Linux:
A comprehensive introduction

How to Use this User Guide

This handbook accompanies the taught sessions for the course. Each section contains a brief overview of a topic for your reference and then one or more exercises.

Exercises are arranged as follows:

- A title and brief overview of the tasks to be carried out;
- A numbered set of tasks, together with a brief description of each;
- A numbered set of detailed steps that will achieve each task.

Some exercises, particularly those within the same section, assume that you have completed earlier exercises. Your teacher will direct you to the location of files that are needed for the exercises. If you have any problems with the text or the exercises, please ask the teacher or one of the demonstrators for help.

This book includes plenty of exercise activities – more than can usually be completed during the hands-on sessions of the course. You should select some to try during the course, while the teacher and demonstrator(s) are around to guide you. Later, you may attend follow-up sessions at ITLP called Computer8, where you can continue work on the exercises, with some support from IT teachers. Other exercises are for you to try on your own, as a reminder or an extension of the work done during the course.

Text Conventions

A number of conventions are used to help you to be clear about what you need to do in each step of a task.

- In general, the word **press** indicates you need to press a key on the keyboard. **Click**, **choose** or **select** refer to using the mouse and clicking on items on the screen. If you have more than one mouse button, click usually refers to the left button unless stated otherwise.
- Names of keys on the keyboard, for example the Enter (or Return) key are shown like this ENTER.
- Multiple key names linked by a + (for example, CTRL+Z) indicate that the first key should be held down while the remaining keys are pressed; all keys can then be released together.
- Words and commands typed in by the user are shown **`like this`**.
- Labels and titles on the screen are shown **like this**.
- Drop-down menu options are indicated by the name of the options separated by a vertical bar, for example **File|Print**. In this example you need to select the option **Print** from the **File** menu or tab. To do this, click when the mouse pointer is on the **File** menu or tab name; move the pointer to **Print**; when **Print** is highlighted, click the mouse button again.
- A button to be clicked will look **like this**.
- The names of software packages are identified *like this*, and the names of files to be used **like this**.

Contents

Exercises

1 Introduction

Today's course is divided into four parts each of which consists of a presentation followed by exercises.

- Getting started: the desktop, office applications, the terminal.
- Using the command line.
- Editors, regular expressions, shell scripts.
- Working on remote computers.

1.1. Aims for Today

The course is designed to help you become a confident Linux user. The topics covered are described in the Course Outline below.

1.2. Course Outline

1.2.1. Session One

This session will cover:

- A brief history of Linux.
- What is Open Source software?
- Who uses Linux.
- Office applications in Linux.
- What is a shell?
- Some simple commands.

The exercises will look at:

- Exploring and configuring the Linux desktop.
- Exploring LibreOffice applications.
- Simple use of the command line.

1.2.2. Session Two

As well as a powerful and useful desktop, Linux also has a command line interface. This session starts to explore the command line. We will look at

- Viewing files, pathnames, getting help.
- Pattern matching
- Pipes or how to build your own commands

The exercises will cover:

- Using commands to manipulate files.
- Getting help.

- Using patterns for searching for files.
- Building your own commands.

1.2.3. Session Three

This session builds on the previous session's introduction to the command line. We will use the command line to do more complicated searches. We will also look at shell scripting.

- Regular expressions.
- Text editors.
- Writing shell scripts.

The exercises cover:

- Using regular expressions patterns for searching.
- Building your own commands.
- Using an editor to develop shell scripts

1.2.4. Session Four

The final session looks at ways of using remote computers. It will also briefly discuss managing your own computer.

- Remote access commnds.
- Using package managers to find and install software.

The exercises will cover

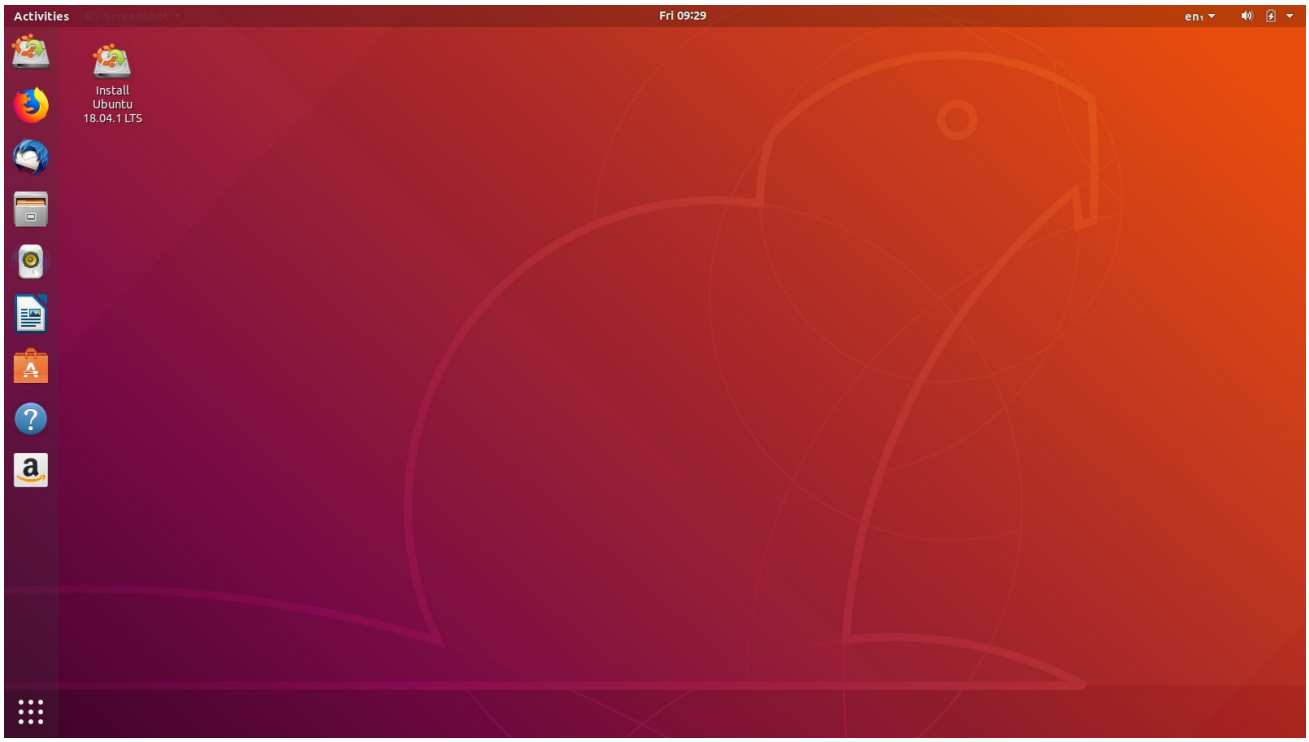
- Using ssh to access a remote computer
- Using scp to move files and directories between computers
- Using screen to leave a program running on a remote computer after disconnection

2 Getting started

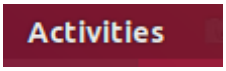
Here are some things to try to help you get to know Ubuntu Linux.

Exercise 1 **A first look**

This is the standard Live Ubuntu start-up screen.



Let's look at the screen more carefully. The bar along the top has three components:



Show current applications and search for others

Time – can be configured to include date

Various settings:

- Language and keyboard settings
- Volume control
- Battery
- Systems settings and logout

On the left side of the Desktop, below the Activities launcher is the Dock.

Under the Dock you should see a vertical list of popular applications. If you hold your mouse over any of these icons then their name pops up.

From the top these are:

Install Ubuntu	Install Ubuntu on your PC. Don't use this now!
Firefox Web Browser	Browse the web
Thunderbird Mail	Read email
Files	Find files and folders and explore the system
Rhythmbox	Music player
LibreOffice Writer	Create documents, similar to Microsoft Word
Ubuntu Software	Find, add, update and remove applications
Help	Get help
Link to Amazon	

The Install icon can be used to install Ubuntu on your PC, but please don’t do this!

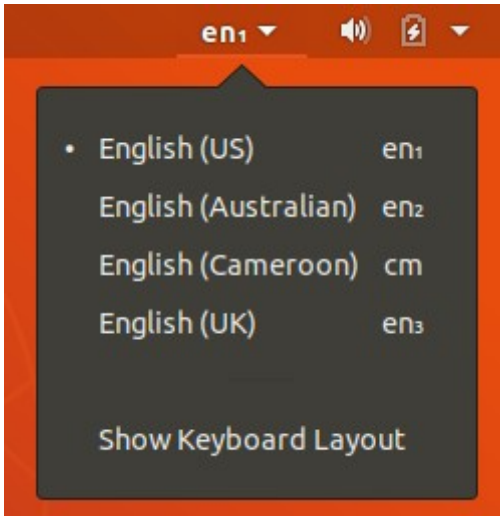
At the bottom of the Dock is

Show Applications

Exercise 2 **Changing the keyboard layout**

The keyboard is currently set up with the US-style layout. To set it to a UK layout

i. Right click on **en₁** on the top right bar



ii. Select **English (UK) en3**

You should now be using a UK Keyboard layout.

Exercise 3 **The home area**

When you log onto a Linux system you are located in your home area. This is where any files that are created during this session are saved. See if you can find a quick way to open a window which shows the contents of your home area.

The answers are at the end of the exercises.

Exercise 4 **Getting to know the desktop**

I. Finding applications

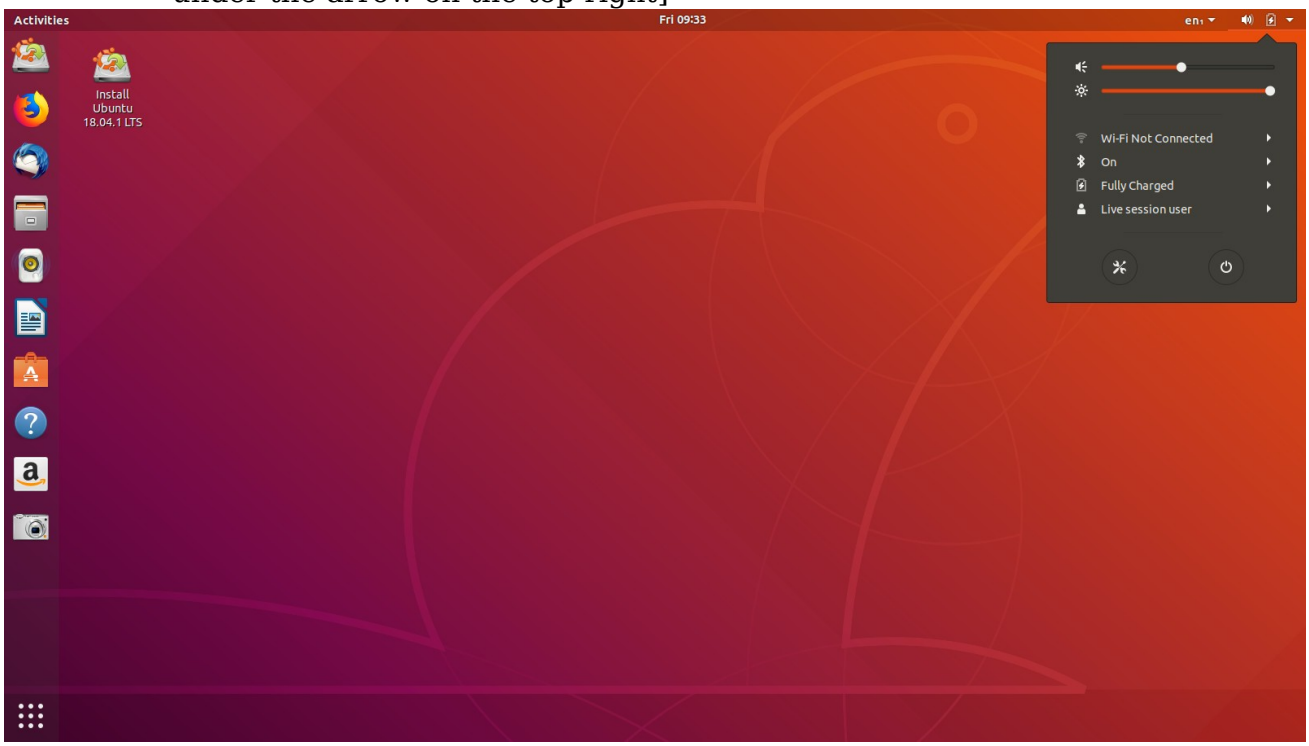
From the Dock find

- The Firefox Web Browser
- LibreOffice Writer

- Help

From the top panel find

- System Settings [Hint: Look for the crossed wrench/screwdriver icon under the arrow on the top right]



II. Window operations

We're going to experiment with actions on windows. Start Firefox. Make sure you can do the following to this window

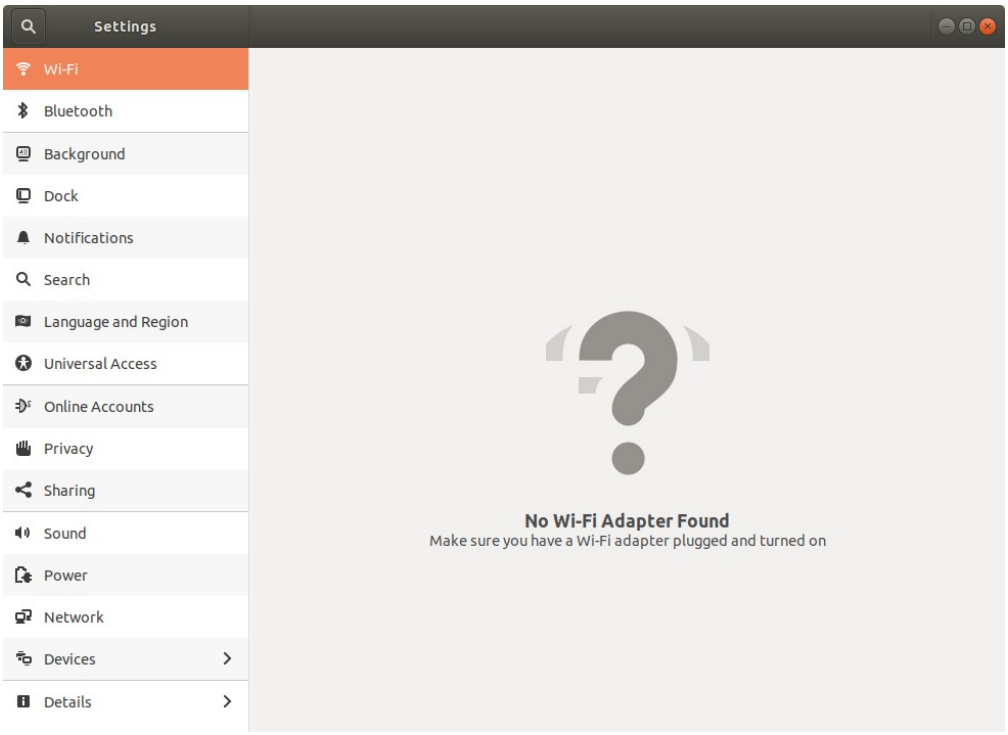
i. Maximise – make full screen size.
ii. Minimise – close the window and send to the Dock.
iii. Restore – bring back a minimised window from the Dock.
iv. Close – exit from a window permanently.
v. Resize – make the window smaller or larger.
vi. Display options for a window. [Hint: right click on the dark grey bar at the top of a window.]

Did you notice that when you have started an application there are small orange dots to the left and right of the icon on the Dock? What happens if you click on a different application? Did you notice that the appearance on the Dock of the active application changes? What happens if you open a new copy of the application so that there are two (or more) instances running?

III. Configuring your desktop

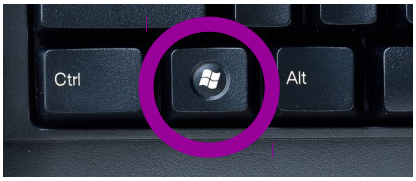
System Settings allows you to configure your desktop environment and many other features.

i. Open the **System Settings** menu and click on **Background**.

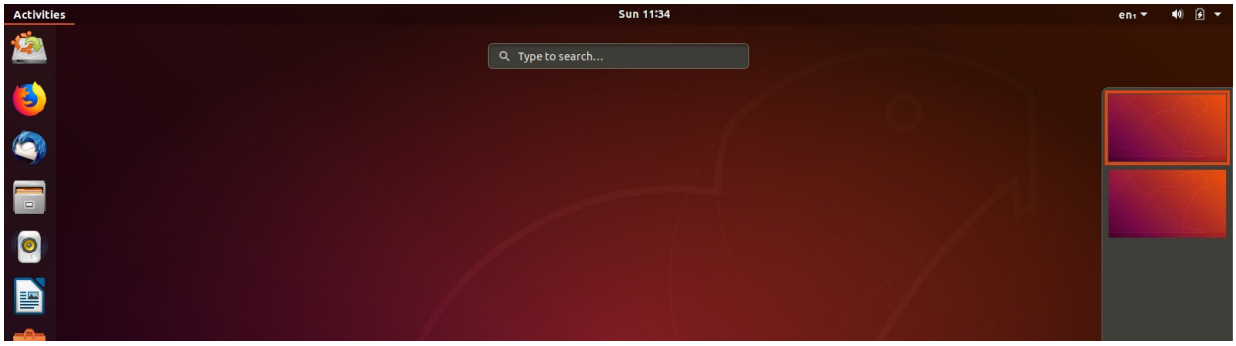


ii. Change your wallpaper. Ubuntu Live has a limited range of wallpapers; a full install will have more.

iii. Linux supports the use of multiple workspaces or desktops. This allows you to organise work more efficiently and reduce clutter. Press the Super (or Windows) key on the bottom left of the keyboard:

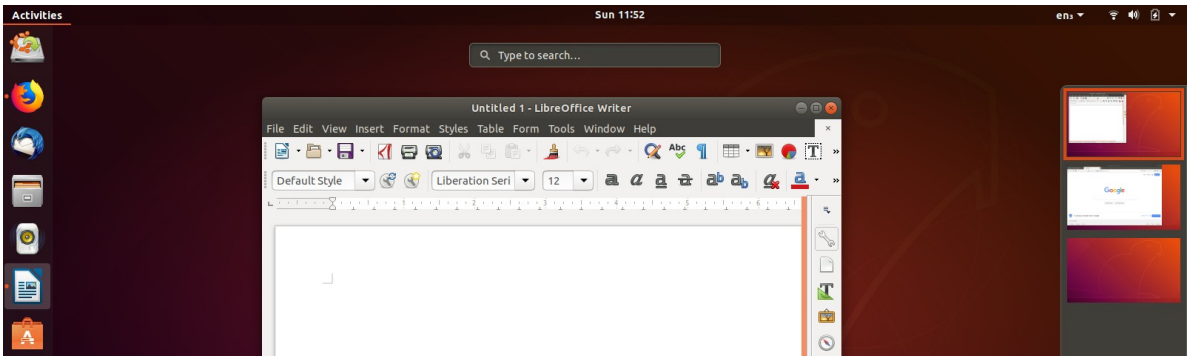


to display additional desktops. You should see something like this:



You can then use the mouse to move between workspaces, and move applications between these workspaces.

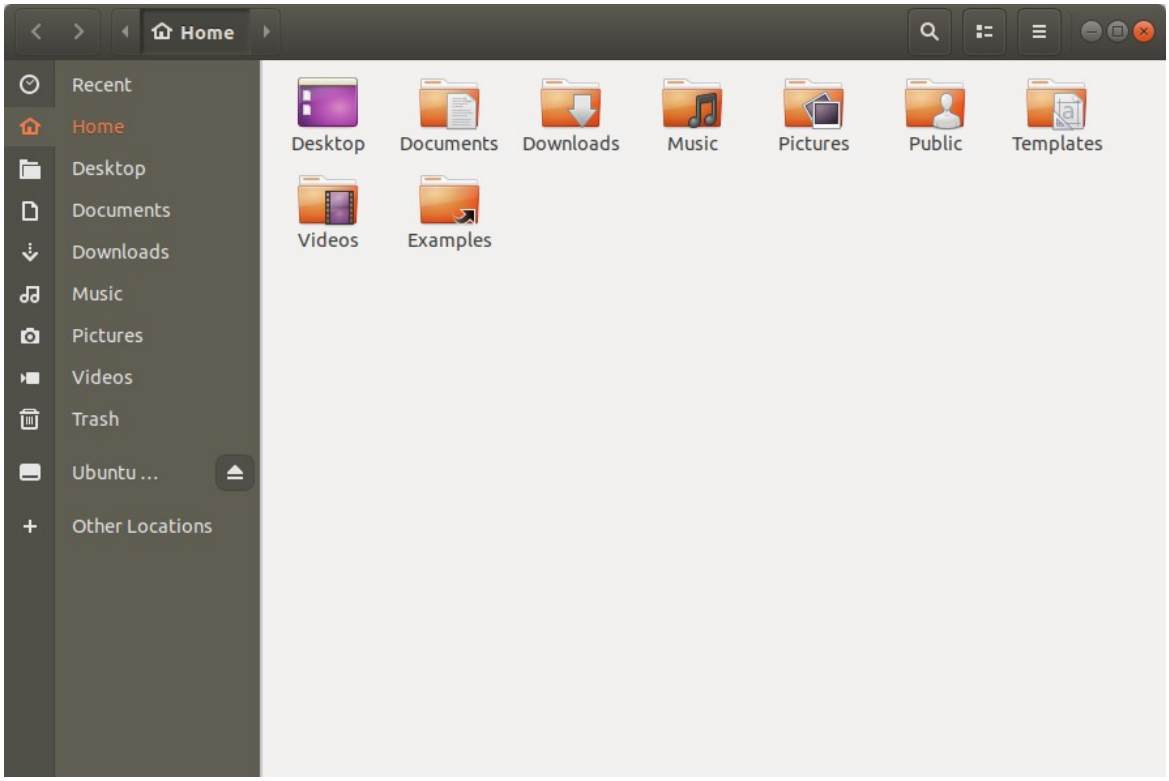
In this screenshort there are applications open in two workspaces.



iv. *More difficult:* Change some keyboard shortcuts. Keyboard shortcuts use the keyboard rather than the mouse to perform actions. Go to **Keyboard** in the **Devices** page of System Settings) and use this to set up a quick way to switch between workspaces. Scroll through this list of shortcuts, looking for **Switch to workspace 1** and replace **Super+Home** by, for example, **CTRL+1** [Hold the CTRL key and 1 down at the same time]. **Switch to workspace 2** to **CTRL+2** and so on. Do this for 4 workspaces. You should now be able to switch between workspaces using these keystrokes. Some keyboard shortcuts are pre-configured.

Exercise 5 **Finding your way around**

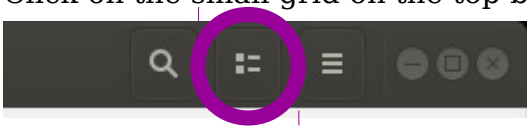
Go to the Dock and open **Files**.



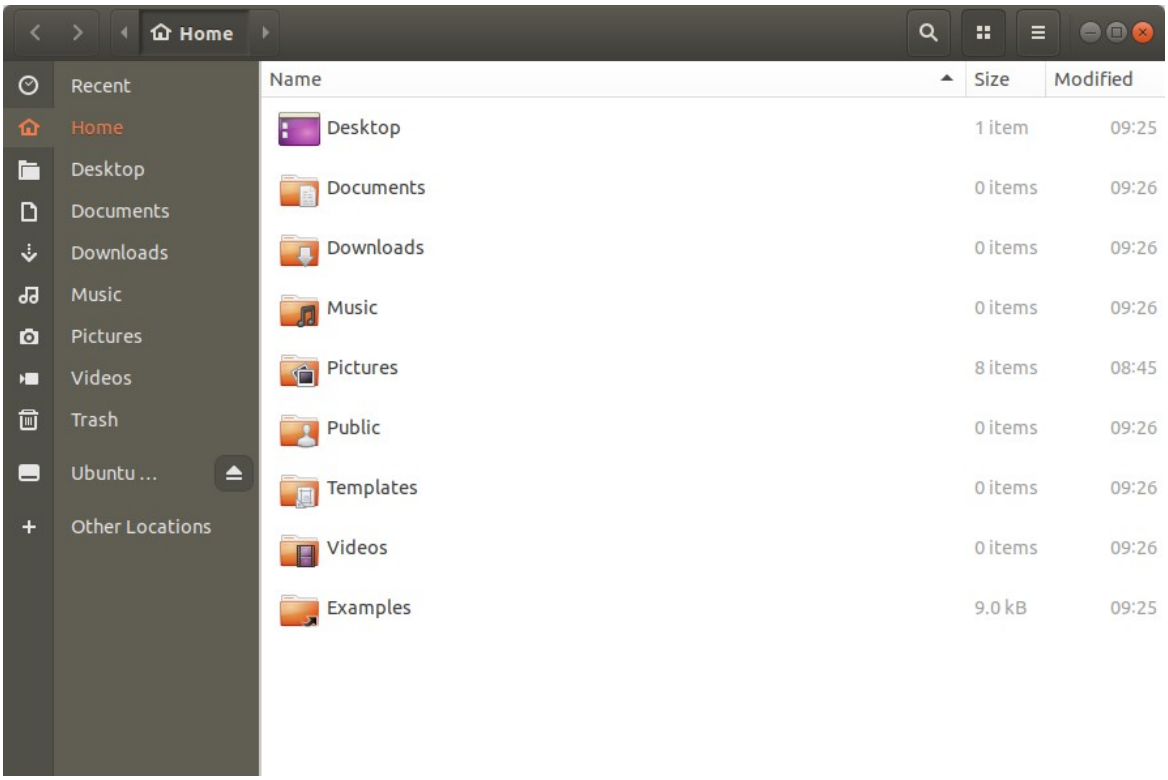
You can use **Files** to browse files and directories (the Linux equivalent of folders).

You should be in an area called **Home**. When you start the file browser, it opens in your home directory. This is the place where your files will be stored by default – that is if you don't specify another location.

Click on the small grid on the top bar



The view in Files should change



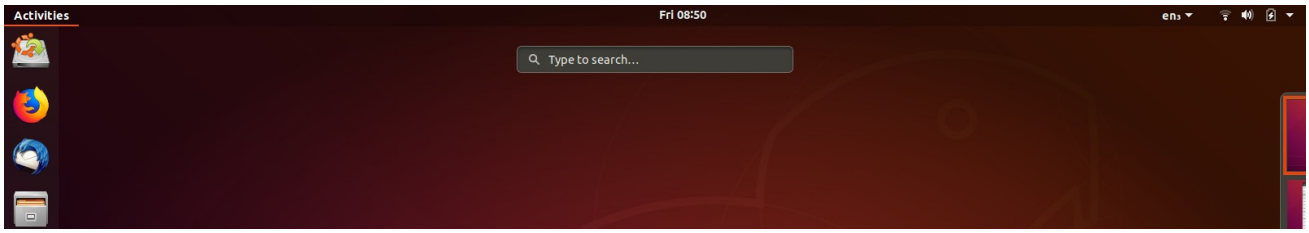
You can change the properties you see for each file and directory by right clicking **Name** above the list of directories. A list of properties appears:

Change this list so that you can see the Type, Owner, Permissions and Modified – Time.

Finally, see if you can find a directory that you can't see inside. We will talk about how privileged accounts are used in the final session.

Exercise 6 **Finding applications not on the Dock**

There are only a limited number of applications on the Dock. What if you want to use something that isn't there? Clicking on the Activities icon displays a window like this:



To find an application you can either browse for it by category or search in the search box. In later sessions we will be needing a terminal window. Enter terminal in the search box and see what happens. You may not need to type in the whole word to get what you want.

Once you have found what you want, a single click on the icon will open the application. As well as opening the application, an icon should also appear on the Dock. If you right click on this icon, you can keep the application there by selecting **Add to Favorites**, even after you have closed it. Test this with the terminal window.

The following two exercises look at the Libreoffice equivalents of Microsoft Word and Microsoft Powerpoint. As time is short, choose the one you are most likely to find useful.

Exercise 7 **Word Processing**

Start **LibreOffice Writer** from the Dock.

Write a short document (perhaps a covering letter for a job application for example). Don't spend too long on this but see if you can find out (from your experience with MS Word or similar) how to insert things like tables, do indentation and so on. If there's something you'd like to see but you're not sure where it is, ask for help.

Now save what you've done. By default the file is saved in ODF (Open Document Format). Once you done this, see if you can find out how to save a document in MS Word format instead. You can also save the file in PDF format. Again see if you can find out how to do this (it's not in quite the same place).

Now let's close this document by clicking on **File** and **Close**.

Use your Firefox browser to visit **`http://www.stats.ox.ac.uk/pub/susan/linux/`**

You should now see an MS Word file, **`Usingmsc.doc`**, available for downloading. Save this file (right click on the link) and make sure it has downloaded by checking your Home Folder Window. Go back to the word processor and open this file. It should work perfectly even though it was created with MS Office.

Although most MS Office files work with LibreOffice, a few don't convert very well so be warned that it's not 100%compatible. (Maybe 98% is a fair number).

Now close Writer and go to the StackExchange exercise.

Exercise 8 **Slide shows**

Use LibreOffice Impress to make your slide show; it is an application similar to MS Powerpoint. You will need to use **Activities** to search for this.

You don't have time to make a large presentation today so we suggest as an exercise that you make one or more of:

- A three page presentation about your course/research
- A poster for an event/party
- A flier for Ubuntu Linux

Use the Firefox browser in Desktop 1 to search for and to download images and insert them into your presentations. Ask your demonstrators if you can't find the features you want to use.

Save your work as both in Open Document format and MS Powerpoint format.

Now close the application.

Exercise 9 **StackExchange**

We will now look at another source of information and help that is available. StackExchange provides a gateway to communities of expertise. A particular benefit of the sites is the lack of additional chat – in general there is a strong focus on direct answers to questions. Browse to **`http://stackexchange.com/about`** to find out more.

Browse to **`http://www.stackexchange.com`** and click on 'Explore our sites!' to see the huge range of topics covered. Let's investigate the 'Ask Ubuntu' site. On my browser the link to this site appears in a large orange box to the right of the large 'Mathematics' box which is near the top on the left hand side. If you can't find the link then use the browser search feature (usually CTRL+F) and enter Ubuntu.

When you click on the 'Ask Ubuntu' box you should see a 'Visit Site' button. Click on this.

Now click on 'Take the 2-minute tour' to see a brief guide.

If, at the end, you have time have a look at other useful sites such as 'Unix & Linux'.

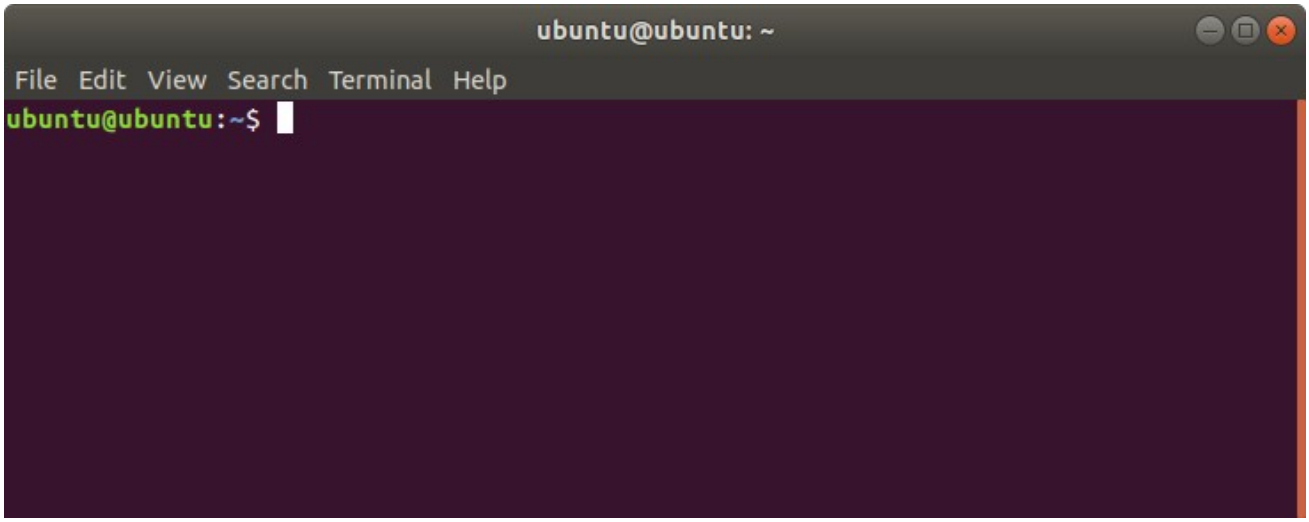
Exercise 10 **Starting a terminal window**

Now that you are more familiar with the Ubuntu desktop, let's start looking at the command line interface.

The first thing we need is a shell prompt/command line. When using a graphical desktop there is usually a terminal application which gives you access to the command line.

Click on 'Activities' and enter Terminal in the search box. When you have found the terminal open it. If you want to keep it on the Dock, right click on the icon on the left hand side of the screen and select '**Add to Favourites**'.

You should see a Window open that looks like this:



Note that it's perfectly possible to have a command line with no graphical desktop at all. This is often the case with server systems which are not used interactively and need all the processor power and memory they can get for computation.

We will be finding out more using remote server systems in the final section.

Exercise 11 **Where am I? What's all this?**

Let's start to look at navigation of the Linux file system. The following commands are introduced:

Command	**Purpose**
pwd	print working directory. In other words, "where am I?"
ls [*options*] *directory*	List files. If used on its own, it lists everything in the "current working directory" (where you are currently "located").
file *filename*	Tells you what sort of file the file called filename (for example) is.
cd	Change directory. In other words, "please change my current location".
man *command*	Command manual pages.

Note that all commands are typed in lower case. There are very few Linux commands which have any uppercase (CAPITAL) letters. We will look at case-sensitivity and file names in the next session.

Right away we can see how *quiet* Linux commands are by default. Try typing in

```
cd
```

at the `ubuntu@ubuntu:~$` prompt and you will get no output at all. This does not mean that anything has gone wrong. For many commands, no output means successful completion.

A digression on prompts. You can customise your prompt to look however you like. We won't do that now, but you will notice that it changes as you move around the file system.

Not all commands are silent. Try

```
pwd
```

You should get a response like: `/home/ubuntu`. Now try

```
ls
```

You should now see a listing of all the files in the directory `/home/ubuntu`. Let's try finding out what sort of files each is. Take the file “Desktop”.

```
file Desktop
```

The shell tells you that this isn't a regular file, it's a directory. In other words it's a special file which acts as a holder for yet more files (like a folder in Windows). If you now try

```
file Desktop/*
```

you should see a description of the two files in that directory.

TIMESAVING INFORMATION

If you haven't already tried this then you should now. A lot of typing can be avoided by several useful shortcuts. The <tab> key can be used to complete commands file names and the arrow keys to recall previous commands and perhaps change them.

Exercise 12 **File and directory manipulation**

Now you are going to create a directory and put some files there. The commands you need are

Command	**Purpose**
cd	change directory. In other words, “please change my current location”.
mkdir *directoryname*	create a directory called directoryname
touch *file1 file2*	create one or more empty file(s) called file1, file2
cp *file1 file2*	copy file1 to file2. Can also be used to copy whole directories.
ls	List files. If used on its own, it lists everything in the “current working directory“ (where you are currently “located”).
rm *file1*	remove (or delete) a file called file1. Can also be used to remove whole directories.

cd

mkdir *directory1*

cd *directory1*

touch *file1 file2 file3 file4*

Remember that words in italic should be replaced by names that you have chosen. Experiment to see what happens if you are not in your home directory. What happens if you try to create a directory in `/usr/bin`? Is there anywhere outside your home directory where you are allowed to create directories? [Hint: look at the top level directory `/` - you should be able to create a files and directories in one of those. The name of the directory might also be a clue. Check in the Answers section below.]

Use the **cp** command to copy one file to another and then use **ls** to check that you have done what you want. Then delete a file using

rm *file1*

Now we are going to copy one directory to another. The commands you need are

cd

cp -r *directory1 directory2*

Use **ls** to make sure you have done what you want. The new directory should contain exactly the same files as the old one. Note use of the **-r** option. This makes **cp** copy the contents of a directory – this is known as a recursive copy.

Finally remove the new directory with

```
rm -rf directory2
```

Note that this is a dangerous command and should be used with care!

Use **ls** to check that this has worked. You should now be familiar with these simple file manipulation commands. Remember that in Linux the **rm** command really does delete files. There is no Recycle Bin to retrieve files that were deleted by mistake.

THIS COMPLETES THE EXERCISES FOR SESSION ONE

3 Command line exercises

Exercise 13 **Viewing files**

We're going to download some files and directories which will be used during these exercises. Although it is possible to use a browser to download this file you can also do this from the command line. Use

```
cd
wget https://www.stats.ox.ac.uk/pub/susan/linux/LinuxFiles.tgz[1]
```

to download the files and then

```
tar -xvzf LinuxFiles.tgz
```

to unpack them.

Command	**Purpose**
cat *file*	show the whole contents of a file called ***file***
more *file*	display the contents of ***file*** a screenful at a time
less *file*	display the contents of ***file*** a screenful at a time but with more options. For example, after starting **less** you can enter **G** and go straight to the end of a file and then move backwards.

Use the following commands to look at the contents of the file google.txt.

```
cd Files
cat google.txt
```

This is not very useful if the file is more than a screenful.

```
more google.txt
```

Note that <space> takes you to the next page and **q** will quit before the end of the file. Now try

```
less google.txt
```

See if you can go straight to the end of the file. Then use **q** to exit.

[1]This command is not available on MacOS. Use curl instead. For example
curl -O http://www.stats.ox.ac.uk/pub/susan/linux/LinuxFiles.tgz

Exercise 14 **Absolute and relative pathnames**

We're now going to make use of two things, the **ls** command and the knowledge that the file called `/usr/share/info` is a directory, to illustrate the concepts of *absolute* and *relative pathnames.*

```
cd
cd ../../usr/share
ls info
```

and you will get a listing of the contents of the directory.

```
ls /usr/share/info
```

and you should get the *same* list of files.

The absolute (i.e. complete) location of the **info** directory is **/usr/share/info**. We have just asked to see what is kept inside it in two different ways. The first is a *relative* pathname while the second is the *full* or *absolute* name.

Imagine the **info** directory is a particular house, say 42, High Street, Abingdon and I ask you to deliver a letter there. I could tell you to deliver the letter to " 42 High Street, Abingdon": the full/absolute address. No matter where you are in the UK, that's enough information. However, if you were already in Abingdon I could tell you to deliver the letter to the relative address of " 42, High Street" or even better, if you were standing on the high street just "number 42" would be enough.

The "**ls info**" command above worked because you were already in the `/usr/share/directory`. It wouldn't work from somewhere else. The command "**ls /usr/share/info**" command will work from anywhere (although it's more long winded). Let's prove it by changing our current location using the **cd** command to go back to the home directory

```
cd
cd Desktop
pwd
```

you should get "`/home/ubuntu/Desktop`" i.e. you have moved into the Desktop directory.

```
ls /home/ubuntu/Desktop
```

should give you the list of files in that directory. In fact you could use "**ls**" on its own without the name of the directory because you have already moved there with **cd**. Let's see what happens when we deliberately do something wrong:

```
ls Desktop
```

should give you an error saying there is "No such file or directory" which is correct. The command fails because Desktop on its own is a *relative* name and you've started from the wrong place.

Let's expand the idea of relative and absolute path names using the **cd** command. Make sure you are still in the Desktop directory before you start (check with **pwd**).

```
pwd
cd ..
```

```
pwd
cd ..
pwd
```

and so on until you can't go any further (you won't see an error, you just stop going anywhere). "**..**" is a special location which means "up one level". All directories contain a "**..**" so you can go up a level. The exception is called "**/**" or "the root" or just "slash". You can't go higher than **/** so "**..**" doesn't take you anywhere. Note that there is another special directory called "**.**" which means "current location". All directories contain a "**.**" directory and we'll see why it is needed later.

During the above task you went up the directories one level at a time. Now reverse the process and go back to the Desktop directory one level at a time. You should be in "**/**".

*Note that you don't have to do the pwds but it may help you visualize what is going on. You can also use **ls** to have a look around each level if you have time.*

```
cd home
pwd
cd ubuntu
pwd
cd Desktop
pwd
```

Try to answer/do the following:

Were you just using absolute or relative paths?

1. Now try to get back to the root (or "**/**") directory with one command only using an absolute path.
2. Now get back to the **/home/ubuntu/Desktop** directory using one command only.
3. What are the contents of the "**/**" directory? From your home directory use one command only to find out.

Exercise 15 **Help commands**

Command	**Purpose**
man *command*	Read the manual page for a command. So **man ls** gives you details about **ls** and **man less** would give you details about **less**.
apropos *word*	Search manual pages for names and descriptions. So **apropos copy** would list all the commands that have the word copy in the description.

Command	Purpose
which *command*	Displays the location of the command you are using.
whatis *command*	Gives a brief description of a command.

If you know what command you need, you can use the man command to find out the details of that comand. Try it with a few of the commands you have used already. Not all commands have as many options as **ls**!

```
man ls
```

to find out details of the **ls** command.

1. What option is used to display modification time?
2. What option is used to display the size of a file?
3. How can you reverse the order of the sort so that the largest/most recently changed file is at the bottom of the list?
4. Check that they do what you expect.

Sometimes you might not be sure exactly what the command is. In that case you can use the apropos command which finds all command descriptions which match a given word. So to find out what commands there are to manipulate files are available use

```
apropos file
```

Note that the output from this command is very long. We will look at a neat way round this in the next session. Here is a real life example. I needed to know which command in this Ubuntu distribution was the equivalent of Microsoft Draw so I ran

```
apropos draw
```

See if you can see the name of the command I used. The answer is at the end of the exercises.

Sometimes you need to know where Linux stores command. Use **which** to display the location of the file. Try it with **less**, **more**, **cp**, **apropos**:

```
which apropos
which cp
which more
which less
```

Did you notice that **more** and **less** are stored in different places? The directory **/bin** conventionally is used to store a few necessary commands that can be used if all else fails. Finally you may have seen a command and want to know briefly what it does. Use the **whatis** command to find out. Try this on some commands.

Exercise 16 **File and directory names**

These are the commands that will be used:

Command	**Purpose**
cd	change directory. In other words, “please change my current location”.
cat *file*	show the whole contents of a file called ***file***

We’re going to look at some of the problems you can encounter with files and directories. You should have a directory called `Files`. Now do this

```
cd
cd Files
cd TestDir
```

First look in the `Cases` directory.

```
cd Cases
```

Make sure that you can read all three files there. Now look in the **OpenThis** directory.

```
cd ..
cd OpenThis
```

1. Now see if you can read the files **star**, **astar** and ***star**. What happens when you try to read the file called ***star**? The * character has caused confusion because it is a wildcard – it matches any character. We will be looking at wildcards and pattern matching in a later exercise. See if you can read this file without reading the other ones. Using google is not cheating!
2. Now change into the directory **Open This**. Double quotes or backslashes help.
3. Now try to read the file called -ReadMe. Using quotations round the filename or the escape character (\) won’t work this time. In each case the command (one of cat, more or less) is interpreting the leading – (hyphen) as an option. Again, don’t be afraid to google to see if you can find the answer to this. Try deleting the file called **-DeleteMe**. To help you with this, **man less** says:

```
--   A command line argument of "--" marks the end  of  option arguments
     Any arguments following this are interpreted as file-names. This can
     be useful when viewing a file whose name begins with a "-" or "+".
```

See the answers for some suggested solutions.

Exercise 17 **Looking at files**

These are the commands that will be used:

Command	**Description**
cat *file*	Show the entire contents of a file called ***file***.
head *file*	Display the first 10 lines of a file.
less *file*	Display the contents of ***file*** a screenful at a time but with more options. For example, after starting `less` you can enter *G* and go straight to the end of a file and move backwards.
man *command*	Read the manual pages to read all about a command. So **man head** would describe how to use the man command.
more *file*	Display the contents of file a screenful at a time.
tail *file*	Display the last 10 lines of a file.
wc *file*	Counts the number of characters, words and lines in a file.

Using

cd Advanced

cat longfile.txt

you see all of longfile.txt; using

less longfile.txt

gives you a screenful at a time. Use the spacebar to move on a screenful, **G** to go to the end of the file and **q** to exit. Now use

head longfile.txt

and

tail longfile.txt

to look at the first and last 10 lines of the file.

Now use the **wc** command to find out the number of lines, words and characters there are in

longfile.txt.

Exercise 18 Using wildcards to match filenames

File globbing or wildcard expansion allows you to use special characters to match more than one file or directory name.

Character	What it matches
*	The * (asterisk or star) matches any number of characters or none.
?	The ? (question mark) matches exactly one occurrence of any character.
[ ]	Matches any characters in a given range.

Change back to your home directory (if you are not already there) and then change to the directory called WildCards.

```
cd
cd WildCards
```

Now experiment with wild card characters. What do the following match?

```
ls foo?
ls foo2*
ls foo[1-2]
```

What command would you need to match just `foo20` and `foo2bar`? [Hint: you might need to use more than one wild card character.] The answers are at the end. Now use

```
wc -l *
```

to find the length of each file. Note that the **-l** is a hyphen followed by the lowercase letter l. You should see output like this:

```
  1 foo
  2 foo1
  2 foo10
  1 foo2
  1 foo20
  3 foo2bar
 10 total
```

Now see if you can create a match so that **wc -l** just shows the files with a 1 (the number one) in their name. Again a possible answer is at the end.

Exercise 19 **Searching and sorting**

In this exercise we will use commands to search for patterns within files and sort the contents of files.

Command	Description
grep *pattern file*	Search for the characters in ***pattern*** within ***file***.
sort *file*	Sorts the contents of one or more files.

Now change into the **Searching** directory.

```
cd
cd Searching
```

I suggest you use the `cat` command to check the contents of the two files, `fruit` and `veg`, so that you can see what they contain. Now use

```
grep melon fruit
```

Can you see what has happened? Only the matching lines in the file are shown. Try

```
grep green fruit veg
```

What do you think has happened here? Did you notice that the file names were included in the output. This is because more than one file (both `fruit` and `veg`) has been searched and so the output informs us where the matches were found.

Using

```
man grep
```

see if you can find the option that causes **grep** to ignore case so that both Melon and melon would be found.

Finally use the **sort** command to order the files. Note that you can sort more than one file which merges the output of all the files.

```
sort fruit veg
```

What is the option that reverses the order – so that the fruit and vegetables are sorted in reverse alphabetical order?

Exercise 20 **Pipes and redirection**

In this exercise we are going to explore two very powerful command-line features which increase the flexibility and range enormously.

Command	Description
du -sk	Displays sizes in Kilobytes of all files in a directory.
grep	Search for the characters in ***pattern*** within ***file***.
sort	Sorts the contents of one or more files.
tail	View the last few lines of a file
wc	Counts the number of characters, words and lines in a file.

and we will be using the following characters. If you haven't already remapped your keyboard you should do that now. See Exercise 2.

Character	**Purpose**
>	Sends the output from a command to the named file. If the file already exists the previous contents will be lost. If the file doesn't exist it will be created.
>>	Appends the output from a command to the named file. If the file doesn't exist it will be created.
<	Reads input from the named file. NB This option is rarely used.
|	Uses the output from one command as the input to the next.

Almost all Unix/Linux commands use standard input for receiving instructions and standard output for displaying the results. So we could run

```
grep green fruit veg > output
```

which would store the output of the **grep** command in a file called `output`. Check this with

```
cat output
```

If you run the command again, this time using

```
grep green fruit veg >> output
```

you should see that there are now two copies of the output. It is also possible to use < redirect the input from the keyboard to a file. For example

```
cat <output
```

also works.

In the previous exercise we used `grep` to look for occurrences of the word **green** in two files. Obviously in this short example we can count how many times green appears, but when there are many matches it would be useful to use `wc` to find out. We can redirect the output from the command into a file.

Note that in all cases the **-l** option to the **wc** command is a minus sign followed by the lower case letter **l**.

```
grep green fruit veg >output
```

and then run wc on the file

```
wc -l output
```

but it would be much more efficient to join the two commands together with a pipe. Use

```
grep green fruit veg | wc -l
```

Here the two commands **grep green fruit veg** and **wc -l** are joined together by a special symbol called a pipe.

Exercise 21 **Finding the largest file**

Now we're going build a longer command which will find the 5 largest files in a directory. When building pipes of commands it often helps if you make sure each link in the pipe works before adding the next.

First display the size in Kilobytes of all the files in the **/usr/bin** directory.

```
du -sk /usr/bin/*
```

Now sort this output by size, so that the largest are first.

```
du -sk /usr/bin/* | sort -nr
```

Now display the final 5 lines which will be the 5 largest files.

```
du -sk /usr/bin/* | sort -nr | head -5
```

Now how you would you find the 5 largest files in the **/usr/bin** directory beginning with the letter '**s**'?

Exercise 22 **Merge information from different files**

Command	**Description**
awk	A pattern scanning and text matching program.
paste	Merge lines of a file

This is a rather contrived example but demonstrates some very useful Unix/Linux commands. Make sure you are still in the Searching directory.

```
cd
```

```
cd Searching
```

Now we are going to use the **awk** command to print out only the first column of the file called `creatures`. Have a look at the file before you run this command.

```
awk '{print $1}' creatures
```

What do you think would appear if you replaced **$1** by **$2**? Make sure you copy the command exactly. In particular you need the single quote character and curly brackets. Now change this to

```
awk '{print "A", $1, "eats"}' creatures
```

As well as a list of animals you should also see that the words “A” and “eats” appears either side of each animal. Now we are going to use the paste command to include the output from the fruit file.

```
awk '{print "A", $1, "eats"}' creatures | paste -d" " - fruit
```

Again, make sure that you have entered the commands exactly as they appear here. To explain what the `paste` command is doing: the **`-d" "`** option makes a space rather than a tab appear before the name of each fruit, the **`–`** before **`fruit`** means that the output from **`awk..`**. is included.

Now see if you can make the fish eat the vegetables!

See the Answers section below for an answer.

Exercise 23 **Unpacking a longer example**

In this exercise you will look at a longer example and repeatedly remove commands to unpack a complex command. Enter these commands.

```
cd
cd Advanced
cat my_wordcount
```

We will be using these commands

Command	**Description**
`sed`	**`sed`** allows you to change the contents of a file; frequently used in pipes.
`sort`	Sorts the contents of one or more files.
`tail`	View the last few lines of a file
`tr`	Translate either groups of characters or single characters.
`uniq`	Report or remove duplicate lines.

When you run the commands

```
chmod +x  my_wordcount
./my_wordcount longfile.txt
```

you should see output like this:

6 microsoft
6 more
6 mr
6 said
6 that
7 has

```
 7 yahoo
 8 engine
 9 and
 9 on
10 pages
10 web
11 in
12 of
13 its
14 a
15 search
16 google
20 to
29 the
```

This is a list of the 20 most common words used in the file **longfile.txt**. Now, from the command line, we're going to run the command repeatedly, each time removing the final element, to unpack how it works.

Using the mouse, copy the contents of my_wordcount and paste into the command line. You should have a very long command like this:

```
sed -e 's/\.//g' -e 's/,//g' -e 's/\!//g' -e "s/\'//g" -e "s/\"//g" -e
's/-//g' longfile.txt | tr ' ' '\012' | tr [:upper:] [:lower:] | sed -e
'/^$/d' | sort | uniq -c | sort -n | tail -20
```

This looks very complicated!

Now lets remove the final pipe which is

```
| tail -20
```

so you have

```
sed -e 's/\.//g' -e 's/,//g' -e 's/\!//g' -e "s/\'//g" -e "s/\"//g" -e
's/-//g' longfile.txt | tr ' ' '\012' | tr [:upper:] [:lower:] | sed -e
'/^$/d' | sort | uniq -c | sort -n
```

Remember that you can use the up arrow and backspace keys to do this. There is no need to type anything in. This time the output shows all the words in the file, not just the 20 most frequent. Now let's remove

```
| sort -n
```

and see what happens

```
sed -e 's/\.//g' -e 's/,//g' -e 's/\!//g' -e "s/\'//g" -e "s/\"//g" -e
's/-//g' longfile.txt | tr ' ' '\012' | tr [:upper:] [:lower:] | sed -e
'/^$/d' | sort | uniq -c
```

Now the list is sorted alphabetically rather than numerically. Again, remove the final pipe,

```
| uniq -c
```

and see what happens.

```
sed -e 's/\.//g' -e 's/,//g' -e 's/\!//g' -e "s/\'//g" -e "s/\"//g" -e
's/-//g' longfile.txt | tr ' ' '\012' | tr [:upper:] [:lower:] | sed -e
'/^$/d' | sort
```

Now you should see an alphabetical list of all the words, but with multiple occurrences of many words.

Remember you can always add

```
| less
```

on to each version of the command so that you can look at the output a screenful at a time.

The **uniq** command (which is very useful) removes duplicates, and with the **-c** option, adds a count of the number of times it has found a match. Now remove the final pipe,

```
| sort
```

again so that you have

```
sed -e 's/\.//g' -e 's/,//g' -e 's/\!//g' -e "s/\'//g" -e "s/\"//g" -e
's/-//g' longfile.txt | tr ' ' '\012' | tr [:upper:] [:lower:] | sed -e
'/^$/d'
```

This time you have all the words in the file with one word on each line but in the order they appeared in the original file, not sorted alphabetically. You can read the contents of **longfile.txt** if you want to check this. Now again remove the last pipe again

```
| sed -e '/^$/d'
```

and see what the output looks like.

```
sed -e 's/\.//g' -e 's/,//g' -e 's/\!//g' -e "s/\'//g" -e "s/\"//g" -e
's/-//g' longfile.txt | tr ' ' '\012' | tr [:upper:] [:lower:]
```

The file no longer contains any blank lines. If you haven't already add **| less** on to this version and the previous version to compare. Again, remove the final pipe,

```
| tr [:upper:] [:lower:]
```

and see what happens.

Did you notice that some uppercase letters appeared? The **tr** command allows you to translate either classes of characters (such as all uppercase characters) or individual characters to something else. In this case we are translating all uppercase characters to their lowercase equivalent. Now remove the final pipe again.

```
sed -e 's/\.//g' -e 's/,//g' -e 's/\!//g' -e "s/\'//g" -e "s/\"//g" -e
's/-//g' longfile.txt | tr ' ' '\012
```

Now you should see the file with many words on each line. In this case we have used **tr** to translate all space characters to the newline character (which is represented by **\012**).. The first command – which is very complicated - removes some punctuation from `longfile.txt`.

```
sed -e 's/\.//g' -e 's/,//g' -e 's/\!//g' -e "s/\'//g" -e "s/\"//g" -e
's/-//g' longfile.txt
```

This is a complicated command! We are using the **sed** editor to match and remove several separate things. Each match begins with **-e** and involves replacing various punctuation characters with nothing at all. In some cases the punctuation character is preceded by "\" because it has special meaning in the **sed** editor.

THIS COMPLETES THE EXERCISES FOR SESSION TWO

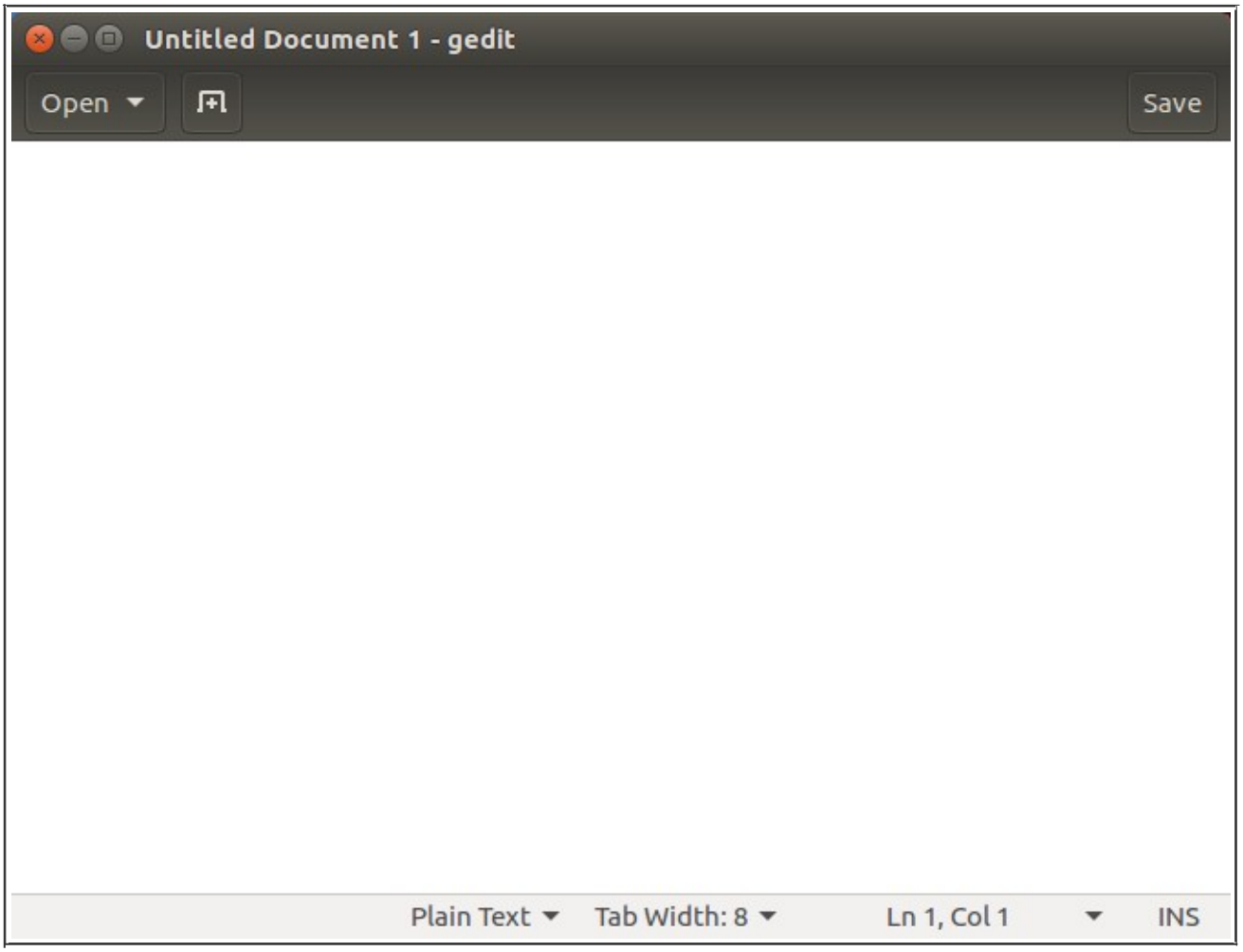
4 Editors, regular expressions, and shell scripts

Exercise 24 **Using gedit**

First open a terminal window so that you can use the command line. Using this window type in

```
gedit newfile &
```

and a window like this should appear. This command starts the gedit editor, creates a file called newfile and returns you to the shell prompt.



The new gedit window you have opened consists of

- a menu bar at the top with Open, New Document and Save buttons. Note that an expanded menu appears on the bar at the top of the screen.
- a main window for entering text

If other files are open then you can have a series of tabs in the main window.

You can now enter text in the main window. You can move around the file with the arrow keys or the Page Up and Page Down keys.

Try them! Now see if you can enter some text into the file, save the text and quit gedit. Now start the editor up again with the same file, change the text, save it and quit again.

A small digression. When you started gedit you entered **`gedit newfile &`**. The **`&`** character has a special function. It allows you to start a command and continue using the terminal window to enter further commands. Technically it is called 'running a program in the background'. See what happens if you don´t include the & - just type in gedit newfile. You will need to exit `gedit` or enter CTRL+C [ie press the CTRL key and C at the same time] to get back control of the command line.

A brief summary of some frequently used command line control sequences are

CTRL+C interrupt a running program

CTRL+D send an end of file, ending text input for most Linux/Unix programs

CTRL+Q unfreezes the screen if CTRL-S has been used to freeze it.

CTRL+U deletes the last line typed

CTRL+Z suspends a running program. Use **`bg`** to continue running the program in the background or **`fg`** to continue running the program as it was.

Exercise 25 **Simple regular expressions**

Or finding needles in haystacks! We are going to use the following commands and shorthand characters..

Command	**Description**
`gedit`	A simple text editor
`grep`	Print lines matching a pattern. Options used: **`-n`** display line numbers **`-E`** use extended regular expressions

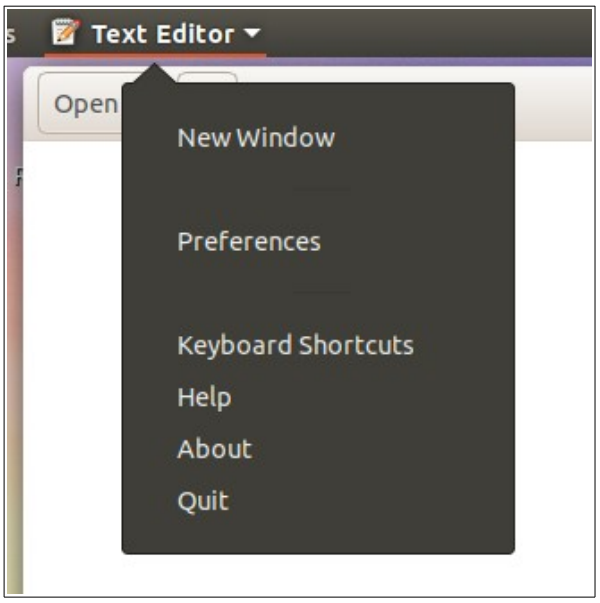
Regular expression shorthand character	**Description**
`^`	Match the beginning of the line
`$`	Match the end of the line

Have a look at the file HAYSTACK. It's going to be easier to look at it in gedit so enter

`cd`

```
gedit HAYSTACK &
```

from a terminal window. If the line numbers are not displayed it is helpful to show them. To do this, on the top panel, expand the TextEditor menu:



and select Preferences. On the View tab select ‘Display line numbers’ which should be the first item.

We'll spend more time looking at gedit in the next session, but for now we're going to use it to show the contents of a file.

Have a look at the file. There are many lines of text with mostly the word 'hay' none or more times. There are some needles hidden in there, as well as some nedles, neeedles and noodles.

A simple search

```
grep -n -E needles HAYSTACK
```

will show all the occurrences of needles in the file.

```
grep -n -E ^needles HAYSTACK
```

will show the lines that contain needles right at the beginning of the line. The search

```
grep -n -E needles$ HAYSTACK
```

will show only the lines that have needles at the end of the line.

How would you search for a line which contains only one occurrence of needles and nothing else?

See the Answers section to find out.

Exercise 26 **Regular expressions with spaces**

Command	Description
grep	Print lines matching a pattern

Regular expression shorthand character	Description
\s	match white space
\b	match a word boundary
\B	match a non-word boundary
+	matches one or more of the previous character

Sometimes words at the beginning of a line are preceded by white space (either a tab or a space). Regular expressions have many character shorthands which allow us to make general searches. In this example we use '\s' to match a single white space character.

```
grep -n -E '^\sneedles' HAYSTACK
```

to find all the lines that begin with a single white space and then needles.

What if there are multiple spaces? We can use the '+' character which will match one or more instances:

```
grep -n -E '^\s+needles' HAYSTACK
```

How many lines end with one or more white spaces?

```
grep -n -E '\s+$' HAYSTACK | wc -l
```

Note that this time, we haven't restricted the search just to lines ending in needles.

In some places hay and needles have been run together. To find only the places where needles is separate from hay use

```
grep -n -E '\bneedles\b' HAYSTACK
```

This is a particularly useful search because it means we don't have to worry about matches for beginning and ends of lines. Incidentally we can reverse this by using the

```
grep -n -E '\Bneedles' HAYSTACK
```

and

```
grep -n -E 'needles\B' HAYSTACK
```

which will find instances where needles are joined to hay either at the beginning or end of the word.

What happens if you use

```
grep -n -E '\Bneedles\B' HAYSTACK
```

See the Answers section.

Exercise 27 **Finding noodles**

Command	**Description**
grep	Print lines matching a pattern

Regular expression shorthand character	**Description**
|	give alternative matches
.	matches one or more characters
{}	specifies a number of matches

Looking at the contents of HAYSTACK, we can see that there are words similar to needles - noodles, nedles and neeedles. How can we find them all?

We could use the alternation character: '|' to find needles or noodles.

```
grep -n -E 'needles|noodles' HAYSTACK
```

This is a little restricted as we may need to specifiy many alternatives. Try this:

```
grep -n -E 'n.{0,2}dles' HAYSTACK
```

This will match all strings that

- start with '**n**'
- have 0, 1 or 2 characters before '**dles**'

Exercise 28 **Changing what you've found.**

This is slightly more challenging

Command	**Description**
grep	print lines matching a pattern
sed	a stream editor; it allows you to change the contents of a file and is often used in piped commands. Options used: **-r** Use extended regular expressions in a search **-e** Add the script to commands to be executed **s/*find*/*replace*/g** Change the string specified by ***find***, by string specified by ***replace***. The **g** at the end stands for global – on each line, all occurrences of the find string are replaced. Without this option only the first occurrence would be changed.

cat	print files on the standard output
diff	compare files line by line, displaying the differences

Use the above to change all occurrences of nedles, needles, and neeedles to noodles.

Check that

```
grep -n -E 'ne{0,3}dles' HAYSTACK
```

finds all occurrences of nedles, needles and neeedles in HAYSTACK. Then enter

```
sed -r -e 's/ne{0,3}dles/noodles/g' HAYSTACK | cat -n
```

The '**| cat -n**' isn't necessary, but adds line numbers to the output to show which lines have been changed.

Note that the regular expression used by **sed** is the same as the one used by **grep**. This is a particularly useful feature of regular expressions.

Finally, send the output to a new file, **NEW_HAYSTACK**.

```
sed -r -e 's/ne{0,3}dles/noodles/g' HAYSTACK >NEW_HAYSTACK
```

All your nedles, needles and neeedles should now be noodles! You can compare the two files with

```
diff HAYSTACK NEW_HAYSTACK
```

This completes the exercises on regular expressions. This is a very brief introduction: they are a powerful and flexible tool.

SHELL SCRIPT EXERCISES

Exercise 29 **An example shell script**

We're going to download a small file containing a bash shell script and change it. Enter

wget https://www.stats.ox.ac.uk/pub/susan/linux/small.sh

in the terminal window. This command will copy the file `small.sh` from my website to your Ubuntu desktop. Use the **ls** command to check this. You may need to make it executable with

chmod +x small.sh

Now enter

./small.sh

and see what output appears. Now start editing the file with

gedit small.sh &

and change “Hello” to “Goodbye”, save the file and quit. Then run the file again to see what happens.

Exercise 30 **Developing your first shell script**

You are now going to create your own version of the hello script. In the terminal window type in the following command and an editor window should appear:

gedit hello &

- Type in the first version of the script – you need the two lines in the box above.

```
#!/bin/bash
echo "Hello world"
```

- Save the script - the file will be called “hello”
- In the terminal window enter the command

chmod +x hello

Remember how files have *properties* associated with them? One such property is whether a file is *executable*. If a file is executable, you can run it (like a .exe file in Windows).

chmod +x file

makes file executable by all users (hence a+x).

Now let's run the script. It is located in your current directory called . so we type:

./hello

You should see the output

Hello world

When you have a working version of the script copy your file “hello”to a new file “hello1” so that if a later version stops working you can revert to a previously working version.

```
cp  hello hello1
```

Version 2 of the script

```
#!/bin/bash
echo "Hello $1"
```

New concept: you can choose who to greet using a command line argument. This is interpreted by the script with $1 .

- Now edit the file so that it looks like the version 2 of the script
- Run the script with a command line argument and check that it works

```
./hello Marge
```

You should see the output

```
Hello Marge
```

Again copy the “hello” file to a new file “hello2” to save a known working version.

Now repeat these steps for the four further examples:

Version 3 of the script

```
#!/bin/bash
for name in $*
do
        echo "Hello $name"
done
```

New concepts:

- **$*** matches all the arguments entered on the command line
- the ***for name in list*** construct is particularly useful for operating on command line arguments. The variable $name is assigned to each argument in turn and then evaluated when used with echo .

After editing the file to make the above changes, run the command

```
./hello Bart Lisa Maggie
```

This should produce the output

```
Hello Bart
Hello Lisa
Hello Maggie
```

Version 4 of the script

```
#!/bin/bash
if [ $# -eq 0 ] ; then
        echo "No one to say hello to"
        exit 1
else
    for name in $*
    do
        echo "Hello $name"
    done
fi
```

New concepts:

- $# contains the number of arguments supplied. You can check this by adding the line

  `echo $#`

  above the line beginning **`if [ $# eq 0 ...`**
- Control flow – the idea that you can choose what happens next based on a condition being met – is introduced using if expression then else fi.
- **`exit 1`** causes the script to stop

After editing the file to make the above changes, run the command

`./hello`

You should see the output:

`No one to say hello to`

Now run the command ***`for name in list`***

`./hello Homer Marge Bart`

which should produce the output

`Hello Homer`

`Hello Marge`

`Hello Bart`

as in version 3.

Version 5 of the script

```
#!/bin/bash
if [ $# -eq 0 ] ; then
        echo "No one to say hello to"
        echo "Please enter people to greet"
        read people
        echo $people
else
        people=$*
fi
for name in $people
do
        echo "Hello $name"
done
```

New concepts:

- Prompting for input from the script. Instead of stopping when no command line arguments are supplied the script now prompts for input. The name or names supplied are stored in the variable people. At this point the names are stored in one of two places so the else clause is used to move the contents of the command line argument to the variable people.
- The for name in loop now uses people rather than $* for this list of names.

Make the above changes and run the command

./hello

now produces the output

No one to say hello to

Please enter people to greet

enter the names:

Homer Marge Bart

and hit return.

you should see

Hello Homer

Hello Marge

Hello Bart

Running

./hello Homer Marge Bart

will also produce

```
Hello Homer
Hello Marge
Hello Bart
```

Now for you to try a couple of things.

- Create a test within the for loop to check for a particular name – say Homer – and change the message for this name. Hint: the test might look something like this.

```
if  [ $name == "Homer"  ]
```

- Create a small file called Names containing a few names. Now run the following command:

```
cat Names  | xargs ./hello
```

Note how easy it is to change where the input comes from. You can download an even longer list of names from here using

```
wget  https://www.stats.ox.ac.uk/pub/susan/linux/Simpsons
```

Version 6 of the script

The final version of this script introduces a slightly more complicated concept.

```
#!/bin/bash
if [ $# -eq 0 ] ; then
        echo "No one to say hello to"
        echo "Please enter people to greet"
        read people
else
        people=$*
fi
for name in $people
do
       echo "Hello `echo $name | rev`"
done
```

New concept:

The line beginning echo “Hello ... has been changed. Looking at this in more detail shows that the there is `(backquote) character before echo $name and after rev. This means that **echo $name | rev** is executed before being displayed on the screen. The effect of this is to pipe the output from echo through the command **rev**, which simply reverses the output.

The backquote is found at the top lefthand side of the keyboard next to 1.

Running the command:

```
./hello Homer Marge Bart
```

will produce the output

```
Hello remoH
Hello egraM
Hello traB
```

that is the names have been reversed.

Exercise 31 **File manipulation scripts**

We are now going to look at some scripts to create and copy files. This script will create several files with similar names.

```
#!/bin/bash
first=$1
last=$2
root=$3

while [ $first -le $last ]; do
     touch $root$first
     let first=$first+1
done
```

Save this in a file called **create**, give the file execute permission and then use

```
./create 1 4 newfile
```

which would create four files called

```
newfile1 newfile2 newfile3 newfile4
```

A while loop is used to repeatedly create files until the number specified is reached. The line `let first=$first+1` adds one to first each time the loop is executed.

Change this script to check that the right number of command line arguments have been given. Print out a message and stop if there aren't three arguments.

The answer is in the Answers section.

Now we will look at a script to copy all files with the same root to another name.

```
#!/bin/bash
let n=1
for file in $1*; do
        cp $1$n $2$n
        let n=$n+1
done
```

So assuming the script is in a file called **mycopy**

```
./mycopy newfile test
```

All files called **newfile1** ... **newfile***n* will be copied to **test1** ... **test***n*.

Try it. What does the $1* in the line beginning for file ... do? Change the script so that the new file name has a dot between the name and the number. [This is very easy!]

[More difficult.] Change the script so that the new file name has a dot after the number and then the date of the form 03Mar13 so that the files look like `test1.27Feb13 ...`

You will need to look at the date command – use **`date --help`** or **`man date`** and Version 6 of the hello script. The answer is below.

Note that there is a very useful command rename which will **`rename`** one or more files based on a regular expression. It may not be installed by default. If you want to investigate this enter

`sudo apt-get install rename`

`rename --help`

`apt-get install` is the command line tool for installing extra command or packages. There is a brief discussion of **`sudo`** in the next session.

Concluding Remarks:

These exercises can only scratch the surface of what can be done with the command line and shell scripts. Don't expect everything you've seen today to sink in. Working with command lines takes some getting used to and the best way to learn is by lots of doing. For now, simply take away the ideas of what this environment is capable of.

THIS COMPLETES THE EXERCISES FOR SESSION THREE

5 Using remote computers

Sometimes you will need to access a remote computer. This may be from home to a Department system, or from a desktop computer to a more powerful computer.

Exercise 32 **Setting up access to IT Services Linux system**

First you need to set up access to the IT services Linux system.

Go to https://www.it.ox.ac.uk/ and click on 'Manage Accounts' on the left side of the bar at the top of the page. You will need to use your Single Sign-On (SSO) account to sign on.

You should see a page displaying accounts you can register for and services you can use. In the 'Other facilities available' section, you should see 'Manage linux shell account'.

Click on this link and you should now see the screen to activate the account.

If you are asked to choose a shell, make sure you choose **/bin/bash**. You should then

Exercise 33 **Using ssh**

Now that the account has been enabled, you can log on.

Command	Description
ssh	ssh connects to a different Linux/Unix system.

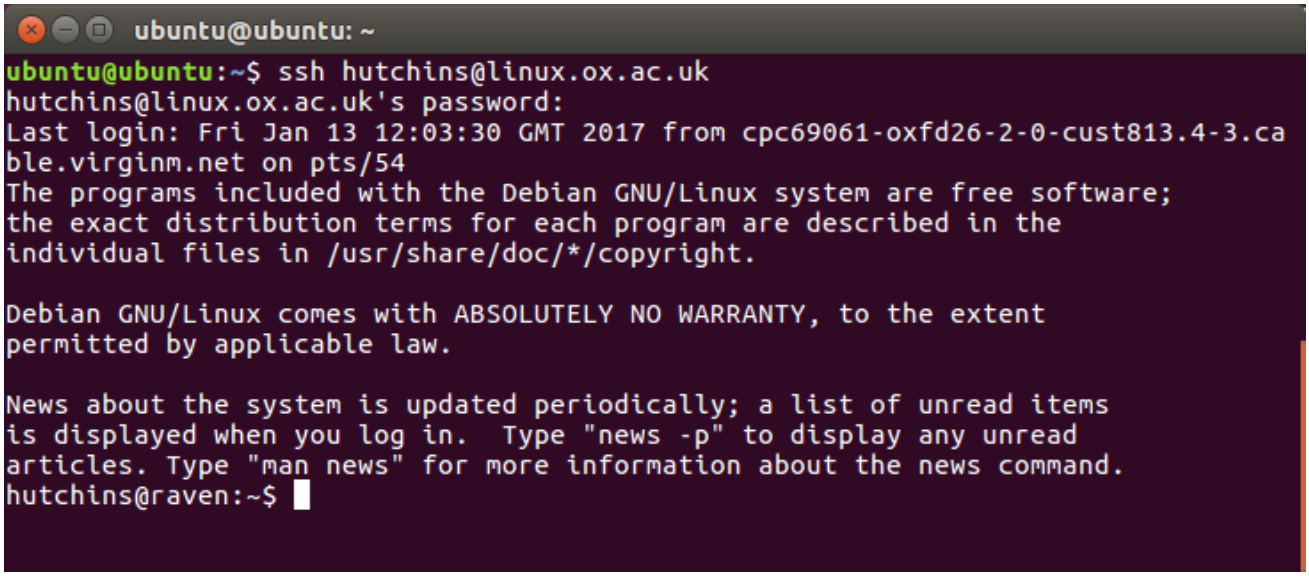
Use

ssh *SSO*@linux.ox.ac.uk

at the login prompt enter your SSO and password. So if your SSO is **coll1234** you would type in

ssh coll1234@linux.ox.ac.uk

You should see a screen like this:



The commands that you have used on the live Ubuntu, will also work on this system, although it is running a different Linux distribution. It is running Debian Jessie.

Use the **cd**, **wget** and **tar** commands from Exercise 14 to download the files to this server.

```
cd
wget https://www.stats.ox.ac.uk/pub/susan/linux/LinuxFiles.tgz
tar -xvzf LinuxFiles.tgz
```

Make sure that commands are behaving in the same way by using examples from previous exercises.

Command	Description
ssh	ssh connects to a different Linux/Unix system. Options used: **-X** Allow X11 forwarding.

It is possible – and sometimes necessary – to open a graphical application on the remote system. To do this logout using

```
exit
```

and log back in again from your local Ubuntu desktop with

```
ssh -X SSO@linux.ox.ac.uk
```

On linux.ox.ac.uk enter

```
xclock &
```

You should see a window like this appear:

Exercise 34 **Copying files between systems**

As well as logging on to remote systems, it is often necessary to copy files and directories from one system to another.

Command	Description
scp	Copy files and directories between systems.

You will need two terminal windows open.

- The local live Ubuntu
- A remote session on linux.ox.ac.uk

On linux.ox.ac.uk, create a new directory to store the files and directories you will be copying.

```
cd
mkdir Copies
```

Use **ls Copies** to make sure it is empty.

Now in the local live Ubuntu terminal type in

```
scp HAYSTACK SSO@linux.ox.ac.uk:~/Copies/.
```

Make sure you type the command exactly as it appears.

The command is quite complex so each component is explained in detail here:

scp command	Description
scp	Copy files and directories between systems.
HAYSTACK	Name of file to be copied.
SSO	Username on remote system. Replace by your single sign-on.
@	Location indicator.
linux.ox.ac.uk	Name of remote system
:	Separator between remote system name and location of file.
~	A short cut which refers to your home directory. Useful if you don’t know the path to your home directory.
/Copies/	The directory where the file will be stored
.	“**.**” indicates that the file will be given the same name as the original.

Now in the linux.ox.ac.uk terminal use

```
ls Copies
```

to make sure the file has been copied.

See if you can copy HAYSTACK from the live Ubuntu session to the same location but with a different name.

See if you can use wild cards to copy all the files beginning foo2 from the Wildcards directory to the same location and with the same name.

Use **`ls Copies`** on linux.ox.ac.uk to make sure the files have copied successfully.

In both cases, see the Answers page for a suggested solution.

Finally, remember that **wget** will download datasets available from the web.

Exercise 35 **Copying directories between systems**

`scp` command	**Description**
`scp`	Copy files and directories between systems. Options used: **`-r`** recursively copy the contents of a directory
`Files`	Name of directory to be copied

On the local live Ubuntu terminal enter

```
cd
scp -r Files SSO@linux.ox.ac.uk:~/Copies/.
```

On the linux.ox.ac.uk terminal check that the directory and contents have been copied.

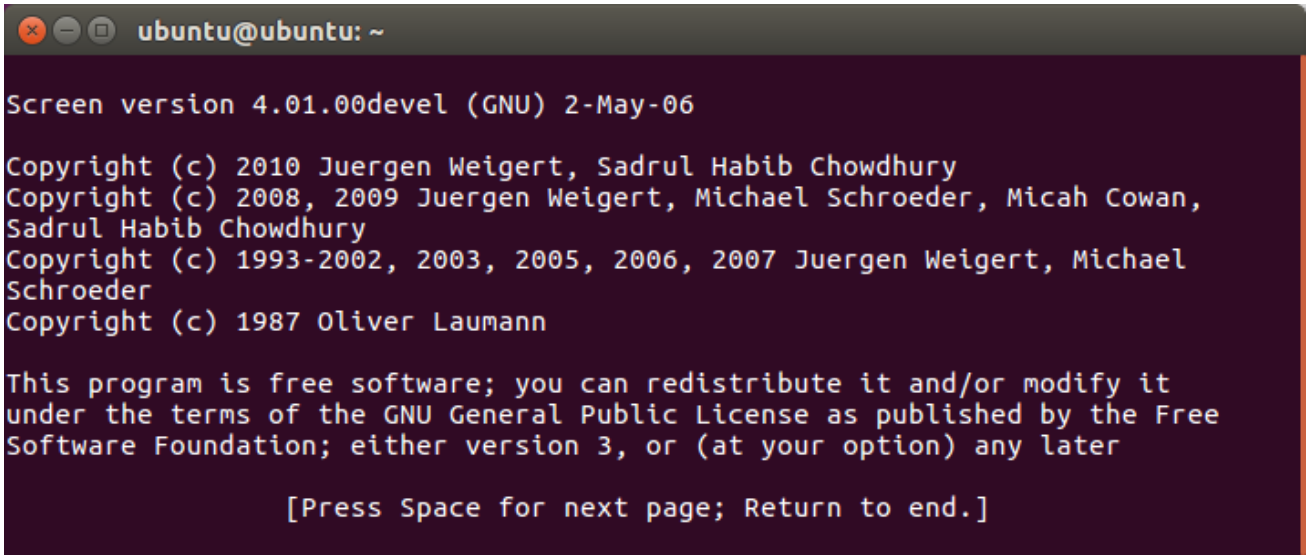
Exercise 36 **Managing sessions on remote systems**

Command	**Description**
`screen`	Connect and disconnect from a session, possibly from multiple locations, and allow long-running processes to persist without an active shell session. Options used: **`-r`** reattach a screen session **`-list`** display all screen sessions

In the linux.ox.ac.uk terminal use

```
screen
```

to start the screen session. You should see a window like this:



Press return and you should see the standard prompt. Now use wget to get the script you will be using

```
cd
wget https://www.stats.ox.ac.uk/pub/susan/linux/my_date.sh
```

Permanently change the permissions, so that the script can be executed.

```
chmod +x ./my_date.sh
```

Have a look at the **my_date.sh** script to see what it does. Don't worry if you can't understand every line.

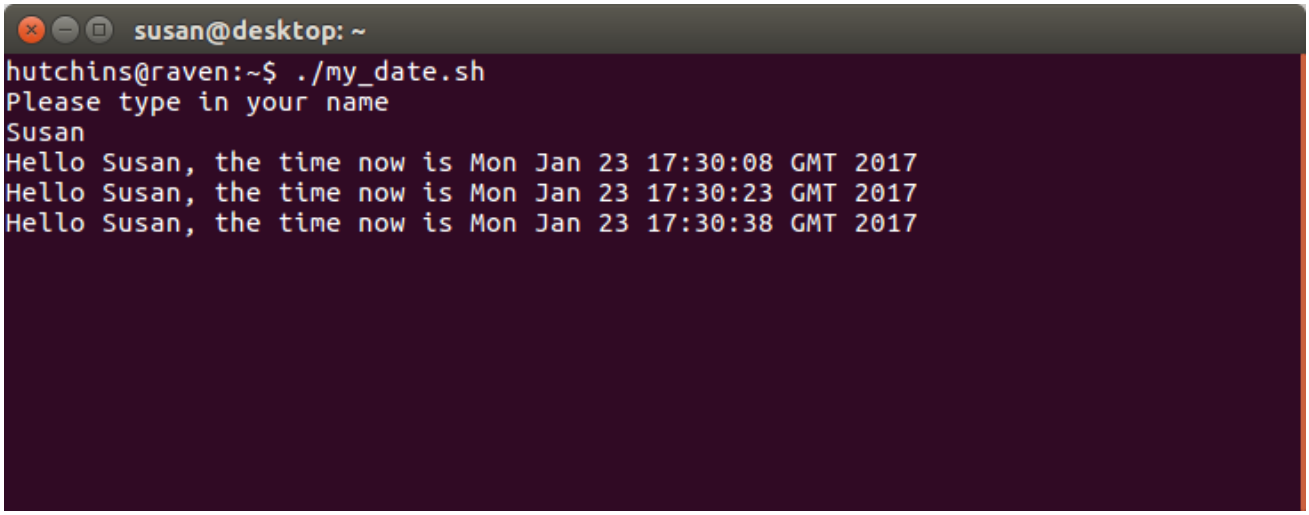
```
cat my_date.sh
```

```
#!/bin/bash
# Ask for name.
# Repeatedly output the name and date, waiting 15 seconds.
# Terminate after 15 minutes.
echo "Please type in your name"
read name
start=`date +%s`
now=$start
while (( (( $start + 900 )) > $now )) ;
do
     echo "Hello $name, the time now is `date`"
     sleep 15
     (( now += 15 ))
done
```

The script displays the date and time every 15 seconds for 15 minutes. Run the script interactively to watch what happens.

```
./my_date.sh
```

Watch the output appearing for a minute or so. You should see something like this:



Now we are going to detach from the screen session so that the script will continue running but we will logout of linux.ox.ac.uk. To detach from the screen session use

```
^CTRL-a d
```

That is, hold down **CTRL** and **a**, then press **D**. You should see a message

```
[detached from XXXX.pts-XX.raven]
```

where each X is a digit.

You can check what screens you have with

```
screen -list
```

and should see something like this:

```
There is a screen on:
     6144.pts-30.raven     (01/23/17 17:29:58)   (Detached)
1 Socket in /var/run/screen/S-hutchins.
```

Logout from linux.ox.ac.uk

```
exit
```

Perhaps from another desktop (swap with your neighbour!), log on again to linux.ox.ac.uk

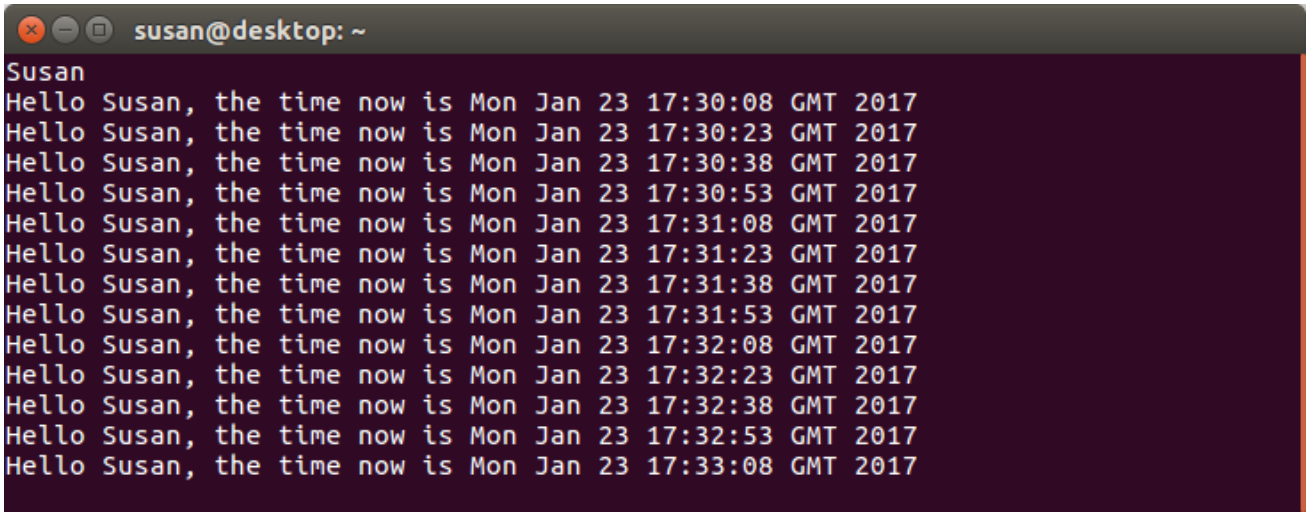
```
ssh SSO@linux.ox.ac.uk
```

replacing SSO by your single sign-on.

Reattach the screen

```
screen -r
```

and you should see the list of times with no interruption.



This is a slightly contrived example. In general output from long running jobs is best saved in a file rather than displayed on the screen, as there limits to the amount of data that a terminal displays. However, the technique for detaching the screen and logging out is the same.

Concluding Remarks:

Accessing remote computers is a common requirement for Linux users. On Windows, a small application called PuTTY provides a secure means for logging on to a Linux system. On Macs, use the terminal window.

6 Answers

Session 1

Exercise 3 Try Dock | Files

Exercise 4 The active application is highlighted in a lighter coloured square. For each open application an orange dot appears.

Exercise 4 Keyboard shortcuts

To create keyboard shortcuts to switch between desktops

1. Open **System Settings | Keyboard**
2. Click on Navigation
3. Scroll down until you find **Switch to workspace 1**
4. Click on Disabled
5. Hold down the **Ctrl** key and press **F1** (on the top lefthand side of the keyboard)
6. Now right click on **Switch to workspace 2**
7. Set this to C**trl** and **F2**
8. Do this for workspace 3 and workspace 4 ...
9. Click on X to save the changes.

   If you now hold down the Ctrl key and press F2 you should switch from Desktop 1 to Desktop 2

Exercise 13 You can also create files in `/tmp`.

Session 2

Exercise 16 Finding a drawing application

This is straightforward:

`apropros draw`

lists several possible matches. The most useful is

`lodraw (1) - OpenOffice.org office suite`

If you enter **`lodraw &`** on the command line the application will start.

Exercise 17 Reading a file called *star

`cat \*star`

`cat “*star”`

are both possibilities. A \ (backslash) is an escape character which stops the star being interpreted as a wildcard. Surrounding file names that contain special characters with quotation marks often work. There may well be other ways to do this.

Changing to a directory called Open This.

cd ..

cd Open\ This

but again there will be alternatives.

Reading a file called `-ReadMe`. Again there are lots of possibilities

cat ./-ReadMe

cat -- -ReadMe

both work. In the first suggestion (**cat ../-ReadMe**) using a relative path overcomes the problem of the leading dash; in the second (**cat -- -ReadMe**) the cat command is given an extra option of two dashes which alerts it to the fact that the filename starts with a dash. Both these options work with the more and less commands too. Similarly to delete the file use

rm -- -DeleteMe

rm ./-DeleteMe

Excercise 19 Wildcards

ls foo? matches

foo1 foo2

ls foo2* matches

foo2 foo20 foo2bar

ls foo[1-2] matches

foo1 foo2

To match just the files `foo20` and `foo2bar` use

ls foo2?*

To use wc -l just to display the files with a 1 in their name.

wc -l *1*

Exercise 20 Searching and sorting

Use **grep -i melon *file*** to find all occurrences of melon whatever the case.

Use **sort -r fruit veg** to reverse the order of the sort.

Exercise 22 Finding the largest file

Use **du -sk /usr/bin/s* | sort -n | tail -5** to find the 5 largest files beginning with 's'.

Exercise 23 Merge information from different files

awk '{print "A", $2, "eats"}' creatures | paste -d" " - veg

Session 3

Exercise 26 Simple regular expressions

```
grep -n -E ^needles$ HAYSTACK
```

will find all lines with just one occurrence of the word needles with no white space either before or after. We'll look at how to match white space in the next set of exercises.

Exercise 27 Regular expressions with spaces

No matches are found, because this search is looking for matches where needles has characters both before and after it - hayneedleshay for example - and there are no instances of this in HAYSTACK.

Exercise 32 File manipulation scripts

```
cp $1$n $2$n.`date +%d%b%y`
```

Session 4

Exercise 35 Copying a single file between systems

```
scp HAYSTACK sso@linux.ox.ac.uk:~/Copies/HAYSTACK2
scp foo2* sso@linux.ox.ac.uk:~/Copies/.
```

Copyright

Acknowledgements

This course was originally developed with Jon Lockley.

Version information

Minor updates – replace Usenet with StackExchange	May 2014	SRH
Updated for Ubuntu 14.04 (Trusty Tahr)	Sep 2014	SRH
Minor corrections	Jan 2015	SRH
Minor corrections and checking. Regular expressions.	Nov 2015	SRH
Major changes to Section 4: replaced software installation with remote access to linux.ox.ac.uk.	Apr 2016	SRH
Added branded front page	Jan 2017	SRH
Corrections for 2017-2018	Apr 2017	SRH
First section rewritten for Bionic Beaver, 18.04	Sep 2017	SRH
Typos fixed immediately after MT2018 presentation	Oct 2018	SRH
Updated footer for HT 2019	Jan 2019	SRH
Minor corrections TT 2019	Apr 2019	SRH

Computer platforms: Linux: a comprehensive introduction

Susan Hutchinson
susan.hutchinson@stats.ox.ac.uk

MT 2018

Your safety is important

- Where is the fire exit?
- Beware of hazards:
  - Tripping over bags and coats
- Please report any equipment faults to us
- Let us know if you have any other concerns

Your comfort is important

- The toilets are along the corridor outside the lecture rooms.
- The rest area has vending machines and a water cooler.
- The seats at the computers are adjustable.
- You can adjust the monitors for height, tilt and brightness.

Session 1
Introducing the Linux desktop

IT Services Linux Courses

Today's course is divided into four parts each consisting of:

- A short presentation.
- Exercises.

The four parts are

- Introducing the Linux desktop.
- Simple use of the command line.
- Further use of the command line and shell scripting.
- Using remote computers and managing your own computer.

If you are comfortable using office applications, browsing the web and using email then this course aims to show that you can use Linux without too steep a learning curve. The first two sessions focus on the similarities between Linux and other operating systems such as Windows and Mac OS.

In the remaining sessions we start to explore the differences between Linux and Microsoft Windows. The course demonstrates many powerful features that have no equivalent in Windows.

Session 1

- What is Linux?
  - Open source and why it is important.
  - Where it came from and how it is made.
- What is Linux used for?
- How to get Linux.
- Linux office applications.
- Your questions and a practical session.

How Linux changed things

- Linux does not come from a single large corporation.
- It offers an alternative approach.
  - Freedom of choice.
  - Freedom to understand and change.
  - Software written with quality rather than profit as a goal.
- Competition and alternative approaches benefit users and consumers.
  - Software developments: firefox for example.
  - Increased awareness of open standards by Microsoft.
  - Easier to work using different systems.

Let's take the example of browsers. Internet Explorer is now quite a good browser, but it needed Firefox – and now Google Chrome – to make this happen. For example, would tabbed browsing have been added to IE without Firefox? Furthermore, issues around security in browsers have been hugely improved. In this case competition has improved the experience for everyone.

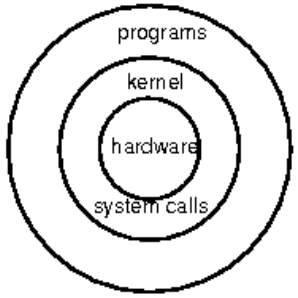
What is Linux?

Linux is an operating system designed by Linus Torvalds in the early 1990s.

An operating system protects the user from the hardware and vice versa.

An operating system has several parts:

- kernel
- system calls
- programs



Other Operating Systems include

- Windows (7, Vista, XP, 2000, 95)
- MacOS
- Unix

The Operating System manages resources such as the processor, disks and memory, and provides a consistent interface through system calls for application programs. This means that application developers do not need to know details of the hardware.

An amusing analogy to give you a flavour of different operating systems is "If Operating Systems Ran Airlines". Enter this into a search engine to find out more.

Linux is related to Unix and certainly appears very similar but works rather differently underneath.

There are other free Unix operating systems if Linux doesn't appeal: see www.freebsd.org for example.

Who makes Linux?

Linus Torvalds created the first Linux kernel in August 1991:

"Hello everybody out there using minix-I'm doing a (free) operating system (just a hobby, won't be big and professional like gnu) for 386 (486) AT clones. This has been brewingsince april, and is starting to get ready."

Text of original email from Linus to the comp.os.unix newsgroup sent on 25 August 1991.

Linus Torvalds developed the first versions of Linux because he wanted to run a Unix-like system on his home PC. This version of Linux did little more than allow Linus to log onto his university's system to check his email. However the project quickly grew into a full operating system kernel and Linus published it as an open source project.

A good book about the early history of Linux is *Just for fun* by Linus Torvalds and David Diamond, pub. Harper Business (2001).

How is Linux developed?

Linux is maintained and developed both by businesses and private individuals.

- Hundreds are involved in work on the Linux kernel.
- Thousands work on the applications which come with Linux distributions.

It is known as open source software.

Linux or GNU/Linux?

- Linux is the kernel.
- GNU is the project to create a Unix-like operating system.

GNU stands for **G**NU's **N**ot **U**nix (terrible Unix joke).

A comprehensive description of the case for open source software and the problems with closed source software can be found in the book *The Cathedral and the Bazaar* by Eric S. Raymond, O'Reilly (2001). The book is also available online. Raymond is a well-known open source advocate so some sections of the book reflect his strongly held views but as a whole the book does make a good case for open source.

Alternatively www.fsfeurope.org will tell you more about free software.

There is more information about GNU, its relationship to the Linux kernel and the GPL (General Public Licence) at www.gnu.org .

GPL is the standard licence for most releases of free, open source software. Several different notions of freedom are incorporated in the idea – freedom to change, freedom to understand, freedom to distribute.

One very important point to remember is that all Unix jokes are truly awful.

What is open source?

```
while(fscanf(fd, "%f", &y)
==1){
     n++;
     sum += y;}
if (n > 0)
     (void) printf("The MEAN
    is %f\n", sum/n)
```

→ Compiler →

```
11001010110110
10010011101010
10010000110101
01011010010100
11010101001011
```

The source code written by the programmer

The binary (or executable) which you run

Open Source means:

- We can see binary and source.
- We are encouraged to read and understand source code.
- We can debug and recompile source.

Closed Source means:

- We are only given binaries.
- We cannot read source.
- We cannot recompile code.

In Windows .exe files contain machine-ready instructions. In Linux [and Unix] these sorts of files are called binaries (although they are usually executable). This is because there are also human readable executables or “scripts” which are lists of commands. Further Linux [2] looks at scripts.

What are the advantages of building software from source? When you are provided with only the binary you can be sure that it wasn't built on your machine. Building your own binary from source means that you can specify that it should be optimised for your own hardware and customised with features that are or are not needed.

If something goes wrong you could debug the software – or at least get someone else to do it for you. You can also change the way it works if it only nearly does what you need.

But you don't have to!

What is Linux used for?

Linux was originally designed for desktop use but this did not make a significant impact on the market.

Linux did quickly gain a large following for

- Servers – for example, web servers
- Internet services (DNS, routers etc)
- Programming
- High performance computing

Significantly improved user interface and economic advantages mean that Linux is gaining popularity on the desktop.

Much of the University infrastructure, particularly at IT services, is based on machines running Linux. IT services organise a tour of the machine room every year and you'll find a penguin badge on most things.

The web also relies heavily on Linux – many web servers are Linux based machines.

Linux desktop systems were very poor compared with commercial alternatives until a few years ago. This made it unlikely to appeal to non-technical users who were using MacOS or Windows. Linux also lacked any good office software. Both of these areas – as we hope to demonstrate – have now been addressed very successfully. However this has left a legacy: Linux still has the reputation of being hard to use.

Getting Linux

The easiest way to get Linux is to download or to buy a “distro” or distribution.

A distribution = a kernel + applications + installation software+ support + documentation.

Typical applications are

- Office software
- Databases
- Programming languages and tools
- Web browsers
- Email readers
- Internet services (www, DNS, NIS, firewalls)
- Games

Most distros come with a version number – for example Fedora 28 or OpenSuse 18.04 but they are not particularly significant. When acquiring Linux the important thing is to find out what version of the kernel is supplied and what versions of software are included. It is simple – with Internet access – to upgrade to the latest version but it is good to start with relatively recent versions.

Current kernel versions are 3.16.x, 4.14.x, 4.18.x

- Office software might be LibreOffice or Calligra
  - Databases might include mySQL
  - Programming languages should include C, C++, Fortran, Perl and Python
  - Web browsers might include Opera, Mozilla Firefox, Midori and Chromium
  - Email readers might include Mozilla Thunderbird, Kontact, Gnome Gmail

Generally, Firefox and Thunderbird, the browser and mail reader from the Mozilla stable are included. Both of these are also available from www.mozilla.org and have versions for Windows as well as Linux.

Linux distros

The two big distros are RedHat/Fedora and Suse:






Debian

Mint

Mepis

Slackware

Mageia

arch

There is no technical reason why a RedHat, Fedora or openSuse (now owned by Novell) installation cannot be done at home. However, in recent years both distros have changed their product lines to focus more on the business user. RedHat are also involved with a free distro called Fedora which is now stable. There is also another distro, CentOS, which is based on RedHat.

Of the other free distributions Debian is the most mature and stable but is not recommended for the newbie (beginner in Linux-speak). Debian variants like Ubuntu are more friendly. Mandriva, Mint and particularly Ubuntu are all aimed at the home user and are a good place to start if you want to try linux at home.

Free Linux distros can be downloaded from www.linuxiso.org .

See http://distrowatch.com/ for a discussion on recent Linux developments.

Ubuntu

For this course we will be using the Ubuntu distro

This version of Ubuntu is a special kind of Linux known as a "Live" system and has two significant features:

- It runs from USB.
- The hard drive is not touched.

It's safe to run this on a Windows system without installing or changing anything.

Ubuntu is a Debian-based version of Linux, providing a simple desktop and straightforward installation. We are using Ubuntu 18.04 LTS (Long Term Support, Bionic Beaver)

We are using Live Ubuntu for this course because it does not change or use the hard drive and so IT Services does not have to rebuild machine especially for this course. This also means that you can try this version of Ubuntu at home safe in the knowledge that is very, very difficult to damage your machine or the data you have on your disk.

The disadvantage of live systems is that it is more fiddly to save data permanently because the hard drive is not easily accessible. However some people find live Ubuntu and a USB memory stick a very useful combination. The slides and exercises were prepared like this. Often, you will need to install software as there is only a limited range on the USB.

If you decide that you like Linux it is better to install a more permanent version on your hard drive.

To download Ubuntu go to http://www.ubuntu.com. We are using Ubuntu 18.04 LTS (Bionic Beaver). LTS versions will continue to get updates for 4 years after release, other releases need upgrading after about 1 year.

Linux and Windows

- You can install Linux on your PC without removing Windows (or any other operating system).
  - At boot, choose which to use.
  - Could use emulation software (VMWare, wine).
- Can share devices using samba.
- Linux will read most Windows file systems.
- Windows won't support Linux file systems.

Because Windows is still the dominant desktop system Linux works hard to support Microsoft standards so that Linux and Microsoft users can work together.

VMware creates a virtual machine which can run binaries for the operating system it emulates. You can run a virtual Windows machine under Linux or the other way round. VMware is not free or open source.

Wine is an open source copy of the Windows system libraries which allow many Windows .exe files to run under Linux. Many software packages run faster under Linux+Wine than under Windows!

WineX is a more powerful but not free version

Oracle (formerly Sun) provide an open source product, VirtualBox which is becoming increasingly popular.

Office applications

Desktop Environments

- Desktop systems in Linux come with a variety of desktop environments.
- Provide an easy to use graphical use interface or **GUI** based on the X window system.
- Choice: KDE or Gnome are the most widely available.
- Generally they provide very similar functionality.
- Competition has produced two very usable solutions.

If you are comfortable using office applications, browsing the web and using email then this course aims to show that you can use Linux without too steep a learning curve. The first session starts by focusing on the similarities between Linux and other operating systems such as Windows and Mac OS.

In the remaining sessions we start to explore the differences between Linux and Microsoft Windows. The course demonstrates many powerful features that have no equivalent in Windows.

Unix systems have had a graphical user interface for some time but these have been largely proprietary. Clearly the GNU/Linux project needed an open source desktop environment that would provide an intuitive user interface.

A graphical user interface comprises two components: the X window system which is very loosely analogous to the kernel and a choice of desktop environments which provide the user with the familiar windows, menus, backgrounds and so on.

LibreOffice and Microsoft #1

- LibreO ce runs on Windows just as well as on Linux and Unix.
- LibreO ce supports all Microsoft data formats.
- LibreO ce o ers almost all the functionality that Microsoft o ce does (a few fancy bits might be missing).
- LibreO ce was far more standardised than Microsoft O ce but the latest version of Microsoft O ce does allow you to save les in an open standard (XML) format.

Most Unix users used (and Mathematicians still use) TeX and LaTeX (the X is pronounced to rhyme with “ch” as in loch) to produce documents. These are very powerful typesetting tools and give far more control than word processors. They are excellent for writing theses, books and papers, particularly those with formulae and pictures but not suitable for short documents and letters. They also have a slide-making environment which is fairly simple to use simply but can be rather difficult to use for complex presentations.

There were other typesetting programs such as nroff/groff/troff which were used for creating manual pages. As you may now predict there are a range of packages available which provide office productivity tools. These usually include a document creator (or word processor), a spreadsheet, a tool for creating presentations and a drawing package.
Microsoft files do not always read perfectly in LibreOffice. Microsoft – as is their right – do not reveal how data in MS files is formatted and these formats are changed from time to time. This means that LibreOffice software developers have to respond to these changes and “reverse engineer” files in order to code software to read files. Clearly not sharing document formats is a good way to make the development of other office software more difficult...

Generally I find that LibreOffice files are substantially smaller than Microsoft files.

More recently Microsoft have started to use some open standards and it is possible to save Microsoft documents in XML.

LibreOffice and Microsoft #2

Microsoft O ce products and their LibreO ce equivalents:

Microsoft Word	=	Writer
Microsoft Excel	=	Calc
Microsoft PowerPoint	=	Impress
Microsoft Paint	=	Draw

All of these applications are installed in Live Ubuntu. The word processor, spreadsheet and presentation software can be found are all available from the Dash and the draw application can be found by clicking on the Dash icon and searching for Draw.

Getting help

Getting help with Linux questions can be di cult so it helps to know where to look. The sites I use often are:

- StackExchange – a network of community-managed sites providing expert answers to questions.
- Google – particularly when I have an error message I don't understand.

StackExchange provides a useful source of source of support. It is a gateway to a network sites answers to questions. Anyone can ask a question and anyone can answer the question, which are are ranked and rated. All sites are moderated so that the content is generally reliable.One useful feature quoted on the 'About' page is: “Stack Exchange is not the place for conversation, opinions or socializing”.

The command line

Why use the command line?

- How does the command line work?
- What is a shell?
- Some simple commands.
- Files and directories.
- Hints and tips for file names.
- Getting help.

The command line

- A graphical user interface (GUI) is available in both Windows and Linux.
- The command line is often unfamiliar to Windows users.
- Compare Windows and Linux when reading a PDF file or starting a browser.
- Either double click on the icon or enter the command

```
evince file.pdf &
firefox &
```

We have now spent some time looking at the Ubuntu Graphical User Interface. We will now focus on the command line. This can seem an unfamiliar place for Windows users.

For example when reading a PDF file in Windows you will either click on the picture or open the application from the start menu and browse to the file. In Linux you are just as likely to enter

evince *filename*

on the command line. Similarly the mozilla browser can be started by entering

firefox

When you execute a command that opens a new window it is customary to include the ampersand character - **&** - before pressing enter. This allows you to continue using the terminal window. So

firefox &

The & is only necessary when the command opens a new window; you don't need it for other commands.

How commands work

A command at its simplest is of the form:

command

Often commands require an argument such as a file name

command *file*

Some examples are

date	[to display the time and date]
gedit *newfile*	[start the **gedit** editor to change the file *newfile]*

This is the format of many commands.

It is also possible to modify the behaviour of a command using options. So for example the command **ls** on its own will display the name of all the files in a directory.

ls

By including options you can display details about the size, last changed date and access permissions of a file and many many other details. Options are specified by a hyphen and a single character so

ls -l

would give a long listing. This is something of a simplification but will do for now.

Speeding things up

Surely all that typing can't be right! How can we speed things up?

Filename and command completion:

- <tab> key completes commands and filenames

What else can we do to save typing?

- arrow keys allow us to:
  - recall previous commands
  - change previous commands

The shell is the command that interprets the commands we enter. As you might expect there are many different shells. We will be using the bash shell.

There are many shortcuts that allow you to use the command line more efficiently. For example, the tab key can be used to complete both commands and filenames. If you enter the command

ev

and then press <tab> once you should hear a beep. That's because there is more than one command beginning with **ev**. Pressing <tab> twice in quick succession should display a list of commands beginning with **ev** . If you then enter the letter i so that you have evi and press <tab> again the command **evince** should appear.

Upper and lower case

Case sensitivity

- Linux commands and filenames are ***case sensitive***:

  BIG is different from **big**.
- Almost all commands use ***lower case***.
- In Windows case is not significant. If you save a file as big.doc, type in BIG.DOC and Word will find it.
- However, if you are working with files in both Linux and Windows you need to take care: Windows will see BIG.DOC and big.doc but can only use BIG.DOC.

Guidelines for file names: don't include:

• spaces • * and ? • hyphens • / and \

One significant difference between Windows and Linux is that Linux is case sensitive. This means that a files called

big
Big
BIG

are all different files. In Windows this is not so. This difference is important if you are sharing information between Windows and Linux.

As we have seen Linux commands use a space as a separator between commands and files. This means that spaces in file names can cause problems. How would you read a file called **My File**? For similar reasons, hyphens (-), slashes (/) and backslashes (\) are best avoided in filenames.

Two things Linux does better

... in my opinion!

Multiple desktops

- reduce clutter
- organise work logically

Flexibility

- better organised desktop
- powerful command line
- choice of many applications

Most distros come with a version number – for example Fedora 18 or Ubuntu 12.04 but they are not particularly significant. When acquiring Linux the important thing is to find out what version of the kernel is supplied and what versions of software are included. It is simple – with Internet access – to upgrade to the latest version but it is good to start with relatively recent versions.

Current kernel versions are 2.6.x and 3.5.x.

Office software might be LibreOffice or Koffice.
Databases might include mySQL.
Programming languages should include C, C++, Fortran, Perl and Python.
Web browsers might include Opera, Mozilla, Netscape and Konqueror.
Email readers might include mutt, pine and evolution.

Also look out for Firefox and Thunderbird, the browser and mail reader from the Mozilla stable. Both of these are available from www.mozilla.org and have versions for Windows as well as Linux. Finally the google chrome browser is also widely used.

Exercises for Session 1

The aims of these exercises are:

- To look at the desktop.
- To explore some components of LibreO ce.
- To take a rst look at the command line.
- Please feel free to:
- Ignore desktop exercises which are not relevant your work.
- Try to do the tasks in LibreO ce that you do with Microsoft O ce.

You can download LibreOffice free from www.libreoffice.org/download/ .

OpenOffice is available from www.openoffice.org.

Session 2
Using the
command line

Session 2

We're now going to look in more detail at the shell and the command line

- What is the shell?
- Navigation – how to move around.
- More advanced use of commands.
- Pipes or how to build your own commands.

Shells

A shell sits between the user and the kernel.

There are several ways of using shells:

- Graphical desktops (indirectly).
- Running applications (indirectly).
- Command line interface (directly).
- Scripts (directly).

- There are different shells available for Linux
- The default shell in Linux is called BASH.

You may not realise it, but when you are using the graphical desktop that it is merely a collection of applications running on top of a shell.

What we are going to look at today are ways of interacting with shells in a more direct manner.

Unix/Linux commands

We can interact directly with a shell with a *shell prompt* aka the ***C**ommand **L**ine **I**nterface*

The UNIX Philosophy: commands should

- do only one small task;
- do it quickly;
- do it quietly and don't ask for confirmation.

If a new requirement arises start again - don't add features to an existing command.

Advantages and disadvantages with this approach:

- Many commands so each is small and simple.
- A lot to remember.

Most of the commands available on early Unix systems are still used today, as well, of course, as many new ones that have since been added.

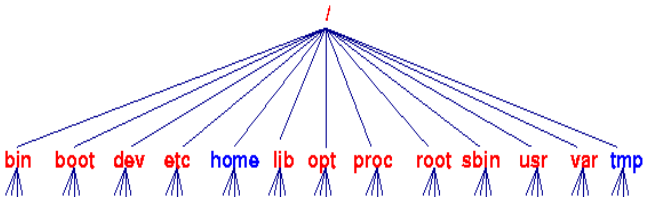
Unix commands tend to be small and have a single function. This means that there are a lot of commands to remember. Another side effect of the long history is that there is generally more than one way to achieve the end you want. Often there is no correct solution although some are neater than others.

It might also seem that giving commands a deliberately obscure name is part of the philosophy. I'm not so sure about that - generally there is an explanation for the name of a command although it isn't always immediately apparent. Believe it or not there is a sensible explanation for why the commands **cat**, **grep** and **awk** are so called!

Files and directories

We can use commands to explore the way Linux locates and stores les.

A Linux system looks a bit like a tree. Here's and example of the top (or bottom) layer:



Linux, like Windows, stores files in a hierarchical way with files stored within folders (except in Unix and Linux we call them directories). You can also have directories within directories.

In Linux and Unix, everything starts at a single place called "/" or sometime, the root. Some people think of root as the top of the structure, some as the bottom. This is unlike windows where there might be a C:, a D: and an E: for example.

In the above diagram you can see that / is itself a directory (it has to be to hold the rest of the file system) and contains a number of directories. I've marked those typically belonging to the "system" in red and those you often store files in in blue.

A digression on paths

Paths describe the location of a file in the filesystem. There are three sorts of paths:

- simple a file or directory name

  newfile

- relative a reference to a file or directory from the current directory

  ../tmp/newfile

- absolute a reference that will work anywhere

  /home/ubuntu/Desktop/tmp/newfile

Linux, like Windows, organises files in a hierarchical directory structure. There are some minor differences: the directory separator in Linux is / whereas in Windows it is \.

Files can be reference in three ways. If, for example, there is a file called **myfile** in your home directory

/export/home/student/username

you can use more to view it in three different ways:

```
more myfile

more ./myfile

more /export/home/student/username/myfile
```

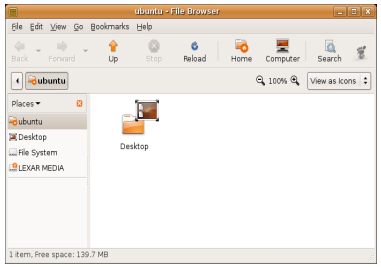
The first is a simple path, the second a relative path and the third a direct path. In the first case you need to be in the same directory to see the file, in the second you indicate the location in terms of where you currently are and in the final case you will be able to see the file from wherever you are.

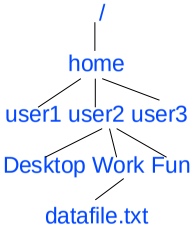
Commands and navigation

The file browser moves you around the system and manipulates your files.

Can use **commands** instead

- **cd** = change directory
- **ls** = list files
- **cp** = copy
- **mv** = move
- **pwd** = where am I?
- **mkdir** = make new directory
- **rm** = remove file
- **rmdir** = remove directory





Learn to navigate up and down directories

You'll probably be used to navigating though a file system with a graphical interface like Internet Explorer. The File Browser serves a similar purpose. The difference is that IE is regarded as an integral part of the Windows OS. The File Browser on the other hand is "just another application" which you can easily remove and do without. The dependence of Windows on big, complex tools like IE is one of its major weaknesses.

Where UNIX **relies** on tools (commands) to do things, it demands they are small and simple.

Note the typically terse names of the Linux commands. They are usually short for something (pwd is short for **p**rint **w**orking **d**irectory for example).

Finally … some commands

Orientation and navigation or where am I and where do I want to go?

- **pwd** [**p**rint **w**orking **d**irectory]
- **cd** *directory* [**c**hange **d**irectory]
- **cd** [go to your home directory]
- **cd ..** [go up one directory]

You can explore the directory hierarchy using

cd ..

to move up to the next level and

cd

to return to your home directory. Your home directory is where files you create are stored and where you start each new session. Your home directory will be something like

/homes/*username*

or

/home/ubuntu

… and more …

File and directory manipulation

- **ls** list files in a directory
  - **ls -a** list all files in a directory
  - **ls -l** display a long listing
  - **ls -la** display a long listing of all files
- **mkdir** *directory* create a directory
- **rmdir** *directory* delete a directory
- **cp** *file1 file2* copy file1 to file2
- **rm** *file* delete a file
- **mv** *file1 file2* move file1 to file2

… and more

There are several ways of looking at the contents of a file:

cat *file* look at the contents of one or more files.

more *file* look at the contents of a file at the end of each screenful.

less *file* like **more** only with more options.

Some other commands

du -sk *file* find out the size of a file

Sort sort the contents of a file, line by line

The **cat** command is said to be named after the verb concatenate as it can also be used to concatenate several files into one. The command displays the contents of a file on the screen. It is only really useful for small files.

more displays a file, pausing at the end of each screenful.

<space>	moves to the next page
q	quits at any time
<return>	moves on a line

less has all the above options and several more. One useful one is

G	move to the end of the file

Other commonly used commands

man get help with a command

whatis short description of a command

lp print a file

Some more powerful commands

find find files matching pattern

grep search for a pattern in a file

wc report the number of characters/words/lines

find . -mtime -5 -exec grep -i statistics {} \; -ls

We will be looking at more complicated commands next session.

The **man** command is particularly useful for finding out all the available options in a file. So

```
man ls
```

will give you a vast amount of information on **ls** including the options. If you are not sure of the name of a command but know what it does then you can do a keyword search with the **apropos** command. If you can't remember what a command does then use

```
whatis ls
```

The commands **find** and **grep** are particularly useful. **find** can search down through directories looking for files matching a given condition such as all files changed within the last 7 days. **grep** will search a given file for a particular pattern. The two commands are often used in conjunction like this

```
find . -mtime -7 -exec grep -i hello  {}\; -ls
```

It has to be said that the syntax is obscure but this command would search all files changed in the last 7 days containing the string “hello”.

What is a file?

In Windows, files:

- Usually include formatting and application information.
- Are used by only one application.
- Have a suffix (part of the name after the .) that determines what sort of file it is.

In Linux, files:

- Are often plain text.
- May be manipulated by many applications.
- Don't need a suffix to determine their type.

A file in Windows is usually (but not always) closely linked to an application. So a .doc file is considered to be a Word document, a .xls file an Excel spreadsheet and so on. Although we cannot see it, a lot of information about the file and the application that runs it is included in the file.

In Linux, files often contain only plain text. When you look at the contents of the file you see all there is. Files are not linked so closely to one application: a file can be viewed, changed and compiled or printed by several different programs.

Wild cards and globbing

This slide could be called file name expansion!

The most commonly used special characters to represent parts of a filename are:

- ***** matches none or more characters
- **?** matches a single character
- **[ ]** matches any characters in a given range
- **[!]** matches any characters not in a given range

So to list all files whose name ends with .txt use

```
ls *.txt
```

The use of wildcards is another way that the shell makes specifying filenames more efficient. So

`ls *.txt`

will match all files ending in .txt. So important.txt, 123.txt, .txt would all be matched but data.txt.1 would not.

`ls ?.txt`

will match all files with a single character before the .txt. So this would match 1.txt, A.txt, +.txt but not 12.txt and so on.

`ls [a-z].txt`

will match all files of the form a.txt, b.txt, ... z.txt. Note, too that wildcards can be used together so

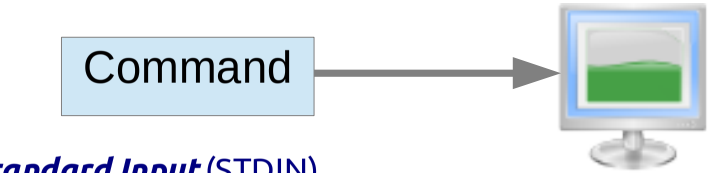
`ls [a-z]*.txt`

will match all files beginning with a-z and ending with .txt and containing any characters in between.

Standard input and output

Linux commands make use of the concepts of

Standard Output (STDOUT)



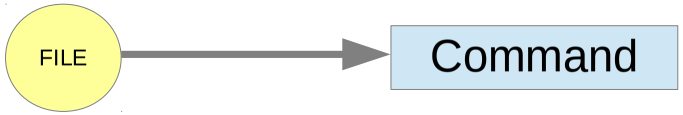
Standard Input (STDIN)

Linux commands can make use of special data streams to move input and output to and from the command. STDIN can be though of as a gateway into the code, STDOUT is a gateway for output. Note that there is a third standard data stream called STDERR (standard error) which commands often use to print error messages and warnings. We won't mention STDERR again today. By default STDOUT gets routed to the screen display. It is also easy to connect a commands STDIN to the keyboard device for example. The STDIN allows a program to ask you questions and you can type responses.

Redirection

Linux can redirect standard output to targets other than the display such as files by using the **>** character.

Or take input from sources other than the keyboard by using the **<** character.



Redirection is a way of “grabbing” STDOUT or STDIN and forcing it to go somewhere other than the default. The most common instance is to redirect STDOUT into a new file. This is extremely useful because it means you can run a command and save the results automatically. To redirect STDOUT use the “>” symbol followed by the target so **command > file.txt** redirects the output from command into a new file called file.txt. To redirect STDIN into a command use “<” like this: **command < file.txt** .

Pipes

If commands use STDIN and STDOUT, is it possible to connect the STDOUT from one command to the STDIN of another?

YES – use pipes: **|**

A simple example

```
du -sk /usr/bin/* | sort -n | tail -5
```

displays the five largest files in the /usr/bin directory

Connecting commands together with pipes is one of the most powerful features of Linux. Linux does not have a command to count the number of files in a directory but it does have one command to list the files (ls) and a second command (wc) to count the number of lines in a list.

You could therefore use a pipe (|) to glue **`ls`** and **`wc`** together:

```
ls | wc -l
```

Note that we are using the **-l** (that is a hyphen followed by the lower case letter l) argument or option for **wc**. To get information about any command use

```
man command
```

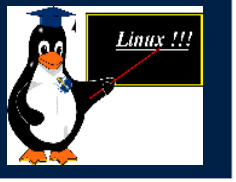
eg

```
man wc
```

Exercises for Session 2

- Using the command line to find your way around.
- Using commands to manipulate files.
- Getting help.
- Using wildcards to match files and directories.
- Searching and sorting.
- Pipes and redirection.
- Building your own commands.

Session 3
Editors,
regular expressions,
shell scripts



Text Editors

Many files in Linux are in plain text format:

- Configuration files.
- Shell programs.
- Manual pages (although sometimes stored in compressed format).

So we need a utility which to let us change text files.

- emacs, xemacs
- vi, vim
- gedit, pico, nano

Common to run an editor in the ***background*** [demo]

The choice of text editors provokes almost religious feelings among some Linux users. There isn't a “right” editor to use. Generally a graphical editor like **gedit** or **emacs** is the friendliest to use. Editors like **vi** are considered much less friendly, but are much quicker for small quick changes to a file.

Putting something into “background” means it continues to run, but is hidden away behind the scenes and is not interactive like a foreground job. Adding an ampersand after a command makes it run in the background. This is useful for scripting because otherwise, you would have to close **gedit** every time you wanted to stop and try your code out. By putting **gedit** in background, you can still use your command line at the same time.

Controlling the command line

- Use **&** to run commands in the background.

  What happens if you forget?

- There are control-key commands which allow you to to manipulate the command line:

CTRL-C interrupt a running program.

CTRL-D send an end of file, ending text input for most Linux/Unix programs.

CTRL-Z suspend a running program.

These are very useful ways of breaking out of a command that looks stuck. For a full list see http://web.cecs.pdx.edu/~rootd/catdoc/guide/TheGuide_38.html

Note that CTRL-C can also be used for copying information. This can cause confusion.

Some editors

vi – visual editor, now often known as vim (vi improved).

- Very fast, supports regular expressions and a relatively small but powerful command set.
- Almost all beginners nd it di cult to learn.

GNU emacs - “extensible, customizable, self-documenting real-time display editor”.

- It is an “ integrated environment”: so can do much else apart from editing.
- It is aware of what sort of le you are editing, so particularly useful for editing programs and scripts.

vi (pronounced vee-eye by purists) can be considered the first real screen based editor. Before that we used editors which allowed you to alter only a single line at a time. This was very difficult!

vi is a “small” editor; that is it has relatively few commands and, in line with much Unix philosophy provides a single, specific function. There is no spell checker or paragraph filler as these features are provided by other commands.

It is however not particularly intuitive to use and initially needs some effort to understand.
emacs (properly GNU emacs) is a very powerful editor. What does powerful mean here? The editor has many features and indeed is sometimes referred to as an integrated environment rather than just an editor. As well as editing files it is possible to read and send email and compile and run programs from within emacs. It is also highly customizable.

emacs is initially easier to learn than vi but its size and complexity can mean it is easy to get overwhelmed by choice.

gedit

GNOME **Edit**or is widely available in Linux

Simple text editor for the GNOME desktop.

- Intuitive – similar to notepad.
- Supports tabs so several les can be edited at once.
- Context aware – highlights syntax.

But if you are familiar with another editor do use that.

gedit is a widely-available and simple-to-use text editor. It has fewer extra features than **emacs** and is easier to get started with than **vi**.

It is possible to add plug-ins to increase the flexibility and features available in gedit. Use

Edit -> Preferences -> Plugins

to find out more.

Regular expressions

What is a regular expression?

- Searches for string patterns within text les.
- Uses metacharacters to extend a pattern.

Examples:

grep green fruit

to search for green anywhere in the le, fruit.

grep ^green fruit

to search for green at the beginning of lines only.

These are both simple regular expression searches.

Regular expressions have some similarities with filename wildcards, but are not the same. Regular expressions are used to find patterns within text files, wildcards are used to match filenames.

Extended regular expressions

Extended regular expressions allow a much richer pattern to be speci ed.

Many powerful features

- Match white space [space, tab]
- Match word boundaries
- Digits only
- Ranges

and many more.

When using regular expressions, extra options to grep are needed. For example,

```
grep -E '\bgreen\b' fruit
```

would find all occurrences of green on its own, but not where it is joined to another word. So

green cabbage

would match, but

greengage

would not.

Some limitations

Extended regular expressions can be used with many commands.

However, the way these are formed varies with di erent applications.

The most common are variations are

- Command line tools (grep, sed and so on)
- Perl
- C#
- PCRE – Perl Compatible Regular Expressions

For our exercises today, we don't need to worry about these differences. Many of the metacharacters and search terms are the same. However, if you are using regular expressions in different applications it's worth checking whether there are differences or limitations.

Note that C# is the Microsoft implementation of ; it provides very good support for regular expressions.

Taking control of the shell

So far we have looked at single commands:

- For example we have run simple commands to do one thing, e.g. **`cd, mkdir, grep`** and so on.

More typically:

- Jobs are more complex than the ones we've seen.
- Need recipes of multiple commands.

So we need to control the ow of :

- Commands.
- Data.

'Real World" problems are often too complicated to solve with a single command. They also need data to be read and written in a controlled way. This session explores some of the ways this can be achieved with a Linux command line interface.

Scripts

- Rather than typing commands on the command line it can be more convenient to put the commands into a single le. This is called a script.
- A script can be run more simply than a series of commands which you have to get exactly right every time.

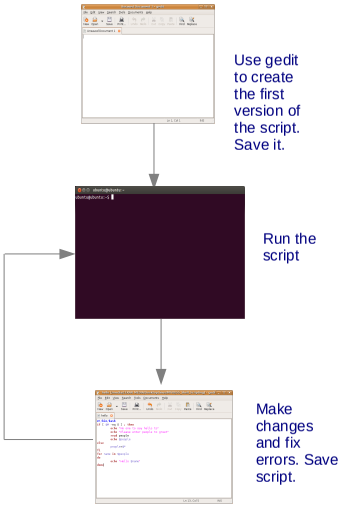
Scripts are just plain text files containing commands and optionally, but usefully, flow control. Flow control is the means of determining the order in which commands are executed.

Writing scripts

- It's usual to write some of the script, try it out, save a working version and add to it. This cycle is repeated.
- Rather than closing your editor every time you want to try the script, run it in the background with “&”
- For example

```
gedit &
emacs &
```

- You keep control of the command line



In the exercises, we recommend you write a script and try it out until it works. When you're happy with it, save it under a different name (with a version number on the end for example). This way, if you make a mistake in the next exercise, you can go back to the earlier saved version and start again.

When to script

- A lot of what you want to do is covered by one or more Linux commands anyway.
- The problem is conceptually simple.
- It doesn't have to be blindingly fast.
- It's something you have to do a lot.
- It's something you want to be automated.

Once you are familiar with the technique, shell scripts are quick to write. They are often used to avoid tedious and repetitive tasks – for example in the exercises we will write a short script to create several files with similar names. They are used, too, automate various system administration tasks that are too trivial to merit a program but for which there is no existing command.

Shell scripts don't require the investment of time and effort that programming in a higher level language such as C or C++ or Perl or Python. Scripts are often characterised as “quick and dirty” but there is, I think, a place for this sort of solution.

When not to script

- Your problem can't be broken down into existing UNIX commands.
- You need lots of data/program ow control.
- It has to be fast.
- It's very numerical.
- It's a one o job.

We have already seen that shell scripts can be seen as a quick and dirty solution. With this in mind any problem that requires a carefully designed solution is not a good candidate for a shell script.

Any application that needs to be fast or involves number crunching or large scale data manipulation should not be solved by a shell script. A program is needed.

Any application that needs a structured solution involving subroutines and functions is too big a problem for a shell script.

Executables

- In Windows .exe files are executable – in Linux the conventions are much looser.
- In Linux if you write a script you have to manually give people permission to run it.
- The **chmod** command changes permissions on a file:

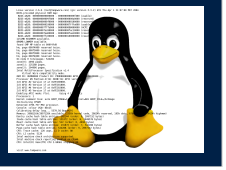
  chmod +x *file*

  allows your script to be executed.

Exercises for Session 3

- Regular expressions
- Use the **gedit** text editor
- Write some shell scripts

Session 4
Using computers remotely



Session 4

- Using computers remotely.
- We will also look brie y at package management and system administration.
- Exercises.

The computer we want to use is not always the one in front of us. How does Linux manage this?

We will also look at the privileged account – root – which is there to enable us to make changes to the system and how systems are managed.

Using remote systems

- Often the computer we are sitting at is not the only one we need to use.
  - More powerful
  - Shared resources
  - Additional software
- Set up your Oxford Single Sign-On (SSO) to access the IT services linux system.

For users of ARC – the academic research computing facility – and for many others, the computer in front of you is not the most powerful or useful computer available.

We need to find ways to access these remote computers.

IT services provide a linux commmand line service. The system is running (at time of writing) Debian 7.11, or the final version of Debian Wheezy. Although this is a different Linux distribution from the one we're using, the command line interface is generally consistent between distributions.

All members of the University can use this system.

Accessing systems and copying data

- Use

  `ssh`

  to access remote computers.
- Use

  `scp`

  to move data.

The ssh command gives us a secure, command line session on a remote machine.

In some cases,

ssh -X remote-system

will allow you to open remote graphical applications on your local system. So for example,

ssh -X coll1234@linux.ox.ac.uk

then

gedit &

Managing jobs on remote systems

- Why?
- Jobs may last longer than a few minutes.
- Don’t want to keep a session on a remote system: lose connection, lose job.
- Use

  `screen`

  to detach from a session and logout.

There are alternatives to `screen`, for example `tmux`. Both commands perform the same function – they allow you to leave a session running on a remote system while disconnecting your local session.

Managing systems

Managing systems

The following slides discuss brie y techniques for

- Managing Ubuntu systems
  - Using a privileged account
  - Maintaining a system: updates
- Installing new software: di erent methods
  - Using the Software Center
  - Using the command line
  - The di cult way!

Why manage packages?

- Complexity of current systems.
- Dependencies – new applications may a ect existing software.
- Each system may be con gured slightly di erently to suit its own environment.
- Enormous range of hardware that must be supported.
- We don't want – if possible – to concern ourselves with these details when we need to install some new packages.

Additionally, as with Windows a mechanism is needed to keep the system up-to-date.

Why do we need package managers.? We have already seen the enormous range of software available in Linux.

Developers cannot predict always what other packages will be used on the same system as their software; how the system is set up or what version or distribution is being used.

Some method of managing these problems was needed. Both package managers keep a database of information about software installed on the system which is used as a reference when a new package is installed.

A means of keeping a system up-to-date is also needed. You could view these package managers as similar to Windows Install Shield.

Ubuntu Software Updater

- Provides graphical access to un-installed but available packages.
- Can also be used to update the system.
- Unfortunately not working correctly on this Live Ubuntu release.
- Will work ne on installed version.

APT is a rather more flexible and powerful version of RPM and yum. It can also deal with software in different formats.

I have little experience of setting up an APT system from scratch but this version of Ubuntu comes configured to run apt successfully.

Other ways of installing software

The quick way:

- Using the command line

  `apt-get install package`

The hard way:

- Software is not always bundled in a format that APT or RPM can use.
- It will come in a single .tgz or .tar.gz or .bz2 le.
- Also known as a tarball.
- Requires rather more knowledge of the system.

Until now we have looked at software that has been easy to download and install. We have not had to concern ourselves with the details of what version we need or where to go to download the software.

But there will be times when this is not possible so that we will have to find the software ourselves. It will then need configuring, building and installing by hand.

One of the many disadvantages with this system is that it is then much harder to remove the software afterwards as it is not always obvious whereabouts on the system all the files have been copied.

Managing your system

- Until now we have used the the system to change our les but not made any system changes.
- Unlike Windows, Linux has a clear and rigid distinction between using a system and making changes to a system, such as installing new software.
- So to make changes a special account is needed.

This “separation of powers” is fundamental to the way Linux (and Unix) systems are designed. As you may remember from an earlier session you were able to move around the whole system but could not remove files apart from those in your home directory.

The root account

- In most Linux systems you will have your own username and password.
- Standard user accounts are set up so that you can change your own home les but not any system les.
- To install new software we need an account that can change les anywhere on the system.
- This account is known as the root account.

Note that because Ubuntu is running from USB separate user accounts are not configured.

To run commands as root you need to use

sudo command

in a command tool Window and press enter. You should now see a different prompt: a # . This a standard Unix/Linux convention for indicating that this account is privileged and so dangerous.

Using sudo

- Some systems use a di erent approach to administering system.
- Use sudo + command when carrying out privileged actions.

```
sudo apt-get install bluefish
```

will install the blue sh editor.

- Normally you will be prompted for a password; this will be remembered by the system for about 15 minutes.

Ubuntu developers decided that this mechanism is more secure than a separate root account.

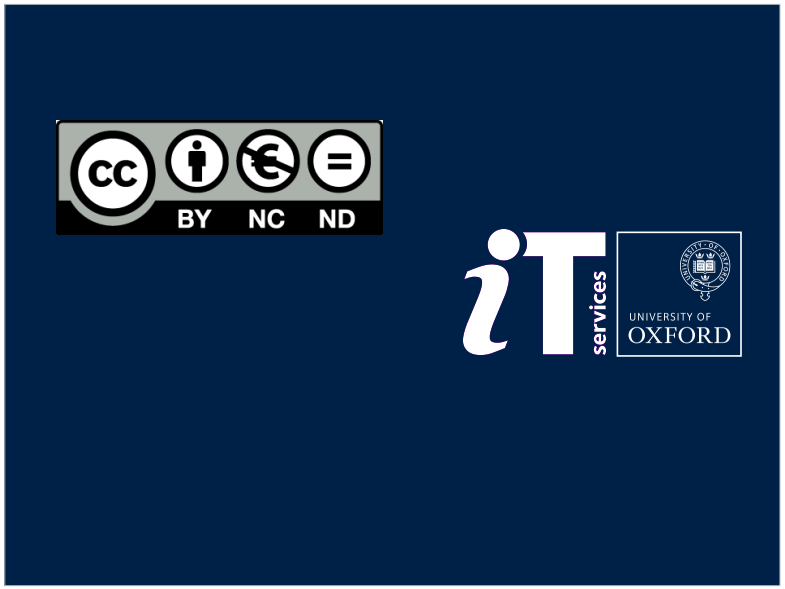
There are advantages and disadvantages to this approach. It is probably more secure: users have one less password to remember. A log is kept of all sudo activity – you can check it later when you are doing the exercises – have a look in `/var/log/auth.log`. It is also possible to configure sudo so that a user can only do a limited range of privileged commands.

A disadvantage of this approach is that it doesn't work particularly well for desktop systems in a network where most accounts are managed by a central server. However, this shouldn't concern home users.

Exercises

We will use the IT services linux service to:

- Log in remotely.
- Copy les between systems.
- Demonstrate a technique to manage jobs on other computers.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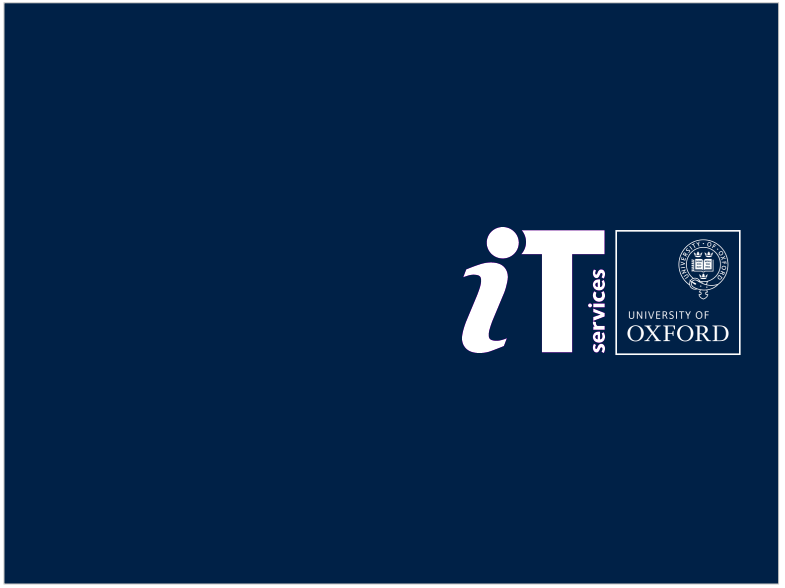
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