Unix
Bash
C
GNU
Systems

Introduction to Software Systems

Comp-206 : Introduction to Software Systems

Lecture Week 1

Joseph Vybihal

Computer Science

McGill University

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Unix
Bash
C
GNU
Systems

Welcome to 206

Lecture 1

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Coordinates

- Joseph Vybihal
- McConnell 323
- Email: jvybihal@cs.mcgill.ca
- URL: www.cs.mcgill.ca/~jvybihal
- Office hours:
  - M & W 14:00-15:00 & F 14:00-16:00
  - Or by appointment
  - Or myCourses discussion board
  - **Triage TA**: TBD

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Student Research Opportunities

My research area: Intelligent Systems

- Artificial intelligence
- Group intelligent interactions (simulated & robotic)
- What is intelligence and thought?
- Inserting intelligent algorithms into every day software

Undergraduate student opportunities

- COMP 400 or COMP 396 or ECSE 457 (DP1 & DP2)
- X396
  - COG
  - PHYS
  - Biology, neurology, …

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Teaching Method

- Laptop
  - You might want to have yours handy
- Slides
  - They serve as both lecture outline, basic notes, and contain links to further readings
- Textbook
  - You are expected to know the assigned chapters
- Digital Ink
  - Some notes will be provided digitally during class
- Lecture recordings
  - Yes, if possible, however, students who attend class do better

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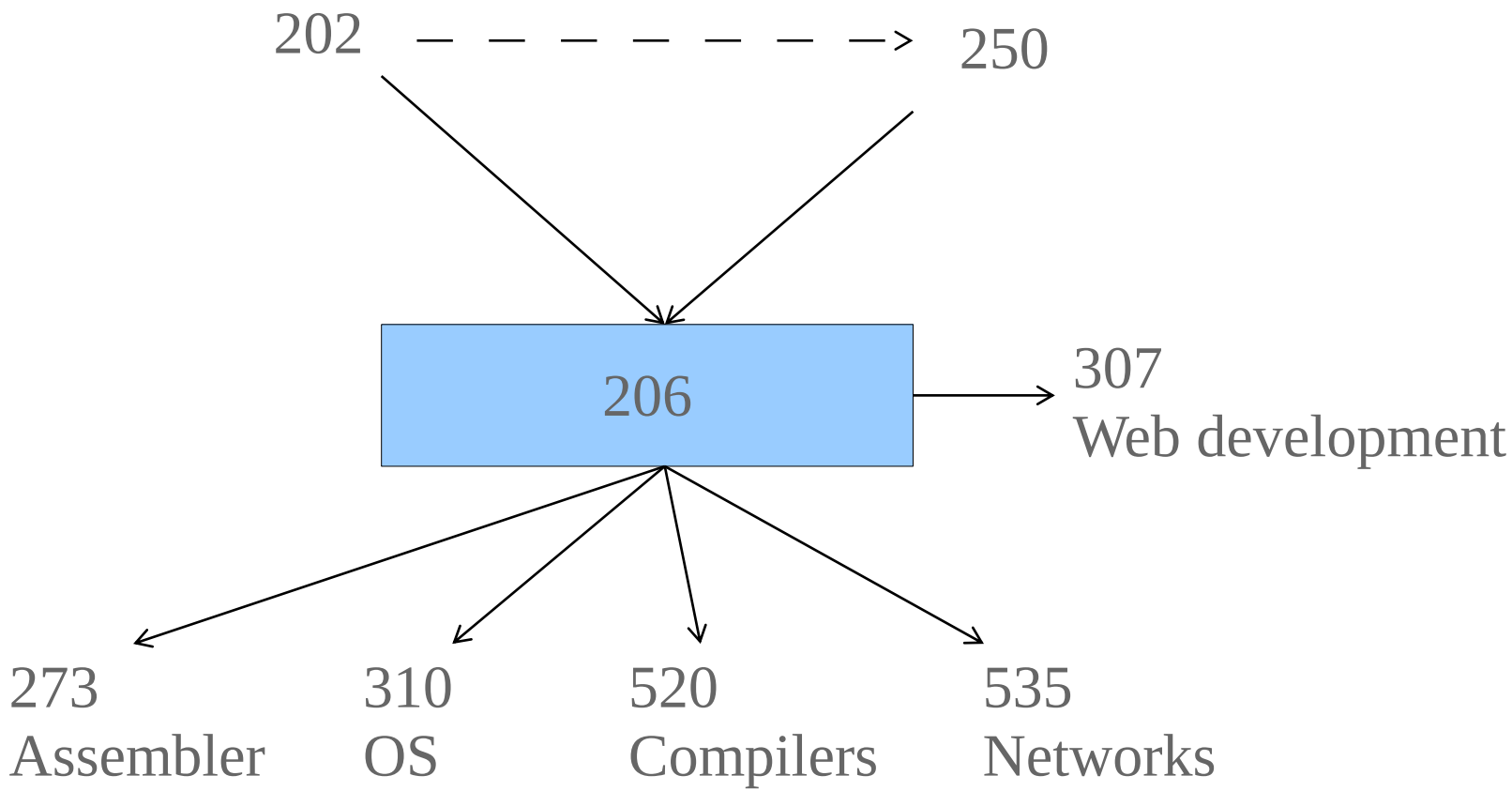
Prerequisites



It is not required but it is recommended to take this course only after you have taken 1 or more programming courses

Unix
Bash
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GNU
Systems

Course Contents

- Introduction to “under the hood” development
  - The command-line interface
  - The Linux operating system
  - Bash programming within a system’s context
  - Low-level system’s programming using the C language
  - Basic software engineering techniques
    - Git, gprof, gdb, make, gcc
    - Software development techniques
  - Multi-language and systems integration programming

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Course Usefulness

Science Students

- Introduction to systems
- Teaches intermediate programming techniques
- Learn algorithms that help in data capture and analysis
- Opens doors to further programming and science courses

Software Engineers

- Combines programming with operating systems
- Introduction to basic software engineering techniques
- Introduces holistic and integrated thinking of the computer for software development
- Introduces system-level programming

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GNU
Systems

Course Evaluation

- 7 mini assignments . 28%
- 2 online tests . . . 20% (10% each)
- 1 final exam . . . . . 52% (during final exam period)

- Deferred exam possible (no supplemental)
- 72% final exam option possible
  - Replaces class tests only

- Final exam tutorial
- Weekly tutorials

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Course Reading Material

- Primary text
  - Software Systems
    Vybihal & Azar
    Kendall/Hunt
    ISBN 978-0-7575-9514-1 (https://www.kendallhunt.com/vybihal/)
- Other texts:
  - Free on web
    - GNU Software; Louksides & Oram; O'Reilly; ISBN 1565921127
  - Just Enough Unix; P.K. Anderson; McGraw Hill;
    ISBN 0697131726
  - C Programming Language; Kernighan & Ritchie; Prentice-Hall;
    ISBN 0131101633

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Course Resources

- Detailed course outline
- MyCourses
  - Assignments
  - Discussion board
  - Grades
  - TA information
  - Lecture slides
  - Lab worksheets

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Labs

- Labs
  - Trottier 3rd floor (any unlocked room and hallway)
  - Assistance:
    - help@cs.mcgill.ca
    - Office: McConnell 209N
    - Phone: 514-398-7087
- Lab accounts
  - **DO NOT** use your McGill account! First.last@mail.mcgill.ca
  - You must use a SOCS account
    - https://newuser.cs.mcgill.ca
    - You must be on campus for this to work or on a VPN
    - Forgot your Username and/or Password?
      - Reset it at https://newpassword.cs.mcgill.ca/

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Software Systems & Systems Programming

Readings: chapter 1,and http://whatis.techtarget.com/definition/system-software, https://en.wikipedia.org/wiki/System_software

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What is a system?

A set of interconnected artifacts

- Each artifact carries out a unique function
- Artifacts can interact with one another
  - Send data
  - Get data
  - Execute a function
- Rules exist that define legal interactions

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Software Systems

Application 1: Java

Application 2: Python

Interactions

Application 3: Operating System

The idea is that the software works together as a team to solve a problem

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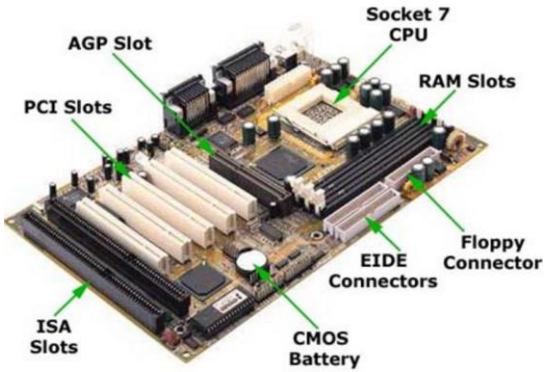
Systems Programming

software

Operating System



Writing software that directly interacts with either the operating system or the machine.

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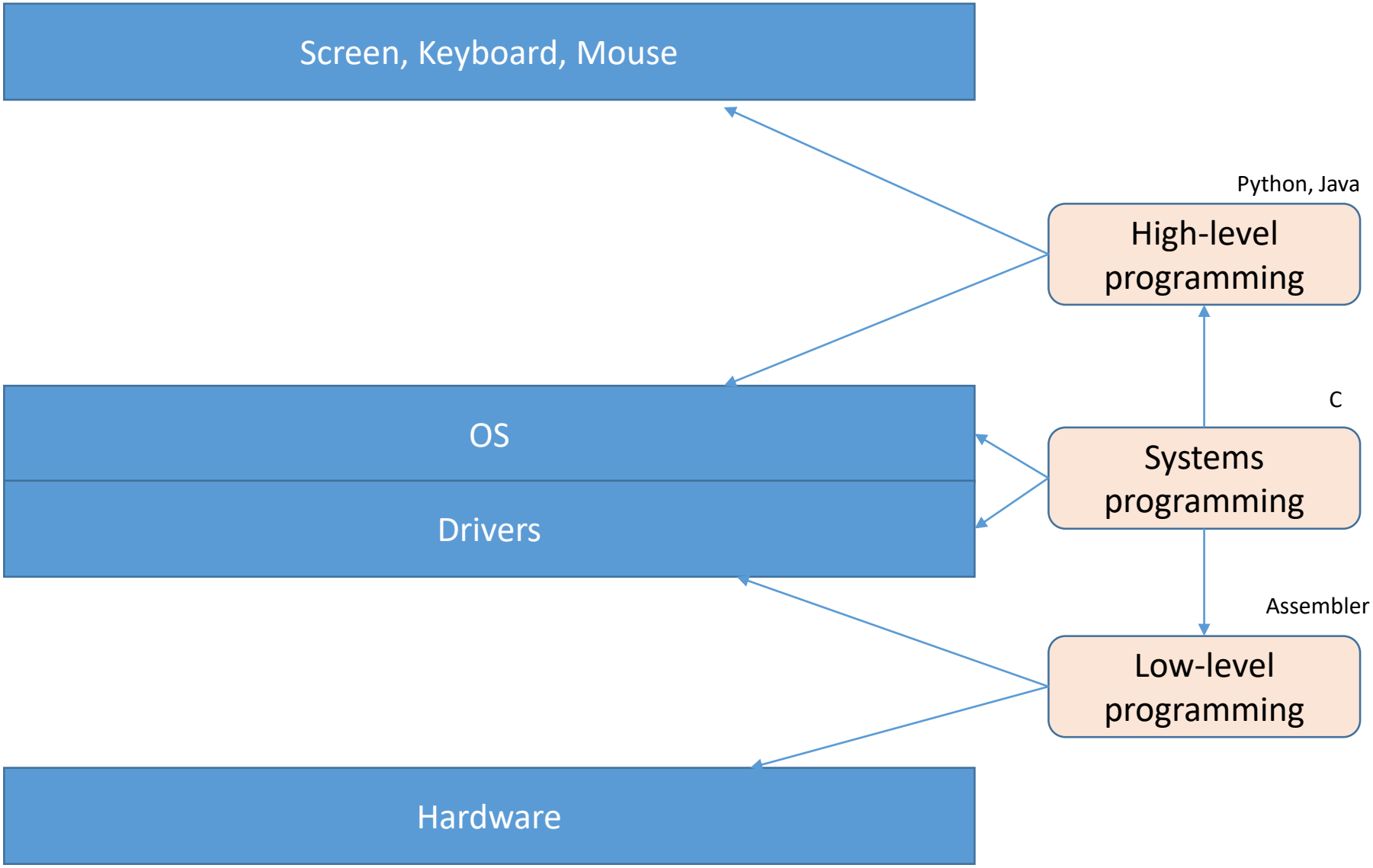
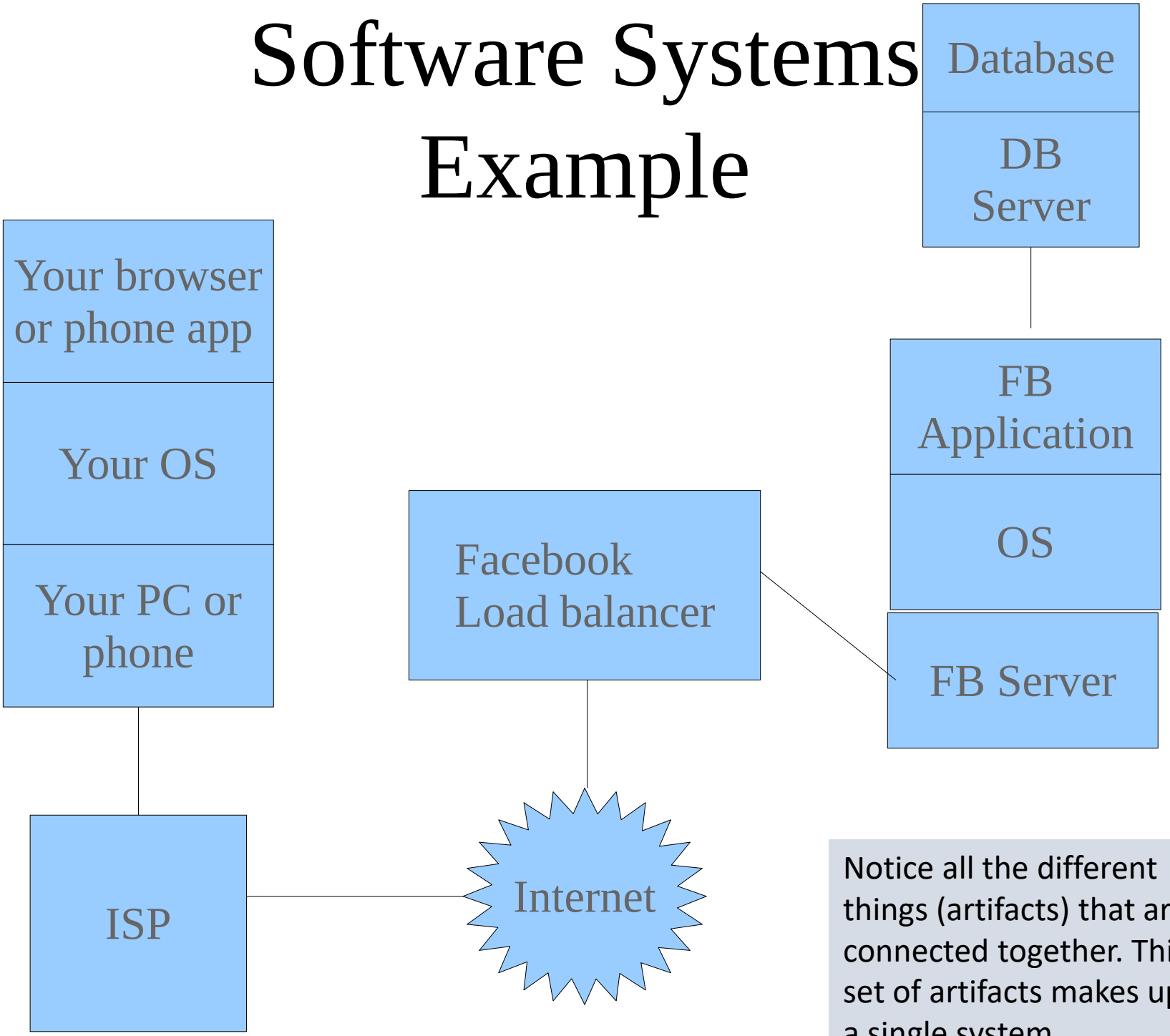
Systems Programming



Software Systems Example



Notice all the different things (artifacts) that are connected together. This set of artifacts makes up a single system.

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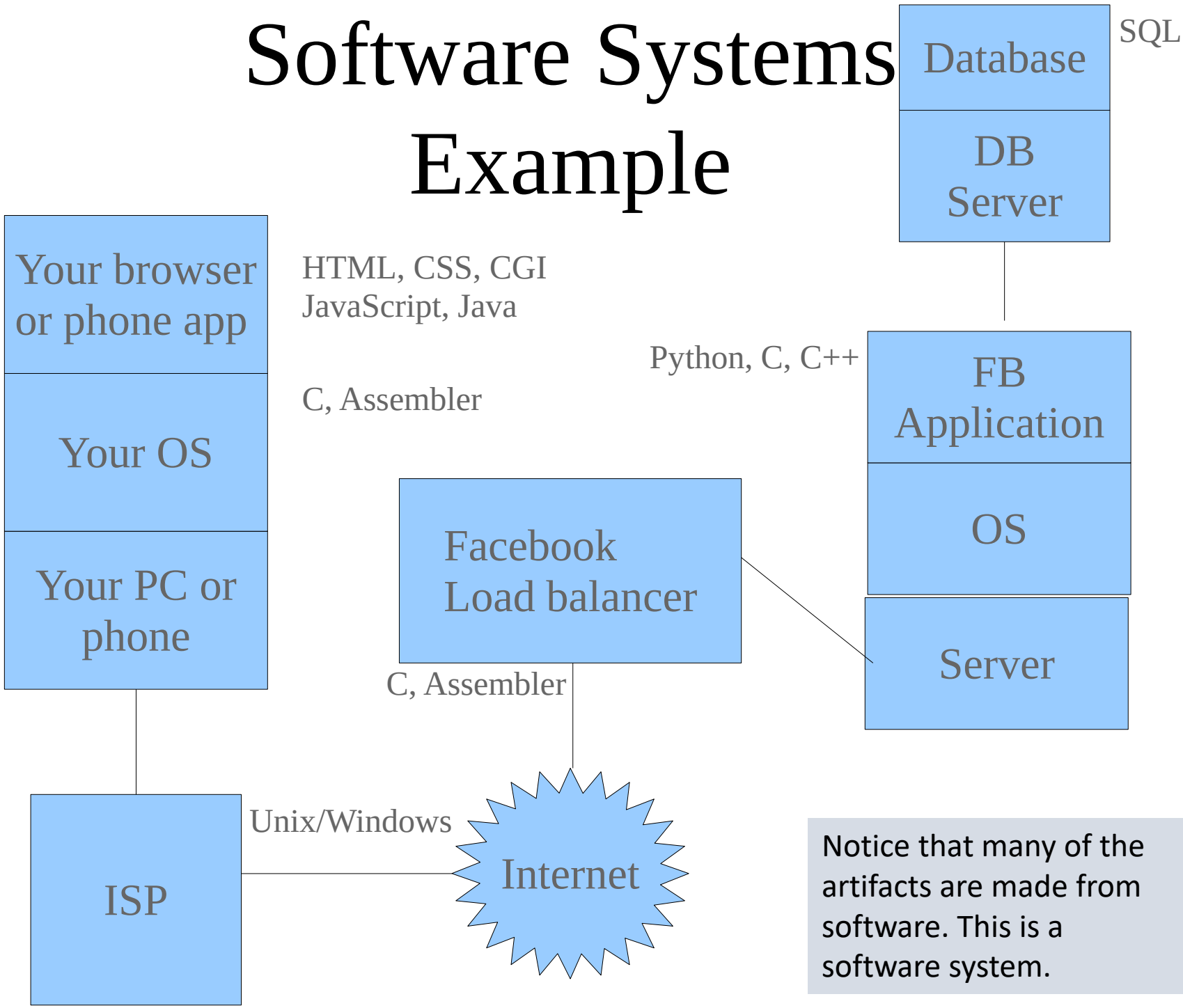
Software Systems Example



Notice that many of the artifacts are made from software. This is a software system.

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Software Systems

As a systems developer, over time, you will acquire the knowledge to be able to integrate many software-based systems.

In this course you will learn to integrate:

- Bash
- Linux
- C
- CGI

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Software Development

Building software is a group effort

GIT, gProf, GDB, Make, GCC

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Command-line Development

```
himanshu@himanshu:~$ ls -l
total 116
-rw---x--x 1 himanshu himanshu    41 Jul  3 23:23 anotherfile
drwxr-xr-x 3 himanshu himanshu  4096 Jul  3 14:26 Desktop
drwxr-xr-x 2 himanshu himanshu  4096 Mar 31 17:54 Documents
drwxr-xr-x 2 himanshu himanshu  4096 Jul  3 21:53 Downloads
-rw-r--r-- 1 himanshu himanshu  8980 Mar 31 17:32 examples.desktop
-rw-r--r-- 1 himanshu himanshu    22 Jul  4 14:42 file1
-rw-r--r-- 1 himanshu himanshu    22 Jul  4 14:42 file2
-rw-r--r-- 1 himanshu himanshu   179 Jul  4 14:38 ls-dump
drwxr-xr-x 3 himanshu himanshu  4096 May 10 20:00 Music
-rw-r--r-- 1 himanshu himanshu     0 Jul  3 21:48 newfil
drwxr-xr-x 2 himanshu himanshu  4096 Jul  4 15:56 Pictures
drwxr-xr-x 3 himanshu himanshu  4096 Jul  4 15:13 practice
-rw-r--r-- 1 himanshu himanshu 20480 Jul  4 15:09 practice.tar
-rw-r--r-- 1 himanshu himanshu  2703 Jul  4 15:19 practice.tar.gz
drwxr-xr-x 2 himanshu himanshu  4096 Mar 31 17:54 Public
-rw---x--x 1 himanshu himanshu    52 Jul  3 23:22 somefile
drwxr-xr-x 2 himanshu himanshu  4096 Mar 31 17:54 Templates
drwxr-xr-x 2 himanshu himanshu  4096 Jul  3 21:31 test
-rw-r--r-- 1 himanshu himanshu   149 Jul  3 21:32 test.tar.gz
-rw-r--r-- 1 himanshu himanshu   310 Jul  3 21:45 test.zip
-rw-r--r-- 1 himanshu himanshu    36 Jul  4 15:56 textfile
drwxrwxr-x 2 himanshu himanshu  4096 Apr 21 12:47 Ubuntu One
-rw-r--r-- 1 himanshu himanshu   101 Jul  4 14:30 uname-output
drwxr-xr-x 2 himanshu himanshu  4096 Mar 31 17:54 Videos
himanshu@himanshu:~$
```

A lot of systems development occurs here. This course focuses on this interface.

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Importance of command line development

- Remote systems development
- OS Jobs (a script to control an OS feature)
- Diagnosing OS & peripheral issues
- Science equipment interfacing
  - Data collection machines
  - Machine controllers
- Not everything has a GUI

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How to do well in this course

- Program everything yourself
- Get used to using all the computer resources
  - Experiment
- Do the readings from the course outline
- Use the Help Desk for technical issues
- Use the TA for class & assignment help
- Use Facebook and Tag me for questions
  - Or the myCourses discussion board

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Questions?

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Lecture 2

What is an operating system?

Unix

Readings: chapter 2, https://www.tutorialspoint.com/operating_system/os_linux.htm

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Outline

- Why is an operating system important?
- The Unix story
- The Unix architecture
- Remote access to the SOCS servers
- The SOCS server architecture
- Login, file transfer, basic working method
- Be careful of…

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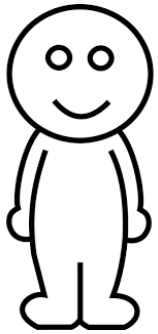
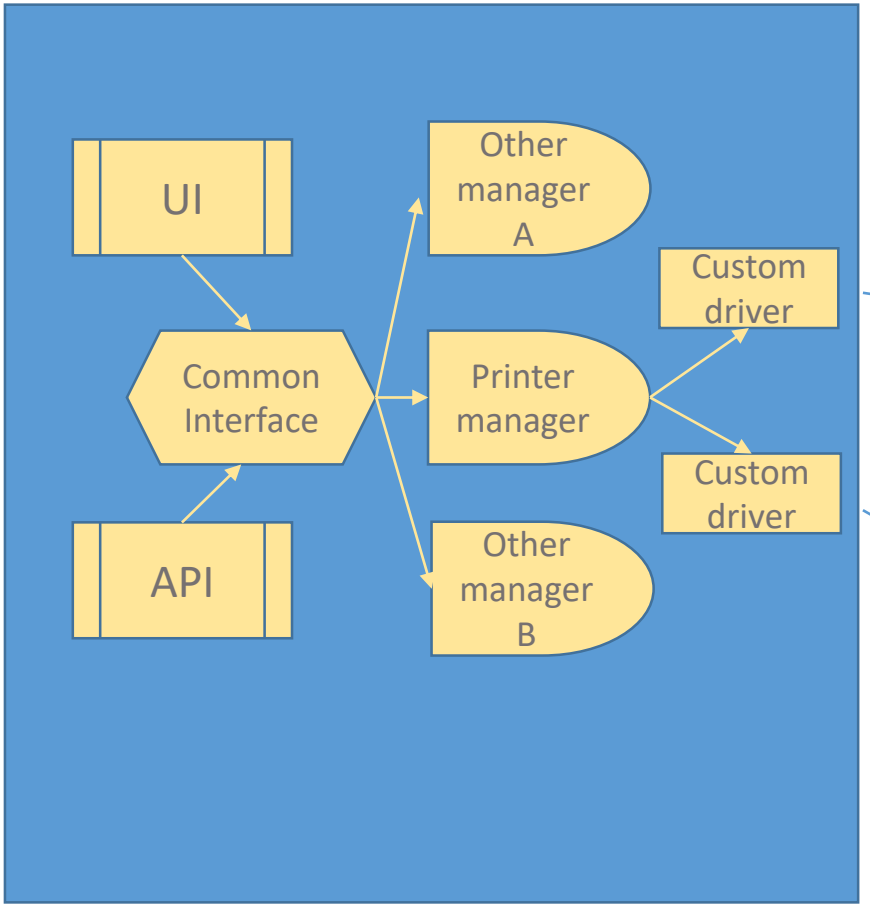
Why is an OS important?

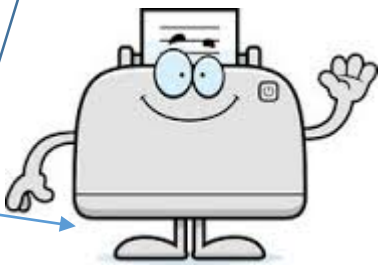
Human language

Electrical signals

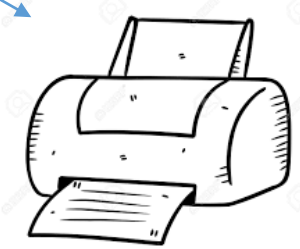


Human





Application



Operating System

Digital language

It manages things for us. Helps us control the computer.

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What is an Operating System?

- An operating system is a piece of software that allows us to **interact** with a computer without having to know the inner working of the computer.

- Its primary function is to **manage** the computer's resources.

- An operating system also provides us with **libraries** to interact with these resources.

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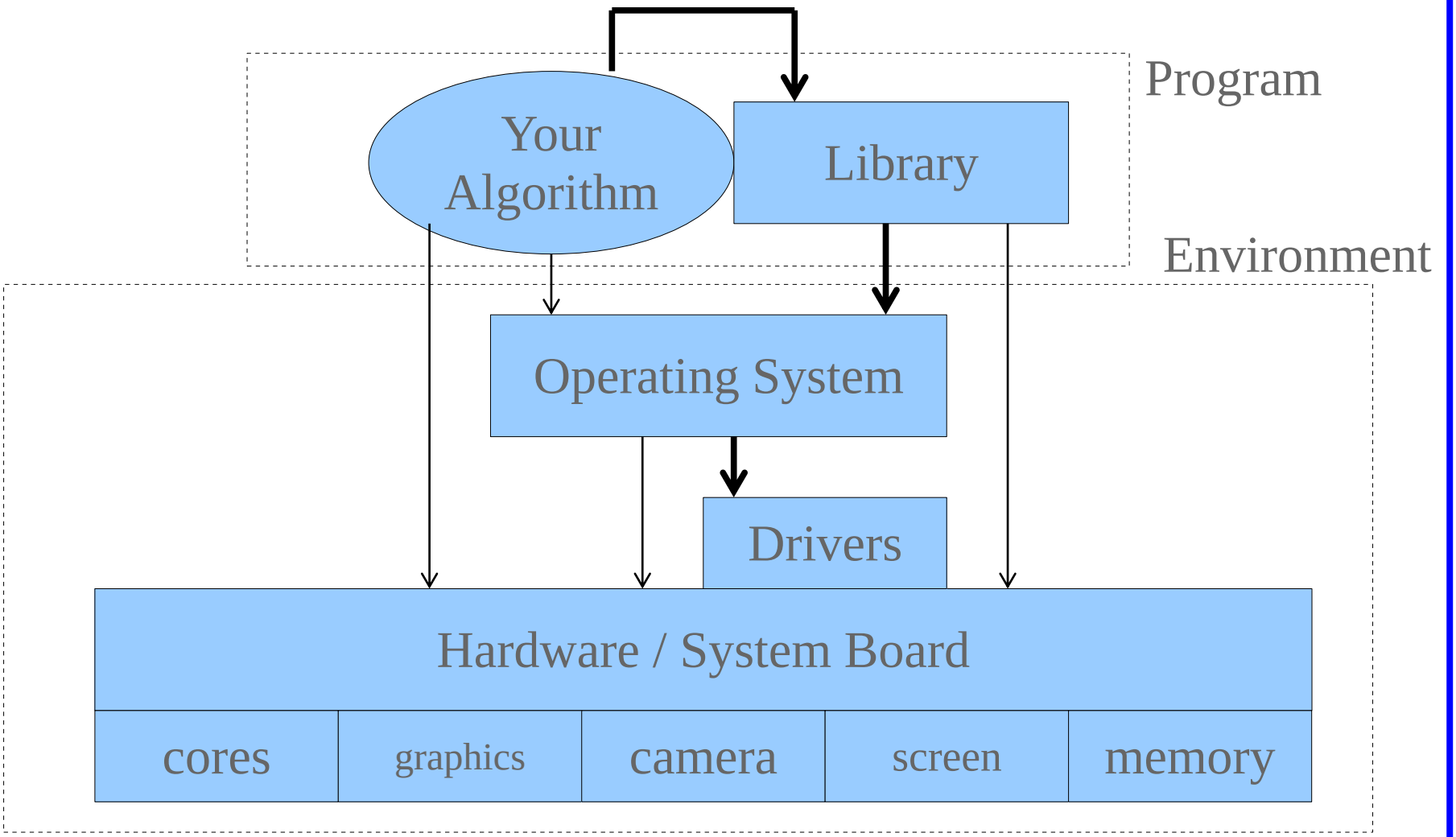
From the POV of the application



Why so many operating systems?

- DOS
- Windows
- Solaris
- Linux
- FreeBSD
- BeOS
- FreeDos
- HP-UX
- AIX
- MacOS X

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A little bit of history…

- The history of Unix begins in a failed operating system by AT&T Bell Laboratories called **Multics** .
- Ken Thompson who was working on this project, wrote a game called *Space Travel* .
- When the project was cancelled, he decided to port the game to the PDP-7 computer.
- He wrote Unix as an operating system to make it easier to port the game.

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Types of Unix

- System V UNIX : Operating Systems based on the original AT&T UNIX code fit in this category. These include most commercial UNIX distribution.
  - AIX, Iris, Solaris, UnixWare, etc.
- BSD UNIX : These Operating Systems are based on the Berkeley Software Distribution (BSD) version of UNIX.
  - FreeBSD, OpenBSD, NetBSD and MacOS X.
- UNIX-like systems : Several Operating Systems behave like UNIX, but are not based on the original AT&T code.
  - Linux, Hurd, Minix

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Unix is...

- Optimized and simple
- Password-based security
- Command-line driven
- Network capable
- Client-server architecture

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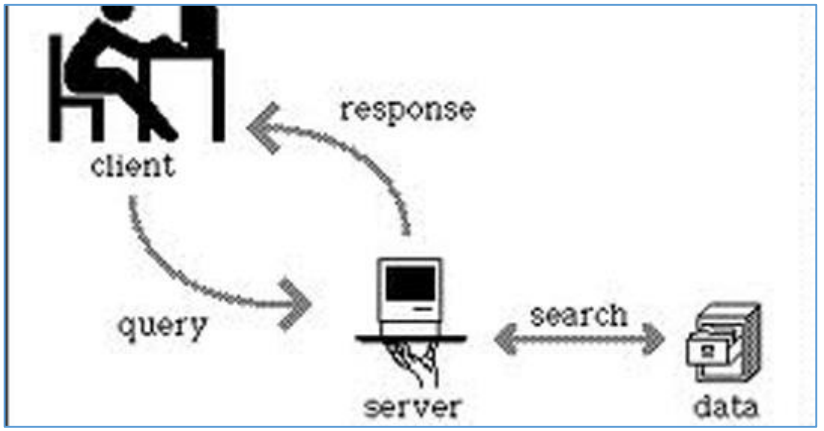
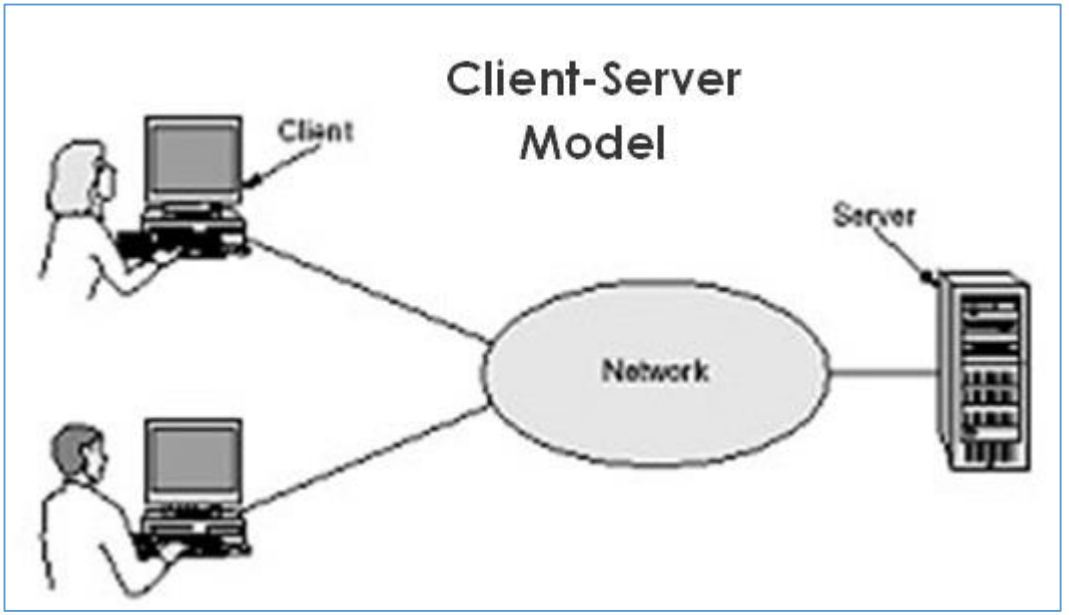
Client-Server Architecture



The model assumes that there is data or software on a server that needs to be shared with a remote computer (client).



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Unix OS Components

IN RAM

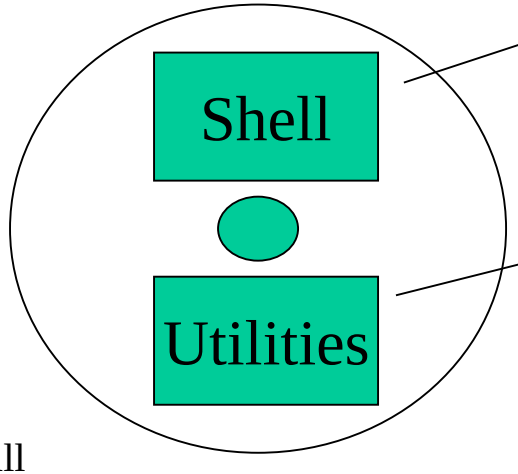
Kernel

- Login
- Knows how to run programs
- Basic common interface
- Memory management

Part in RAM
Part IS disk

File System

- Defines the way the disk drive is formatted
- The file allocation table (FAT)
- The data structure on disk that makes files real
- Reading and writing to disk and peripherals
- User commands to interact with files



- A user interface
- Has a global memory
- Has commands to interact with OS

- Additional OS commands and programs
- Third party commands and programs
- Drivers and managers

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SOCS Unix Server Access

- Labs
  - Trottier 3rd floor (any unlocked room and hallway)
  - Assistance:
    - help@cs.mcgill.ca
    - Office: McConnell 209N
    - Phone: 514-398-7087
- Lab accounts
  - **DO NOT** use your McGill account! First.last@mail.mcgill.ca
  - You must use a SOCS account
    - https://newuser.cs.mcgill.ca
    - You must be **on campus** for this to work **or on a VPN**
    - Forgot your Username and/or Password?
      - Reset it at https://newpassword.cs.mcgill.ca/

Get your account

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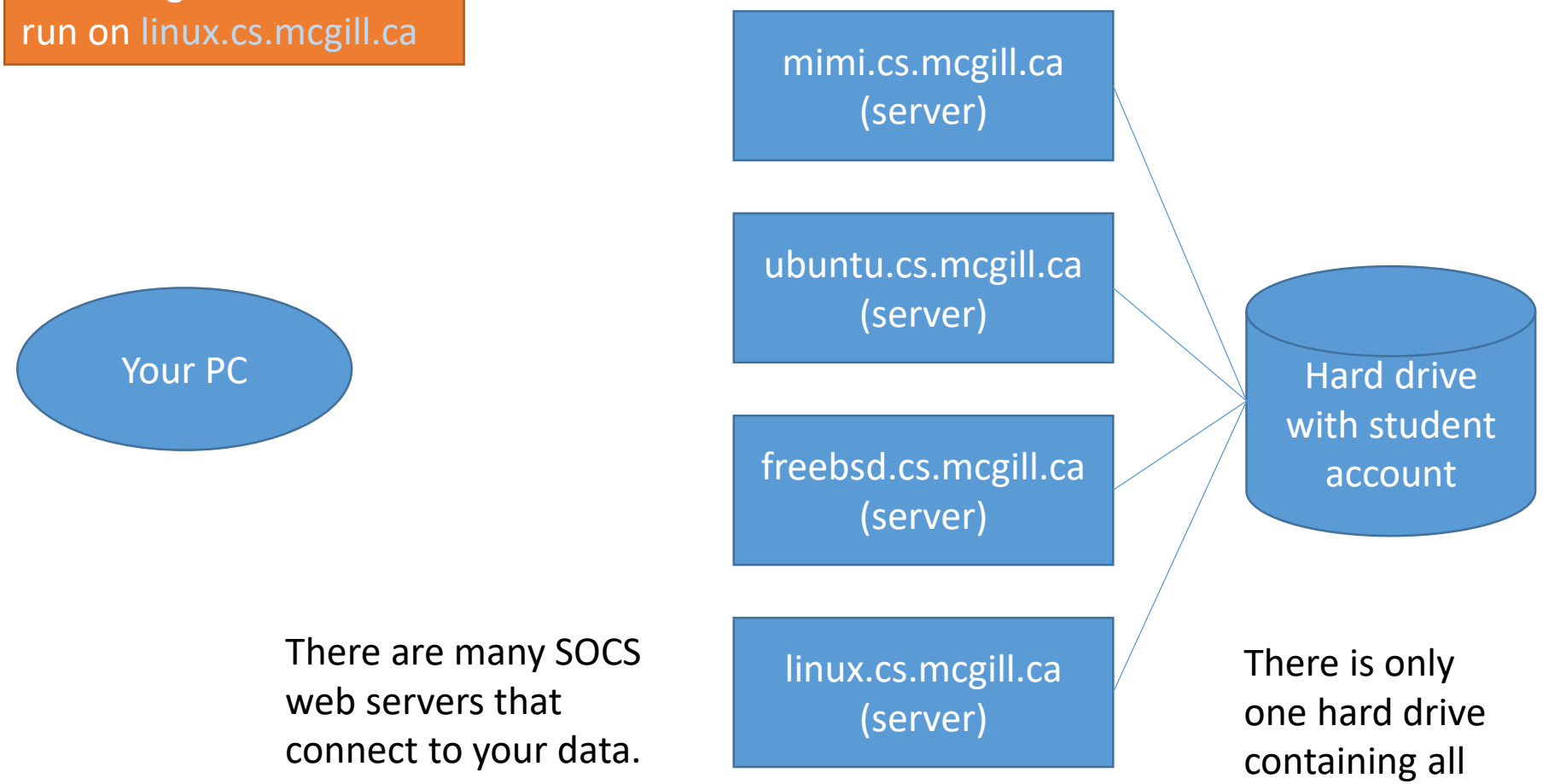
SOCS Server Architecture

Your assignments must run on linux.cs.mcgill.ca



There are many SOCS web servers that connect to your data. IMPORTANT: each server is configured differently.

There is only one hard drive containing all your account information

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Remote Access

WINDOWS	MAC	LINUX
WinSCP (file transfer) Putty (command line)	Viper ftp light Or FileZilla (file transfer) ssh (command line)	FileZilla (file transfer) ssh (command line)

https://filezilla-project.org/index.php
Windows, Mac, and Linux
https://winscp.net/eng/download.php
Windows
http://www.putty.org/
Windows

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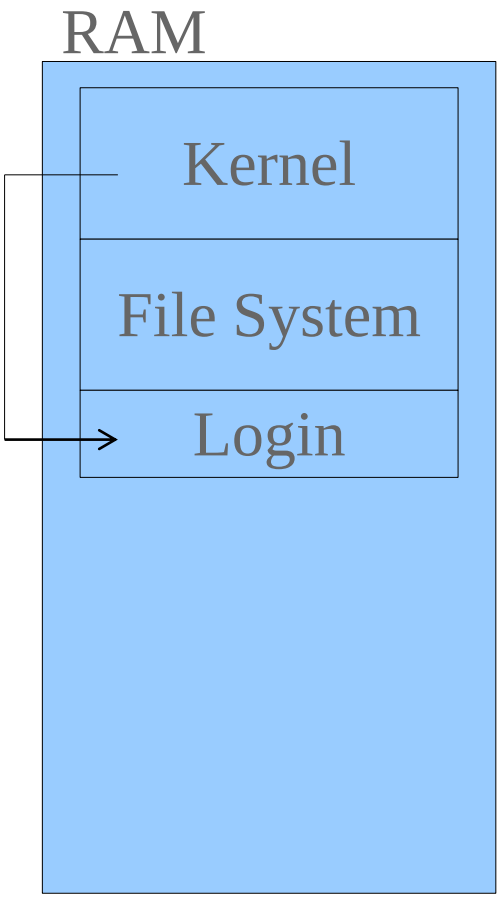
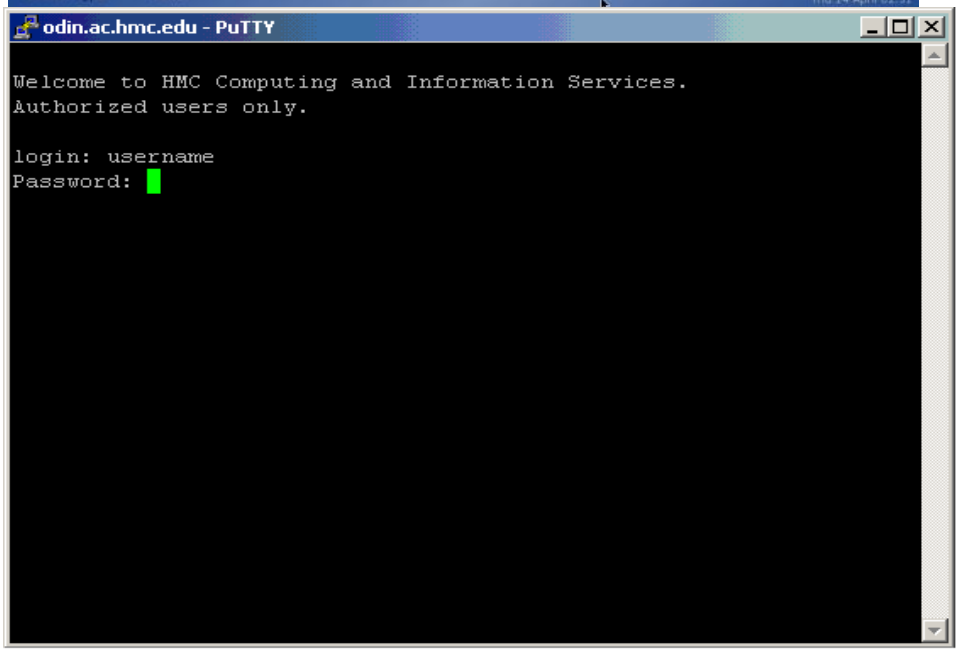
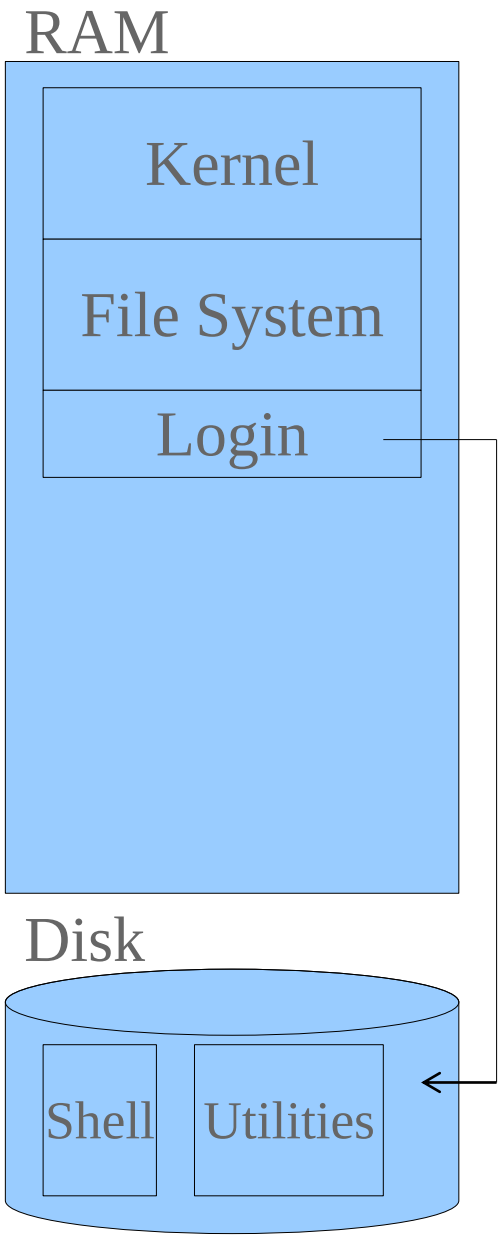
Login


RAM
Kernel
File System
Login
Disk
Shell
Utilities


Welcome to shangan
Username:
Password:
kubuntu
Session Type
Menu

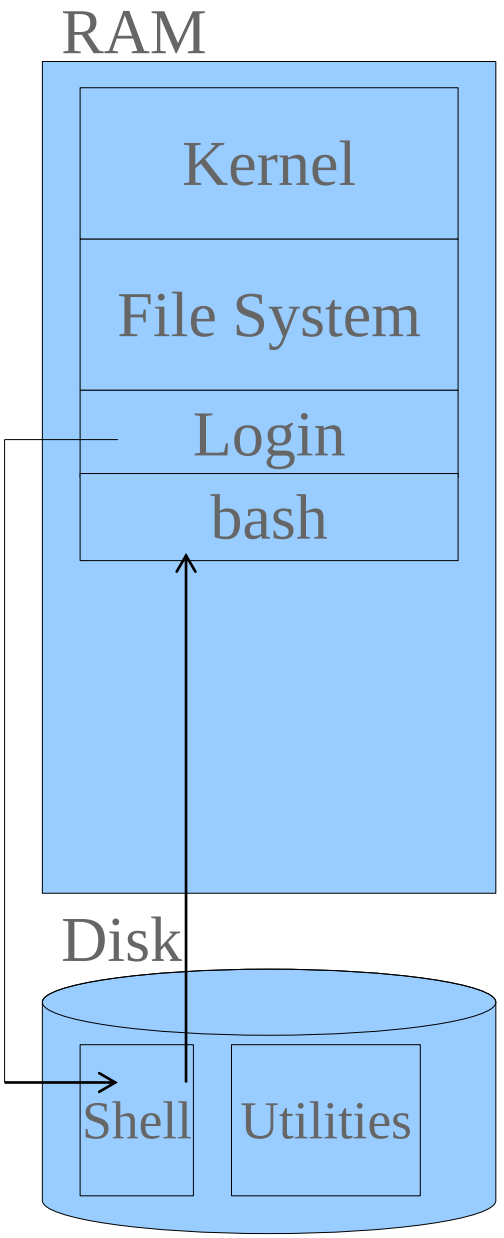

odin.ac.hmc.edu - PuTTY
Welcome to HMC Computing and Information Services.
Authorized users only.
login: username
Password:

Login



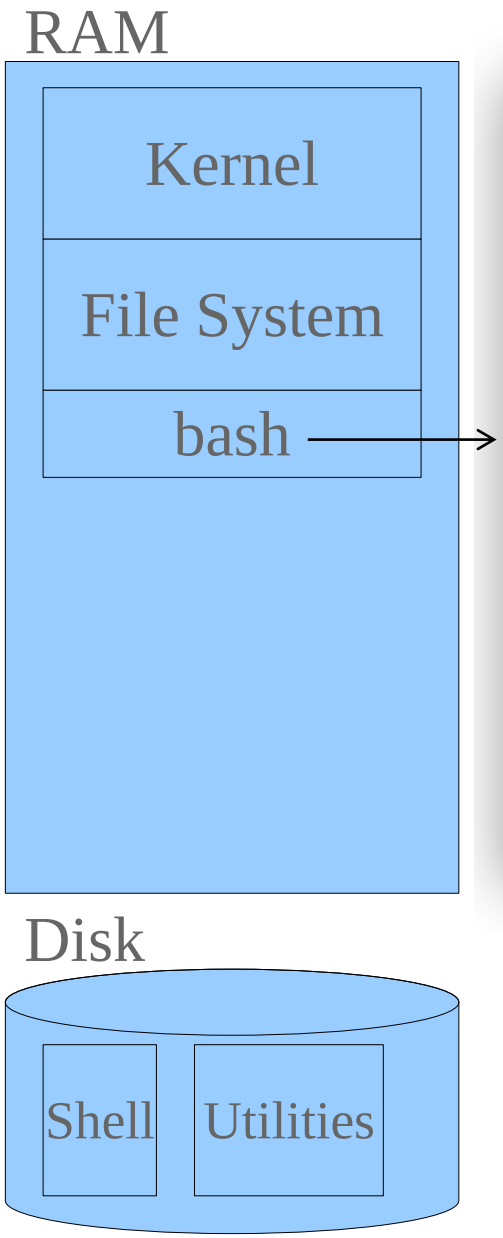
Failed login is logged

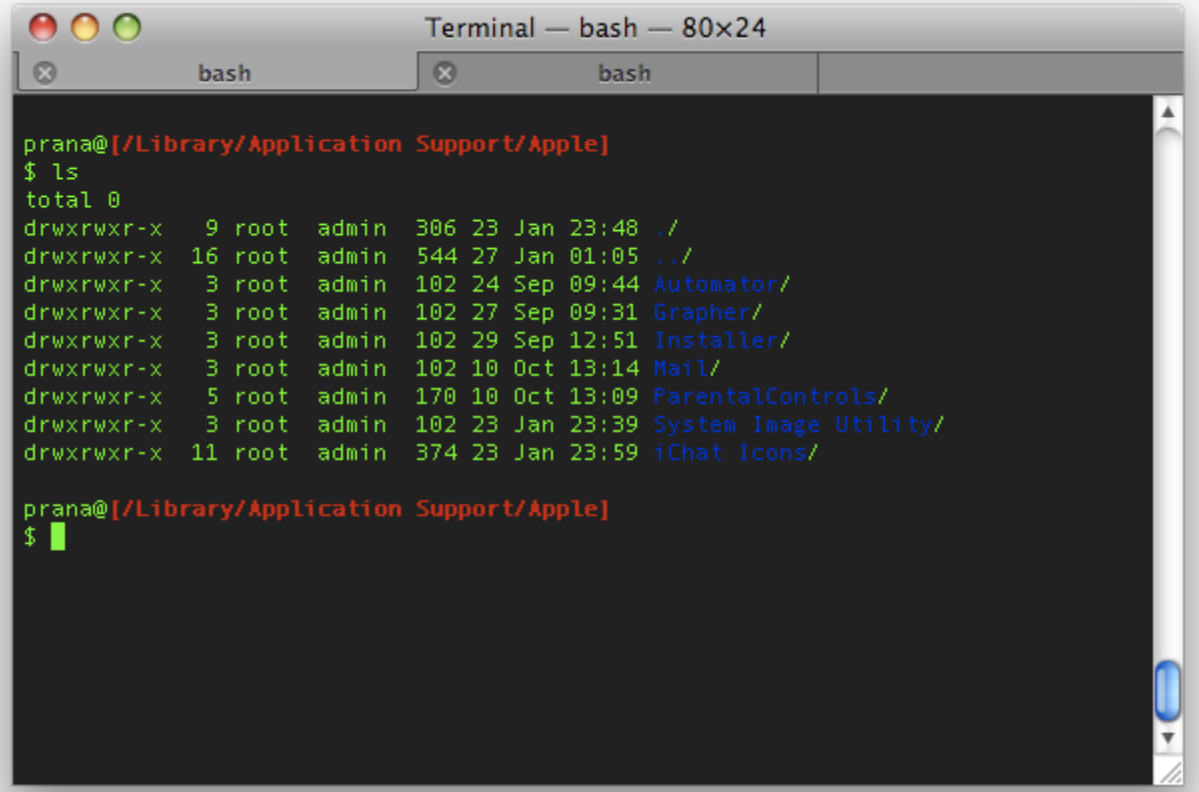
Login



On success

Command Line Shell





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Demo & Procedures

- Logging in
  - linux.cs.mcgill.ca
- File transfer
  - WinSCP file transfer example
  - Putty command-line example
- Basic working method
  - Do not use your computer to complete the assignments because they will not run the same way on the SOCS servers
  - Login to the command-line
  - Do your work
  - If you want to make a backup of your work then use the File Transfer software to copy your work to your laptop
  - Logout

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Be careful of…

- Each web server is installed with different libraries. This means that if you compile or create on one server it might not run the same on another server.
- Text file formats are not exactly the same between Windows, OS X, and Linux. If you develop on your laptop then transfer the file to the server, the file will probably not work correctly.
  - Same problem with copy-paste and cut-paste

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The Shell

Readings: chapter 2, https://www.tjhsst.edu/~dhyatt/superap/unixcmd.html

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Outline

- The shell environment
  - Login
  - Home vs. Root directory
  - Paths
- The command line
  - Basic Commands

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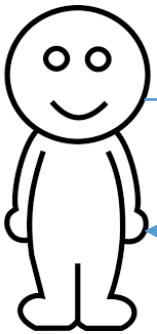
What is a shell?

```
himanshu@himanshu:~$ ls -l
total 116
-rw---x--x 1 himanshu himanshu    41 Jul  3 23:23 anotherfile
drwxr-xr-x 3 himanshu himanshu  4096 Jul  3 14:26 Desktop
drwxr-xr-x 2 himanshu himanshu  4096 Mar 31 17:54 Documents
drwxr-xr-x 2 himanshu himanshu  4096 Jul  3 21:53 Downloads
-rw-r--r-- 1 himanshu himanshu  8980 Mar 31 17:32 examples.desktop
-rw-r--r-- 1 himanshu himanshu    22 Jul  4 14:42 file1
-rw-r--r-- 1 himanshu himanshu    22 Jul  4 14:42 file2
-rw-r--r-- 1 himanshu himanshu   179 Jul  4 14:38 ls-dump
drwxr-xr-x 3 himanshu himanshu  4096 May 10 20:00 Music
-rw-r--r-- 1 himanshu himanshu     0 Jul  3 21:48 newfil
drwxr-xr-x 2 himanshu himanshu  4096 Jul  4 15:56 Pictures
drwxr-xr-x 3 himanshu himanshu  4096 Jul  4 15:13 practice
-rw-r--r-- 1 himanshu himanshu 20480 Jul  4 15:09 practice.tar
-rw-r--r-- 1 himanshu himanshu  2703 Jul  4 15:19 practice.tar.gz
drwxr-xr-x 2 himanshu himanshu  4096 Mar 31 17:54 Public
-rw---x--x 1 himanshu himanshu    52 Jul  3 23:22 somefile
drwxr-xr-x 2 himanshu himanshu  4096 Mar 31 17:54 Templates
drwxr-xr-x 2 himanshu himanshu  4096 Jul  3 21:31 test
-rw-r--r-- 1 himanshu himanshu   149 Jul  3 21:32 test.tar.gz
-rw-r--r-- 1 himanshu himanshu   310 Jul  3 21:45 test.zip
-rw-r--r-- 1 himanshu himanshu    36 Jul  4 15:56 textfile
drwxrwxr-x 2 himanshu himanshu  4096 Apr 21 12:47 Ubuntu One
-rw-r--r-- 1 himanshu himanshu   101 Jul  4 14:30 uname-output
drwxr-xr-x 2 himanshu himanshu  4096 Mar 31 17:54 Videos
himanshu@himanshu:~$
```

A program that has three basics tasks: (a) get user input, (b) display OS information, (c) store session information.



Read user input	Parse user input	Call OS
Display result from OS	Local memory	Convert to human readable form

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Why so many shells?

- x Window
- Bash
- sh
- tsh
- csh
- tcsh
- cmd

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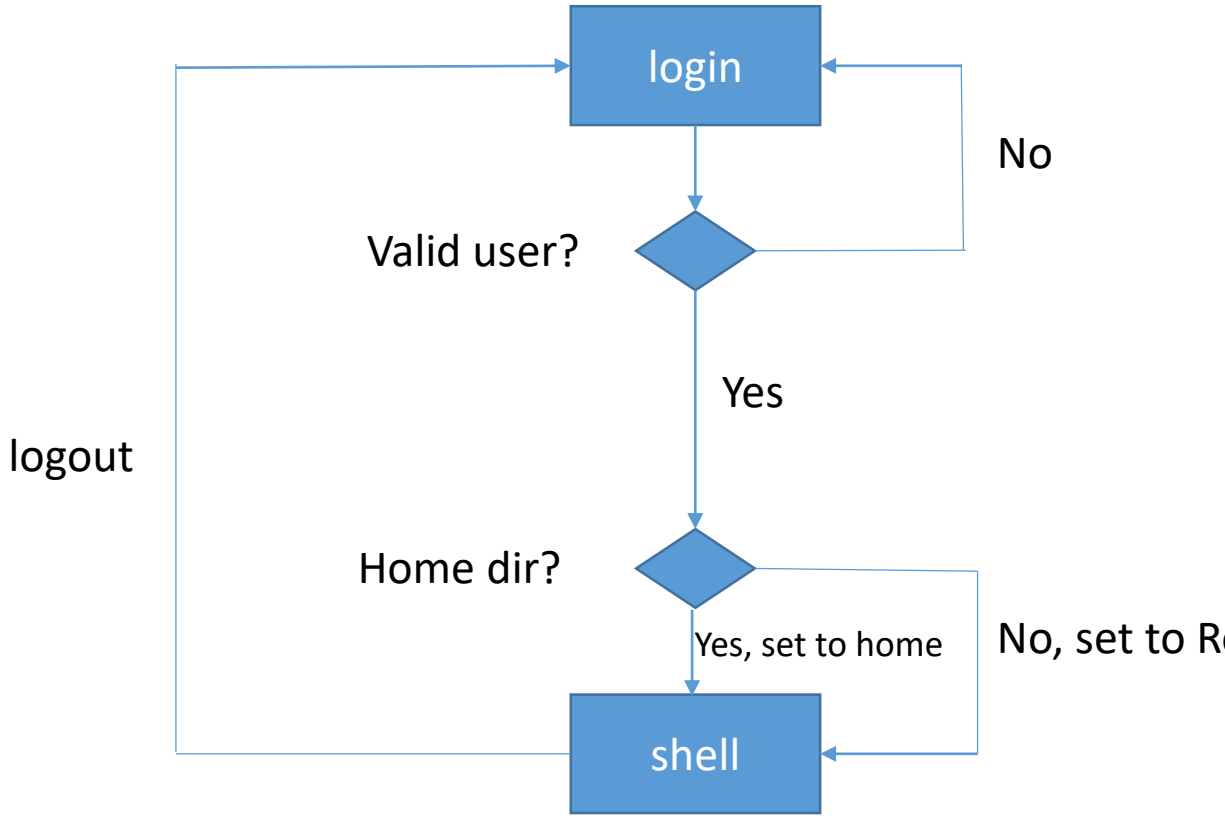
The shell environment



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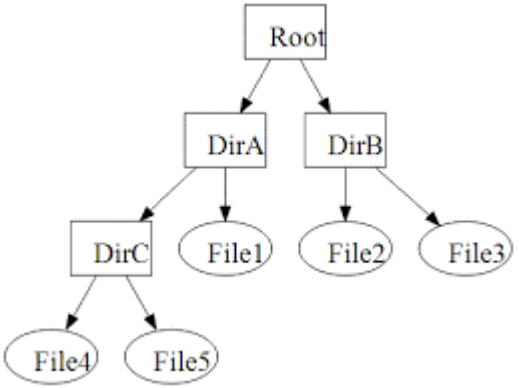
Directory

- Linux "directory" is a folder
  - Synonyms: Dir, Folder, Directory
  - Def: An OS structure that contains files. This structure can be assigned a name.

- 4 special directories
  - Home
    - This is the top folder in the user's directory tree
    - Special symbol: ~
  - Root
    - This is the top folder of the OS
    - Special symbol: /
  - Current
    - The directory you are currently within
    - Special symbol: .
  - Parent
    - The directory "above" the current directory
    - Special symbol: ..



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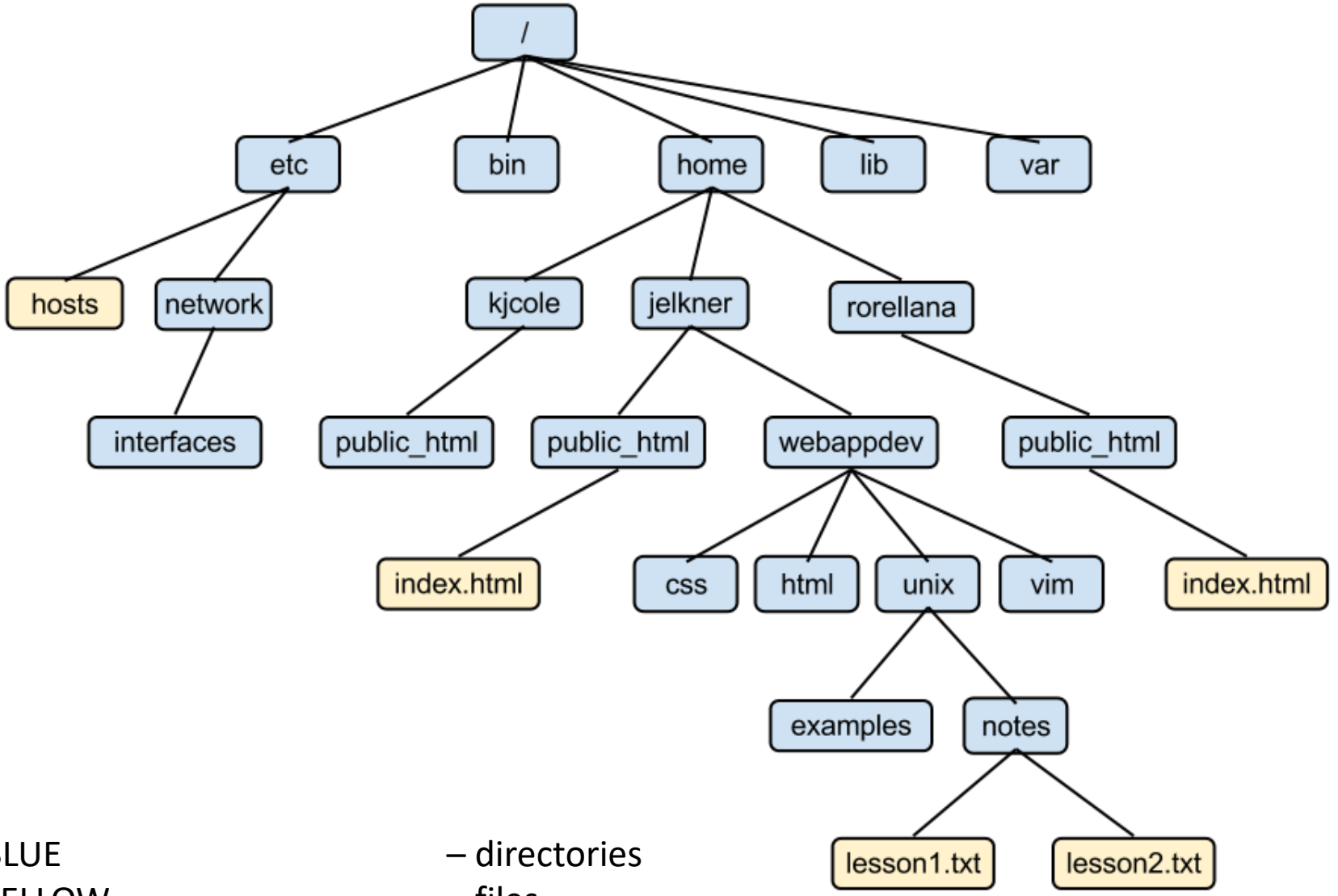

BLUE – directories
YELLOW – files
/ - is the root
Kjcole, jelkner, rorellana – examples of home directories

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Path

Def: A path is a string that describes the location of a file or directory within an OS.

Two ways of expressing a path:

1. Absolute path
   - Def: a string that begins at the Root
   - Syntax: “/dir/dir/dir/file” or “/dir/dir/dir”
2. Relative path
   - Def: a string that begins at the current location
   - Syntax: “dir/dir/file” or “../dir/dir/file” or “file”

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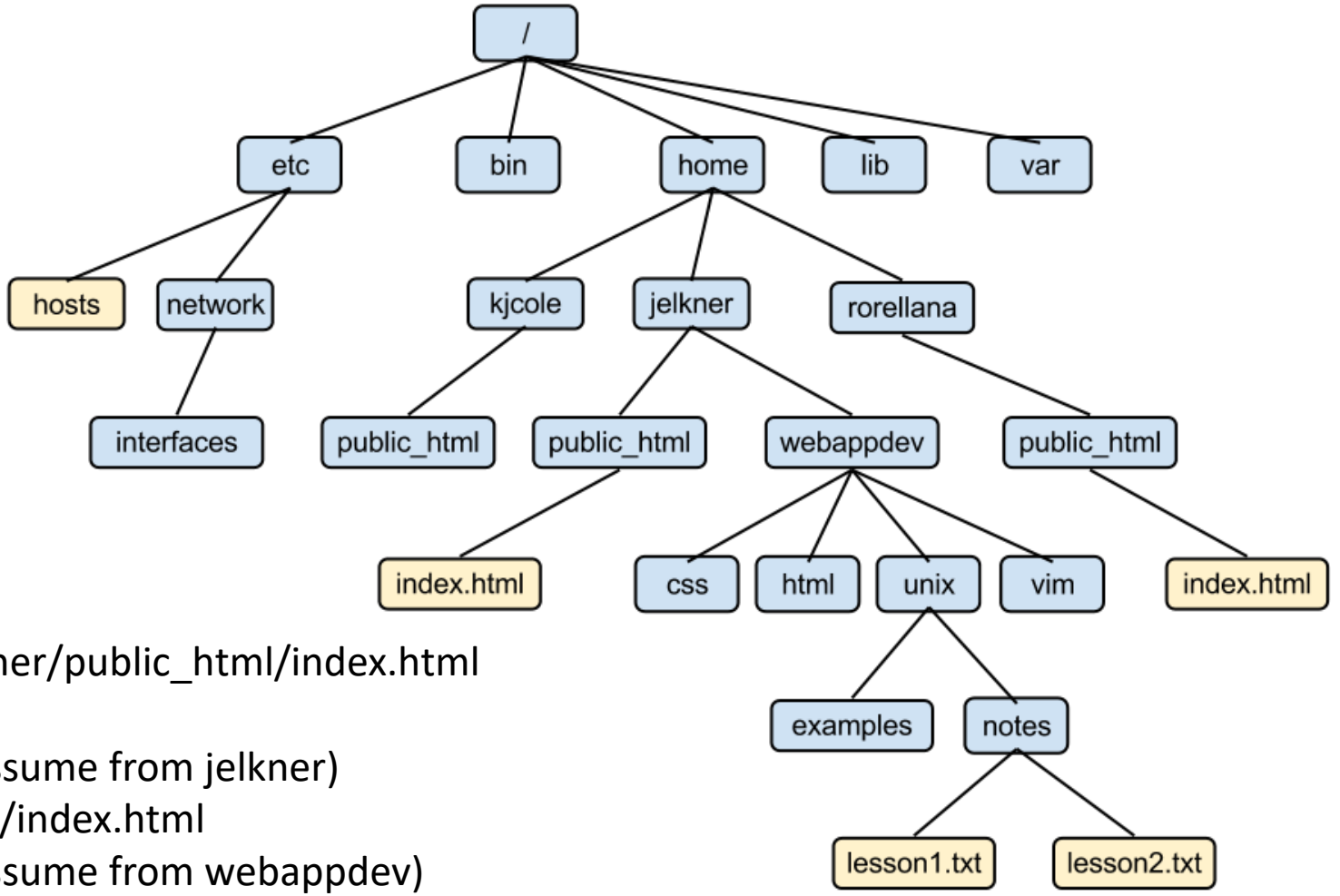
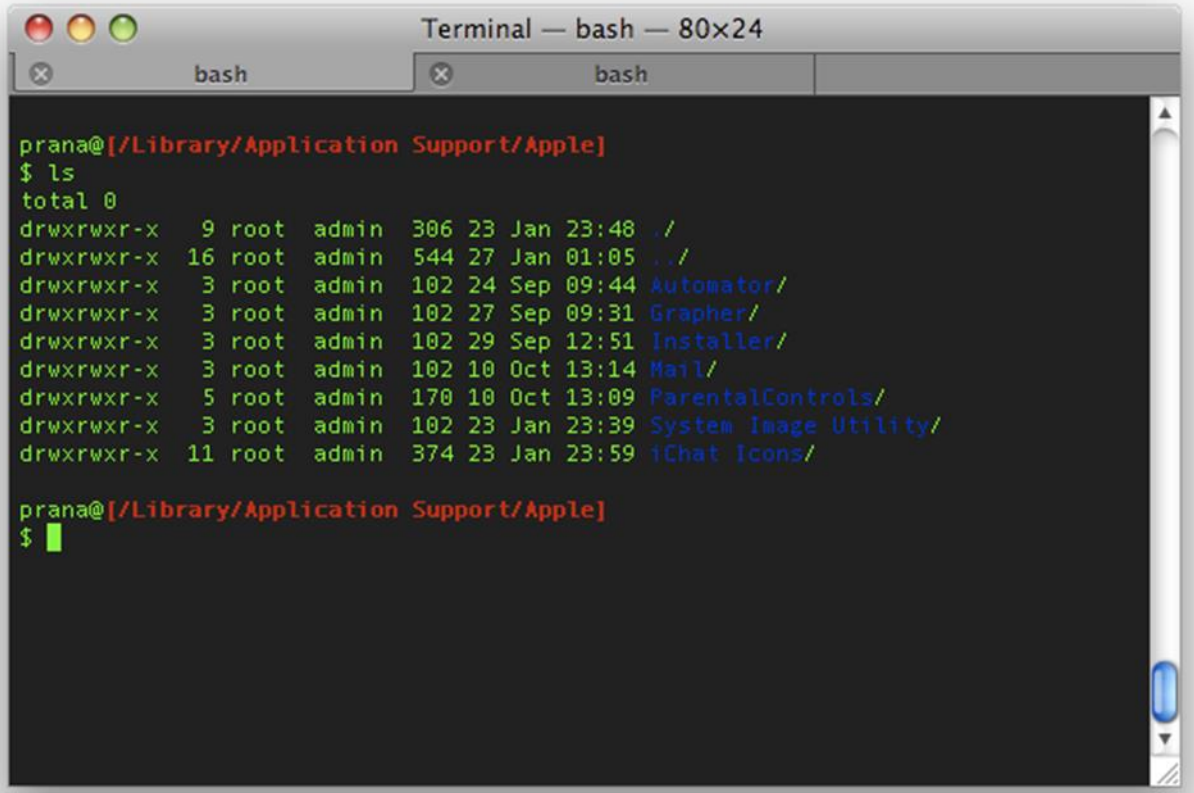
Path examples



Absolute:
/home/jelkner/public_html/index.html

Relative: (assume from jelkner)
public_html/index.html
Relative: (assume from webappdev)
../public_html/index.html
Relative: (assume from vim)
../../public_html/index.html

The command line



prompt →

Command Format:
Program switches arguments

Example Syntax:
$ ls –l ass1.pdf

Where:
Program - the command
Switches - modifies behavior of command
Arguments - input passed to the command

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The directory listing

```
[mimi] [~] ls
SummerCampEng.flv  public_html  public_html.2005  summ.tgz
[mimi] [~]
```

```
$ ls -l /bin/ar
-r-xr-xr-x   1 bin      bin        21428 Sep 24  1983 /bin/ar
$
```

```
[mimi] [~] ls -l
total 3092
-rw-------    1 summcamp 16618    1376256 Jun  5 10:44 SummerCampEng.flv
drwxr-xr-x   11 summcamp 16618       4096 Jun  7 11:41 public_html
drwxr-xr-x    3 summcamp 16618       4096 Jan  4  2006 public_html.2005
-rwx------    1 summcamp 16618    1780739 Jul  5  2005 summ.tgz
[mimi] [~
```

owner

size

links

group

Modification date

permissions

What does everything mean?

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Directory Content

- See the contents of a directory (folder)

  ls

- See contents in long format

  ls –l

- See a particular file in long format

  ls –l letter.doc

- Display all the files and hidden files

  ls -a

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Current Directory

- `pwd` (print working directory)

  displays the current directory you are in (considered default)

  Syntax : pwd

  Usage : pwd
  Result : Displays to the screen /home/jack (for example)

- `cd` (change directory)

  allows a user to change their current directory.

  Syntax : cd PATH

  Usage : cd ../home

  Result : current working directory is now ../home

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```
$ whoami
Jvybihal
$ pwd
/jack
$ ls
Stuff.txt    source
$ cd source
$ ls
F1.java f2.java f3.java
$ cd ..
$ ls
Stuff.txt   source
$ cd /
I am at the root now
$ cd/jack/source
$ mkdir docs
$ ls
F1.java f2.java f3.java docs
```


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Directory Manipulation

- cd [directory]
  - change directory
- ls [options] [directory or file list]
  - directory contents or file permissions
- mkdir [options] directory
  - make a directory
- pwd
  - print working (current) directory
- rmdir [options] directory
  - remove a directory

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File Manipulation

- cp [options] file1 file2
  - copy file1 into file2. This command creates or overwrites file2.
- mv [options] file1 file2
  - move file1 into file2
- rm [options] file
  - remove (delete) a file or directory

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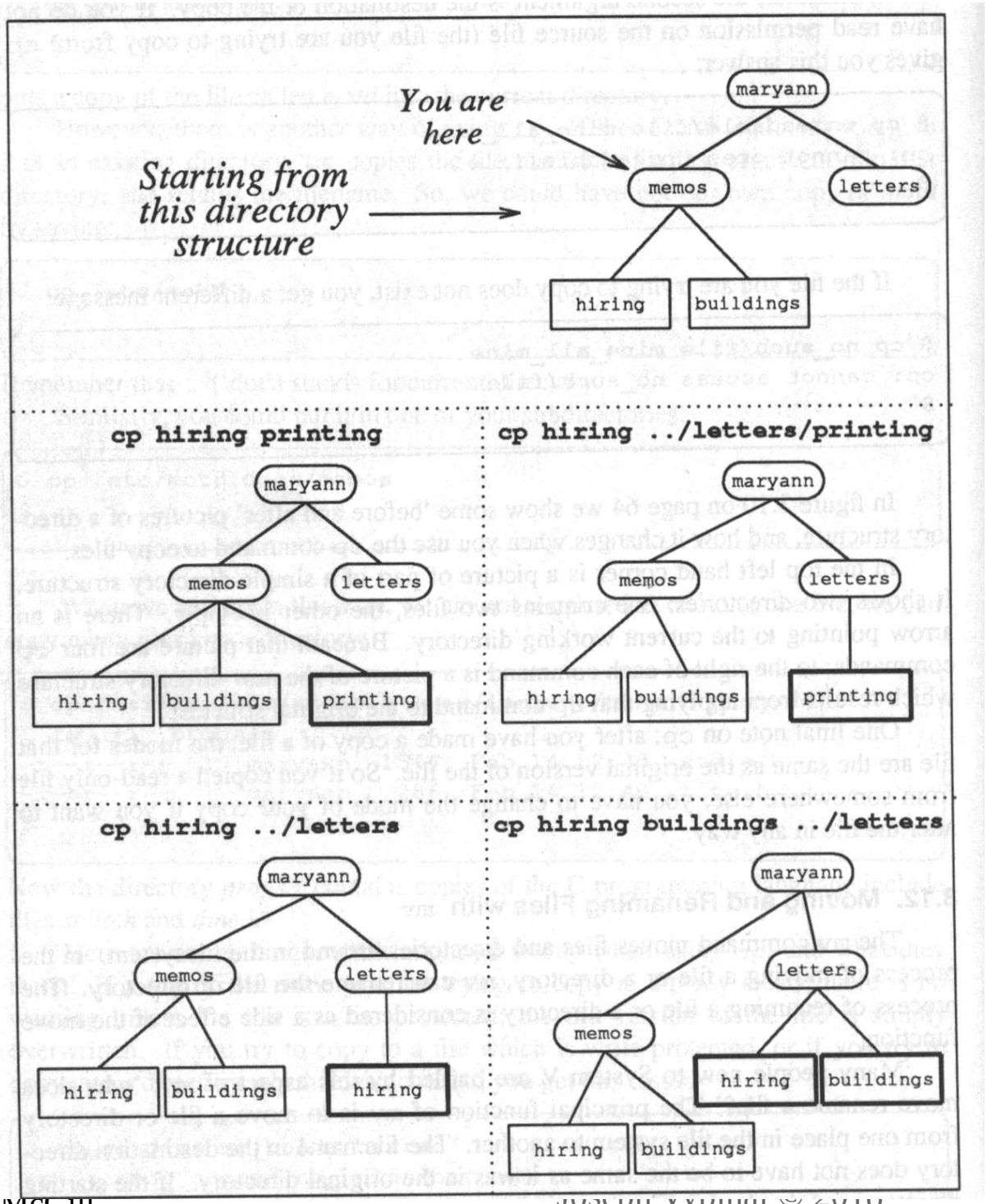

Copy Command

$ cp from to

From = filename
From = path/filename

To = From syntax
To = path

$ cp from from to

Options for cp, mv and rm

$ cp -r /jack /mary/source

- -i : interactive (cp, mv and rm)

– prompt and wait for confirmation before proceeding

- -r or -R: recursive (cp, rm)

– recursively visits a directory, first visiting the files and subdirectories beneath it

- -f : force : (mv, rm)

– don’t prompt for confirmation (overrides -i)

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Cat and More

- cat [options] files
  - file concatenate and display the concatenated result

- more [options] file
  - page through a text file

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Logout vs. Exit

- The *logout* command closes the shell and logs you out
- The *exit* command closes the shell (however, if there is no other shell to send you to then it will automatically call *logout*.

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Linux Manual

- The `man` command allows you to access the on-line manual pages of the various commands available on the shell.
  - These pages are often referred to as “man pages”.
- The man pages are your first source of information when working in the shell.
- To access a man page, simply type man and the name of the command at the prompt.

```
man ls
```


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```
$ man date
date(1)                                                    date(1)
                        Version 1.1


NAME
     date - print and set the date

SYNOPSIS
     date [yymmddhhmm[.ss]]

DESCRIPTION
     If no argument is given, the current date and time are printed.
     If an argument is given, the current date is set.  yy is the
     last two digits of the year; the first mm is the month number;
     dd is the day number in the month; hh is the hour number (24
     hour system); the second mm is the minute number; ss is optional
     and is the seconds.  For example:

             date 10080045

     sets the date to Oct 8, 12:45 AM.  The year, month and day may
     be omitted, the current values being the defaults.  The system
     operates in GMT.  Date takes care of the conversion to and from
     local standard and daylight time.

FILES
     /usr/adm/wtmp to record time setting

SEE ALSO
     utmp(5)

DIAGNOSTICS
     'No permission' if you aren't the super-user and you try to change
     the date; 'bad conversion' if the date set is syntactically incorrect.
                                    . . . . .
$
```

$ man date