

*January Exam***LAYERED ARCHITECTURE**

Each layer in the architecture offers a set of services to the layer above, using the services from the layer below. Communication is passed from the highest layer down to the lowest layer, then back up.

Advantages

- Structured way to discuss system components.
- Allows changing the implementation of a specific layer without affecting other layers.
- Simplifies implementation of a protocol into dealing with only a subset of communication.
- Allows different choices of protocols at each layer for different uses
- Allows functions of communication to be distributed across different systems, as long as they implement the functions & services.

Disadvantages

- Layers may duplicate lower-layer functionality.
- Higher-layer protocols may need information from lower-layer protocols it cannot access.
- Increased system complexity
- Optimization of the system must be done at each layer

ISO/OSI Layers

Application Interface between user & OSI model, allows protocols like HTTP, DNS, etc.

Presentation Common representation of data, encryption, data compression

Session Session setup, teardown, recovery of session, authentication

Data Comm. & Netwk. Sec.

Transport Network-level flow control, segment splitting, controlling reliability of data transfer, port addressing

Network Routing of datagrams across a network, network-level addressing, router-management messaging

Link node-to-node data transfer, MAC, link-level flow control

Physical Transmission of bits, coding of transmission across medium

TCP/IP

Application Includes Presentation & Session functionality, HTTP, DNS, FTP, SMTP

Transport TCP & UDP

Internet IPv4 & IPv6, ICMP

Data-Link ARP, Ethernet & Wi-Fi frame control

Physical

The TCP/IP model is a description of the TCP/IP architecture, the ISO/OSI model is a fixed framework. TCP/IP has less layers than ISO/OSI. ISO/OSI is generic for any layered network, TCP/IP is specific to ARPANET/the Internet.

INTERNET PROTOCOL

IPv4 & IPv6 both use the version field in the datagram header. IPv4 uses '4', IPv6 uses '6'.

IPv6 Improvements over IPv4

- Increased address space
- simpler 40-byte header
- QoS guarantees & priority for 'flows', i.e. video & audio streams.
- Improved security
- Hierarchical addressing

- Support for mobile computing
- Autoconfiguration facility

IPv6 and IPv4 Interoperability

- IPv6-capable routers have a 'dual-stack' for sending/receiving both IPv4 & IPv6 packets.
- Two IPv6 nodes communicating over an IPv4 route encapsulate IPv6 packets within the IPv4 data field (tunneling).
- IPv6 node communicating with an IPv4 host may use a NAT to translate IPv6 addresses to IPv4 addresses. They may also use application-level translation if specific NAT hardware is not deployed on the route.

IPv4 NAT

Specialized hardware is used to convert private address ranges to a single public address. Each private address has a port number associated, which is used for addressing, stored in a NAT Translation Table. This allows for multiple nodes to share one address, meaning reallocation of IP addresses from the ISP is circumvented.

TCP & UDP

TCP is a connection-oriented, reliable transport-layer protocol. UDP is a connectionless, best-effort transport-layer protocol.

TCP Services

- In order transmission
- Reliable data transmission via receiver ACKs
- Congestion control to prevent low network QoS.
- Flow control to prevent receiver buffer overflow.
- Process addressing via port numbers
- Multiplexing
- Data integrity checksums

UDP Services

- Process addressing via port numbers
- Low latency transmission
- Multiplexing
- Data integrity checksums

TCP is best for applications that require complete data, i.e. file downloads, remote server control, UDP is best for low-latency applications, i.e. gaming, streaming, DNS.

Congestion Control Algorithms

Slow Start CongWin doubles every successful transmission until threshold reached.

Congestion Avoidance CongWin increases by one TCP segment every successful transmission.

Fast Retransmit 3 dup-ACKS received for packet, assume all future packets also lost, retransmit.

Fast Recovery Cut threshold in half and restart CA from threshold.

If timeout occurs and not 3 dup-ACKs, restart from SS.

Congestion Control Parameters

- CongWin, starts at 1 TCP segment size, at sender
- Threshold, starts at 64kb or RecvWin size, at receiver
- Retransmission timer, set at double the RTT, at sender.

Flow Control

TCP flow control is used to prevent the receiver buffer from overflowing along with keeping throughput high. The RecvWin size is advertised by the receiver, and represents the available space in the receiver buffer.

Clark's algorithm waits for the RecvWin buffer to be doubled before advertising. Nagle's algorithm combines multiple small packets before transmission, to prevent high overhead.

Reliable connection over Unreliable link

- Checksum for data integrity
- segment number for segment ordering & missing segments
- ACKs for message reception
- NAKs for telling sender to resend data
- Sender-side timer for retransmission of packet if no ACK/NAK received.

TCP RTT Calculation

- At start, $SRTT \leq R$, $RTTVAR \leq R/2$, $RTO \leq 4 * RTTVAR$
- After each RTT, $RTTVAR \leq 3/4RTTVAR + 1/4(SRTT - R')$,
 $SRTT \leq 7/8SRTT + 1/8R'$,
 $RTO \leq SRTT + 4 * RTTVAR$,
 so more weight given to old value.

MAC AT THE LINK LAYER

Fixed Resource Allocation

- Frequency
- Time
- Space
- Coding

Advantages/Distadvantages of Approach

Channel Partition Efficient & fair channel sharing at high load, inefficient at low load

Random Access Efficient at low load/users, inefficient at high load due to collisions

Collision Avoidance Inbetween performance

Slotted ALOHA

- Single node may transmit at full channel capacity
- Only slot timings need to be synced across nodes
- Collisions waste slots
- Wasteful slots when idle

ROUTING

Types of routing

Link-state Global knowledge of every link and cost in the network.

Distance-vector Each node only knows its neighbours and costs.

Dijkstra's algorithm

From starting node u , iterate across all nodes and set cost from u to v (current node) to corresponding cost, else ∞ .

Find node not in visited nodes, add to visited nodes and update cost to v if less than current amount.

Continue until all nodes visited.

Router Queueing

If switching fabric slower than input ports, queueing occurs at input ports.

If output link is slower than output port arrival rate, then queueing occurs at output port.