HEP Computing
Part I
Intro to UNIX/LINUX
Adrian Bevan

Lectures 1,2,3

Lecture 1

- Files and directories.
- Introduce a number of simple UNIX commands for manipulation of files and directories.
- communicating with remote machines

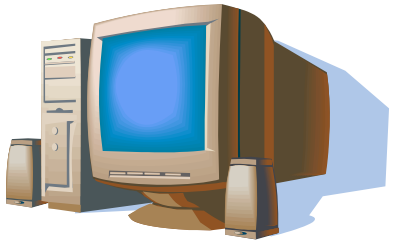
What is LINUX

- LINUX is the operating system (OS) kernel.
- Sitting on top of the LINUX OS are a lot of utilities that help you do stuff.
- You get a 'LINUX distribution' installed on your desktop/laptop. This is a sloppy way of saying you get the OS bundled with lots of useful utilities/applications.
- Use LINUX to mean anything from the OS to the distribution we are using.
- UNIX is an operating system that is very similar to LINUX (same command names, sometimes slightly different functionalities of commands etc).
  - There are usually enough subtle differences between LINUX and UNIX versions to keep you on your toes (e.g. Solaris and LINUX) when running applications on multiple platforms …be mindful of this if you use other UNIX flavours.
  - Mac OS X is based on a UNIX distribution.

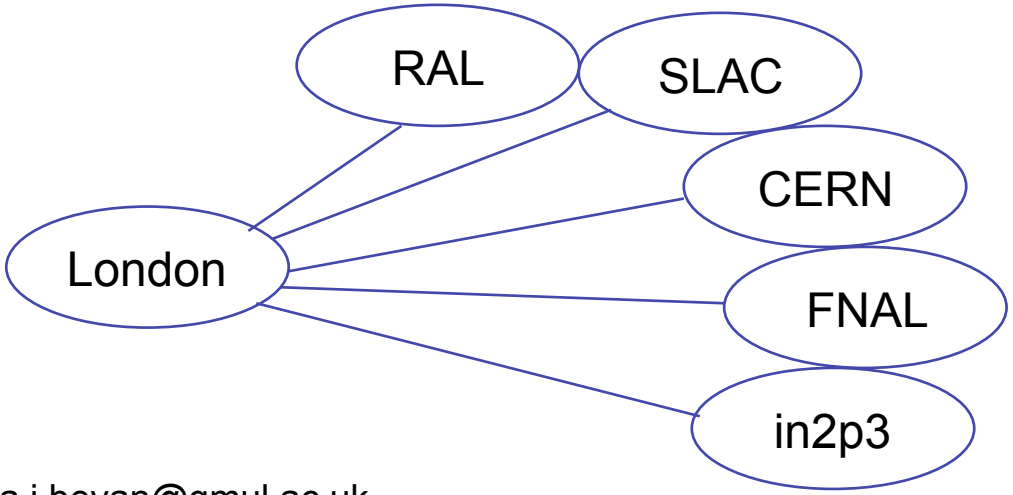
Accessing a machine

- You need a user account
  → you should all have one by now

- can then log in at the terminal
  (i.e. sit in front of a machine and type in your user name and password to log in to it).



- you can also log in remotely to a machine somewhere else



The command line

- A user interfaces with Linux by typing commands into a shell.
  - if you are familiar with windows then think of a shell being something like the DOS prompt.
- The shell is a program that knows how to find commands to run and how to run them.

Some useful commands

(these and more get introduced by example in the following pages)

ls <dir>	list the content of a directory
cd <dir>	change directory to the specified one
mkdir <–p> <dir>	make a new directory (–p makes missing parents)
cp <file> <newfile>	make a copy of a file
mv <file name> <new file name>	rename a file
tail <file>	look at the end of a file
head <file>	look at the start of a file
cat <file>	show the file from start to finish on the terminal
more <file>	file viewer
less <file>	file viewer (more versatile than more)
sleep <nSeconds>	sleep for a number of seconds before continuing
gzip <file>	zip a file up
tar cvf somefile.tar <directory>	make a tar file (archive files or directory trees)
tar xvf somefile.tar	unpack a tar file
tar cvzf somefile.tgz <directory>	make a tar file and zip it up in one go
tar xvzf somefile.tgz	unpack a zipped tar file

Files and directories

- Files and directories are stored on a file system.
- the root file system starts at `/`
- sitting in this are many different directories e.g. you can see what is there using `ls`

```
somehost ~ > ls /
afs/       bin/   data/  home/    lost+found/  opt/    root/  u01@  u04@  usr/
afscache/  boot/  dev/   initrd/  misc/        pippo/  sbin/  u02@  u05@  var/
bfactory@  cern@  etc/   lib/     mnt/         proc/   tmp/   u03@  u06@
```

- Directories are organised in a hierarchical structure
  → a `/` separates one directory level from the next [c.f. `\` in Windows]
- e.g. `/usr/bin` is the subdirectory `bin` that is in the sub directory `usr` found in `/`
- You have a home directory that can be access via `~username` e.g. `~smith` or `~/` for short

Manipulating files and directories

- make a new directory with the mkdir command

```
mkdir test
```

- list the files in a directory using the ls command

```
ls test
```

- change into the directory you just made using the cd command

```
cd test
```

- can now make another directory

```
mkdir test2
```

- now if you list the files in the directory test (type `ls`) you'll see

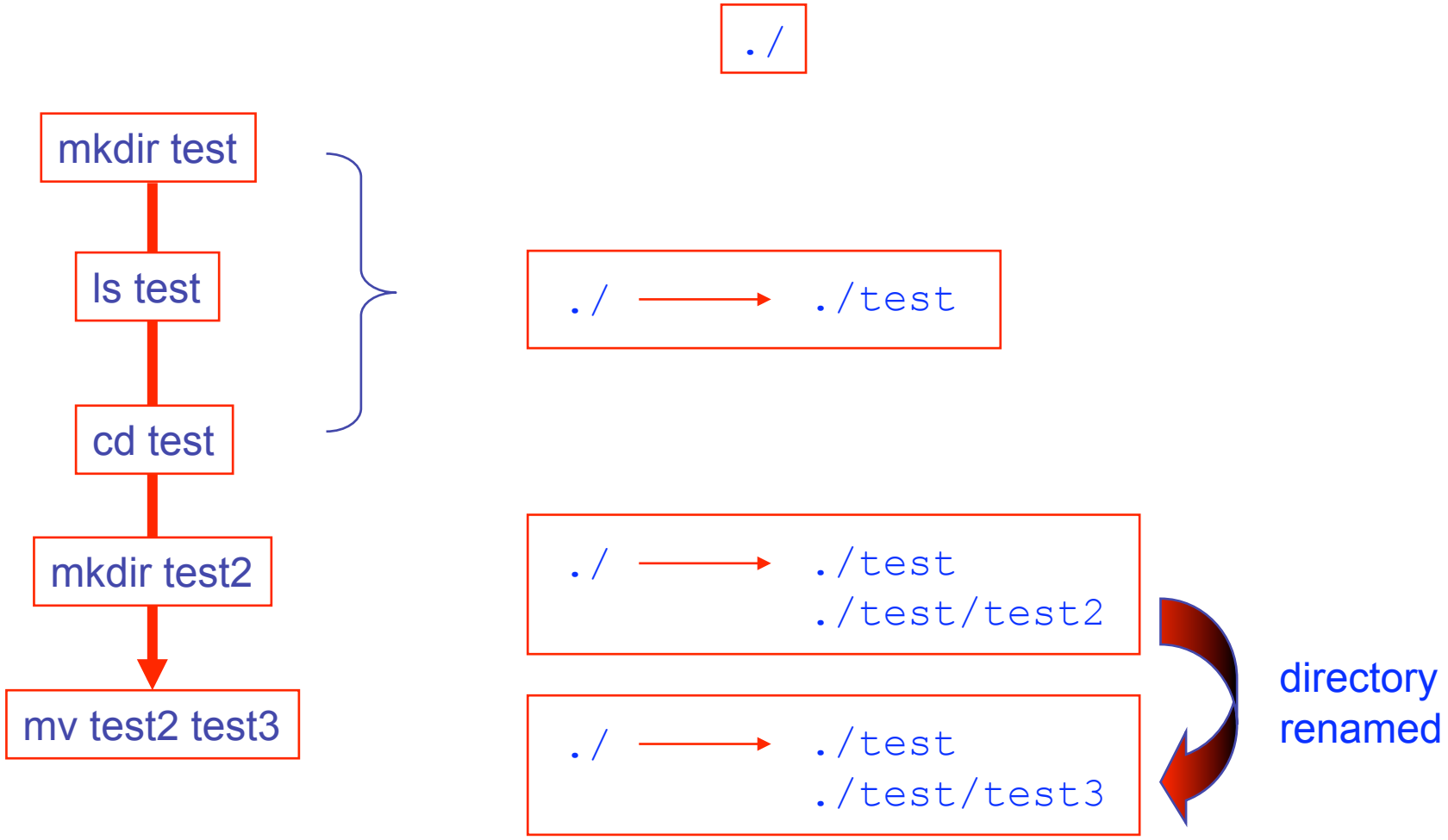
```
test2
```

which you just made. You can then rename the new directory with

```
mv test2 test3
```

and using `ls` again you can see that the new directory is now called `test3`

(sub)directories:



Manipulating directories and files (II)

- What if you get lost and want to go home?

```
cd
cd ~/
cd $HOME
```

All are equivalent and will take you to your home directory (the one you appear at when you log in)

- How can you tell which directory you are currently in?

```
pwd
```

- Is there an easy way to go to the previous directory?

```
cd -
```

- How do I get to one directory down the tree?

```
cd ../
```

Looking at the content of a file

- You already have a file called ~/.bash_profile which is one of your login scripts. How can you look at this file? If you just ls in your home directory it is not there …
  `ls -a` will show the hidden files (names starting with a '.')

1. `cd` to your home directory [if you are in a subdir using `cd` will take you home]
2. try to use the commands cat, tail, head, more and less to look at the file .bash_profile

```
cat .bash_profile              # print the file to the screen
head .bash_profile             # print the first 10 lines
head -20 .bash_profile                # print first 20 lines
tail .bash_profile             # print last 10 lines
tail -30 .bash_profile                # print last 30 lines
more .bash_profile             # use more to look at the file
less .bash_profile             # use less to look at the file
```

N.B. use '`q`' in more or less to quit and return to the command prompt

→ in less you can use the up and down arrows to move through the file

→ `/` followed by a string entered into less will search for that string

→ `?` followed by a string entered into less will search *backwards* for that string

Exercise

1. try using the commands described on the last few pages to get familiar with them

2. play with the sleep command type

```
> sleep 5
```

then

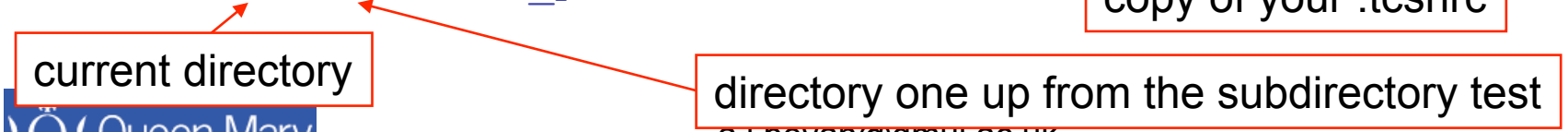
```
> sleep 10; mkdir iJustWokeUp
```

(include the semi-colon, `';'` after `sleep 10`). You see that you can use sleep to delay execution of a command. `';'` is a command separator for the shell

3. copy `.bash_profile` to the directory test that you made earlier

```
> cp .bash_profile test/
> ls -a test/                    # use -a to see hidden files
                                 # (these start with a .)
```

```
bfa ~/ > ls -a test
./   ../   .bash_profile
```



Communicating between different machines

Some group machines may use telnet and ftp for communication (login and copy).

```
> telnet somemachine.somedomain
> telnet MyComputer.MyUni.ac.uk

> ftp somemachine.somedomain
> ftp MyComputer.MyUni.ac.uk
```

ftp is generally discouraged.
It's a good idea not to use it!

Almost all machines you will encounter will not use these programs. Instead you need to use ssh/scp to login or copy a file to a new machine.

```
> ssh <options> somemachine.somedomain
> ssh MyComputer.MyUni.ac.uk

> scp <options> <source> <target>
> scp test.eps MyComputer.MyUni.ac.uk:./myEpsFiles/
```

Local File | Remote Host | file path on remote host

where <options> are command line options that you can type in if you want to.
[N.B. the angled brackets are not to be input but indicate that this is an option]

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Logon and copy examples:

Example of using ssh to log into a machine

```
> ssh -l username hostname.MyUni.ac.uk
> ssh username@hostname.MyUni.ac.uk
> ssh hostname.MyUni.ac.uk
```

Equivalent forms of using the command. N.B. if you don't specify the username it will be assumed that you want to use your for the connection.

Example of using scp

```
> scp test.ps username@hostname:./public_html/
```

copy a single file to a subdirectory on another machine

```
> scp -r test-dir username@hostname:./public_html/
```

recursively copy a directory to another machine

So why do/should you care?

→most … if not all … of your work will be done at remote machines

Lecture 2

- Text Editing
- `sed` and `awk`
- Environment variables and aliases
- Archiving files

Text editing

As soon as you want to start to do analysis/write reports etc … you need to edit files. There is nothing like word available for editing code so you have to learn how to use a text editor.

Some UNIX Text Editors:

(x)emacs	nice gui/text based editor – most people use this
vi	very useful for sysadmin/minimal system work
pico, vim, …	

EMACS:

to start emacs:

> emacs <somefile> &	to start a gui emacs session (&=run in background)
> emacs –nw <somefile>	to start a text session

Useful resources can be found:

GNU's online manual

http://www.gnu.org/manual/manual.html

man pages give a summary of information

emacs help → enter this by opening emacs and pressing F1 twice

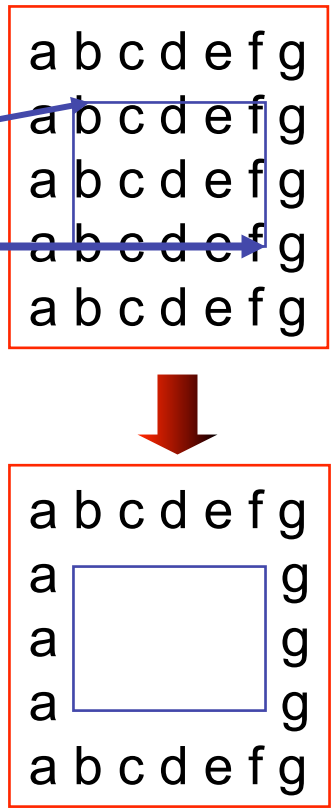
Aside: On mac OS you need to replace Alt with Esc

Some of the emacs commands you should know:

[ctrl-x]+f	open a file	[alt-x]+goto-line	go to line #
[ctrl-x]+i	insert a file	[ctrl-x]+(	start defn. of a macro
[ctrl-x]+s	save a file	[ctrl-x]+)	close dfn of a macro
[ctrl-x]+[ctrl-c]	close emacs	[ctrl-x]+e	execute a macro
[alt-x]+ispell-buffer	run ispell from emacs	[ctrl-x]+ u # command # times	repeat next
[alt-x]+spell-region	run ispell from emacs	[alt-x]+query-replace	replace string with another one

e.g. of editing a region

[ctrl-space] mark the start of a region
[ctrl-x]+r+k mark the end of a region and kill it
[ctrl-x]+r+y paste a region



There are MANY more commands available
these are just the ones that I use most often

Emacs examples

- Open an emacs session and start typing into the file; `emacs -nw test.txt`
- When you have some text, save the file `[ctrl-x]+s`
- then close the file using `[ctrl-x]+[ctrl-c]`
- you should now have a file test.txt – you can see it is there by using the `ls` command

  `ls -l test.txt`
- now you can try using `less` or `more` to view the file:

  `less test.txt`
- if you now open a new file called test2.txt, you can insert the original file using

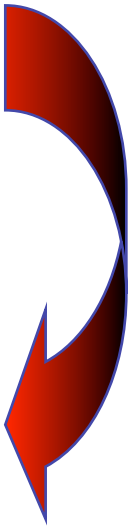
  `[ctrl-x]+i` followed by `test.txt`

  if you want to play about with the file some more you can do so. Then save test2.txt using [ctrl-x]+s.
- Try using the `[alt-x] query-replace` command to change all of the letters `'a'` for `'X'` in what you have written (you are prompted for the strings to match and can either approve the change on a one by one basis or do all at once using !).
- you should play around for a while with the various commands listed on the previous page to get used to things a bit.

emacs –nw test.txt

Enter a few lines of text into the terminal

`[ctrl-x]+s`



The file is empty until you save it

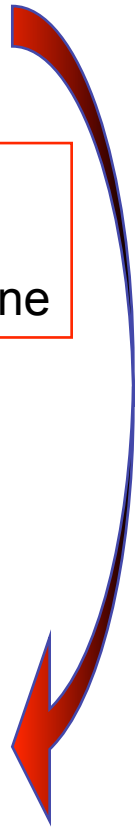
Make a new file called somefile.txt, and edit your original

emacs –nw test.txt

Move the cursor to the end of somefile.txt and try to add the content of another file to this one

`[ctrl-x]+i` followed by `test.txt`

`[ctrl-x]+s`



The file is not updated until you save it

sed and awk

These are command line text editing utilities to help process information involving replacement of strings/extracting columns of text from files etc.

Some useful examples:

```
sed -e 's/A/B/' <filename>
```
substitute A for B in 1st instance on line in the whole file

```
sed -e 's/A/B/g' <filename>
```
substitute A for B in whole file

```
awk  '{print $1}' <filename>
```
print the first column of file [space separator used by default]

```
awk -F'=' '{print $1}' <filename>
```
use the '=' character as a separator

```
awk '{s+=$1}END{print "sum = " s}' <filename>
```
add up the numbers in the first column

→ try to use sed and awk on test.txt and test2.txt.

Look at the GNU manuals for gawk & search on google for awk/sed
O'Reilly "sed & awk" is a good book to read

Some simple examples

```
sed 's/the/THE/g' test.txt
```
replace ‘the’ with ‘THE’

```
sed 's/the/THE/' test.txt
```
replace the first ‘the’ per line with ‘THE’

```
awk '{print $1}' test.txt
```
print the first word on each line

```
echo "hello world" | sed 's/world/universe/'
```
substitute `world` for `universe` in print out

sed and awk can do a lot more than shown here … see extra material for a few ideas

Some more UNIX command line examples

```
grep <string> test.txt > myStringFile
```

search for `<string>` in the file and redirect the output to a file called `myStringFile`

```
./myBin >& myBin.log &
 tail -f myBin.log
```

run the binary – writing to a log file (passing stdout and stderr to that log file) and then follow the tail of the log file as it gets written out

```
cat file2 >> file1
```

append the content of `file2` at the end of `file1`

```
export MYVAR=val; ./myBin >& mylog & tail -f mylog
```

do several things on one line

```
ls /usr/local/bin/?v*
```

e.g. pattern a search for binaries with a single character followed by a '`v`' and finishing with anything else.

Some more commands

check how much free space you have left on an afs file system

```
[somehost] ~ > fs lq
Volume Name                    Quota       Used %Used    Partition
u.bevan                       500000     454441   91%<<        68%     <<WARNING
```

`rm <aFile>`

to remove the file aFile. Deleting a file on LINUX/UNIX means that it has gone!

now you've seen the rm command, you know how to delete things

→ you might want to use the following until you get more confident

`rm -i <aFile>`

- Note that the work areas you have and use are generally not backed up.
- if you have something that is important (e.g. thesis) you should ask how to make back up copies on a regular basis (if you don't know how to do it) so that you don't loose everything if you accidentally delete the original or a hardware failure looses the disk etc.
- At outside labs there is usually a copy of your home area backed up once a day
  - check if this exists and if the backup it suits your needs.

Environment Variables

There are many so called environment variables set in a shell. To list these type

`printenv`	tcsh/sh
`env`	tcsh/sh

The most important one is:

PATH — set the search path for commands so the system knows where to look for them. This is the search path that a shell uses to find a command. If a command is not in one of the directories listed in $PATH then you have to refer to it using the full path name e.g.

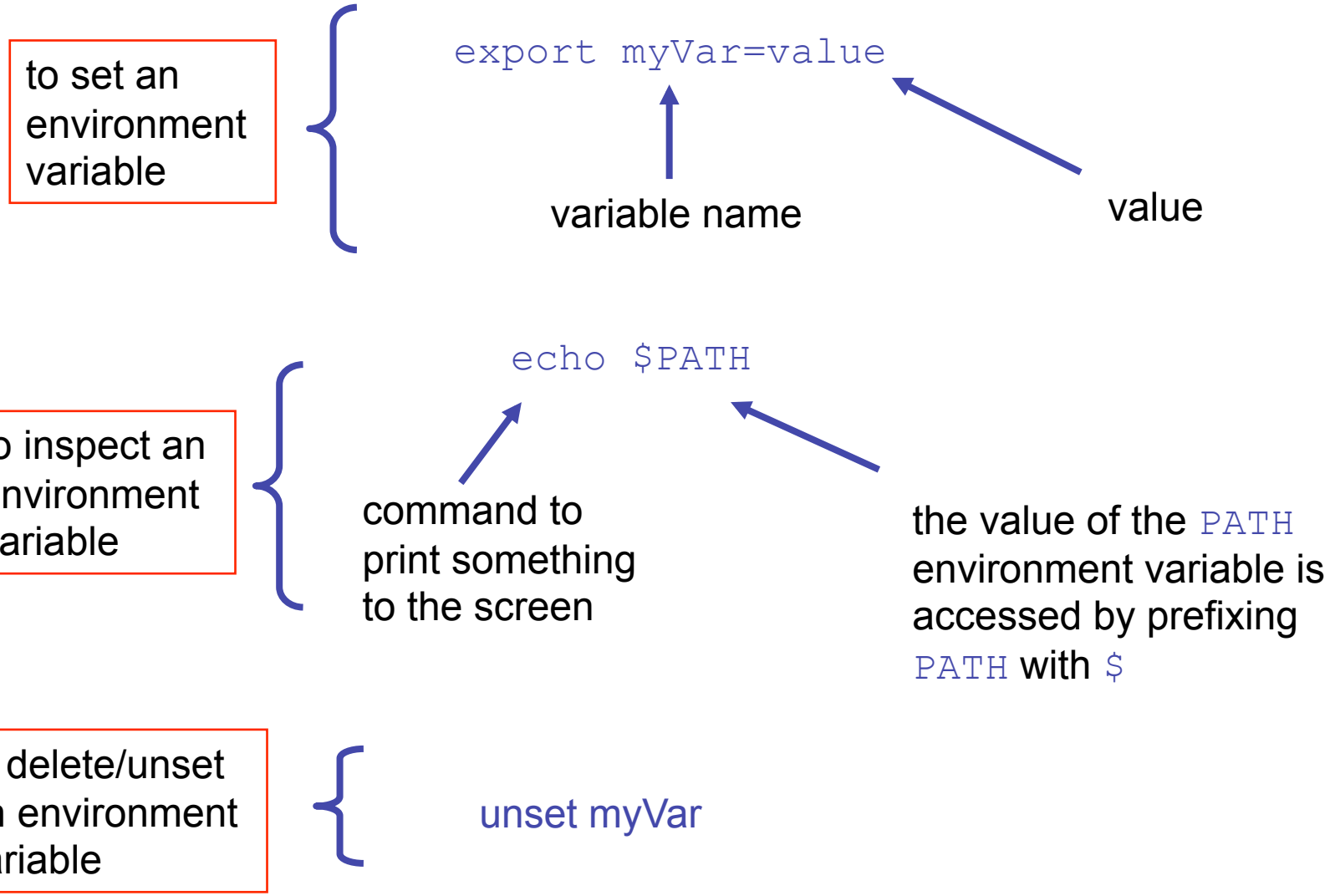
/usr/bin/perl

instead of perl

How do you know if you can see a command? Use `which` to search for it. If the shell can find a command by looking through the locations in $PATH it returns the one it finds first. e.g.

```
somehost ~ > which perl
/usr/bin/perl
```

Using environment variables



Sometimes you want to append to an existing variable, e.g. PATH. You can do this like

```
export PATH=<new path to add>:$PATH
```

- `command not found` means just that – the system can not find the command when searching the directories listed in $PATH

These examples are for sh. For the tcsh they differ slightly and I'll leave it to you to find out how to manipulate the environment variables there.

A few other useful variables are:

EDITOR	set the default text editor
PRINTER	the default printer (what lpr will try to print to unless you tell it otherwise)
PAGER	e.g. set `more` or `less` as the default pager

e.g.

```
export EDITOR=emacs
export PAGER=less
export PRINTER=oa2
```

Aliases

An alias is a command short cut that you can specify. These usually go into your login scripts such as .cshrc/.tcshrc etc

e.g.

```
alias rm='rm -i'
alias ls='ls -F'
```

`rm -i` prompts you to confirm you want to delete something

you can see the list of aliases by typing `alias` at the command line:

```
alias clean='rm *~'
alias l.='ls -d .* --color=tty'
alias ll='ls -l --color=tty'
alias ls='ls -l'
…
```

This can be useful so that you don't have to type in the full command to ssh to an outside lab all the time, or to customize your setup as you like.

Examples

- List the environment variables already set for you.
- Check the variables EDITOR, PAGER and PRINTER. Are these defaults ok? if not change them: e.g. I have

```
[somehost] ~ > env | grep EDITOR
EDITOR=vi
[somehost] ~ > env | grep PAGER
PAGER=less
[somehost] ~ > env | grep PRINTER
PRINTER=oa1
```


you probably want emacs

Ask a local what the names of your printers are

- Could have just echo(ed) the variables instead.
- Make a directory called `scripts` and add this to your PATH. You'll use this later on.

Compressing files and directories

- You can compress files to save space. The `gzip/gunzip` commands are used to zip/unzip files. Large savings in space can be had in compressing ascii files … on the other hand sometimes binary files are packed so efficiently that you don't get any gain from using these utilities to compress those files.

- use `ls -l` to see how big a file is (`ls -lh` shows the file size in Kb/Mb/Gb)

- e.g. compressing a single file

```
gzip thesis.ps
```

this command will write a compressed file called `thesis.ps.gz` that should be a lot smaller than the original thesis.ps

- you can then unzip the file by using

```
gunzip thesis.ps.gz
```

- This can be quite handy if you have very limited disk space (e.g. at SLAC/CERN etc)

- what about dealing with the content of a directory tree?

Archiving files

- If you have a lot of files that you want to store you can make an archive before moving/compressing them. The most common utility you will see for this is called `tar`. The name comes from the historical origin as a Tape ARchival program.

- Other programs exist such as dd & cpio etc.

- to make an archive of the directory test

```
cd                              # return to your home directory
tar cvf test.tar test/          # make the archive file
```

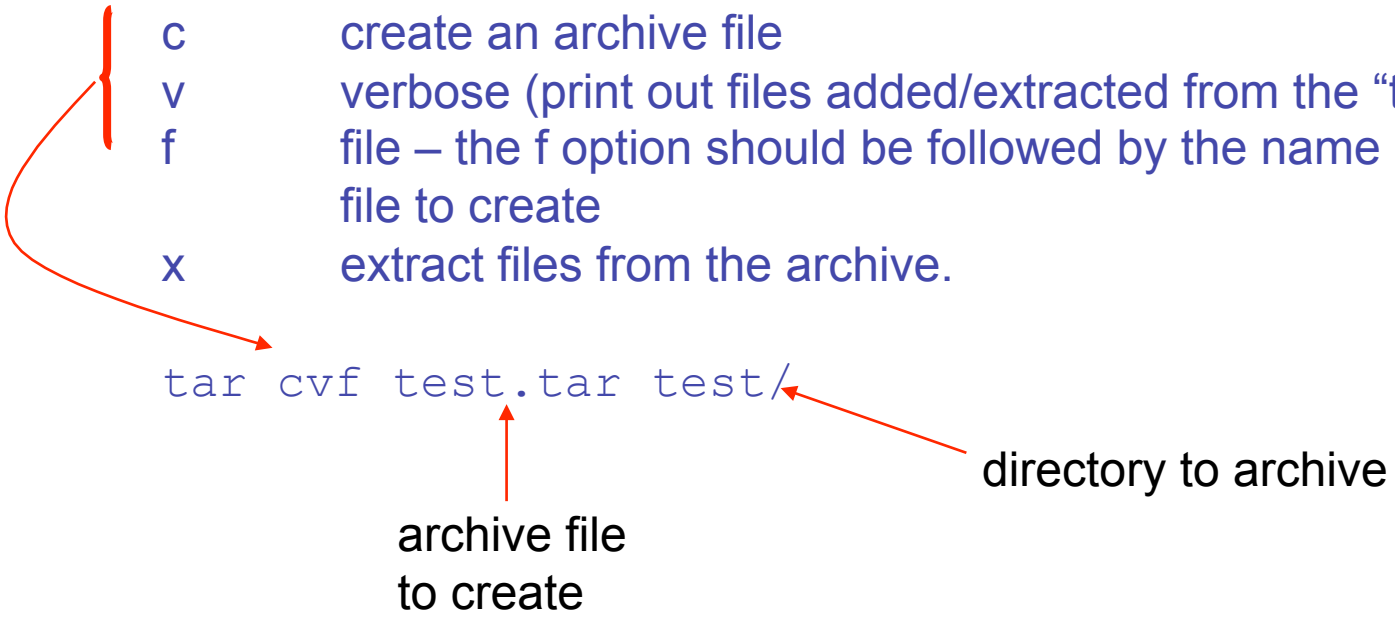
- you should now have a file called test.tar in your home directory that can be compressed using gzip. To unpack the archive in a new directory

```
mkdir new-test
cd new-test
cp ~/test.tar .
tar xvf test.tar    # unpack the archive in ~/new-test
```

here the destination is the current directory

so `new-test` now contains a complete copy of the directory tree test

What did the options given to tar mean???



if you use the option ‘z’ when using tar, you can compress the archive at the same time as making it. e.g.

```
tar zcvf test.tgz test/
tar zxvf test.tgz
```

- So How are you supposed to know all of this for the different commands?

Man Pages

- system commands usually come with man pages
  → these are instructions on how to use the command.
  e.g. type the following to look at the ls man page

```
> man ls
```

```
NAME
       ls - list directory contents

SYNOPSIS
       ls [OPTION]... [FILE]...

DESCRIPTION
       List information about the FILEs (the current directory by
       default).  Sort entries alphabetically if none of -cftuSUX
       nor --sort.

       -a, --all
              do not hide entries starting with .

       -A, --almost-all
              do not list implied . and ..

       -b, --escape
              print octal escapes for nongraphic characters
.
.
.
```

If you are not sure of a command name you can always try using `man -k` followed by a search string to see if any matches might exist; e.g. type `man -k copy`

Finding files

Sometimes you will loose track of where a particular file is. Either you are looking for something you have written, or something that you've been asked to find. There are two useful utils for tracking down files:

set the path to start searching

```
find . -name core
```

name the file/string you are looking for

```
locate core
```

locate uses a database of files that is automatically updated on a LINUX machine so it is usually a lot quicker than using find to locate a file (unless you have made the file AFTER the db was last updated).

Exercise

1. Try following the examples on using `gzip` and tar to compress and archive the dummy directory

2. If you've not already done so, download the example tgz files and unpack these in your home directory. Look at the content of ~/Lectures for each new examples file you add.

3. Run the command

   ```
   du -sh ~/Lectures
   ```

   to see how much disk is used in total and compare this with the sum of file sizes for partN_examples.tgz that you've unpacked using `ls -lh`
   [N.B.] most of the space is taken up by root files that are already compressed so the reduction in size is not great for part3_examples.tgz.

4. Look at the man pages for some of the commands you now know. HINT *the commands you know now do a lot more than you have learnt about so far. Details on the man page tell you what else they can do … sometimes the description isn't that easy to follow!*

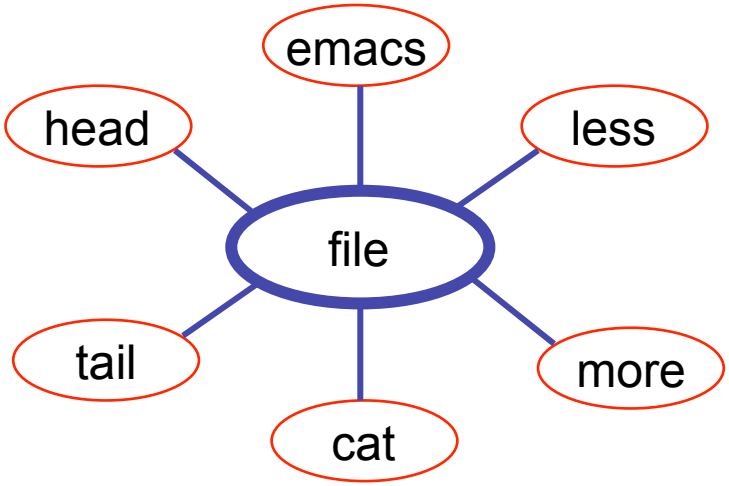
5. If you're happy with this – look at the extra material

Lecture 3

- Review the relationships between the most important concepts and commands covered in the lectures 1 and 2.

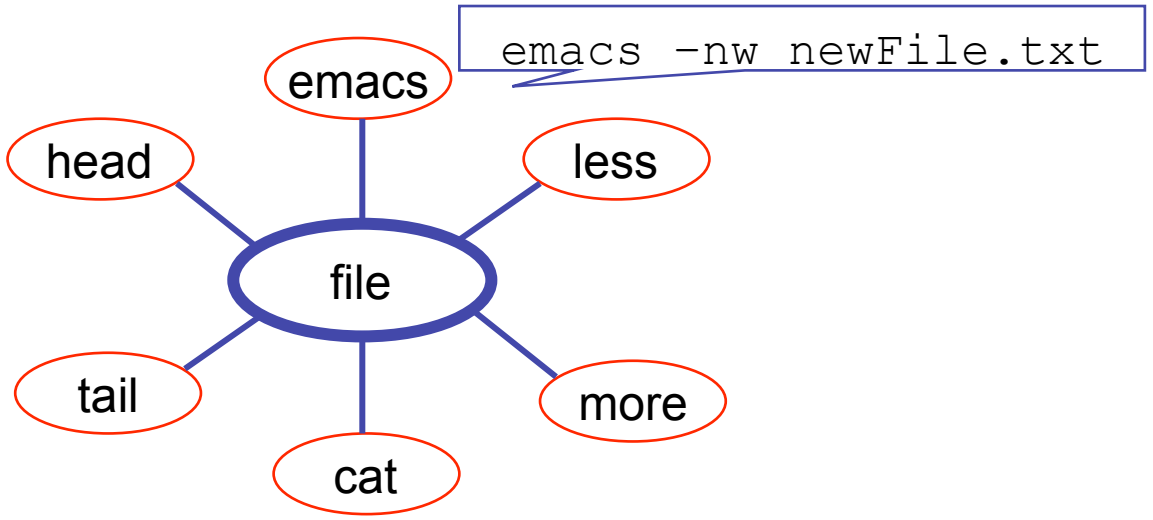
- Introduce web resources available.

Command Relationship Summaries



Most of what you will do with computers is, in essence, manipulating information in files. These commands cover a range of ways to look at the content of files and edit them.

It's a good idea that you make yourself familiar with the behavior of these Commands and know how to use them if you've not done so yet.



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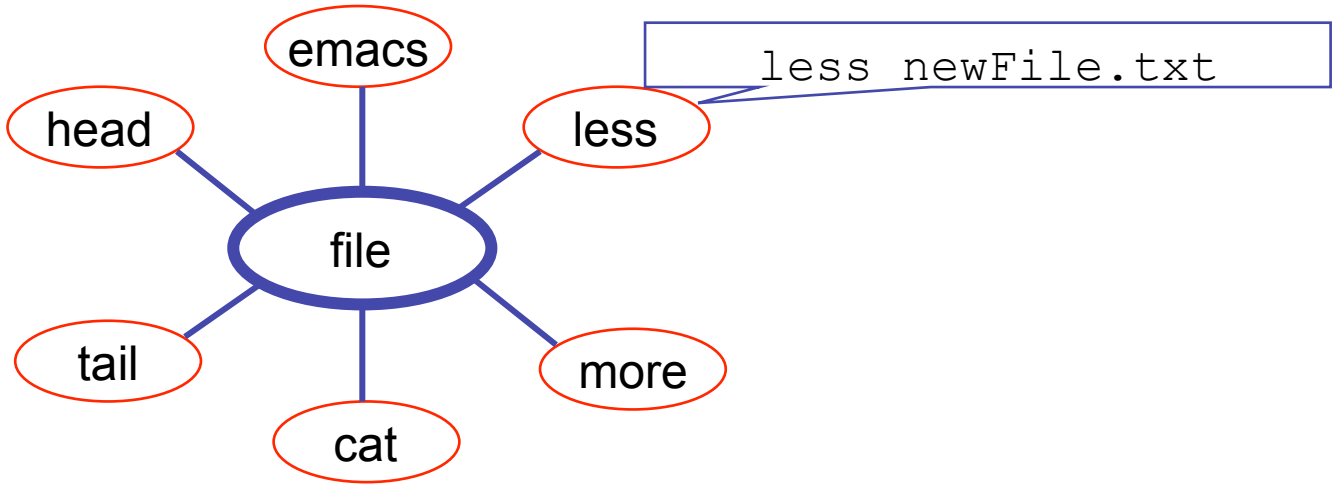

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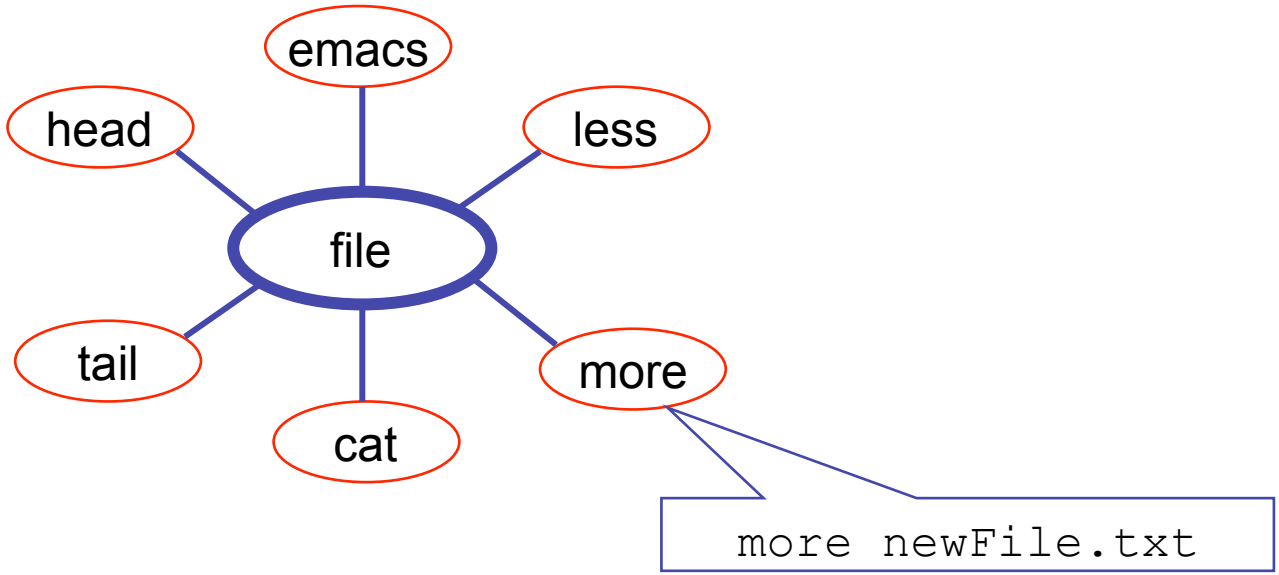

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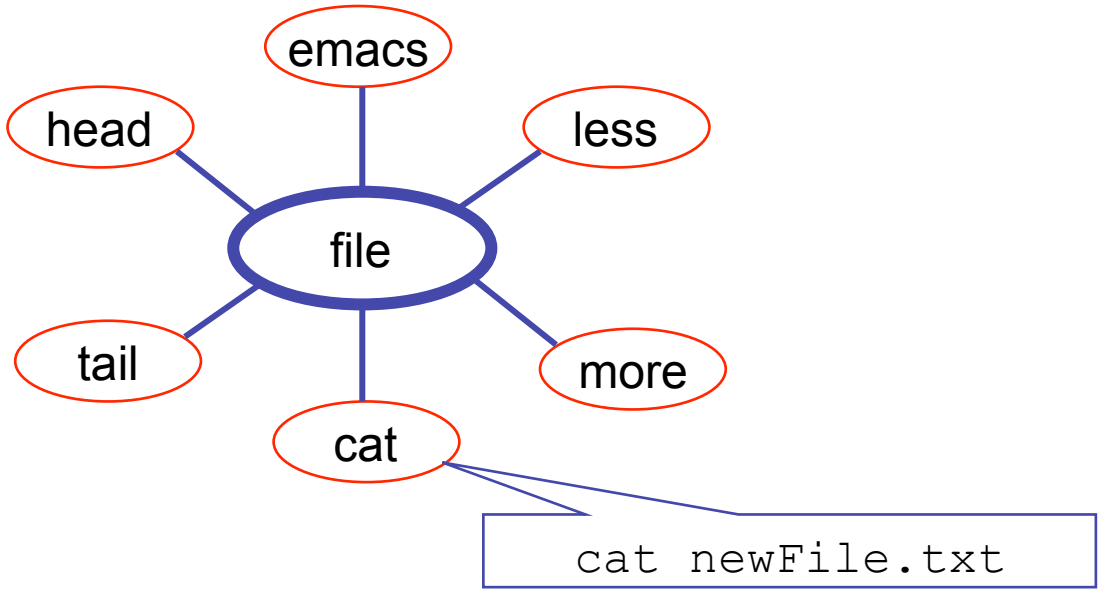

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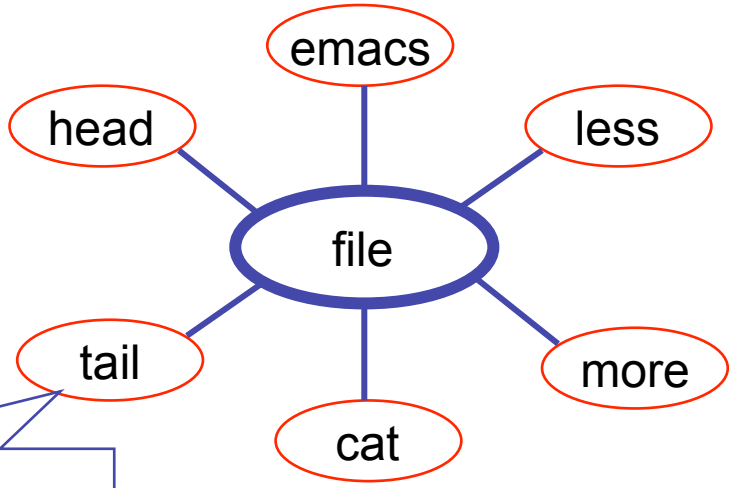


```
tail newFile.txt
tail -100 newFile.txt
```

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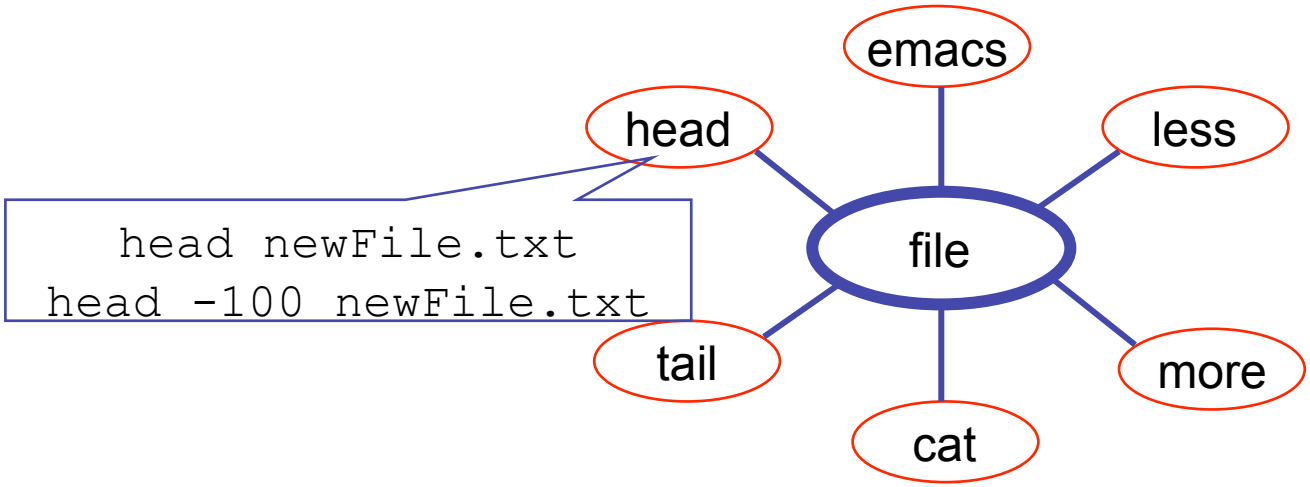

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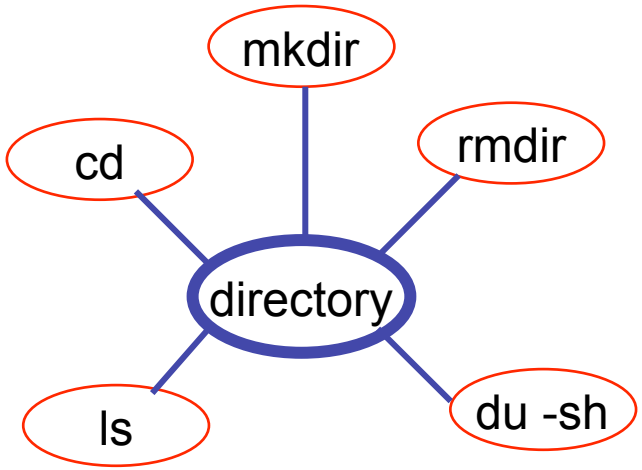
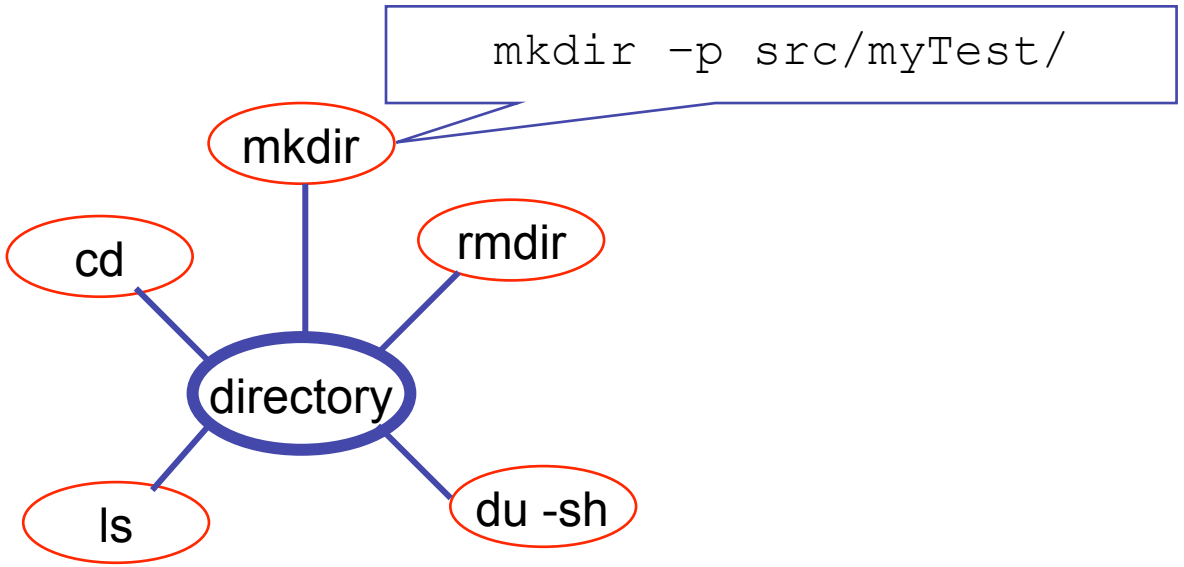


Very Quickly you will see that a structured system for storing files is needed → you need sub-directories. These commands are useful to manipulate your directories.



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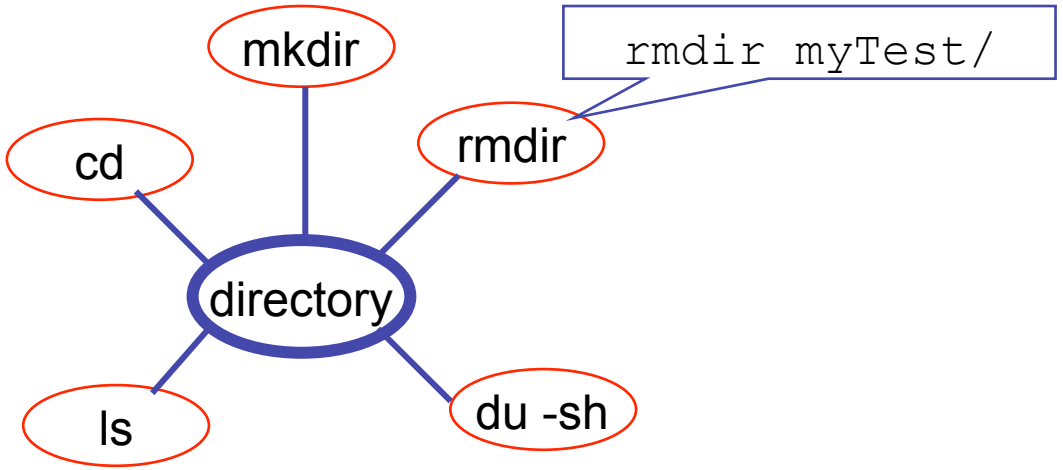

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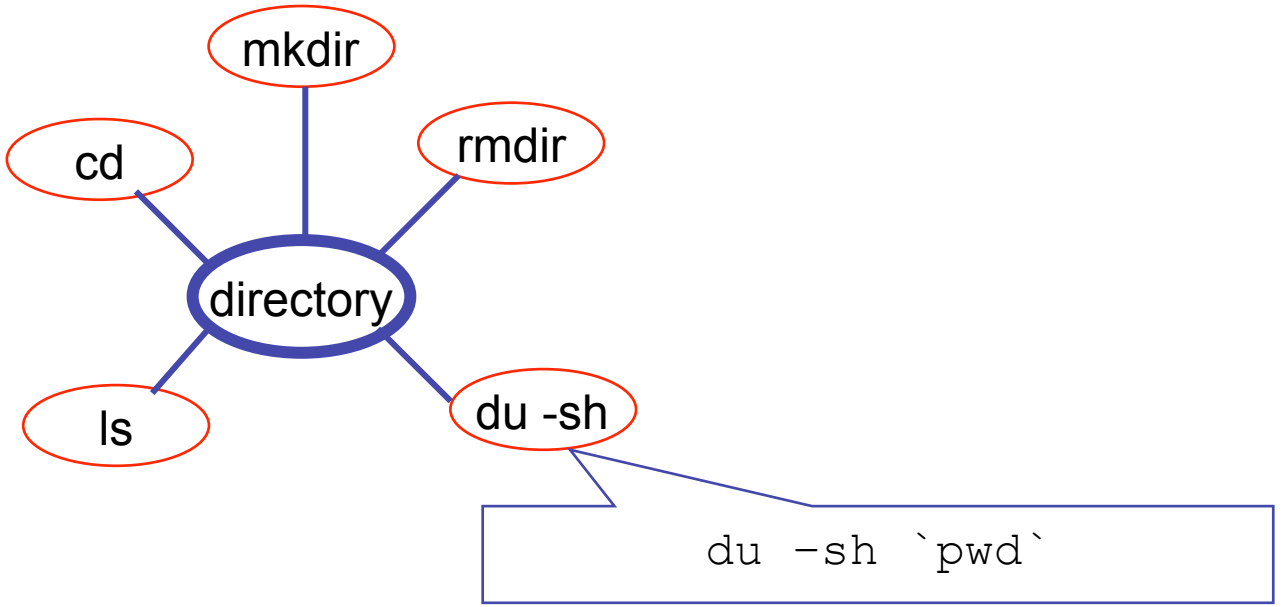

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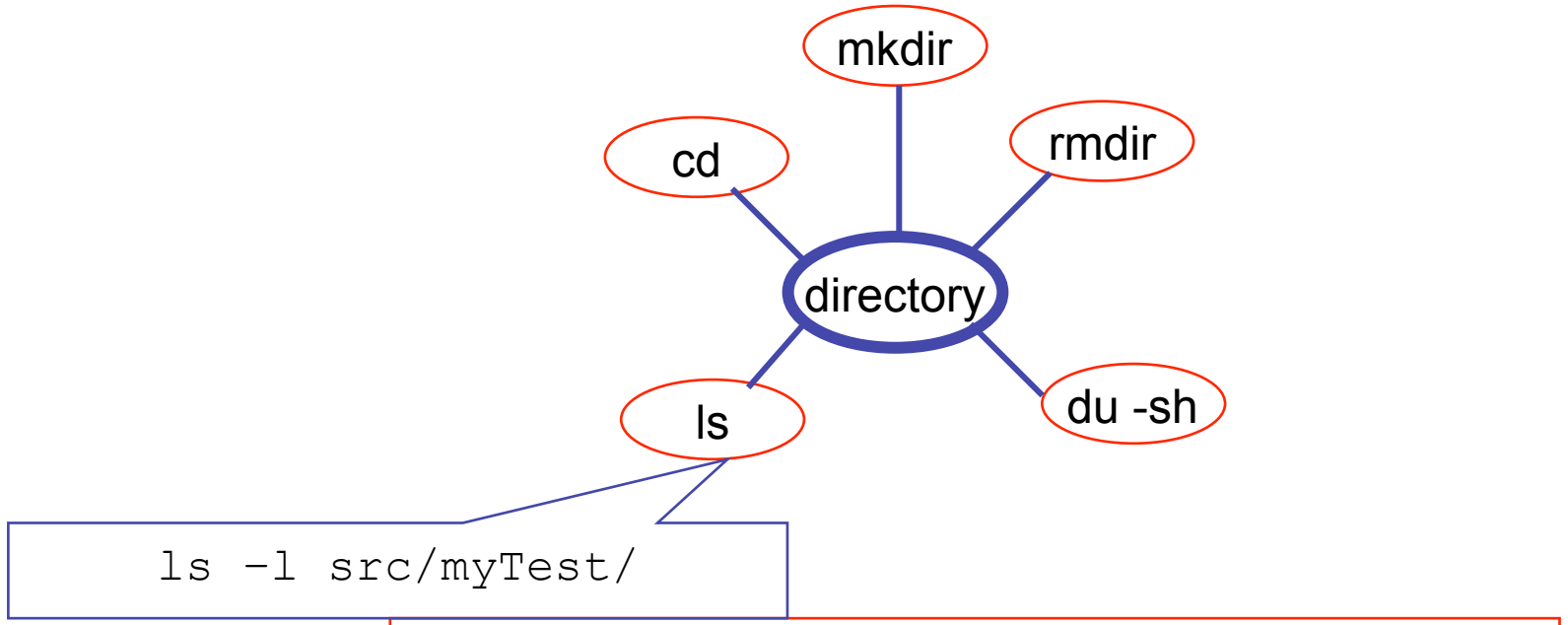

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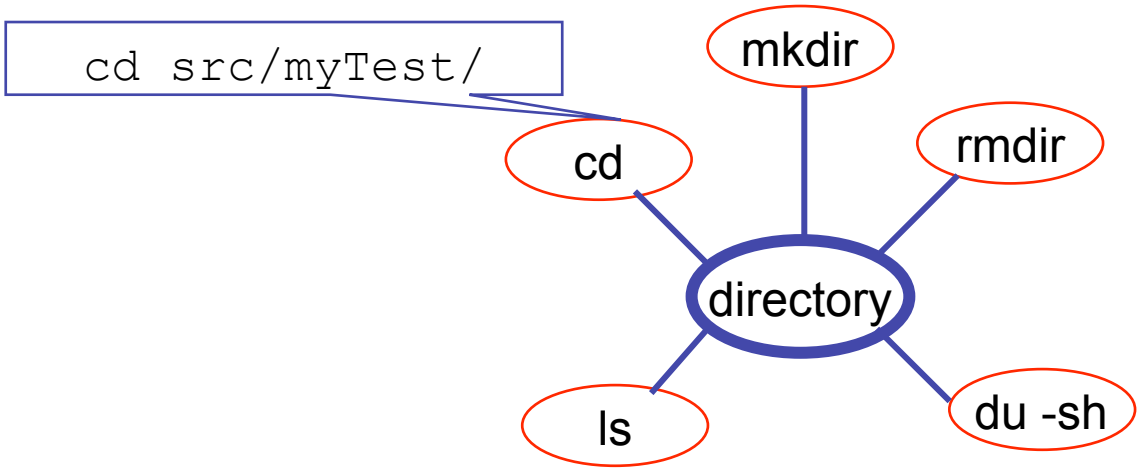

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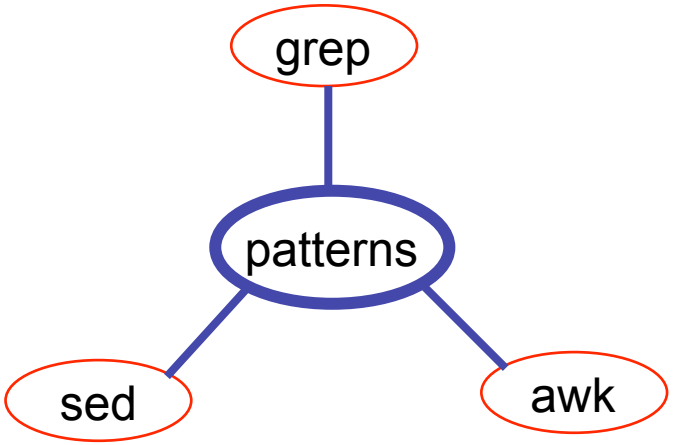
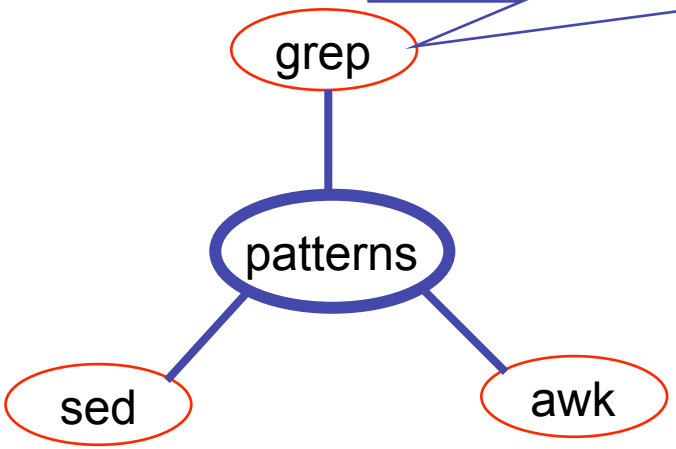


When manipulating files there will come a time when you want to look for a string or pattern, and either Extract or modify it. Basic use of these commands Can save enormous amounts of time with repetitive tasks.

```
grep Hello helloWorld.pl

grep -i hello helloWorld.pl
```



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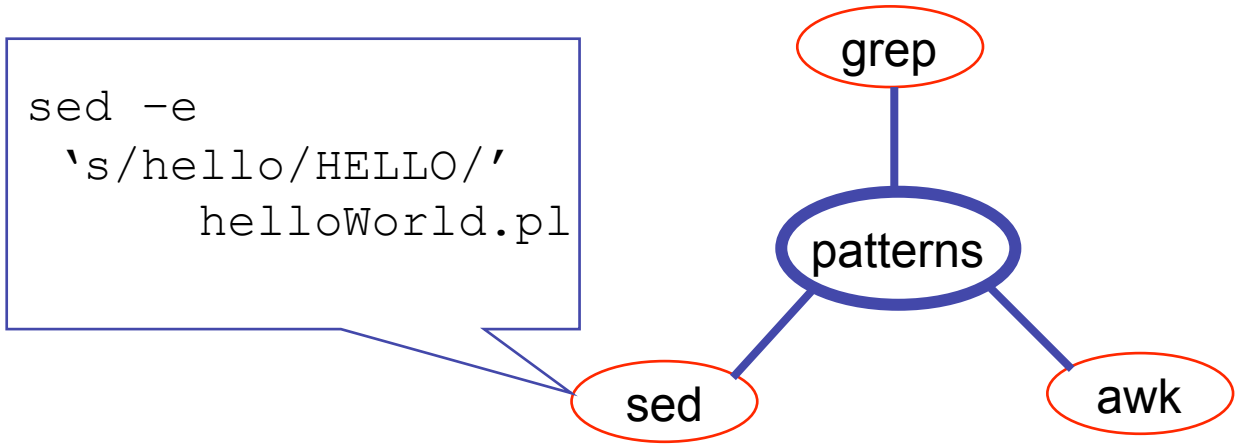

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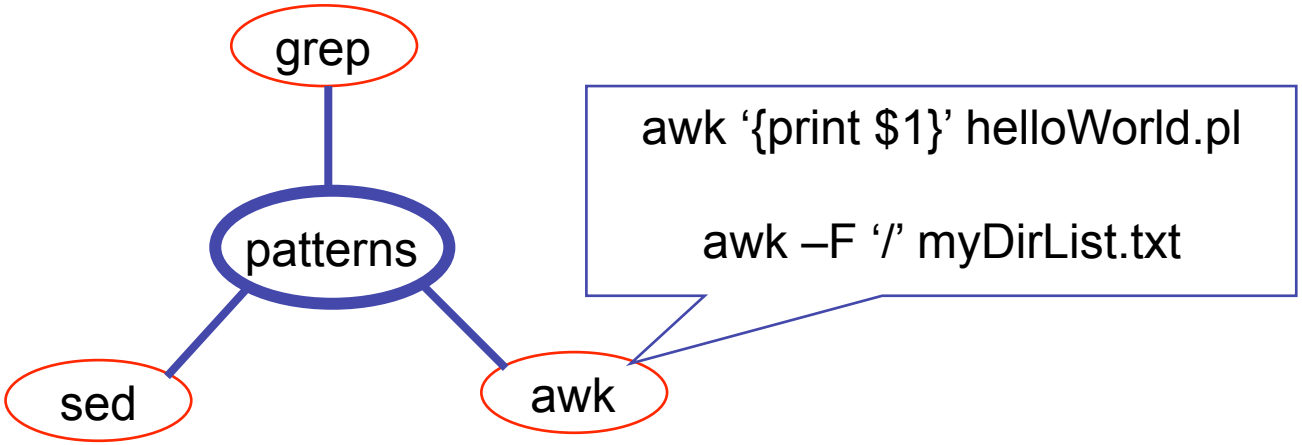


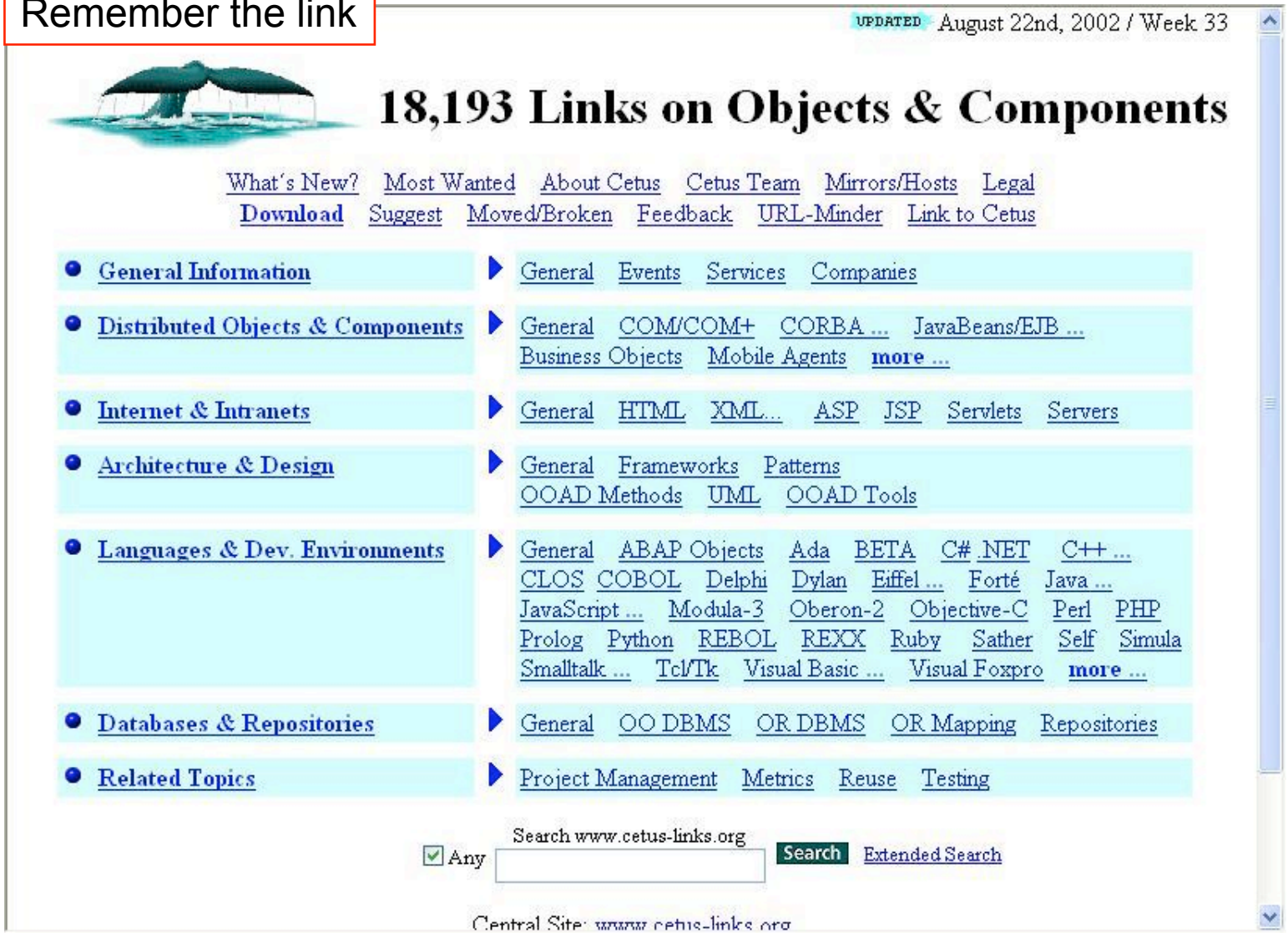
When manipulating files there will come a time when you want to look for a string or pattern, and either Extract or modify it. Basic use of these commands Can save enormous amounts of time with repetitive tasks.

Available Resources

- If you are stuck with a problem there are several resources available to you:
  - collaborators in your group or on your experiment.
  - books: library, colleague's bookshelf etc.
  - web resources:
    - www.google.co.uk is surprisingly good in helping you find useful technical websites.
    - An alternative is cetus-links (URL on next page)

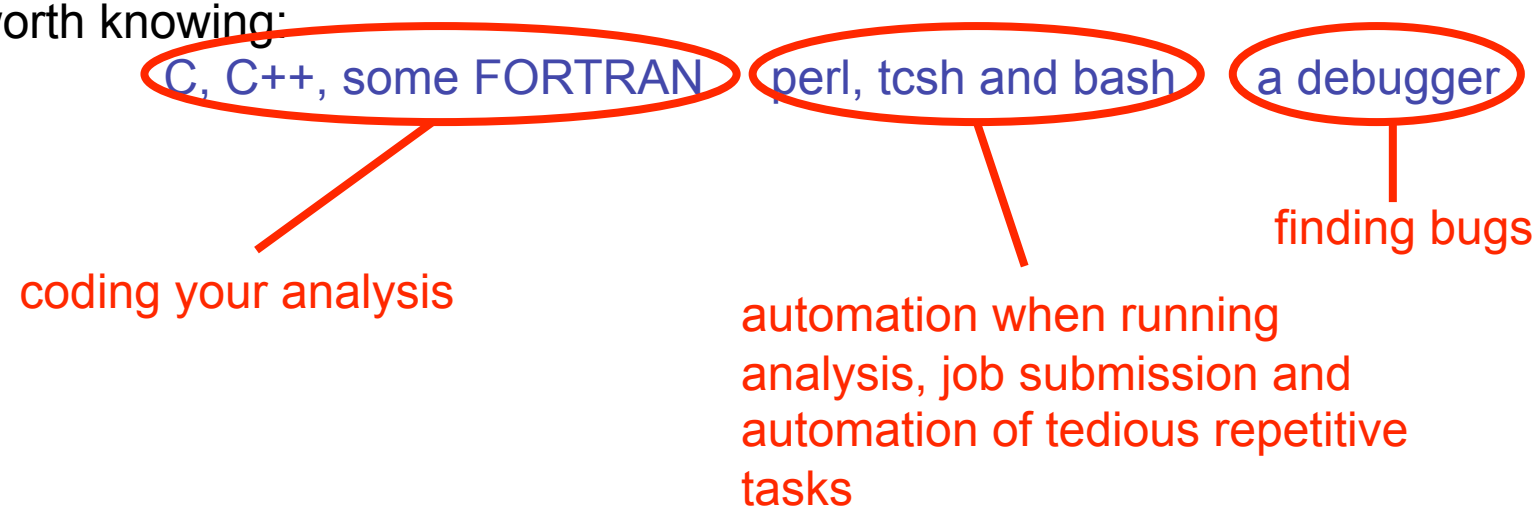
This website contains links to beginner and advanced web based resources on most programming languages you might want to use (*except FORTRAN*)

Remember the link



Code Development

Before moving on from this introduction, here is a biased opinion of what is worth knowing:



Along the way you may also learn a bit about design patterns and Object Orientated programming.

If you do, don't worry about good design to begin with just learn the syntax. When you know this then you'll start to pick up what is good and what is bad. Writing 'good code' takes a long time … so be patient and don't worry too much about making mistakes when you are learning.

Extra Material for Part 1

You'll find some material on the following topics in the extra material

- more complicated uses of `sed`
- Some jargon you'll encounter
- Writing your own `Makefile`
- Simple use of a debugger to identify null pointers