Research Computing at UC

Linux 101

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First things first...

• This is an introductory tutorial; if you are interested in something more advanced please start the conversation by sending an email to arc_info@uc.edu
• This tutorial is focused on using Linux in a research computing environment; i.e. using the command line from a terminal.
• To login to the ARCC you must be on the UC campus or using the UC VPN.
• People are standing by to help.
• While you are logging in, we will cover basic terms, history, etc.
Logging into the ARCC

• ssh **USERNAME@arcc.uc.edu**
  
  • ssh is a command to connect from your laptop to another system. It is natively available on Macs & Linux boxes. PuTTY is a popular ssh client for Windows ([https://www.putty.org/](https://www.putty.org/))
  
  • Your USERNAME will be your UC 6+2 for UC individuals or as otherwise identified in an email you received.
  
  • If you have problems connecting, instead of arcc.uc.edu try the IP address 10.127.5.254
First and foremost!

• This is a live presentation with the goal of showing how to use the Linux command line interpreter.
• The slides for this tutorial are less important than trying the commands as they are presented.
• At some point I’m all but certain this will become less structured and more of a stream of consciousness. Please ask questions!
• And most importantly, never preface a live demonstration with anything more predictive than “Watch this...”
The man pages are your friend

• The help command for Linux
• man <command>
The Google machine (search engines) are your friends

• Other search engines:
  • bing : Window’s users
  • duckduckgo : privacy concerns
  • altavista : before Google there was AltaVista; old timers like me
  • YouTube : most tutorials are videos
Getting started

- **Linux vs Unix**
  - Linux is open source developed by the Linux community
  - Unix was developed by AT&T Bell Labs, is not open source, and is copyrighted
- **ssh** – a command line interface used to connect between servers
  - Native to Linux and Macs
  - putty for Windows ([https://www.putty.org](https://www.putty.org))
- `#` - comment in Linux; i.e. whatever follows the hashtag will not be executed
- **stdin, stdout, stderr** : input and output IO streams; e.g. input from a keyboard, output to a terminal and output to the terminal for error messages
- **directories** – the same as folders on a Windows or Mac. Contains files. Some important directories are the current working directory (.) and the HOME directory (~)
• **man**: the “help” for Linux; e.g. man bash, man ls, man salloc, etc.
  • **man –k <keyword>**: give me all the man pages with <keyword>
• **pwd**: present working directory; what directory am I sitting in
• **ls**: show me the files in this directory
• **cd**: change Directory
  • cd dd2020-hpc - move down into the dd20202-hpc directory
  • cd .. - move up one directory
• **cp**: copy a file
  • cp –rp /opt/ohpc/dd2020-hpc .
    • Recursively copy the directory at /opt/ohpc/training/fdw-L101-210122 to my current directory
Getting started (continued)

- **cat**: stream a whole file to stdout
- **more**: stream a file one page at a time to stdout
- **less**: like more but you can move up and down in the file using the arrow keys; exit with `q`
- **module**: change your Linux environment; e.g. add applications
- **echo**: repeat the argument to stdout (the terminal)
Getting started (continued)

- **PATH**: a list of directories where applications are; to see the current path do `echo $PATH`
- **ls**: a command for listing files and the contents of directories
- **environment**: usually thought of as the state of the shell variables
- **shell**: the command line interpreter. Examples include `sh`, `bash`, `zsh`, `korn`, `tcsh`, etc.
- **process**: a running application. Use the commands `ps` or `top` to see running processes
  - Parent, child processes
  - Process ID (PID)
- **Editors**: an application for creating and modifying text in a file
Editors available on Linux

• **nano**
  • Easiest to use but not always available
  • Menu at the bottom of the screen
  • Use control-x (^x) to exit

• **vi** (also sometimes called vim)
  • always available on a Linux system
  • Cheatsheet available at [https://devhints.io/vim](https://devhints.io/vim)
  • enter insert mode with `i`
  • Exit insert mode with Esc key
  • Exit editor with Esc-wq to save work
  • Exit editor with Esc-q! to not save work
Editors available on Linux  (continued)

• emacs
  • very complicated
  • very powerful
  • Written in lisp; very extensible

• GUI editors
  • Works great if you have X11 working via the ssh connection
    • To see if X11 is working, do `echo $DISPLAY`
  • gedit
  • nedit

• sed
  • Meant for pipeline processing; e.g. cat file | sed ‘s/this/that/g’ > out.txt
Once logged in, setting up our environment...

set up our environment

module avail
  # what modules are available to load
module spider
  # more detailed listing of modules
module load gnu9
  # loading a module into your environment
module list
  # what modules are loaded
Once logged in, let’s prep our environment...

# copy over the files needed for the tutorial

cp –rp /opt/ohpc/training/fdw-L101-210114 .
  # note the space and a period ^

cd fdw-L101-210122
ls -al
Compile and run our hello world example

# start with the worlds simplest C program
less simple.c
    # remember to type q to exit out of less
gcc -o simple simple.c
./simple
# doesn’t look like much happened; but, it does everything that any program does except work (work as in the physics sense of the word)
Compile and run our hello world example

```
less hello.c
    # remember to type q to exit out of less
gcc -o hello hello.c
exit
```
Commands and Concepts

• kernel

• command syntax
  • `<command> <parameters>`
  • `ls -al`

• process
  • `ps -ef`, `ps aux`
  • `top`
  • `w`, `who`
  • shell (`sh`, `bash`, `tcsh`, `zsh`)
Commands and Concepts

• environment
  • printenv
  • variables
  • ~ . ? _ PATH MANPATH

• alias
• quotes ("',')
• backquote
Commands and Concepts

• file system
  • directories, folders
  • / (the root directory)
  • /var
  • /tmp
  • /home
  • /opt
  • /usr
    • /usr/bin, /usr/man, /usr/lib, /usr/local
Commands and Concepts

- files
  - executables or applications
  - tab completion

- pipes
  - `>>` |

- sockets

- `cat`
- `wc`
- `echo`
- more or less
- `head` or `tail`
Commands and Concepts

- cat
- wc
- echo
- more or less
- head or tail
- which
- ls /usr/bin
- dos2unix unix2dos
- tar, zip
- gzip gunzip
Commands and Concepts

- Containers (Docker, Singularity)
  - file
  - process
  - VM vs Container
Some Other Introductory Tutorials & References

- Basic Linux introduction
  - [https://training.linuxfoundation.org/training/introduction-to-linux](https://training.linuxfoundation.org/training/introduction-to-linux)

- Beginner’s Guide to the Bash Terminal
  - [https://www.youtube.com/watch?v=oxuRxtrO2Ag](https://www.youtube.com/watch?v=oxuRxtrO2Ag)

- Cheatsheets
  - [https://devhints.io/](https://devhints.io/)
  - [https://devhints.io/bash](https://devhints.io/bash)

- Introduction to High Performance Computing Systems, ADACS
  - [https://www.youtube.com/watch?v=7zJUceJiYxQ](https://www.youtube.com/watch?v=7zJUceJiYxQ)

- tutorialspoint
  - [https://www.tutorialspoint.com/unix_commands/](https://www.tutorialspoint.com/unix_commands/)
  - [https://www.tutorialspoint.com/unix_commands/bash.htm](https://www.tutorialspoint.com/unix_commands/bash.htm)
Singularity (docker) References & Other Tutorials

XSEDE/Container_Tutorial
https://github.com/XSEDE/Container_Tutorial/tree/master/Gateways2020

Sylabs (developers of singularity) tutorial videos
https://sylabs.io/videos

naked-singularity registry
https://github.com/mkandes/naked-Singularity
ARC Clusters (ARCC)

- **ARCC-1** - a.k.a. the *Pilot* cluster
  - Explore what is involved in establishing research cyberinfrastructure
  - Acquired in three phases
    - Started with Dr Prashant Khare’s startup cluster
    - Addition funded by the Office of Research
    - Expansion of Dr. Khare’s original cluster
  - Dell PowerEdge 36 C6420, dual Intel Gold 6148 2.4 GHz, 20 core CPU (40 total cores), 192 GB RAM
  - Dell PowerEdge R740xd Storage node, 96 TB raw
  - Dell PowerEdge R740 GPU server dual Intel Gold 6148 2.4 GHz, 20 core CPU (40 total cores), 192 GB RAM, Nvidia V100-32G GPU
  - 100 Gb/s OmniPath switch fabric
  - Initial integration Dec-2018 and installed in the UC Data Center Jan-2019
ARC Clusters (continued)

- **ARCC-2** will be UC’s first production cluster
  - Funded in part by an NSF MRI grant with Dr Prashant Khare as the project PI.
  - Additional resources provided by UC Office of Research.
  - Architected for longevity and expandability using today’s (2020/2021) best technologies. We will be adding to this cluster over the next three to five years.
  - Strategic integration of compute, networking, storage into cohesive environment.
  - Expected production date Q1/2021
ARC Clusters (continued)

• **ARCC-2** (continued)

• *Excuse our Dust : Under construction*
  • Currently 19 compute nodes and one GPU node with two Nvidia V100 GPUs
  • Compute nodes: HPE Apollo 2000, dual AMD EPYC 7452 (Rome), 32 cores (64 total) 2.3GHz, 256 GB RAM, Gen4 PCIe bus
  • GPU nodes: HPE Proliant DL 385 Gen10+ GPU nodes, dual AMD EPYC 7452 (Rome), 32 cores (64 total), 1TB RAM, dual Nvidia A100-40 GPUs , Gen4 PCIe bus
  • One login node, one management node
ARC Clusters (continued)

- **ARCC-2** (continued)
- **Excuse our Dust : Under construction**
  - Funded expansion includes:
    - ~1.5 PB of storage and two data transfer nodes in Q1/2021
    - Additional compute and GPU resources probably in Q2/2021
      - Timing dependent upon completion of upgrades to the data center facilities
    - Component costs at the time acquisition; but, we’re looking at adding ~50 compute modes (AMD Milan) and half dozen GPU nodes (AMD Milan and NVIDIA V100 or A100 GPUs)
SLURM – Simple Linux Utility for Resource Management

• Combined resource manager and scheduler
• Resource manager
  • Inventory resources (nodes, sockets, cores, memory, licenses, GPUs, etc.)
• Scheduler
  • Map job requirement onto available resources
  • Predict when resources will become available
  • Complex scheduling algorithms e.g. optimize for memory or network topologies, fairshare scheduling, advanced reservations, preemption resource limits; e.g. access restrictions, user & group quotas, etc.
Some basic Slurm commands

- **salloc**: allocate resources for an interactive job
- **sbatch**: queue a batch script and allocate resources for the job when they become available
- **srun**: utilize resources allocated for a job (or job step) via the `salloc` or `sbatch` commands
- **squeue**: check the status of queued jobs
  - `squeue --start -j <jobid>`  # when will my job start?

Some basic Slurm commands (continued)


- **sprio**: view factors comprising a job's priority
- **sinfo**: view the state of the system
- **scancel**: cancel queued or running jobs
- **sattach**: attach stdin/out/err to a running job
- **sbcast**: copy a file to local storage (e.g. /tmp) on all the nodes allocated to a job
Questions, Comments, Suggestions?
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