Study Guide for

Advanced Linux System Administration I

Lab work for LPI 201

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Contents

The Linux Kernel

This module will describe the kernel source tree and the documentation available. We will also apply patches and recompile patched kernels. Information found in the **/proc** directory will be highlighted.

1. Kernel Components

Modules

`Module Components in the Source Tree`

In the kernel source tree **/usr/src/linux**, the kernel components are stored in various subdirectories:

Subdirectory	Description	Example
./drivers	contains code for different types of hardware support	pcmcia
./fs	code for filesystem supported	nfs
./net	code for network support	ipx

These components can be selected while configuring the kernel (see **2. Compiling a Kernel**).

`Module Components at Runtime`

The **/lib/modules/<*kernelversion*>/kernel** directory, has many of the same subdirectories present in the kernel source tree. However only the modules that have been compiled will be stored here.

Types of Kernel Images

The various kernel image types differ depending only on the type of compression used to compress the kernel.

The **make** tool will read the /usr/src/linux/Makefile to compile

- A compressed linux kernel using **gzip** is compiled with: `make zImage`
The compiled kernel will be:

/usr/src/linux/arch/*i386*/boot/zImage

- A compressed linux kernel using better compression is compiled with: `make bzImage`

The compiled image will be:

/usr/src/linux/arch/*i386*/boot/bzImage

- One can also use: `make zdisk` or `make bzdisk` to create compressed kernels on a floppy. The compiled kernel will be written to:

```
/dev/fd0
```

Remember to put a floppy in the drive!

Documentation

Most documentation is available in the **/usr/src/linux/Documentation** directory. The main files are the following:

File	Description
00-INDEX	Summary of the contents for each file in the Documentation directory
Configure.help	Contains the help displayed when configuring a kernel

The **Configure.help** file also provides further information for when a kernel module doesn't load properly. Specific options and aliases for **/etc/modules.conf** are specified in that file.

Information about compiling and documentation is available in **/usr/src/linux/README**.

The version of the kernel is set at the beginning of the Makefile.

```
VERSION = 2
PATCHLEVEL = 4
SUBLEVEL = 22
EXTRAVERSION =
```

Make sure to add something to the EXTRAVERSION line like
`EXTRAVERSION=-test`

This will build a kernel called **2.4.22-test**
Notice: You need the "–" sign in EXTRAVERSION or else the version will be 2.4.22test

2. Compiling a Kernel

Compiling and installing a kernel can be described in three stages.

- **Stage 1: configuring the kernel**

Here we need to decide what kind of hardware and network support needs to be included in the kernel as well as which type of kernel we wish to compile (modular or monolithic). These choices will be saved in a single file:

`/usr/src/linux/.config`

Creating the .config file	
Command	Description
make config	Edit each line of .config one at a time
make menuconfig	Edit .config browsing through menus (uses ncurses)
make xconfig	Edit .config browsing through menus (uses GUI widgets)

When editing the **.config** file using any of the above methods the choices available for most kernel components are:

Do not use the module (n)
Statically compile the module into the kernel (y)
Compile the module as dynamically loadable (M)

Notice that some kernel components can only be statically compiled into the kernel. One cannot therefore have a totally modular kernel.

When compiling a **monolithic** kernel none of the components should be compiled dynamically.

- **Stage 2: compiling the modules and the kernel**

The next table outlines the various 'makes' and their function during this stage. Notice that not all commands actually compile code and that the **make modules_install** has been included

Compiling	
Command	Description

make clean	makes sure no stale **.o** files have been left over from a previous build
make dep	adds a **.depend** with headers specific to the kernel components
make	build the kernel
make modules	build the dynamic modules
make modules_install	install the modules in **/lib/modules/***kernel-version/*

Stage 3: Installing the kernel image

This stage has no script and involves copying the kernel image manually to the boot directory and configuring the bootloader (LILO or GRUB) to find the new kernel.

3. Patching a Kernel

Incremental upgrades can be applied to an existing source tree. If you have downloaded the linux-2.4.21.tgz kernel source and you want to update to a more recent kernel linux-2.4.22 for example, you must download the patch-2.4.22.gz patch.

Applying the Patch

The patch file attempts to overwrite files in the 2.4.21 tree. One way to apply the patch is to proceed as follows:

```
cd /usr/src
zcat patch-2.4.22.gz | patch -p0
```

The **-p** option can strip any number of directories the patch is expecting to find. In the above example the patch starts with:

```
--- linux-2.4.21/...
+++ linux-2.4.22/...
```

This indicates that the patch can be applied in the directory where the **linux-2.4.21** is.

However if we apply the patch from the **/usr/src/linux-2.4.21** directory then we need to strip the first part of all the paths in the patch. So that

```
--- linux-2.4.21/arch/arm/def-configs/adsagc
+++ linux-2.4.22/arch/arm/def-configs/adsagc
```

becomes

```
--- ./arch/arm/def-configs/adsagc
+++ ./arch/arm/def-configs/adsagc
```

This is done with the **-p1** option of **patch** effectively telling it to strip the first directory.

```
cd /usr/src/linux-2.4.21
zcat patch-2.4.22.gz | patch -p1
```

Testing the Patch

Before applying a patch one can test what will be changed without making them:

```
patch -p1 –dry-run  < patchfile
```

Recovering the Old Source Tree

To make sure the old configuration (.config file) is saved copy the .config file to the **/boot** directory.

```
cp .config /boot/config-kernelversion
```

The **patch** tool has two ways of keeping track of the changed files:

1. You can apply the patch with the **-b** option

```
patch -b -p0 < patch-file
```

By default this option keeps all the original files and appends a ".orig" to them.

2. You can backup the old changed file to a directory of your choice

```
mkdir oldfiles
patch -B oldfiles/ -p0 < patch-file
```

This has the advantage of letting you create a backup patch that can restore the source tree to it's original state.

```
diff -ur linux-2.4.21 oldfiles/linux-2.4.21  > recover-2.4.21-
patch
```

NOTICE
Applying this recover-2.4.21-patch will have the effect of removing the 2.4.22 patch we just applied in the previous paragraph

Building the New Kernel after a patch

Simply copy the old .config to the top of the source directory.

```
cp /boot/config-kernelversion /usr/src/linux-
kernelversion/.config
```

Next 'make oldconfig' will only prompt for new features.

```
make oldconfig
make dep
make clean bzImage modules modules_install
```

4. Customising a Kernel

Loading Kernel modules

Loadable modules are inserted into the kernel at runtime using various methods.

The **modprobe** tool can be used to selectively insert or remove modules and their dependencies.

The kernel can automatically insert modules using the **kmod** module. This module has replaced the **kerneld** module.

When using **kmod** the kernel will use the tool listed in **/proc/sys/kernel/modprobe** whenever a module is needed.

Check that **kmod** has been selected in the source tree as a static component:

```
grep -i "kmod" /usr/src/linux/.config
CONFIG_KMOD=y
```

When making a monolithic kernel the CONFIG_MODULES option must be set to no.

The /proc/ directory

The kernel capabilities that have been selected in a default or a patched kernel are reflected in the **/proc** directory. We will list some of the files containing useful information:

/proc/cmdline
Contains the command line passed at boot time to the kernel by the bootloader

/proc/cpuinfo
CPU information is stored here

/proc/meminfo
Memory statistics are written to this file

/proc/filesystems
Filesystems currently supported by the kernel. Notice that by inserting a new module (e.g cramfs) this will add an entry to the file. So the file isn't a list of all filesystems supported by the kernel!

/proc/partitions
The partition layout is displayed with further information such as the name, the number of block, the major/minor numbers, etc

/proc/sys/
The **/proc/sys** directory is the only place were files with write permission can be found (the rest of /proc is read-only). Values in this directory can be changed with the **sysctl**

utility or set in the configuration file **/etc/sysctl.conf**

/proc/sys/kernel/hotplug
Path to the utility invoked by the kernel which implements hotplugin (used for USB devices or hotplug PCI and SCSI devices)

/proc/sys/kernel/modprobe
Path to the utility invoked by the kernel to insert modules

/proc/sys/overflowgid/uid
Maximum number of users on a system. The filesystem uses 16 bits for the user and group fields, so the maximum is 2^16 = 65534 which is usually mapped to the user **nobody** or **nfsnobody** more recently

/proc/modules
List of currently loaded modules, same as the output of **lsmod**

Example: Patch the linux-2.4.22-1.2149.nptl kernel to support Extended Attributes and Posix Access Control Lists (ACL) for ext2 and ext3 filesystems.

ACLs are beyond this course. All we need to know is that they provide a greater flexibility for directory and file permissions on the filesystem allowing, for example, several groups to access resources with different permissions.

WARNING
This patch will fail on older kernel versions (e.g linux-2.4.22-1.2115.nptl **)**

Install the 2.4.22-1.2149.nptl kernel and point the /usr/src/linux link to the new source. Then do:

```
cd /usr/src/linux
```

```
bzcat /usr/src/ea+acl+nfsacl-2.4.22-0.8.65.patch.bz2 | patch -p1
–dry-run
```

If there are no error messages then run **patch** with no **–dry-run** option. Next, we compile the new kernel:

```
Add EXTRAVERSION=-acl to the Makefile
make mrproper
cp configs/kernel-2.4.22-i686.config .config
make oldconfig   (answer y to all questions relative to ACLs)
make dep bzImage modules modules_install
```

Quick test:
Once you have rebooted with the new kernel, add the **acl** option into **/etc/fstab** on any EXT3 filesystem

```
LABEL=/usr   /usr      ext3    defaults,acl    1 2
```

You can then use the **setfacl** to add assign permissions for different groups on the same directory.

We first create two groups **eng** and **sales**:
\

```
groupadd eng
groupadd sales
```

Then add a directory called /usr*NEWS*:

```
mkdir /usr/NEWS
```

The **getfacl** is a tool that lists ACL privileges. So before we do anything lets look at the following output:

```
getfacl /usr/NEWS
# file: share
# owner: root
# group: root
```

```
user::rwx
group::r-x
other::r-x
```

Next add **rwx** permissions on NEWS for the group sales:

```
setfacl -m g:sales:rwx NEWS/
```

List the ACL privileges:

```
getfacl NEWS/
# file: NEWS
# owner: root
# group: sales
user::rwx
group::r-x
group:sales:rwx
mask::rwx
other::r-x
```

Finally add **r_x** permissions for the group **eng** and list the permissions:

```
setfacl -m g:eng:r-x NEWS/


getfacl NEWS/
# file: NEWS
# owner: root
# group: sales
user::rwx
group::r-x
group:sales:rwx
group:eng:r-x
mask::rwx
other::r-x
```

The kernel patch has worked. The above tools are not in the 201 objectives.

System Startup

Customising the boot process involves understanding how startup script are called. The chapter also describes common problems that arise at different points during the booting process as well as some recovery techniques. Finally we focus our attention on the “initial ram disk” (or initial root device) *initrd* stage of the booting process. This will allow us to make decisions as to when new initial ram disks need to be made.
.

1. Customising the Boot Process

`Overview of init`

In order to prevent processes run by users from interfering with the kernel two distinct memory areas are defined. These are referred to as “kernel space memory” and “user space memory”. The **init** process is the first program to run in user-space.

Init is therefore the parent of all processes. The init program's configuration file is **/etc/inittab**

`Runlevels`

Runlevels determine which processes should run together. All processes that can be started or stopped at a given runlevel are controlled by a script (called an “init script” or an “rc script”) in **/etc/rc.d/init.d**

List of rc scripts on a typical system						
anacron	halt	kudzu	ntpd	rusersd	syslog	ypxfrd
apmd	identd	lpd	portmap	rwalld	vncserver	
atd	ipchains	netfs	radvd	rwhod	xfs	
autofs	iptables	network	random	sendmail	xinetd	
crond	kdcrotate	nfs	rawdevices	single	ypbind	
functions	keytable	nfslock	rhnsd	snmpd	yppasswdd	
gpm	killall	nscd	rstatd	sshd	ypserv	

Selecting a process to run or be stopped in a given runlevel is done by creating symbolic links in the
/etc/rc.d/rcN.d/ directory, where N is a runlevel.

Example 1: selecting **httpd** process for runlevel 3:

```
ln -s  /etc/rc.d/init.d/httpd /etc/rc.d/rc3.d/S85httpd
```

Notice that the name of the link is the same as the name of the process and is preceded by an **S** for *start* and a number representing the order of execution.

Example 2: stopping **httpd** process for runlevel 3:

```
rm /etc/rc.d/rc3.d/S85httpd
ln -s  /etc/rc.d/init.d/httpd /etc/rc.d/rc3.d/K15httpd
```

This time the name of the link starts with a **K** for *kill* to make sure the process is stopped when switching from one runlevel to another.

Starting Local scripts

We want to run a script at a given run level. Our script will be called ***printtotty10*** and will simply print the message given as an argument to /dev/tty10.

/bin/printtotty10

```
#!/bin/bash
echo $1 > /dev/tty10
```

1. One way to have the script started at a specific run level is to add a line in **/etc/inittab** like

```
pr10:3:once:/bin/printtotty10 "Printtotty was started in inittab"
```

This is not always the best way to do this. What if many scripts need to be started? The inittab file would look messy.

2. We can write a custom rc-script. We follow the usage to call the script the same name as the actual tool we want to startup.

/etc/rc.d/init.d/printtotty10

```
#!/bin/sh
```

```
# chkconfig: 345 85 15
# description: This line has to be here for chkconfig to work ... \
#The script will display a message on /dev/tty10
#First source some predefined functions such as echo_success()
./etc/rc.d/init.d/functions

start()  {
        echo -n  "Starting printtotty10"
        /bin/printtotty10 "printtotty10 was started with an rc-script "
        echo_success
        echo
}


stop() {
        echo -n "Stopping custom-rc"
        /bin/printtotty10 "The custom script has stopped"
        echo_success
        echo
}
case "$1" in
  start)
        start;;
  stop)
        stop;;
esac
exit 0
```

3. The ***prittotty10*** script can be started at boot time by placing the command in **/etc/rc.d/rc.local**. The **rc.local** script is the last rc-script to be run.

Notice: When setting up a linux server as a router it is possible to switch on ip-forwarding at boot time by adding the following line to **rc.local**:

```
echo 1 > /proc/sys/net/ipv4/ip_forward
```

However it is better to use the **sysctl** mechanism to switch ip-forwarding on every time the network interface is started. This is done by adding the following line to **/etc/sysctl.conf**:

```
net.ipv4.ip_forward = 1
```

2. System Recovery

When a system crashes and fails to restart it is necessary to alter the normal booting process. We will describe a few solutions here.

Overriding the INIT stage

This is necessary if the boot process fails due to a faulty init script. Once the kernel successfully locates the root file system it will attempt to run **/sbin/init**. But the kernel can be instructed to run a shell instead which will allow us to have access to the system before the services are started.

At the LILO or GRUB boot prompt add the following kernel parameter:

```
init=/bin/bash
```

At the end of the kernel boot stage you should get a **bash** prompt. Read-write access to the root filesystem is achieved with the following

```
mount /proc
mount -o remount,rw /
```

Errors at the end of the kernel stage

- If the kernel can't mount the root filesystem it will print the following message:

```
Kernel panic: VFS: Unable to mount root fs on 03:05
```

The number **03** is the major number for the first IDE controller, and **05** is the 5th partition on the disk. The problem is that the kernel is missing the proper modules to access the disk.

We need to boot the system using an alternative method. The fix next involves creating a custom **initrd** and using it for the normal boot process.

Question: In the case above since the drive isn't a SCSI drive what could have caused the problem?

- If the wrong root filesystem was parsed to the kernel by the boot loader (LILO or GRUB) then the INIT stage cannot start since **/sbin/init** will be missing

```
Kernel Panic: No init found. Try passing init= option to kernel
```

Again we need to boot the system using a different method, then edit the bootloader's configuration file (telling the kernel to use another device as the root filesystem), and reboot.

In both scenarios above it isn't always necessary to use a rescue disk. In fact, it often is a case of booting with a properly configured kernel. But what happens if the we don't have the option? What if the bootloader was reconfigured with the wrong kernels using no initial root disks or trying to mount the wrong root filesystem?

This leads us to the next possible cause of booting problems.

Missconfigured Bootloaders

At this stage we need to use a rescue method to boot the system. We already know from 101 that any Linux distribution CD can be used to start a system in *rescue mode*. The advantage of these CDs is that they work on any Linux system.

We next describes a preventative method which can only recover a specific system. We will create a floppy rescue disk which we then use in the case of an emergency (simple!)

All we need is a floppy with a Linux kernel image that can boot, and this image must be told were the root filesystem on the hard drive is.

The following creates a bootable floppy which will launch a linux kernel image

```
dd if=/boot/vmlinuz of=/dev/fd0
```

Finally **rdev** is used to tell the kernel where the root filesystem is. The next command must be run on the system we wish to protect and the floppy with the kernel must be in the drive

```
rdev /dev/fd0 /dev/hda2
```

Bootloader Kernel Parameters

load_ramdisk=n	If n is 1 then load a ramdisk, the default is 0
prompt_ramdisk=n	If n is 1 prompt to insert a floppy disk containing a ramdisk
nosmp or maxcpus=N	Disable or limit the number of CPUs

apm=off	Disable APM, sometime needed to boot from yet unsupported motherboards
init=	Defaults to /sbin/init but may also be a shell or an alternative process
root=	Set the root filesystem device (can be set with **rdev***)
mem=	Assign available RAM size
vga=	Change the console video mode (can be changed with **rdev*)**

*The **rdev** manual pages say; "The rdev utility, when used other than to find a name for the current root device, is an ancient hack that works by patching a kernel image at a magic offset with magic numbers. It does not work on architectures other than i386. Its use is strongly discouraged. Use a boot loader like SysLinux or LILO instead"

Troubleshooting LILO

When installing LILO the bootloader mapper, **/sbin/lilo**, will backup the existing bootloader.

For example if you install LILO on a floppy, the original bootloader will be save to /boot/boot.0200

Similarly when changing the bootloader on an IDE or a SCSI disk the files will be called boot.0300 and boot.0800 respectively. The original bootloader can be restored with:

```
lilo -u
```

By default the second stage LILO is called **/boot/boot.b** and when it is successfully loaded it will prompt you with a "boot: ".

Here the possible errors during the boot stage (taken from the LILO README)

- nothing LILO is either not installed or the partition isn't active
- L The first stage loader has been loaded but the second stage has failed
- LI The second stage boot loader has loaded but was unable to execute

```
This could be cause if /boot/boot.b moved and /sbin/lilo wasn't rerun
```

- LIL The second stage boot loader has been started, but it can't load the descriptor table from the map file or the second stage boot loader has been loaded at an incorrect address

```
This could be cause if /boot/boot.b moved and /sbin/lilo wasn't rerun.
```

- LIL- The descriptor table is corrupt

```
This could be cause if /boot/map moved and /sbin/lilo wasn't rerun.
```

3. Customised initrd

In most cases a "customised initrd" requires running **mkinitrd** which will determine the kernel modules needed to support block devices and filesystems used on the root device.

The mkinitrd script

The following are methods used in the **mkinitrd** script to determine critical information about the root device and filesystem.

-The root filesystem type:

Using **/etc/fstab** the script determines which filesystem is used on the root device and the corresponding module (for example **ext3** or **xfs**).

-Software RAID:

Using **/etc/raidtab** the **mkinitrd** script deduces the names of the raid arrays to start all the devices (even non root).

-LVM root device

Once the root device `$rootdev` is determined in **/etc/fstab** the major number is obtained from the following line:

```
root_major=$(/bin/ls -l $rootdev | awk '{ print $5 }')
```

If this corresponds to a logical volume, the logical volume commands are copied onto the ram disk.

The **mkinitrd** script will transfer all the required tools and modules to a file mounted as a loop device on a temporary directory. Once unmounted, the file is compressed and can be used as an initrd.

Example:

As an example we will copy the content of an existing initrd to a new initrd and change the root filesystem type form ext3 to ext2..

1. Uncompress the current initrd

```
cp /boot/initrd-your-kernel-version.img /tmp/initrd.img.gz
gunzip /tmp/initrd.img.gz
```

2. Mount the current initrd using a loop device

```
mkdir /mnt/current
mount -o loop /tmp/initrd.img /mnt/current
```

3. Estimate the size needed for the new initrd:

```
df -k /mnt/current
Filesystem           1K-blocks      Used Available Use% Mounted on
/tmp/initrd.img            317       191       126  61% /
mnt/current
```

4. Create a new image file called initrd-new.img of size 161K

```
dd if=/dev/zero of=/tmp/initrd-new.img bs=1K count=317
```

5. Estimate the number of inodes needed in the current initrd:

```
df -i /mnt/current
Filesystem            Inodes   IUsed   IFree IUse% Mounted on
/tmp/initrd.img           48      33      15   69% /mnt/current
```

6. Create a filesystem on the file /tmp/initrd-new.img with 48 inodes

```
mke2fs -F -m 0 -N 48 /tmp/initrd-new.img
```

7. Mount the file on a new directory and copy across all the files of the current initrd to the new one:

```
mkdir /mnt/new
mount -o loop /tmp/initrd-new.img /mnt/new
(cd /mnt/current/; tar cf - .) | (cd /mnt/new; tar xf -)
```

8. Edit the /mnt/new/linuxrc file and delete the line where the ***ext3*** module is inserted. Also replace the ***ext3*** option by **ext2** at the **mount** command.

9. Finally, unmount the /tmp/initrd-new.img then compress and rename it.

```
gzip /tmp/initrd-new.img ; mv /tmp/initrd-new.img.gz /boot/initrd-
test.img
```

Or

```
gzip < /tmp/initrd-new.img > /boot/initrd-test.img
```

10. Create a new kernel entry in /etc/lilo.conf or /boot/grub/grub.conf instructing the bootloader to use the new initrd.

Sample **grub.conf:**

```
title linux (2.4.22)
        root (hd0,1)
        kernel /vmlinuz-2.4.22 ro root=LABEL=/
        initrd /initrd-2.4.22.img

title broken?
        root (hd0,1)
        kernel /vmlinuz-2.4.22-1.2115.nptl ro root=LABEL=/
        initrd /initrd-new.img
```

Sample **lilo.conf**:

```
 image=/boot/vmlinuz-2.4.22-1.2115.nptl
     initrd=/boot/initrd-2.4.22.img
     read-only
     label=linux
     append=”root=LABEL=/”
image=/boot/vmlinuz-2.4.22-1.2115.nptl
     initrd=/boot/initrd-new.img
     read-only
     label=broken?
     append=”root=LABEL=/”
```

The Linux Filesystem

This objective covers most points seen in LPI 101. Configuring **automount** is a new feature where special attention has to be payed to the syntax.

1. Operating the Linux Filesystem

When adding new filesystems to the existing root filesystem the key file involved is **/etc/fstab** which assigns a mount point, a mount order and global options per device.

/etc/fstab options	
ro or **rw**	Read only or read write
noauto	Do not respond to **mount -a.** Used for external devices CDROMs ...
noexec	Executables cannot be started from the device
nosuid	Ignore SUID bit throughout the filesystem
nodev	Special device files such as block or character devices are ignored
noatime	Do not update atimes (performance gain)
owner	The device can be mounted only by it's owner
user	Implies **noexec**, **nosuid** and **nodev**. A single user's name is added to **mtab** so that other users may not unmount the devices
users	Same as **user** but the device may be unmounted by any other user

Mount will also keep track of mounted operations by updating **/etc/mtab**. The content of this file is similar to another table held by the kernel in **/proc/mounts**.

Regular local filesystems

When the system boots all local filesytems are mounted from the **rc.sysinit** scrpt. The **mount** command will mount every thing in **/etc/fstab** that has not yet been mounted and that is not encrypted or networked:

```
mount -a -t nonfs,smbfs,ncpfs -O no_netdev,noloop,noencrypted
```

When shutting down, all filesystem are unmounted by the **halt** script by scanning the **/proc/mounts** file with the help of some **awk** commands!

Swap Partions and SWAP files

At boot time, swap partitions are activated in **/etc/rc.d/rc.sysinit**

```
swapon -a
```

Similarly when the system shuts down swap is turned off in the **halt** rc-script:

```
SWAPS=`awk '! /^Filename/ { print $1 }' /proc/swaps`
[ -n "$SWAPS" ] && runcmd "Turning off swap: " swapoff $SWAPS
```

Example 1: Making a swap file of 10MB

1.

```
dd if=/dev/zero of=/tmp/SWAPFILE bs=1k count=10240
```

2.

```
mkswap /tmp/SWAPFILE
```

3.

```
 swapon /tmp/SWAPFILE
```

5.

```
cat /proc/swaps
Filename                    Type            Size    Used    Priority
/dev/hda6                   partition       522072  39744   -1
/tmp/SWAPFILE               file            10232   0       -2
```

Example 2: Making a swap partition of 16MB

1. Make a new partition (e.g /dev/hda16) of type swap (82) and size 16MB. Reboot

2. Make a swap filesystem on the devices

```
mkswap /dev/hda16
```

3. Add the following to **/etc/fstab**

```
/dev/hda16 swap swap  pri=-1 0 0
```

4. Make the swap partition available with `swapon -a`

Notice that if two swap partition are defined the kernel will automatically access them in “striped”mode, provided they have been mounted with the same priority determined by the **pri=** option in **/etc/fstab**

2. Maintaining a Linux Filesystem

This section covers a list of commands related to filesystem maintenance.

fsck - check and repair a Linux file system

Main options:

- -b use alternative superblck
- -c check for bad blocks
- -f force checking even when partition is marked clean
- -p automatic repair
- -y answer yes to all question

sync - flush filesystem buffers

Updates modified superblocks and inodes and executes delayed writes. The operating system keeps data in RAM in order to speed up operations. This may cause data to be lost in the event of a crash unless sync is executed. Sync will simply call the 'sync' system call. Another way of doing this is to use the 'ALT+sysreq+s' key combination

badblocks - search a device for bad blocks

It is recommended NOT to use badblocks directly but to use the **-c** flag with **fsck** or **mkfs**.

Main options:

-b	block size
-c	number of blocks tested at a time
-i	file with a list of known bad blocks, these blocks will be skipped
-o	output file, passed to **mkfs**

mke2fs - create an ext2/3 filesyste

Main options:

-b	blocksize
-i	number of bytes between consecutive inodes 'bytes-per-inode'
-N	number of inodes
-m	Percentage of blocks reserved for user root
-c	Check for bad blocks
-l	Read bad blocks from file
-L	Set a volume LABEL
-j/-J	Create journal (ext3)
-T	Optimise filesystem "type", values are:

news	one inode per 4kb block
largefile	one inode per megabyte
largefile4	one inode per 4 megabytes

dumpe2fs - dump filesystem information

dumpe2fs prints the super block and blocks group information for the filesystem present on a device

debugfs - ext2 file system debugger

debugfs is used to test and repair an ext2 filesystem. The main options are:

-w	open the filesystem as writeable
-b	blocksize

tune2fs - adjust tunable filesystem parameters on second extended filesystems

Main options:

-l	read the superblock
-L	set the device's volume LABEL
-m	change the filesystems reserved blocks for user root
-j or -J	set a journal

3. Configuring automount

Mounting can be automated using a mechanism called **automount** or **autofs**.

The **/usr/sbin/automount** is invoked with the rc-script **/etc/init.d/autofs**.

```
service autofs start
```

This script reads the configuration file **/etc/auto.master** also called a *map*. The map file defines mount points to be monitored by individual **automount** daemons.

Sample /etc/auto.master
/extra /etc/auto.extra
/home /etc/auto.home

When **autofs** is started it will invoke an instance of **/usr/sbin/automount** for each mount point defined in the master map **/etc/auto.master**.
When the map file **/etc/auto.master** is changed it is necessary to restart **autofs**. For example if mount points have been deleted, then the associated **automount** daemon is terminated. Likewise, new daemons are started for newly defined mount points.

Multiple filesystems can be mounted on a single mount point. These filesystems as well as the mount options needed (filesystem type, read-write permissions, etc) are defined in a separate file.

Sample /etc/auto.extra		
cdrom	-fstype=iso9660,ro,user,exec,nodev,nosuid	:/dev/cdrom
nfs	-fstype=nfs,soft,intr,rsize=8192,wsize=8	192 192.168.3.100:/usr/local

```
/extra
  |____ cdrom
  |____ nfs
```

The CDROM will automatically be accessible in **/extra/cdrom** and the NFS share is mounted as soon as the **/extra/nfs** directory is accessed

NOTICE
<u>In the above example</u>:
The directories /extra/cdrom and /extra/nfs **must not be created**
New entries in **/etc/auto.extra** are immediately made available: adding 'new -fstype=*ext3 :/dev/hda2*' to the file will automatically make **/extra/new** available
By default a mounted device will stay mounted for 5 minutes: if we uncomment the 'cdrom' device in the map file **/etc/auto.extra** shortly after the CDROM has been accessed, then the device will still be available for approximately 5 minutes in **/extra/cdrom**

Hardware and Software Configuration

This module will cover the configuration of components which need both kernel support and software tools.

1. Software RAID

RAID stands for “Redundant Array of Inexpensive Disks” and was originally designed to combine cheap hard disks together. RAID can either increase **speed** or **reliability** depending on the RAID level used.

RAID Levels

RAID-Linear

1	5
2	6
3	7
4	8

read	write	redundancy
0	0	no

RAID-0 (stripe)

1	2
3	4
5	6
7	8

read	write	redundancy
+	+	no

RAID-1 (mirror)

1	1
2	2
3	3
4	4

read	write	redundancy
+	-	yes

RAID-4

1	2	p
3	4	p
5	6	p
7	8	p

read	write	redundancy
+	-	yes

RAID-5

1	2	p
p	3	4
5	p	6
7	8	p

read	write	redundancy
+	0	yes

Spare Disks

If spare disks are configured they will be used in the RAID array as soon as one of the array disks fail.

Kernel and software components

Software raid is handle by the following kernel module:

RAID0	raid0.o
RAID1	raid1.o
RAID4 or RAID5	raid5.o

The **raidtools** package will provide these most common tools:

/sbin/lsraid query raid devices
/sbin/mkraid create md devices from instructions given in **/etc/raidtab**
/sbin/raidstart and raidstop start and stop the md devices

Once a meta device has been successfully created the information can be found in

/proc/mdstats

Booting from a RAID root device (exercise)

1. Make two new partitions of the same size as the root device of type "Linux raid autodetect".

One can make a smaller new root partition by checking the actual used space on the current root device

```
df -h /
Filesystem            Size  Used Avail Use% Mounted on
/dev/hda7             286M  71M  201M  27% /
```

Use **fdisk** to create the new partions (e.g /dev/hda14 and /dev/hda15) Reboot.

2. Configure software RAID 1 on these partitions

/etc/raidtab	
raiddev	/dev/md0
	raidlevel 1
	nr-raid-disks 2
	nr-spare-disks 0
	chunk-size 4
	persistent-superblock 1
	device /dev/hda14
	raid-disk 0
	device /dev/hda15
	raid-disk 1

Use the raidtools to make the array and start it up:

```
mkraid /dev/md0
raidstart /dev/md0
```

Make an EXT2 filesystem on the new meta device and mount it on **/mnt/sys**:

```
mke2fs /dev/md0
mkdir /mnt/sys
mount /dev/md0 /mnt/sys
```

3. Copy all files on the current root device to the new root device:

```
(tar lcvf - /) | (cd /mnt/sys; tar xvf -)
```

The **l** option for **tar** is an instruction to stay on the same file system.

4. Prepare to reboot

The **mkinitrd** script will read **/etc/raitab** and **/mnt/sys/etc/fstab** to customise an initrd.

Edit **/mnt/sys/etc/fstab** and change the root device to **/dev/md0** as well as the filesystem type to **ext2.**

/mnt/sys/etc/fstab
/dev/**md0** / **ext2** defaults 1 1

Make the initial rootdisk and call it *initrd-raid.img*

```
mkinitrd  --fstab=/mnt/sys/etc/fstab /boot/initrd-raid.img $(uname -r)
```

Uncompress /boot/initrd-raid.img and mount it on a loop device to check that **linuxrc** will insert the correct modules.

Reconfigure LILO/GRUB to change the following

Sample **lilo.conf**:

```
image=/boot/vmlinuz-2.4.22-1.2115.nptl
    initrd=/boot/initrd-raid.img
    read-only
    root=/dev/md0
    label=linux-raid
```

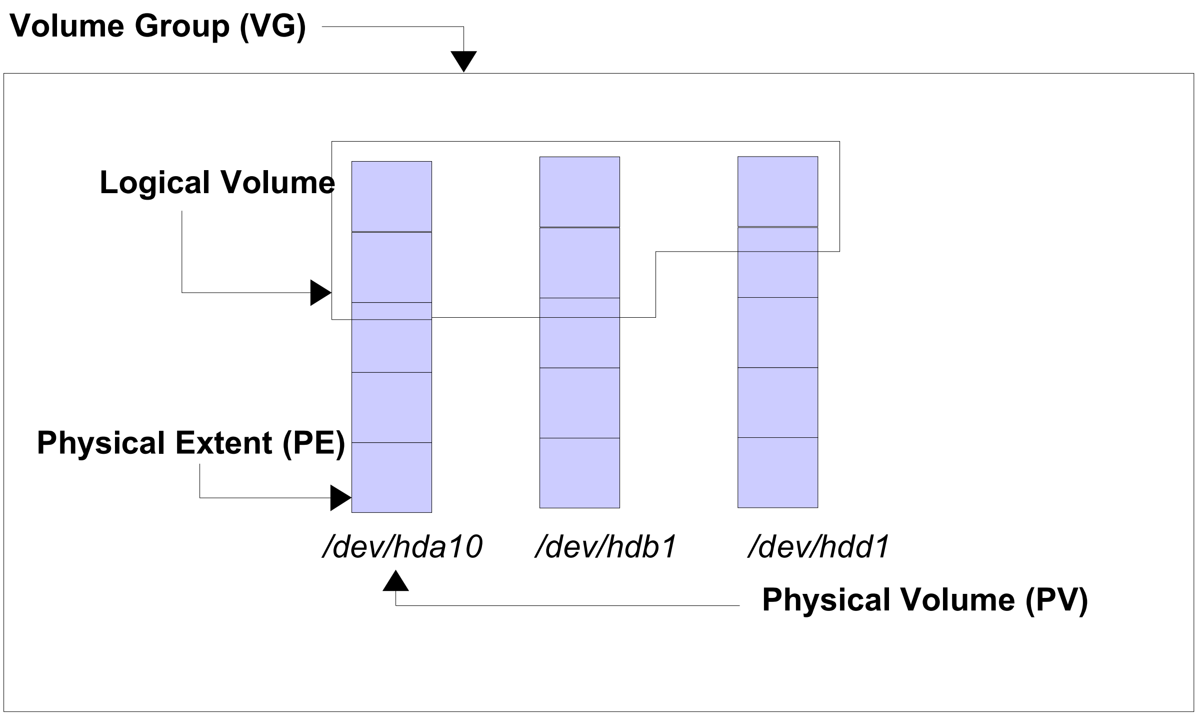
2. LVM Configuration

- Logical Volume Management (LVM)

The Logical Volume Management framework allows one to group different block devices (disks, partitions, RAID arrays...) together as a single larger device, the volume group (VG).

Individual devices used to form a volume group are referred to as physical volumes (PV).

Physical volumes once regrouped into a volume group lose their individual character. Instead the entire volume group is divided into physical extents (PE) of fixed size (4MB by default) from which logical volumes (LV) are created. A logical volume can be thought of as a partition.



Kernel and software components

The LVM kernel module is **lvm-mod.o**. The software tools are installed by the **lvm** package which provides in particular **/sbin/vgscan**. This command will start the LVM environment by scanning all the volume groups and build the **/etc/lvmtab** as well as databases in **/etc/lvmtab.d** which are used by all the other LVM tools.

Main LVM tools :

PV tools:	pvcreate, pvmove, pvchange, pvdisplay, pvscan ...
VG tools:	vgcreate, vgremove, vgchange, vgdisplay, vgscan ...

LV tools:	lvcreate, lvextend, lvreduce, lvremove, lvchange, lvscan ...

We won't need to use or know all the above tools. We will rather focus on the various LVM components (as depicted in the next diagram) and the commands needed to create these components: **pvcreate**,**vgcreate** and **lvcreate**.

Example:

Create a volume group called *volumeA* with three physical volumes (3 partitions in this case) and create a logical volume called *lv0* of size 150MB initially.

1. Run **vgscan** to create the **/etc/lvmtab** file

2. Create three new partitions (say /dev/hda16, /dev/hda17, /dev/hda18) of 100MB each. Make sure you toggle the partition type to **8e** (Linux LVM). Then reboot.

3. Prepare the physical volumes

```
pvcreate /dev/hda16
pvcreate /dev/hda17
pvcreate /dev/hda18
```

4. Create a volume group called *volumeA* with the above physical volumes:

```
vgcreate volumeA /dev/hda16 /dev/hda17 /dev/hda18
```

This will create a directory called `/dev/volumeA/`. The default PE size of 4MB will be used, one can change this with the **-s** option.

5. Create a logical volume called lv0 of size 150MB on this volume group

```
lvcreate -L 150M -n lv0 volumeA
```

This will create the block device `/dev/volume1/lv0`

6. Make a filesystem on lv0 and mount it on **/mnt/lvm**

```
mkfs -t ext3 /dev/volumeA/lv0
mkdir /mnt/lvm
mount /dev/volumeA/lv0 /mnt/lvm
```

This wouldn't be very different from other partition types if it weren't for the possibility to change the logical volume's size at anytime. Let's first show how to reduce the existing 150MB logical volume **lv0** with the **esfsadm** tool installed by the **lvm** package.

```
umount /mnt/lvm
e2fsadm -L 25 /dev/volumeA/lv0
```

NOTICE
The **-L** option refers to size in megabytes. The is the case with most LVM tools. The **-l** option can be used to specify logical extents (LE) instead. The default size of an LE is 4MB.

.

The next section will show how to add a new physical volume (a disk) to a volume group and demonstrates how an existing logical volume can be made larger by including physical extents available in the volume group to itself. Once this is done the **e2fsadm** tool will resize the filesystem across the logical volume.

- Extending the Volume Group with a RAID 0 device

> So far we have:
>
> VG = /dev/hda16 + /dev/hda17 + /dev/hda18
>
> and we would like to add a RAID0 device to this

1. Create three more partitions (e.g /dev/hda19, /dev/hda20 and /dev/hda21) of size 50MB and of type “Linux raid autodetect” (fd) – reboot!

2. Edit /etc/mtab to add the following RAID 0 device:

```
raiddev /dev/md1

        raid-level 0
        nr-raid-disks 3
```

```
nr-spare-disks 0
persistent-superblock 1
chunk-size 4
device /dev/hda19
raid-disk 0
device /dev/hda20
raid-disk 1
device /dev/hda21
raid-disk 2
```

3. Start the raid meta device:

```
mkraid /dev/md1
raidstart /dev/md1
```

4. Add this device to the Volume Group *volumeA*

Before adding the device to the volume group run **pvscan** to see which physical volumes are available. Notice that **/dev/md1** is not listed.

We now prepare /dev/md1 as a PV (physical volume):

```
pvcreate /dev/md1
```

When running **pvscan** again the output should look like the following. Notice that */dev/md1* is now listed.

```
pvscan
pvscan -- reading all physical volumes (this may take a while...)
pvscan -- ACTIVE  PV "/dev/md1"   is in no VG [305.62 MB]
pvscan -- ACTIVE  PV "/dev/hda10" of VG "volumeA"[96 MB / 0 free]
pvscan -- ACTIVE  PV "/dev/hda11" of VG "volumeA"[96 MB / 0 free]
pvscan -- ACTIVE  PV "/dev/hda12" of VG "volumeA"[96 MB / 84 MB free]
pvscan -- total:4[611.46 MB]  /in use:3[305.83 MB]  /in no VG:1 [305.62 MB]
```

We next add the device */dev/md1* to the volume group ***volumeA*:**

```
vgextend volumeA /dev/md1
```

At this stage the volume group has four devices:

VolumeA = /dev/hda10 + /dev/hda11 + /dev/hda12 + /dev/md1

We can take 50MB from */dev/md1* and add them to **lv0** (unmount the volume first)

```
lvextend -L +50 /dev/volumeA/lv0 /dev/md1
```

The original **lv0** volume had 150 megabytes. The **+** flag in front of the requested size has added 50MB to the logical volume, making it about 200 megabytes. But we haven't extended the filesystem across the entire logical volume yet.

The output of **lvscan** will show 80MB available. This corresponds to the 25 megabytes resizing done with **e2fsadm** on p. 21 plus the 50MB added by **lvextend** above

.

```
lvscan
lvscan -- ACTIVE            "/dev/volumeA/lv0" [80 MB]
lvscan -- 1 logical volumes with 80 MB total in 1 volume group
lvscan -- 1 active logical volume
```

The next command will extend the filesystem to 80 megabytes:

```
e2fsadm -L 80 /dev/volume/lv0
```

If you remount this volume on **/mnt/lvm** you can see the new available space with **df**.

REBOOT WARNING

The LVM tools need the **lvm-mod.o** module and in our case the metadevice **/dev/md1**. You need to create a new initrd with **mkinitrd** or add the following lines to a new initrd:
`insmod /lib/lvm-mod.o`
`raidautorun /dev/md1`

REBOOT WARNING
The volume group is then activated with **vgscan** from the **rc.sysinit** script.

Booting from a logical volume root device

As with software RAID we are going to investigate some issues we need to consider when using LVM on the root device.

First make sure the volume we have created previously is mounted. If it isn't then do

```
mount /dev/volumeA/lv0 /mnt/lvm
```

Next we archive the root device in the same way as we did for RAID:

```
tar clvf - / | (cd /mnt/lvm/; tar xvf -)
```

Edit **/mnt/lvm/etc/fstab** and enter

```
/dev/volumeA/lv0   /     ext2    defaults 0 1
```

Edit /etc/lilo.conf or /etc/grub.conf to add a new entry where the kernel points to the new root logical volume. For a 2.4.22 kernel an additional entry in **/etc/grub.conf** looks like this:

```
title lvm-root
        root (hd0,1)
        kernel /vmlinuz-2.4.22 ro root=LABEL=/
        initrd /initrd-2.4.22-lvm.img
```

All we need is the initrd **initrd-2.4.22-lvm.img**.

Once again we will run **mkinitrd** with —fstab=<fstab> which we will use to make the script read our new fstab file **/mnt/lvm/etc/fstab**. We test this:

```
mkinitrd --fstab=/mnt/lvm/etc/fstab /boot/initrd-lvm.img $(uname -r)
```

If we mount this initial ram disk we can see that this is going to work by looking at the **linuxrc** script.

linuxrc

```
echo "Loading lvm-mod.o module"
insmod /lib/lvm-mod.o
echo Creating block devices
mkdevices /dev
echo Scanning logical volumes
vgscan
echo Activating logical volumes
vgchange -ay
----snip---
```

3. CD Burners and Linux

Hardware detection

The tools available on the commandline to burn CDs assume that the CD writer is a SCSI device. However most cheaper CD burner are IDE devices and we need a **ide-scsi.o** module to drive the CD burner device.

If you run **cdrecord** with the **-scanbus** option you will see that the tool is looking for a SCSI device.

If the CD burner is attached as a secondary master (./dev/hdc) then the following entry in /etc/modules.conf will enable the **ide-sci** module for this device :

/etc/modules.conf (from the CD-Writing HOWTO)

```
options ide-scsi=/dev/hdb
options ide-cd ignore=hdb
alias scd0 sr_mod
pre-install sg     modprobe ide-scsi     # load ide-scsi before sg
pre-install sr_mod modprobe ide-scsi # load ide-scsi before sr_mod
pre-install ide-scsi modprobe ide-cd   # load ide-cd  before ide-scsi
```

The device will be seen as **/dev/scd0** and can be added to **/etc/fstab** with it's own mount point.

The following command shows that the hardware has been correctly detected:

```
cdrecord -scanbus
Cdrecord 2.0 (i686-pc-linux-gnu) Copyright (C) 1995-2002 J�rg Schilling
Linux sg driver version: 3.1.24
Using libscg version 'schily-0.7'
cdrecord: Warning: using inofficial libscg transport code version (schily - Red
Hat-scsi-linux-sg.c-1.75-RH '@(#)scsi-linux-sg.c        1.75 02/10/21 Copyright
1997 J. Schilling').
scsibus0:
        0,0,0     0) 'PHILIPS ' 'CDRW48A         ' 'P1.3' Removable CD-ROM
        0,1,0     1) *
        0,2,0     2) *
        0,3,0     3) *
        0,4,0     4) *
        0,5,0     5) *
        0,6,0     6) *
        0,7,0     7) *
```

Iso9660 Filesystem and burning CDs

Store all the data that need to be copied in a separated directory (e.g backups/). We next need to create an isoimage of this directory as follows:

```
mkisofs -o baskups-image.iso backups/
```

Check the image file by mounting it as a loop device:

```
mount -o loop backups-image.iso /mnt
ls /mnt
umount /mnt
```

Finally, burn the CD with **cdrecord**. From the output of `cdrecord -scanbus` on the previous page we see that the CD writer device is seen as ***dev=0,0,0*** so we type:

```
cdrecord -v dev=0,0,0 backups-image.iso
```

Copying Bootable CDs

This is useful for example when copying the first disk for a Linux distribution.

Put the bootable CD into the CDROM tray. Do not mount the disk! Then type:

```
dd if=/dev/cdrom of=distro-inst1.iso
```

Once this is done you can update the image with **rsync** before burning it, this will fix data corruptions that could have been copied from the CD:

```
rsync -av ftp.somesite.org::/path-to-iso/distro-inst1.iso  .
```

5. Configuring PCMCIA Devices

The **cardmgr** utility monitors the PCMCIA slots. It will scan the **/proc/devices** file searching for the *pcmcia* entry. If this entry isn't there then **cardmgr** will exit.

In order to get the kernel to write an entry into **/proc/devices** it is necessary to load the relevant modules. Only once kernel support is enabled will **cardmgr** work properly. The module names are kept in the following configuration files:

For RedHat like distributions: **/etc/sysconfig/pcmcia**

For Debian like distributions: **/etc/pcmcia.conf**

The main module is called **pcmcia_core** and uses two other modules called **yenta_socket** and **ds**.

One can start **cardmgr** on the commandline after having inserted the above kernel modules

```
modprobe pcmcia_core
modprobe yenta_socket
modprobe ds
cardmgr
cardmgr[18772]: watching 2 sockets
```

But it is best to use the rc-script provided with the **pcmcia-cs** package:

```
/etc/rc.d/init.d/pcmcia restart
```

The configuration file with a database of possible devices (e.g modems, wireless network interfaces, memory cards ...) is called **/etc/pcmcia/config**.

To get infornation about your pcmcia card use the **cardctl** utility. Put the card into the pcmcia slot and run:

```
cardctl info
....snip....
PRODID_1="Xircom"
PRODID_2="CardBus Ethernet 10/100 + Modem 56"
PRODID_3="CBEM56G"
....snip....
```

We can check that this card is listed in **/etc/pcmcia/config**. The next table shows the information relevant to this card, in particular the **xircom_cb** module needed.

/etc/pcmcia/config – section relevent to scanned card
card "Xircom CBEM56G-100 CardBus 10/100 Ethernet + 56K Modem"
version "Xircom", "*", "CBEM56G"
bind "xircom_cb" to 0

File and Service Sharing

This module covers SAMBA and NFS. The objectives state a few specific implementations such as file servers and printer shares.

1. Samba Client Tools

nmblookup
`nmblookup trainer-1`
`querying trainer-1 on 192.168.3.255`
`192.168.3.101 trainer-1<00>`

smbpasswd	
smbpasswd -a USER	add a samba user
smbpasswd -e USER	enable a samba user

smbtar
Script using smbclient to archive SMB shares directly to tape

smbclient	
smbclient //HOST/SHARE	Logs onto the specified share
smbclient -L //HOST	List all available shares

Output of smbstatus

```
Samba version 2.2.7a-security-rollup-fix
Service     uid     gid     pid     machine
----------------------------------------------
dean        dean    dean     3106   trainer-1 (192.168.3.101) Mon Nov 26 13:34:54 2003
IPC$        nobody  nogroup  3106   trainer-1 (192.168.3.101) Mon Nov 26 13:34:45 2003
IPC$        nobody  nogroup  3106   trainer-1 (192.168.3.101) Mon Nov 26 13:34:53 2003
dean        dean    dean     3106   trainer-1 (192.168.3.101) Mon Nov 26 13:35:14 2003
netlogon    dean    dean     3106   trainer-1 (192.168.3.101) Mon Nov 26 13:34:54 2003
public      nobody  nogroup  3145   drakelap (192.168.3.100) Mon Nov 26 13:35:34 2003
IPC$        nobody  nogroup  3106   trainer-1 (192.168.3.101) Mon Nov 26 13:34:54 2003
No locked files
```

2. Configuring a SAMBA server

The SAMBA server configuration file **smb.conf** is usually in **/etc/samba/**. Within the '[global]' options, parameters such as the 'WORKGROUP = ' can be set.

The SAMBA server uses two daemons called **nmbd** and **smbd** implementing NMB and SMB services respectively. Both daemons are started with the single rc-script:

```
/etc/rc.d/init.d/smb start
```

- The LanManager host file **lmhosts**

This file is usually in the same directory as the **smb.conf** file and is read by **nmbd** to resolve netBIOS hostnames. The file content is similar to /etc/hosts:

```
10.0.0.20 accounts
```

- Shared Directories

We will define one share called '`readshare`' which is readable and another called '`rw-share`' which has read-write permissions but is only accessible for user '`tux`':

The smb.conf options

```
[readshare]
comment = Read-only Directory
path = /usr/local/news/
guest only = yes
browseable = yes  # this is optional

[rw-share]
comment = Read-write Share for tux
path = /usr/local/documents
browseable = yes
guest ok = yes
writeable = yes
valid users = tux
```

- Sharing Printers

We choose to export all printers defined with CUPS on the Linux server. The following configuration will enable this:

The smb.conf options

```
[global]
printcap name = cups
load printers = yes
printing = cups

# printing without filters
[printers]
comment = All Printers defined using CUPS
path = /var/spool/samba
browseable = no
guest ok = yes              # allow 'guest account to print'
writable = no
printable = yes
create mode = 0700
# printer drivers must be on the client side
print command  = lpr-cups -P %p -o raw %s -r
```

- Implementing WINS with Samba?

On a NetBIOS network machine names are resolved using “Windows information network services” or WINS.
Clients can either use broadcasts to query host names or be configured to use a **WINS server**. This server reduces the amount of traffic on the network due to broadcasts.

SAMBA as a WINS server
To enable WINS in SAMBA the following option is set in **smb.conf**

```
wins support = yes
```

Windows clients can then be configured to use the SAMBA server as a WINS server.

Second WINS server
A NetBIOS network generally only has one WINS server. If a second server is configured then the servers should be able to synchronise their host information. One can configure SAMBA to register on an existing network as a second WINS server by giving it the address of this server with the option:

```
wins server = <existing wins server>
```

NOTICE
The options '`wins support`' and '`wins server`' are mutually exclusive. The '`wins server`' option registers the SAMBA server with an existing WINS server **and** enables WINS capabilities, there is no need to set '`wins support`' as well.

- Samba server as a Domain Controller

Options selected in /etc/samba/smb.conf:

```
security = users
domain master = yes
local master
preferred master = yes
domain logon = yes
```

```
[netlogon]
path=/var/lib/samba/netlogon
writable = no
public = no
```

Notice: You don't need to have a logon script. This netlogon share is something the Windows client needs to connect to even if it is empty

2. Configuring an NFS server

The NFS server runs the following daemons:

```
rpc.nfsd
rpc.mountd
```

These services are started with the **nfs** sevice:

```
/etc/init.d/nfs start/stop/status/restart/reload
```

In addition `rpc.statd` is used to notify the client when the NFS service is unexpectedly interrupted, and `rpc.lockd` allows clients to lock files accessed on the server.

These services are started with the **nfslock** service:

```
/etc/init.d/nfslock start/stop/status/restart
```

Programs using remote procedure calls (RPC) use specific program numbers listed in **/etc/rpc**. When a RPC service is started it will tell **portmap** which port number it is using as well as its program number.

It is necessary for **portmap** to be running before starting any NFS service

RPC clients connect to the **portmap** service, although it is possible to work around **portmap** if the RPC program number is known.

The /etc/exports file

Syntax:

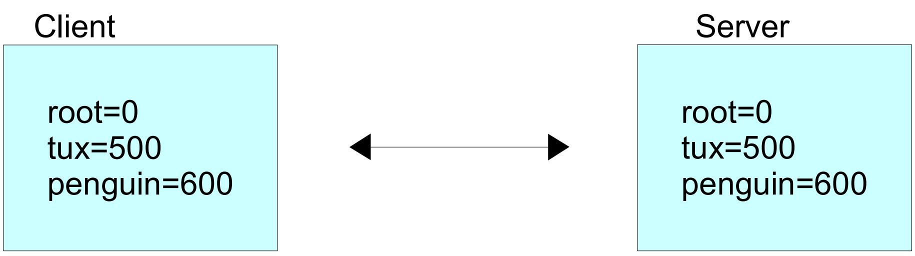
```
directory <host>(<option1,option2,...>) <host>(<option1,...>)
```

/etc/exports common options:

Option	Description
`ro`	Read only. There is also the read-write option `rw`
`no_root_squash`	override the default (root_squash) where root is mapped to user nobody
`async`	the server writes to disk at predefined intervals (may cause data loss)
`sync`	use sync rather than async when exporting a directory read-write

User Mappings

Once a remote directory is mounted on the local client one would expect local users to access their files as if the directory was locally mounted. However this will only be the case if UIDs on both the local and remote systems correspond.



NFS is generally used in an environment where UIDs are common between the server and the clients.

Anonuid and Anongid

It is possible, using **anonuid** and **anongid** options to assign a unique anonymous UID or GID per exported directory. Users mounting that share will be given the rights of that anonymous ID on the server. For example, everybody accessing the share bellow will inherit the right of the remote user with UID=150 and GID=100

```
/share        *(rw,anonuid=150,anongid=100)
```

Root Squashing

By default the root user on the client system will be mapped to the user **nobody** on the server. This option is disabled in **/etc/exports** with the **no_root_squash** option

Finally, it is possible to map all users from any client to the user **nobody** with the **all_squash** option.

TCPwrappers

The **portmap** tool has been compiled with libwrap giving us the option to control access through **/etc/hosts.allow** and **/etc/hosts.deny**.

```
strings `which portmap ` |grep hosts.allow
```

Using exportfs and nfsstat

The **exportfs** command with no arguments will show all exported directories.

exportfs options	
-r	re-read `/etc/exports` and export all directories listed
-u	unexport all shares (until `exportfs -r` is called)
-a	applies to all exports
-o	specify directories not listed in /etc/exports

The **nfsstat** displays statistics about NFS server and client activity. The information is read from two files:

`/proc/net/rpc/nfs` contains information about NFS client activity
`/proc/net/rpc/nfsd` contains information about the NFS server

nfsstat options	
-s	show only server statistics
-c	shpw only client statistics
-n	print NFS statistics only
-r	print RPC statistics only
-o	print statistics for specific utility (nfs,rpc,net,fh,rc)

3. Setting up an NFS Client

Mount options	
`soft`	When a major timeout happens send the calling program an I/O error, rather than retry indefinitely.
`hard`	When a major timeout happens, report “server not responding” and continues to reconnect indefinitely unless the `intr` option is also specified
`bg`	If the first mount fails retry subsequent mounts in the background (default is `fg`)
`intr`	Allows NFS requests to be interrupted
`nolock`	Sometimes needed with older NFS servers
`rsize=`*`n`* `wsize=`*`n`*	*Set* communication block sizes for read and write. The default is 1024 bytes. On a clear network the speed may be improved by setting *`n`* to 8192

ERRORS	Possible cause
`mount: RPC: Program not registered`	The remote NFS server is not running
`mount:` *`IP`*`:`*`share`* `failed, reason given by server: Permission denied`	Wrong directory

The **showmount** tool can view NFS shares available on a remote host. The main options are:

`showmount -a` *`server`*	lists client IP and directory mounted
`showmount -e` *`server`*	lists the content of /etc/exports from the server
`showmount -d` *`server`*	lists only the exported directories on the server

System Maintenance

This module covers the **syslogd** similarly to LPI 102. The added emphasis is on remote logging and name resolution. Sotware packaging is covered here to. We will see how to make our own RPM package.

1. System Logging

Stopping and Starting syslogd

The **syslogd** daemon is responsible for system logging. It is started as a service:

```
/etc/rc.d/init.d/syslogd start/stop/status/restart/condrestart
```

The following lines are from the **syslogd** rc-script:

```
if [ -f /etc/sysconfig/syslog ] ; then
        . /etc/sysconfig/syslog
```

The **/etc/sysconfig/syslog** file defines the following default variables:

```
SYSLOGD_OPTIONS="-m 0"
KLOGD_OPTIONS="-2"
```

Configuration File

The configuration file is **/etc/syslog.conf** with the following format:

FACILITY.PRIORITY ACTION

Facilities
auth, authpriv, cron,daemon, kern, lpr, mail, mark, news, security (same as auth), syslog, user, uucp and local0 to local7

Priorities
debug, info, notice, warning,err, crit, alert, emerg
The following are deprecated:
error (same as err), warn (same as warning), panic (same as emerg)

Actions

Flat file	Full path to a file, usually in /var/log/
Terminal	use /dev/tty*N* to output logs to
Username	if Username is logged in, send logs to the user's tty
Host	send logs to a remote host. Prepend the remote host's IP with a @ sign.

Sending logs to a remote server

A seen above the local **syslogd** can send logs to a remote host (say 192.168.10.33) running a **syslogd**. Assume we want to send all logs to this remote host, this would be the syntax:

```
*.*  @192.168.10.33
```

Configuring syslogd to accept remote logs

In this case we want remote systems to send their logs to our server. The only option that needs to be added at startup is `-r`.

Edit /etc/sysconfig/syslog and add the -r option to the `SYSLOGD_OPTIONS variable`

```
SYSLOGD_OPTIONS="-r -m 0"
```

Then restart the **syslog** service.

Name resolution

Once a server has been setup as a remote logging server it will accept logs from hosts on the network. By default these hosts will appear with an IP address in the logs unless the hosts are listed in **/etc/hosts**. This is due to the fact that **syslogd** cannot use DNS services. In fact **syslogd** has not been compiled with libresolv.so, as seen below:

```
ldd syslogd
libc.so.6 => /lib/i686/libc.so.6 (0x40024000)
/lib/ld-linux.so.2 => /lib/ld-linux.so.2 (0x40000000)

ldd ping
libresolv.so.2 => /lib/libresolv.so.2 (0x40024000)
libc.so.6 => /lib/i686/libc.so.6 (0x40035000)
/lib/ld-linux.so.2 => /lib/ld-linux.so.2 (0x40000000
```

2. Packaging Software

Here is an overview of the specfile and its sections

Desciption	
Summary	A summary of what the package provides
Name	Name of the package
Version	Package version
Release	Package release
Copyright	Copyright agreement under which the package is released
Group	The package group (Amusement, Documentation ...)
Source	Path to the archive containing source and files
BuildRoot	Path to the temporary (fake) root filesystem

Macros and Section	
%define	Define a variable that can be referenced later in the SPEC file
%description	Paragraph type description for the package (usually longer than Summary
%prep	The preparation section, includes unpacking the source archive and patching
%setup	Unpack the source archive
%patch	Apply patches if needed
%build	The build section, includes commands to run in the BUILD directory and execute the next commands (make, ...)
%install	The install section, includes command to copy files from the BUILD directory to the fake $RPM_BUILD_ROOT directory
%clean	Delete all files in $RPM_BUILD_ROOT
%files	List of files in the package
%doc	List which files are part of the documentation
%config	List which files are configuration files

Example: Copy fstab to /tmp/etc/fstab

We can build a simple RPM package that installs an fstab file into /tmp/etc/. The spec file will look like this:

```
#This is the Header section
Summary: Installs a fstab file to /tmp/etc
%define name tmp-fstab
%define version 0.2
%define release 1
Name: %{name}
Version: %{version}
Release: %{release}
Copyright: Freely distributable
Group: Documentation
Source: %{name}-%{version}.tar.gz
Packager: Adrian Thomasset <adrian@linuxit.com>

#The BuildRoot directory is a temporary replacement for root (/) while the package is being built.
BuildRoot: /var/tmp/rpm-%{name}/


%description
This package copies a file called fstab to /tmp/etc/


%prep
#The %setup macro simply opens the archived files from SOURCES into BUILD and changes #directory to it
(/../../BUILD/%{name}-%{version}/
%setup


#All the work is done here: $RPM_BUILD_ROOT is a reference to the variable defined using the %BuildRoot
command earlier
%install

rm -rf $RPM_BUILD_ROOT
mkdir -p $RPM_BUILD_ROOT/tmp/etc/
install -m 644 fstab $RPM_BUILD_ROOT/tmp/etc/fstab

%clean
rm -rf $RPM_BUILD_ROOT
#Define which files must be copied to the binary RPM package. The $RPM_BUILD_ROOT is #taken as the root
directory
%files
/tmp/etc/fstab
%defattr(-,adrian,adrian)
```

All that is left to do is to prepare the source. In this case we need to create a directory called

tmp-fstab-0.2 containing fstab. Notice that the name and the version correspond to the name and version defined in the SPEC file

```
mkdir tmp-fstab-0.2
cp /etc/fstab tmp-fstab-0.2/
```

Next we archive the directory and copy this to the SOURCES directory

```
tar cvzf tmp-fstab-0.2.tar.gz tmp-fstab/
cp tmp-fstab-0.2.tar.gz /path/to/SOURCES/
```

System Automation

This module covers most scripting objectives for LPI 201. You do not need to learn a new language such as perl or bash. All that is expected is to accurately describe what a script is doing. Knowing the exact syntax for a specific scripting language is not expected.

The best way to train for this is to go through a few examples. For this we will implement the suggested automated tasks in the LPI objectives.

1. Writing simple perl scripts (using modules)

The online documentation for perl is contained in the **perldoc** package. The man pages are split into sections. For example the ***perlintro*** section can be accessed with:

```
man perlintro
```

or

```
perldoc perlintro
```

Here is a summary of this perldoc.

Perl scripts must be readable and executable. The first line of the script must point to the interpreter.
For example if `which perl` returns `/usr/bin/perl`, then the first line in a script should be:
`#!/usr/bin/perl`

There are three variable types which can be declared and referenced as in the following script:

```
    # Scalars
    my $VARIABLE = “value”;                    #declare VARIABLE
    print (“$VARIABLE  \n”);                   #print VARIABLE
```

```
    # Arrays
    my @ARRAY = ("color1","color2","color3");   # declare ARRAY
    $index=0                     # print ARRAY
    while ($index < @ARRAY)  {
      print ("element of $index is @ARRAY[$index] \n");
      $index++;
     }
```

```
# Hashes or Associative Arrays ({key,value} pairs)
      my %HASH=("color1", "blue","color2", "red", "color3", "white");
      foreach $key (keys %HASH) {
            print ("The key $key corresponds to the value $HASH{$key} \n");
            }
      @color_rank =  sort keys %HASH;  # assign the keys to an array
```

2. Using the Perl taint module to secure data

The **taint** module is used to check that external variables supplied by the user cannot be used to exploit the system. This module is automatically used when running scripts that have the setuid or setgid bit turned on. It is possible to force a perl script to switch the **taint** module on with the **-T** option.

For example the system call bellow will allow any user to read files with read access :

```
insecure.pl
#!/usr/bin/perl
$FILENAME=ARGV[0]   # this is the equivalent to $1 in bash
system("/usr/bin/less", $FILENAME);
```

If the script is set SUID root or if the **-T** option is used then the **taint** module will be called and this script will not execute.

```
check-secure.pl
#!/usr/bin/perl -T
$FILENAME=ARGV[0]   # this is the equivalent to $1 in bash
system("/usr/bin/less", $FILENAME);
```

In fact the **check-secure.pl** script isn't secure, it simply won't run with SUID root or the **-T** option. Here is a version of insecure.pl which works around the taint mechanism and is VERY INSECURE !!

```
if (open (FILE,"$FILENAME")) {
 $line = <FILE>;
 while ($line ne "") {
          print ($line);
          $line = <FILE>;
          }
}
```

3. Installing Perl modules (CPAN)

Read the following perldoc pages for information on perl modules

man perlmod

A set of specific functions such as file or array manipulations can be written as modules and imported into new scripts with the directive:

use *module*

The modules can be downloaded from www.cpan.org and build as follows:

Unpack the archive and type

```
perl Makefile.pl
make
make test
make install
```

This can also be done with the commandline

```
perl -MCPAN -e “install MODULENAME”
```

Modules are installed in subdirectories of **/usr/lib/perl**. One can check if a specific module is installed with:

```
perl -MMODULENAME -e 1
```

For an example application using perl modules see the Appendix.

4. Check for process execution

Searching through the output of **ps** for a process using **grep** will sometimes return a positive status even though the process is not running!

This is due to the fact that the **grep** process itself is sometimes printed out by **ps.** As in the example below:

```
ps au|grep junk
root   13643  0.0  0.2  1724  600 pts/1   S    11:22   0:00 grep junk
```

Needless to say, there aren't any pre-installed tools called *junk* in general, so the above line would return a positive evaluation in a script!

There is a work around for this problem.

Use pgrep

This tool will search the output of **ps** for the PIDs of all processes that match the search criteria. For example:

```
ps aux | pgrep -u root httpd
```

will match all **httpd** processes run by user **root**. One can also use **pgrep** like **grep** with a single keyword.

Use |grep -v grep

By piping the output of **ps** into *grep -v grep* one can prevent **grep** from matching itself. This will not work however if the process you are monitoring contains the string *grep*.

```
ps aux | grep smbd | grep -v grep
```

5. Monitor Processes and generate alerts

This objective gives us the opportunity to use bash's control flow capabilities to make decisions when checking for the status of a given process.

Say we want to check that the **smbd** daemon is running, then restart it and send a message if it is stoped and do nothing if it is still running. The following script will do this:

```
#!/bin/bash
PROCESS=smb
if ps aux | grep "$PROCESS" | grep -v grep >/dev/null ; then
        echo Process $PROCESS is running
else
        echo Process $PROCESS is stopped - Restarting it ...
        /etc/rc.d/init.d/smb start > /dev/null
fi
```

Checking the response from a host using **ping**

```
#!/bin/bash
while (true)
do

#get the times from 10 ping outputs
   x=$(ping -c 10 $1 | cut -d"=" -f4 | tail +2|head | sed "s/ms//")

#loop through the times to check which ones are longer than 14ms
   for times in $x
       do
          dectimes=$(echo $times | cut -d. -f1) # get an integer
          if [ $(($dectimes-14)) -gt 0 ]; then
```

```
             echo Time exceeded 14ms:  $times
          fi
       done
done
```

- Schedule scripts that parse log files and email them

We can use a perl script to run **last** in order to read **/var/run/utmp** and get it to search for the string *still* which will match all logged users and mail the line to root.

```
#!/usr/bin/perl
$LOGFILE="/tmp/lastlog";
$line="0";
system("last> $LOGFILE");

open (MAIL, "| mail root");

if (open (FILE,"$LOGFILE")) {

        while ($line ne "") {
             $line=<FILE>;
              if ($line =~ still) {
                  print MAIL $line;
              }
        }
}
close MAIL;
```

If this script needs to run every hour and it is called /usr/bin/last-log.pl, then you can create a symbolic link in **/etc/cron.hourly** pointing to it.

- **Monitor changed files and generate email alert**

A 128-bit fingerprint (or “message-digest) for a file can be computed with **md5sum**.

The foillowing script will check the MD5 checksums for all the files in **/etc** and compare the output from each run with **diff**. If there are any differences the changed files are mailed to user root

```
#!/bin/bash
touch /tmp/md5old
touch /tmp/md5new
mv /tmp/md5new /tmp/md5old

for files in $(find /etc -type f )
do
        md5sum $files >> /tmp/md5new
done

x=$(diff /tmp/md5old /tmp/md5new)

if [ -z "$x" ]; then
        break
else
        echo $x |mail root
fi
```

Notice that the first time you run this script all the files will be seen as changed!

Checking valid MD5 fingerprints can be done from the STDIN or from a list of pre-computed sums using **md5sum -c** (--check). We first compute these sums with

```
find /etc -type f | xargs md5sum > etc-md5.dat
```

We next pass the content of *etc-md5.dat* to **md5sum -c**.

If for example we delete a few blank lines in **/etc/sysctl.conf** we can see that something has changed with:

```
md5sum -c etc-md5.dat | grep -v OK
/etc/sysctl.conf: FAILED
md5sum: WARNING: 1 of 1906 computed checksums did NOT match
```

- Write a script that notifies administrators when somebody logs in or out

It may not be a good idea to mail all this information but it is possible to gather it and possibly format it using XML or HTML.

Here we read from a list of users we wish to monitor */etc/checks* and send an email as soon as they are logged in.

This can run through a cron every minute. This does imply that when somebody from the list is logged in, an email every minute would be sent!

```
#!/bin/bash
for luser in $(cat /etc/checks)
 do
  x=$(last |grep $luser|grep still)
  if [ -n "$x" ]; then
    echo User $luser is logged in | mail root;
  fi
 done
```

6. Using rsync

Rsync works like an optimised **rcp** or **scp** command. It will copy to the destination directory only the files that are missing or have been changed in the source directory. Even with changed files **rsync** will send only the difference between the two files.

The syntaxes are:

```
rsync SRC HOST:/DEST
rsync HOST:/SRC  DEST
```

One can change the value of the remote shell variable RSYNC_RSH used by rsync :

```
export RSYNC_RSH=ssh
```

Here is an example script using **rsync** to keep “Fedora Updates” updated on the local server:

```
#!/bin/sh

cd /var/ftp/pub/updates/fedora

(
date
echo
echo "=== Sync Files ==="
rsync -vaz --delete --delete-excluded --exclude="*/debug/*"
rsync://rsync.mirror.ac.uk:873/download.fedora.redhat.com/pub/fedora/linux/core/up
dates/1/
linux/core/updates/1/ 2>&1
echo "=== Sync Files Done ==="
echo
date
) | mail -s "Fedora Updates Sync Results" andrew@anvil.org
```

AppendixA

Example Perl Module:

The Spreadsheet::WriteExcel perl module can generate spreadsheet files.
This module is dependent on the Parse::RecDescent module. So we need the following module sources:

Parse-RecDescent-1.94.tar.gz
Spreadsheet-WriteExcel-0.42.tar.gz

Extract the archives and run

```
perl Makefile.PL
make
make test
make install
```

Then try the following test script:

```
#!/usr/bin/perl -w
#
use strict;
use Spreadsheet::WriteExcel;

# vars
my($workbook,$worksheet,$format,$col,$row);

# Create a new Excel workbook
$workbook = Spreadsheet::WriteExcel->new("perl.xls");

# Add a worksheet
$worksheet = $workbook->add_worksheet();
```

```
#  Add and define a format
$format = $workbook->add_format(); # Add a format
$format->set_bold();
$format->set_color('red');
$format->set_align('center');

# Write a formatted and unformatted string, row and column notation.
$col = $row = 0;
$worksheet->write($row, $col, "Hi Excel!", $format);
$worksheet->write(1,    $col, "Hi Excel!");

# Write a number and a formula using A1 notation
$worksheet->write('A3', 1.2345);
$worksheet->write('A4', '=SIN(PI()/4)');

$workbook->close();
```