Internet

CPE 401 / 601
Computer Network Systems

slides are modified from **Dave Hollinger** and **Daniel Zappala**

Network

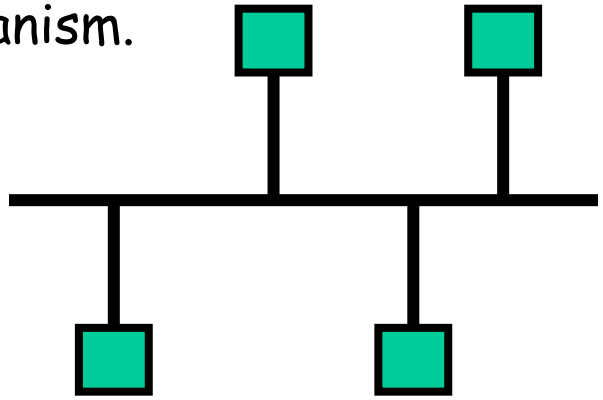
" ... communication system for connecting end-systems"

End-systems a.k.a. "hosts"

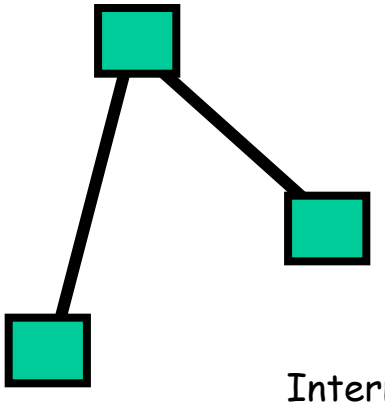
- PCs, workstations
- dedicated computers
- network components

Multiaccess vs. Point-to-point

- Multiaccess means shared medium.
  - many end-systems share the same physical communication resources (*wire, frequency, ...*)
  - There must be some arbitration mechanism.



- Point-to-point
  - only 2 systems involved
  - no doubt about where data came from !



LAN - Local Area Network

- connects computers that are physically close together (< 1 mile).
  - high speed
  - multi-access
- Technologies:
  - Ethernet 10 Mbps, 100Mbps
  - Token Ring 16 Mbps
  - FDDI 100 Mbps

WAN - Wide Area Network

- connects computers that are physically far apart. "long-haul network".
  - typically slower than a LAN.
  - typically less reliable than a LAN.
  - point-to-point
- Technologies:
  - telephone lines
  - Satellite communications

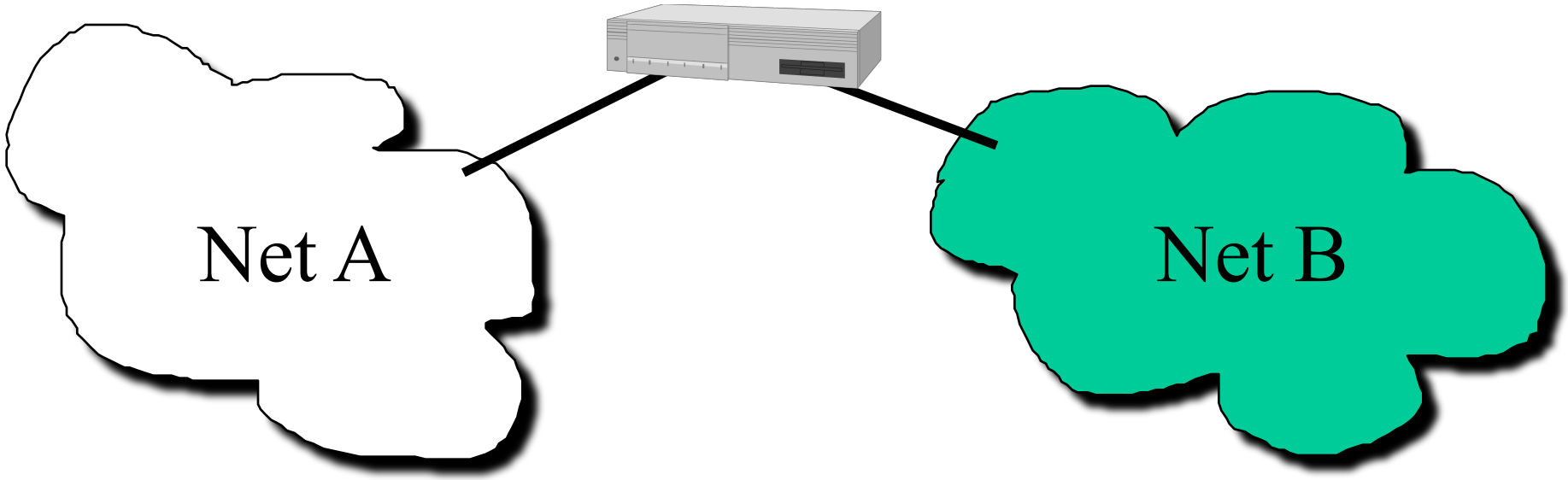
MAN - Metropolitan Area Network

- Larger than a LAN and smaller than a WAN
  - example: campus-wide network
  - multi-access network

- Technologies:
  - coaxial cable
  - microwave

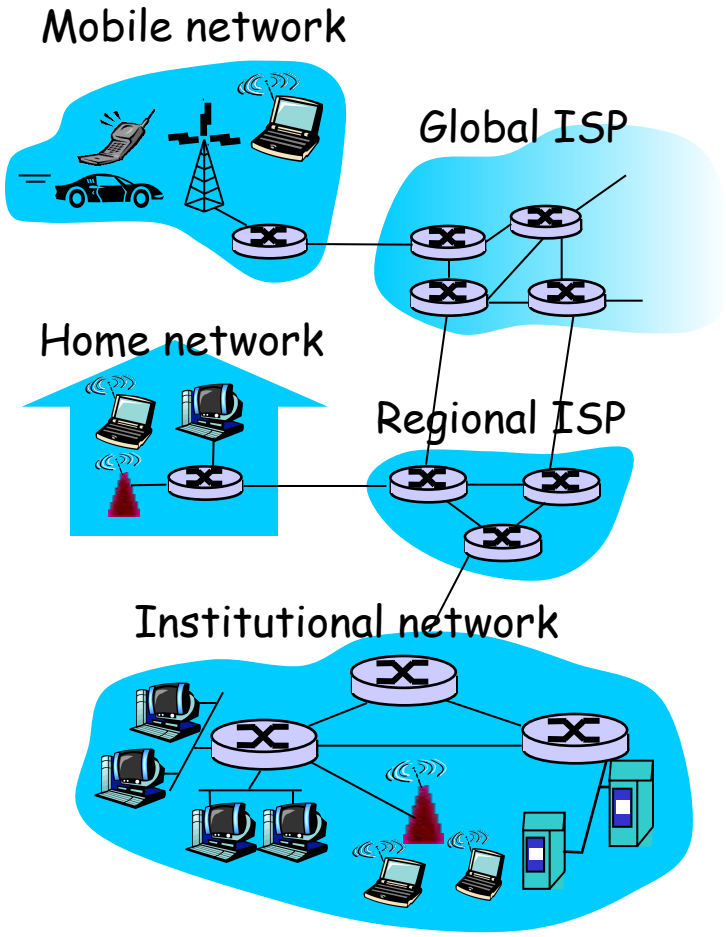
Internetwork

- Connection of 2 or more distinct (possibly dissimilar) networks.
- Requires some kind of network device to facilitate the connection.

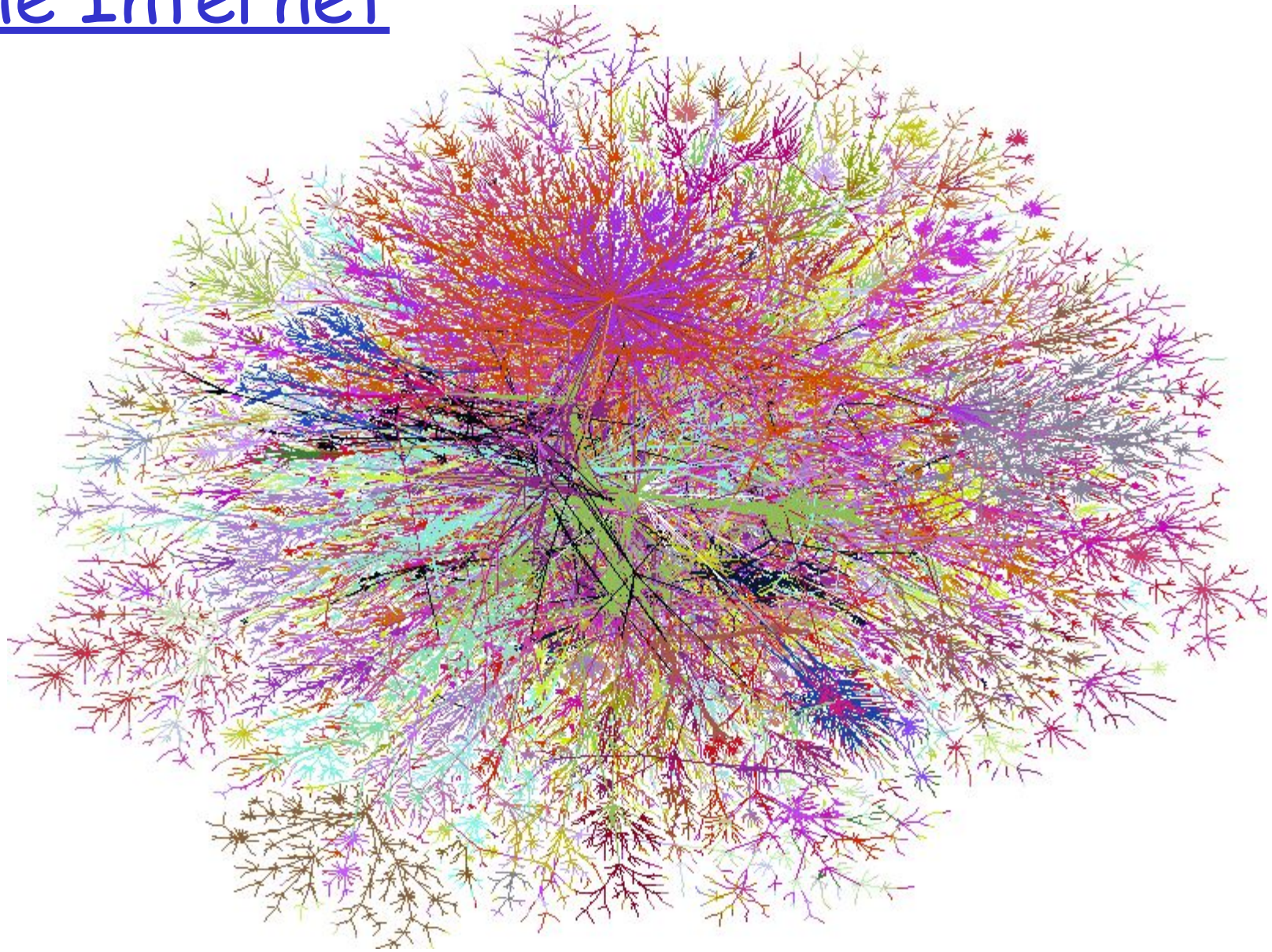


The Internet

- millions of connected computing devices: *hosts = end systems*
  - running *network apps*
- *communication links*
  - fiber, copper, radio, satellite
- *routers:* forward packets (chunks of data)



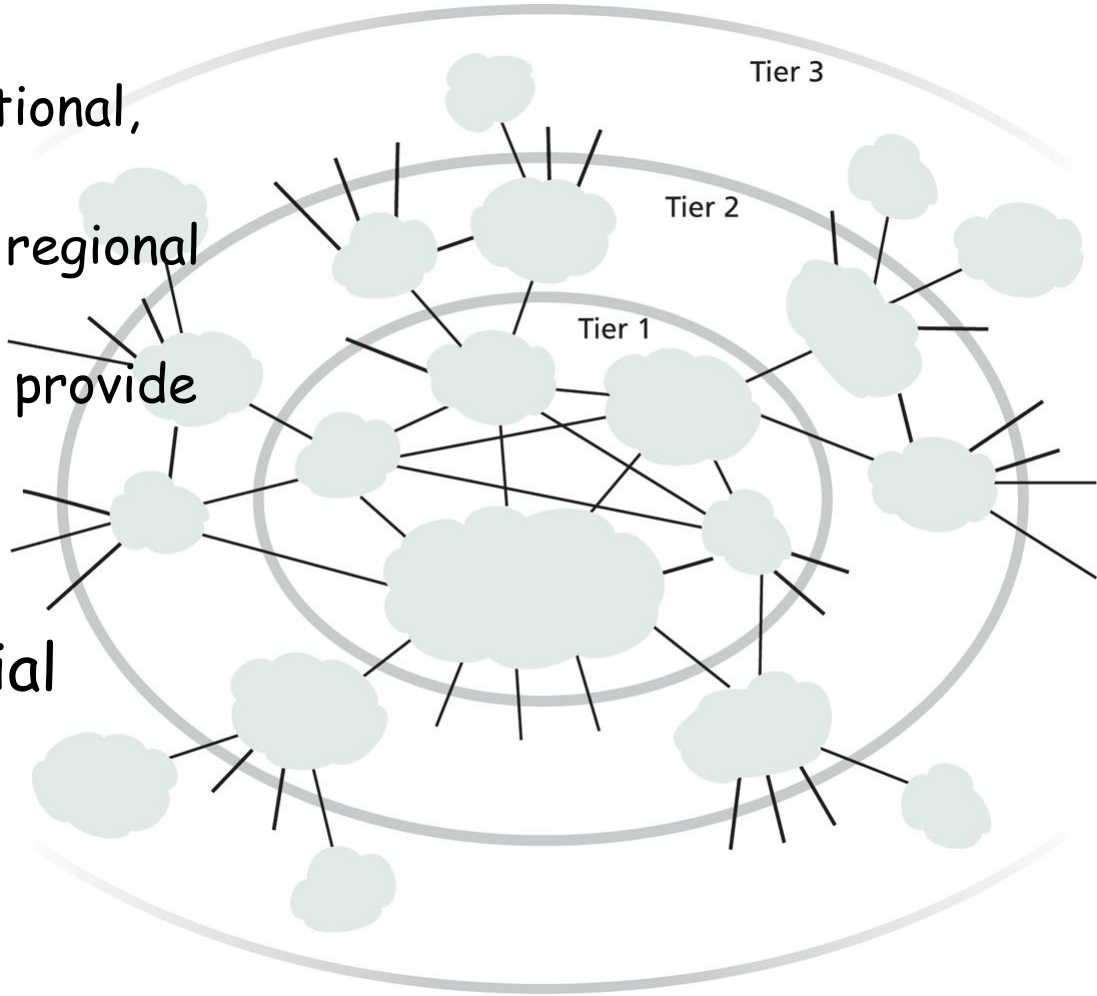
The Internet



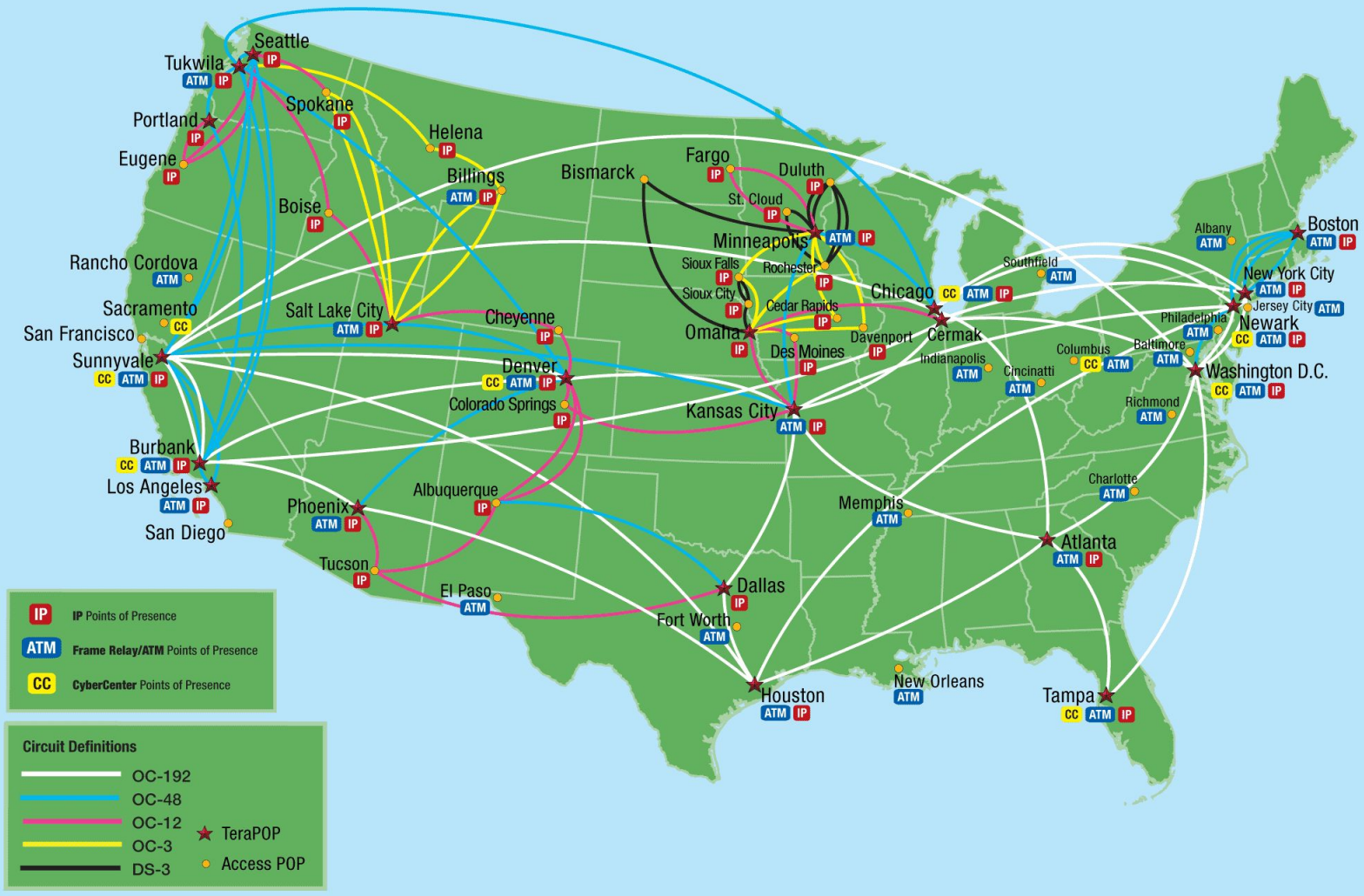
Internet Mapping Project, Bill Cheswick

A Network of Networks

- roughly hierarchical
  - Tier-1 ISPs provide national, international coverage
  - Tier-2 ISPs provide regional coverage
  - Tier-3 and lower levels provide local coverage
- any tier may sell to business and residential customers
- any ISP may have a link to any other ISP (not strictly hierarchical)



Qwest® iQ Networking™ Map

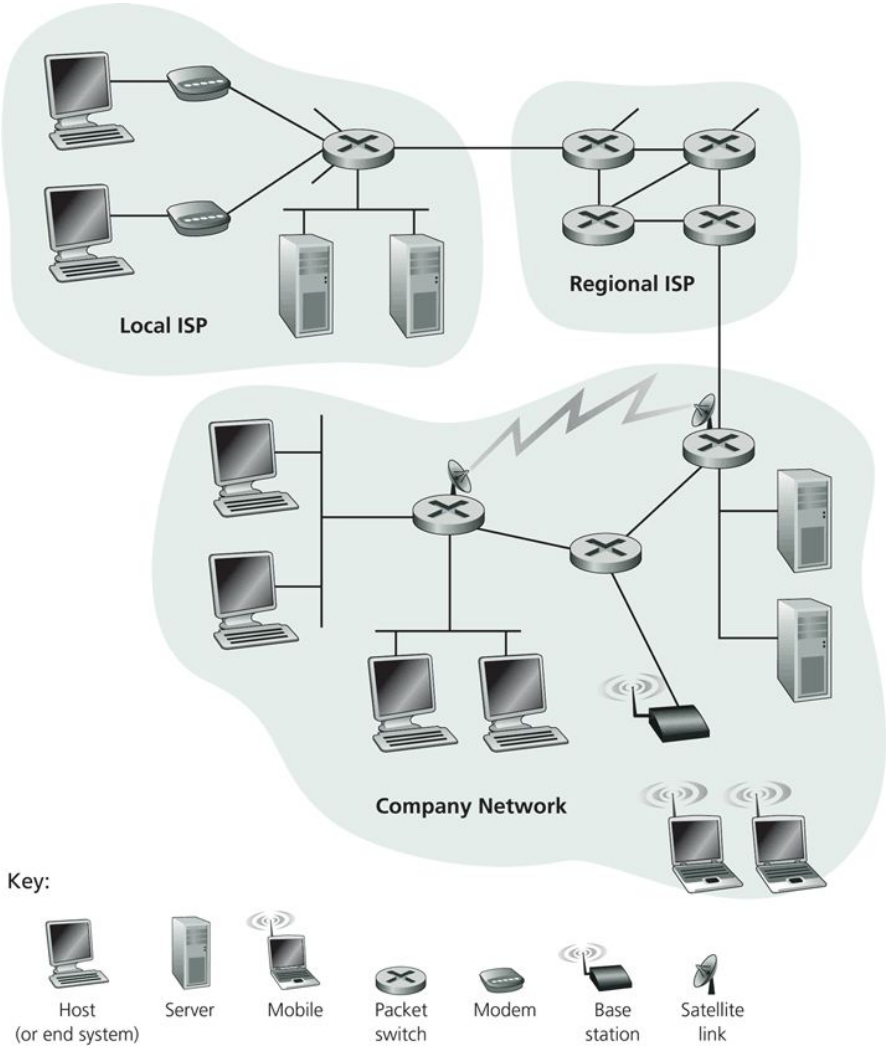


As of February 2006
BM030604

Qwest
Spirit of Service®

Many Different Internet Service Providers

- Each network is independent
- Interoperability requires using Internet standards: IP, TCP
  - the Internet is global and must run these standards
  - your private intranet can do whatever you want it to do



Internet Design Goals

- primary goal: interoperability among existing networks
  - a network of networks
  - obey administrative boundaries
- secondary goals
  - fault tolerance
  - multiple transport protocols
  - support a variety of networks
  - distributed management
  - cost effective, low effort for host attachment, accountability
- first three were more important, so remaining four did not receive as much attention
- no mention of security

Internet Design Principles

- minimal assumptions about services network should support
  - ability to send packets
  - no reliability or security

- end-to-end principle
  - keep the core of the network as simple as possible,
  - put complex functionality at the edges
  - *exception*: significant performance improvement

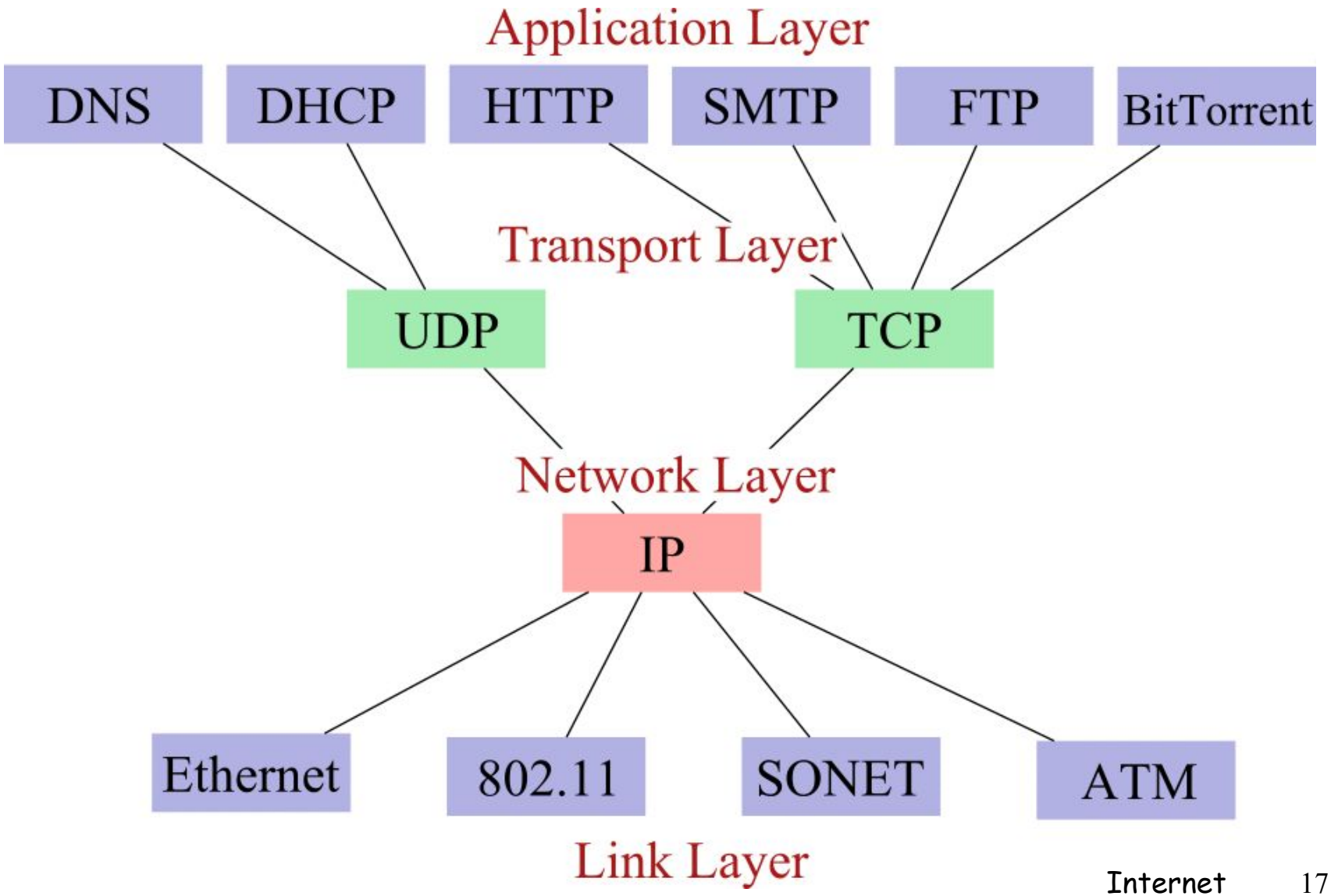
Network Models

- Using a formal model allows us to deal with various aspects of Networks abstractly.
- We will look at a popular model (OSI reference model).
- The OSI reference model is a *layered* model.

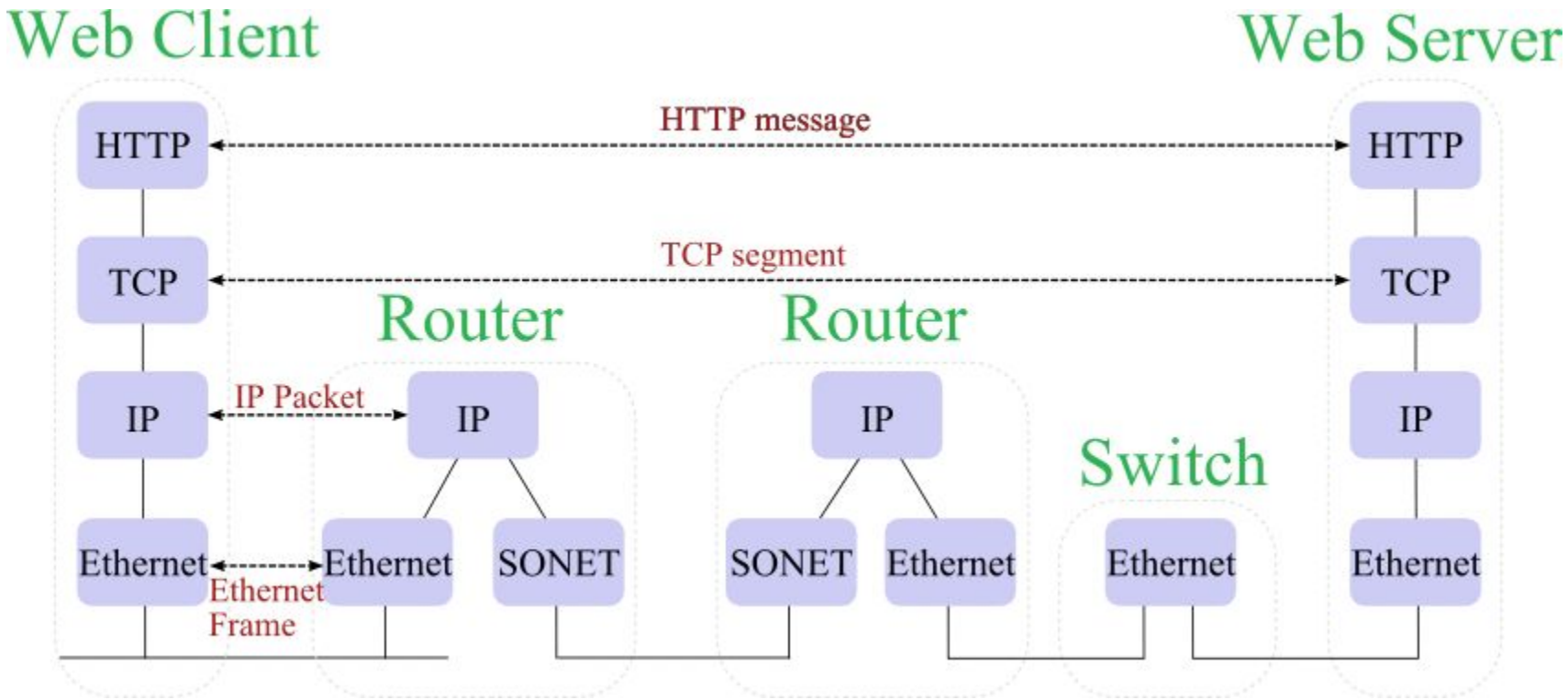
Layering

- Divide a task into pieces and then solve each piece independently (or nearly so).
- Establishing a well defined interface between layers makes porting easier.
- Major Advantages:
  - Code Reuse
  - Extensibility

The Internet Hourglass

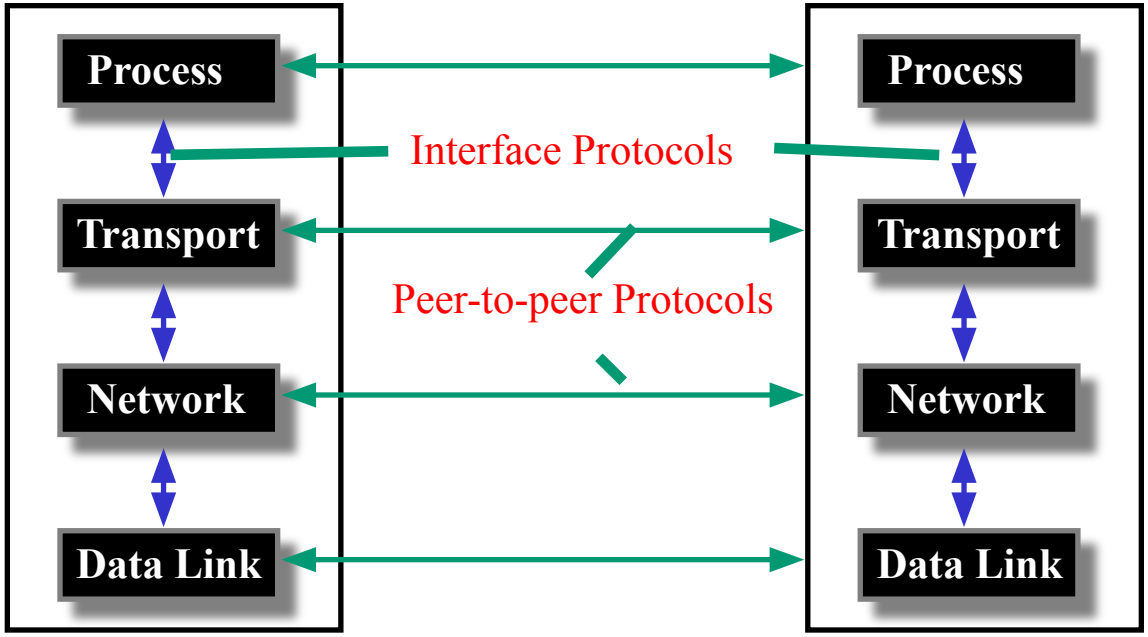


The Internet at each Hop



Interface and Peer-to-peer Protocols

- Interface protocols describe communication between layers on the same endpoint.
- Peer-to-peer protocols describe communication between peers at the same layer.



What's a protocol?

human protocols:

- "what's the time?"
- "I have a question"
- introductions

… specific msgs sent

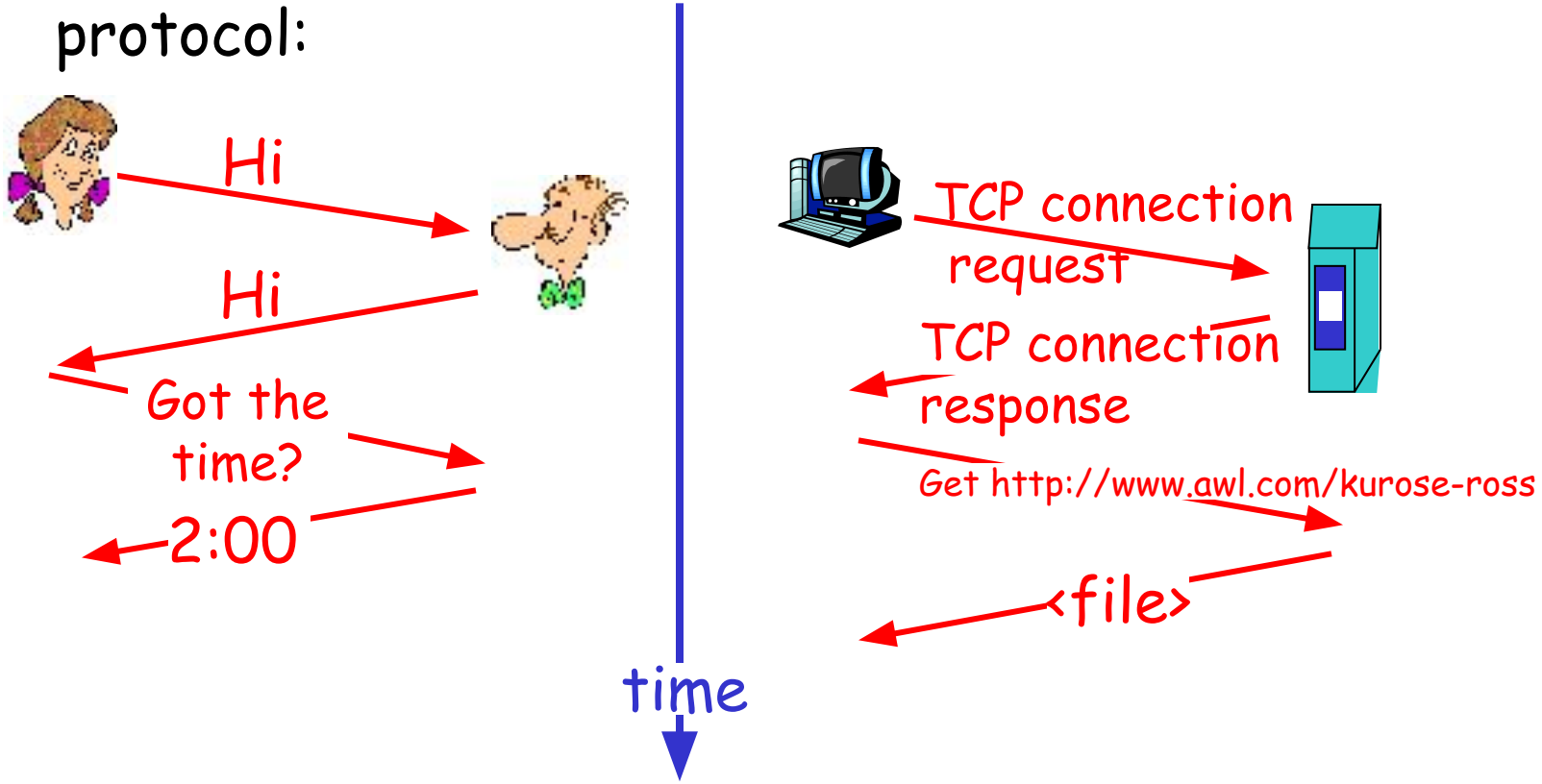
… specific actions taken when msgs received, or other events

network protocols:

- machines rather than humans
- all communication activity in Internet governed by protocols

What's a protocol?

a human protocol and a computer network protocol:



Q: Other human protocols?

Protocol

- An agreed upon convention for communication.
  - both endpoints need to *understand* the protocol.
- Protocols must be formally defined and unambiguous!
- Protocols define
  - format,
  - order of msgs sent and received among network entities,
  - actions taken on msg transmission, receipt
- We will study lots of existing protocols and perhaps develop a few of our own.

Programs & Processes

- A *program* is an executable file.
- A *process* or *task* is an instance of a program that is being executed.
- A single program can generate multiple processes.

Client - Server

- *A server* is a process - not a machine !
- A server waits for a request from a client.
- A client is a process that sends a request to an existing server and (usually) waits for a reply.

Client - Server Examples

- Server returns the time-of-day.
- Server returns a document.
- Server prints a file for client.
- Server does a disk read or write.
- Server records a transaction.

Servers

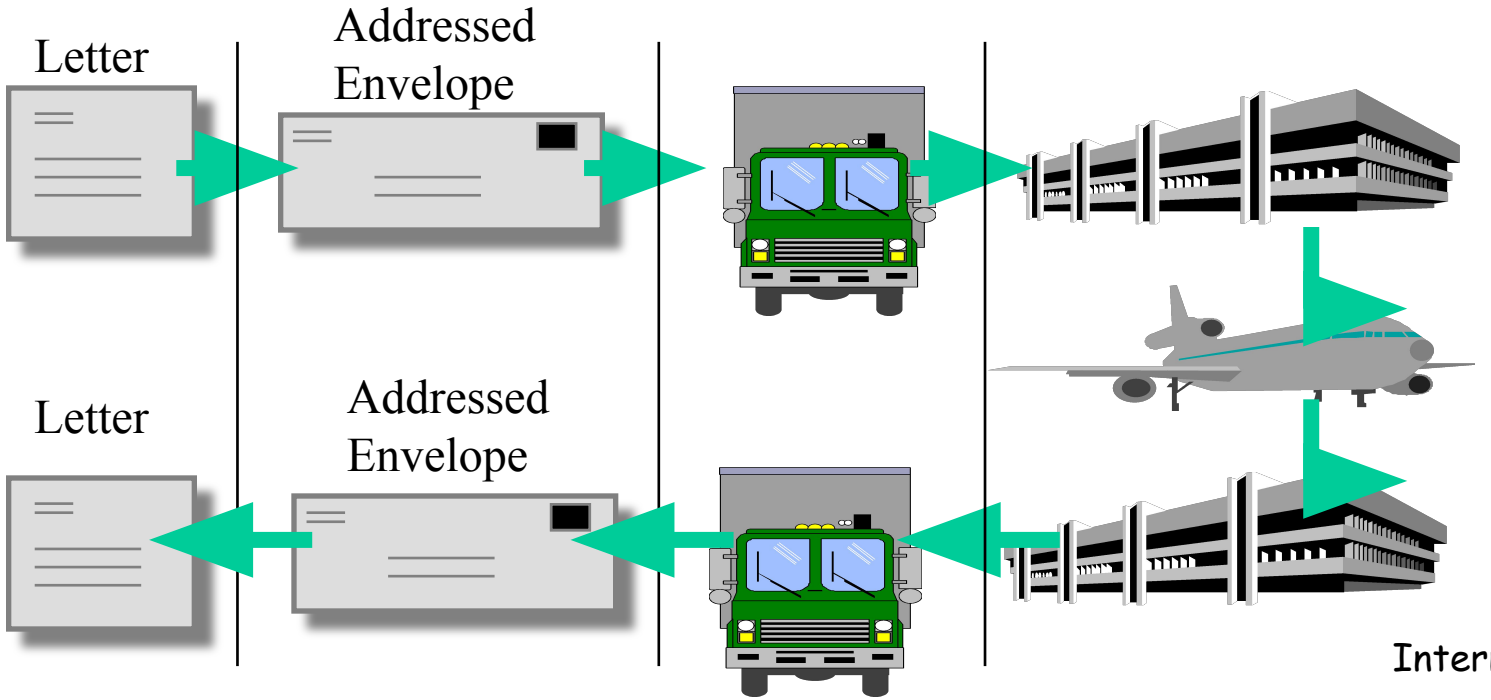
- Servers are generally more complex (more interesting).
- Basic types of servers:
  - *Iterative* - server handles one client at a time.
  - *Concurrent* - server handles many clients at a time.
- We will study the differences later.

Thought Exercise

- Come up with an example of a layered system.
- Describe the interface and peer-to-peer protocols for your example.

Layering Example: Federal Express

- Letter in envelope, address on outside
- FedX guy adds addressing information, barcode.
- Local office drives to airport and delivers to hub.
- Sent via airplane to nearest city.
- Delivered to right office
- Delivered to right person



Layered Software Systems

- Network software
- Operating systems
- Windowing systems

Unix is a Layered System