/no)? yes
9882: Warning: Permanently added 'server' (RSA) to the list of known
      hosts.
```

If the server's identity should change, a massive warning is printed, and the connection is closed.

```
foo@bar:~ $ ssh foo@server
9894: @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
9894: @    WARNING: REMOTE HOST IDENTIFICATION HAS CHANGED!     @
9894: @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
9894: IT IS POSSIBLE THAT SOMEONE IS DOING SOMETHING NASTY!
9894: Someone could be eavesdropping on you right now (man-in-the-
      middle attack)!
```

```
9894: It is also possible that the RSA host key has just been
      changed.
9894: The fingerprint for the RSA key sent by the remote host is
52:bb:d6:a9:72:74:a1:64:68:40:89:64:51:c8:77:c0.
9894: Please contact your system administrator.
9894: Add correct host key in /home/foo/.ssh/known_hosts to get rid
      of this message.
9894: Offending key in /home/foo/.ssh/known_hosts:122
9894: RSA host key for server has changed and you have requested
      strict checking.
9894: Host key verification failed.
```

SSH client risks

Apart from inadvertently talking to a man in the middle, there are a number of security risks using the SSH client

- If you forward your X display to the remote host (using **ssh -X**) then you can tunnel the display data over an encrypted connection. The drawback side is that root on the remote server can pop up a window on your X server and log your keystrokes.
- If you are running ssh-agent with agent forwarding the server to which you connect may use your key on your behalf.
- The default protocols that are used are (firstly) protocol version 1, then protocol version 2. You can change this globally by editing the **ssh_config** file.

Key-based authentication

The procedure for logging into a remote machine using a key is as follows:

Generate the key with **ssh-keygen -t dsa**. (RSA keys can be generated with **ssh-keygen -t rsa**). You should supply the key with a nice unguessable password. The password can be quite complex without compromising the functionality of **ssh**, since you can use **ssh-agent** to store the decoded key.

```
foo@bar:~ $ ssh-keygen -t rsa
Generating public/private rsa key pair.
Enter file in which to save the key (/home/foo/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/foo/.ssh/id_rsa.
Your public key has been saved in /home/foo/.ssh/id_rsa.pub.
The key fingerprint is:
c2:f7:40:cb:80:18:1f:26:f4:fe:db:d1:7a:fc:4e:60 foo@bar
```

Log into the remote host, and append your public key to **.ssh/authorized_keys** (note the American spelling). You can do this using console based cut and paste. To be sure that permissions are set correctly set **umask 077** before creating the **.ssh** directory or the **authorized_keys** file. If the permissions on the **authorized_keys***[32] files are incorrect, they are ignored by the **sshd** server.

```
foo@bar:~ $ ssh server 'cat >> .ssh/authorized_keys' <
```

32 Some versions of ssh use authorized_keys2 and known_hosts2 for ssh protocol version 2, as opposed to version 1.

```
      .ssh/id_rsa.pub
```

To store a decoded version of your key in memory, you use **ssh-agent**. When you run **ssh-agent** it produces a shell script displaying its own settings. To add a key, you use **ssh-add**. The unlocked key remains available to ssh while **ssh-agent** runs and the **SSH_AUTH_SOCK** environment variables are set in your session. To use **ssh-agent** in a once-off fashion, you would do something like this:

```
foo@bar:~ $ eval $(ssh-agent)
foo@bar:~ $ ssh-add .ssh/id_dsa
foo@bar:~ $ ssh user@remote
foo@bar:~ $ killall ssh-agent
```

You can also ask **ssh-agent** to run a particular command for you.

```
foo@bar:~ $ ssh-agent bash -i
bash-2.05 $ ssh-add
Enter passphrase for /home/foo/.ssh/id_dsa: *****
Identity added: /home/foo/.ssh/id_dsa (/home/foo/.ssh/id_dsa)
bash-2.05 $ ssh server 'uptime;who|wc -l'
  1:30pm  up   0:25,  6 users,  load average: 0.00, 0.05, 0.19
      6
bash-2.05 $ exit
exit
foo@bar:~ $
```

A useful application of **ssh-agent** is to begin an X Windows session[33] with an **ssh-agent** available for caching keys for **ssh** sessions:

```
exec ssh-agent startx
```

Client side troubleshooting

Occasionally a SSH connection fails. **ssh -v** verbosely prints information about the connection as it proceeds.

```
foo@bar:~ $ ssh -v server
OpenSSH_3.5p1, SSH protocols 1.5/2.0, OpenSSL 0x0090609f
10009: debug1: Reading configuration data /home/foo/.ssh/config
10009: debug1: Connecting to server [10.0.0.32] port 22.
10009: debug1: Connection established.
10009: debug1: identity file /home/foo/.ssh/id_dsa type 2
10009: debug1: SSH2_MSG_KEXINIT sent
10009: debug1: SSH2_MSG_KEXINIT received
... etc, etc ... many screens of it ...
```

28.4 Review

Quiz questions

1. What makes **ssh** different to **telnet**?
2. How do you configure **sshd** to allow access only from trusted IP addresses?
3. What is the effect of **/etc/nologin** on **sshd**?

33 If you are using KDE you should experiment with typing **fish://user@ssh-server/** in the "Run Command" window or browser location bar.

4. In which file does the AllowGroups directive appear?
5. What does **~/.ssh/known_hosts** do?
6. How do you install a key on a remote host account?

Assignment

1. Create a ssh key for yourself which is protected with a password. Load the key into a running ssh-agent process and then use this key to log in to a server.
2. Set up a SSH server to use only SSH protocol 2. Disable login as root, and only allow logins using key based authentication. Allow access to this server only from your workstation.
3. **rsync** is used for copying files while conserving bandwidth. Use **rsync** to make a copy of a directory on a remote system, such as this example.

   ```
   rsync -a -v -e ssh root@server:/etc ~/server-backups/
   ```

   After running the **rsync** once, run it again to see the improvement in performance.

Answers to quiz questions

1. Encryption, and verification of who you are talking to. Better suited for scripts.
2. Using tcpwrappers – **hosts.allow** and **hosts.deny**.
3. Only root can login when the file exists.
4. **/etc/ssh/sshd_config**
5. It lists the public keys of machines that have been contacted using **ssh**.
6. Append your **id_rsa.pub** to the remote **authorized_keys** file, making sure the permissions are 0600 for the file and 0700 for the directory.

29 Security administration

> Kaufman's Law: A policy is a restrictive document to prevent a recurrence of a single incident, in which that incident is never mentioned.
>
> */usr/share/fortune/fortunes2*

LPIC topic 1.114.1 — Perform security administration tasks [4]

Weight: 4

Objective

Candidates should know how to review system configuration to ensure host security in accordance with local security policies. This objective includes how to configure TCP wrappers, find files with SUID/SGID bit set, verify packages, set or change user passwords and password aging information, update binaries as recommended by CERT, BUGTRAQ, and/or distribution's security alerts. Includes basic knowledge of ipchains and iptables.

Key files, terms, and utilities include

/proc/net/ip_fwchains	**ipchains** status
/proc/net/ip_fwnames	**ipchains** chain names
/proc/net/ip_masquerade	**ipchains** masquerading status
find	**find -type f -perm -4001** finds files with set-uid bits
ipchains	**ipchains** sets up firewall rules
passwd	set password and password ageing
socket	create TCP connections
iptables	**iptables** sets up stateful firewall rules

29.1 Security policy

The site security handbook, RFC 2196, details the contents of a security policy. The following approach to designing a security policy is suggested.

- Identify what you are trying to protect.
- Determine what you are trying to protect it from.
- Determine how likely the threats are.
- Implement measures which will protect your assets in a cost-effective manner
- Review the process continuously and make improvements each time a weakness is found.

In setting goals for a security policy, you will have the following trade-offs:

- services offered versus security provided
- ease of use versus security
- cost of security versus risk of loss

In order to verify whether a system conforms to a security policy, you need the policy, and you need to be able to determine:

1. Network services (e.g. SMTP, RPC, POP3):
   a) Identify what network services are offered by a server (**netstat** and **(x)inetd.conf**).

b) Identify which users can use the service (e.g. a POP3 user may have access to the FTP service).

c) Identify what authentication method is required to use the service (e.g. user name and password, cryptographic key, etc.)

d) Identify which networks and hosts can use the service (i.e. TCP wrappers and firewall based access control).

e) Identify whether the service offers only the required features (e.g. for a web server directory listing, personal home directories and the proxy function may be unnecessary).

2. List the processes that are running (**pstree** or **ps -ax**).

3. Evaluate the software that is installed (use package management commands and find set-uid and set-gid programs).

A machine is made to comply with the security policy by eliminating network services, stopping processes and removing software not allowed by the security policy.

29.2 Password ageing

User accounts can be disabled in one of the following ways:

- The password was not changed during the grace period after the warning time.
- The account expiry date has passed
- The administrator suspends the account manually.

The mechanisms for this are discussed in the section on users and groups.

29.3 Setuid and setgid files

When an executable with the set-uid bit set runs, it can choose to set its user ID to the user that owns the file on the filesystem. The set-gid bit allows the program to set its group ID. An attacker who gains control of a non root account will generally search for a buggy set-uid program which will run code of his choice and elevate his privileges. The number of these programs should therefore be limited as far as possible.

The **find** command can be used to find files according to their permissions.

find -perm -2001 finds files which have at least the set-gid bit and the world-executable bit set.

```
foo:~ $ find /usr/bin -perm -2001 | xargs ls -ld
-rwxr-sr-x    1 root     tty         10340 Mar 14 02:42
      /usr/bin/wall
-rwxr-sr-x    1 root     tty          8384 Mar 14 02:42
      /usr/bin/write
```

find -perm -4001 finds files which have at least the set-uid bit and the world-executable bit set.

```
foo:~ $ find /usr/bin -perm -4001 | xargs ls -ld
-rwsr-xr-x    1 root     root        35436 Mar 14 02:31 /usr/bin/at
-rwsr-xr-x    1 root     shadow      58668 Mar 17 17:39
      /usr/bin/chage
-rwsr-xr-x    3 root     shadow      73680 Mar 17 17:39
      /usr/bin/chfn
```

```
-rwsr-xr-x    3 root     shadow      73680 Mar 17 17:39
      /usr/bin/chsh
-rwsr-xr-x    1 root     root        23032 Mar 14 02:15
      /usr/bin/crontab
-rwsr-xr-x    1 root     root         4648 Mar 17 16:23
      /usr/bin/mandb
-rwsr-xr-x    1 root     root        23836 Mar 17 17:39
      /usr/bin/newgrp
-rwsr-xr-x    3 root     shadow      73680 Mar 17 17:39
      /usr/bin/passwd
-rwsr-xr-x    1 root     root       268768 Mar 18 19:37 /usr/bin/ssh
```

You can search the entire disk for risky executables.

```
foo:~ $ find / -type f -perm +7000 -perm -001 2>/dev/null > execlist
foo:~ $ xargs ls -ld < execlist
```

29.4 TCP wrappers

Access to network services that run from **inetd** and **xinetd** can be restricted by TCP wrappers. Many other applications also filter new connections through the TCP wrappers library. The files **/etc/hosts.deny** and **/etc/hosts.allow** (in that order) determine if a particular source address can connect to a service.

It is important to check whether the the restrictions actually do apply by testing from a number of IP addresses. It is easy to make errors in the process.

- Occasionally, applications are compiled without support for the TCP wrappers library. This is an error that you need to test.
- If the entries in the files are incorrect, the restrictions do not take effect.

```
# hosts.deny designed to fail
ftp: ALL
ssh: ALL

# hosts.allow designed to fail
ftp: 10.0.22.3
ssh: 10.0.22.3
```

29.5 Firewalls

Firewalls regulate connections between your server or network and the outside world. The most simplest way of doing this is to regulate who can speak to whom and which protocols may be used.

A network packet filter is analogous to a physical filter. Some network packets pass through the filter, and others are blocked by the filter. Some filters are capable of modifying packets in transit. Traffic passes through the filter in two directions. This is true even for a simple server – packets are sent, and packets are received in response.

There are a few categories of filter:

- **No filter: Router** – Packets pass through from one interface to another without any modification (except a change to the TTL). This is what you get by running

```
echo 1 > /proc/sys/net/ipv4/ip_forward
```

- **Packet filter** (e.g. **ipchains**) – Each packet that passes through the filter is evaluated independently of all other packets. This is a fairly quick process, but it is not possible to guard against certain probes. The **nmap** ACK probe may pass through the filter if the source port is set correctly: acknowledging TCP data (TCP ACK) even though there was never a connection will result in the protected server sending a TCP RST if the port is listening, or no response if the port is closed.

  This functionality is included on most modern routers. Linux has this functionality implemented with **ipchains**.
- **Stateful packet filter** (netfilter) – A stateful packet filter tracks the connections that packets passing through the firewall belong to. This makes it possible to discriminate between packets which belong to an existing connection, and packets which do not. This makes writing packet filtering rules simpler.

  The Linux stateful inspection framework is netfilter and the tool used to configure it is called **iptables**.
- **Content filtering** – Content filtering involves searching the data transferred for malicious content, such as viruses. This generally involves the use of proxy servers. Netfilter can divert traffic to a filtering proxy, but it does not include the proxy itself.

29.5.1 TCP, UDP, ICMP and IP

Both **iptables** and **ipchains** filter network traffic based on the properties of packets of data that they handle. Packets can be discriminated between based on these properties.

- **-s** source IP address and **-d** destination IP address – every IP packet has a source IP address (chosen by the sender) and a destination IP address. When the first packet of a conversation is sent, these addresses are as expected. The reply packet naturally has the source and destination reversed (it is returning to the original source).
- **-p** protocol – you will deal mostly with UDP, TCP and ICMP packets.
- **--sport** source port and **--dport** destination port (in **ipchains**, the port is listed after the IP address)
- TCP flags (e.g. SYN **-y** or **--syn**).
- Interface (**-i** in-interface, **-o** out-interface for both **ipchains** and **iptables**, and **--in-interface**, **--out-interface** for **iptables**.)

29.5.2 iptables

Tables and chains

The **iptables** "filter" table contains three default chains which filter all the traffic passing through the machine. Each chain contains a list of rules, which are processed in order from top to bottom. When a packet matches a rule, the action that you specify is taken. A packet may be allowed or rejected.

These are the chains in the default table **-t filter**.

- **INPUT** – The INPUT chain decides which packets should be seen by processes running on the netfilter machine. This is where protection for the firewall goes.
- **OUTPUT** – The OUTPUT chain determines what packets may be sent from the netfilter machine. For a server it can be quite useful to restrict the traffic that the machine may send out. This will interfere with the communications of a back door process.
- **FORWARD** – The FORWARD chain applies to packets that would pass through the netfilter machine. (The FORWARD chain is consulted for packets that have been mangled by NAT as well, but more on this later.)

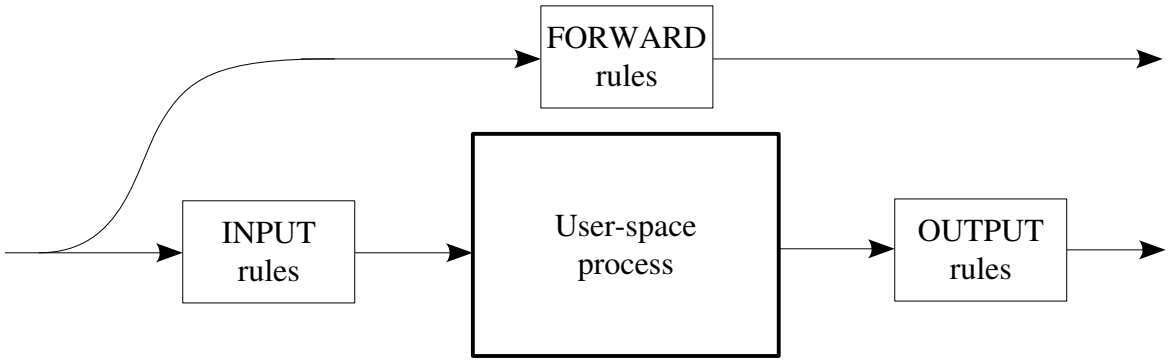


Illustration 1: iptables filtering rules

The chains relate to processes on the local machine as illustrated in the diagram.

You can create your own chains as the target for **iptables** rules. These can be used for optimisation and to avoid duplication of rules.

Jump targets

There are a few straightforward things a netfilter firewall can do in response to a packet:

- **-j ACCEPT** – The packet is accepted, and if it signals a new connection, the information for this connection is added to the connection tracking table (cat /proc/net/ip_conntrack).
- **-j DROP** – The packet is discarded. The entropy of the universe increases.
- **-j REJECT** – An error message is sent back to the originator of the packet. The default is to send an ICMP message, although it is possible to send a tcp-reset message for TCP connections (meaning that the connection is not listening).

There are a number of slightly more esoteric actions you can take in response to a received packet.

- **-j LOG** – This makes a kernel log message describing the packet. This is most often used to make a note of traffic that was blocked.
- **-j MARK** – The packet can be tagged for special treatment in other parts of the networking subsystem. This is used by the clever people to do bandwidth and routing control.

Command syntax

The **iptables** command can do the following:

- **iptables -t table** – this selects a particular table for the **iptables** command, i.e. **nat**, **mangle**

or **filter**. The default is **filter**.

- **iptables -A somechain [rule] -j ACTION** – add rules to the end of a chain. Most rules specify a number of properties of the packet, and an action to jump to (e.g. **-j DROP**)

```
iptables -A INPUT -j DROP
```

- **iptables -I somechain [rule] -j ACTION** – inserts rules at the front of the chain.
- **iptables -F [somechain]** – remove all rules from the chain. If no chain name is given, all the rules in the table are removed.
- **iptables -P somechain ACTION** – each chain can have a policy which is the last rule in the chain. The policy remains in place even when the chain is flushed.
- **iptables -L [somechain]** – list rules in a chain and its policy, or list for all the chains in the table.

```
iptables -L
iptables -L -v -n
iptables -t nat -L -v -n
```

When adding rules to chains the order of the parameters is significant. For example, if you want to use **--dport 25**, you must first specify **-p tcp** (protocol TCP).

```
iptables -A INPUT -p tcp --dport 25 -j ACCEPT
```

Rules can refer to kernel modules, e.g. **-m state**. Most modules accept additional parameters, which must come after the **-m** parameter.

```
iptables -A FORWARD -m state --state ESTABLISHED,RELATED -j ACCEPT
```

Packet matching

The **iptables** command is used to set up new rules. To get a taste for how it works you can block all packets on your own machine:

```
ping -c 1 localhost                  # ping myself
iptables -F                          # Flush the -f filter table
iptables -A INPUT -j REJECT          # Add a rule with no conditions
ping -c 1 localhost                  # try it again
iptables -F                          # Flush the -f filter table
```

Each rule specifies a condition and a jump target. Rules can refer to the packet and meta-information about the packet. The jump target is generally **-j ACCEPT** or **-j DROP**. To see how the rules work, it is useful to use the **-j LOG** target.

- IP – For all IP packets, you can consider the interface that was used for the packet (**--in-interface xxx**, **--out-interface xxx**) and the source (**--source**) and destination (**--dest**) address contained in the packet:

```
iptables -F
iptables -A INPUT --in-interface eth0 -j LOG
iptables -A OUTPUT --destination www.google.com -j LOG
iptables -A INPUT --source www.google.com -j LOG
ping -c 3 www.google.com
```

- TCP – If you want to match a TCP packet, you can specify any of the IP options (destination address, source address), and additionally a number of TCP-specific options (destination port, source port and TCP flags).

Log one side of a TCP stream, then log both sides.

```
iptables -F
iptables -A INPUT --protocol tcp --dport 80 -j LOG
lynx -dump http://localhost/
iptables -A OUTPUT --protocol tcp --sport 80 -j LOG
lynx -dump http://localhost/
```

Log only the first packet of the TCP stream.

```
iptables -F
iptables -A INPUT --protocol tcp --dport 80 --syn -j LOG
lynx -dump http://localhost/
```

- **-m state --state X,Y,Z** – The stateful inspection part is activated by using the "state" module. Loading this module causes the kernel to track all connections and to attempt to assign new packets to a connection. This provides you the ability to distinguish between NEW, ESTABLISHED and INVALID connections. Packets which are RELATED to an existing connection (such as ICMP packets) are also tracked.

  Allowing only ESTABLISHED and RELATED packets to arrive at your machine constitutes a fairly effective personal firewall system:

```
iptables -F
iptables -P OUTPUT ACCEPT
iptables -P INPUT DROP
iptables -A INPUT --in-interface lo -j ACCEPT
iptables -A INPUT -m state --state ESTABLISHED,RELATED -j ACCEPT
iptables -A INPUT -p tcp --dport 80 -m state --state NEW -j ACCEPT
```

- **-m limit** – The limit modules restricts the rate at which a rule may match traffic. One of the most useful combinations is to combine the limit rule with the LOG target.

  Here we log random packets.

```
iptables -F INPUT
iptables -A INPUT -m limit -j LOG
```

  The default limit is three per hour, but to allow the first five.

```
iptables -F INPUT
iptables -A INPUT -m limit --limit 3/hour --limit-burst 5 -j LOG
```

Network address translation

NAT (formerly called IP masquerading) enables you to change the address(es) of a packet in transit. A regular IP packet is identified by two parts: a source address and a destination address. NAT extends the stateful inspection capabilities and specifies how each connection should be translated in transit. Each connection tracked with:

- Source IP address and port number
- Destination IP address and port number
- NAT Source IP address and port number
- NAT Destination IP address and port number

The main reasons to do NAT are ...

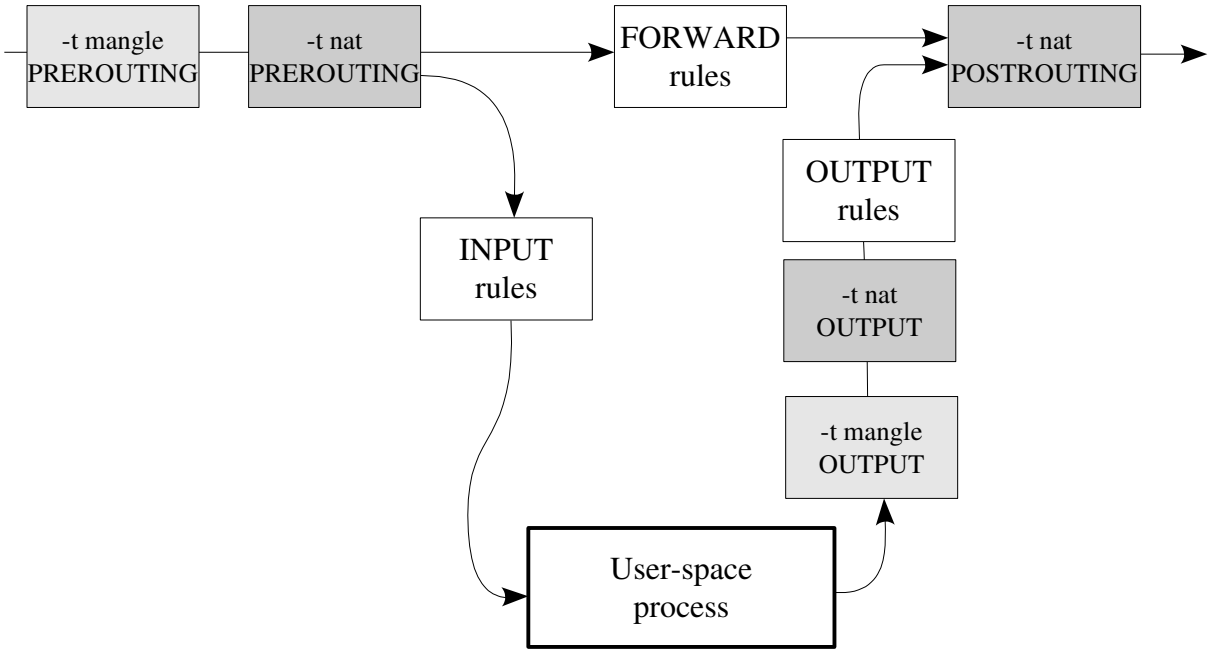


Illustration 2: navigating iptables – what your packets go through (some chains omitted)

Dial-up – If you dial in to the Internet with a modem, you can connect a medium sized network to the Internet using a single IP address. This is the classic "IP masquerading" configuration, and is called SNAT (source address of outgoing packets is modified).

- Virtual servers – If you have a limited number of IP addresses allocated to you, you may want to run multiple services on a single IP address. By changing the destination address of packets (DNAT) you can forward the connections to the correct server. DNAT can also be used for load balancing.
- Transparent proxying – It is sometimes useful to intercept outgoing connections, such as HTTP or SMTP and divert these to a proxy server. This is also DNAT, since the destination address is altered.

When a new connection is established, it passes through two chains in the **iptables -t nat** table:

- **PREROUTING** – These rules are processed before a routing decision is made. Since no routing has been done at this stage, you cannot filter on the output interface at this stage. You can change the destination of the connection with a **-j DNAT** target.
- **POSTROUTING** – The **POSTROUTING** rules are consulted after the routing decision has been made. At this stage you can change the apparent source of the connection with a **-j SNAT** target. The **-j MASQUERADE** target is like the **-j SNAT** target, but it automatically determines the IP address to use.

NAT becomes a little tricky when you combine it with filtering rules. In this environment, to make a NAT connection, you will need these elements:

- A **POSTROUTING SNAT** or **PREROUTING DNAT** rule which modifies either the source address or the destination address (or both).
- A rule in the **FORWARD** chain which will accept the modified connection.

- Packet forwarding must be enabled (usually).
- The connection tracking module must be loaded (**ip_conntrack**). Usually the kernel module loader will take care of this. If the connection uses an unusual protocol that transmits IP addresses (such as FTP), then a supporting kernel module must be loaded too (e.g. **ip_conntrack_ftp**)

IP masquerade

To hide your entire network behind a dial-up gateway, this is the code:

```
modprobe ip_conntrack_ftp
iptables -t nat -A POSTROUTING -o ppp0 -j MASQUERADE
echo 1 > /proc/sys/net/ipv4/ip_forward
```

The **MASQUERADE** target differs from the **SNAT** target in that you do not have to specify the revised IP address. The MASQUERADE target is used in the **POSTROUTING** chain rather than the **PREROUTING** chain. The reason is that an output interface has been chosen at that point.

Firewall script

An **iptables** firewall is traditionally implemented by a script which contains a number of **iptables** commands. Having a script allows the firewall to be configured when the system starts up.

A firewall script will generally start with the values that may be used further down.

```
#!/bin/bash
OUTSIDE_IF=eth0               # external interface
OUTSIDE_IPADDR=10.35.224.51   # IP address of external interface
INSIDE_IF=eth1                # Interface for our own network
INSIDE_IPADDR=192.168.1.100   #
INSIDE_NET=192.168.1.0/24      # Our own network
TCPSERVERS="25 80"
```

After this, the existing chains and rules are flushed and removed.

```
iptables -F
iptables -X
iptables -t nat -F
iptables -t nat -X
```

The overall policy for the firewall is given. These will apply if no rule matches, and also when **iptables -F** is issued.

```
iptables -P FORWARD DROP
iptables -P OUTPUT ACCEPT
iptables -P INPUT ACCEPT
```

Specific exceptions are listed for each chain.

```
iptables -A INPUT -m state --state ESTABLISHED,RELATED -j ACCEPT
iptables -A INPUT --in-interface lo -j ACCEPT
iptables -A INPUT --in-interface $INSIDE_IF -j ACCEPT
```

The **for** ... **do** shell syntax can be used to create rules which differ only in one detail. These rules accept all traffic destined for either the web server or the mail server, regardless of the source.

```
for PORT in $TCPSERVERS; do
  iptables -A INPUT -p tcp --dport $TCPSERVERS \
      -m state --state NEW -j ACCEPT
done
```

And some miscellaneous rules ...

```
iptables -A INPUT -p icmp --icmp-type echo-request -j ACCEPT
iptables -A INPUT -j DROP
```

Here we allow all the "inside" machines to send packets to the OUTSIDE_, but only replies to return. This is not a particularly good firewall.

```
iptables -A FORWARD -m state --state ESTABLISHED,RELATED -j ACCEPT
iptables -A FORWARD -m state --state NEW -i $INSIDE_IF -j ACCEPT
iptables -A FORWARD -j DROP
```

The NAT rules below rules do outgoing IP address masquerading for the internal network, and redirect SMTP and DNS requests to the local server. Since these connections are permitted by the FORWARD chain and the INPUT chain, no further rules are necessary.

```
iptables -t nat -A POSTROUTING --source $INSIDE_NET -o $OUTSIDE_IF \
      -j MASQUERADE
# Or we could have said ...
# iptables -t nat -A POSTROUTING --source $INSIDE_NET -o $OUTSIDE_IF
      \
#     -j SNAT --to $OUTSIDE_IPADDR
iptables -t nat -A PREROUTING -i $INSIDE_IF -p tcp --dport 25  \
      -j DNAT --to $INSIDE_IPADDR:25
iptables -t nat -A PREROUTING -i $INSIDE_IF -p udp --dport 53  \
      -j DNAT --to $INSIDE_IPADDR:53
```

Kernel tweaks

The Linux kernel has a number of adjustable IP parameters[34] which can affect the security of your machine and network. The default settings of these are generally appropriate for a workstation which is not running any services, but they can be improved for a server and a firewall machine.

The parameters are adjusted by writing values to files in the directory **/proc/sys/net/ipv4**. The document for these settings is **Documentation/filesystems/proc.txt** in the kernel source tree.

These parameters apply to IP packets in general:

- **ip_forward** – If you have configured proxies rather than a network filtering, then you do not need to enable IP forwarding. This makes it a little harder to probe the internal parts of your network.
- **icmp_echo_ignore_*** – You can configure your system to ignore broadcast pings, or all pings.
- **tcp_syncookies** – This helps the server to face a TCP SYN denial of service attack. If your system detects that it is receiving too many TCP connections, it switches into a mode where it sends syn cookies to the apparent sender of the connection request. If the sender is really trying to communicate, the connection will continue.

34 These are not part of netfilter or **ipchains**, but show up in the **/proc** filesystem.

- **ip_always_defrag** – IP fragments can make your firewall very complex. It is a good idea™ to defragment (assemble all fragments into a single packet) before processing the packet.
- **ipfrag_time** – This is the time in seconds to keep an IP fragment in memory. Newer kernels have this instead of **ip_always_defrag**.
- **ip_conntrack_max** – This value should be set to reflect the number of concurrent connections your server will be tracking.
- **icmp_*** – the files **icmp_destunreach_rate**, **icmp_echoreply_rate**, **icmp_paramprob_rate** and **icmp_timeexceed_rate** determine the rate at which ICMP packets are sent out (in packets per 100 ms).
- **ip_local_port_range** – When an outgoing connection is made, a local port number is allocated. By setting this range judiciously, even ipchains can be made to discriminate between outgoing and incoming connections (for a single host or IP masquerading). The default range is 1024-4999.

There are also settings for the interfaces on the machine.

- **conf/*/accept_redirects** – If you are not routing, the default for this value is "yes" which can be unhealthy for security. If you do accept redirects, you should only accept them from gateways by setting the secure_redirects flag.
- **conf/*/accept_source_route** – Routers are configured to accept source routing by default. Source routing allows connections that explicitly specify your router as the gateway. Usually this is a bad idea.
- **conf/*/rp_filter** – The kernel includes code to determine whether the packet which it has received could have originated on the network it was received from. Turning this option on makes spoofing internal traffic harder. If you would like to know when these packets arrive, you can turn on **conf/*/log_martians**.
- **conf/*/bootp_relay** – This will configure the kernel to route packets that appear to be BOOTP packets. For a firewall, this would be a bad idea.
- **conf/*/proxy_arp** – Turning off proxy arp is a good idea (unless you are planning to act as a PPP server or use strange routing).
- **conf/*/flush** – When you write a 1 to this file you cancel all the redirected routes.

Many distributions apply settings from **/etc/sysctl.conf** on startup. You can modify this file or add lines to your firewall script to apply the tunable parameters.

```
echo "1" > ip_forward
cd /proc/sys/net/ipv4
for F in conf/*/rp_filter           ; do echo "1" > $F ; done
for F in conf/*/proxy_arp           ; do echo "0" > $F ; done
for F in conf/*/accept_redirects    ; do echo "0" > $F ; done
for F in conf/*/accept_source_route ; do echo "0" > $F ; done
for F in conf/*/rp_filter           ; do echo "1" > $F ; done
for F in conf/*/log_martians        ; do echo "1" > $F ; done
for F in conf/*/bootp_relay         ; do echo "0" > $F ; done
for F in conf/*/flush               ; do echo "1" > $F ; done
```

29.5.3 ipchains

The design of **ipchains** is simpler than **iptables**, and as a result it is harder to achieve comparable results. **ipchains** rules can use packet matching based on properties of an individual packet, but you cannot perform any state tracking. This means that an explicit rule must be written to match reply packets of established and related connections. When a firewall protects a single machine this does not matter much, but a firewall that protects a network is harder to implement.

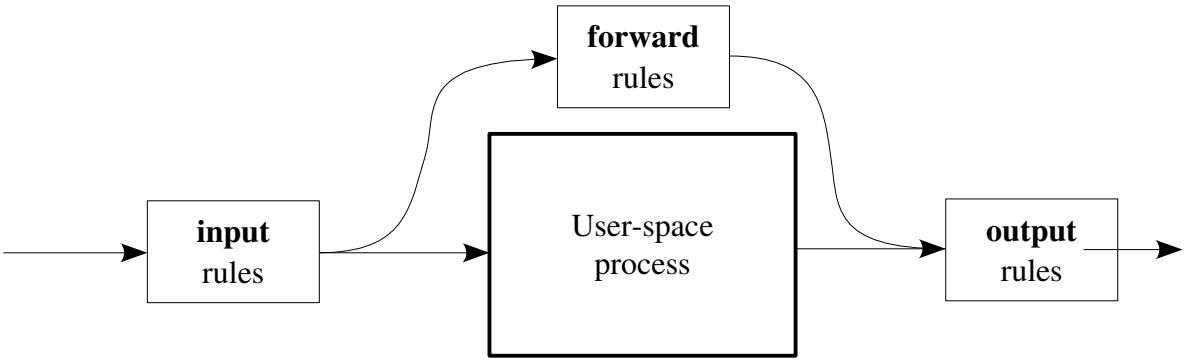


*Illustration 3: ipchains filtering style – when forwarding, "*input*" and "*output*" are consulted*

The behaviour of **ipchains** when handling forwarded packets is that the packet passes through the input chain, the forward and the output chain. (Note also that the names of the chains are also written in lower case, unlike iptables!)

Command syntax

The **ipchains** command can do the following:

- **ipchains -A somechain [rule] -j ACTION** – add rules to the end of a chain. Most rules specify a number of properties of the packet, and an action to jump to (e.g. **-j DENY**, **-j REJECT** or **-j ACCEPT**)

```
ipchains -A input -j DROP
ipchains -A output -j DROP
```

- **ipchains -I somechain [rule] -j ACTION** – inserts a rule at the front of a chain.
- **ipchains -F [somechain]** – remove all rules from the chain. If no chain name is given, all rules are removed.
- **ipchains -P somechain ACTION** – each chain can have a policy which is the last rule in the chain. The policy remains in place even when the chain is flushed.
- **ipchains -L [somechain]** – list rules in a chain and its policy, or list for all the chains.

```
ipchains -L
ipchains -L -v -n
```

ipchains firewall

Here's an **ipchains** based firewall that could be used to protect a server running as a HTTP

proxy server.

```
#!/bin/bash

OUTSIDE_IF=eth0                # external interface
OUTSIDE_IPADDR=10.35.224.51    # IP address of external interface
ANYWHERE=0.0.0.0/0            # Any IP address
DNSSERVER=10.35.22.21         #
INSIDE_IF=eth1                 # Interface for our own network
INSIDE_IPADDR=192.168.1.100    #
INSIDE_NET=192.168.1.0/24       # Our own network
UNPRIVPORTS=1024:65535         # Local ports which can be used by
      anyone
```

This pair of rules allows the server to speak to itself via the loopback interface. Notice that there are two rules, unlike **ipchains**.

```
ipchains -A input  -i lo -j ACCEPT
ipchains -A output -i lo -j ACCEPT
```

The ICMP protocol is vital to maintaining TCP connections and mostly helpful. One can eliminate a number of harmful ICMP types, but it's a lot of extra work. With these two lines, **ping** should work.

```
ipchains -A input  -p icmp -j ACCEPT
ipchains -A output -p icmp -j ACCEPT
```

To make DNS work, we must be able to send UDP requests to our DNS server, and receive its replies.

```
ipchains -A output -i $OUTSIDE_IF -p udp\
      -s $OUTSIDE_IPADDR $UNPRIVPORTS \
      -d $DNSSERVER 53 -j ACCEPT
ipchains -A input -i $OUTSIDE_IF -p udp\
      -s $DNSSERVER 53 \
      -d $IPADDR $UNPRIVPORTS -j ACCEPT
```

The **-y** switch matches TCP SYN packets, and **-p tcp ! -y** matches any TCP packet except a SYN packet. This means that only one-way TCP connections are allowed.

```
for PORT in 80 443 ; do
ipchains -A output -i $OUTSIDE_IF -p tcp \
           -s $OUTSIDE_IPADDR $UNPRIVPORTS \
           -d $ANYWHERE $PORT -j ACCEPT
ipchains -A input -i $ OUTSIDE_IF -p tcp ! -y \
           -s $ANYWHERE $PORT \
           -d $IPADDR $UNPRIVPORTS -j ACCEPT
done
```

The system is running a proxy server on port 3128 for the internal network, so we allow access to that from the internal interface.

```
ipchains -A input -i $INSIDE_IF -p tcp\
           -s $INSIDE_NET $UNPRIVPORTS \
           -d $INSIDE_IPADDR 3128 -j ACCEPT
ipchains -A output -i $INSIDE_IF -p tcp ! -y\
           -s $INSIDE_IPADDR 3128 \
           -d $INSIDE_NET $UNPRIVPORTS -j ACCEPT
```

One of the protocols a proxy server will use is FTP. Allowing unrestricted FTP connections

via **ipchains** is not for the faint of heart. The FTP protocol differentiates between the initial control connection (from client to server, port 21) and the subsequent data connections (from server port 20 to client, or from client to server port 20).

Control connection from the local client to the remote server (and responses):

```
ipchains -A output -i $OUTSIDE_IF -p tcp \
          -s $OUTSIDE_IPADDR $UNPRIVPORTS \
          -d $ANYWHERE 21 -j ACCEPT
ipchains -A input -i $OUTSIDE_IF -p tcp ! -y \
          -s $ANYWHERE 21 \
          -d $OUTSIDE_IPADDR $UNPRIVPORTS -j ACCEPT
```

Data connection from client to server (passive mode) (and responses)

```
ipchains -A output -i $OUTSIDE_IF -p tcp \
          -s $OUTSIDE_IPADDR $UNPRIVPORTS \
          -d $ANYWHERE $UNPRIVPORTS -j ACCEPT
ipchains -A input -i $OUTSIDE_IF -p tcp ! -y \
          -s $ANYWHERE  $UNPRIVPORTS \
          -d $OUTSIDE_IPADDR $UNPRIVPORTS -j ACCEPT
```

Incoming data connection from the remote server (port 20) (active mode) (and responses). Note that this rule allows *anyone anywhere* to make an incoming TCP connection to your server, provided they set their source port to 20. For this reason, it is sometimes omitted.

```
ipchains -A input -i $OUTSIDE_IF -p tcp \
          -s $ANYWHERE 20 \
          -d $OUTSIDE_IPADDR $UNPRIVPORTS -j ACCEPT
ipchains -A output -i $OUTSIDE_IF -p tcp ! -y \
          -s $OUTSIDE_IPADDR $UNPRIVPORTS \
          -d $ANYWHERE 20 -j ACCEPT
```

We don't need any further rules, since the policy on the input and output chain handles all other cases.

29.6 Security updates

Software contains a number of bugs when it is released, including security related bugs that will provide unintentional features to an attacker. Over time many of these bugs become known, either to the authors, or to people using the software, or to researchers and black-hatters who investigate the software.

There are two approaches to the disclosure of problems related to computer security.

- Minimum disclosure – this involves keeping the details of vulnerabilities in software secret, and issuing updates without complete explanations as to what is updated. Historically Microsoft has followed this model. Minimum disclosure has often lead to bugs remaining unfixed for years, while attackers continue to use the bug to gain unauthorized access to systems.
- Full disclosure – complete information about vulnerabilities in software is made public, occasionally before a patch for the vulnerability is available. Most software projects for Linux handle security vulnerabilities in this way. Full disclosure has forced software companies and projects to correct bugs by making it impossible to continue to run the .

To avoid your server being compromised due to publicly known bugs, you must update the software when the bug announcement is made. Bug announcements are made in a number of forums:

- BUGTRAQ – the BUGTRAQ mailing list is historically the forum of choice for disclosing security problems. It is a moderated list, which means that only appropriate content is published.
- Full-disclosure – The company SecurityFocus which runs the BUGTRAQ mailing list has been bought by Symantec Corporation. Symantec does not entirely support full disclosure, so to balance the effect that this may have on the content of the BUGTRAQ mailing list, an unmoderated and independent mailing list named Full-disclosure has been created, also for discussion of security vulnerabilities.
- CERT – The Computer Emergency Response Team coordinates responses to security compromises, identifies trends in intruder activity and disseminates information to the broad community. Their site is **www.cert.org**.
- SANS - The SANS (SysAdmin, Audit, Network, Security) Institute provides news digests, research summaries, security alerts and papers at **www.sans.org**.

Each vendor also publishes its own security updates. These is generally a security link from the vendor home page. Vendor updates are usually signed with a public key, or supplied with a MD5 checksum.

To install an update:

For most RPM based distributions you will install an update something like this.

```
md5sum update-3.1.2.i386.rpm         # and check what you see ...
rpm --checksig update-3.1.2.i386.rpm
rpm -Fvh update-3.1.2.i386.rpm
```

For Debian ...

```
apt-cache update
apt-get upgrade
```

29.7 Socket

The program **socket** can be used to access TCP sockets from a shell[35].

In **client** mode **socket** connects to a given port at a given host and reads data from the socket.

This will connect to a mail server, similar to **telnet**.

```
socket mail.example.com 25
```

Here we send an HTTP request (without a Host: header) to **www.example.com**:

```
echo -ne 'GET / HTTP/1.0\r\n\r\n' | socket www.example.com www
```

In server mode ("-s" on the command line) **socket** acts as a server and accepts incoming connections to the port. Standard input and output are used.

Capture a web server request ...

```
cat index.html | socket -s 8080 &
```

35 The capabilities of **socket** are similar to **netcat**. **netcat** as a client is similar to **socket**. **netcat -l -p 8080** is equivalent to **socket -s 8080**.

```
lynx -dump localhost:8080
```

29.8 Review

Quiz questions

1. What is a security policy?
2. How are TCP wrappers configured?
3. What command can be used to find files in **/usr/bin** and **/usr/sbin** with the SGID bit set?
4. How do you verify that a downloaded package has not been tampered with?
5. How do you set up password ageing for a user?
6. What are the errors in each of the following **iptables** configuration commands?

```
iptables -A INPUT --dport 80 --syn --protocol tcp -j LOG
iptables -F forward
iptables -t nat -A PREROUTING -i eth0 -j MASQUERADE
iptables -t filter -A INPUT -m state --state ESTABLISHED, RELATED \
      -j ACCEPT
```

7. What does the following **ipchains** rule accomplish?

```
ipchains -A output -i eth0 -p udp \
      -s 192.168.44.23 1024:65535 \
      -d 196.25.1.1 53 -j ACCEPT
```

8. What additional **ipchains** rule is necessary to make the above traffic effective on a firewall with a DROP policy?

Assignment

1. Write a personal firewall protection script using **ipchains**. The script should drop all incoming packets, and specifically should prevent the external use of the ports 53 (udp and tcp) and 25, 80. When the firewall is active, the machine should not respond to ICMP echo requests or traceroute. The machine should be able to make any outgoing connection and receive reply traffic. Test the
2. Write an equivalent script using **iptables**.
3. Write a brief security policy for your personal machine, and implement it using TCP wrappers and either **iptables** or **ipchains**.

Answers to quiz questions

1. A document, which, if followed, makes you as secure as you think you are.
2. Editing /etc/hosts.allow and /etc/hosts.deny.
3. find /usr/{s,}bin -perm -2000
4. rpm --checksig package.rpm
5. Using the **passwd** command.
6. dport cannot be used before the protocol is specified; the forward chain should be capitalised; one cannot use the MASQUERADE target until the POSTROUTING step; the

list of possible states must be given as a single parameter with no spaces.

7. UDP DNS lookups packets generated by non-root processes at 192.168.44.23 are permitted to 196.25.1.1 53.

```
ipchains -A output -i eth0 -p udp \
      -s 192.168.44.23 1024:65535 \
      -d 196.25.1.1 53 -j ACCEPT
```

8. Similar rules for the input and forward chains.

30 Host security

> A debugged program is one for which you have not yet found the conditions that make it fail.
>
> — *Jerry Ogdin*

LPIC topic 1.114.2 — Setup host security [3]

Weight: 3

Objective

Candidate should know how to set up a basic level of host security. Tasks include syslog configuration, shadowed passwords, set up of a mail alias for root's mail and turning of*f* all network services not in use.

Key files, terms, and utilities include

/etc/inetd.conf or /etc/inet.d/*	services offered by inetd or xinetd
/etc/nologin	if present only root can log in
/etc/passwd	user database
/etc/shadow	encrypted passwords of users
/etc/syslog.conf	system logging configuration

30.1 Miscellaneous security notes

30.1.1 Shadow passwords

Most current distributions set up shadow passwords by default. If you have **/etc/passwd** and **/etc/group** with encrypted passwords in them, you should use **pwconv** and **grpconv** to convert to shadow passwords. This prevents an attacker from running a dictionary based attack to obtain increased privileges. You can always reverse the process with **pwunconv** and **grpunconv**.

30.1.2 Root mail

A lot of important mail is sent by default to the user root. Apart from messages generated by **cron** and various installation programs, **/etc/aliases** contains a number of email redirections.

- Mail for various system accounts is redirected to root, e.g. “ftp”, “uucp” and “news”.
- RFC2142 specifies mailbox names for common roles, including “postmaster”, “security”, “abuse” and “hostmaster”. For most of these mail is redirected to root for default installations of Linux.

Because root seldom logs in and reads mail, you should redirect these mails to someone who cares – a regular user.

```
foobar:~ $ vi /etc/aliases
# It is probably best to not work as user root and redirect all
# email to "root" to the address of a HUMAN who deals with this
```

```
# system's problems. Then you don't have to check for important
# email too often on the root account.
# Gerald Smith is our sysadmin ...
root:   gerald
postmaster:     root
hostmaster:     root
abuse: root
foobar:~ $ newaliases
```

Not all local delivery agents will deliver mail to root. Postfix delivers all mail to root to "nobody".

30.1.3 *Syslog*

The following log facilities are used by processes that produce relevant information for security:

- **authpriv** and **auth** – logins and su's
- **kern** – firewall messages generated by **iptables -j LOG** (along with a number of .

Your distribution may separate the log levels like this in **syslog.conf**, but this is by no means standardised across distributions:

```
auth,authpriv.*                 /var/log/auth.log
*.*;auth,authpriv.none          -/var/log/syslog
daemon.*                        -/var/log/daemon.log
kern.*                          -/var/log/kern.log
lpr.*                           -/var/log/lpr.log
mail.*                          -/var/log/mail.log
user.*                          -/var/log/user.log
uucp.*                          /var/log/uucp.log
```

The kind of information that can appear in the log that is relevant to your system's security includes:

- Failed and successful logins. An attacker unsuccessfully try to gain access a number of times.
  ```
  Sep 17 04:28:49 grock proftpd[9016]: refused connect from
       p50916675.dip.t-dialin.net (80.145.102.117)
  Sep 17 12:42:09 grock sshd[14605]: Failed password for plex from
       196.22.233.34 port 43445 ssh2
  Jul 18 10:49:13 grock /usr/sbin/named[4535]: client
       155.239.184.6#2468: update denied
  ```
- Unexplained server error messages and crashes, possibly related to the attempted exploitation of bugs.
  ```
  Sep  9 12:11:31 grock sendmail[31018]: NOQUEUE: SYSERR(root):
       opendaemonsocket: daemon MTA: server SMTP socket wedged:
       exiting
  ```
- Firewall messages, indicating that a packet violated firewall policy.
  ```
  Dropped-outgoing IN=eth0 OUT=eth1 SRC=192.168.1.3 DST=192.19.4.11
       LEN=48 TOS=0x00 PREC=0x00 TTL=127 ID=47664 DF PROTO=TCP
       SPT=3441 DPT=139 WINDOW=64240 RES=0x00 SYN URGP=0
  ```

30.1.4 nologin

If you create a file named **/etc/nologin** its contents are displayed when a non-root user tries to log in.

```
foobar:~ # echo "Login disabled during maintenance" > /etc/nologin
foobar:~ # telnet localhost
Connected to localhost
Escape character is '^]'.

foobar login: realuser
Password: realpassword
Login disabled during maintenance

Login incorrect
```

The **nologin** file is usually removed by boot-time scripts. While it is present **telnet**, **rlogin**, **login** and **ftp** will not allow login except for root. **sshd** refuses logins too.

30.2 Disabling unused services

It is good practice to limit the number of services on your server to the absolute minimum. The rationale for this is that the fewer the points of attack, the less likely it is that the attack will succeed.

In addition to minimising the services offered, each service should be configured to offer the minimum functionality to an attacker:

- Unused features should be disabled, either at compile time, or by configuration.
- Access to the service should be limited to networks that need it.
- Services which are only occasionally used should be disabled, and only enabled on demand.
- Authentication should be required where this is appropriate.

inetd and xinetd

To disable a service which is offered via **inetd**, you comment out the relevant line in **/etc/inetd.conf**.

With this configuration file, FTP is disabled, and SSH is enabled.

```
# inetd.conf
# ftp   stream  tcp     nowait  root    /usr/sbin/tcpd  vsftpd
ssh     stream  tcp     nowait  root    /usr/sbin/sshd -i
```

You must also send a signal to **inetd** to tell it to reload the configuration file

```
killall -1 inetd
kill -HUP $( cat /var/run/inetd.pid )
```

To disable a service offered by **xinetd** you add the parameter **disabled = yes** to the configuration file.

```
foobar:~ $ cat /etc/xinetd.d/echo
service echo
{
        type            = INTERNAL
        id              = echo-stream
```

```
        socket_type     = stream
        protocol        = tcp
        user            = root
        wait            = no
        disable         = yes
}
foobar:~ $ cat /etc/xinetd.d/ssh
service ssh
{
        flags           = REUSE
        socket_type     = stream
        wait            = no
        user            = root
        server          = /usr/sbin/sshd
        server_args     = -i
        disable         = no
}
```

The changes take effect when you send a signal to **xinetd** to tell it to reload its configuration file. Any of these will do the job.

```
kill -HUP $( cat /var/run/xinetd.pid )
killall -1 xinetd
killall -HUP xinetd
```

Stand-alone services

Services that do not depend on **inetd** are started by their own startup scripts in **/etc/init.d**. To disable one of these services, the symbolic link to the startup script can be deleted.

```
foobar:~ # runlevel
N 5
foobar:~ # cd /etc/init.d/rc5.d/
foobar:/etc/init.d/rc5.d $ ls S*
S01random   S07hotplug  S10firewall       S11smbfs      S15xinetd
S05network  S08pcmcia   S10portmap        S14alsasound  S16cron
S06syslog   S08resmgr   S11postfix        S15kbd        S17xdm
foobar:/etc/init.d/rc5.d $ rm S14postfix
```

There are a number of distribution-specific methods for removing a boot-time service:

```
insserv -r postfix                  # some SuSE versions
chkconfig --del postfix             # RedHat and similar
update-rc.d -f postfix remove       # Debian
```

30.3 Review

Quiz questions

1. Which file controls where mail for **root** is delivered?
2. How do you disable a telnet server?
3. In which files on your system can passwords appear? Why are some of the files more problematic?
4. How does the presence of **/etc/nologin** affect logging in as root?

Assignment

1. Install a FTP server, telnet server, NFS server and Samba. Now disable all of the server you do not use.
2. Set up **syslogd** to log all messages to a console **/dev/tty8**.
3. Determine what effect the presence of **/etc/nologin** has on the each of these – existing login sessions, SMTP, POP3, FTP, SSH, Telnet, console login.

Answers to quiz questions

1. **/etc/aliases** and **/root/.forward**
2. Uninstall the software (i.e. delete the executable file in.telnetd).
3. /etc/passwd and /etc/shadow. Hashed passwords in /etc/passwd can be read by any local user.
4. Not at all.

31 User limits

Genius has its limits, but stupidity is not handicapped in this way.

LPIC topic 1.114.3 — Setup user level security [1]

Weight: 1

Objective

Candidate should be able to configure user level security. Tasks include limits on user logins, processes, and memory usage.

Key files, terms, and utilities include

quota	show user's disk usage
usermod	change a user's details in the password database

31.1 Process limits

The Linux kernel supports limits on the amount of resources a program can allocate. The limits of a process are inherited by all the processes it creates.

Resource limits are configured with a soft limit and a hard limit. If additional resources are required, a user can request additional space, up to the hard limit using **ulimit**. This is part of the shell, and is documented in the **bash** man page.

```
foobar:~ $ help ulimit
ulimit: ulimit [-SHacdflmnpstuv] [limit]
    Ulimit provides control over the resources available to
      processes
    started by the shell.

        -S      use the `soft' resource limit
        -H      use the `hard' resource limit
        -a      all current limits are reported
        -c      the maximum size of core files created
        -d      the maximum size of a process's data segment
        -f      the maximum size of files created by the shell
        -l      the maximum size a process may lock into memory
        -m      the maximum resident set size
        -n      the maximum number of open file descriptors
        -p      the pipe buffer size
        -s      the maximum stack size
        -t      the maximum amount of cpu time in seconds
        -u      the maximum number of user processes
        -v      the size of virtual memory
```

One way to set the process limits is add a number of calls to **ulimit** in **/etc/profile**.

```
TMOUT=3600              # set the shell idle timeout
[ `whoami` = 'root' ] || {
    ulimit    -c 20000  # hard/soft: no coredumps > 20mb
    ulimit -S -n 250    # softlimit: no more than 250 file
      descriptors
```

```
    ulimit -S -u 100    # softlimit: no more than 100 processes
    ulimit -S -d 50000  # softlimit: no more than 50mb memory
      (netscape)
    ulimit -H -d 512000 # hardlimit: no more than 512mb memory
      (hard)
    ulimit -S -m 30000  # softlimit: max resident set size is 30 MB
    ulimit    -f 670000 # hard/soft: no files > ISO image allowed
    ulimit -S -s 15000  # softlimit: max stack size of a program is
      15MB
}
```

These settings limit the amount of damage that a single user can do accidentally. To some extent the deliberate damage a user can do is also limited.

PAM (pluggable authentication modules) includes support for setting resource limits when a particular system is used. The **pam_limits.so** module loads the resource limits specified in **/etc/security/limits.conf** as part of setting up the session.

```
xserver:~ # cat /etc/pam.d/xdm
#%PAM-1.0
auth     required       pam_unix2.so    nullok #set_secrpc
account  required       pam_unix2.so
password required       pam_unix2.so    #strict=false
session  required       pam_unix2.so    debug # trace or none
session  required       pam_devperm.so
session  required       pam_resmgr.so
# most xdm configurations do not include this!
session required        pam_limits.so
```

The **/etc/security/limits.conf** below sets the limits similar to the **ulimit** statements in **/etc/profile**.

```
foobar:~ # cat /etc/security/limits.conf
# Limits that apply to everyone in the users group - a local hack,
     YMMV
@users          soft    rss             10000
@users          soft    priority        10
@users          soft    core            20000
@users          soft    nofile          250
@users          soft    nproc           100
@users          hard    fsize           670000
@users          soft    fsize           670000
@users          soft    stack           15000
```

Process limits should be set so that your programs run normally they run within the limits. When processes exceed the limits, they crash. This crash can sometimes prevent the exploitation of security holes.

31.2 More limits

Login limits

Apart from the prohibition on user logins while **/etc/nologin** exists, PAM allows you to limit the number of concurrent user logins.

```
# members of the student group can only log in 4 times
@student        -       maxlogins       4
```

usermod limits

The **usermod** command allows you to set an expiry date for an account.

```
usermod -e 2005-06-19 joe            # expire joe's account in June
      2005
```

After **-e** you give the date on which the user account will be disabled, in the format *YYYY-MM-DD*.

Disk quotas and security

An angle of attack for a malicious user user is to fill up your server's disk space with useless junk. Setting quotas for disk space prevents this attack. So set quotas for users and groups! Quota related commands include ...

- **edquota** – edit a user's quota
- **quota** – show current quotas
- **repquota** – report on all quotas

31.3 Review

Quiz questions

1. When limits are set with **ulimit** what enforces these limits?
2. Where are **ulimit** parameters set?
3. What kind of command is **ulimit**?
4. How can you limit user logins?
5. Why would you want to limit the number of processes a user can run?
6. How are quotas relevant to security?
7. What limits can the **usermod** command set?

Assignment

Determine the smallest values for each configurable process for your login session as a regular user. Configure these limits in **/etc/profile** and then in **/etc/security/limits.conf**. Test whether the limits are applied for a graphical login using **xdm** and a console login.

Answers to quiz questions

1. Process limits, enforced by the kernel.
2. During login, by the PAM library or the profile script.
3. A bash built-in command.
4. “username - maxlogins 4” in **/etc/security/limits.conf**. To do this indirectly, you can limit the number of processes the user can run.
5. You may have a computer with finite resources.
6. Limiting the amount of disk space for a user can prevent certain types of attack (e.g. filling

up the disk)

7. You can change the group of a user, and thereby make group quotas or process limits apply.

32 Glossary

This glossary defines some terms which may be unfamiliar to the uninitiated. Some glossary terms are defined in the LPI 101 course notes, and are not repeated.

- 0x00c0ffee
- 1024
- about
- ASCII
- argument
- bash
- BIOS
- bleeding edge
- boot
- buffer
- bus
- cat
- character
- client
- CLUE
- CMOS
- comment
- console
- CPU
- database
- default
- display
- distribution
- DMA
- DNS
- DOS
- environment
- execute
- FAQ
- field
- filesystem
- font
- foobar
- fortune
- geometry
- GPL
- group
- home directory
- host
- HOWTO
- I/O
- IDE
- interrupt
- journal
- Kernel
- LBA
- library
- Linux
- LPI
- LPIC
- LUN
- make
- man pages
- media
- metacharacter
- modem
- mount
- network address
- NIC
- ownership
- package
- parallel
- parameter
- PCI
- peripheral
- permission
- pipe
- PnP
- ppp
- proc
- process
- protocol
- rc
- recursive
- resources
- root
- rwx
- script
- SCSI
- serial
- server
- setuid
- shell
- source code
- ssh
- standard input, outut and error
- swapfile
- switch
- syntax
- tab space
- terminal
- text
- timeout
- tree
- variable
- verbose
- wildcard
- zzz

Terms

authentication To prove you are who you say you are. This is frequently done by providing a correct user name and password, and sometimes by cryptographic keys.

authorisation Once you have authenticated yourself, you should be allowed to to specific things.

backup A copy of your data, for just in case you lose your originals. Actually, backups are for *when* you lose your originals. Never make backups on **/dev/null**.

broadcast To send network traffic to everyone.

command line A command that is typed in the shell is a command line. The boot-time options are also a command line (**/proc/cmdline**).

dependencies One thing requiring another, such as a X based program requiring the X11 client library, or a kernel module requiring a specific kernel version.

firewall A device to selectively block network traffic. On Linux, firewalls are frequently implemented using **iptables** or **ipchains**.

module Modules in Linux are generally kernel modules, which are compiled code which can be installed into a running Linux kernel.

pipeline Sending the input of one process to another.

```
ls | grep file | cat > output
```

scripting To write a script that performs a task.

encryption To scramble a message with the intention that it should be unreadable to outside parties.

log Many events are written to log files as they occur, and these are mostly in the directory **/var/log**, e.g. **/var/log/messages**. Real logs grow on trees and are made of wood. Printing out your logs will use many trees.

That's all for now folks ... all the good stuff is in the 101 glossary.

33 Index