Chapter 15 addendum

CSMA/CD and IP

CSMA/CD (Ethernet)

- Commonly, coaxial cable or twisted-pair at 10 Mbps
- Standard media
  - 10 Base 2
    - Thin wire coaxial cable (0.25 inch) with maximum segment length of 200 m
  - 10 Base 5
    - Thick wire coaxial cable (0.5 inch diameter) with maximum segment length of 500 m
  - 10 Base T
    - Hub (star) topology with twisted-pair drop cables
  - 10 Base F
    - Hub (star) topology with optical fiber drop cables
CSMA/CD

• Thick-wire connections made with a tap; uses transceiver
• Transceiver functions
  – Send and receive data to and from the cable
  – Detect collisions on the cable medium
  – Provide electrical isolation between the coaxial cable and cable interface electronics
  – Protect the cable from any malfunctions in either the transceiver or the attached device (jabber control)

CSMA/CD

• Controller card
  – Encapsulation and de-encapsulation of frames for transmission and reception on the cable
  – Error detection
  – DMA
CSMA/CD

- Frame format
  - Preamble (7 octets, each equal to 10101010)
    - Used for bit synchronization
  - Start-of-frame delimiter (1 octet, 10101011)
  - Destination and source network addresses
    - 2 or 6 octets
    - Individual address or group address specified by first bit
  - Length indicator (2 octets)
  - Data (≤ 1500 octets)
  - Pad (optional), if needed to make minimum length requirements
  - Frame check sequence (i.e., CRC); 4 octets

CSMA/CD

- Frame transmission
  - Monitor link until empty. If not-empty, wait until empty and also for interframe gap time before transmitting (to allow the passing frame to be received)
  - During transmission, monitor to detect collision
  - If collision detected, stop transmission and turn on “jam signal” to guarantee that everyone detects the collision
  - Schedule retransmission after delaying for a short, randomly selected, time interval
CSMA/CD

- Collision
  - Retransmission of frame attempted up a defined maximum number of tries: attempt limit
  - Repeated collisions indicate a busy medium, so progressively increases time delay between repeated retransmission attempts. **Truncated binary exponential backoff**
    - After transmission of jam sequence, delay for random integral number of slot times before attempting to retransmit the affected frame
    - **Collision window**: effectively twice the time for the first bit of the preamble to propagate to all parts of the cable medium (corrupted signal may need to propagate back)
    - **Slot time** defines worst-case time delay must wait
    - Slot time = 2 x (transmission path delay) + safety margin
    - Number of slot times to wait is a uniformly distributed random integer R in the range 0 <= R < 2^K, where K = min(N, backoff limit)

TCP/IP

- Internet’s protocol; developed in 1980’s
- Supports communication across heterogeneous networks (i.e., internets)--note small “i”
- No official protocol model, but can arrange tasks into five relatively independent layers
  - Application layer
  - Host-to-host, or transport layer
  - Internet layer
  - Network access layer
  - Physical layer
TCP/IP protocol layers

- Application layer
  - Logic to support user applications (ISO session, presentation, and application layers)
- Host-to-host, or transport layer
  - Message transfer between clients; packetizing; maintaining packet order, etc. (ISO transport layer)
  - TCP (also UDP)
- Internet layer
  - Procedures to allow data to traverse multiple, interconnected networks (ISO network layer, in part)
  - IP: internet protocol

TCP/IP protocol layers

- Network access layer
  - Exchange of data between an end system and the network to which it is attached (ISO link layer and network layer, in part)
  - Examples: X.25 (packet switching), Ethernet, etc.
- Physical layer
  - Physical interface between a data transmission device and a transmission medium or network (ISO Physical layer)
TCP/IP concepts

- Logically, each level communicates with its peer
- Physically, message begins at application level and passes through each lower-level layer in turn
  - Each layer adds a header to the message on transmission, strips the header off on receipt
  - More information about header contents later
    - Example information in TCP header includes destination port, sequence number, checksum
    - Example information in IP header includes destination subnetwork address, facilities requests (e.g., priority in the subnetwork)
Protocol data units in the TCP/IP architecture

TCP and UDP

- Transport layer protocols
- TCP: reliable connection for the transfer of data between applications
- UDP: connectionless service for application-level procedures; does not guarantee delivery, preservation of sequence, or protection against duplication; enables messages to be sent with only a minimum of protocol overhead
- Protocol goals reflected in headers (follow)
TCP and UDP headers

<table>
<thead>
<tr>
<th>Bit: 0</th>
<th>4</th>
<th>10</th>
<th>16</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Port</td>
<td>Destination Port</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acknowledgement Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Header Length</td>
<td>Unused</td>
<td>Flags</td>
<td>Window</td>
<td></td>
</tr>
<tr>
<td>Checksum</td>
<td>Urgent Pointer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Options + Padding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TCP header

<table>
<thead>
<tr>
<th>Bit: 0</th>
<th>16</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Port</td>
<td>Destination Port</td>
<td></td>
</tr>
<tr>
<td>Segment Length</td>
<td>Checksum</td>
<td></td>
</tr>
</tbody>
</table>

UDP header

TCP/IP applications

- Simple Mail Transfer Protocol (SMTP) [TCP]
- File Transfer Protocol (FTP) [TCP]
- Telnet [TCP]
- Name Server Protocol (NSP)
- Simple Network Management Protocol (SNMP) [UDP]
Network services, Internet style

tcpmux 1/tcp
echo 7/tcp
echo 7/udp
discard 9/tcp sink null
discard 9/udp sink null
systat 11/tcp users
daytime 13/tcp
daytime 13/udp
netstat 15/tcp
chargen 19/tcp ttys0 source
chargen 19/udp ttys0 source
ftp-data 20/tcp
ftp 21/tcp
telnet 23/tcp
smtp 25/tcp mail
time 37/tcp timserver
time 37/udp timserver
name 42/udp nameserver
whosis 43/tcp nicname # usually to sri-nic
domain 53/udp
domain 53/tcp
bootps 67/udp # BOOTP/DHCP server
bootpc 68/udp # BOOTP/DHCP client
hostnames 101/tcp hostname # usually to sri-nic
sunrpc 111/udp rpcbind
sunrpc 111/tcp rpcbind
tftp 69/udp
rje 77/tcp
finger 79/tcp
link 87/tcp ttys0
supdup 95/tcp
iso-tsap 102/tcp
x400 103/tcp # ISO Mail
x400-and 104/tcp
canet-ns 105/tcp
pop-2 109/tcp # Post Office
uucp-path 117/tcp
nntp 119/tcp uucp # Network News Transfer
ntp 123/tcp # Network Time Protocol
ntpd 123/udp # Network Time Protocol
NeWS 144/tcp news # Window System

Host specific functions

tftp 69/udp
rje 77/tcp
finger 79/tcp
link 87/tcp ttys0
supdup 95/tcp
iso-tsap 102/tcp
x400 103/tcp # ISO Mail
x400-and 104/tcp
canet-ns 105/tcp
pop-2 109/tcp # Post Office
uucp-path 117/tcp
nntp 119/tcp uucp # Network News Transfer
ntp 123/tcp # Network Time Protocol
ntpd 123/udp # Network Time Protocol
NeWS 144/tcp news # Window System
# UNIX specific services
#
# these are NOT officially assigned
#
exec 512/tcp
login 513/tcp
shell 514/tcp cmd # no passwords used
printer 515/tcp spooler # line printer spooler
courier 530/tcp rpc # experimental
cucp 540/tcp uucpd # uucp daemon
kdiff 512/udp comsat
who 513/udp whod
syslog 514/udp
talk 517/udp
route 520/udp routed
new-rwho 550/udp new-rwho # experimental
rmonitor 560/udp rmonitor # experimental
monitor 561/udp
pcserver 600/tcp # ECD Integrated PC board srvr
kerberos 750/udp kdc # Kerberos key server
ufsd 1008/tcp ufsd # UFS-aware server
ufs 1008/udp ufsd
ingreslock 1524/tcp
listen 2766/tcp # System V listener port
nfs 2049/udp nfs # NFS server daemon (cits)
nfs 2049/tcp nfs # NFS server daemon (cots)
lockd 4045/udp # NFS lock daemon/manager
lockd 4045/tcp
dtspc 6112/tcp # CDE subprocess control
fs 7100/tcp # Font server
xaudio 1103/tcp xaserver # X Audio Server