# Lecture #2
# CSC 200-04L Fall 2018

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# Agenda

- Algorithms
  - Example:  Cost to send a Fax
- Operating Systems
  - Definition and Types of Operating Systems
  - Common Features of Operating Systems
  - Compare Windows & Unix
- Networks
  - TCP/IP Overview
  - OSI Model
  - Firewalls
  - Hubs and Switches

# Algorithm

- An algorithm is a step-by-step problem-solving process in which a solution is arrived at in a finite amount of time
- The algorithm is the “how” of solving the problem, specifies the steps to work to the solution of the problem
- Specified in English sentences, “pseudo-code”, or a flow chart, NOT in a specific computer programming language

# Algorithm (Cont)

- Algorithms resemble recipes. Recipes tell you how to accomplish a task by performing a number of steps. For example, to bake a cake the steps are: preheat the oven; mix flour, sugar, and eggs thoroughly; pour into a baking pan; and so forth.
- However, “algorithm” is a technical term with a more specific meaning than “recipe”, and calling something an algorithm means that the following properties are all true:
- An algorithm is an unambiguous description that makes clear what has to be implemented.
- An algorithm expects a defined set of inputs. For example, it might require two numbers where both numbers are greater than zero. Or it might require a word, or a list of zero or more numbers.

From: https://fiftyexamples.readthedocs.org/en/latest/algorithms.html

# Algorithm (Cont)

- An algorithm produces a defined set of outputs. It might output the larger of the two numbers, an all-uppercase version of a word, or a sorted version of the list of numbers.
- An algorithm is guaranteed to terminate and produce a result, always stopping after a finite time. If an algorithm could potentially run forever, it wouldn't be very useful because you might never get an answer.
- Most algorithms are guaranteed to produce the correct result. It's rarely useful if an algorithm returns the largest number 99% of the time, but 1% of the time the algorithm fails and returns the smallest number instead.
- If an algorithm imposes a requirement on its inputs (called a precondition), that requirement must be met. For example, a precondition might be that an algorithm will only accept positive numbers as an input. If preconditions aren't met, then the algorithm is allowed to fail by producing the wrong answer or never terminating.

From: https://fiftyexamples.readthedocs.org/en/latest/algorithms.html

# Algorithm Example

- Suppose that the cost of sending an international fax is calculated as follows:
  - Service charges $3.00
  - $0.20 per page for the first 10 pages
  - $0.10 for each additional page.
- Design an algorithm that asks the user to enter the number of pages to be faxed. The algorithm then uses the number of pages to be faxed to calculate the amount due.
- Use the algorithm we come up with to determine the cost of sending a 2 page fax, a 9 page fax, and a 20 page fax

# What is an Operating System?

- An operating system (OS) is software, consisting of programs and data, that manages computer hardware resources, and provides common services for execution of application software.
- Differs from Application Software
  - Application Software performs specific tasks for a user (for example, word processor or web browser)

based on http://en.wikipedia.org/wiki/Operating_system

# Types of Operating Systems

- Single User vs. Multi User
  - A multi-user operating system allows multiple users to access a computer system concurrently
  - Timesharing is multi-user
- Multi-tasking vs. Single-tasking
  - Single-tasking OS allows only a single program is allowed to run at a time
  - Multi-tasking allows the execution of multiple tasks at a time
- Real-Time Operating System
  - Multitasking OS for executing real-time applications
  - RTOS use specialized scheduling algorithms to provide deterministic performance (low “jitter”)

# BIOS & Bootloader

- BIOS = Basic Input Output System
  - Firmware that resides in ROM on the PC's motherboard
  - Purpose:
    - initialize and test the system hardware components
    - Starts a bootloader
- Bootloader:
  - a small program that loads the programs and data into RAM to start an operating system
  - Computer may have multiple Operating Systems, bootloader can select
  - Example: GNU Grub: http://en.wikipedia.org/wiki/GNU_GRUB

Based on: http://en.wikipedia.org/wiki/BIOS

# Common Features of Operating Systems

- Booting
- Interfacing with Users
- Managing Resources
- File Management
- Security and Accounting

Based on: http://www.mtsac.edu/~rpatters/CISB11/Chapters/Chapter_05/Chap05/LectureMain.htm

# Common Features of Operating Systems: Booting

- Loads the Operating System Kernel into RAM
- kernel is the central engine of the operating system that remains in memory the entire time the PC (other portions of OS can be swapped in/out of RAM as the computer is running)
- Determines what hardware is attached to the system, tests, and loads software to control (drivers)
- Runs start up tasks (finishing installs, starting anti-virus software, etc.)
  - Why do you need to reboot to finishing an install sometimes?

Based on: http://www.mtsac.edu/~rpatters/CISB11/Chapters/Chapter_05/Chap05/LectureMain.htm

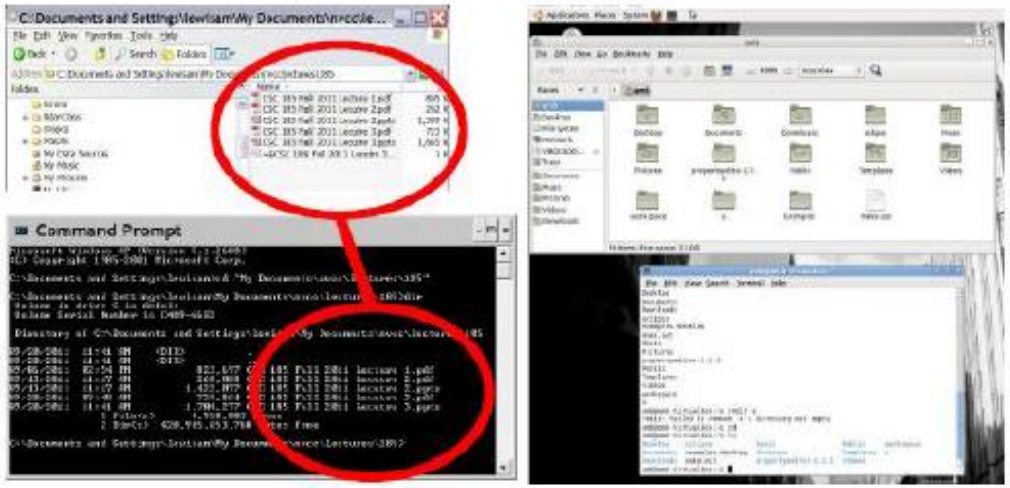
# Common Features of Operating Systems: Interfacing with Users

- Translate user instructions and actions into a form the computer understands (User to Computer)
- Translates feedback from the hardware and software into a form the user understands (Computer to User)
  - Screen, audio, or other (eg: making the mobile device vibrate)
- Two major categories of Operating System user interfaces:
  - Command Line: user types commands into the operating system
  - GUI: user interacts with a pointing device

Based on: http://www.mtsac.edu/~rpatters/CISB11/Chapters/Chapter_05/Chap05/LectureMain.htm

# Common Features of Operating Systems: Interfacing with Users (Cont)

- Left is Windows, Right is Linux
- Top is GUI, Bottom is Command Line Interface
- Note: GUI and Command Line provide different views of similar data…in this case, what files are in a particular folder



# Common Features of Operating Systems: Manage Resources

- OS starts/stops application programs
  - OS retrieves them from disk and loads them into RAM
- OS manages system resources and makes them available to devices and programs when they are needed
  - If a problem occurs, such as a program stops working or there are too many programs open for the amount of memory available, the OS will typically notify the user and suggest a solution, such as to close some programs
- OS maps computing scheduling user jobs to be performed using those resources.
  - Scheduling routines in the operating system determine the order in which jobs are processed on the computer system hardware, such as hard drives and printers, as well as which commands get executed first if the user is working with more than one program at a time.
  - An operating system serving multiple users does not necessarily assign jobs on a first-come, first-served basis. For example, some users may have higher priority than others or the devices needed to process the next job in line may not be available -- these factors affect how system resources are allocated.

Based on: http://www.mtsac.edu/~rpatters/CISB11/Chapters/Chapter_05/Chap05/LectureMain.htm

# Common Features of Operating Systems: Manage Resources (CONT)

- The operating system also schedules operations throughout the computer system so that different parts of the system can work on different portions of the same job at the same time.
  - Because input and output devices work much more slowly than the CPU itself, the CPU may complete billions of calculations for several different programs while a single document is being printed.
  - Using a number of techniques, the operating system juggles the computer's work in order to employ system devices as efficiently as possible.

Based on: http://www.mtsac.edu/~rpatters/CISB11/Chapters/Chapter_05/Chap05/LectureMain.htm

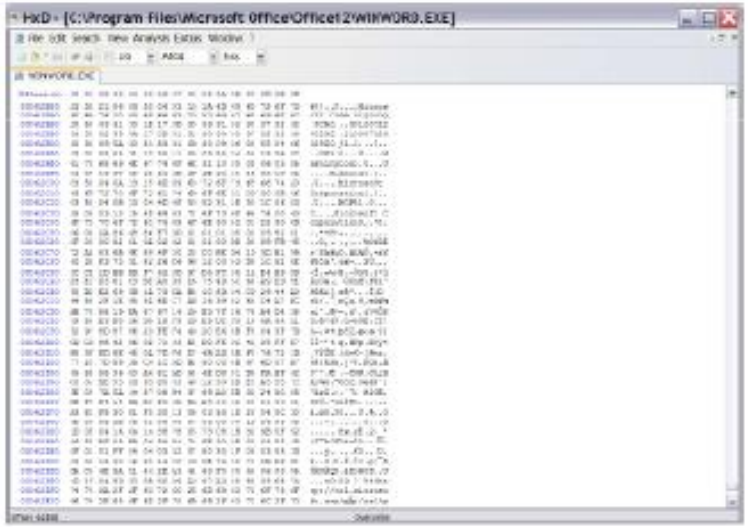
# Common Features of Operating Systems: File Management

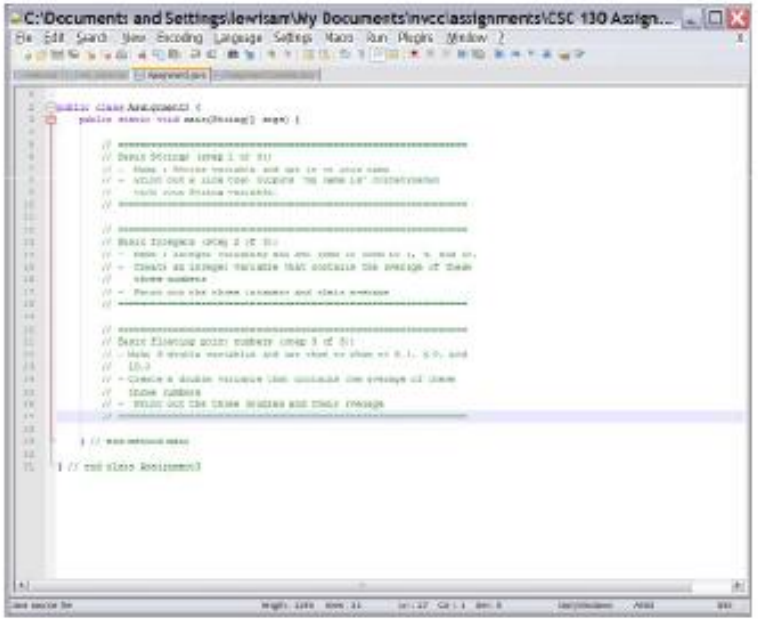
- A computer file is a resource for storing information, typically in secondary storage
  - Files are chunks of bytes that need to be stored and accessible for the user of the system
  - Example Files:
    - Word Processing Documents (DOC File)
    - Photograph (JPEG File)
    - Web Page (HTML File)
  - Two broad types of files:
    - Text (read by a person)
    - Binary (read by a program)
- The Operating System creates, updates, and deletes files based on user or application program requests
- Files are organized into directories

Based on: http://www.mtsac.edu/~rpatters/CISB11/Chapters/Chapter_05/Chap05/LectureMain.htm

# Common Features of Operating Systems: File Management (Cont)

- Example of Binary versus Text Files:



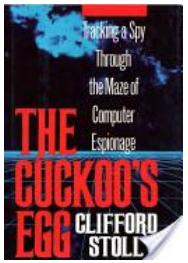



# Common Features of Operating Systems: File Management

- File System:  The way a computer organized, names, stores, and manipulates files
- Directory or Folder?
  - Used interchangeably in this class
  - Folder is a bucket to hold files, analogous to a paper folder
  - Directory (or folder) is a structured list of documents files and directories (or folders) stored on the computer

# Common Features of Operating Systems: Security & Accounting

- Security:
  - Protect against unauthorized access by using passwords or other security procedures to prevent outsiders from accessing system resources that they are not authorized to access.
  - Ensure that application programs can not view or modify the memory in use by another program
- Accounting:
  - Keep track of who is using which resources and/or modifying the systems
  - Typically stored in logs
- FYI, an Interesting book related to these two topics:
  - The Cuckoo's Egg by Stoll



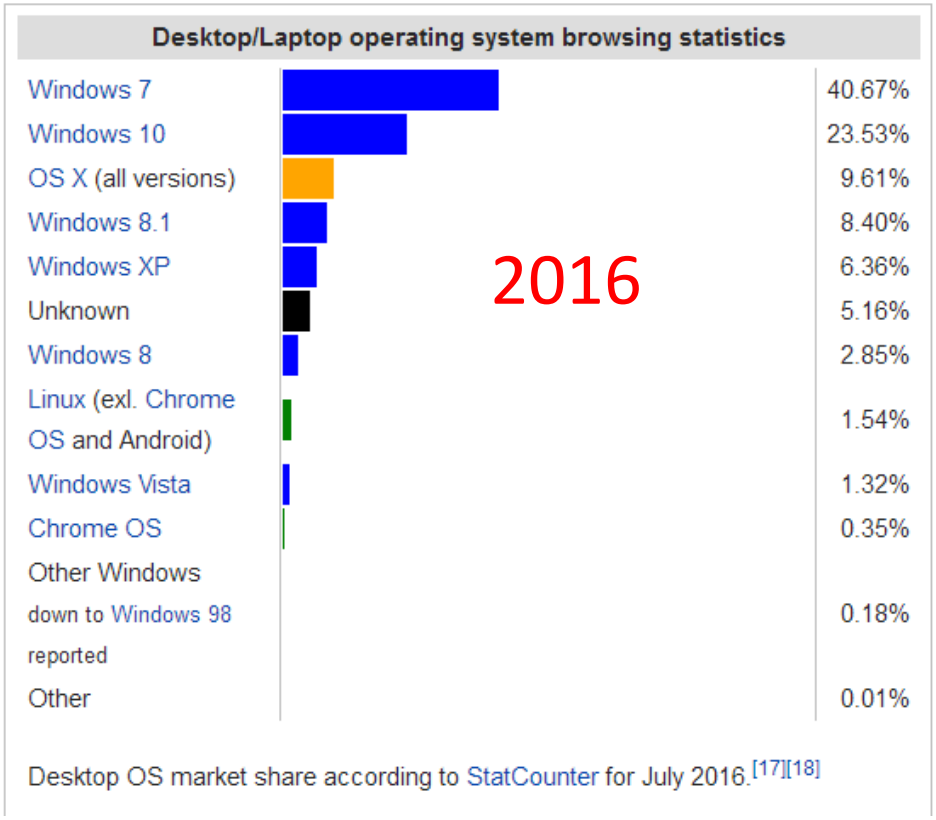

Based on: http://www.mtsac.edu/~rpatters/CISB11/Chapters/Chapter_05/Chap05/LectureMain.htm

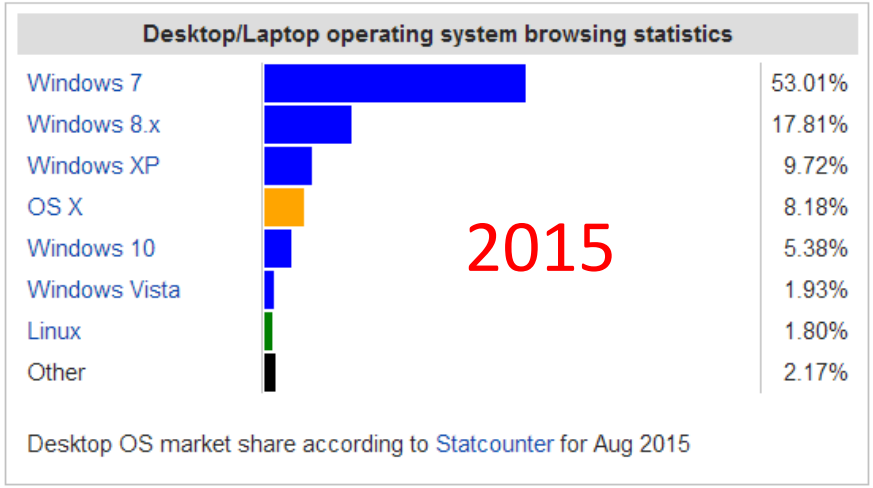
# Operating Systems
# Compare Windows and Unix

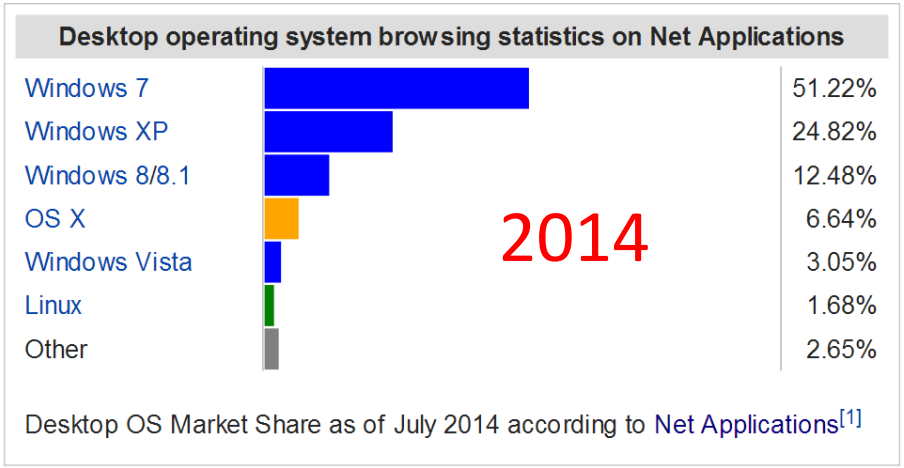
- Unix
  - multitasking, multi-user computer operating system
  - originally developed in 1969 by a group of AT&T employees at Bell Labs
  - Evolution:
    - Open Source (BSD, Linux, Darwin)
    - Commercial (AIX, Solaris, HP-UX, OSX, etc)
- Not-Unix (aka Windows)
- Review Table @ http://en.wikipedia.org/wiki/Comparison_of_operating_systems

# Operating Systems
# Compare Windows and Unix

- OS Usage (from http://en.wikipedia.org/wiki/Usage_share_of_operating_systems)



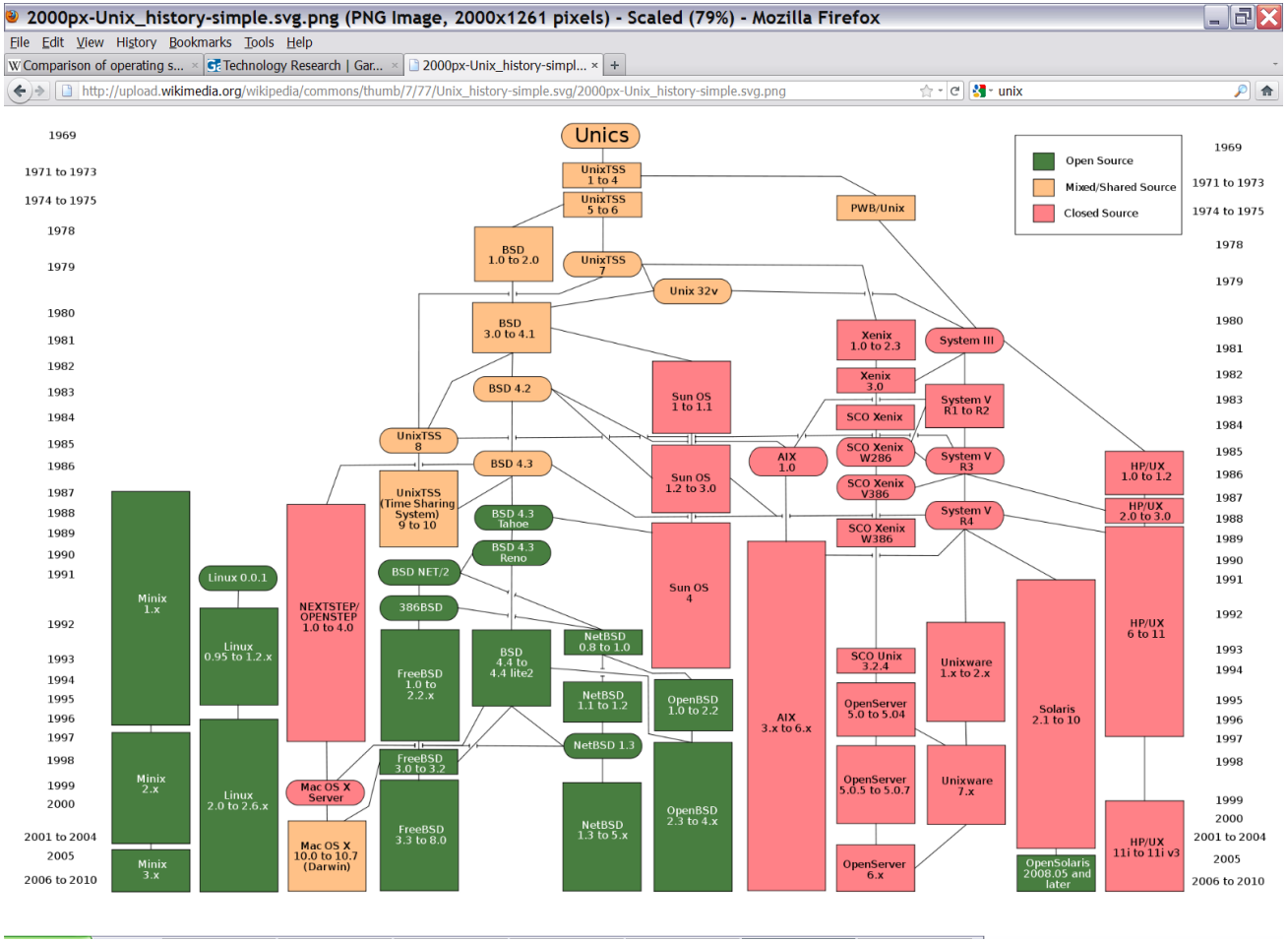



# Unix History

- Unix is used extensively in scientific programming
  - Both Unix and the C programming language were developed by AT&T Bell Labs and freely distributed to government and academic institutions
  - This led to it being ported to a wide variety of machine families than any other operating system
  - As a result, Unix became synonymous with "open systems“
  - The Unix environment and the client–server program model were essential elements in the development of the Internet
- Originally, Unix was meant to be a programmer's workbench rather than be used to run application software.
  - the system grew larger when the operating system started spreading in the academic circle
  - many individual users started adding their own tools to the system and passing it along to colleagues (that’s why the names are “crazy”)

From http://en.wikipedia.org/wiki/Unix

# Unix History




http://upload.wikimedia.org/wikipedia/commons/thumb/7/77/Unix_history-simple.svg/1000px-Unix_history-simple.svg.png

# Unix Philosophy

- Unix systems are characterized by various common concepts:
  - the use of plain text for storing data
  - a hierarchical file system
  - treating devices and certain types of inter-process communication (IPC) as files
  - the use of a large number of software tools
  - small programs that can be strung together through a command line interpreter using pipes

From http://en.wikipedia.org/wiki/Unix

# Windows: Microsoft History

- Paul Allen and Bill Gates were childhood friends with a passion in computer programming, were seeking to make a successful business utilizing their shared skills.
- The January 1975 issue of Popular Electronics featured Micro Instrumentation and Telemetry Systems's (MITS) Altair 8800 microcomputer.
  - Allen noticed that they could program a BASIC interpreter for the device; after a call from Gates claiming to have a working interpreter, MITS requested a demonstration.
  - Since they didn't actually have one, Allen worked on a simulator for the Altair while Gates developed the interpreter.
  - Although they developed the interpreter on a simulator and not the actual device, the interpreter worked flawlessly when they demonstrated the interpreter to MITS in Albuquerque, New Mexico in March 1975
  - MITS agreed to distribute it, marketing it as Altair BASIC.
  - They officially established Microsoft on April 4, 1975, with Gates as the CEO.

http://en.wikipedia.org/wiki/Microsoft

# Windows:
# Microsoft History

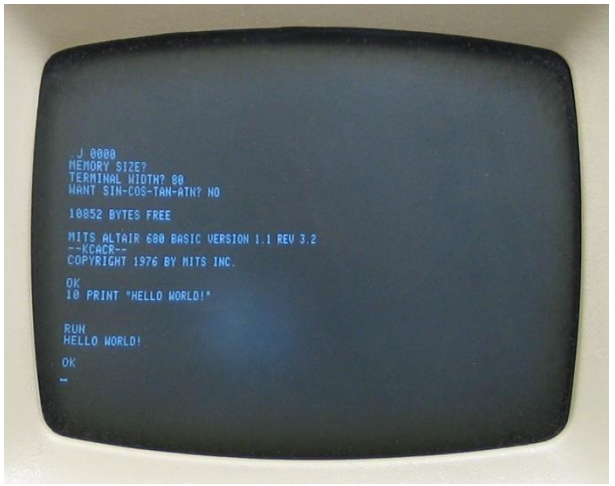
http://en.wikipedia.org/wiki/File:1981BillPaul.jpg


http://www.old-computers.com/museum/photos/mits_altair-8800_2.jpg

Net Worth

Paul Allen = $13,000,000,000 (2011)

Bill Gates = $56,000,000,000 (2011)




http://www.altair680kit.com/images/070707-Basic_Demo_CRT_2789.jpg

# Microsoft History: Founders

## #1 Bill Gates

Real Time Net Worth As of 9/2/16

**$78.6 Billion**

2016 Billionaires Net Worth

**$75** Billion

**Cofounder, Bill & Melinda Gates Foundation**

| | |
|---|---|
| Age | 60 |
| Source Of Wealth | Microsoft, Self Made |
| Self-Made Score | 8 |
| Residence | Medina, WA |
| Citizenship | United States |
| Marital Status | Married |
| Children | 3 |
| Education | Drop Out, Harvard University |

**Bill Gates on Forbes Lists**

#1 Richest In Tech (2016)

#1 in 2015

The Richest Person In Every State (2016)

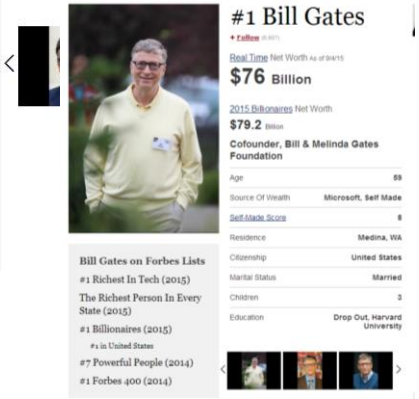
#1 Billionaires (2016)

#1 in United States

The Richest Person In America's 50 Largest Cities (2016)

#6 Powerful People (2015)

#1 Forbes 400 (2015)




## #40 Paul Allen

Real Time Net Worth As of 9/2/16

**$18.7 Billion**

2016 Billionaires Net Worth

**$17.5** Billion

| | |
|---|---|
| Age | 63 |
| Source Of Wealth | Microsoft, investments, Self Made |
| Self-Made Score | 8 |
| Residence | Mercer Island, WA |
| Citizenship | United States |
| Marital Status | Single |
| Education | Drop Out, Washington State University |

**Paul Allen on Forbes Lists**

#11 Richest In Tech (2016)

#12 in 2015

#40 Billionaires (2016)

#22 in United States

#26 Forbes 400 (2015)


From Forbes.com

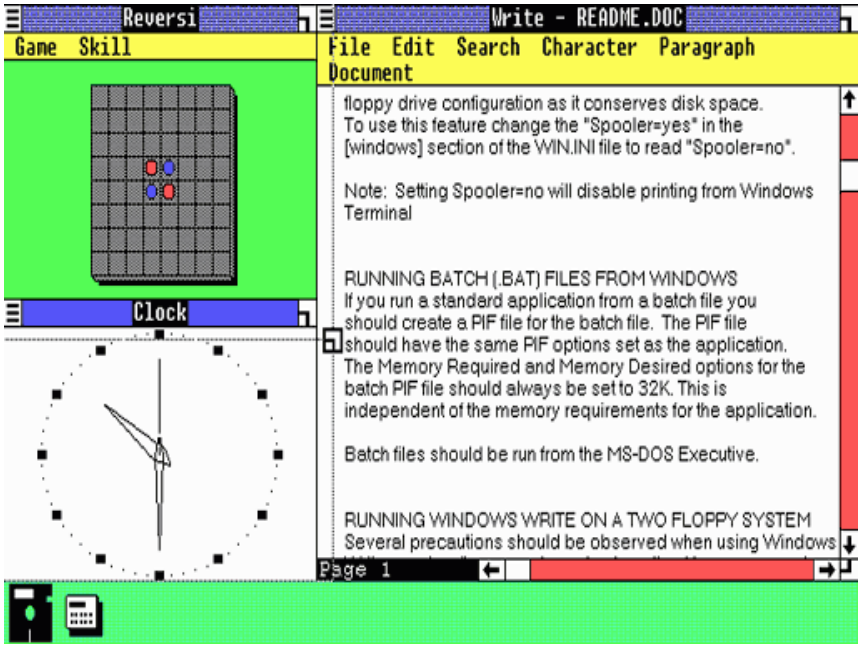
# Windows:
# Microsoft History

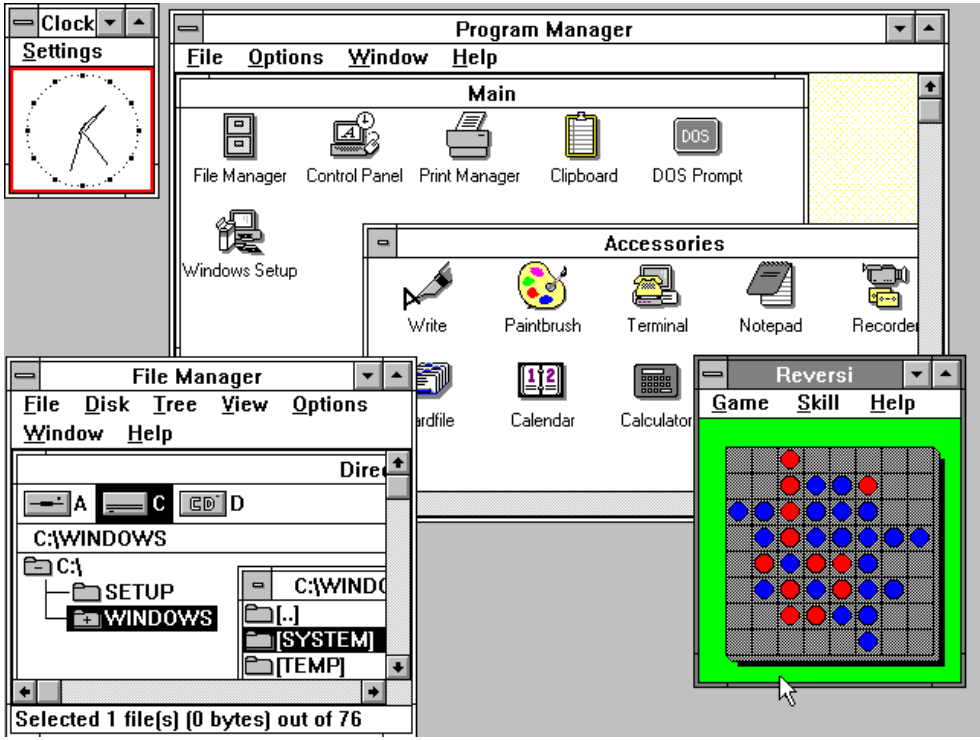
- Microsoft entered the OS business in 1980 with its own version of Unix, called Xenix.
- However, it was DOS (Disk Operating System) that solidified the company's dominance
  - After negotiations with Digital Research failed, IBM awarded a contract to Microsoft in November 1980 to provide a version of the CP/M OS, which was set to be used in the upcoming IBM Personal Computer (IBM PC)
  - For this deal, Microsoft purchased a CP/M clone called 86-DOS from Seattle Computer Products, branding it as MS-DOS, which IBM rebranded to PC-DOS
  - Following the release of the IBM PC in August 1981, Microsoft retained ownership of MS-DOS.


Xenix

# Windows:
# Microsoft History

- While jointly developing a new OS with IBM in 1984, OS/2, Microsoft released Microsoft Windows, a graphical extension for MS-DOS, on November 20



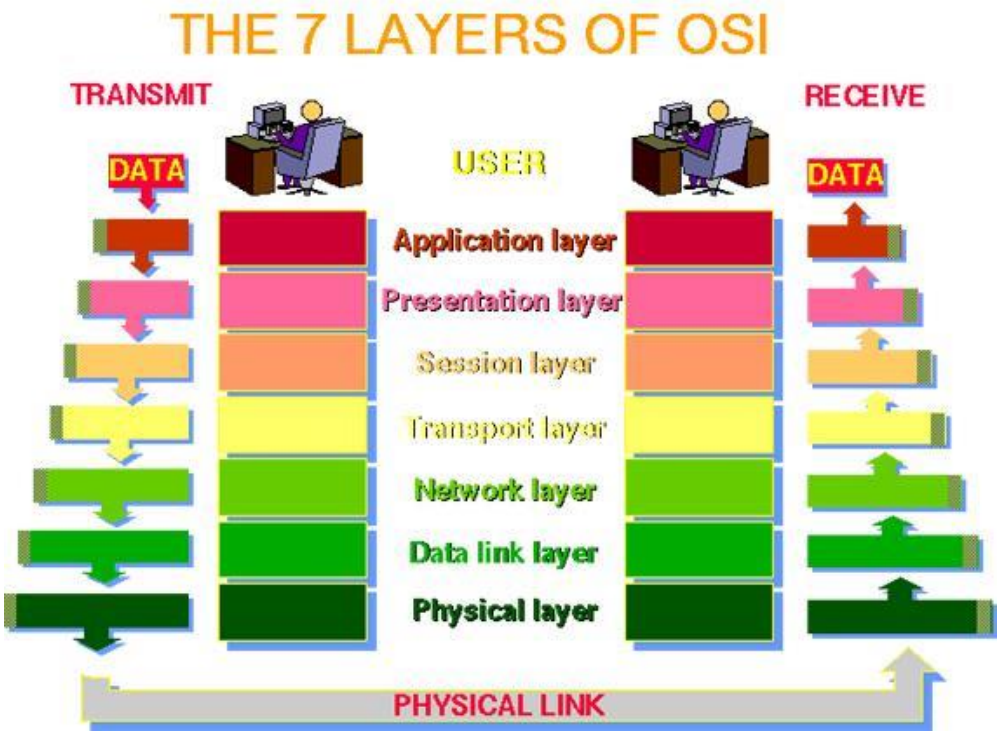



# Networks: TCP/IP

- TCP = Transmission Control Protocol
- IP = Internet Protocol
- Used for computer-to-computer communication across a network
- Most common computer communications protocol in the world
- To learn more: “TCP/IP Illustrated” by Richard Stevens

# Networks: OSI model

- OSI = Open Systems Interconnect
- Reference model for computer communications
- Model based on protocol layer, each layer has a small defined job to do to make the communications work

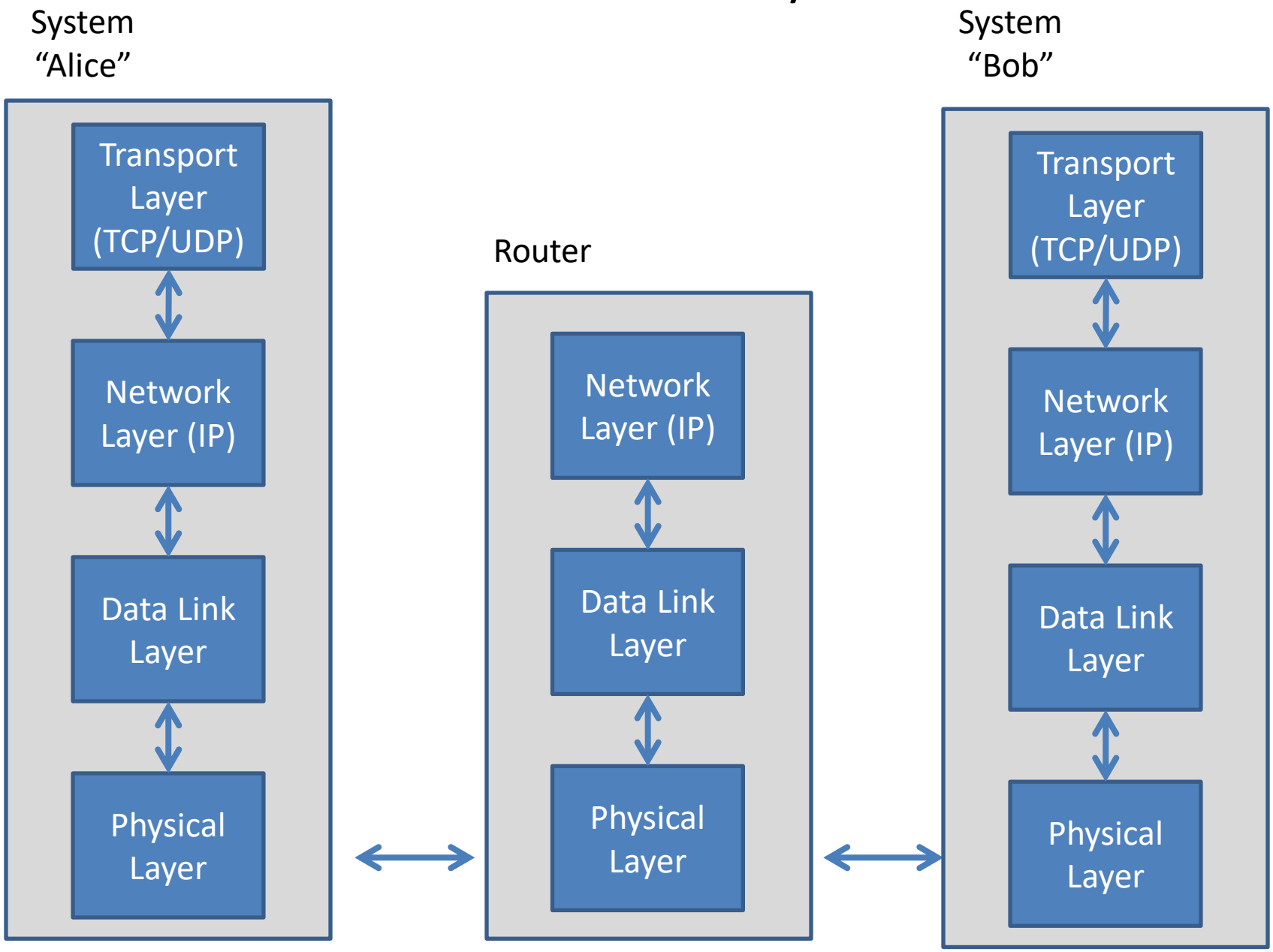



Source = http://www.petri.co.il/osi_concepts.htm

# Networks: OSI Layers

- Layer 7 = Application Layer: Acts as a window to the communications channel for the applications, interpreting data and turning it into meaningful information for the applications
- Layer 6 = Presentation Layer: How data elements are represented for transmission (order of bits & bytes, format of floating point numbers, etc)
- Layer 5 = Session Layer: Coordinates difference sessions between the communication machines. Initiating, maintaining, and managing sessions
- Layer 4 = Transport Layer: provides reliable communications stream between the two systems, handling packet ordering, retransmitting lost packets, providing error checking, etc.
- Layer 3 = Network Layer: moving data from source to target over networks, routers, switches, etc
- Layer 2 = Data Link Layer: moving data from one hop of the network
- Layer 1 = Physical Layer: actually transmits bit across the physical link (copper, fiber, wireless, etc)

# Networks: OSI Layers

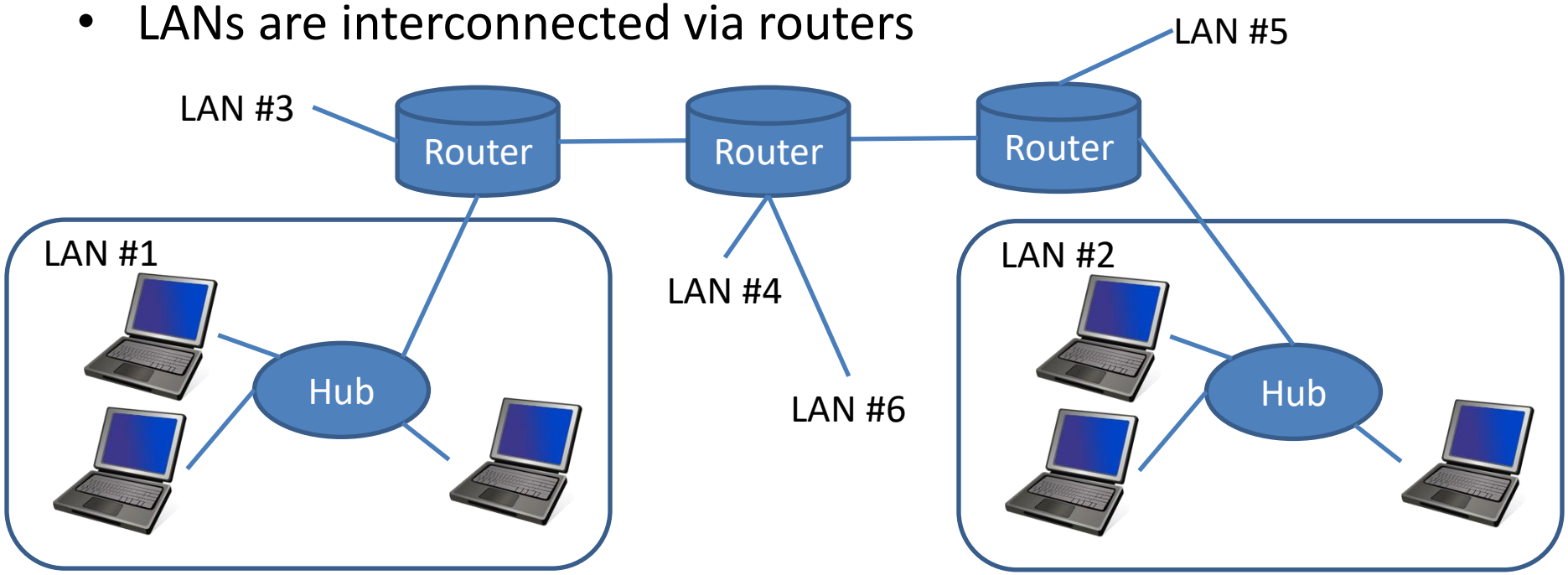


# Networks: TCP

- TCP: workhorse of the internet, used by many applications
  - Web Browsing via Hypertext transfer protocol (HTTP)
  - Secure shell (remote command prompt) via SSH
  - File Transfer via FTP
  - Email, via simple mail transfer protocol (SMTP) and Post Office Protocol (POP)
- Port:
  - Every TCP packet includes two port numbers: Source and destination
  - There are 2^16 (65,536) different TCP ports
  - Think of them as “doorways” into/out of TCP devices
  - Systems “listen” on Ports for data
    - An open port has an active listener running
    - A close post doesn’t have a listener running
  - Some examples (commonly assigned ports)
    - TCP Port 21 = FTP, TCP Port 80 = HTTP, TCP Port 25 = SMTP, etc

# Networks: IP

- Purpose of IP is to carry packets end to end across a network
- LAN = local area network
  - Computers connected via a hub, switch, or wireless access point (no routers)
- LANs are interconnected via routers



# Networks: IP Addresses

- IP addresses identify a particular machine on the network
- 32 bits for an “IPv4” address
- Usually written in “dotted-quad” notation:
  - 4 numbers between 0 and 255 seperated by periods
  - Some examples:
    - NVCC’s web server is 164.106.130.6
    - Google.com is 74.125.131.99
- IP address contains network address and host address on that particular network
  - Netmask defines how much of the address identifies the network and how much of the IP address identifies the host
- Every IP packet contains a source IP address and a destination IP address

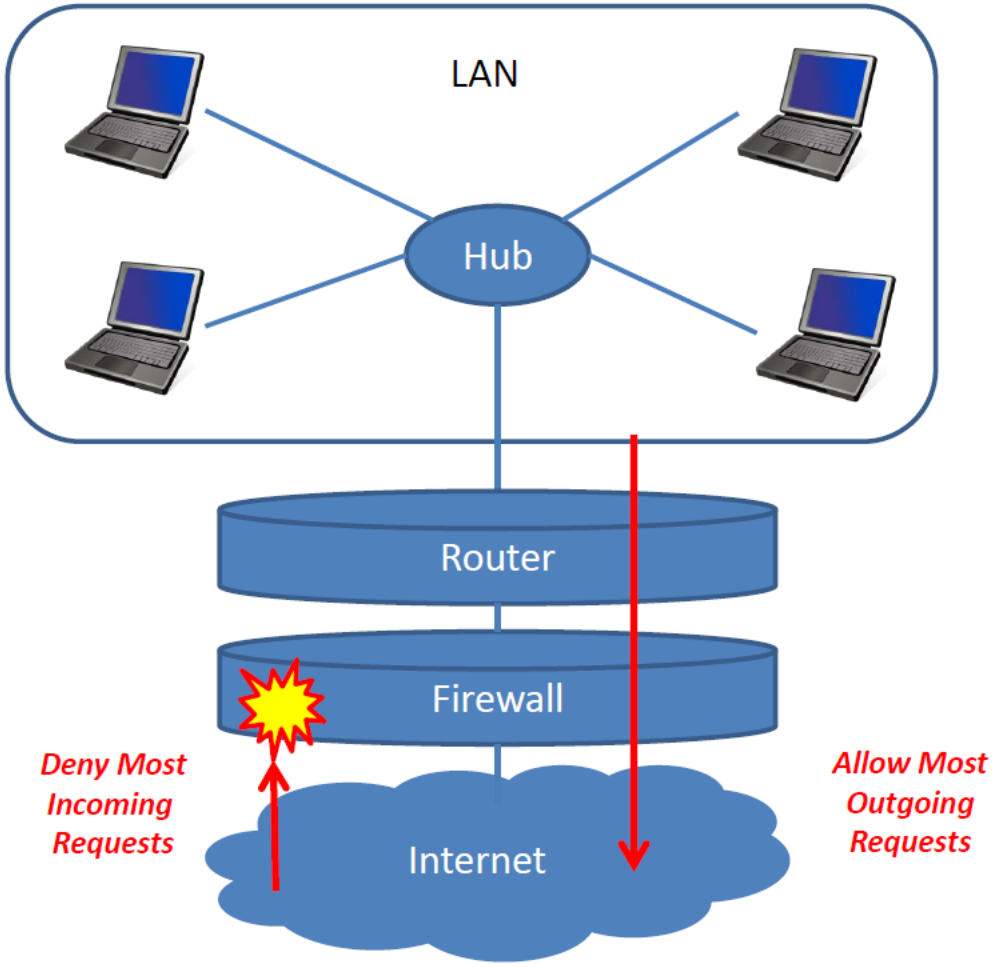
# Networks: Packet Fragmentation

- As IP data moves over the networks, it may be fragmented, or broken into smaller pieces.
- Packet size is optimized for the type of link:
  - High latency network (like satellite downlink) do better with longer packets
  - Low latency network (like cable modem) do better with smaller packets
- IP routers or firewalls can split packets smaller ones to improve performance
- IP must reassemble the smaller packets back into the larger one downstream.

# Networks: Firewalls

- Firewalls control the flow of traffic between networks
- They sit on the border between networks, acting as a gateway and making decisions about what traffic gets through and what gets stopped.
- Systems outside the network (good and bad) can access the network only in ways allowed by the firewall.
- Types of Firewalls:
  - Traditional Packet Filters (decision based on each packet's source/destination IP address, source/destination TCP/UDP port, TCP control bits, etc). Behavior programmed by filtering rules or Access Control Lists
  - Stateful Packet Filters: remembers earlier packets and uses this to help make decisions, maintains a state table for connections and drops packets that are invalid for the current state
  - Proxy Based Firewalls: Focus on the application data going through. For example, the y make sure that the incoming data is a properly formatted HTTP request instead of just checking that it is headed to the correct port.

# Networks: Firewalls



# Networks: ARP

- ARP = address resolution protocol
- Maps IP address to physical hardware's MAC address: http://en.wikipedia.org/wiki/MAC_address
- When a system has a packet to send, it sends out an ARP query, which is broadcast to all systems on the LAN.
- ARP query asks "who knows the MAC address of IP address w.x.y.z"
- Systems respond with the MAC address and the sender sends to that MAC and caches the mapping

# Networks: Hubs and Switches

- Hub and switches connect multiple computers together.
  - Hub = dumb, input from one interface is sent out to all systems
  - Switch = smarter
    - Listens to data and associates MAC addresses with individual links
    - Sends data only to the link with the destination address
    - Cuts down on traffic
  - See the GIF files on this page: http://www.directsystems.com/support/switchvshub.php