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 $0 \le R < 2^K$, 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
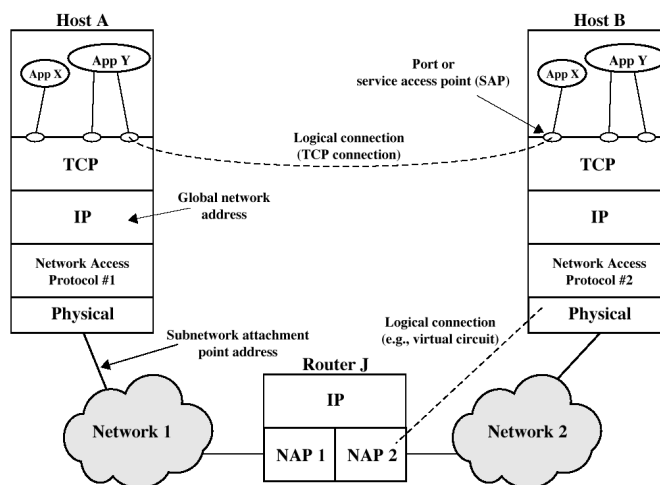 - Network access layer
  - Physical layer

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)
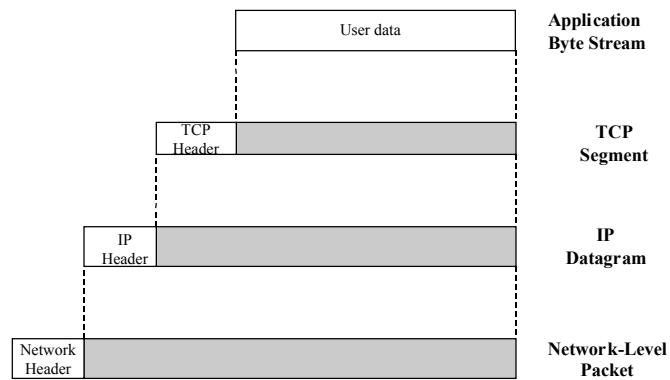
TCP/IP concepts

Protocol stack

- 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)
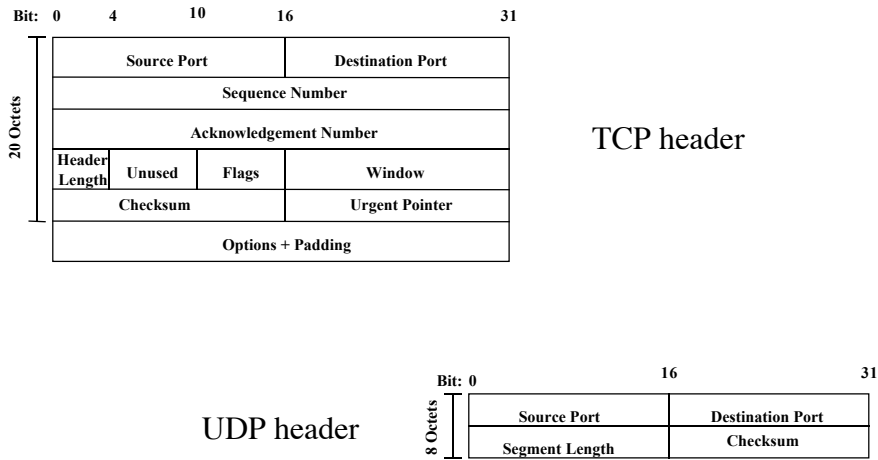
Protocol data units in the TCP/IP architecture

	Box	Label
	User data	**Application Byte Stream**
TCP Header		**TCP Segment**
IP Header		**IP Datagram**
Network Header		**Network-Level Packet**

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

Bit: 0   4   10   16   31

Source Port	Destination Port
Sequence Number	
Acknowledgement Number	
Header Length / Unused / Flags / Window	
Checksum	Urgent Pointer
Options + Padding	

20 Octets

TCP header

Bit: 0   16   31

UDP header

Source Port	Destination Port
Segment Length	Checksum

8 Octets

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]

```
#ident    "@(#)services      1.16     97/05/12 SMI"      /* SVr4.0 1.8      */
#
# 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              ttytst source
chargen         19/udp              ttytst 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
whois           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
```

```
#
# Host specific functions
#
tftp            69/udp
rje             77/tcp
finger          79/tcp
link            87/tcp              ttylink
supdup          95/tcp
iso-tsap   102/tcp
x400            103/tcp                                 # ISO Mail
x400-snd   104/tcp
csnet-ns   105/tcp
pop-2           109/tcp                                 # Post Office
uucp-path 117/tcp
nntp            119/tcp        usenet         # Network News Transfer
ntp             123/tcp                                 # Network Time Protocol
ntp             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
uucp            540/tcp         uucpd               # uucp daemon
biff            512/udp         comsat
who             513/udp         whod
syslog          514/udp
talk            517/udp
route           520/udp         router routed
new-rwho  550/udp            new-who              # experimental
rmonitor  560/udp            rmonitord # experimental
monitor         561/udp                            # experimental
pcserver  600/tcp                            # ECD Integrated PC board srvr
kerberos  750/udp         kdc             # Kerberos key server
kerberos  750/tcp         kdc             # Kerberos key server
ufsd            1008/tcp ufsd                # UFS-aware server
ufsd            1008/udp ufsd
ingreslock    1524/tcp
listen          2766/tcp                      # System V listener port
nfsd            2049/udp nfs             # NFS server daemon (clts)
nfsd            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
```