High Performance Research Computing

A Resource for Research and Discovery

TEXAS A&M UNIVERSITY

HPRC Short Course

Introduction to Linux

DIVISION OF RESEARCH

TEXAS A&M UNIVERSITY

For Assistance…

Website:	hprc.tamu.edu
Email:	help@hprc.tamu.edu
Telephone:	(979) 845-0219
Visit us:	Henderson Hall, Room 114A

Help us, help you -- *we need more info*

- Which Cluster
- NetID
- Job ID(s) if any
- Location of your job files, input/output files
- Application used & module(s) loaded if any
- Error messages
- Steps you have taken, so we can reproduce the problem

Course Outline

1 Accessing the System	Secure shell
2 Directories	Our first commands
3 Gedit	An easy text editor
4 File Manipulation	Copy, rename/move & remove
5 Passing output & Redirection	Learning about operators
6 The Linux file system	Attributes and permissions
7 Environment Variables & $PATH	Storing and retrieving information
8 Basic Shell Scripting	Making Linux work for you

Your Login Password

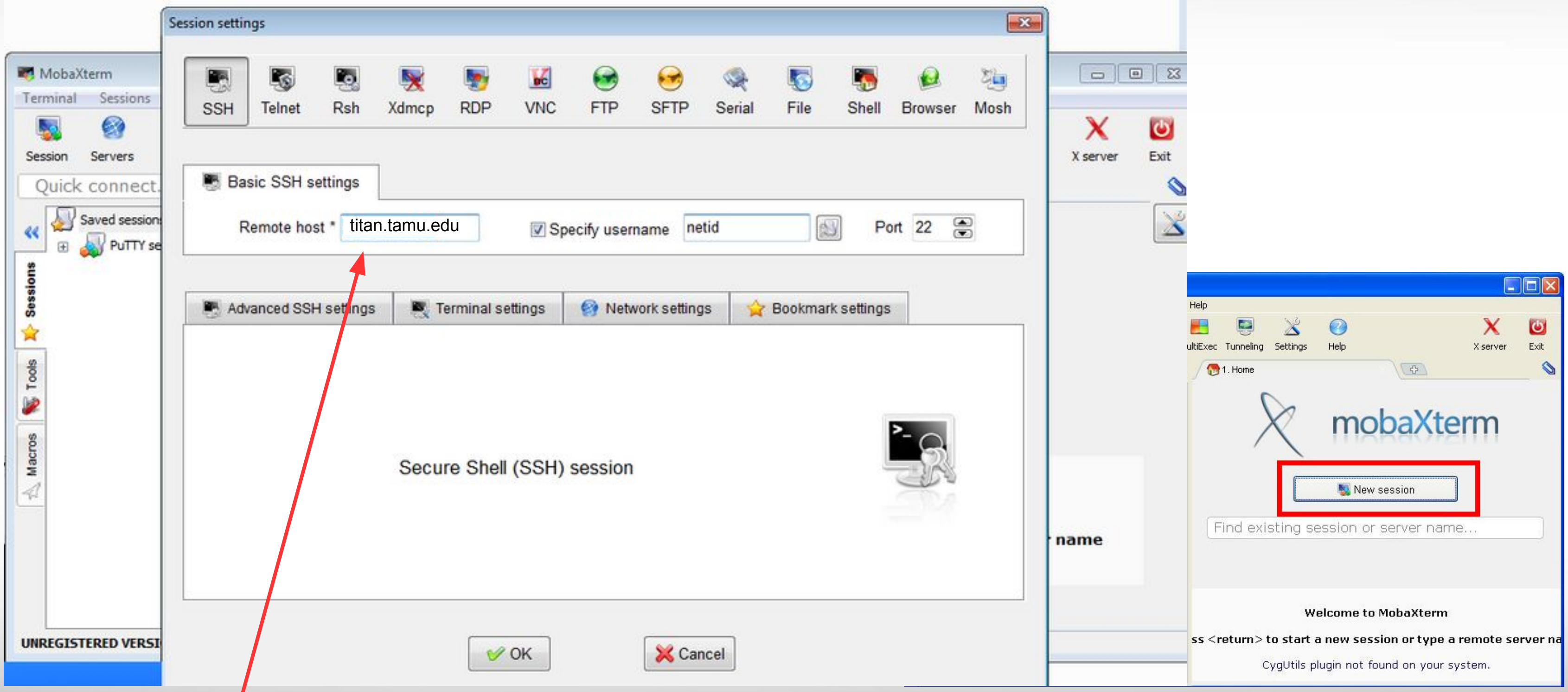
- Both State of Texas law and TAMU regulations prohibit the sharing and/or illegal use of computer passwords and accounts;
- Don’t write down passwords;
- Don’t choose easy to guess/crack passwords;
- Change passwords frequently

1. Accessing the system

- SSH (secure shell)
  - The only program allowed for remote access; encrypted communication; freely available for Linux/Unix and Mac OS X hosts;
- For Microsoft Windows PCs, use *MobaXterm*
    - https://hprc.tamu.edu/wiki/HPRC:MobaXterm
      - You are able to view images and use GUI applications with MobaXterm
  - or *Putty*
    - https://hprc.tamu.edu/wiki/HPRC:Access#Using__PuTTY
      - You can not view images or use GUI applications with PuTTY

Using SSH - MobaXterm on Windows

https://hprc.tamu.edu/wiki/HPRC:MobaXterm



Session settings

Basic SSH settings

Remote host * titan.tamu.edu

☑ Specify username netid

Port 22

Secure Shell (SSH) session

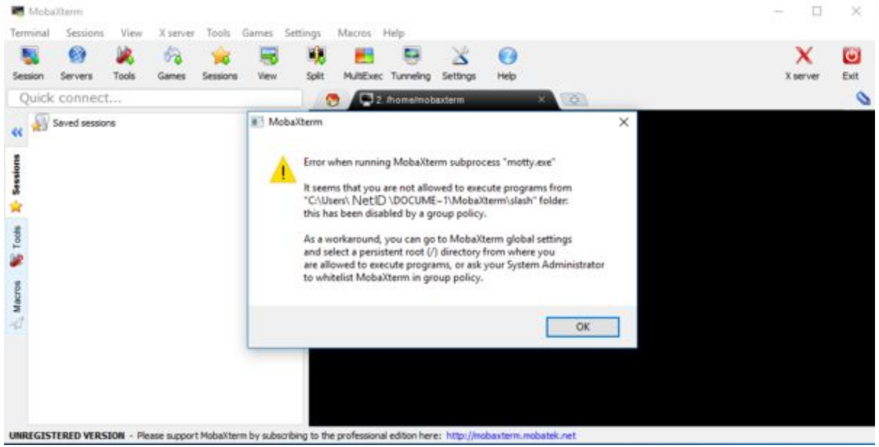
Welcome to MobaXterm

ss <return> to start a new session or type a remote server na

CygUtils plugin not found on your system.

Use **titan.tamu.edu** as Remote host name.

Possible Error - MobaXterm on Windows



Error when running MobaXterm subprocess "motty.exe"

It seems that you are not allowed to execute programs from "C:\Users\ NetID \DOCUME~1\MobaXterm\slash" folder: this has been disabled by a group policy.

As a workaround, you can go to MobaXterm global settings and select a persistent root (/) directory from where you are allowed to execute programs, or ask your System Administrator to whitelist MobaXterm in group policy.

UNREGISTERED VERSION - Please support MobaXterm by subscribing to the professional edition here: http://mobaxterm.mobatek.net

Solution:

https://hprc.tamu.edu/wiki/HPRC:MobaXterm#Running_MobaXterm_on_Open_Access_Lab_workstations

Using SSH (on a Linux Client)

```
ssh -X NetID@titan.tamu.edu
```

You may see something like this the first time you connect to the remote machine from your local machine:

```
Host key not found from the list of known hosts.
    Are you sure you want to continue connecting (yes/no)?
```

Type yes, hit enter and you will then see the following:

```
Host 'titan.tamu.edu' added to the list of known hosts.
NetID@titan.tamu.edu's password:
```

Mac users may need to use ssh -Y to enable X11 so you can view images and use GUI software

```
ssh -Y NetID@titan.tamu.edu
```

The host **`titan.tamu.edu`** is for this Linux class only and *is not* an HPRC cluster.
To use the HPRC clusters, you must apply for an HPRC account.

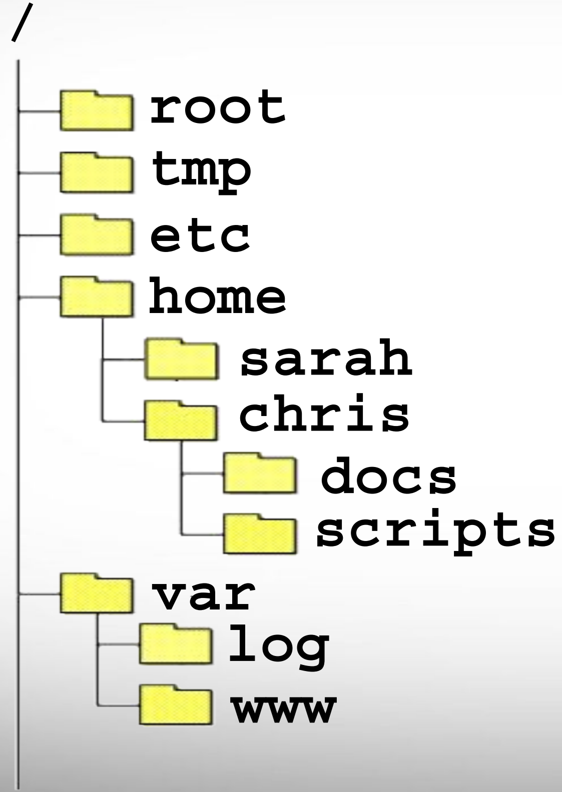
2. Directories

Quick Q&A

● What is a directory?	Directory = folder
● Where am I?	In your Home Directory: `/home/NetID`
● How do I move around?	You *change directory*
● Where could I go?	Anywhere you have permission

We’ll talk about each of these and more in this section.
If you have any questions please feel free to stop and ask for clarification.

Finding your way around the Linux directory structure



```
/
  root
  tmp
  etc
  home
    sarah
    chris
      docs
      scripts
  var
    log
    www
```

```
/

/root
/tmp
/etc
/home
/home/sarah
/home/chris
/home/chris/docs
/home/chris/scripts
/var
/var/log
/var/www
```

Where Am I?

`pwd` command (print work directory)

Linux commands in green for you to type

```
pwd
```

command output in blue

```
/home/user_NetID
```

list contents of your pwd

```
ls
```

Common Directory Commands

mkdir command to make a new directory:

```
mkdir my_dir
```

cd to change to another directory:

```
cd my_dir
```

rmdir to remove an empty directory:

```
rmdir my_dir
```

Linux Commands Have Options

Leave a space between the command and the options

double dash means there is a single option which is usually a descriptive word

```
ls --all
```

`--all`	show all files including hidden files which begin with **.**

single dash means each character is an option

```
ls -a -l
```

`-a`	show all files including hidden
`-l`	show file details

most options can be combined behind one dash

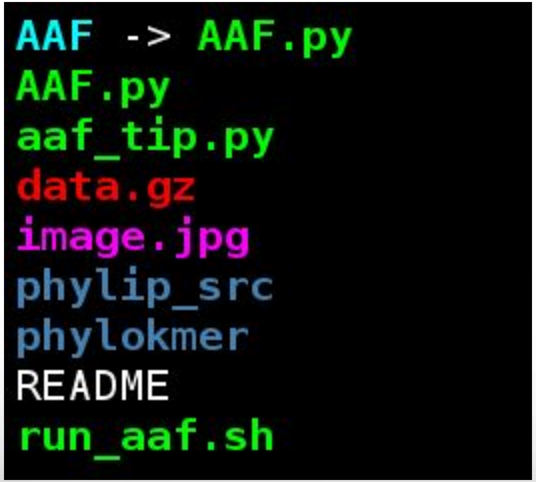
```
ls -al
```

`-a`	show all files including hidden
`-l`	show file details

`.`	current working directory
`..`	parent directory

UNIX Terminal Attributes

File and directory names are colored
based on their attributes such as permissions and extension



```
AAF -> AAF.py
AAF.py
aaf_tip.py
data.gz
image.jpg
phylip_src
phylokmer
README
run_aaf.sh
```

TURQUOISE	Symbolic link
GREEN	Executable file
RED	Compressed files
PURPLE	Image files
BLUE	Directories
WHITE	Text files

Search for Linux Commands Options

Search the manual page for the Linux command `ls`

```
man ls
```

Page up	Move up one page
Page down	Move down one page
Spacebar	Move down one page
Mouse scroll wheel	Move up and down
`/all`	search the man page for the text 'all'
`n`	search forward for next found match
`N`	search backwards next found match
`g`	go to first line
`G`	Go to last line
`q`	quit

File and directory names

Commonly used:

A-Z	
a-z	
0-9	
.	
-	dash
_	underscore

Avoid using:

	spaces
()	parenthesis
“ '	quotes
?	Question mark
$	Dollar sign
*	Asterisk
\	back slash
/	forward slash
:	colon

- Avoid spaces.
- File and directory names are case sensitive
- Avoid spaces in the file name ("`my data file.txt`" vs "`my_data_file.txt`").
- Avoid creating files on your Windows computer and copying to UNIX especially with spaces in the file name

Changing Directories: the `cd` cmd

- Return to your home directory

```
cd
cd ~
cd ~/
```

- To switch to the parent directory of the current directory:

```
cd ..
```

- Return to previous pwd

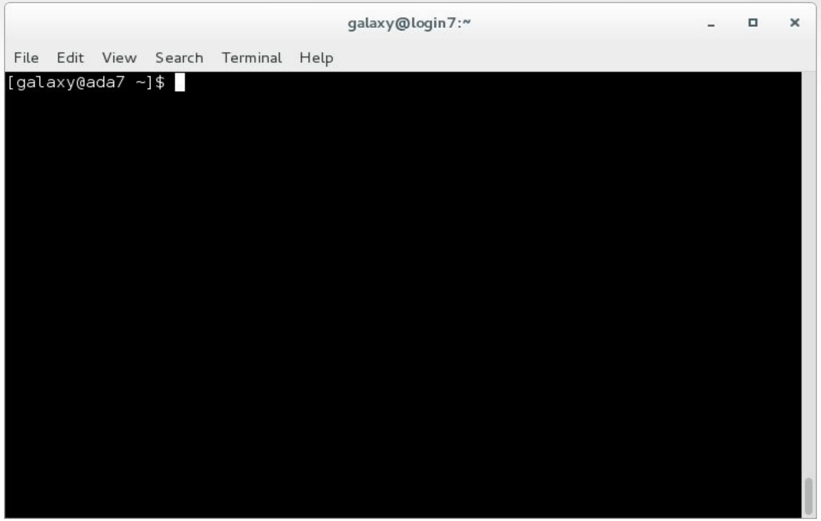
```
cd -
```

```
cd
mkdir temp
mkdir temp/hg19
cd temp
pwd
cd hg19
pwd
cd ../..
pwd
cd -
pwd
cd ..
pwd
cd
pwd
```

Clear Contents on Screen

Type **`clear`** command to clear screen contents.

```
clear
```



```
[galaxy@ada7 ~]$
```

You can still scroll up in your terminal to see past contents

You can also use Ctrl+L to clear contents

Absolute vs. Relative Path

```
/
/root
/tmp
/etc
/home
/home/sarah
/home/chris/project
/home/chris/docs/README
/var
/var/log
/var/www
```

If you are in the **`project`** directory

```
pwd
```

```
/home/chris/project
```

The relative path to the README file is `../docs/README`

```
ls ../docs/README
```

The absolute path to the README file `/home/chris/docs/README`

```
ls /home/chris/docs/README
```

3. The *Gedit* Text Editor

From the Linux terminal command line enter this command to start gedit and edit a file called my_favorite_foods.txt

```
gedit my_favorite_foods.txt &
```

The ‘&’ will detach gedit from the terminal so you can continue to use the terminal

Recommendations for naming files:

Use all lowercase characters
Separate words with an underscore
Make the filename concise and very descriptive of the file contents even if the name seems long

Some common file extensions are :

.pl	a Perl script
.py	a Python script
.gz	a file that has been compressed (zipped) to reduce file size (.zip)
.txt	a generic text file
.tsv	tab separated values (columns are separated by a tab)
.csv	comma separated values
.jar	a Java Archive file

Editing an ASCII file

- There are many editors available under Linux.
- Text mode
  - nano (simple)
  - vi or vim (more advanced)
  - emacs (more advanced)
- Graphic mode (require X11)
  - gedit
  - xemacs / gvim
- Be aware that a text file edited under Windows editors will most likely add CRLF characters. Use **`dos2unix`** to convert a DOS/Windows edited text file to UNIX format.

Use Tab to Complete a File Name

Type the first few characters of the file name

```
ls my
```

then hit the **tab key** to autocomplete the file name

```
ls my_favorite_foods.txt
```

then hit enter to see the command results

If the tab key did not complete the file name then either
the file does not exist or there are two or more files that begin
with the same characters in which case you need to hit tab twice
then type a few more characters and hit tab again to complete.

Count the Lines in a File

```
wc my_favorite_foods.txt
```

```
29 109 876 my_favorite_foods.txt
```

What does the output mean?

Use the man page for **`wc`** to find out.

How do you just print the newline counts?

4. File Manipulation

Quick Recap

Now you have:

- Connected to a system remotely
- Made and removed directories
- Moved around the system a bit
- Created a text file

In this section we'll discuss:

- How / where to get files
- Copying and moving files
- Removing a file
- Displaying the contents of a file

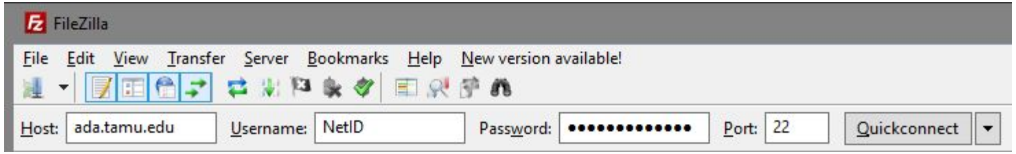
We'll talk about each of these and more in this section.
If you have any questions please feel free to stop and ask for clarification.

Transfer Data From Windows Host to Linux Host

On a Windows system, there are several applications to transfer files between remote machines:

- MobaXterm
- WinSCP
- FileZilla*

*personal favorite

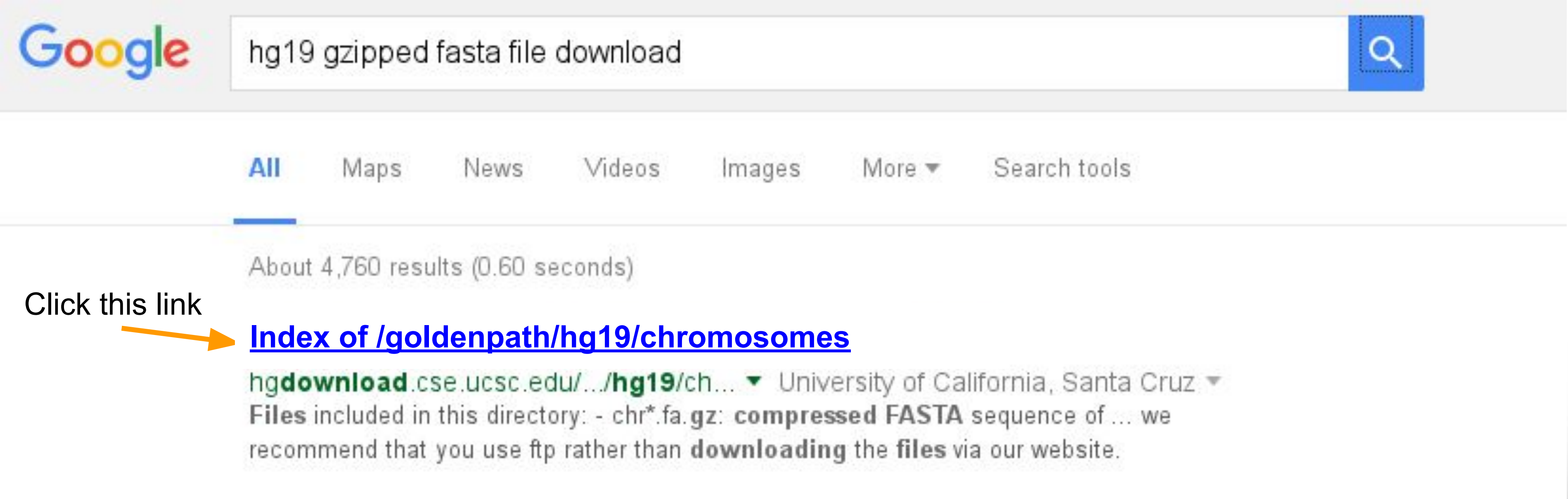

FileZilla
File Edit View Transfer Server Bookmarks Help New version available!
Quickconnect

Host: ada.tamu.edu Username: NetID Password: ••••••••••••• Port: 22

Data transfer, including management practices such as ***tar & compression*** will be covered in our Data Management Practices short course

https://hprc.tamu.edu/training/data_management.html

Download a File from the Web to Your pwd



hg19 gzipped fasta file download

About 4,760 results (0.60 seconds)

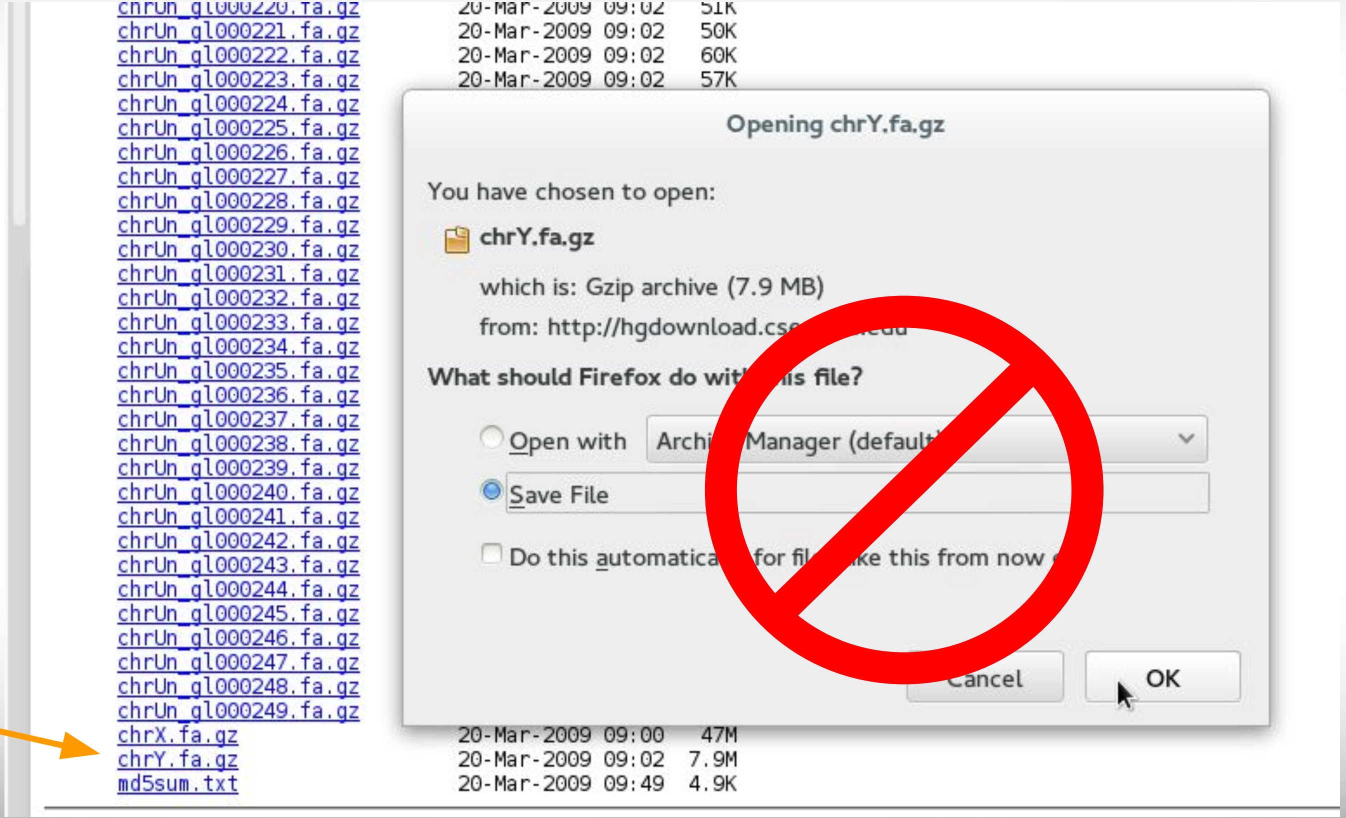
Click this link

Index of /goldenpath/hg19/chromosomes

hg**download**.cse.ucsc.edu/.../**hg19**/ch... ▾ University of California, Santa Cruz ▾

Files included in this directory: - chr*.fa.**gz**: **compressed FASTA** sequence of ... we recommend that you use ftp rather than **downloading** the **files** via our website.

Don't Left Click and download a file to your desktop



```
chrUn_gl000220.fa.gz          20-Mar-2009 09:02   51K
chrUn_gl000221.fa.gz          20-Mar-2009 09:02   50K
chrUn_gl000222.fa.gz          20-Mar-2009 09:02   60K
chrUn_gl000223.fa.gz          20-Mar-2009 09:02   57K
chrUn_gl000224.fa.gz
chrUn_gl000225.fa.gz
chrUn_gl000226.fa.gz
chrUn_gl000227.fa.gz
chrUn_gl000228.fa.gz
chrUn_gl000229.fa.gz
chrUn_gl000230.fa.gz
chrUn_gl000231.fa.gz
chrUn_gl000232.fa.gz
chrUn_gl000233.fa.gz
chrUn_gl000234.fa.gz
chrUn_gl000235.fa.gz
chrUn_gl000236.fa.gz
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chrUn_gl000244.fa.gz
chrUn_gl000245.fa.gz
chrUn_gl000246.fa.gz
chrUn_gl000247.fa.gz
chrUn_gl000248.fa.gz
chrUn_gl000249.fa.gz
chrX.fa.gz                    20-Mar-2009 09:00   47M
chrY.fa.gz                    20-Mar-2009 09:02  7.9M
md5sum.txt                    20-Mar-2009 09:49  4.9K
```

Opening chrY.fa.gz

You have chosen to open:

chrY.fa.gz

which is: Gzip archive (7.9 MB)

from: http://hgdownload.cse edu

What should Firefox do wit is file?

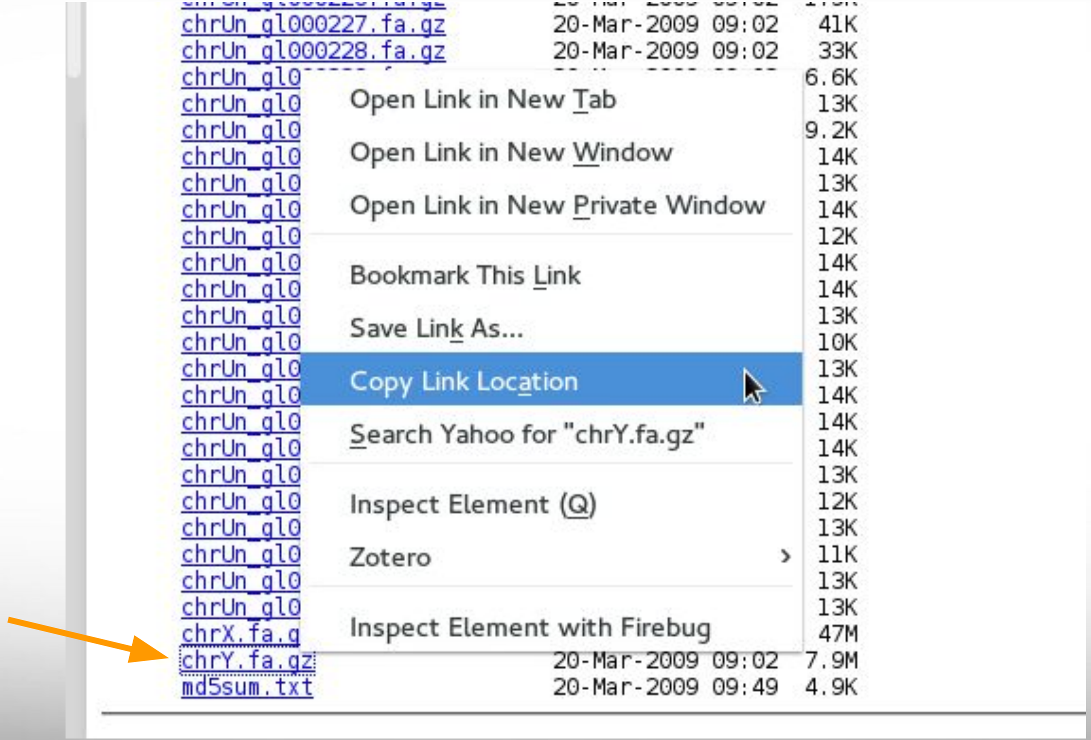
○ Open with Archi Manager (default

● Save File

□ Do this automatica for fil ke this from now o

go to the bottom of the web page

Right Click and Copy the URL so you can download it directly to your Linux pwd



```
chrUn_gl000227.fa.gz          20-Mar-2009 09:02   41K
chrUn_gl000228.fa.gz          20-Mar-2009 09:02   33K
chrUn_gl0                                        6.6K
chrUn_gl0                                         13K
chrUn_gl0                                        9.2K
chrUn_gl0                                         14K
chrUn_gl0                                         13K
chrUn_gl0                                         14K
chrUn_gl0                                         12K
chrUn_gl0                                         14K
chrUn_gl0                                         14K
chrUn_gl0                                         13K
chrUn_gl0                                         10K
chrUn_gl0                                         13K
chrUn_gl0                                         14K
chrUn_gl0                                         14K
chrUn_gl0                                         14K
chrUn_gl0                                         13K
chrUn_gl0                                         12K
chrUn_gl0                                         13K
chrUn_gl0                                         11K
chrUn_gl0                                         13K
chrUn_gl0                                         13K
chrX.fa.g                                         47M
chrY.fa.gz                    20-Mar-2009 09:02  7.9M
md5sum.txt                    20-Mar-2009 09:49  4.9K
```

Copying a File Directly to a LINUX Directory

```
cd ~/temp/hg19
```

Use the **wget** command to get a file from a URL

Type **wget** then a space then right click and paste the URL

```
wget http://hgdownload.cse.ucsc.edu/goldenpath/hg19/chromosomes/chrY.fa.gz
```

```
wget http://hgdownload.cse.ucsc.edu/goldenpath/hg19/chromosomes/md5sum.txt
```

List the directory contents to see the file with details (-l)
and human readable file sizes (-h)

```
ls -lh
```

Copying and Renaming Files

Use the tab key to help prevent typos when typing filenames and directories

1a.

```
cp ch                             (then hit tab)
```

UNIX will complete the file name for you

1b.

```
cp chrY.fa.gz
```

Make a copy of the `chrY.fa.gz` file called `chrY_copy.fa.gz`

1c.

```
cp chrY.fa.gz chrY_copy.fa.gz
```

Rename the `chrY_copy.fa.gz` file to `chrY_hg19.fa.gz`

```
mv chrY_copy.fa.gz chrY_hg19.fa.gz
```

Deleting Files: The **rm** Command

```
rm [options] [file_name]
```

- Commonly used options with the rm command

  -i   prompt user before any deletion

- Use the wildcard * to list all files ending with gz

Exercise:

```
ls *gz

rm -i chrY.fa.gz

ls
```

Displaying File Contents

- Check the file size before attempting to open with a text editor

```
ls -lh md5sum.txt
```

```
cat md5sum.txt
```

- `cat` prints all the contents of a file(s) to the screen.
- The `more` command, and its improved version `less`, display a text file one page (screen) at a time.
    - Hit space bar for next page; `less` search function is similar to man pages
    - Type `q` to quit
    - Use `zmore` or `zless` for compressed files (.gz)

```
more md5sum.txt
less md5sum.txt
zmore chrY_hg19.fa.gz
```

Displaying File Contents

- Use head and tail commands to see first and last 10 lines of a file respectively

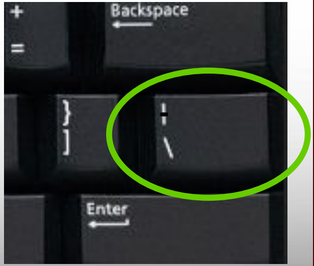
```
head md5sum.txt

tail md5sum.txt
```

- **head** and **tail** are not for compressed files (.gz)
- There is not a zhead or ztail command
- Use **zcat** together with the **head** or **tail** command
- Use the pipe **|** to send output of first command to the second command

```
zcat chrY_hg19.fa.gz | head

zcat chrY_hg19.fa.gz | tail
```



grep – Searching for Pattern(s) in Files

```
grep [options] PATTERN [files ...]
```

```
grep chrX md5sum.txt
```

the -i option is to ignore case

```
grep -i chrx md5sum.txt
```

Count the number of lines that match pattern

```
grep -c random md5sum.txt
```

grep – Searching For Pattern(s) in Files

Search multiple matches

```
grep -e chrX -e chrY md5sum.txt
```

Exclude a pattern; show non-matching lines

```
grep -v random md5sum.txt
```

Use **zgrep** for compressed files (.gz)

```
zgrep chr chrY_hg19.fa.gz
```

5. Passing output & Redirection

So far, all our commands have sent their output to the screen.

In this section, we will enter commands & send their output somewhere else.

Some common operators are shown below.

We’ve already used one of these before.

<table>
<tr><td>&lt;</td><td>redirects input</td></tr>
<tr><td>&gt;</td><td>redirects output</td></tr>
<tr><td>&gt;&gt;</td><td>appends output</td></tr>
<tr><td>|</td><td>passes output of one command to anothe</td></tr>
</table>

```
bsub < job_script.sh
```

```
command > out.txt
```

```
command >> out.txt
```

```
command1 | command2
```

Redirection Operators

<	redirects input
>	redirects output
>>	appends output
<<	input from *here document* (search the web for examples)

```
bsub < job_script.sh
```

```
command > out.txt
```

```
command >> out.txt
```

2>	redirects error
&>	redirects output and error
>&	redirects output and error
2>&1	redirects error to where output is going
1>&2	redirects output to where error is going

```
command 2> error.txt
```

```
command &> out-error.txt
```

```
command >& out-error.txt
```

Passing the Output of Linux Commands

Use the pipe character **|** to send results to another command

Search for the string 'chrX' in the output of md5sum.txt

```
cat md5sum.txt | grep chrX
```

Use the standard output redirect operator **>** to **create** a new file

```
grep chrX md5sum.txt > chr_xy.txt
```

Use the standard output redirect operator **>>** to **append** to a file

```
grep chrY md5sum.txt >> chr_xy.txt
```

History of Your Commands

- Your commands are saved to a file in your home directory (`.bash_history`)
- You can use the up/down arrows to scroll through your previous commands
- Type **`history`** to see your previously entered commands

```
history
history | tail
```

See the last 10 commands

- Search your history commands using | and grep

```
history | grep wget
```

Types of File: the `file` cmd

```
file [name]
```

Displays a brief description of the contents or other information for a file or related object.

```
file md5sum.txt
```

```
md5sum.txt: ASCII text
```

```
file chrY_hg19.fa.gz
```

```
chrY_hg19.fa.gz: gzip compressed data,
 was “chrY.fa”, last modified ...
```

CRLF Line Terminators

Windows editors such as Notepad will add hidden Carriage Return Line Feed (CRLF) characters that will cause problems with many applications

```
cd ~/intro_to_linux/
```

```
file DOS_script.sh
```

```
DOS_script.sh: ASCII English text, with CRLF line terminators
```

```
dos2unix DOS_script.sh
file DOS_script.sh
```

```
DOS_script.sh: ASCII English text
```

6. The Linux Filesystem

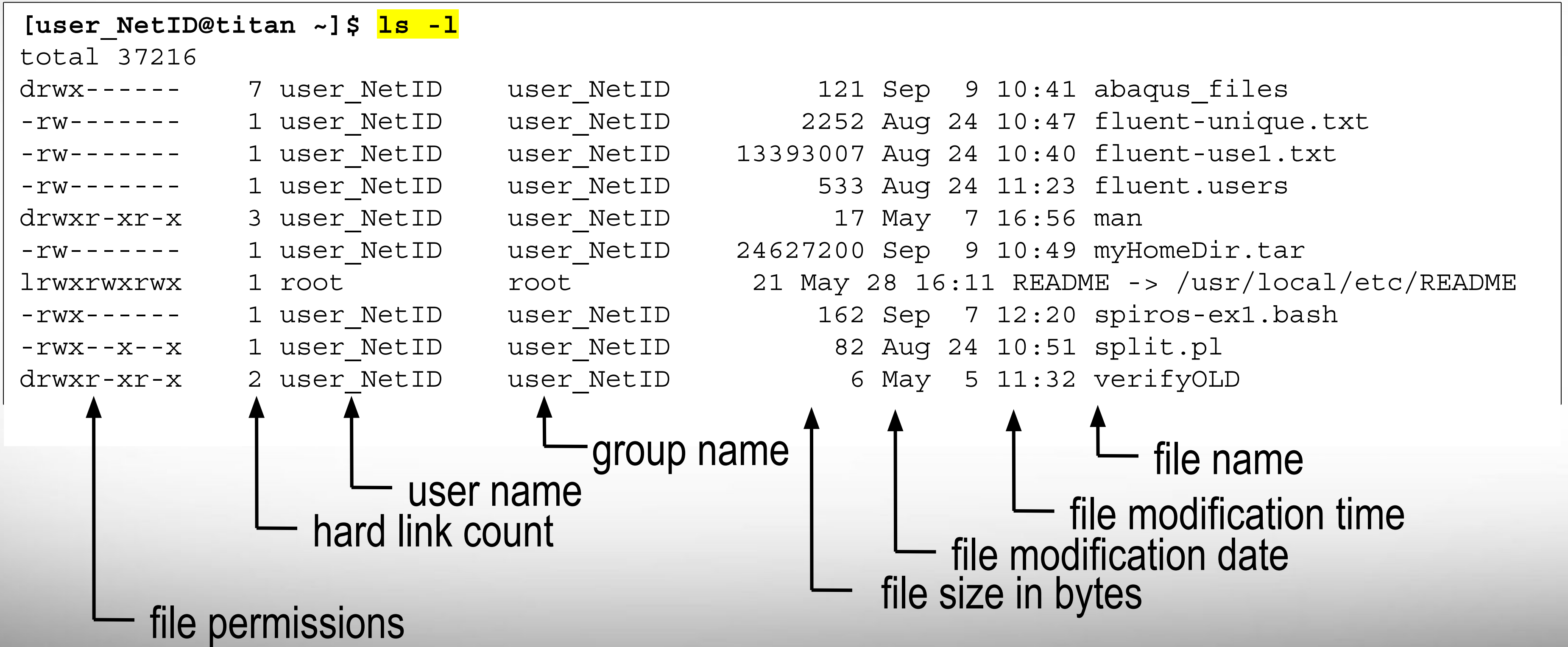
Typically, you won’t be the only user of a system. Other users will have their data as well.

How can we see the “who / what / when / where” of a file?

We’ll take a brief look at:

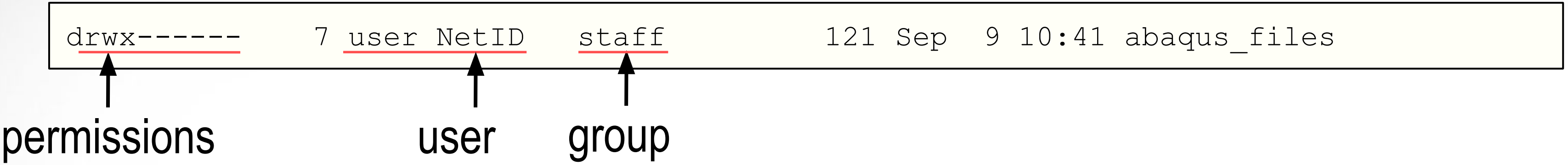
- File attributes
- File ownership & permissions
- Changing permissions

File Attributes: A look with `ls`



```
[user_NetID@titan ~]$ ls -l
total 37216
drwx------    7 user_NetID    user_NetID         121 Sep  9 10:41 abaqus_files
-rw-------    1 user_NetID    user_NetID        2252 Aug 24 10:47 fluent-unique.txt
-rw-------    1 user_NetID    user_NetID    13393007 Aug 24 10:40 fluent-use1.txt
-rw-------    1 user_NetID    user_NetID         533 Aug 24 11:23 fluent.users
drwxr-xr-x    3 user_NetID    user_NetID          17 May  7 16:56 man
-rw-------    1 user_NetID    user_NetID    24627200 Sep  9 10:49 myHomeDir.tar
lrwxrwxrwx    1 root          root            21 May 28 16:11 README -> /usr/local/etc/README
-rwx------    1 user_NetID    user_NetID         162 Sep  7 12:20 spiros-ex1.bash
-rwx--x--x    1 user_NetID    user_NetID          82 Aug 24 10:51 split.pl
drwxr-xr-x    2 user_NetID    user_NetID           6 May  5 11:32 verifyOLD
```

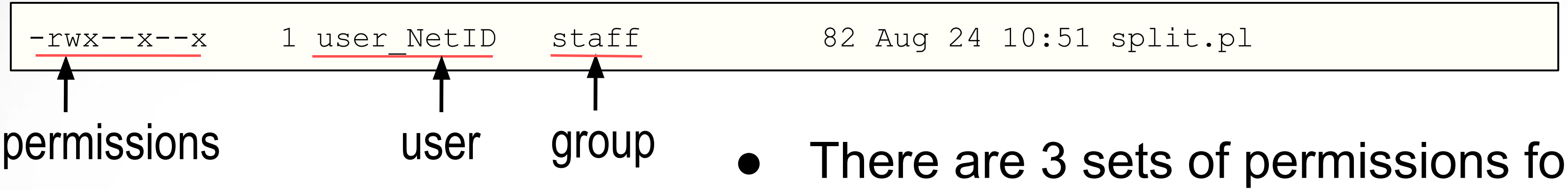
Directory Permissions



```
drwx------     7 user NetID    staff            121 Sep   9 10:41 abaqus_files
```

- The meanings of the permission bits for a directory are slightly different than for regular files:
  - `r` permission means the user can list the directory’s contents
  - `w` permission means the user can add or delete files from the directory
  - `x` permission means the user can cd into the directory; it also means the user can execute programs stored in it
- Notice that if the file is a directory, the leading bit before the permissions is set to `d` , indicating directory.

File Ownership and Permissions



```
-rwx--x--x    1 user_NetID   staff          82 Aug 24 10:51 split.pl
```

-	rwx	--x	--x
	user	group	other

- There are 3 sets of permissions for each file
  - 1st set - user (the owner)
  - 2nd set - group (to which file owner belongs)
  - 3rd set - other (all other users)
- The r indicates read permission
- The w indicates write permission
- The x indicates execute permission

Changing Attributes: The **chmod** cmd

```
chmod [options] [permission mode] [target_file]
```

```
cd ~/temp/hg19
```

```
chmod 755 chr_xy.txt    ( the permissions will be set to   -rwxr-xr-x )

chmod o-x chr_xy.txt    ( the permissions will change to -rwxr-xr-- )

chmod ug-x chr_xy.txt   ( the permissions will change to -rw-r--r-- )

chmod g+w chr_xy.txt    ( the permissions will change to -rw-rw-r-- )
```

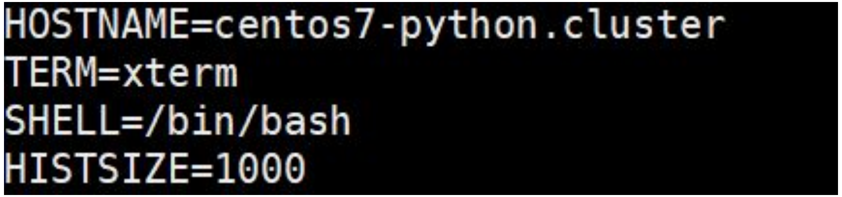
```
 u = user                 r = read
 g = group                w = write
 o = other                x = execute
-x = remove executable permissions
+x = enable executable permissions
```

7. Environment Variables & the $PATH

Variables store information we provide them.

Environment variables store information that is used across different processes in a Linux system.

There are many Environment Variables.



```
HOSTNAME=centos7-python.cluster
TERM=xterm
SHELL=/bin/bash
HISTSIZE=1000
```

We’ll talk about 2 Environment Variables:

- $HOME
- $PATH

Bash Environment Variables

Use all caps for Bash Environment variable. `A-Z 0-9 _`
Use lowercase for the variables that you create. `a-z 0-9 _`

HOME Pathname of current user's home directory
PATH The search path for commands.

Use the `echo` command to see the contents of a variable

```
echo $HOME
```

```
/home/user_NetID
```

list contents of your $HOME directory

```
ls $HOME
```

The Search Path

- The shell uses the PATH environment variable to locate commands typed at the command line
- The value of PATH is a colon separated list of full directory names.
- The PATH is searched from left to right. If the command is not found in any of the listed directories, the shell returns an error message
- If multiple commands with the same name exist in more than one location, the first instance found according to the PATH variable will be executed.

```
echo $PATH
```

```
PATH=/opt/TurboVNC/bin:/software/tamusc/local/bin:
/software/lsf/9.1/linux2.6-glibc2.3-x86_64/bin:
/usr/local/bin:/bin:/usr/bin:/usr/local/sbin:/usr/sbin:
/sbin:/usr/lpp/mmfs/bin:/opt/ibutils/bin:/home/user_NetID/bin
```

add a directory to the PATH for the current Linux session

```
export PATH=$PATH:/home/user_NetID/bin
```

8. Basic Shell Scripting

A shell script is a text file that contains one or more UNIX commands that can be run as a single batch of commands.

Ideal for automating tasks.

It is good practice to name shell scripts with: **`.sh`**

Shell Script Exercise

create a shell script

```
gedit my_script.sh &
```

make your shell script executable

```
chmod 755 my_script.sh
```

run your shell script

```
./my_script.sh
```

```
#!/bin/bash
# HPRC shell script exercise

my_name="Dylan”

echo “Howdy $my_name” > names.txt
cat my_favorite_foods.txt >> names.txt

mkdir script_output

mv names.txt script_output

cd script_output

cat names.txt
```

```
exit        # exit the terminal session
            # can also use Ctrl+d to detach session
```

References

Here are some slides from TACC on the similar subject.

- Linux/Unix Basics for HPC: October 9, 2014 (with video) [TACC]
  - https://portal.tacc.utexas.edu/-/linux-unix-basics-for-hpc
- Express Linux Tutorial: Learn Basic Commands in an Hour [TACC]
  - https://portal.tacc.utexas.edu/c/document_library/get_file?uuid=ed6c16e9-bcbc-4b70-9311-5273b09508b8&groupId=13601