ISO/OSI Stack, LAN Technologies (Ethernet, Token Ring)

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OSI Model

- Open Systems Interconnection Reference Model, developed in 1984 by the International Standards Organization (ISO).
- It is a way of sub-dividing a communications system into smaller parts called layers.
- A layer is a collection of conceptually similar functions that provide services to the layer above it and receives services from the layer below it.
- Provides a set of design standards for equipment manufacturers so they can communicate with each other. It is basic guideline for protocol development.

1. Physical Layer

- Conveys the bit stream through the network at the electrical and mechanical level.
- Defines physical means of moving data over network devices.
- Interfaces between network medium and devices.
- Defines optical, electric and mechanical characteristics: voltage levels, timing of voltage changes, physical data rates, transmission distances and physical connection.

2. Data Link Layer

- Takes a string of bits and delivers it across a link.
- Conveys the bit stream through the network at the electrical and mechanical level (i.e., Layer 1).
- Turns packets into raw bits and bits into packets.

Framing and Error detection :

(*i*) Break the bit stream up into frames.

(*ii*) Compute an error-detection code.

(*iii*) Transmit each frame separately.

3. Network Layer

- Translates logical network address and names to their physical address (e.g., device name to MAC address).
- **Responsible for :**

  (*i*) Addressing.

  (*ii*) Determining routes for sending.

  (*iii*) Managing network problems such as packet switching, data congestion and routing.
- Breaks the data into smaller unit and assembles data.
- Shields higher layers from details of how the data gets to its destination.

4. Transport Layer

- Divides streams of data into chucks or packets
- Reassembles the message from packets
- Provide error-checking to guarantee error-free data delivery, with no losses or duplications.
- Provides acknowledgment of successful transmissions.
- Requests retransmission if some packets don't arrive error-free.
- Provides flow control and error-handling.

5. Session Layer

- Establishes, maintains and ends sessions across the network.
- Responsible for name recognition (identification) so only the designated parties can participate in the session.
- Provides synchronization services by planning check points in the data stream.
- If session fails, only data after the most recent checkpoint need be transmitted.
- Manages who can transmit data at a certain time and for how long.

6. Presentation

- Translates from application to network format and vice-versa.

- All different formats from all sources are made into a common uniform format that the rest of the OSI can understand.
- Responsible for protocol conversion, character conversions, data encryption/decryption, expanding graphics commands and data compression.
- Sets standards for different systems to provide seamless communication from multiple protocol stacks.

7. Application Layer

- Used for applications specially written to run over the network.
- Allows access to network services that support applications.
- Directly represents the services that directly support user applications (e.g., file transfer and email).
- What the user sees or does.

PROTOCOLS	
Application	NNTP, SIP, SSI, DNS, FTP, Gopher, HTTP, NFS, NTP, SMPP, SMTP, DHCP, SNMP, Telnet, Netconf
Presentation	MIME, XDR, TLS, SSL
Session	Named Pipes, NetBIOS, SAP, SIP, L2TP, PPTP
Transport	TCP, UDP, SCTP, DCCP
Network	IP (IPv4, IPv6), ICMP, IPsec, IGMP, IPX, AppleTalk
Data Link	ATM, SDLC, HDLC, ARP, CSLIP, SLIP, PLIP, IEEE 802.3, Frame Relay, ITU-T G.hn DLL, PPP, X.25
Physical	EIA/TIA-232, EIA/TIA-449, ITU-T V-Series, I.430, I.431, POTS, PDH, SONET/SDH, PON, OTN, DSL, IEEE 802.3 IEEE 802.11, IEEE 802.15, IEEE 802.16, IEEE 1394, ITU-T G.hn PHY, USB, Bluetooth

Token Ring (IEEE 802.5)

- **Characteristics of Token Ring**
  (*i*) It offers connectionless communication.
  (*ii*) It uses ring topology.
  (*iii*) It uses token passing as an access control method.
  (*iv*) There are no collisions, priorities are possible, offers deterministic service.

- **Token Holding Time (THT):**
  (*i*) The maximum time a token frame can be with held by a station, by default it is set to 10 msecs.
  (*ii*) No station can keep the token beyond THT (It solves monopolization problem)
- **Monitor:**
  (*i*) The station with highest priority/MAC address and which generates the token frame is called monitor.
  (*ii*) Monitor maintains Minimum TRT and Maximum TRT.

  Min TRT = Propagation delay + (Number of stations × Delay at each station)

  Max TRT = Propagation delay + (Number of stations × THT)
- **Frame format of 802.5:**
  (*i*) To bypass a faulty station two data rates are there
  (a) 4 Mbps (minimum ring length of 1200 meters)
  (b) 16 Mbps (minimum ring length of 300 meters)
  (*ii*) Frame format of 802.5
  (a) Data Frame

	SD	AC	FC	DA	SA	Data	CRC	ED	FS
Bytes	(1)	(1)	(1)	(2/6)	(1)	(0-4500)	(4)	(1)	(1)

Starting Delimiter (SD): JK0JK000 [J&K are non data symbols]

Access Control (AC): PPPTMRRR $\begin{bmatrix} T = 1 \text{ for data} \\ = 0 \text{ for token} \end{bmatrix}$

Ending Delimeter (ED): JK1JK1IE [I = Intermediate frame Indication, E = Error detection bit]

Frame Status (FS): ACrrACrr [r = unused bit]

A (Destination)	*C* (Frame Acceptance)
0	0 → Destination not present and frame not accepted
0	1 → Not posible
1	0 → Destination present and frame not accepted
1	1 → Destination present and frame accepted

(b) Token Frame

SD	AC	ED
(1)	(1)	(1)

(c) Abort Frame

SD	ED
(1)	(1)

- **Ring Latency (RL):** Time taken for a bit to travel around ring.

$$RL = \frac{d}{v} + \frac{Mb}{R}\text{ (seconds)} = \frac{dR}{v} + Mb\text{ (bits)}$$

where d : Length of link (meters), v : Velocity (m/s),
M : Number of station, R : Data rate of link (bps)

- Data transfer rate $= \dfrac{f}{t_1 + t_2 + \dfrac{f}{B}}$;

where f : Frame length, B : Channel capacity or bandwidth,
t_1 : Ring latency time, t_2 : token observing time

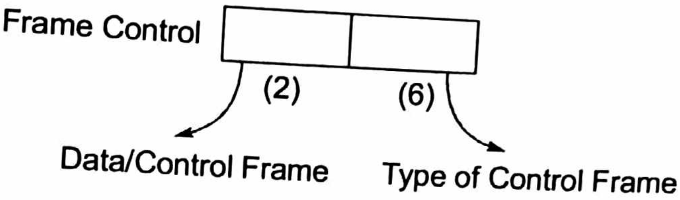
- Length of link (in bits) $= R \times \dfrac{d}{v}$

$$\text{Utilization} = \frac{T_1}{T_1 + T_2} = \frac{1}{1 + \frac{a}{N}};\ \textbf{if } a < 1$$

$$= \frac{1}{a\left(1 + \frac{1}{N}\right)};\ \textbf{if } a > 1$$

where T_1 : Average time to transmit a data frame
T_2 : Average time to pass a token
N : Number of stations

- **For minimum Token Size:** Propagation delay = Transmission delay
- **Types of Control Frame:**
  - (*i*) **Becon Frame:** (000010) to find major faults in ring
  - (*ii*) **Claim Token:** (000011) used in election process of monitor
  - (*iii*) **Purge:** (000100) used to clear unwanted signals
  - (*iv*) **Active monitor present:** (000101) to inform all the stations that monitor is alive
  - (*v*) **Stand by monitor present:** (000110) to carryout neighbour identification process
  - (*vi*) **Duplicate address test:** (000000) For virtual PC, physical address may change



Delay Token Ring Reinsertion Strategy (DTR)	Early Token Ring Reinsertion Strategy (ETR)
(a) Token is reinserted after getting the entire data packet	(a) Token is reinserted as soon as data transmission is over
(b) Efficiency is low and always only one packet is available on the link	(b) Efficiency is high and many packets can be available on the link
(c) Reliability is high. THT = 10 ms	(c) Reliability is low, no meaning of THT
(d) It is used under no load conditions	(d) It is used under high load conditions
(e) Cycle time = $a + b + c + d$	(e) Cycle time = $a + c + d$ a : Packet transmission time b : Ring latency c : Token transmission d : Propagation delay between stations

Ethernet (IEEE 802.3)

- **Characteristics of Ethernet:**
  (*i*) It offers connectionless communication
  (*ii*) No acknowledgment, no flow and error control
  (*iii*) It uses bus topologies for its operation
  (*iv*) It uses CSMA/CD as accessing technology

Maximum duration for contention slot = 2 × Propagation delay

$$\text{Contention Period} = \frac{2 \times \text{Propagation delay}}{A}; A = 1/e$$

- **Frame Format:**

	Preamble	SFD	DA	SA	Length	Data	CRC
Bytes	7	1	6	6	2	(46 to 1500)	4
	1010....10	10101011					

Minimum Ethernet Frame Size:

$DA + SA$ + Length + Data (min) + CRC

= 6 + 6 + 2 + 46 + 4 bytes = 64 bytes

Maximum Ethernet Frame Size:

$DA + SA$ + Length + Data (max) + CRC

= 6 + 6 + 2 + 1500 + 4 bytes =1518 bytes

- Channel efficiency (utilization η) = $\dfrac{1}{1+\dfrac{2BLe}{vf}} = \dfrac{1}{1+5.44a}$

$$a = \frac{\text{Propagation delay}}{\text{Transmission delay}} = \frac{d/v}{f/B}$$

If length of packet increases η also increases

where f : Frame length, v : Speed of signal propagation
e : Contention slots/frame, L : Cable Length (d)
B : Network bandwidth, a : Propagation delay
$2T$: Duration of each slot = 2 × propagation delay
A : Slot probability = $(1/e)$

- The probability of one station succeeding in putting its traffic on a network of 'n' stations is given as $nP(1-P)^{n-1}$
- **CSMA/CD for ethernet:**

$$\text{Utilization } \eta = \frac{1}{1+6.44a}\begin{bmatrix}\text{used when ack information}\\ \text{is not provided}\end{bmatrix}$$

$$C.P. = \text{Number of slots} \times \text{Slot duration} = e \times 2 \times (d/v)$$

$$\text{Utilization} = \frac{T.P.}{T.P.+C.P.} = \frac{\left(\frac{1}{2a}\right)}{\left(\frac{1}{2a}\right)+\left(\frac{1-A}{A}\right)}$$

where, $\dfrac{1}{2a}$ = Transmision Interval

$\dfrac{1-A}{A}$ = Contention Interval

$$A = \left(1-\frac{1}{N}\right)^{N-1};\ N = \text{Number of stations}$$

Flow Control

- The procedures to be followed by the transmitter sender and receiver for efficient transmission and reception is called as flow control.
- **Two approaches**
  - **Stop and wait – Error control (stop and wait ARQ)**
  - **Sliding Window Protocol (SWP)**

Stop and Wait ARQ

- Only one frame at a time on the link ⇒ poor utilization ⇒ poor efficiency
- Efficiency $\eta = \dfrac{t_{transmit}}{(t_{transmit}) + (2\, t_{propagation})}$

$$= \frac{f/B}{f/B + RTT} = \frac{1}{1+2a} \quad \left[\because \; a = \frac{t_{propagation}}{t_{transmission}}\right]$$

- It is an example of closed loop control protocol.
- Positive ACKs are numbered in Stop and Wait.
  Negative ACKs are not numbered
- **Throughput = 1 window/RTT = 1 Packet/RTT**
- It is a **special category of SWP** of window size = 1

Go-back N (GBN) ARQ

- Receiver window size (RWS) = 1
- Sender window size (SWS) = $2^K - 1$ where, K is number of bits received for window size in the header.
- Efficiency = $(2^K - 1) \times \dfrac{t_{transmission}}{t_{transmission} + RTT}$
- $W_S + W_R \leq$ ASN (Available Sequence Number)
- Uses cumulative/Piggybacking acknowledgments
- GBN is called as "conservating protocol".

Selective Repeat (SR)

- $W_S = W_R = \dfrac{N}{2}$; $N \rightarrow$ maximum ASN (2^K)
- It uses piggybacking/cumulative/Independent acknowledgments.
- It accepts out of order of packets.
- Efficiency = $(2^{K-1}) \times \dfrac{t_{transmit}}{t_{transmit} + RTT}$
- With piggyback throughput = $\dfrac{2 \times \text{Packet}}{RTT}$
- Round Trip Time (RTT): It is minimum acknowledgment waiting time.
  RTT = 2 × Propagation delay
- **Time Out:** It is the maximum acknowledgment waiting time

Wireless IEEE 802.11:

- **Wireless hosts:** In the case of wired networks, hosts are the end-system devices that run applications.
- **Wireless links:** A host connects to a base station (defined below) or to another wireless host through a wireless communication link.
- **Base station:** A base station is responsible for sending and receiving data (e.g., packets) to and from a wireless host that is associated with that base station. Access points in 802.11 wireless LANs are examples of base stations.

  Two Types of mode:

  (*i*) **Infrastructure mode:** since all traditional network are provided by the network to which a host is connected via the base station.

  Types of Infrastructure mode:

  (a) **Single-hop, infrastructure-based:** Base station is used in these networks which is connected to a larger wired network where all communication is between this base station and a wireless host over a single wireless hop.

  (b) **Multi-hop, infrastructure-based:** A base station is present that is wired to the larger network where some wireless nodes may have to relay their communication through other wireless nodes in order to communicate via the base station.

  (*ii*) **Adhoc networks:** wireless hosts have no such infrastructure with which to connect. In the absence of such infrastructure, the hosts themselves must provide for services.

  Types of Adhoc mode:

  (a) **Single-hop, infrastructure-less:** In this no base station that is connected to a wireless network.

  (b) **Multi-hop, infrastructure-less:** There is no base station in these networks, and nodes may have to relay messages among several other nodes in order to reach a destination.

- **Basic service set (BSS):** A BSS contains one or more wireless stations and a central base station, known as an access point (AP) in 802.11.
- Each 802.11 wireless station has a 6-byte MAC address also each AP also has a MAC address for its wireless interface.
- 802.11b and 802.11g use the 2.4 Ghz ISM band offering only 33 non-overlapping channels.
- 802.11a uses 55GHz ISM band offering at-least 23 non-overlapping channels.

- 802.11n can use either the 2.4 GHz or the 55 GHz band while 802.11c uses only the 55 GHz band.
- **WiFi jungle:** Any physical location where a wireless station receives a sufficiently strong signal from two or more APs.
- **Scanning:** The process of scanning channels and listening for beacon frames is known as **Passive scanning**. In **Active scanning**, wireless station broadcasting a probe frame that will be received by all APs within the wireless host's range. APs respond to the probe request frame with a probe response frame. The wireless host can then choose the AP with which to associate from among the responding APs.

  (*i*) Passive scanning:
  - (a) Beacon frames sent from Aps.
  - (b) Association request frame sent: Host to selected AP.
  - (c) Association response frame sent: Selected AP to Host.

  (*ii*) Active scanning:
  - (a) Probe request frame broadcast from Host.
  - (b) Probes response frame sent from APs.
  - (c) Association request frame sent: Host to selected AP.
  - (d) Association response frame sent: Selected AP to Host.
- Instead of using collision detection, 802.11 uses collision-avoidance techniques. Second, because of the relatively high bit error rates of wireless channels, 802.11 (unlike Ethernet) uses a link-layer acknowledgment/retransmission (ARQ) scheme.
- The 802.11 MAC protocol uses **link-layer acknowledgments SIFS and DIFS.**
- Binary exponential backoff uses.
- **Hidden Terminal Problem** is avoided by using RTS (Request to Send) and CTS (Clear to Send).

Frame Format:

2 bytes	2 bytes	6 bytes	6 bytes	6 bytes	2 bytes	6 bytes	0 to 2312 bytes	2 bytes
FC	D	Address-1	Address-2	Address-3	SC	Address-4	Frame body	FCS

Frame Format

Frame Control

Protocol version	Type	Subtype	To DS	From DS	More flag	Retry	Power management	More data	WEP	Rsvd
2 bits	2 bits	4 bits	1 bit	1 bit	1 bit	1 bit	1 bit	1 bit	1 bit	1 bit

Subfield of Frame Control