Networks and Protocols

- networks and protocols
  - definitions
  - motivation
  - history
- protocol hierarchy
  - reasons for layering
  - quick tour through the layers
- main example: the Internet

Networks

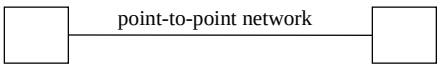
- A network is a set of machines connected by communication links.
- Machines can be
  - general-purpose computers
  - other devices (phones, Coke machines)
  - specialized network components
    - » routers
    - » switches

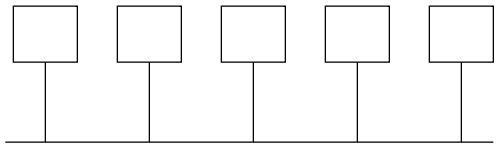
Motivation

- Why connect to a network?
  - share resources
  - help people communicate
- Sharing resources
  - from printers to supercomputer centers
- Helping people communicate
  - email, Web, active documents

Direct connectivity

- point-to-point or multiple access





multiple access network

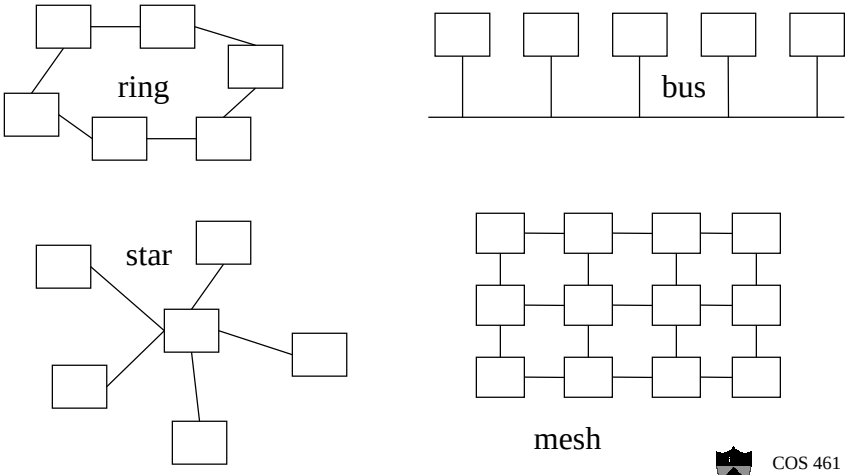
Media

- links can use many physical media
  - copper wire
  - optical fiber
  - radio
  - infrared
  - line-of-sight laser
  - layer on another network
    - » example: modem connection uses phone network

Copper Wires vs. Optical Fibers

- advantages of fiber
  - higher bandwidth
  - smaller and lighter
  - less prone to interference
  - less prone to eavesdropping
- advantages of copper
  - simple
  - cheap to interface to

Topologies



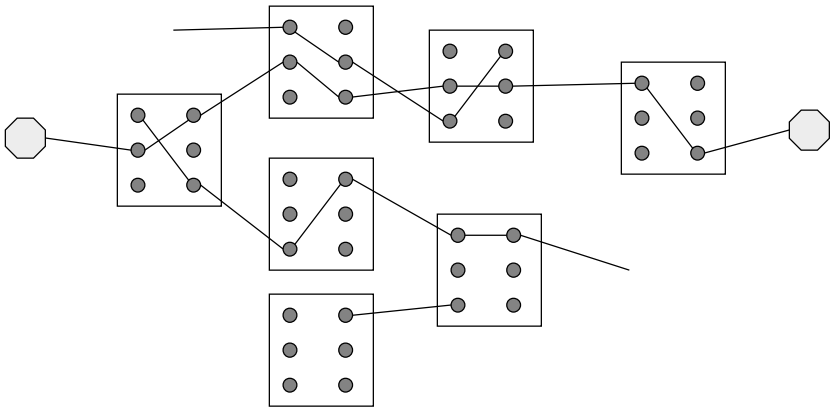
Network elements

- Intranet: many elements in one administrative domain
- Internet: collection of interconnected networks, across administrative domains
- host: a computer on the net
- router: host that routes packets from one link to another
  - often dedicated, with no applications

Circuit Switching

- example: telephony
- resources reserved during call setup
- resources dedicated for duration of call
- conservative
  - guarantee quality of service to all calls
  - resources dedicated even if call doesn't always need them
  - good for constant-bit-rate traffic

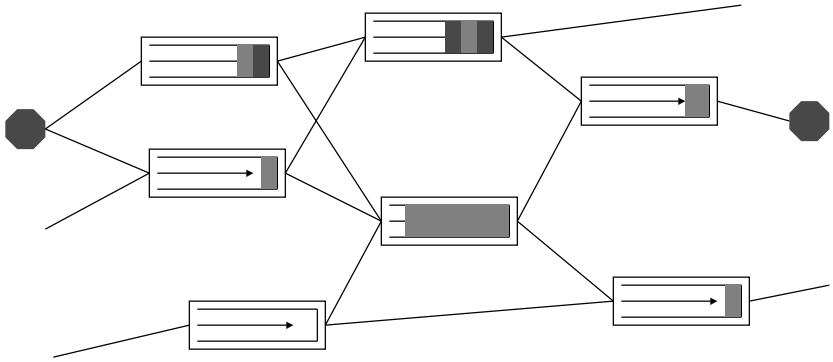
Circuit Switching



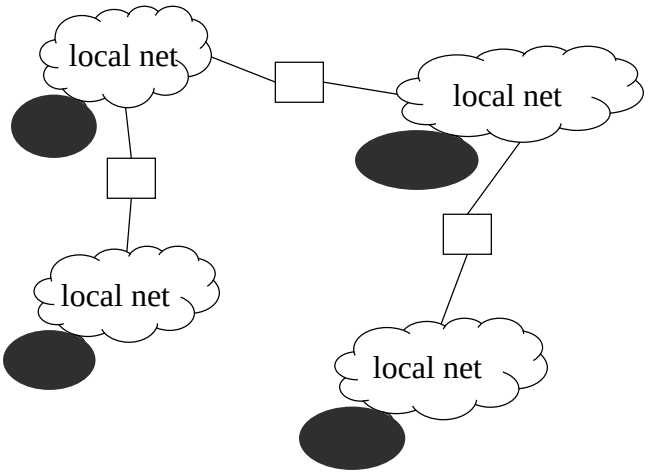
Packet Switching

- alternative to circuit switching
  - example: Internet
- entering data divided into packets
- packets in network share resources
  - no performance guarantees
- queue packets if link contention
- statistical multiplexing of resources

Packet Switching



Packet Switching in the Internet



Virtual Circuit

- cross between circuit switching and packet switching
- set up path before data flows
- resources along path are shared
- example: asynchronous transfer mode (ATM)
- cheaper than circuit switching, better guarantees than packet switching
- but: complicated

History of Networking

- 1870's
  - circuit-switched phone network
- 1960's
  - packet-switched data networks
  - 4-node ARPAnet in 1969
- 1970's
  - multiple-access nets (Aloha, Ethernet)
  - commercial nets (DECnet, IBM SNA)
  - 100-node ARPAnet in 1979

History of Networking

- 1980's
  - proliferation of LANs, WANs
  - 100k-node Internet in 1989
- 1990's
  - 4M-node Internet in 1995
  - commercialization
    - » ISPs
  - wireless LANs

Layering in Networks

- simplify complex engineering
  - layer N relies on services of layer N-1
  - layer N provides services to layer N+1
- interfaces between layers define services
- hide complexity
  - separate implementation from interface

Layered Protocols

Protocol

- a protocol specifies:
  - a set of rules for how network elements interact
  - the format of the messages exchanged
  - actions to take on receipt of messages
- specifications must be *exact*
- interoperability: ability of different implementations to work together

Protocol Hierarchy

- "official" seven-layer model
  - usually taught and memorized
  - seldom used except as terminology
- in practice, Internet uses four-layer model
  - focus on this model in this course
- top to bottom: application layer, transport layer, network layer, data link layer

Application Layer

- process-to-process communication
- supports application functionality
- examples
  - file transfer protocol (FTP)
  - simple mail transfer protocol (SMTP)
  - hypertext transfer protocol (HTTP)
  - network news transfer protocol (NNTP)
- you can add your own

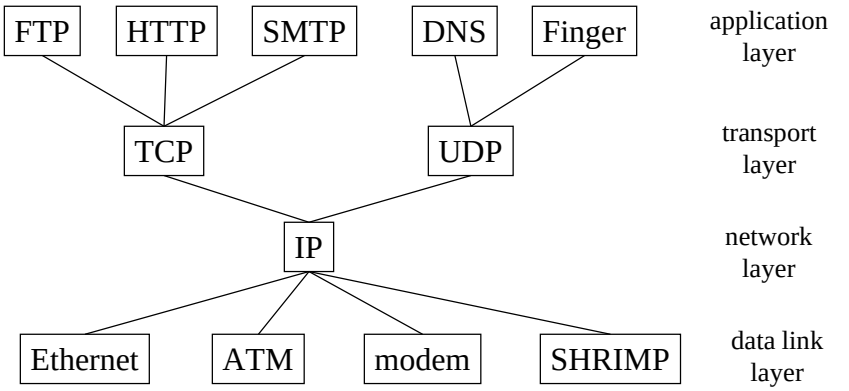
Transport Layer

- transmission control protocol (TCP)
  - provides reliable byte stream service
  - flow control
  - congestion control
- user datagram protocol (UDP)
  - provides unreliable unordered datagram service

Network Layer

- Internet protocol (IP)
  - the key to the architecture
  - can use many different data links layers
  - treats each network in the Internet as a link
  - no quality of service guarantee
  - can lose and misorder packets
  - "best effort" service

Data Link/Physical Layer

- comes from underlying network
  - Ethernet
  - ATM
  - phone/modem
  - you can (in theory) build your own

Internet Hierarchy