Metcalfe's Law The value of a network grows $O(n^2)$, where n is the number of nodes in a network.

Baud Rate The number of signal changes per second.

Bandwidth The bits per second that can be transmitted.

Data Rate = Baud Rate (symbols/second)×$\log_2$ (# of distinct symbols)

Simple and Inexpensive Ethernet is simple and inexpensive to implement.

Shared Medium All devices on a network share the same medium. (Defunct)

Carrier Sense Multiple Access w/ Collision Detection (CSMA/CD) Devices listen before transmitting. If collision detected, devices wait a random amount of time before retransmitting. (Defunct)

MAC Consists of 48 bits, with the first 24 bits being the Organizationally Unique Identifier (OUI).

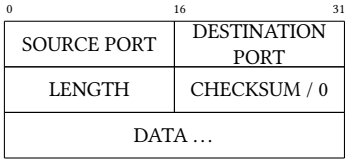
Broadcast Address FF:FF:FF:FF:FF:FF
Multicast Address First bit 1.
(e.g. 01:00:5E:00:00:01)
Local Address Second-least sig. bit 1.
(e.g. 02:00:00:00:00:01)

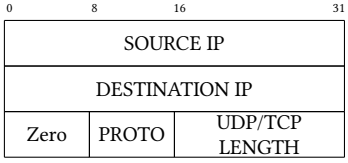
Application	HTTP, FTP, …
Transport	TCP, UDP
Internet	Datagrams
Link	MAC, Frames
Physical	Ethernet, WiFi

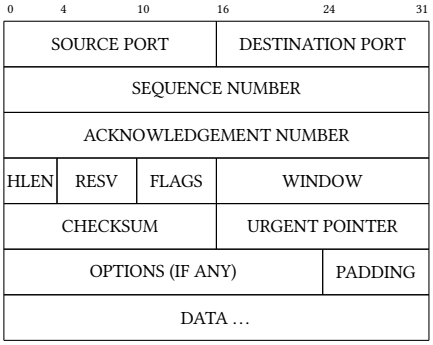
all 0s		This host
all 0s	host	Host on network
all 1s		Local broadcast
net	all 1s	Net broadcast
127	any	Loopback

Device	Function	Layer	Key Characteristics
Repeater	Amplifies or regenerates signals to extend transmission distance	Physical	Signal Amplification
Hub	Connects devices in a network, broadcasting data to all devices	Data Link	Simple, No intelligience / learning
Bridge	Filters traffic between two networks, forwards based on MAC		Reduces collision domains
Switch	Smart HUB that forwards based on MAC		Learns MAC addresses

DHCP Dynamic IP assignment, uses UDP (server 67, client 68).
Mail Submission Agent (MSA) Submits mail to the Mail Transfer Agent (MTA).
Mail Transfer Agent (MTA) Transfers mail between servers.
Mail Delivery Agent (MDA) Delivers mail to the recipient's mailbox.
Mail Retrieval Agent (MRA) Retrieves mail from the mailbox.
Simple Mail Transfer Protocol (SMTP) Used by the MSA and MTA.
Internet Message Access Protocol (IMAP) Used by the MRA, allows for marking email as read.
Post Office Protocol 3 (POP3) Used by the MRA, worse IMAP.







socket Creates a socket
bind Assigns an address to a socket
listen Marks a socket as passive
accept Accepts a connection request
connect Initiates a connection
send Sends data
recv Receives data
close Closes the socket

Flow Control

Silly Window Syndrome Data sent in inefficiently small chunks (high overhead). Either delay ACK and ad 0 window size (Clark's), or buffer data (Nagle's).

Valid ports are $[1, 65535]$, with $[1, 1023]$ being privileged.

$$RTT = \alpha \cdot RTT + (1 - \alpha) \cdot RTT_{\text{sample}}$$
$$Timeout = \beta \cdot RTT$$
Upon Timeout : $Timeout = \gamma \cdot \text{Timeout}$

Congestion Control

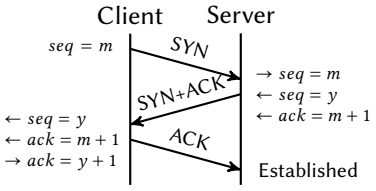
Slow Start *Exponentially* increase window, till congestion window size.
Congestion Avoidance *Linear* increase in window size.
Karn's Algorithm Multiply timeout by γ upon timeout.

Classful Addressing

Class A	0XXXXXXX	/8
Class B	10XXXXXX	/16
Class C	110XXXXX	/24
Class D	1110XXXX	/31
Class E	1111XXXX	/32

'This' network host bits 0.
Broadcast host bits 1.

TCP



RED

TCP

- Connection-oriented
- Stream-based
- Reliable
- High Overhead

Server

- `socket`
- `bind`
- `listen`
- `accept`
- `send` / `recv`
- `close`

Client

- `socket`
- `connect`
- `send` / `recv`
- `close`

UDP

- Connectionless
- Message-based
- Unreliable
- Low Overhead

Server

- `socket`
- `bind`
- `recvfrom`
- `sendto`
- `close`

Client

- `socket`
- `sendto`
- `recvfrom`
- `close`