CSIS 4222

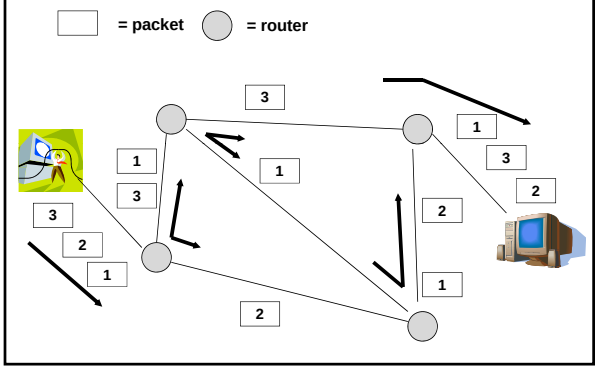
TCP/IP Networking Summary

Computer Networks

- Idea from the mid-1960s
  - Break up a message into small pieces
  - Send each piece individually, possibly along different paths
  - Let host at other end put it together
- Advantages
  - Helps when sending a large message
  - No one in the middle can figure it out

Piece: packet
Path: routing
} Packet switching

Sending a Message



What's Needed in a Packet?

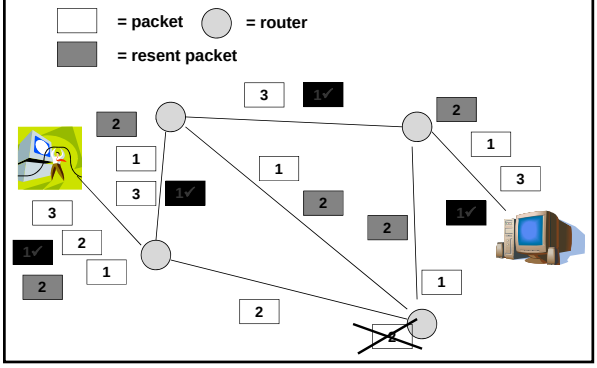
- Destination/source addresses
- What's it for (email, web,…?)
- Packet sequence number
  - Indicates start, middle, or end
- *Actual Data* (a part of the message)

} **Headers**

How to Communicate?

- Need rules that both sides understand
  Rule = protocol
- For example
  What should be in a packet
  What to do if a packet is lost
- Routers need to decide which way to send

When a packet is lost

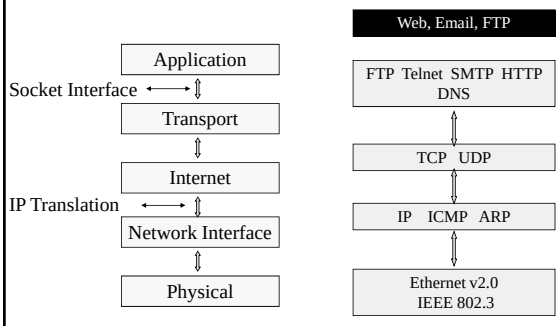


The Internet World

Functional view

- Applications: web, email, ftp
- Reliable transfer of information: end-to-end
- Routing in the network

Viewed as a protocol stack



TCP/IP Layer Summary

- Physical Layer
  - Handles the mechanical and electrical details of the physical medium
  - Physical "MAC" addressing
- Network Interface Layer
  - Prepares frames for the physical network
  - Binding of software to hardware (NIC)

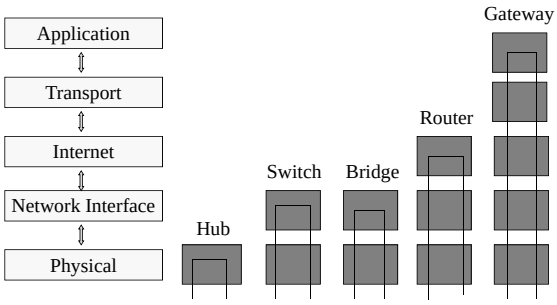
TCP/IP Layer Summary

- Internet Layer
  - IP addressing
  - Route data from source to destination
  - Host-to-host (unreliable) delivery
- Transport Layer
  - Application-to-application delivery
  - Connectionless or connection-oriented

TCP/IP Layer Summary

- Application Layer
  - Software application services for accessing network resources
  - Sockets (specify IP address, port number, protocol)

Networking Devices and TCP/IP



Networking Devices and TCP/IP

- Repeaters & hubs
  - Regenerates electrical signals between two network segments
- Bridges
  - Connect two or more network segments
    - Generally with identical network standards
  - Interpret physical addresses
  - Independent of protocol

Networking Devices and TCP/IP

- Switches
  - Functions similar to a bridge but faster
- Routers
  - Interpret logical addresses
  - May change frame format
  - Intelligent and configurable
  - Handle different protocols

Networking Devices and TCP/IP

- Routers, con't.
  - Can improve security
    - By direction: restricting inbound connections
    - By port/protocol: allow SMTP but not FTP
    - By address: Allow access to WWW and SMTP servers
    - By date/time
  - Can include firewall software for additional security
  - Reduce network congestion
    - Do not route broadcast messages
    - Drop packets if traffic is too much to handle
  - Isolate problems without taking down entire network

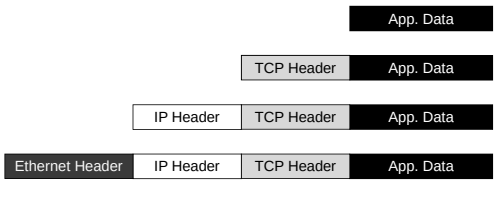
Networking Devices and TCP/IP

- Gateways (high-level)
  - Translate from one networking architecture to another
    - Ethernet to Token Ring
  - Convert multiple protocols
    - TCP/IP to SNA (IBM)
  - Use physical and logical addressing
  - Interpret data within the protocol
    - Unicode-ASCII-EBCDIC
- Note: Routers are commonly called gateways, but do not operate at the high levels shown here

Packets: What's in a name?

- Generic name: Protocol Data Unit (PDU)
- TCP/UDP segment: (transport layer)
- IP datagram: (internet layer)
- Frame: (e.g. Ethernet frame at MAC layer)
- Each layer adds its own header

PDU View - Encapsulation



Headers:
TCP = 20 bytes, IP = 20 bytes, Ethernet = 22 bytes
Ethernet trailer: 4 bytes

Basic TCP/IP Idea

- Network carries small pieces of information (datagrams)
  - Routes the datagrams
  - Unreliable delivery
- The end host takes care of transport layer
  - Sender: breaks message into pieces
  - Receiver: reassembles
  - Retransmission with acknowledgement

Note

- Splitting delivery into two parts:
  - Transport layer
  - Network layer
- TCP/IP
  - The end hosts maintain the state (TCP)
  - Routers are stateless (IP)
    - Don't know anything about connections

Routing Architecture

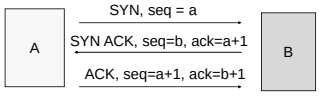
- Network divided into two parts
  - Intra-domain routing
    - RIP, OSPF
  - Inter-domain routing
    - BGP
- Interconnected national and regional backbones (public exchange points)
  - Region = AS

TCP

- Provides reliable end-to-end delivery
- Needs fragmentation & reassembly
- Needs timers
  - If datagram doesn't reach its destination, need to retransmit (how long to wait?)
- Network may be congested
  - How much more to pump in?
  - Guideline: Bandwidth-delay product
    T1 (1.5Mbps), delay 25 ms $\Rightarrow$ 4687 bytes
  - Sliding window, RTT, etc.

TCP Handshake

- TCP uses three-way handshake for establishing a connection



a: A's starting sequence #
b: B's starting sequence #

TCP Algorithms

- Start slowly
- Increase rate as ACKs are received
- When time out occurs (probably packet loss due to *congestion*)
  - Be cautious, reduce rate (window size)
  - Increase gradually
  - Additive increase, multiplicative decrease

Why is TCP Important?

- All well known reliable data applications ride on it
  - Email, ftp, telnet, web,…
- Applications have their own application layer protocol
  - SMTP, FTP, telnet, HTTP

Example

Client side:

- Makes HTTP request to www.stockton.edu
- Client opens a TCP connection to server
  - TCP connection established
  - Sends HTTP request
  - HTML file transfer starts from server side
- TCP connection closes

During HTML File Transfer

- Break file into chunks and give to TCP
- TCP breaks into smaller segments for use by IP
- IP routes datagrams unreliably
- If datagram loss occurs, TCP retransmits starting slowly (does not tell application)

UDP

- Transport Layer protocol for services that don't need reliable transfer
  - RealAudio, VoIP, etc.
- Unregulated
  - During congestion, TCP slows down, UDP may not
  - A big issue for emerging services

Domain Names

- Mnemonic
  - www.stockton.edu www.google.com
- A name can be mapped to either another name or an IP address
  - www.stockton.edu ⇒ loki.stockton.edu
    ⇒ 134.210.1.200
- DNS: name to address mapping
  - Supports user applications, e.g. web request first needs to map name to IP address
  - Distributed database
  - If name server is down, can't connect unless you know the IP address

TCP Over Wireless

- TCP was designed for wired networks
  - Packet loss to TCP means congestion
    TCP reduces window size
- But in wireless communication
  - Bit-error is high
  - Hand-off is a connectivity problem
- So TCP over wireless reduces window size when it "sees" a loss due to bit-error/hand-off

TCP Over Wireless

- Possible solutions
  - End-to-end
    - To recover from multiple loss, use selective ACK
    - Use explicit loss notification
    - ACK suppression
  - Split-connection
    - Use separate connection for the wireless part
  - Link-layer
    - Hide loss from TCP

      Forward error correction/link level retransmission