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

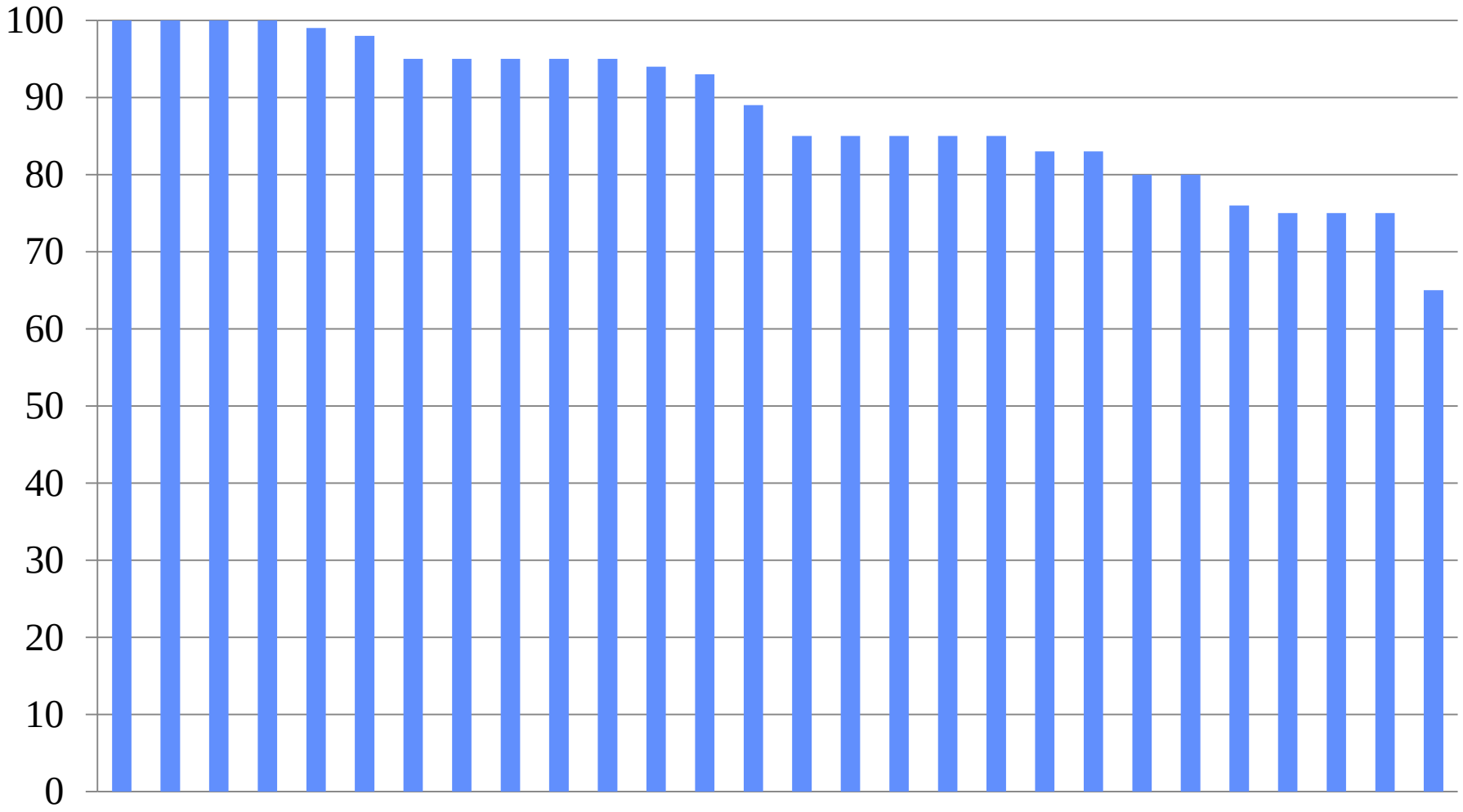
Computing

Week 9

LBSC 671

Creating Information Infrastructures

Midterm Results (Tentative)



Goals for Today

- Understand what makes stupid computers seem smart
- Understand how the Internet works

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

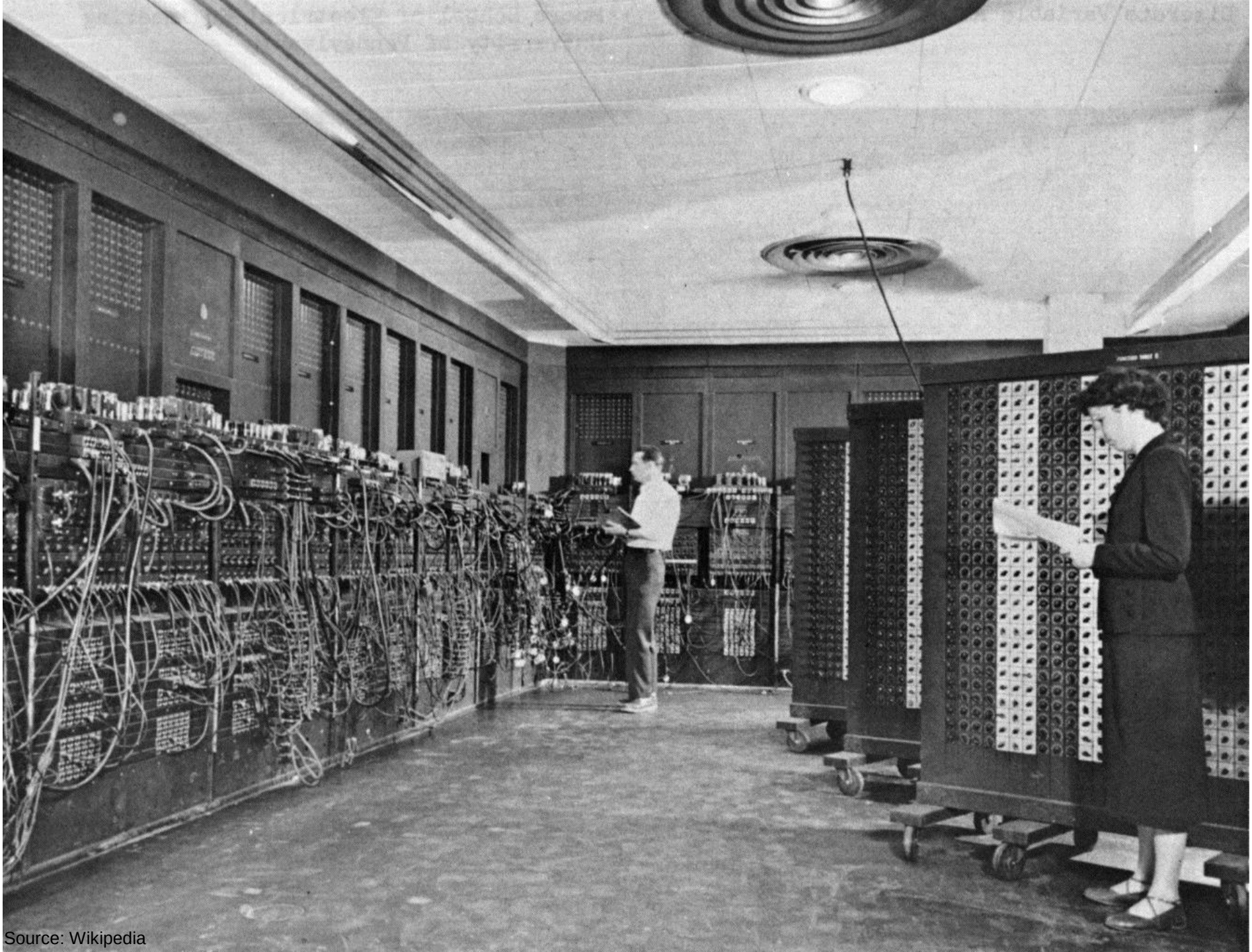
A Very Brief History of Computing

- 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



Source: Wikipedia

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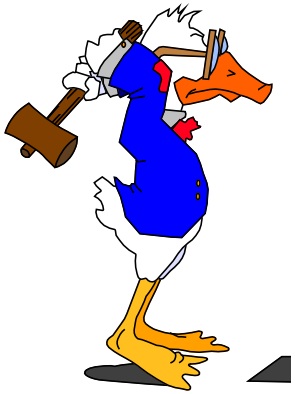
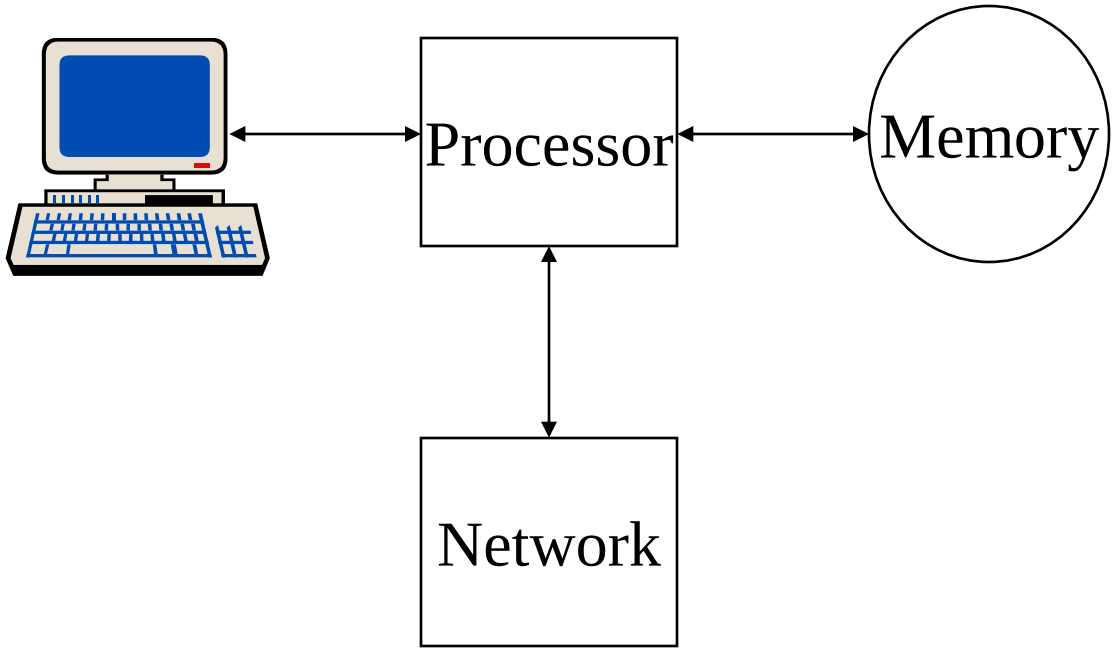
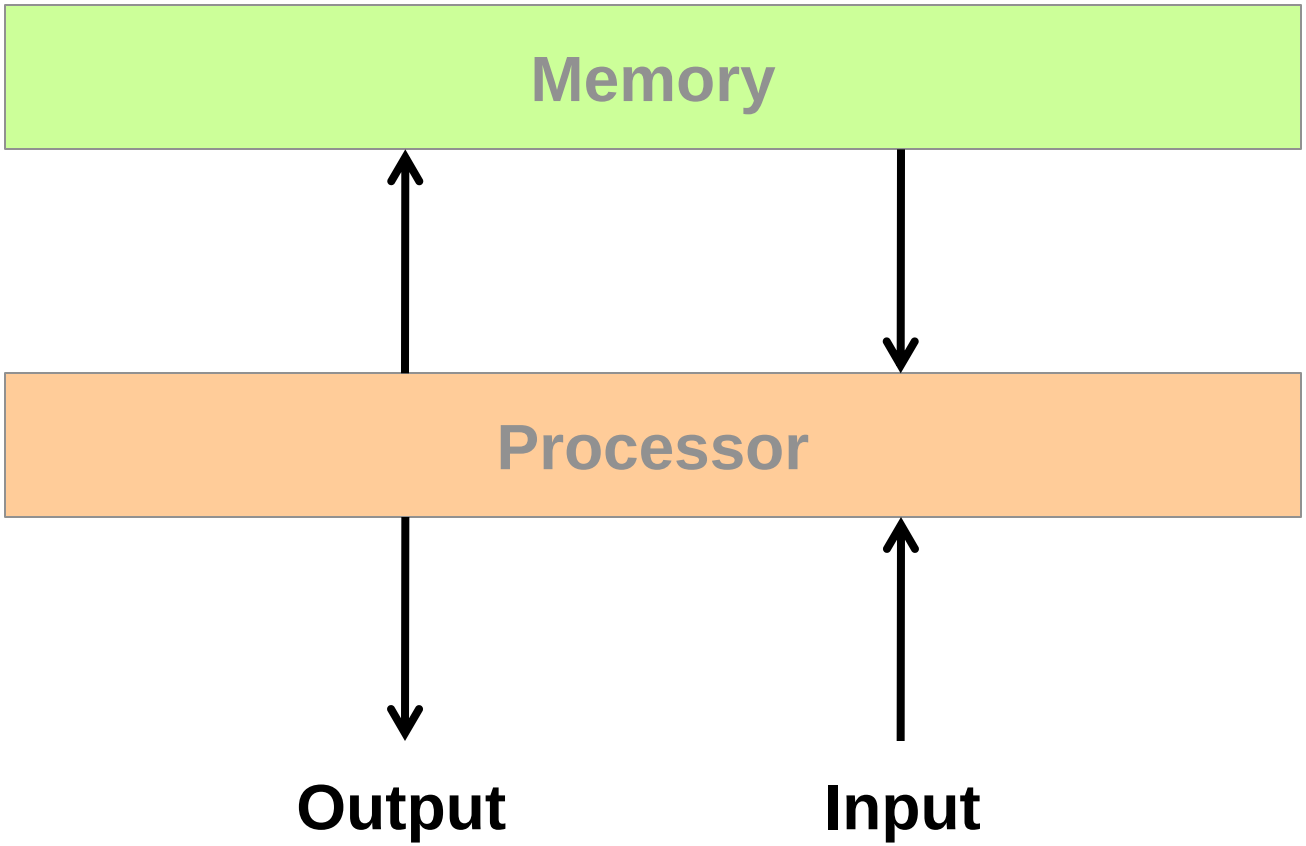
The Big Picture





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, …


Memory
Processor
Output
Input

Computer Hardware

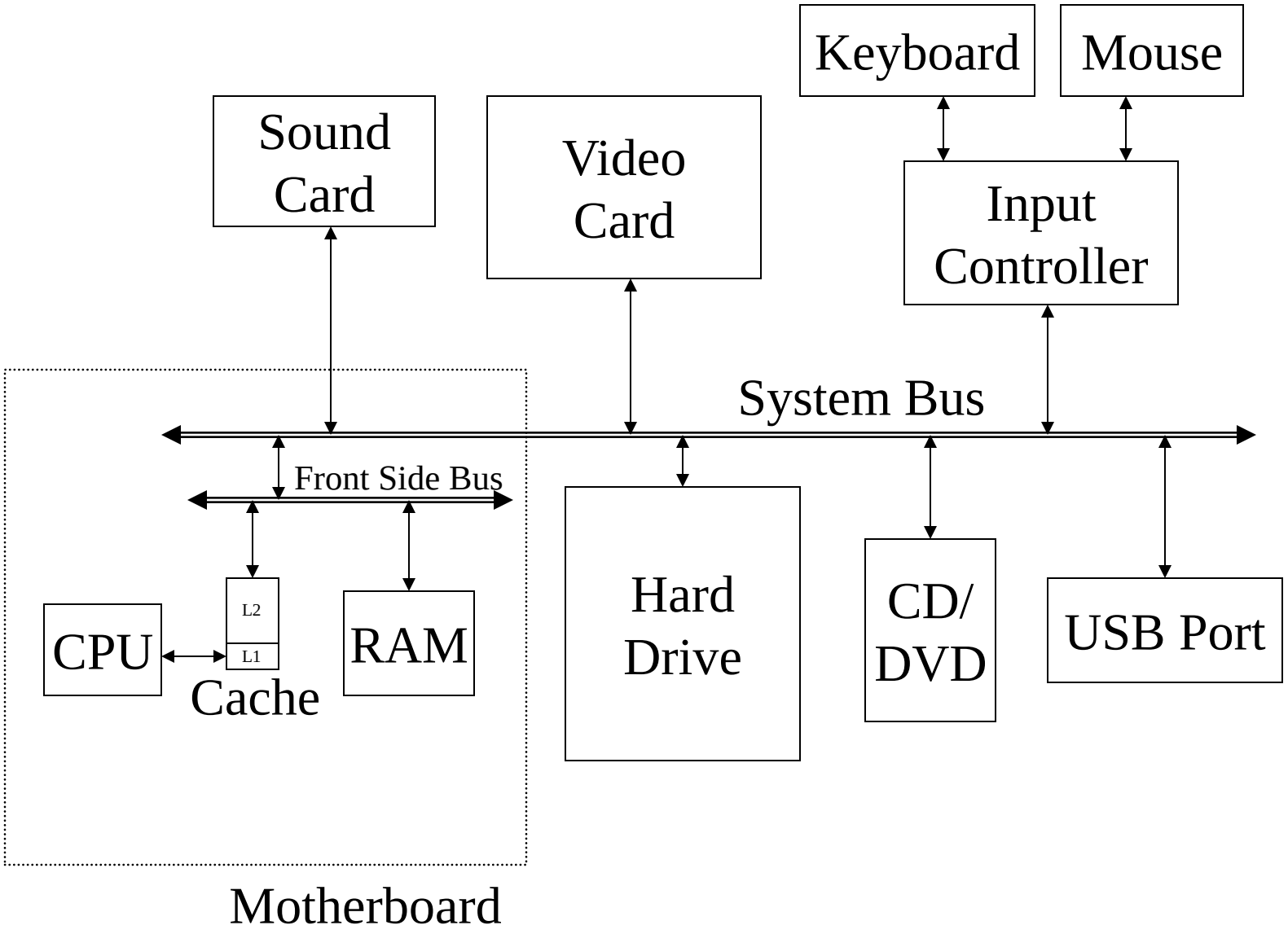
- Central Processing Unit (CPU)
  - Intel Xeon, Motorola Power PC, …
- Communications “Bus”
  - FSB, PCI, ISA, USB, Firewire, …
- Storage devices
  - Cache, RAM, hard drive, flash memory, …
- External communications
  - Modem, Ethernet, GPRS, 802.11, …

“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)

Extracted From Shelly Cashman Vermatt's Discovering Computers 2004

System Architecture



The Storage Hierarchy

Type	**Speed**	**Size**	**Cost**
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

File System

- Paths specify location of files on a hard drive
- Folder metaphor
  - Hierarchically nested directories

    /afs/wam.umd.edu/home/wam/j/i/jimmylin/home
    C:\Documents and Settings\Jimmy Lin\My Documents
  - Absolute vs. relative paths

    ../pub

    ..\Desktop
    ~/oard

Directory Tree Exercise

- First, visually explore the directory tree
  - PC: Windows Explorer
  - Mac: Finder
- Then launch a shell
  - PC: type cmd in search box
  - Mac: Applications->Utiities->Terminal
- Then navigate around
  - “tree .”plots the tree from here (PC only)
  - “dir” (PC) or “ls” (Mac) lists the present directory
  - “cd WINDOWS” takes you “down” in the tree
  - cd .. takes you “up” in the tree

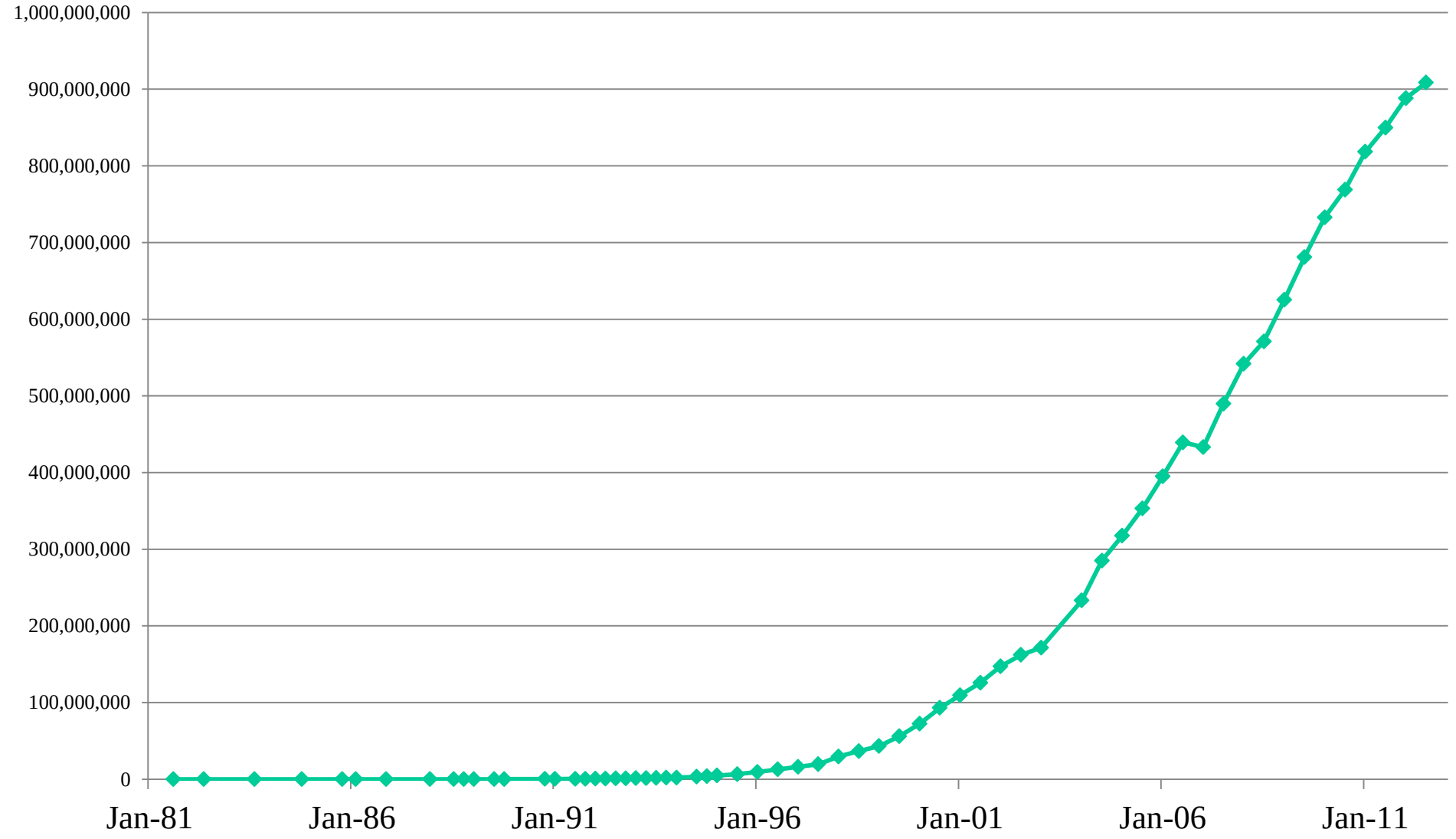
The Internet

- 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)

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 908 million Internet “hosts” (July 2012)
  - Key standards: HTTP, URL, HTML, XML

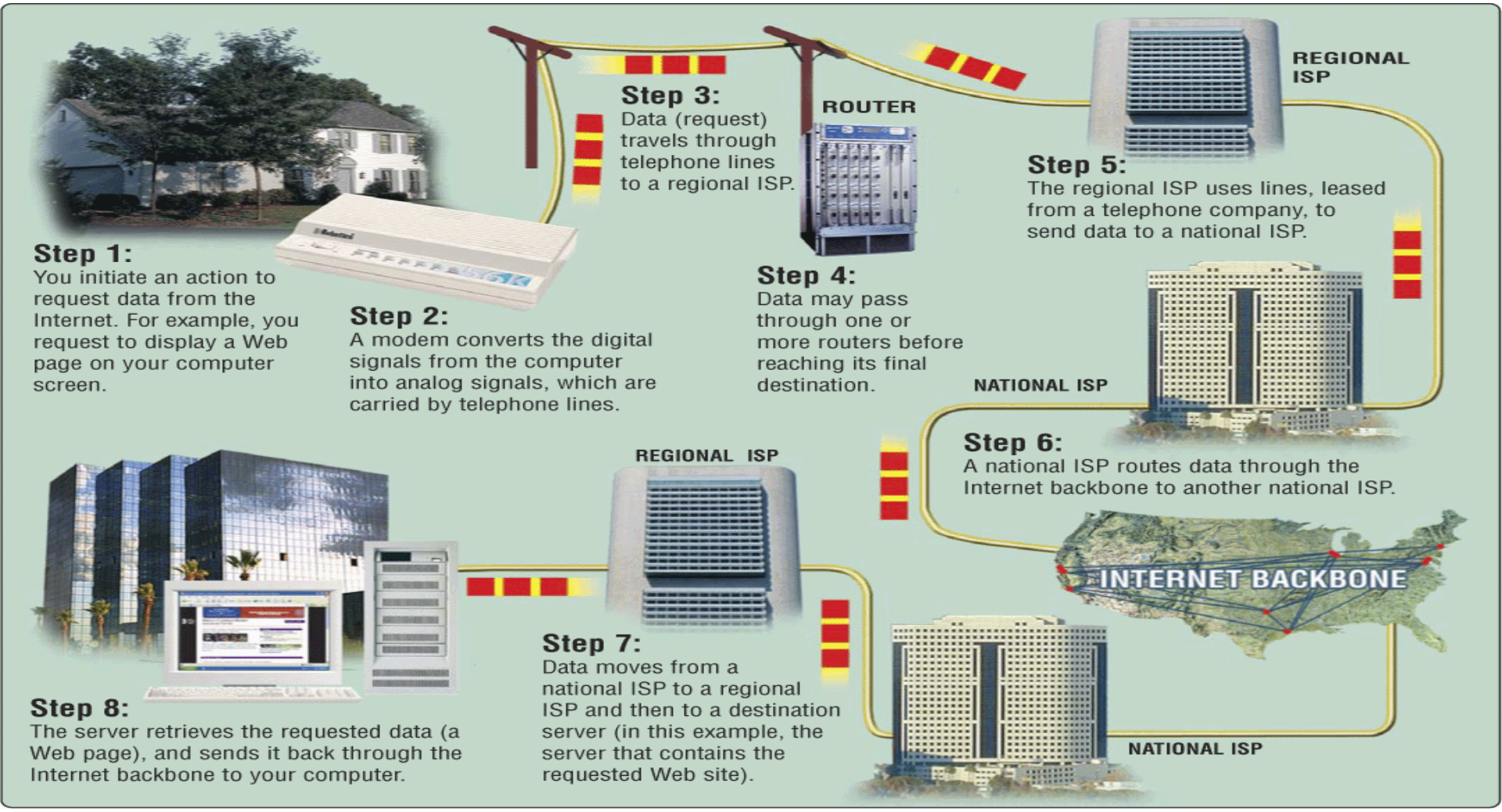
What Changed in 1994?



Types of Digital Channels

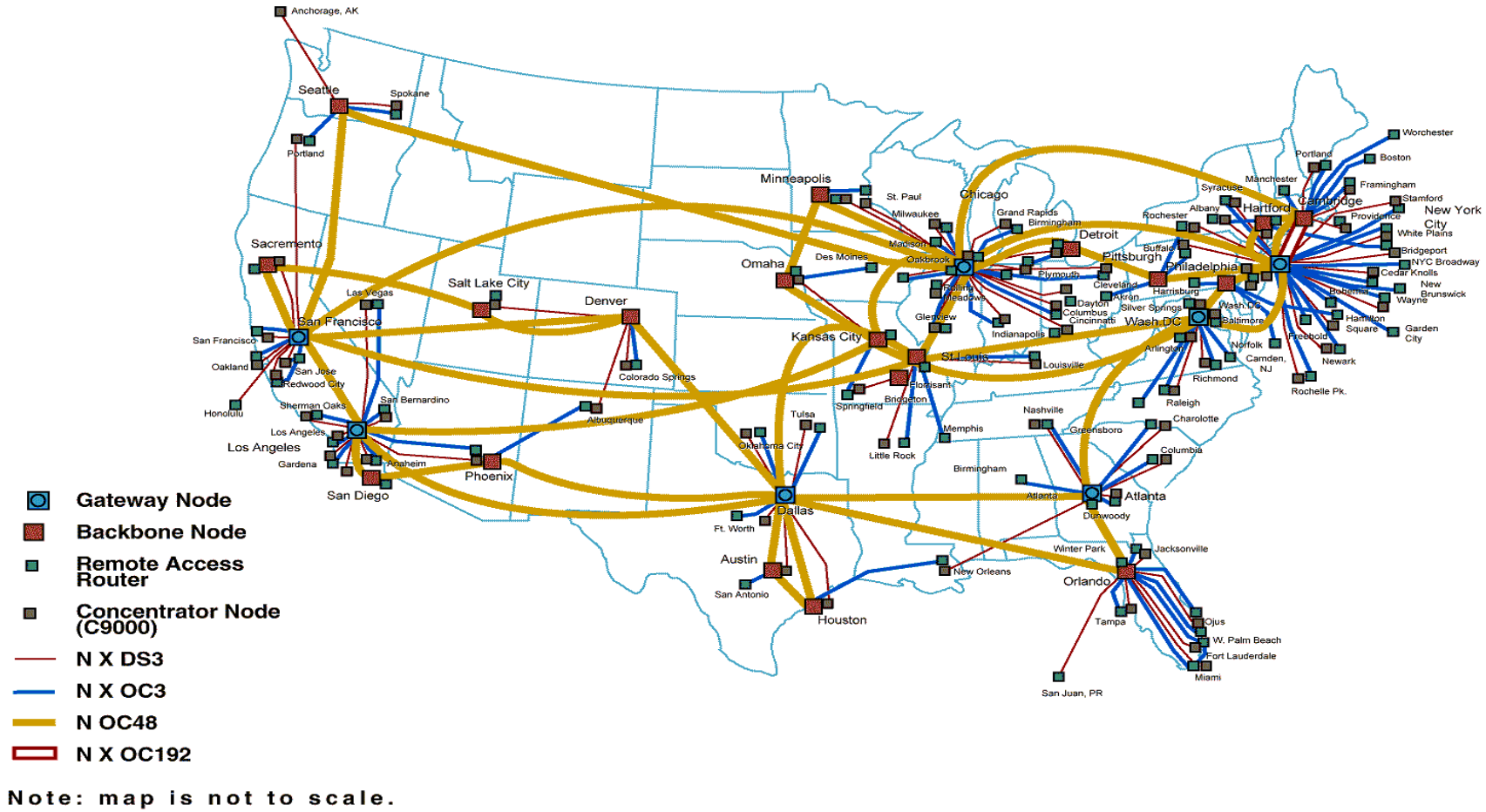
- "Backbone"
  - Microwave
  - Satellite
  - Fiber
- "Last mile" wired
  - ADSL
  - Cable modem
  - Fiber
- "Last mile" wireless
  - Wi-Fi (IEEE 802.11)
  - GSM/4G

A Network of Networks



AT&T IP BACKBONE NETWORK

2Q2000



Note: map is not to scale.

http://www.geog.ucl.ac.uk/casa/martin/atlas/isp_maps.html

Thinking About Speed

- 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

Units of Time

Unit	**Abbreviation**	**Duration (seconds)**
second	sec/s	1
millisecond	ms	10^{-3} = 1/1,000
microsecond	μs	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

Units of Frequency

Unit	**Abbreviation**	**Operations per second**
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 Size

Unit	**Abbreviation**	**Size (bytes)**
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	$2^{50} = 1,125,899,906,842,624$

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**

Types of Internet “Nodes”

- Hosts
  - Computers that use the network to do something
- Routers
  - Specialized computers that route packets
- Gateway
  - Routers that connect two networks
- Firewall
  - Gateways that pass packets selectively

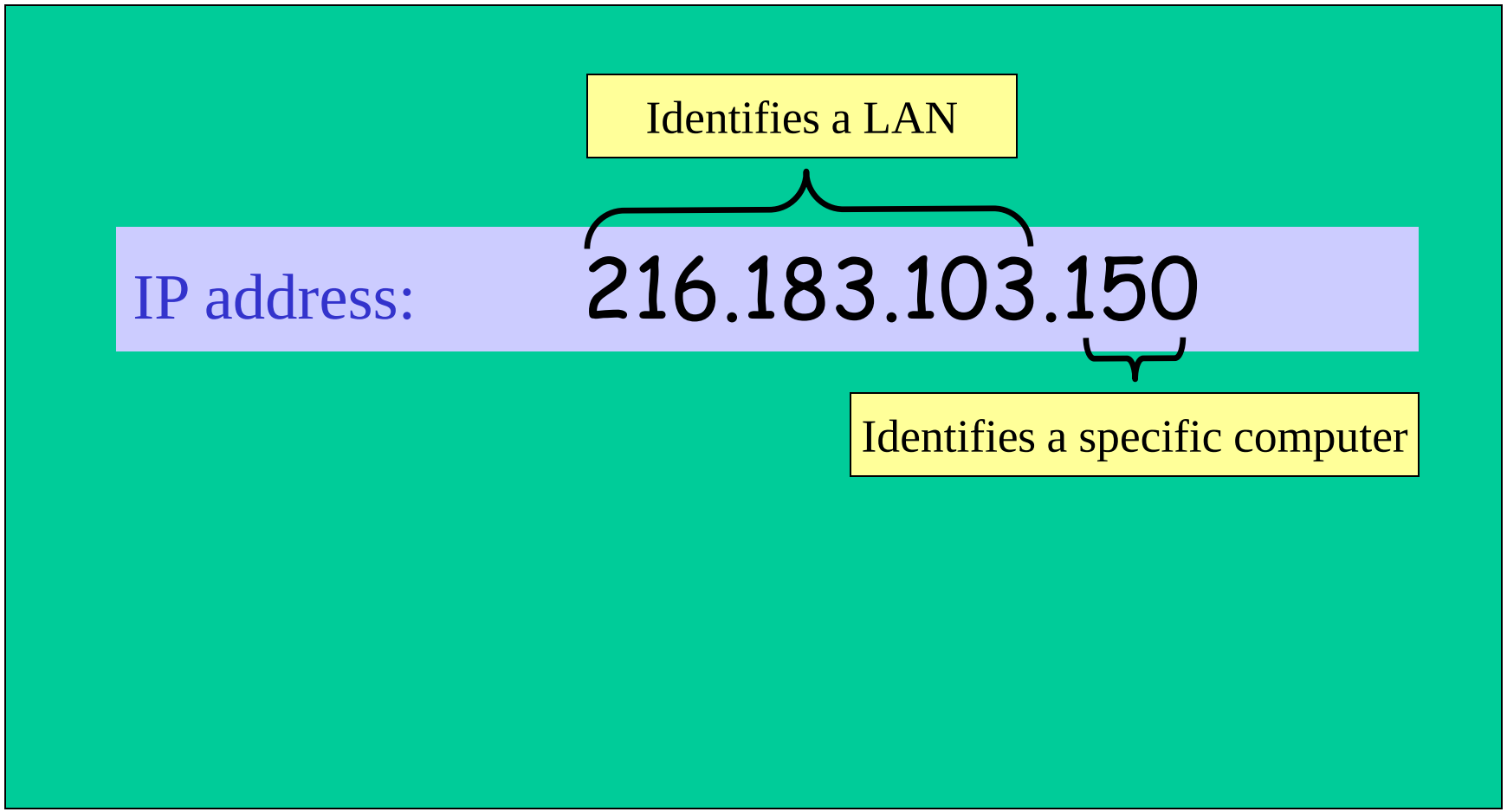
IP Address

- Every host (and every router) is identified by an “Internet Protocol” (IP) address
- 32 bit number, divided into four “octets”

128.8.11.33
216.239.39.99
199.181.132.250

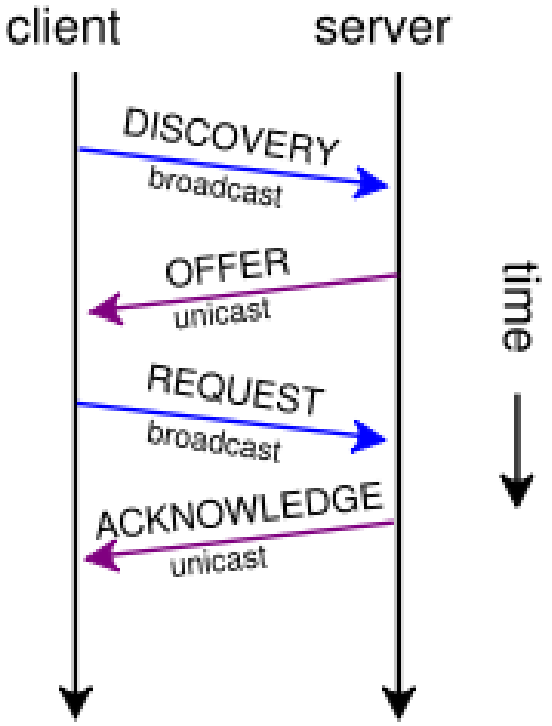
Example: point your browser at http://128.8.237.77/

An Internet Protocol (IP) Address



Dynamic IP Addresses

- Dynamic Host Configuration Protocol (DHCP)

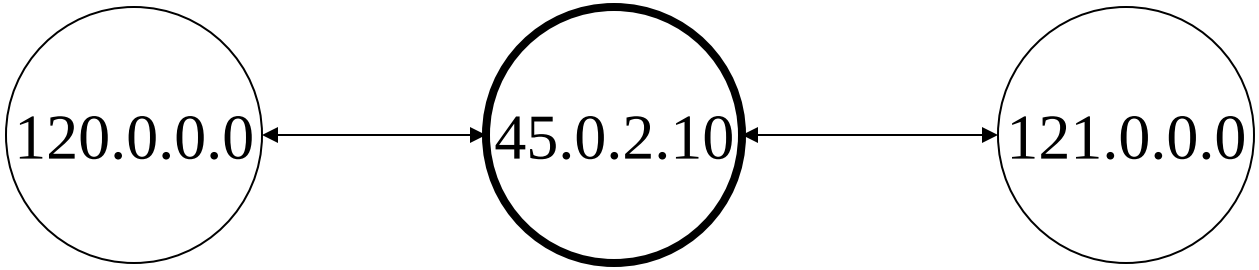


Hands-on:
Learn About Your IP Address

- Find your IP address
  - Bring up a command window
    - In Windows, type “cmd” in the search box!
  - Type “ipconfig /all” (and press enter)
- See who “owns” that address
  - Use http://remote.12dt.com/
- See where in the world it (probably) is
  - http://www.geobytes.com/ipLocator.htm

Routing Tables

IP Prefix	Next Router	Estimated Delay
216.141.xxx.xxx	120.0.0.0	18 ms
216.xxx.xxx.xxx	121.0.0.0	34 ms
101.42.224.xxx	120.0.0.0	21 ms
xxx.xxx.xxx.xxx	121.0.0.0	250 ms



TraceRoute

- See how packets get from South Africa to you
  - http://services.truteq.com/
- Look at the same data visually
  - http://visualroute.visualware.com/

Domain Name Service (DNS)

- "Domain names" improve usability
  - Easier to remember than IP addresses
  - Written like a postal address: specific-to-general

- Each "name server" knows one level of names
  - "Top level" name servers know .edu, .com, .mil, …
  - .edu name server knows umd, umbc, stanford, …
  - .umd.edu name server knows wam, ischool, ttclass, …
  - .wam.umd.edu name server knows rac1, rac2, …

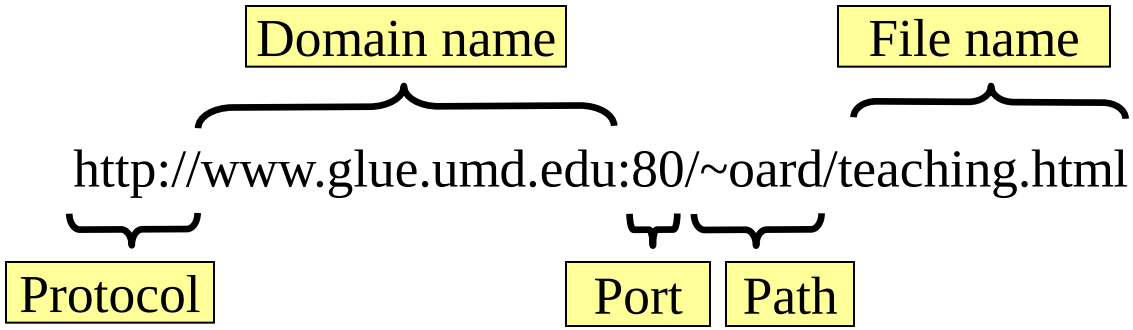
IP Addresses and Domain Names

IP address: 128.8.10.142

Domain Name: wam.umd.edu

Uniform Resource Locator (URL)

- Uniquely identify Web pages



Ports

- Well-known ports
  - 22 Secure Shell (for SSH and SFTP)
  - 25 Simple Mail Transfer Protocol (SMTP)
  - 53 Domain Name System (DNS)
  - 68 Dynamic Host Configuration Protocol (DHCP)
  - 80 Hypertext Transfer Protocol (HTTP)
  - 143 Internet Message Access Protocol (IMAP)
  - 554 Real-Time Streaming Protolol (RTSP)
- Registered Ports
  - 8080 HTTP server run by ordinary users
- Ephemeral Ports

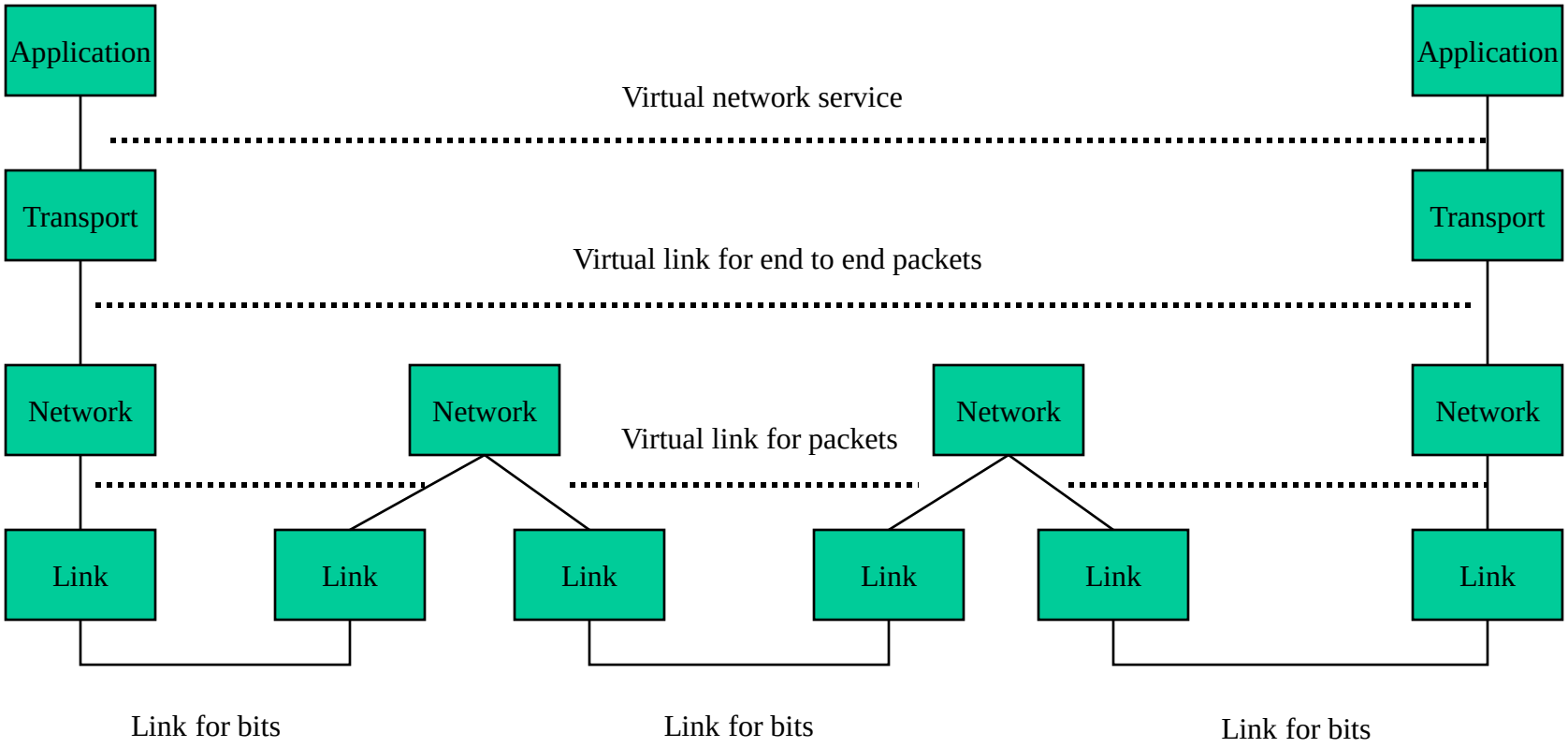
Port Mapping

- Internet Service providers lease one IP address
  - But home networks may contain many machines
- Network Address Translation (NAT)
  - Each internal machine gets a private IP address
  - Ports on internal machines are mapped both ways
- Port forwarding
  - Permits public server to run in the local network

The TCP/IP “Protocol Stack”

- Link layer moves bits
  - Ethernet, cable modem, DSL
- Network layer moves packets
  - **IP**
- Transport layer provides services to applications
  - UDP, **TCP**
- Application layer uses those services
  - DNS, SFTP, SSH, …

TCP/IP layer architecture



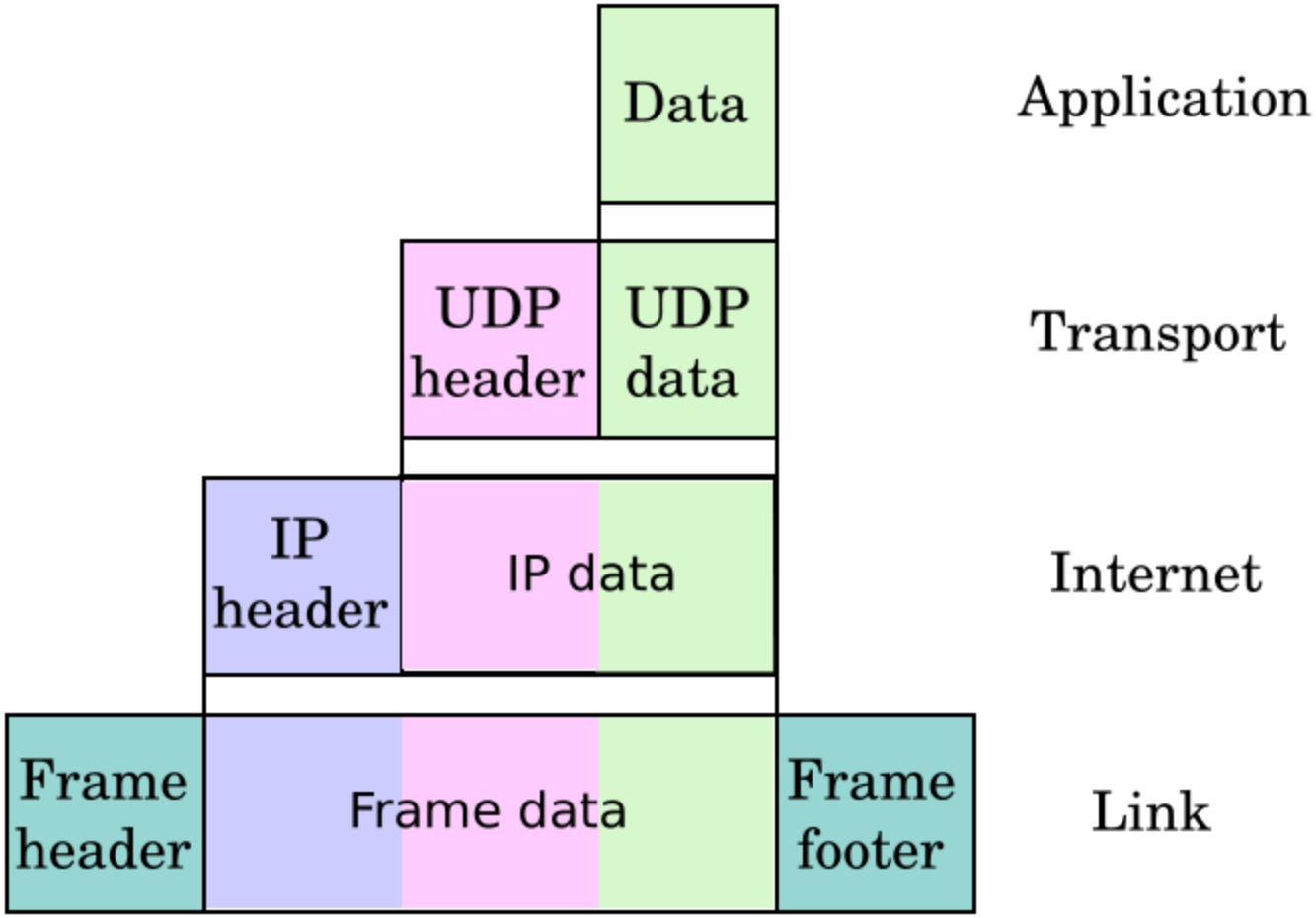
Transmission Control Protocol (TCP)

- Built on the network-layer version of UDP
- Guarantees delivery all data
  - Retransmits missing data
- Guarantees data will be delivered in order
  - “Buffers” subsequent packets if necessary
- No guarantee of delivery time
  - Long delays may occur without warning

User Datagram Protocol (UDP)

- The Internet's basic transport service
  - Sends every packet immediately
  - Passes received packets to the application
- No delivery guarantee
  - Collisions can result in packet loss
- Example: sending clicks on web browser

UDP/IP Protocol Stack



File Transfer Program (FTP)

- Used to move files between machines
  - Upload (put) moves from client to server
  - Download (get) moves files from server to client
- Both visual and command line interfaces available
- Normally requires an account on the server
  - Userid “anonymous” provides public access

Hands On:
Graphical Secure FTP

- SFTP to “terpconnect.umd.edu”
- Change directory to “/pub/USERID”
- Upload or download files
- You can see these files at:
  http://terpconnect.umd.edu/~USERID/

Network Abuse

- Flooding
  - Excessive activity, intended to prevent valid activity
- Worms
  - Like a virus, but self-propagating
- Sniffing
  - Monitoring network traffic (e.g., for passwords)

Encryption

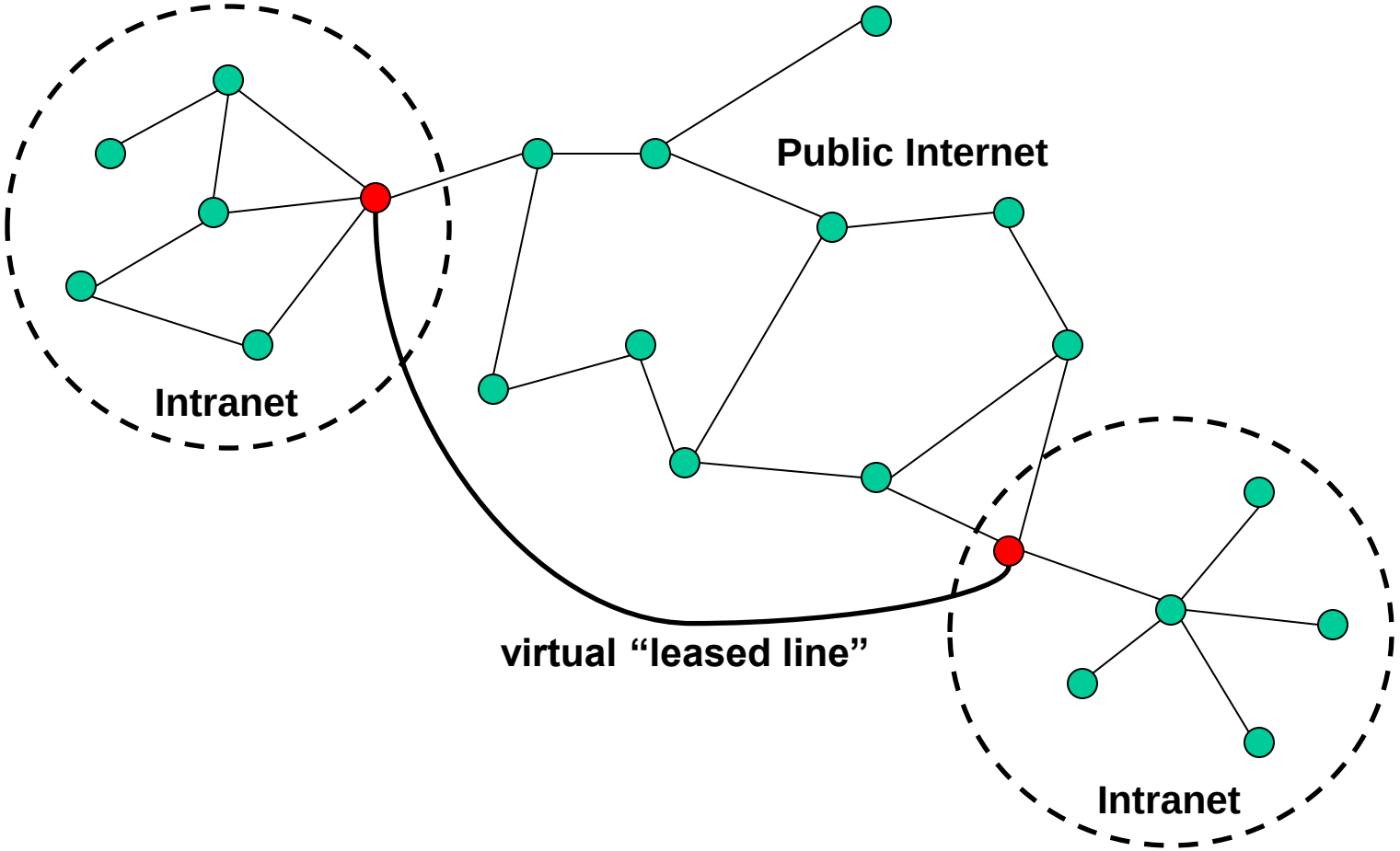
- Secret-key systems (e.g., DES)
  - Use the same key to encrypt and decrypt
- Public-key systems (e.g., PGP)
  - Public key: open, for encryption
  - Private key: secret, for decryption
- Digital signatures
  - Encrypt with private key, decrypt with public key

Encrypted Standards

- Secure Shell (SSH)
  - Replaces Telnet
- Secure FTP (SFTP)/Secure Copy (SCP)
  - Replaces FTP
- Secure HTTP (HTTPS)
  - Used for financial and other private data
- Wired Equivalent Protocol (WEP)
  - Used on wireless networks
- Virtual Private Network (VPN)
  - Not really a “standard”

Virtual Private Networks

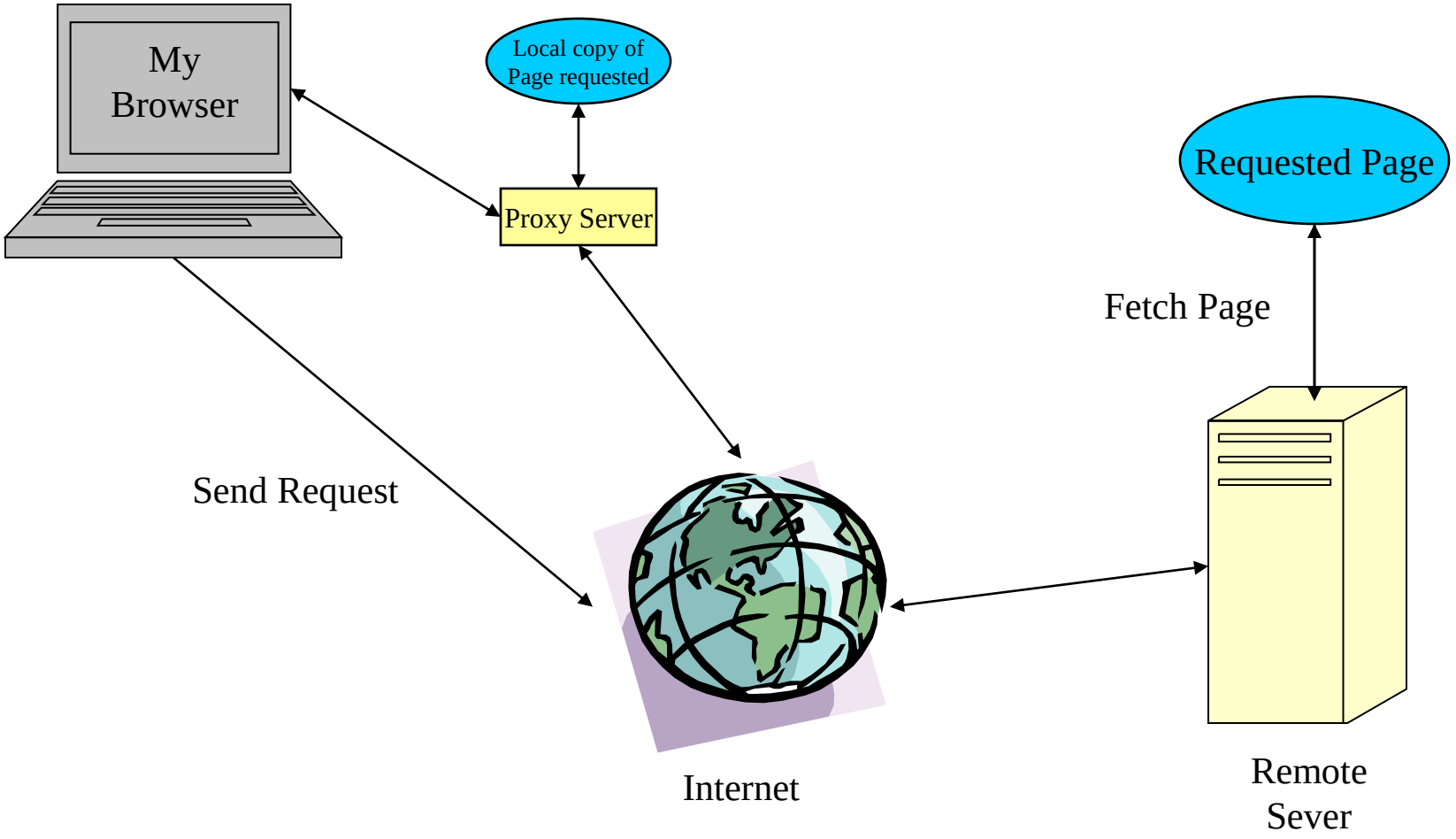
a secure private network over the public Internet



Internet ≠ Web

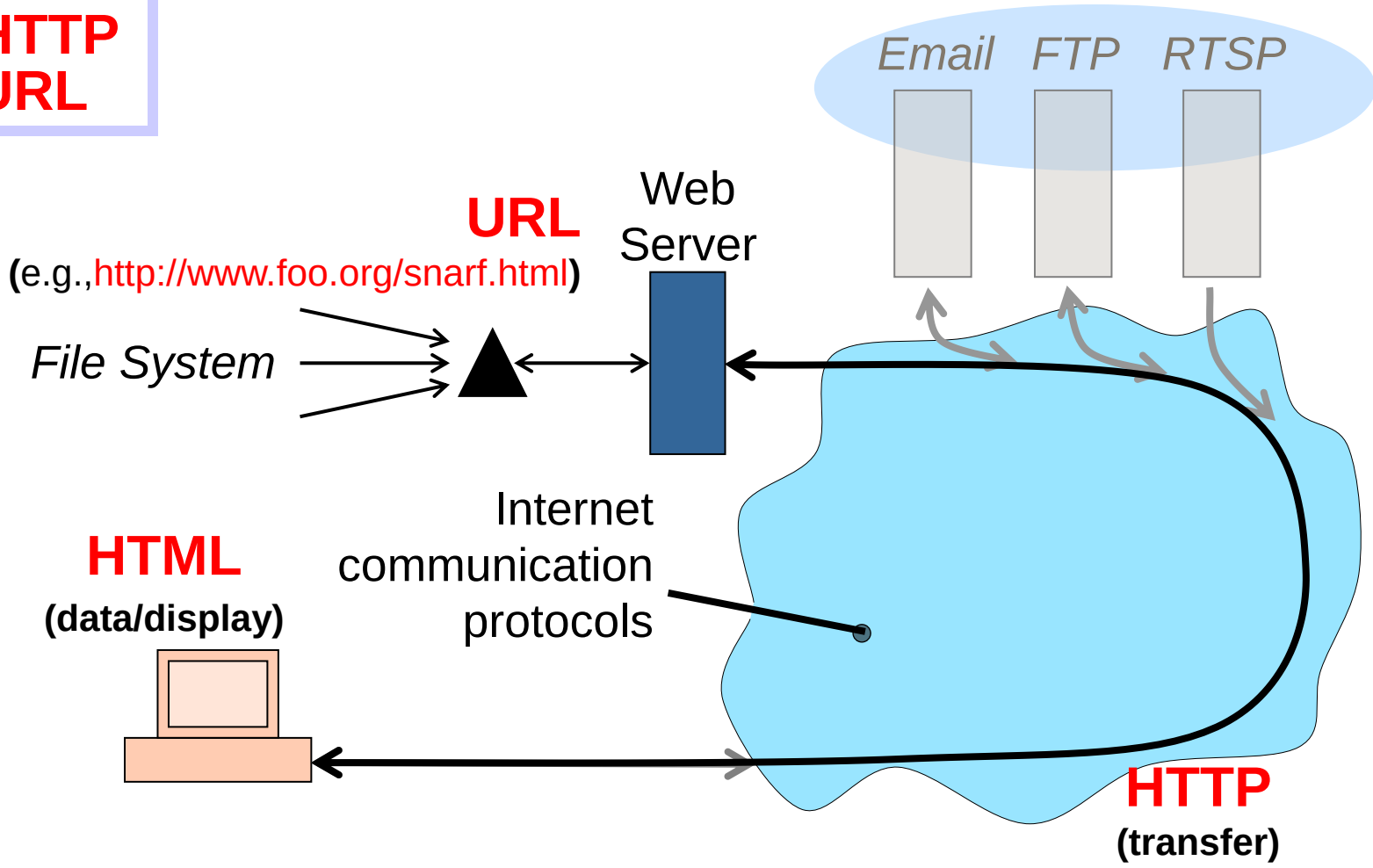
- Internet: collection of global networks
- Web: way of managing information exchange
- There are many other uses for the Internet
  - File transfer (FTP)
  - Email (SMTP, POP, IMAP)

The World-Wide Web



"The Web"

HTML
HTTP
URL



Web Standards

- HTML
  - How to write and interpret the information
- URL
  - Where to find it
- HTTP
  - How to get it

HyperText Transfer Protocol (HTTP)

- Send request

  GET /path/file.html HTTP/1.0
  From: someuser@jmarshall.com
  User-Agent: HTTPTool/1.0

- Server response

  HTTP/1.0 200 OK
  Date: Fri, 31 Dec 1999 23:59:59 GMT
  Content-Type: text/html
  Content-Length: 1354
  <html><body> <h1>Happy New Millennium!</h1> … </body> </html>

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?