



# College of Information Studies

University of Maryland Hornbake Library Building College Park, MD 20742-4345

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# Computers

Week 1

LBSC 690

Information Technology

# Goals

- By the end of this class, you will...
  - Know what's in a computer
  - Understand what makes stupid computers seem smart
  - Have ways to think about “space,” “time” and “speed”

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## *A COMPUTER WANTED.*

WASHINGTON, May 1.—A civil service examination will be held May 18 in Washington, and, if necessary, in other cities, to secure eligibles for the position of computer in the Nautical Almanac Office, where two vacancies exist—one at \$1,000, the other at \$1,400..

The examination will include the subjects of algebra, geometry, trigonometry, and astronomy. Application blanks may be obtained of the United States Civil Service Commission.

*The New York Times*

Published: May 2, 1892

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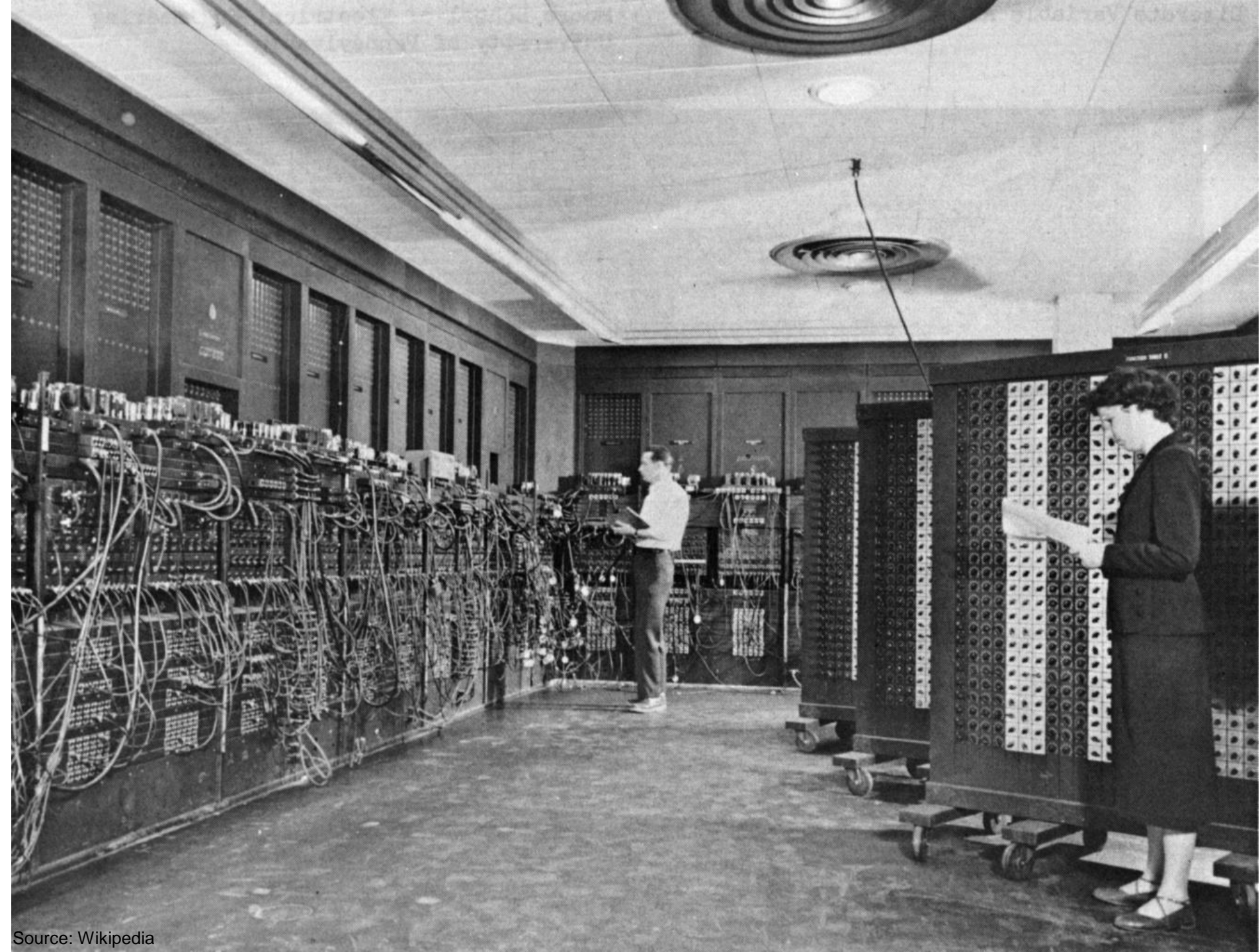
# A Very Brief History of Computing

- Hardware
  - Mechanical: essentially a big adding machine
  - Analog: designed for calculus, limited accuracy
  - Digital: early machines filled a room
  - Microchips: designed for missile guidance
- Software
  - Numeric: computing gun angles
  - Symbolic: code-breaking

# Commercial Developments

- Mainframes (1960's)
  - IBM
- Minicomputers(1970's)
  - DEC
- Personal computers (1980's)
  - Apple, Microsoft
- Networks (1990's)
  - Web
- Convergence (2000's)
  - Cell phone/PDA, HDTV/Computer, ...





Source: Wikipedia



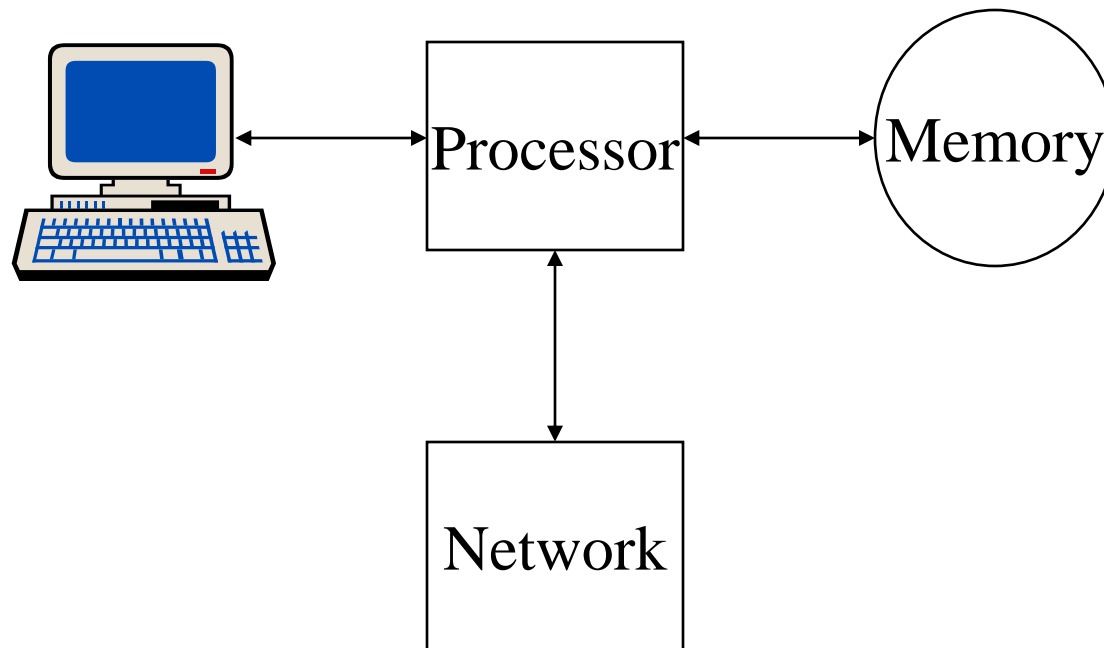
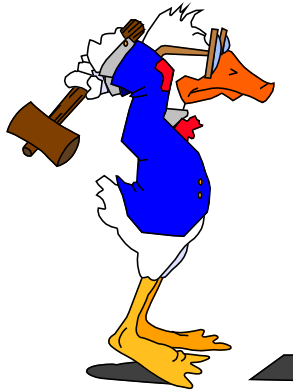








# The Big Picture



# Binary Data Representation

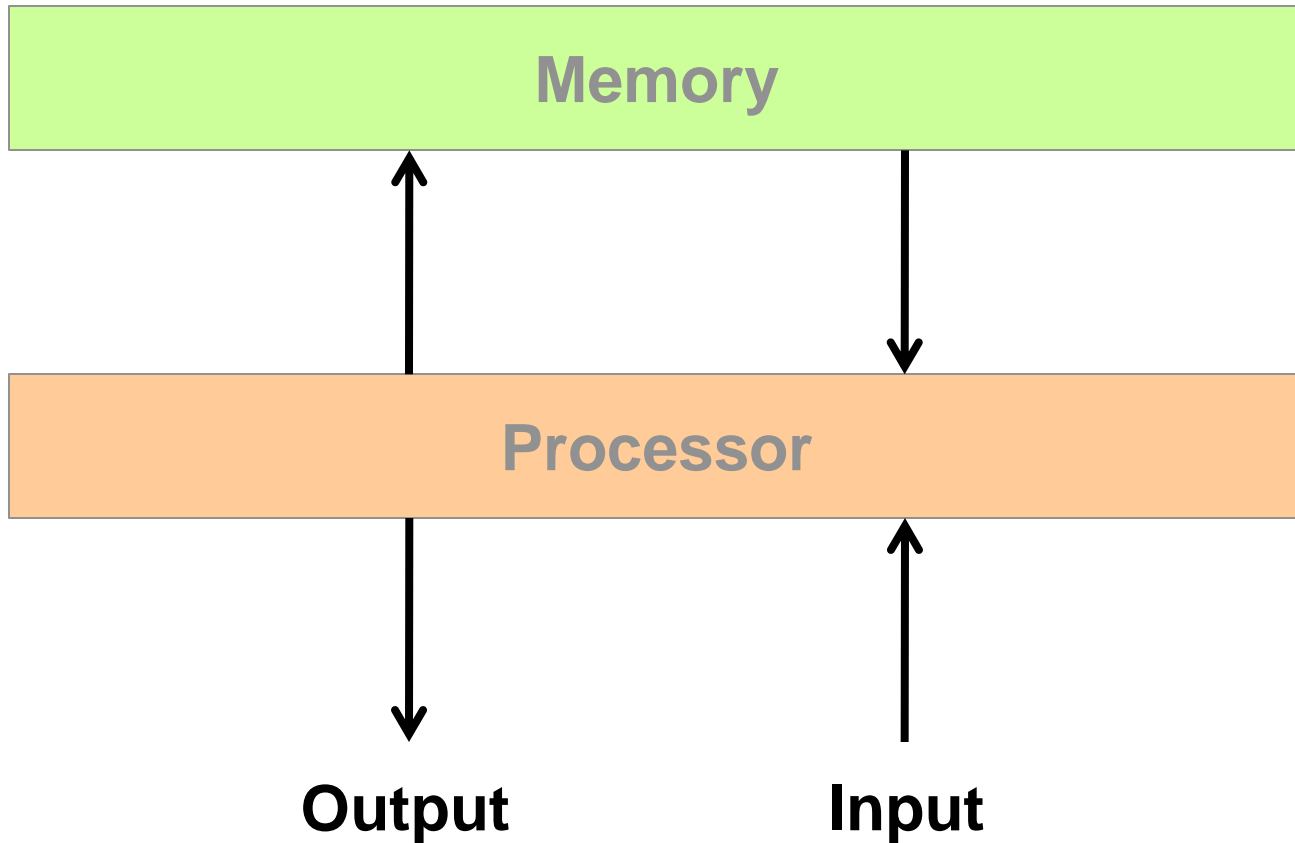
**Example: American Standard Code for Information Interchange (ASCII)**

01000001 = A	01100001 = a
01000010 = B	01100010 = b
01000011 = C	01100011 = c
01000100 = D	01100100 = d
01000101 = E	01100101 = e
01000110 = F	01100110 = f
01000111 = G	01100111 = g
01001000 = H	01101000 = h
01001001 = I	01101001 = i
01001010 = J	01101010 = j
01001011 = K	01101011 = k
01001100 = L	01101100 = l
01001101 = M	01101101 = m
01001110 = N	01101110 = n
01001111 = O	01101111 = o
01010000 = P	01110000 = p
01010001 = Q	01110001 = q
...	...

# Hardware Processing Cycle

- Input comes from somewhere
  - Keyboard, mouse, microphone, camera, ...
- The system does something with it
  - Processor, memory, software, network, ...
- Output goes somewhere
  - Monitor, speaker, robot controls, ...

# What is a computer?



# Computer Hardware

- Central Processing Unit (CPU)
  - Intel Xeon, Motorola Power PC, ...
- Communications “Bus”
  - FSB, PCI, ISA, USB, Firewire, ...
- Storage devices
  - Cache, RAM, hard drive, floppy disk, ...
- External communications
  - Modem, Ethernet, GPRS, 802.11, ...







**What's that?**

# Units of Frequency

<b>Unit</b>	<b>Abbreviation</b>	<b>Operations per second</b>
hertz	Hz	1
kilohertz	KHz	$10^3 = 1,000$
megahertz	MHz	$10^6 = 1,000,000$
gigahertz	GHz	$10^9 = 1,000,000,000$

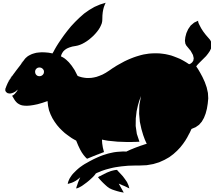
# Units of Time

<b>Unit</b>	<b>Abbreviation</b>	<b>Duration (seconds)</b>
second	sec/s	1
millisecond	ms	$10^{-3} = 1/1,000$
microsecond	$\mu\text{s}$	$10^{-6} = 1/1,000,000$
nanosecond	ns	$10^{-9} = 1/1,000,000,000$
picosecond	ps	$10^{-12} = 1/1,000,000,000,000$
femtosecond	fs	$10^{-15} = 1/1,000,000,000,000,000$

# The Storage Hierarchy

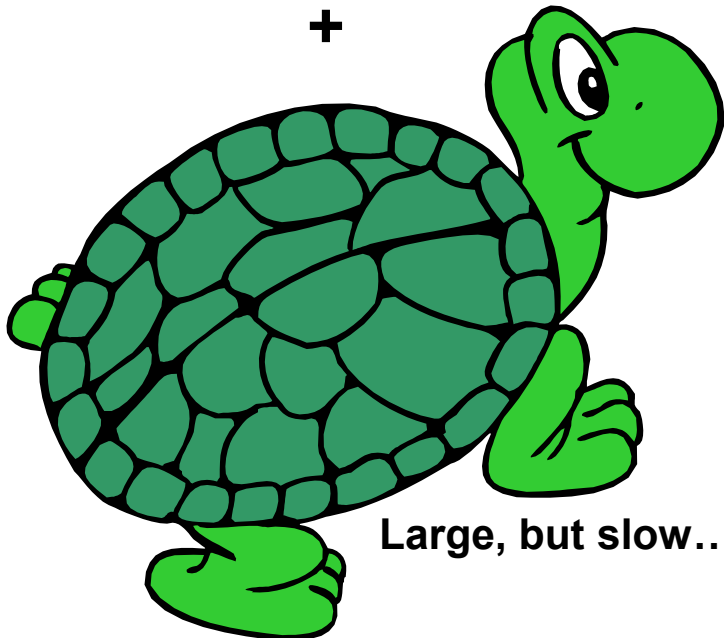
- Speed, cost, and size:
  - You can easily get any 2, but not all 3
- Fast memory is expensive
  - So large memory is slow!
  - But fast access to large memories is needed
- Solution:
  - Keep what you need often in small (fast) places
    - Keep the rest in large (slow) places
  - Get things to the fast place before you need them

# Best of Both Worlds



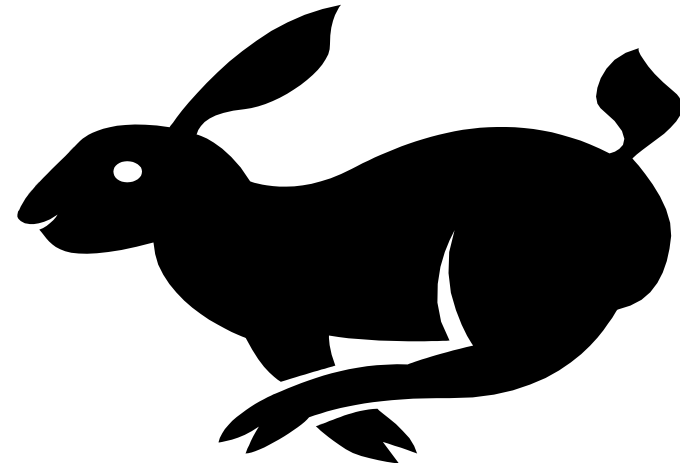
Small, but fast...

+



Large, but slow...

=



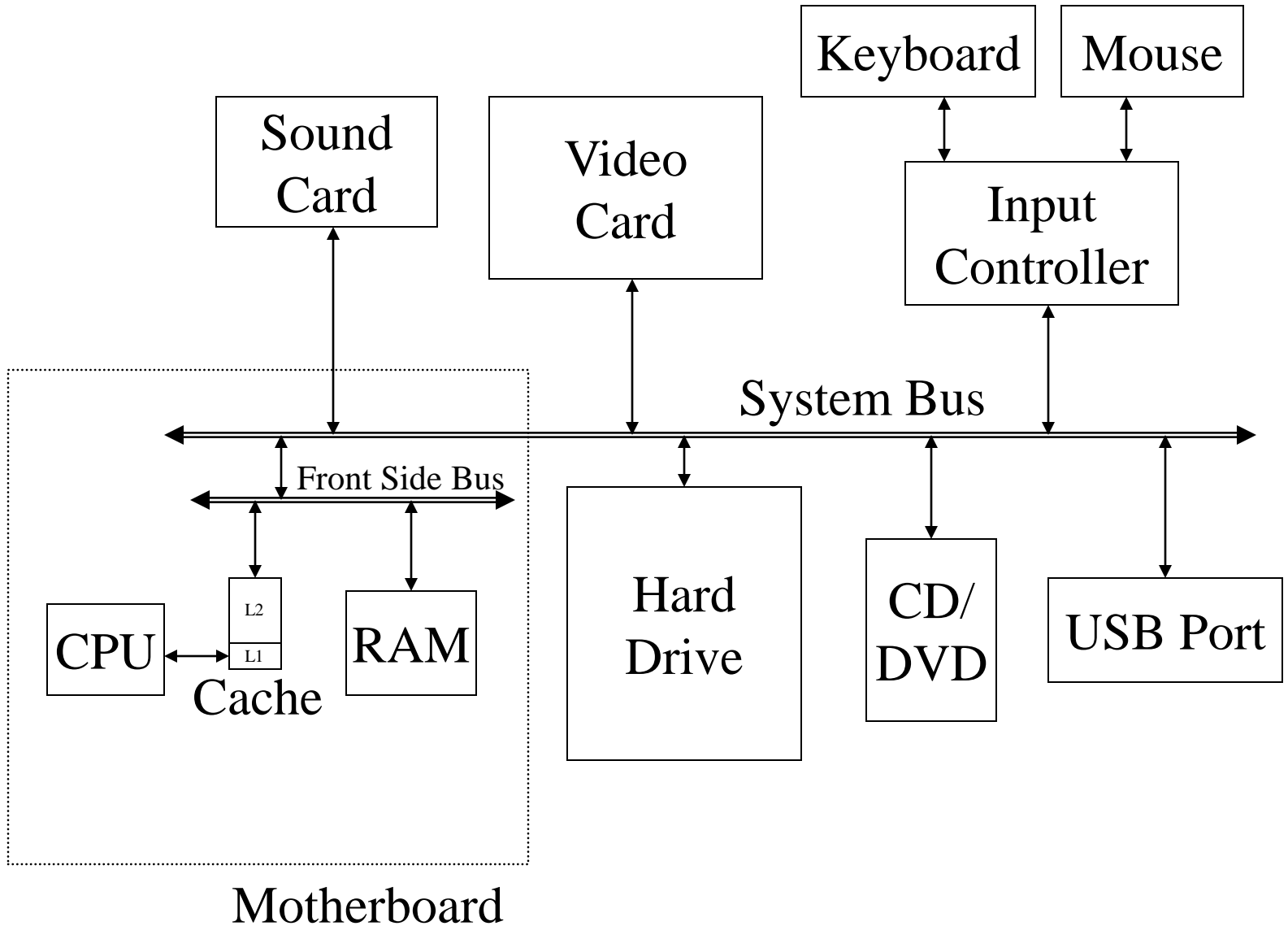
Is Large and seems fast

Think about your bookshelf and the library...

# Locality

- **Spatial locality:**
  - If the system fetched  $x$ , it is likely to fetch data located near  $x$
- **Temporal locality:**
  - If the system fetched  $x$ , it is likely to fetch  $x$  again

# System Architecture





# Everything is Relative

- The CPU is the fastest part of a computer
  - 3 GHz Core 2 Duo = 6,000 MIPS
    - 3 operations per processor every nanosecond
- Cache memory is fast enough to keep up
  - 128 kB L1 cache on chip (dedicated, CPU speed)
  - 4 MB L2 cache on chip (shared, CPU speed)
- RAM is larger, but slower
  - 1 GB or more, ~6 ns

# Units of Size

<b>Unit</b>	<b>Abbreviation</b>	<b>Size (bytes)</b>
bit	b	1/8
byte	B	1
kilobyte	KB	$2^{10} = 1024$
megabyte	MB	$2^{20} = 1,048,576$
gigabyte	GB	$2^{30} = 1,073,741,824$
terabyte	TB	$2^{40} = 1,099,511,627,776$
petabyte	PB	$2^{50} = 1,125,899,906,842,624$

# The Storage Hierarchy

<b>Type</b>	<b>Speed</b>	<b>Size</b>	<b>Cost</b>
Registers	~300 ps	256 B	Very expensive
Cache	~1 ns	4 MB	Expensive
RAM	~10 ns	1 GB	Cheap
Hard drive	~10 ms	1 TB	Very cheap

# “Solid-State” Memory

- ROM
  - Does not require power to retain content
  - Used for “Basic Input/Output System” (BIOS)
- Cache (Fast low-power “Static” RAM)
  - Level 1 (L1) cache: small, single-purpose
  - Level 2 (L2) cache: larger, shared
- (“Dynamic”) RAM (Slower, power hungry)
  - Reached over the “Front-Side Bus” (FSB)
- Flash memory (fast read, slow write EEPROM)
  - Reached over USB bus or SD socket
  - Used in memory sticks (“non-volatile” storage)



**elixir**  
M2U51264DS8HC3G-5T  
512MB DDR-400MHz-CL3  
PC3200U-30331  
Warranty Void If Removed  
0542.MN05A1107A.5YM0410N08.XX.CN

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# “Rotating” Memory

- Fixed magnetic disk (“hard drive”)
  - May be partitioned into multiple volumes
    - In Windows, referred to as C:, D:, E:, ...
    - In Unix, referred to as /software, /homes, /mail, ...
- Removable magnetic disk
  - Floppy disk, zip drives, ...
- Removal optical disk
  - CDROM, DVD, CD-R, CD-RW, DVD+RW, ...

# How Disks Work

## Step 1:

The circuit board controls the movement of the head actuator and a small motor.

## Step 2:

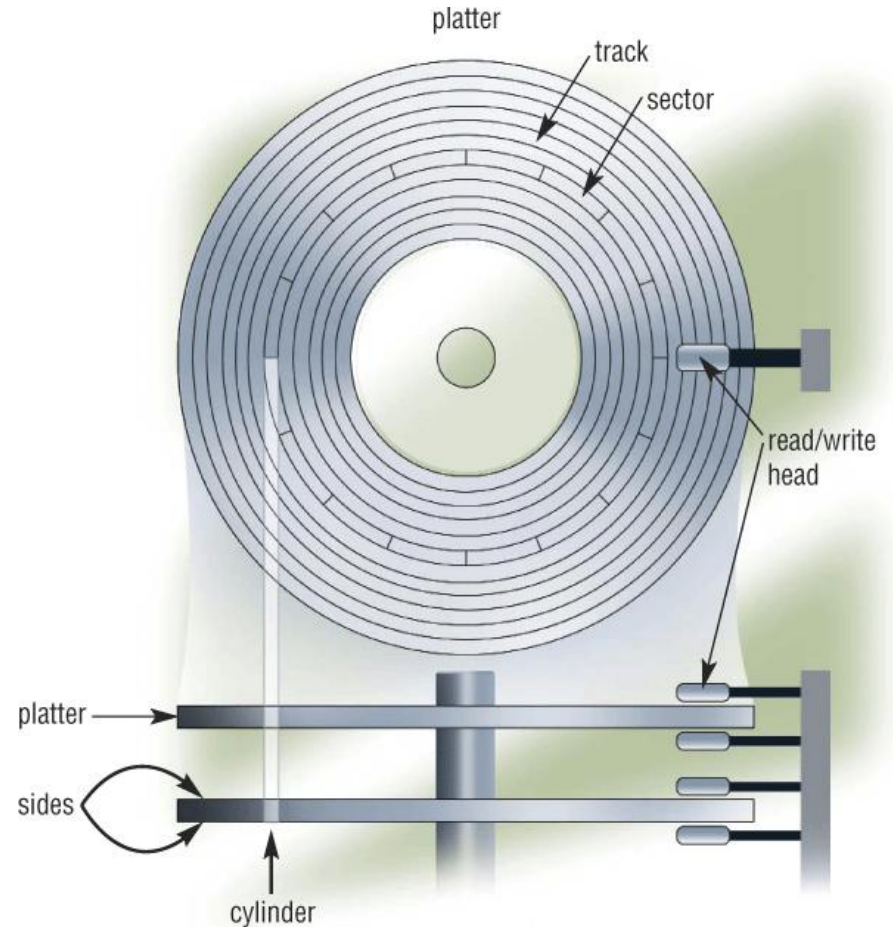
A small motor spins the platters while the computer is running.

## Step 3:

When software requests a disk access, the read/write heads determine the current or new location of the data.

## Step 4:

The head actuator positions the read/write head arms over the correct location on the platters to read or write data.



# Trading Speed for Space

- Hard disk is larger than RAM but much slower
  - typical: 10 ms access time, 100 GB (at 5400 rpm)
    - One thousand times larger than RAM
    - 10 million times slower than the CPU!
- The initial access is the slow part
  - Subsequent bytes sent at 17 MB/sec (60 ns/byte)
- As “virtual memory,” makes RAM seem larger
  - But too little physical RAM results in “thrashing”

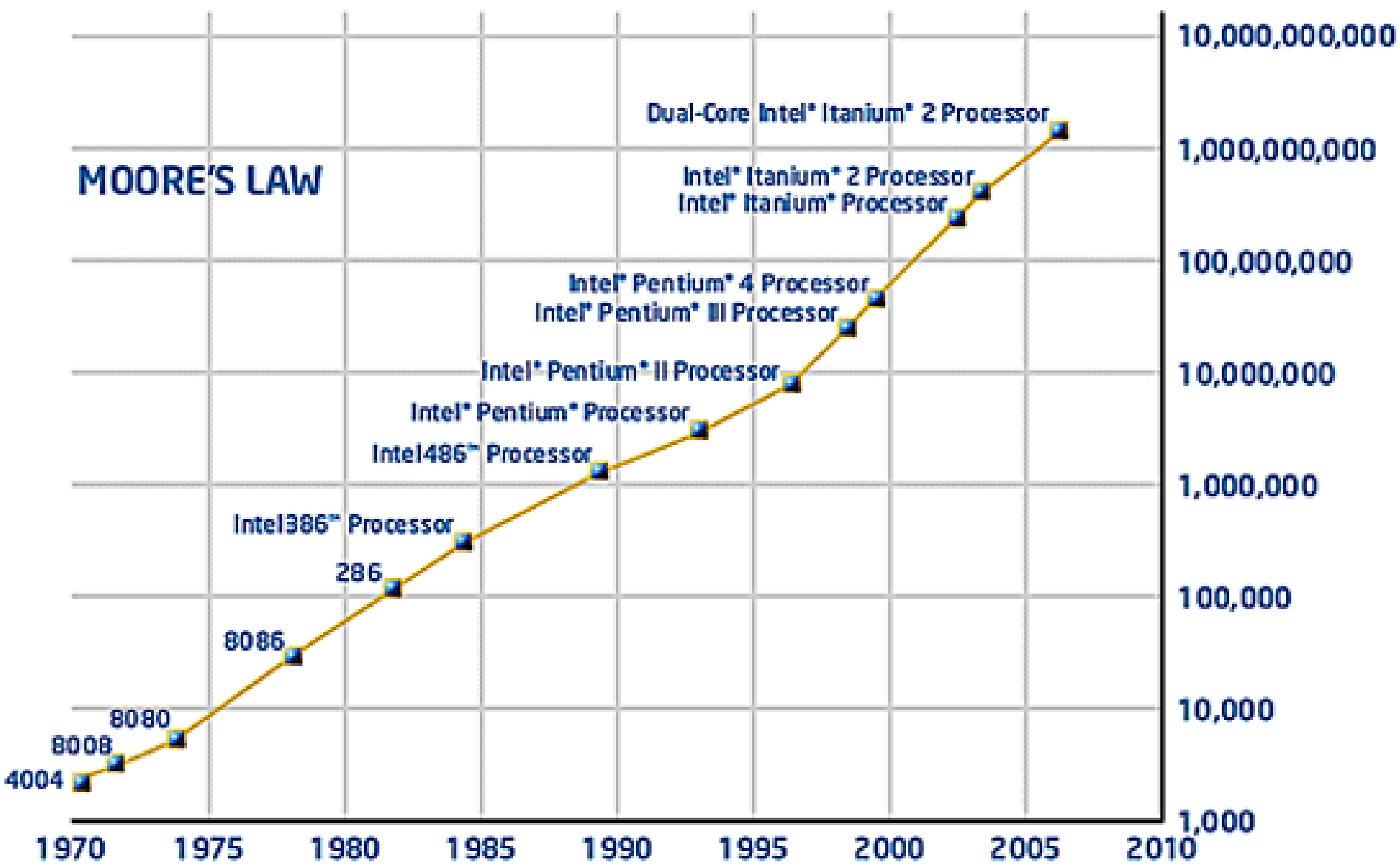


# Breaks

- Typically, two breaks
  - 10 minute break after the first hour
  - 5 minute break after the second hour

transistors

# MOORE'S LAW



# Discussion Point: Moore's Law

- Processing speed doubles every 18 months
  - Faster CPU, longer words, larger cache, more cores
- Cost/bit for RAM drops 50% every 12 months
  - Less need for “virtual memory”
- Cost/bit for disk drops 50% every 12 months
  - But transfer rates don't improve much
- Why????

# Parallel Processing



**More “cores” (CPU’s) = more computation**

# Parallel Storage

- Disks can fail in two ways:
  - Bad sectors (data sectors, directory sectors)
  - Mechanical failure
- RAID-5 arrays “stripe” blocks across disks
  - Faster parallel data transfer
  - ~30% “parity” allows “hot swap”
    - Continuity of operations in the event of a disk failure
    - Automatic reconstruction of any one failed disk’s contents

# Tape Backup

- Tapes store data sequentially
  - Very fast transfer, but not “random access”
- Used as backup storage for fixed disks
  - Weekly incremental backup is a good idea
    - With a complete (“level zero”) monthly backup
- Used for archival storage
  - Higher data density than DVD’s

# Discussion Point: Migration

- What format should old tapes be converted to?
  - Newer tape
  - CD
  - DVD
- How often must we “refresh” these media?
- How can we afford this?

# Course Goals

- Conceptual
  - Understand computers and networks
  - Appreciate the effects of design tradeoffs
  - Evaluate the role of information technology
- Practical
  - Learn to use some common tools
  - Solve a practical problem
  - Develop a personal plan for further study



# Some Motivating Questions

- What are the technical implications for:
  - Privacy?
  - Copyright?
- How will digital repositories develop?
  - How will they interact with distance education?
  - What are the implications for archives?
- How might digital interaction impact:
  - Roles of authors, publishers, and readers?
  - Access by disadvantaged populations?

# Some iSchool Courses on IT

- LBSC

- 607: E-Government
- 683: Electronic Records
- 708X: E-Discovery
- 784: Digital Preservation

- INFM

- 741: Social Computing
- 743: Internet Applications

- INST

- 630: Programming
- 631: HCI Fundamentals
- 733: Database Design
- 715: Knowledge Management
- 734: Information Retrieval
- 736: Computational Linguistics
- 737: Digging into Data

# Instructional Staff

- Professor: Dr. Doug Oard
  - Offices: HBK 2119F/AVW 3145
  - Email: [oard@umd.edu](mailto:oard@umd.edu) (finds me anywhere)

# Approach

- Readings
  - Provide background and detail
- “Socratic” sessions
  - Provide conceptual structure
- “Practicum” sessions, homework, project
  - Provide hands-on experience
- Quiz, exams
  - Measure progress

# The Grand Plan

Computers

Databases

Networks

Access/SQL

Web Design

Search Engines

HTML/CSS

Programming

Quiz

CMS

ILS/DAMS

Midterm

Joomla

Info Mngmt

Project

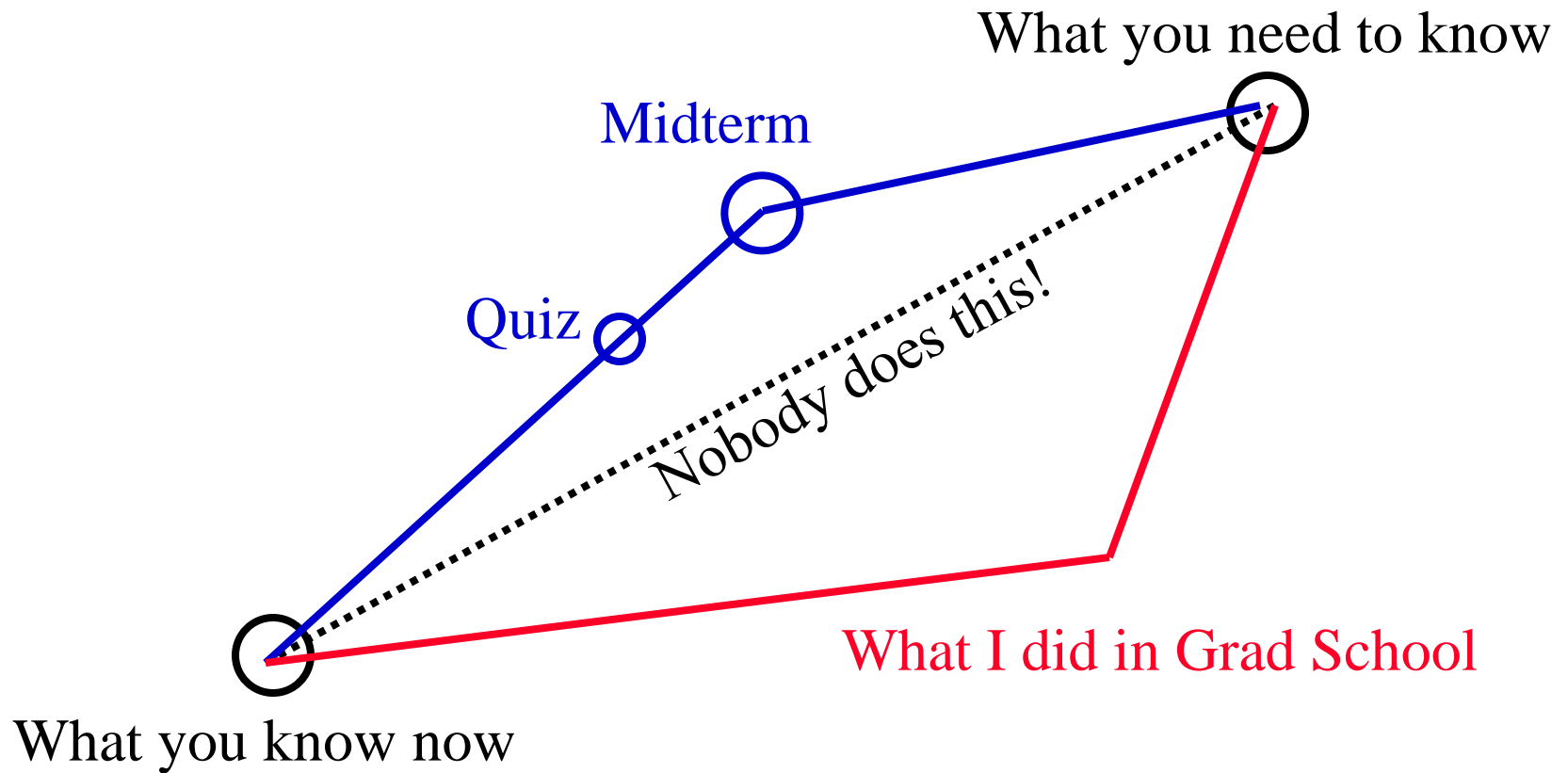
Info Mngmt

Final

# A Personal Approach to Learning

- Work ahead, so that you are never behind
- Find new questions everywhere
  - Then find the answers somewhere
- Enrich your practical skills relentlessly
- Pick topics you want to learn more about
- Start thinking about your project soon
  - Find partners with complementary skills

# Getting From Here to There



# Grading

- 35-38% individual work
  - Exams: 25% for the best, 10% for the other
- 12-15% your choice (individual or group)
  - 3% each for best 5 of the 6 homework/quiz
- 40% working in 3-person project teams
- 10% for demonstrated thought leadership
  - In class, on the mailing list, in your groups



# Some Observations on Grading

- One exam is worth more than all the homework
  - Message: Use the homework to learn the material
- Midterm grades predict final grades well
  - Message: Develop sound study skills early
- You need not be good at everything to get an A
  - But you do need to be excellent at several things

# The Fine Print

- Group work is encouraged on homework
  - But you must personally write what you turn in
- Deadlines are firm and sharp
  - Allowances for individual circumstances are included in the grading computation
- Academic integrity is a serious matter
  - No group work during the exams or the quiz!
  - Scrupulously respect time limits

# Course Materials

- Textbook
- Readings
- Videos
- Daily access to a networked computer!

# Computing at Maryland

- Computer Labs
  - HBK 2018 (posted hours)
  - PG2 Open Workstation Lab (24 hours)
  - Need an OIT “LPCR” account for printing
- WAM
  - Web server and Web space

# Homework Goals

- Think about relative speed and relative size
- Interpret specifications for computer systems
- Try some “back of the envelope” calculations
- Some helpful hints:
  - Use a spreadsheet!

# Team Exercise

- Form into groups of 4
  - Be sure you have someone who has used Excel before in your group
- Answer question 1(d) from the Fall 1996 final exam (available on the course Web site)

# Before You Go

On a sheet of paper, answer the following (ungraded) question (no names, please):

What was the muddiest point in today's class?

# Get-Ahead Slides



# Network

- Computers and devices connected via
  - Communication devices
  - Transmission media



# Why Network?

- Sharing data
- Sharing information
- Sharing hardware
- Sharing software
- Increasing robustness
- Facilitating communications
- Facilitating commerce

# Packet vs. Circuit Networks

- Telephone system (“circuit-switched”)
  - Fixed connection between caller and called
  - High network load results in busy signals
- Internet (“packet-switched”)
  - Each transmission is routed separately
  - High network load results in long delays

# Packet Switching

- Break long messages into short “packets”
  - Keeps one user from hogging a line
- Route each packet separately
  - Number them for easy reconstruction
- Request retransmission for lost packets
  - Unless the first packet is lost!

# Networks of Networks

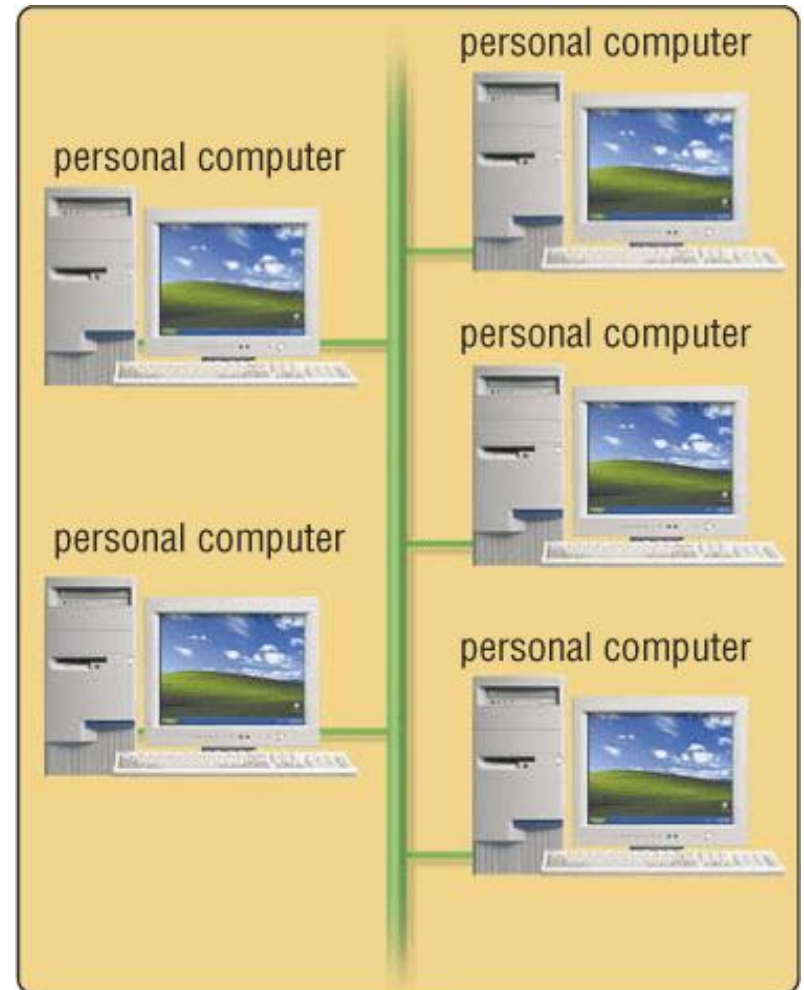
- Local Area Networks (LAN)
  - Connections within a room, or perhaps a building
- Wide Area Networks (WAN)
  - Provide connections between LANs
- Internet
  - Collection of WANs across multiple organizations

# Local Area Networks

- Within a campus or an office complex
  - Short-distance lines are **fast** and **cheap**
  - Fast communications makes routing simple
- Ethernet is a common LAN technology
  - All computers are connected to the same cable
    - Ordinary phone lines can carry 10 Mb/sec
    - 100 Mb/s connections require special cables
    - 1 Gb/s connections require special switches
  - Every host broadcasts everything to all others
    - Collisions limit throughput to about 50% utilization

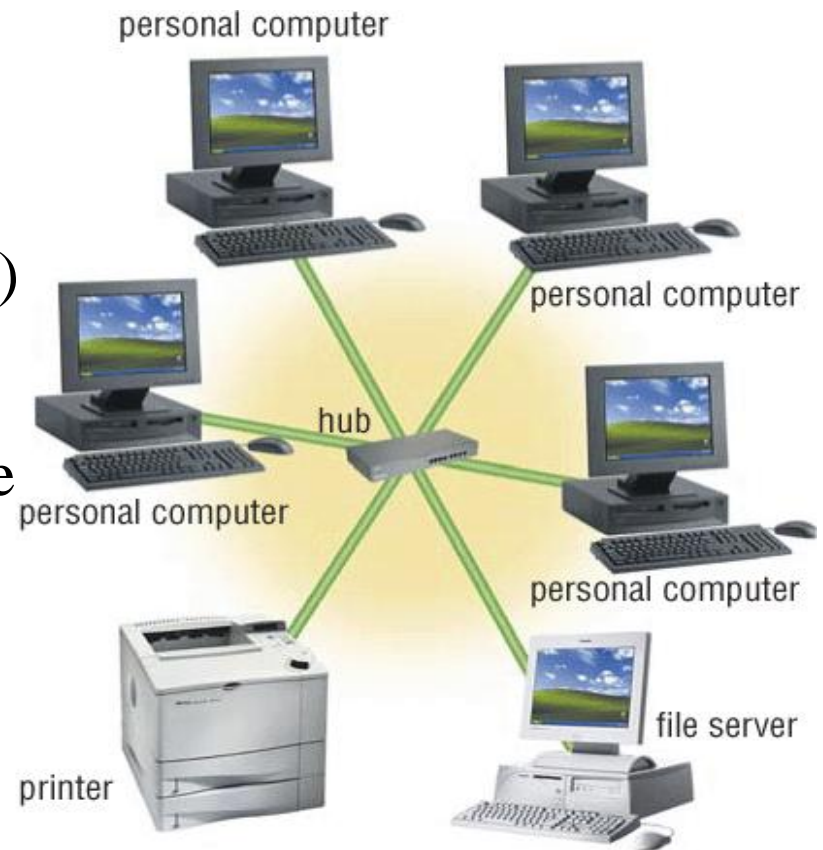
# Shared Network

- All attach to the same cable
  - Ethernet and “cable modems”
- Transmit anytime
  - Collision detection
  - Automatic retransmission
- Inexpensive and flexible
  - Easy to add new machines
  - Robust to computer failure
- Practical for short distances
  - Half the bandwidth is wasted



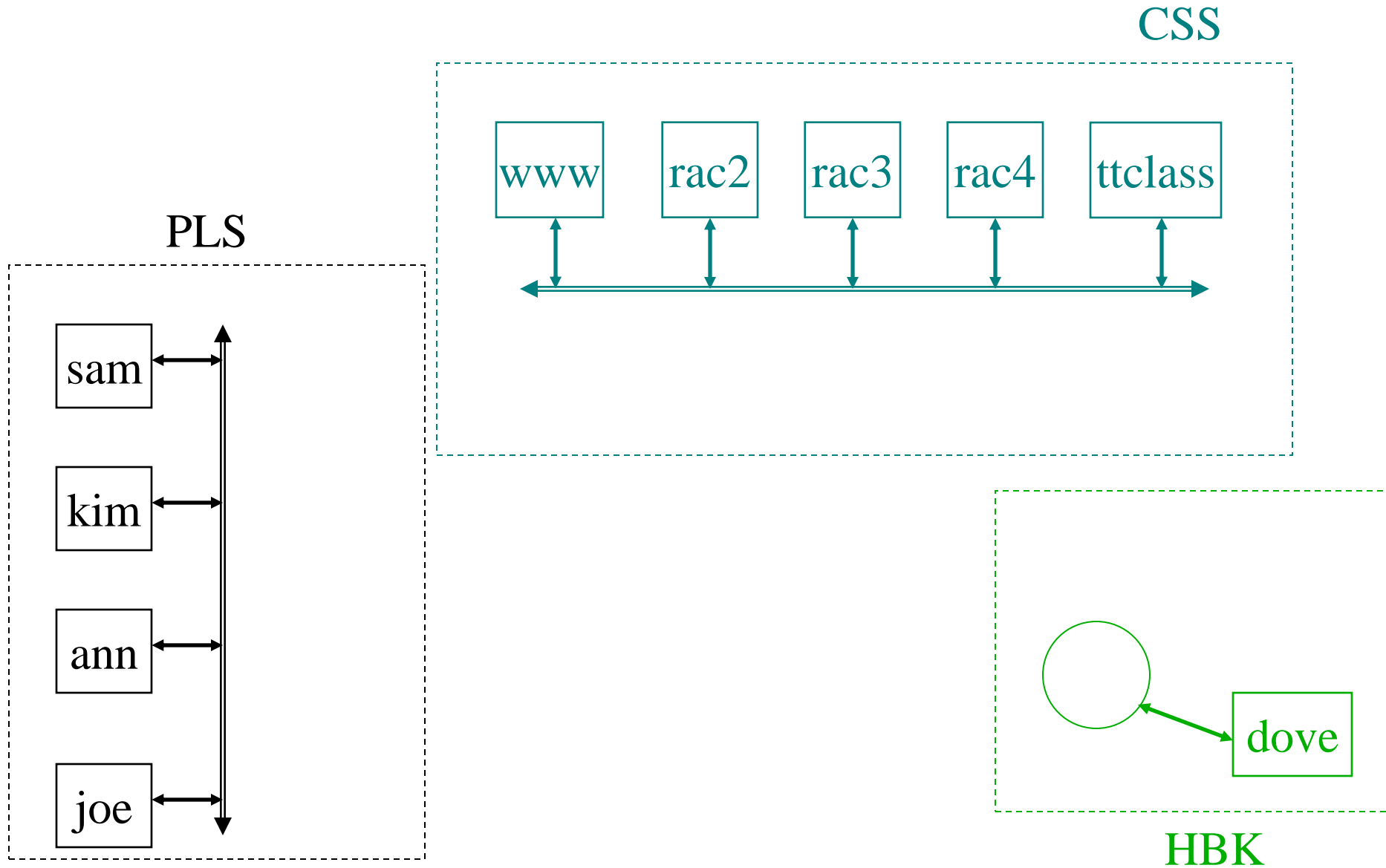
# Switched (“Star”) Network

- All attach directly to a hub
  - Switched Ethernet
  - Digital Subscriber Lines (DSL)
- Higher cost
  - Line from hub to each machine
  - Hub must handle every packet
  - Hub requires backup power
- Much higher bandwidth
  - No sharing, no collisions
  - Allows disks to be centralized





# Local Area Networks



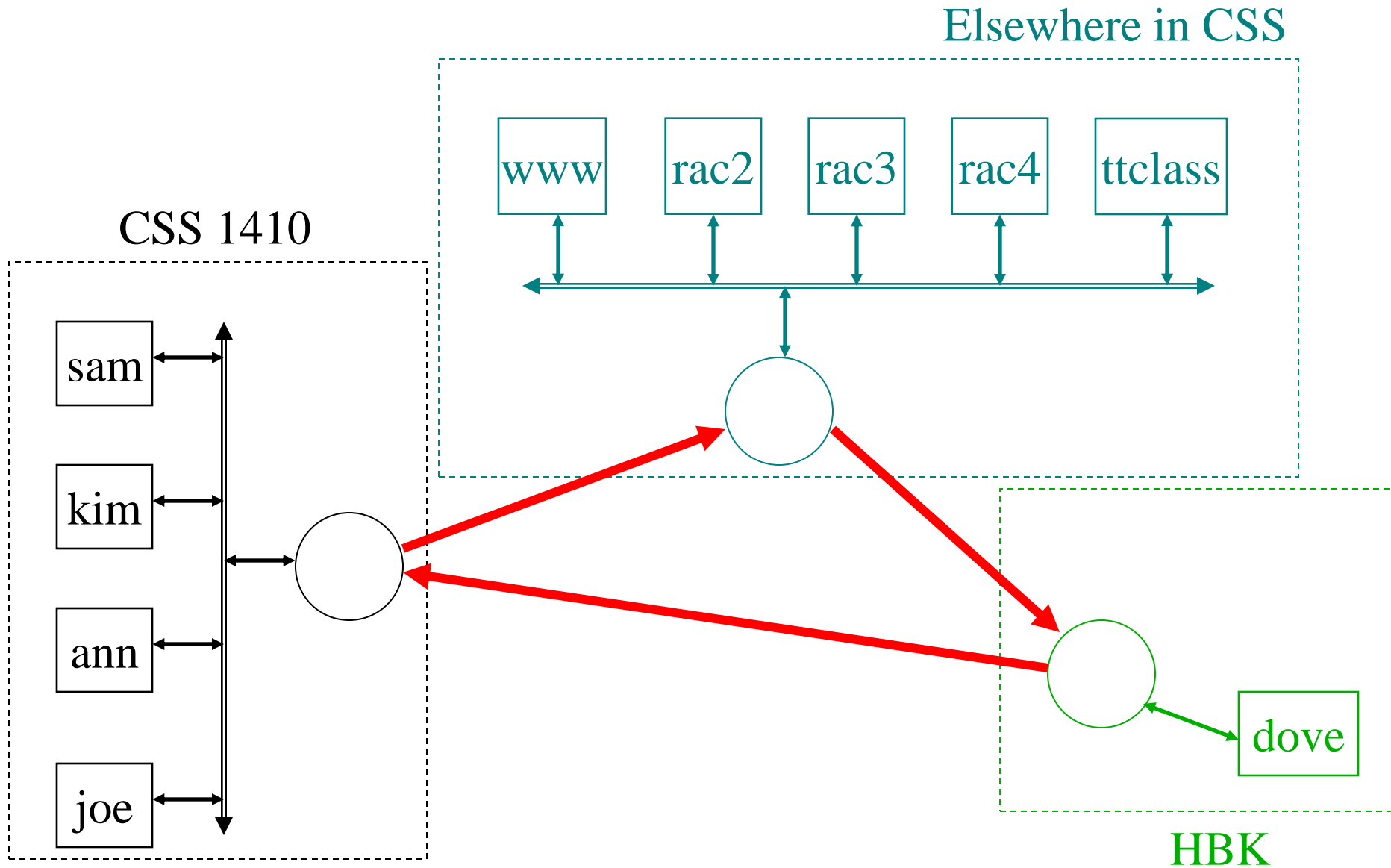
# Wireless Networks

- Radio-based Ethernet
  - Effective for a few rooms within buildings
- “Access Point” gateways to wired networks
  - Available throughout most of the Maryland campus
  - Commercial providers offer “hot spots” in airports, etc.
- “WiFi WLAN” is available in several speeds
  - IEEE 802.11b: 10Mb/s (good enough for most uses)
  - IEEE 802.11g: 54Mb/s (required for wireless video)
  - IEEE 802.11n: 248Mb/s (and longer range)
- Computer-to-computer networks are also possible
  - “Bluetooth” is the most common (very short range)

# Wide Area Networks

- Campus, regional, national, or global scale
- Expensive communications must be used well
  - Limiting to two hosts allows 100% utilization
- Routing is complex with point-to-point circuits
  - Which path is shortest? Which is least busy? ...

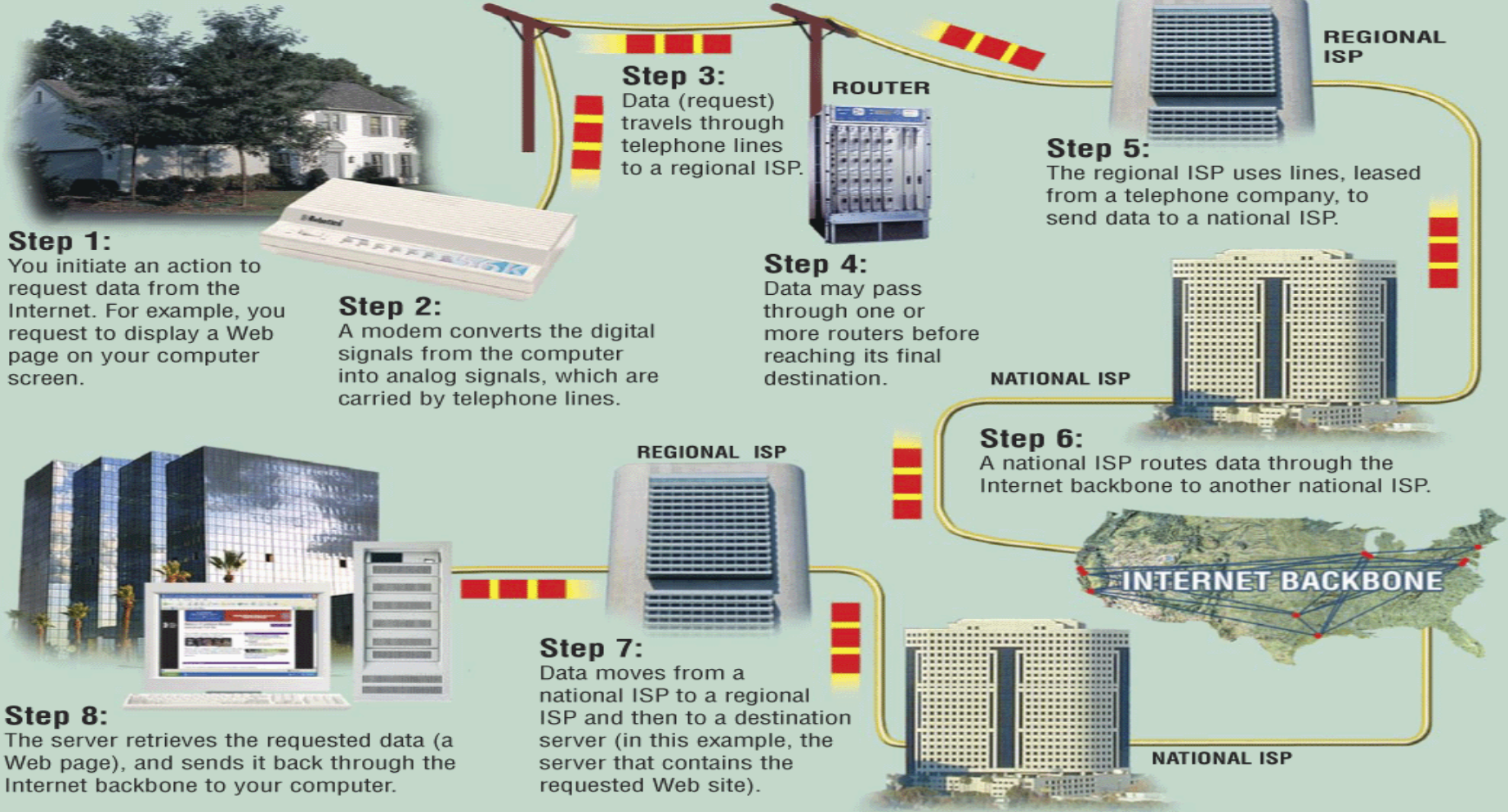
# Maryland's Campus Network



# The Internet

- Global collection of public “IP” networks
  - Private networks are often called “intranets”
- Independent
  - Each organization maintains its own network
- Cooperating
  - Internet Protocol (IP) address blocks
  - Domain names
  - World-Wide Web Consortium (W3C)
  - Computer Emergency Response Team (CERT)

# Overview



# A Short History of the Internet

- 1969: Origins in government research
  - Advanced Research Projects Agency (ARPAnet)
  - Key standards: UDP, TCP, DNS
- 1983: Design adopted by other agencies
  - Created a need for inter-network connections
  - Key standards: IP
- 1991: World-Wide Web added point-and-click
  - Now 150 million Internet “hosts”
  - Key standards: HTTP, URL, HTML, XML

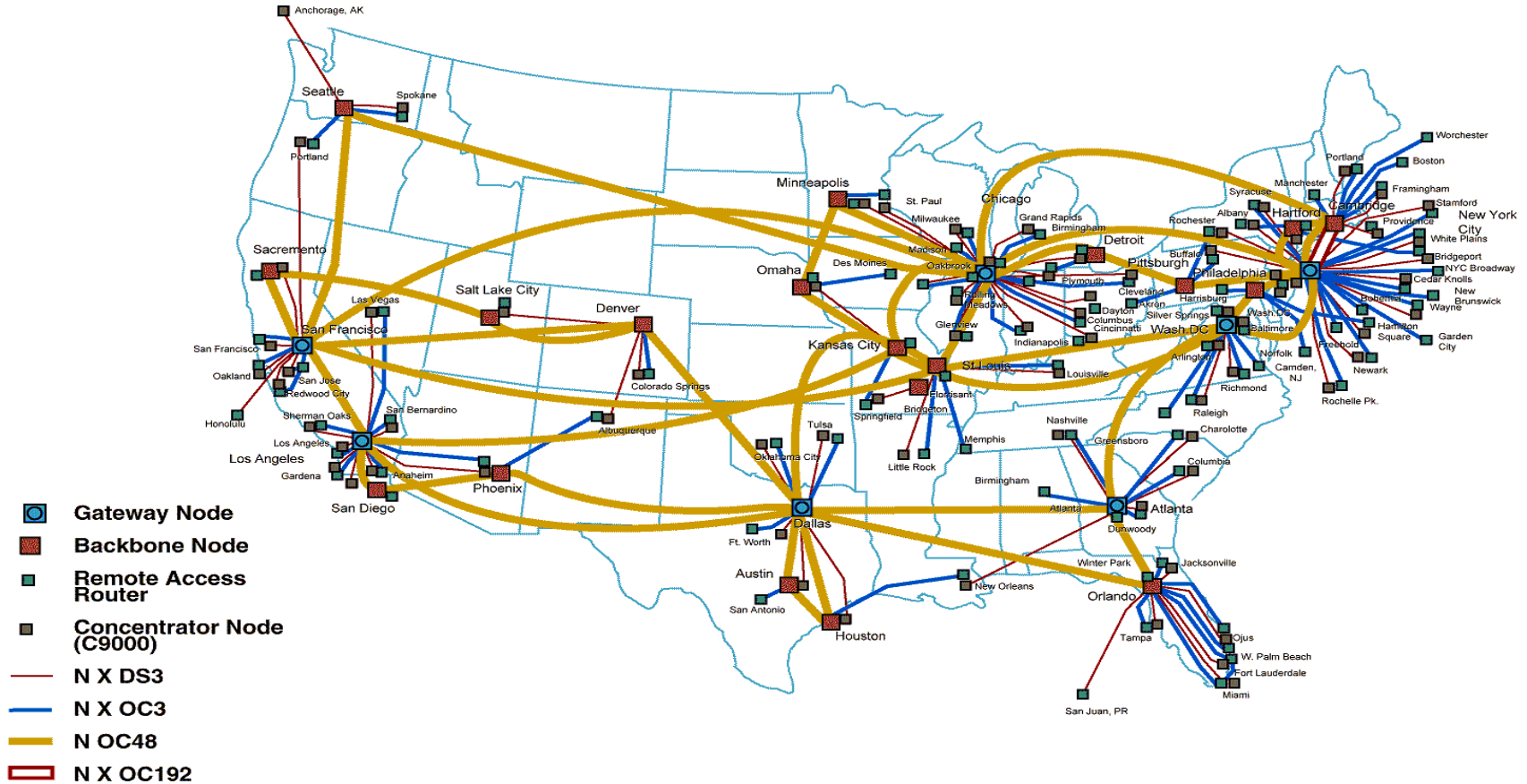
# Internet $\neq$ Web

- Internet: collection of global networks
- Web: way of managing information exchange
  - More details on this next week
- There are many other uses for the Internet
  - File transfer (FTP)
  - Email (SMTP, POP, IMAP)





# AT&T IP BACKBONE NETWORK 2Q2000



Note: map is not to scale.

# Thinking About Speed

- Speed can be expressed two ways:
  - How long to do something once?
    - Memory speed measured as “access time”
  - How many things can you do in one second?
    - Processor speed measured in “instructions per second”
- Convenient units are typically used
  - “10 microseconds” rather than “0.00001 seconds”

# Some Definitions

- **Latency**

- The amount of **time** it takes data to travel from source to destination

- **Bandwidth**

- The amount of data that can be transmitted in a fixed amount of **time**

# The Complete Picture

- Two parts of moving data from here to there:
  - Getting the first bit there
  - Getting everything there
- Fundamentally, there's no difference:
  - Moving data from the processor to RAM
  - Saving a file to disk
  - Downloading music from a server in China