Computer Systems and Networks

ECPE 170 – Jeff Shafer – University of the Pacific

Linux Basics

Pre-Lab

- Everyone installed Linux on their computer
- Everyone launched the command line ("terminal") and ran a few commands
- **What problems were encountered?**
  - **Virtualization support in processor not enabled (BIOS)**
  - VMWare Player (current version) only runs on Windows 64
  - 3D graphics virtualization incompatible with specific hardware
  - Old virtual machine software
  - Others?
- Tip: If you have problems maximizing your VM to full screen, or doing copy-and-paste between Linux and Windows, make sure you installed the VM tools

Person of the Day: Linus Torvalds

- Creator of **Linux Kernel**
  - Started in 1991
  - First developer – hobby project (for fun!)
  - Modern kernel is product of work by thousands of programmers
  - Currently "final authority" on what is included in the kernel
- Creator of **Git version control system**
  - Initially for Linux kernel dev

Operating System Tasks

- **What does the OS need to do?**
  - Schedule processes to run
  - Memory management
  - Interrupt handling (manage hardware in general)
  - Security (between processes)
  - Network access
  - Storage management (filesystem)
  - Graphical user interface
    - May be a **middleware** layer on top of the OS

Operating Systems – Processes

- **Process management** is a key operating system task
- OS must initially **create processes** when you run your program
- OS can allow processes to **access resources**
  - Must *schedule* access to *shared* resources (e.g., CPU)
- OS can allow processes to **communicate** with each other
- OS must **clean up** after process finishes
  - Deallocate resources (e.g. memory, network sockets, file descriptors, etc…) that were created during process execution

Operating Systems – Scheduling

- The operating system schedules process execution
  - What processes are allowed to run at all?
  - What processes are allowed to run right now?
- **Context switches** occur when the CPU is taken from one process and given to another process
  - CPU *state* (registers, current PC, etc…) is preserved during a context switch

Operating Systems – Scheduling

- **Preemptive Scheduling**
  - Each process is allocated a timeslice
  - When the timeslice expires, a context switch occurs
    - A context switch can also occur when a higher-priority process needs the CPU

Breakout Rooms

What to expect from OS w.r.t Security when there are several Processes?

Operating Systems – Security

- Process A is forbidden from reading/modifying/writing the memory of Process B
  - **Virtual memory** is a huge help here!
  - Each process has a separate *virtual* address space that maps to different regions of *physical* memory
- Process A has other limits besides which memory pages it can access
  - **What are some other limits?**
  - Amount of memory consumed
  - Number of open files on disk
  - Which files on disk can be read/written

Operating Systems – Filesystem

- OS is responsible for managing data on persistent storage
- Job of the **filesystem!**
  - What files exist? (i.e. names)
  - How are they organized? (i.e. paths/folders)
  - Who owns and can access them? (i.e. usernames, permissions)
  - Where are individual file blocks stored on the disk?
    - *i.e. filename "database.dat" is really composed of 15823 blocks, of which block 1 is located at logical block address #... on the hard drive.*

Operating Systems – Device Management

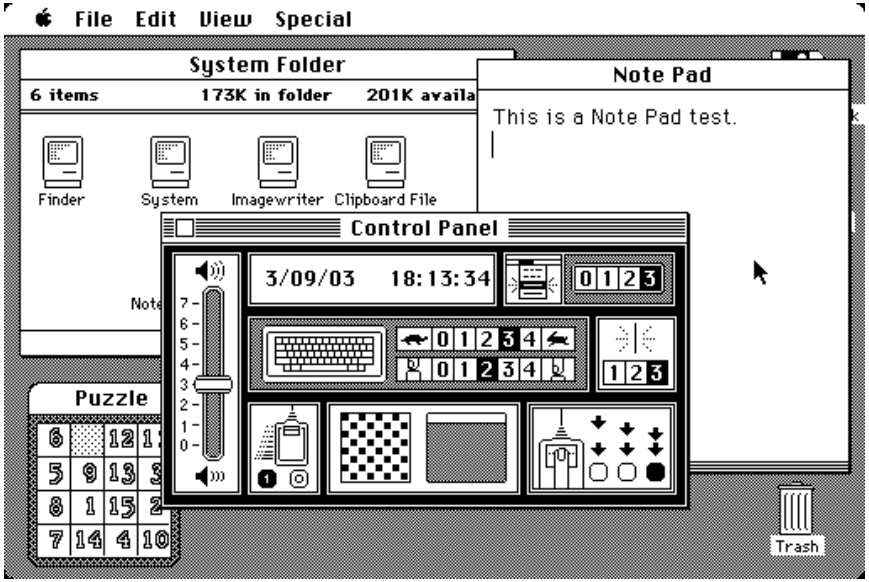
- Manage devices
  - How do we send data to the NIC for transmission?
  - How do we render an image for display on screen?
  - How do we read a block of data from our RAID disk controller?
- Operating systems can be extended through **device drivers** to manage new hardware
  - Hardware vendors write software to manage their devices
  - OS provides a fixed interface (API) that driver must follow
- Common task for a device driver is **responding to interrupts** (from that device)

Operating Systems – The Kernel

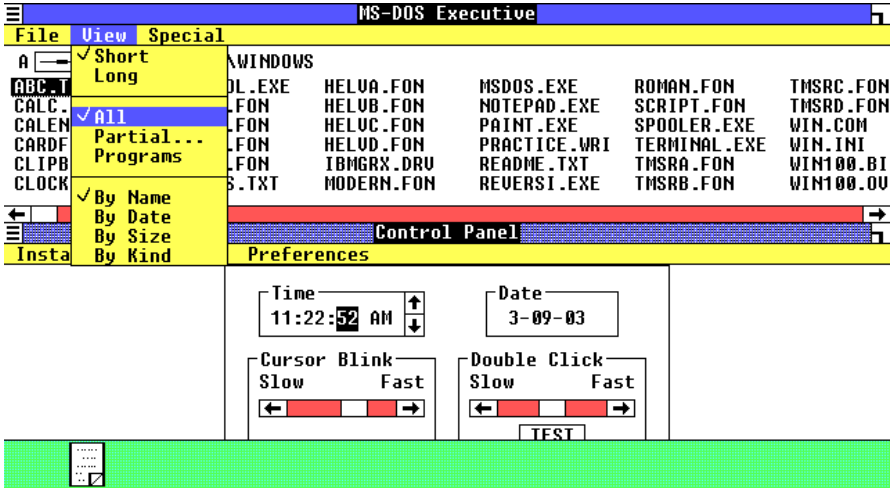
- Who does all this essential work in the operating system? (besides the GUI)
  - The **kernel** (i.e. the heart or core of the OS)
- Kernel performs:
  - Scheduling
  - Synchronization
  - Memory management
  - Interrupt handling
  - Security and protection

Operating Systems – GUI

- Operating systems with **graphical user interfaces** (GUI) were first brought to market in the 1980s



Apple Mac OS 1.0 (released 1984)



Microsoft Windows 1.0 (released 1986)

Captures from http://www.guidebookgallery.org/screenshots

Significant evolution in GUI design in subsequent decades

Operating Systems – GUI

- Technical perspective:
  - The GUI is one of the **least important parts** of the operating system
- A GUI does not even have to be part of the *true* OS at all
  - Windows 1.0 was just a **program that ran on top** of MS-DOS, the *true* operating system (of that era)
- *But to a user, the GUI is one of the most important parts of the OS!*

Command-Line

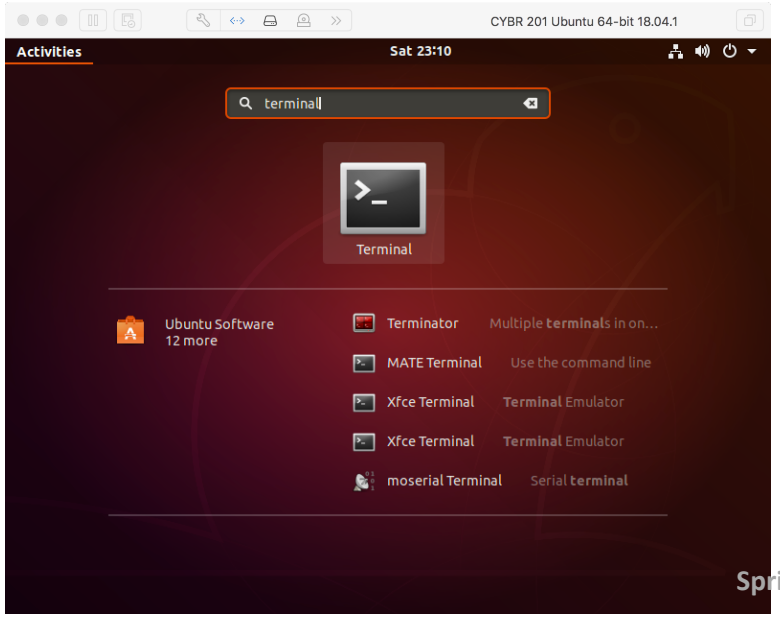
Advantages of Command Line

Advantages of Windows / GUI

Linux Command Line

In-Class Activity

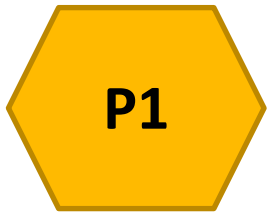
1. Launch your Linux virtual machine!
2. Open the **Terminal** – a text-based interface that accepts your commands (Applications button -> Terminal)
3. Open Canvas and today's *In-Class Participation* assignment



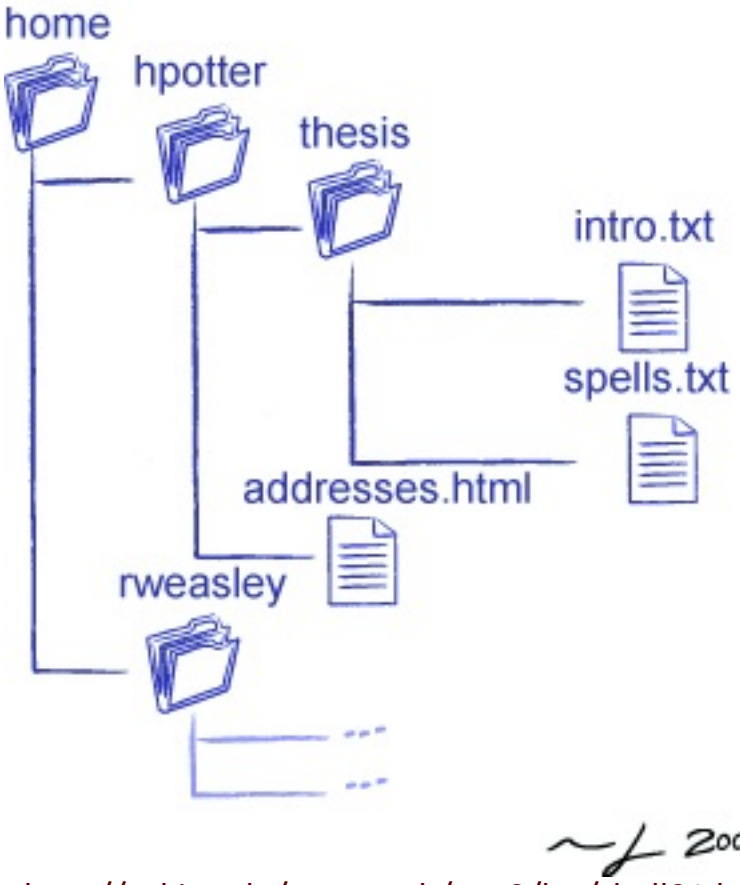
Problem 1 – Which Shell?

- A shell is a user program that defines how your terminal window behaves for input commands
  - Command-line interpreter
  - Parses user input and carries out commands
- Many types exist: `sh`, `bash` (Bourne again), C syntax motivated: `csh`, `tsh`, etc.
- Find out what shell is being used:

```
$ echo $SHELL
```



Directory Structure



http://osl.iu.edu/~pgottsch/swc2/lec/shell01.html

- **Root directory: /**
- **Absolute** path:
  - `/home/hpotter/thesis/intro.txt`
- **Relative** path:
  - If I am already in `/home/potter/`
  - `addresses.html`

Problem 2 – Navigation Skills

- Where are we?

```
$ pwd
```

Print Working Directory

- What items exist here?

```
$ ls
```

List items

```
$ ls [options] [location]
```

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Basic Operations

- Tilde (~) sign refers to your home directory. You can perform either

```
$ ls /home/you/Documents
```

```
$ ls ~/Documents
```

Navigation Skills

- Dot (.) sign refers to current directory. Try:

```
$ ls .
```

- Double dot (..) refers to the parent directory of your current directory. Try:

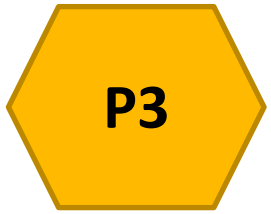
```
$ ls ..
```

Problem 3 – Navigation Skills

- Change directory

```
$ cd [location]
```

- Hint: There's a very easy shortcut to change directory to your home directory…



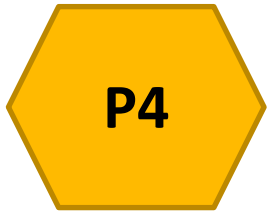
Problem 4 – Documentation

- Documentation ("manual") on commands

```
$ man [command]
```

- Example usage
  - Hidden files have a (.) before the filename
    - `.secret`, `.bashrc`, …
  - Type `ls` – Do you see any hidden files?
  - Using the man command, find out what option you need to use with `ls` to list the hidden files

```
$ ls -a
```



Basic Operations

Do these steps in your VM!

- Create a directory called `Linux_tutorial` inside your home directory

```
$ mkdir [options] [dirname]
```

- Change to the `Linux_tutorial` directory
- Create a blank file called `example1`

```
$ touch example1
```

Basic Operations

Do these steps in your VM!

- Put something in the file via output redirection

```
$ echo "Tiger Roar" > example1
```

- Copy file `example1` to `example2`

```
$ cp example1 example2
```

- Move the `example2` file to your home directory

```
$ mv example2 ~
```

Basic Operations

Do this step in your VM!

- Remove the file `example2`

```
$ rm ~/example2
```

- General form of command

```
$ rmdir [options] [dirname]
```

```
$ rm [options] [filename]
```

Piping

Do this step in your VM!

- Change to `/etc` directory and count the number of files in that directory. You only have 60 seconds. Tick tock!!
- Tip: Combine list tool with another tool that will count the number of words (or lines)

```
$ cd /etc
$ ls -l | wc -l
```

Problem 5 –Wildcards

- Directory listings can use wildcards to search for matching file names
- Example: In `/etc` directory, list all files with `.conf` extension

```
$ ls *.conf
```

- Example: In `/etc` directory, list all files where second letter is d and with `.conf` extension

```
$ ls ?d*.conf
```

* – Zero or more characters
? – Single character
[] – Range of characters

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File Permissions

- Linux provides you privacy with files via permissions
  - **r** read – the contents of the file can be viewed
  - **w** write – something can be written to the file
  - **x** execute – the file can be executed if an executable or script
- Permission is granted to three types of people
  - **owner** – the one who created the file, also called user (u)
  - **group** – the file belongs to a single group (g)
  - **others –** everyone else (o) but the group or the owner

Problem 6 – File Permissions

- *Create the requested file with the requested contents, and obtain a directory listing…*

```
-rw-rw-r-- 1 shafer shafer 18 Sep  4 14:40 example3
```

owner has read and write permissions, but not execute

group has read and write permissions, but not execute

others have read only permissions

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File Permissions

- The `example3` file can't be executed – try it:

```
$ ./example3
```

Problem 7 – File Permissions

```
$ chmod [permissions] [file]
```

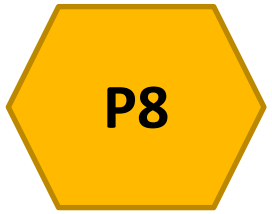
- Changing the file permissions requires answers some questions
  - Whose permissions are we changing?
    - `[ugoa]`: owner, group, others, or all
  - Are we granting or revoking permission?
    - **+**: providing **-**: revoking
  - What are we providing?
    - **r** (read), **w** (write), or **x** (execute)

```
$ chmod u+rwx file
```
Provides rd/wr/ex to owner

```
$ chmod g-x file
```
Removes ex for group

Problem 8 – Wrap-up

- Open-ended questions based on what we've learned today
- *Take 5 minutes and complete…*



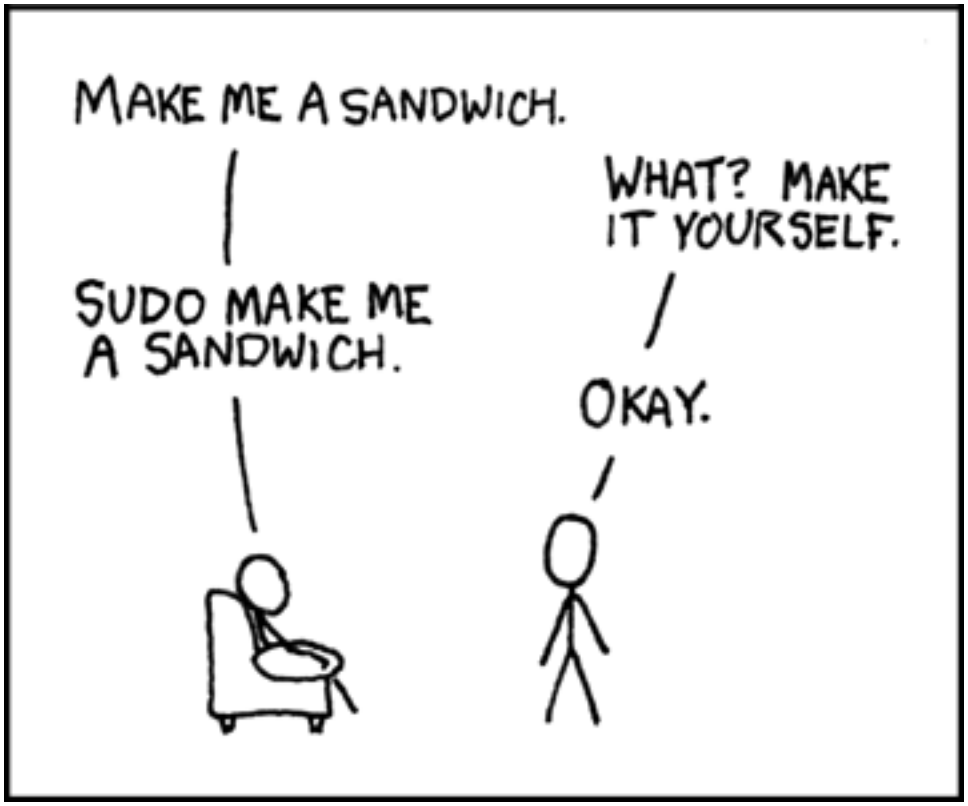
Shell Shortcuts

- <TAB> key to auto-complete commands
- <UP ARROW> key to cycle through previous commands

These two tips make your life so much easier!

Linux: Sudo Command

- `sudo <<command>>`
- Command is run as root user
- root = “Administrator”



http://xkcd.com/149/

Labs

Labs

- Labs have (at most) two graded elements:

1. **Pre-Lab "checkpoint"** – quick verification that pre-lab *appears* to be done
    1. Due at start of first day of lab
2. **Lab Report**
    1. Submit all source code used with lab report
    2. Due by posted date after lab

Lab Reports

- Not really “reports”, more like “worksheets”
- Create in LibreOffice (aka *OpenOffice*) using example template on website
- Export in **PDF format**
- Submit
  - Via Canvas *Assignments* section for Lab 1 only!
  - Via Version control for Lab 2 and beyond

Upcoming Schedule

- Today
  - **Lab 1 – Linux Basics**
- Thursday
  - **Lab 2 – Version Control**
- Deadlines
  - **Lab 2 pre-lab checkpoint – Start of class Thursday**
  - **Lab 1 Report – Jan 23rd, 2021 by 5am**
    - Submit via Canvas
  - **Lab 2 Report – Jan 26th, 2021 by 5am**