

# SEES: Using Linux Tools

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# Outline

- 1 Introduction
- 2 Getting Started
- 3 Getting Help
- 4 Basic File Handling
- 5 Linux File Hierarchy, Permissions & Ownership
- 6 Looking at files
- 7 The Command Shell
  - Features of the Shell
- 8 More text processing
- 9 Simple Shell Scripts
- 10 Control structures and Operators
- 11 Miscellaneous Tools

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## What is the Linux OS?

- Free Open Source Operating System

**Free** Free as in Free Speech, not Free Beer

**Open-Source** Permit modifications and redistribution of source code

- Unix-inspired
- Linux Kernel + Application software
- Runs on a variety of hardware
- Also called GNU/Linux

# Why Linux?

- Free as in Free Beer
- Secure & versatile

## Why Linux for Scientific Computing?

- Free as in Free Speech
- Can run for *ever*
- Libraries
- Parallel Computing

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# Logging in

- GNU/Linux does have a GUI
- Command Line for this module
- Hit `Ctrl + Alt + F1`
- Login
- `logout` command logs you out

# Where am I?

- Logged in. Where are we?
- `pwd` command gives the present working directory

```
$ pwd  
/home/user
```



# What is in there?

- `ls` command lists contents of `pwd`

```
$ ls  
jeeves.rst psmith.html blandings.html Music
```

- Can also pass directory as argument

```
$ ls Music  
one.mp3 two.mp3 three.mp3
```

- the Unix world is case sensitive

# New folders

- `mkdir` creates new directories

```
$ mkdir sees
```

```
$ ls
```

- Special characters need to be escaped OR quoted

```
$ mkdir software\ engineering
```

```
$ mkdir "software engg"
```

- Generally, use hyphens or underscores instead of spaces in names

# Moving around

- `cd` command changes the `pwd`

```
$ cd sees
```

```
$ pwd
```

```
/home/user/sees/
```

- Alternately written as `cd ./sees`
- Specifying path relative to `pwd`
- `..` takes one level up the directory structure

```
$ cd ..
```

- We could use absolute path instead of relative

```
$ cd /home/user/sees/
```

# New files

- `touch` command creates a blank file

```
$ pwd  
/home/user  
$ cd sees  
$ touch first  
$ ls  
first
```

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# What does a command do?

- `whatis` gives a quick description of a command

```
$ whatis touch  
touch (1) - change file timestamps
```

- `man` command gives more detailed description

```
$ man touch
```

- Shows all tasks that the command can perform
- Hit `q` to quit the `man` page
- For more, see the `man` page of `man`

```
$ man man
```

# Using additional options

- `-h` or `-help` give summary of command usage

```
$ ls --help
```

- List out all files within a directory, recursively

```
$ ls -R
```

- Create a new directory along with parents, if required

```
$ pwd
```

```
/home/user/
```

```
$ ls sees/
```

```
$ mkdir -p sees/linux-tools/scripts
```

# Searching for a command

- `apropos` searches commands based on their descriptions

```
$ apropos remove
```

- Returns a list of all commands that contain the search term
- In this case, we are interested in `rm`, `rmdir`



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# Removing files

- `rm` is used to delete files

```
$ rm foo
```

- `rm` works only for files; not directories
- Additional arguments required to remove a directory
- `-r` stands for recursive.
- Removes directory and all of it's content

```
$ rm -r bar
```

- `rmdir` can also be used; Explore

# Copying Files

- `cp` copies files from one location to another

```
$ cp linux-tools/scripts/foo linux-tools/
```

- New file-name can be used at target location
- `foo` copied to new location with the name `bar`

```
$ cp linux-tools/scripts/foo linux-tools/bar
```

- `cp` overwrites files, unless explicitly asked not to
- To prevent this, use the `-i` flag

```
$ cp -i linux-tools/scripts/foo linux-tools/b  
cp: overwrite `bar'?
```

# Copying Directories

- `-r` is required to copy a directory and all its content
- Copying directories is similar to copying files

```
$ cd /home/user
```

```
$ cp -ir sees course
```

# Moving Files

- `cp` and `rm` would be one way
- `mv` command does the job
- Also takes `-i` option to prompt before overwriting

```
$ cd /home/user
```

```
# Assume we have course directory already created
```

```
$ mv -i sees/ course/
```

- No prompt! Why?

```
$ ls course
```

- `sees` became a sub-directory of `course`
- `mv` command doesn't over-write directories
- `-i` option is useful when moving files around
- `mv` to rename — move to same location with new name

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# Linux File Hierarchy

- / is called the root directory
- It is the topmost level of the hierarchy
- For details `man hier`

# Permissions and Access control

- In a multi-user environment, access control is vital
- Look at the output of `ls -l`

```
drwxr-xr-x    5 root users 4096 Jan 21 20:07
```

- The first column shows the permission information
- First character specifies type of the file
- Files have `-`; Directories have `d`
- 3 sets of 3 characters — for user, group and others
- `r`, `w`, `x` — for read, write, execute
- Either the corresponding character or `-` is present



# Changing the permissions

- Permissions can be changed by owner of the file
- `chmod` command is used
- `-R` option to recursively change for all content of a directory
- Change permissions of `foo.sh` from `-rw-r--r--` to `-rwxr-xr--`

```
$ ls -l foo.sh
$ chmod ug+x foo.sh
$ ls -l foo.sh
```

# Symbolic modes

Reference	Class	Description
u	user	the owner of the file
g	group	users who are members of the file's group
o	others	users who are not the owner of the file or members of
a	all	all three of the above; is the same as <i>ugo</i>

Operator	Description
+	adds the specified modes to the specified classes
-	removes the specified modes from the specified classes
=	the modes specified are to be made the exact modes for the specified

Mode	Name	Description
r	read	read a file or list a directory's contents
w	write	write to a file or directory
x	execute	execute a file or recurse a directory tree

# Changing Ownership of Files

- `chown` changes the owner and group
- By default, the user who creates file is the owner
- The default group is set as the group of the file

```
$ chown alice:users wonderland.txt
```

- Did it work? **Not every user can change ownership**
- Super-user or `root` user alone is empowered

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# cat

- Displays the contents of files

```
$ cat foo.txt
```

- Concatenates the text of multiple files

```
$ cat foo.txt bar.txt
```

- Not-convenient to view long files

# less

- View contents of a file one screen at a time

```
$ less wonderland.txt
```

- q: Quit
- Arrows/Page Up/Page Down/Home/End: Navigation
- ng: Jump to line number n
- /pattern: Search. Regular expressions can be used
- h: Help

- Statistical information about the file
- the number of lines in the file
- the number of words
- the number of characters

```
$ wc wonderland.txt
```

# head & tail

- let you see parts of files, instead of the whole file
- `head` – start of a file; `tail` – end of a file
- show 10 lines by default

```
$ head wonderland.txt
```

- `-n` option to change the number of lines

```
$ head -n 1 wonderland.txt
```

- `tail` is commonly used to monitor files
- `-f` option to monitor the file
- `Ctrl-C` to interrupt

```
$ tail -f /var/log/dmesg
```



# cut

- Allows you to view only certain sections of lines
- Let's take `/etc/passwd` as our example

```
root:x:0:0:root:/root:/bin/bash
```

- View only user names of all the users (first column)

```
$ cut -d : -f 1 /etc/passwd
```

- `-d` specifies delimiter between fields (default TAB)
- `-f` specifies the field number
- Multiple fields by separating field numbers with comma

```
$ cut -d : -f 1,5,7 /etc/passwd
```

# cut

- Allows choosing on the basis of characters or bytes
- Example below gets first 4 characters of `/etc/passwd`

```
$ cut -c 1-4 /etc/passwd
```

- One of the limits of the range can be dropped
- Sensible defaults are assumed in such cases

```
$ cut -c -4 /etc/passwd
```

```
$ cut -c 10- /etc/passwd
```

# paste

- Joins corresponding lines from two different files

<code>students.txt</code>	<code>marks.txt</code>
Hussain	89 92 85
Dilbert	98 47 67
Anne	67 82 76
Raul	78 97 60
Sven	67 68 69

```
$ paste students.txt marks.txt
```

```
$ paste -s students.txt marks.txt
```

- `-s` prints content, one below the other
- If first column of marks file had roll numbers? How do we get a combined file with the same output as above (i.e. without roll numbers). We need to use `cut` & `paste` together. But how?

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# Redirection and Piping

```
$ cut -d " " -f 2- marks1.txt \  
> /tmp/m_tmp.txt  
$ paste -d " " students.txt m_tmp.txt
```

or

```
$ cut -d " " -f 2- marks1.txt \  
| paste -d " " students.txt -
```

- The first solution used Redirection
- The second solution uses Piping

# Redirection

- The standard output (stdout) stream goes to the display
- Not always, what we need
- First solution, redirects output to a file
- `>` states that output is redirected; It is followed by location to redirect

```
$ command > file1
```

- `>` creates a new file at specified location
- `>>` appends to a file at specified location

# Redirection ...

- Similarly, the standard input (stdin) can be redirected

```
$ command < file1
```

- input and the output redirection could be combined

```
$ command < infile > outfile
```

- Standard error (stderr) is the third standard stream
- All error messages come through this stream
- `stderr` can also be redirected

# Redirection ...

- Following example shows `stderr` redirection
- Error is printed out in the first case
- Error message is redirected, in the second case

```
$ cut -d " " -c 2- marks1.txt \  
> /tmp/m_tmp.txt
```

```
$ cut -d " " -f 2- marks1.txt 1> \  
/tmp/m_tmp.txt 2> /tmp/m_err.txt
```

- `1>` redirects `stdout`; `2>` redirects `stderr`

```
$ paste -d " " students.txt m_tmp.txt
```



# Piping

```
$ cut -d " " -f 2- marks1.txt \  
  | paste -d " " students.txt -
```

- – instead of FILE asks `paste` to read from `stdin`
- `cut` command is a normal command
- the `|` seems to be joining the two commands
- Redirects output of first command to `stdin`, which becomes input to the second command
- This is called piping; `|` is called a pipe

# Piping

- Roughly same as – 2 redirects and a temporary file

```
$ command1 > tempfile  
$ command2 < tempfile  
$ rm tempfile
```

- Any number of commands can be piped together

# Tab-completion

- Hit tab to complete an incompletely typed word
- Tab twice to list all possibilities when ambiguous completion
- Bash provides tab completion for the following.
  - 1 File Names
  - 2 Directory Names
  - 3 Executable Names
  - 4 User Names (when they are prefixed with a ~)
  - 5 Host Names (when they are prefixed with a @)
  - 6 Variable Names (when they are prefixed with a \$)

# History

- Bash saves history of commands typed
- Up and down arrow keys allow to navigate history
- `Ctrl-r` searches for commands used

# Shell Meta Characters

- “meta characters” are special command directives
- File-names shouldn't have meta-characters
- /<>!\$%^&\*|{}[]"'`~;

```
$ ls file.*
```

- Lists `file.ext` files, where `ext` can be anything

```
$ ls file.?
```

- Lists `file.ext` files, where `ext` is only one character

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# sort

- `sort` can be used to get sorted content
- Command below prints student marks, sorted by name

```
$ cut -d " " -f 2- marks1.txt \  
  | paste -d " " students.txt - \  
  | sort
```

- The default is sort based on the whole line
- `sort` can sort based on a particular field

## sort ...

- The command below sorts based on marks in first subject

```
$ cut -d " " -f 2- marks1.txt \  
  | paste -d " " students.txt -\  
  | sort -t " " -k 2 -rn
```

- `-t` specifies the delimiter between fields
- `-k` specifies the field to use for sorting
- `-n` to choose numerical sorting
- `-r` for sorting in the reverse order



# grep

- `grep` is a command line text search utility
- Command below searches & shows the marks of Anne alone

```
$ cut -d " " -f 2- marks1.txt \  
| paste -d " " students.txt - \  
| grep Anne
```

- `grep` is case-sensitive by default

# grep ...

- `-i` for case-insensitive searches

```
$ cut -d " " -f 2- marks1.txt \  
| paste -d " " students.txt - \  
| grep -i Anne
```

- `-v` inverts the search
- To see everyone's marks except Anne's

```
$ cut -d " " -f 2- marks1.txt \  
| paste -d " " students.txt - \  
| grep -iv Anne
```

## tr

- `tr` translates or deletes characters
- Reads from `stdin` and outputs to `stdout`
- Given, two sets of characters, replaces one with other
- The following, replaces all lower-case with upper-case

```
$ cat students.txt | tr a-z A-Z
```

- `-s` compresses sequences of identical adjacent characters in the output to a single one
- Following command removes empty newlines

```
$ tr -s '\n' '\n'
```

## tr ...

- `-d` deletes all specified characters
- Only a single character set argument is required
- The following command removes carriage return characters (converting file in DOS/Windows format to the Unix format)

```
$ cat foo.txt | tr -d '\r' > bar.txt
```

- `-c` complements the first set of characters
- The following command removes all non-alphanumeric characters

```
$ tr -cd '[:alnum:]'
```

# uniq

- `uniq` command removes duplicates from **sorted** input

```
$ sort items.txt | uniq
```

- `uniq -u` gives lines which do not have any duplicates
- `uniq -d` outputs only those lines which have duplicates
- `-c` displays the number of times each line occurs

```
$ sort items.txt | uniq -u  
$ sort items.txt | uniq -dc
```

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# Shell scripts

- Simply a sequence of shell commands in a file
- To save results of students in `results.txt` in `marks` dir

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

```
mkdir ~/marks
```

```
cut -d " " -f 2- marks1.txt \  
| paste -d " " students.txt - \  
| sort > ~/marks/results.txt
```

# Shell scripts ...

- Save the script as `results.sh`
- Make file executable and then run

```
$ chmod u+x results.sh  
$ ./results.sh
```

- What does the first line in the script do?
- Specify the interpreter or shell which should be used to execute the script; in this case `bash`



# Variables & Comments

```
$ name=FOSSEE  
$ count=`wc -l wonderland.txt`  
$ echo $count # Shows the value of count
```

- It is possible to create variables in shell scripts
- Variables can be assigned with the output of commands
- **NOTE:** There is no space around the = sign
- All text following the # is considered a comment

# echo

- echo command prints out messages

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

```
mkdir ~/marks
```

```
cut -d " " -f 2- marks1.txt \  
| paste -d " " students.txt - \  
| sort > ~/marks/results.txt
```

```
echo "Results generated."
```

# Command line arguments

- Shell scripts can be given command line arguments
- Following code allows to specify the results file

```
#!/bin/bash
mkdir ~/marks
cut -d " " -f 2- marks1.txt \
| paste -d " " students.txt - \
| sort > ~/marks/$1
echo "Results generated."
```

- \$1 corresponds to first command line argument
- \$n corresponds to *n*th command line argument
- It can be run as shown below

```
$ ./results.sh grades.txt
```

# PATH

- The shell searches in a set of locations, for the command
- Locations are saved in “environment” variable called PATH
- `echo` can show the value of variables

```
$ echo $PATH
```

- Put `results.sh` in one of these locations
- It can then be run without `./`

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# Control Structures

- `if-else`
- `for` loops
- `while` loops
- `test` command to test for conditions
- A whole range of tests that can be performed
  - `STRING1 = STRING2` – string equality
  - `INTEGER1 -eq INTEGER2` – integer equality
  - `-e FILE` – existence of `FILE`
- `man page of test` gives list of various tests

# if

- Print message if directory exists in `pwd`

```
#!/bin/bash  
if test -d $1  
then  
echo "Yes, the directory" \  
$1 "is present"  
fi
```

# if-else

- Checks whether argument is negative or not

```
#!/bin/bash
if test $1 -lt 0
then
echo "number is negative"
else
echo "number is non-negative"
fi

$ ./sign.sh -11
```



# [ ] - alias for test

- Square brackets ( [ ] ) can be used instead of `test`



```
#!/bin/bash
if [ $1 -lt 0 ]
then
echo "number is negative"
else
echo "number is non-negative"
fi
```

- spacing is important, when using the square brackets

# if-else

- An example script to greet the user, based on the time

```
#!/bin/sh  
# Script to greet the user  
# according to time of day  
hour=`date | cut -c12-13`  
now=`date +"%A, %d of %B, %Y (%r)"`  
if [ $hour -lt 12 ]  
then  
mess="Good Morning \  
$LOGNAME, Have a nice day!"  
fi
```

## if-else ...

```
if [ $hour -gt 12 -a $hour -le 16 ]
then
mess="Good Afternoon $LOGNAME"
fi
if [ $hour -gt 16 -a $hour -le 18 ]
then
mess="Good Evening $LOGNAME"
fi
echo -e "$mess\nIt is $now"
```

- \$LOGNAME has login name (env. variable)
- backquotes store commands outputs into variables

## for

## Problem

Given a set of `.mp3` files, that have names beginning with numbers followed by their names — `08 - Society.mp3` — rename the files to have just the names. Also replace any spaces in the name with hyphens.

- Loop over the list of files
- Process the names, to get new names
- Rename the files

# for

- A simple example of the `for` loop

```
for animal in rat cat dog man  
do  
echo $animal  
done
```

- List of animals, each animal's name separated by a space
- Loop over the list; `animal` is a dummy variable
- Echo value of `animal` — each name in list

```
for i in {10..20}  
do  
echo $i  
done
```

# for

- Let's start with echoing the names of the files

```
for i in `ls *.mp3`  
do  
echo "$i"  
done
```

- Spaces in names cause trouble!
- The following works better

```
for i in *.mp3  
do  
echo "$i"  
done
```

## tr &amp; cut

- Replace all spaces with hyphens using `tr -s`
- Use `cut` & keep only the text after the first hyphen

```
for i in *.mp3
do
echo $i|tr -s " " "-"|cut -d - -f 2-
done
```

Now `mv`, instead of just echoing

```
for i in *.mp3
do
mv $i `echo $i|tr -s " " "-" \
|cut -d - -f 2-`
done
```

# while

- Continuously execute a block of commands until condition becomes false
- program that takes user input and prints it back, until the input is quit

```
while [ "$variable" != "quit" ]  
do  
  read variable  
  echo "Input - $variable"  
done  
exit 0
```



# Environment Variables

- Pass information from shell to programs running in it
- Behavior of programs can change based on values of variables
- Environment variables vs. Shell variables
- Shell variables – only current instance of the shell
- Environment variables – valid for the whole session
- Convention – environment variables are UPPER CASE

```
$ echo $OSTYPE  
linux-gnu  
$ echo $HOME  
/home/user
```

# Environment Variables ...

- The following commands show values of all the environment variables

```
$ printenv | less  
$ env
```

- Use `export` to change Environment variables
- The new value is available to all programs started from the shell

```
$ export PATH=$PATH:$HOME/bin
```

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# find

- Find files in a directory hierarchy
- Offers a very complex feature set
- Look at the `man` page!
- Find all `.pdf` files, in current dir and sub-dirs

```
$ find . -name '*.pdf'
```

- List all the directory and sub-directory names

```
$ find . -type d
```

## cmp

- Compare two files

```
$ find . -name quick.c
./Desktop/programs/quick.c
./c-folder/quick.c
$ cmp Desktop/programs/quick.c \
c-folder/quick.c
```

- No output when the files are exactly the same
- Else, gives location where the first difference occurs

# diff

- We know the files are different, but want exact differences

```
$ diff Desktop/programs/quick.c \  
c-folder/quick.c
```

- line by line difference between files
- > indicates content only in second file
- < indicates content only in first file

# tar

- *tarball* – essentially a collection of files
- May or may not be compressed
- Eases the job of storing, backing-up & transporting files

# Extracting an archive

```
$ mkdir extract  
$ cp allfiles.tar extract/  
$ cd extract  
$ tar -xvf allfiles.tar
```

- `-x` — Extract files within the archive
- `-f` — Specify the archive file
- `-v` — Be verbose



# Creating an archive

```
$ tar -cvf newarchive.tar *.txt
```

- `-c` — Create archive
- Last argument is list of files to be added to archive

# Compressed archives

- `tar` can create and extract compressed archives
- Supports compressions like `gzip`, `bzip2`, `lzma`, etc.
- Additional option to handle compressed archives

Compression	Option
<code>gzip</code>	<code>-z</code>
<code>bzip2</code>	<code>-j</code>
<code>lzma</code>	<code>--lzma</code>

```
$ tar -cvzf newarchive.tar.gz *.txt
```

# Customizing your shell

- Bash reads `/etc/profile`, `~/.bash_profile`, `~/.bash_login`, and `~/.profile` in that order, when starting up as a login shell.
- `~/.bashrc` is read, when not a login shell
- Put any commands that you want to run when bash starts, in this file.