

Unit 1 – Basics, Models, Services

Q1. Computer network kya hai? LAN, MAN, WAN aur internetwork ka concept samjhao.

Computer network autonomous computers ka group hai jo communication links ke through resources share karte hain, jaise files, printers, applications, internet access. LAN (Local Area Network) chhote geographic area, jaise office, lab ya building me limited computers ko high speed (Ethernet, Wi-Fi) se connect karta hai; typically single organization ke control me hota hai. MAN (Metropolitan Area Network) ek city size area cover karta hai, jise cable TV networks ya city-wide campus networks ka example diya jata hai. WAN (Wide Area Network) large geographic distance cover karta hai, jisme leased lines, satellite links, public networks use hote hain; internet sabse bada WAN example hai. Internetwork ka matlab multiple heterogeneous networks ko routers ke through jodna, taki user ko ek single logical network jaisa experience mile; TCP/IP suite isi ke liye design hua. Exam me iske sath topologies ya advantages/disadvantages bhi pooch sakte hain.

Q2. OSI reference model aur TCP/IP model ko compare karo. Layers ke functions briefly likho.

OSI model 7 layers define karta hai: Physical, Data Link, Network, Transport, Session, Presentation, Application. Physical bits transmission, Data Link framing + error detection, Network routing + logical addressing, Transport end-to-end delivery + flow control, Session dialog control, Presentation data translation/encryption/compression aur Application user services (HTTP, FTP) handle karta hai. TCP/IP model practically deployed 4-layer model hai: Link (Physical + Data Link combined), Internet (Network), Transport, Application (upper three OSI layers combined). TCP/IP bottom-up design hai jo real protocols (IP, TCP, UDP) describe karta hai, jabki OSI more theoretical top-down model hai. Dono models encapsulation, layering, protocol stacks ke basic ideas share karte hain, lekin layer boundaries aur responsibilities thodi different hain; theoretical questions me diagrams ke sath difference table expected hota hai.

Q3. Connection-oriented aur connectionless services me antar likho. Example protocols bhi do.

Connection-oriented service me communication start hone se pehle logical connection establish hota hai, jisme sender-receiver ke beech path, resources, sequence numbers set kiye jate hain. Data ordered, reliable way se deliver hota hai; lost packets retransmit kiye jate hain, aur end par connection release hota hai (telephone call jaisa). TCP typical connection-oriented transport protocol hai, jo three-way handshake, flow control, congestion control, error control provide karta hai. Connectionless service me koi dedicated setup nahi hota; har packet independent datagram hai jo different route se ja sakta hai aur order guarantee nahi hoti. UDP connectionless transport protocol hai, jo fast but unreliable datagram service deta hai, jahan real-time streaming, DNS queries jaisi applications khud error handling manage karti hain. Exam me reliability, overhead, use-cases ke basis par comparison points likhna scoring hota hai.

Unit 2 – Physical Layer & Switching

Q4. Transmission media ke main types (twisted pair, coaxial, fiber optics, unguided) explain karo.

Guided media me signal physical path follow karta hai. Twisted pair cable me do insulated copper wires twist kiye jate hain jisse interference kam hota hai; ye telephone lines, Ethernet (UTP, STP) me use hota hai, cost kam lekin bandwidth limited. Coaxial cable me central conductor, dielectric insulator, metallic shield aur outer jacket hote hain; baseband coax digital LANs ke liye, broadband coax analog cable TV ke liye use hota hai. Fiber optic cable glass/plastic core me light pulses ke form me data transmit karta hai, extremely high bandwidth, low attenuation, immunity to EMI provide karta hai; long-distance backbone links ke liye best hai. Unguided media me signal air/vacuum se propagate hota hai; radio waves wide area, microwaves line-of-sight point-to-point, infrared short-range links ke liye use hote hain. Right medium selection cost, distance, bandwidth, noise environment par depend karta hai.

Q5. Circuit switching, message switching aur packet switching me difference samjhao.

TDM/FDM ka role likho.

Circuit switching me call ke dauran source-destination ke beech dedicated path reserve hota hai; fixed bandwidth milta hai, delay stable hota hai (PSTN phone network). Message switching store-and-forward technique use karta hai jahan complete message intermediate nodes par temporarily store ho kar aage forward hota hai; dedicated circuit nahi hota, delay variable ho sakta hai. Packet switching message ko small fixed-size packets me tod kar network se bhejta hai; har packet independent route se ja sakta hai aur routers unhe store-and-forward karte hain (Internet ka basis). Circuit switching me multiplexing ke liye mostly FDM (different frequency bands) ya TDM (different time slots) use hota hai taki multiple calls same physical link share kar sakein. Packet switching better link utilization, robustness aur statistical multiplexing deta hai, isliye data networks me preferred hai, jabki circuit switching real-time voice ke liye traditional choice tha.

Q6. MODEM aur ISDN services kya hain?

MODEM (Modulator-Demodulator) digital data ko analog carrier par modulate karta hai taa ki telephone analog lines se data transmit ho sake, aur receiver side par demodulate karke wapas digital form me convert karta hai. Ye legacy dial-up internet connections ka main device tha, jahan speed few Kbps se le kar tens of Kbps tak hoti thi. ISDN (Integrated Services Digital Network) digital telecommunication service hai jo same network par voice, data, video jaise multiple services provide karta hai. Basic Rate Interface (BRI) 2B+D channels (2 bearer, 1 data/signaling) deti hai, jabki Primary Rate Interface (PRI) zyada bearer channels ke sath higher bandwidth provide karti hai. ISDN circuit-switched digital connections use karta hai, jisse dial-up se fast aur reliable data services possible hoti hain; aaj kal mostly DSL, cable, fiber ne replace kar diya hai, lekin exam me ye classic digital access example ke roop me pucha jata hai.

Unit 3 – Data Link & Network Layer Basics

Q7. Data Link layer ke main functions (framing, error detection/correction, flow control) explain karo.

Data Link layer ka kaam raw physical bit stream ko reliable link me convert karna hai. Framing bits ko identifiable frames (start/end boundary ke sath) me group karta hai, jisse receiver correctly data units identify kar sake; techniques: character count, byte stuffing, bit stuffing. Error detection ke liye parity, checksum, cyclic redundancy check (CRC) jaise codes use hote hain; CRC polynomial division based strong technique hai jo burst errors detect kar sakti hai. Error correction me Hamming codes jaise forward error correction schemes use ho sakte hain jahan receiver directly wrong bit(s) identify karke correct kar sakta hai. Flow control ensure karta hai ki fast sender slow receiver ko overwhelm na kare; popular techniques Stop-and-Wait, Sliding Window (Go-Back-N, Selective Repeat) hain. Saath hi Data Link layer media access control (shared channel par collision handling) bhi many LAN technologies me manage karta hai.

Q8. Sliding window protocol, Go-Back-N ka working principle samjhao.

Sliding window protocols full duplex reliable communication ke liye use hote hain jahan sender ek time par multiple outstanding frames pipeline me rakh sakta hai. Window size N define karta hai kitne frames bina ACK ke send kiye ja sakte hain; receiver cumulative ya individual acknowledgements bhejta hai. Go-Back-N me receiver out-of-order frames discard karta hai aur last correctly received in-order frame ka ACK bhejta rehta hai. Agar sender ka timer expire ho jaye (kisi ek frame ka ACK na aaye) to woh us frame se lekar sare subsequent unacknowledged frames ko dubara send karta hai ("go back n"). Is protocol ka advantage implementation simplicity hai, lekin error rate high hone par bandwidth waste hoti hai kyunki correct frames bhi dubara transmit hote hain. Iske contrast me Selective Repeat sirf lost/corrupt frames ko retransmit karta hai, lekin receiver side buffering aur complex logic ki need hoti hai.

Q9. Multiple access protocols ALOHA, CSMA ka basic idea likho.

Shared broadcast channel (jaise LAN) par multiple stations ko access coordinate karne ke liye multiple access protocols use hote hain. Pure ALOHA random access protocol hai jahan station jab bhi data ho direct transmit karta hai; collision hone par random backoff ke baad dubara try karta hai, iski maximum efficiency low (~18%) hoti hai. Slotted ALOHA time slots use karta hai jisme transmission sirf slot boundaries par allowed hai; isse collisions kam hote hain aur efficiency ~36% tak badh jati hai. CSMA (Carrier Sense Multiple Access) me station transmit karne se pehle channel sense karta hai; agar medium idle hai to transmit, busy hai to wait. Variants jaise 1-persistent, non-persistent, p-persistent CSMA different sensing/backoff strategies use karte hain. CSMA/CD (Collision Detection) Ethernet ke liye special hai, jahan transmission ke dauran collision detect hote hi transmission abort aur exponential backoff apply hota hai.

Unit 4 – MAC Sub-layer, LAN Standards, Devices

Q10. Framing aur static vs dynamic channel allocation ko LAN/MAN context me explain karo.

Framing Data Link/MAC layer ka function hai jahan bit stream ko logical frames me divide kiya jata hai. Static channel allocation me link bandwidth fixed sub-channels (FDM: frequency bands, TDM: time slots) me divide hoti hai aur har user ko ek dedicated portion milta hai; isse collision zero, lekin utilization low ho sakta hai agar users bursty traffic generate karte hain. Dynamic channel allocation me koi permanent reservation nahi hoti; users demand ke basis par channel share karte hain. Random access protocols (ALOHA, CSMA) dynamic schemes ka example hain jahan collision ki possibility hoti hai par average utilization achha mil sakta hai. Reservation, polling, token passing jaise controlled dynamic methods deterministic access aur bounded delay provide karte hain, specially real-time traffic ke liye. LANs (Ethernet, Token Ring, Token Bus) inhi principles par different MAC strategies implement karte hain.

Q11. IEEE 802.3 Ethernet aur 802.5 Token Ring ka comparison karo. Bridges aur routers ka role bhi likho.

IEEE 802.3 Ethernet broadcast bus/star topology par based hai jahan CSMA/CD random access protocol se medium share hota hai; aaj ke switched Ethernet me collisions practically eliminate ho chuke hain. Data rate 10 Mbps se lekar multi-Gbps tak vary karte hain, frame format preamble, addresses, type/length, data, CRC se milkar banta hai. IEEE 802.5 Token Ring me logical ring topology hoti hai jahan special token frame ring me circulate karta hai; sirf token holder hi transmit kar sakta hai, isse collision free deterministic access milta hai. Bridges Data Link layer devices hain jo multiple LAN segments ko connect karte hain, MAC addresses ki basis par frames forward/filter karte hain; transparent bridges learning + spanning tree use karte hain, source-routing bridges specially Token Ring environment me use hote hain. Routers Network layer devices hain jo IP addresses aur routing tables ke basis par packets forward karte hain, different technologies (Ethernet, Token Ring, WAN links, ATM) ko internetwork karne me key role play karte hain.

Q12. ISDN, ATM, X.25 ka chhota note likho.

ISDN digital telephony/networking standard hai jo voice + data services ek hi interface par provide karta hai; circuit-switched digital connections, BRI/PRI interfaces iski khasiyat hain. X.25 early packet-switched WAN protocol suite hai jo virtual circuits, reliable delivery aur heavy error correction provide karta tha; ye low-speed noisy links ke liye design hua tha aur public data networks me popular tha. ATM (Asynchronous Transfer Mode) high-speed cell-switching technology hai jisme fixed-size 53-byte cells use hote hain; ye circuit switching ki QoS guarantees aur packet switching ki efficiency combine karne ki koshish karta hai. ATM different service classes (CBR, VBR, UBR) define karta hai jisse voice, video, data ko ek hi fabric par carry kiya ja sakta hai. Aaj IP-based MPLS networks ne largely X.25/ATM ko replace kar diya hai, lekin ye exam me historic WAN technologies aur QoS concept samjhane ke liye important topics hain.

Unit 5 – Network Layer & Internetworking

Q13. Network layer design issues, shortest path routing aur flooding explain karo.

Network layer ka kaam source se destination tak packets ka path select karna, logical addressing provide karna, congestion control aur internetworking handle karna hai. Design issues me store-and-forward packet switching, service type (connection-oriented vs connectionless), routing algorithms, congestion control policies, QoS, addressing schemes, datagram size, fragmentation include hote hain. Shortest path routing graph algorithms (Dijkstra, Bellman-Ford) use karta hai jahan networks ko weighted graphs aur links ko costs (delay, hop count, bandwidth) se represent kiya jata hai. Flooding me har incoming packet ko except incoming link ke alawa sare outgoing links par forward kar diya jata hai; isse reliability high hoti hai lekin traffic explosion avoid karne ke liye hop count, sequence numbers jaise controls ki need hoti hai. Flooding emergency routing ya distributed database update jaisi limited scenarios me useful hai, regular data traffic ke liye nahi.

Q14. IP addressing, subnets, fragmentation aur firewall ka concept likho.

IPv4 address 32-bit logical identifier hai jo network part + host part me divide hota hai; earlier classful (A/B/C) scheme use hoti thi, ab classless (CIDR) notations /n common hain. Subnetting me organization apne address block ko internal sub-networks me divide karta hai; subnet mask decide karta hai kitne bits network/subnet/host ke liye use honge, isse routing flexibility aur broadcast domain control milta hai. Jab IP datagram kisi aise link se guzarna padta hai jiska MTU chhota hai, to router us datagram ko fragments me tod kar aage bhejta hai; each fragment apna header carry karta hai aur destination par reassembly hoti hai. Firewalls security devices/software hain jo private network aur external networks (internet) ke beech traffic filter karte hain; ye packet filtering, stateful inspection, application gateway techniques se unwanted access, attacks aur unauthorized traffic ko block karte hain. Network Address Translation (NAT) bhi aksar firewall ke sath use hota hai jisse private IP ranges ko public internet par map kiya jata hai.

Q15. Congestion control aur prevention policies ke basics explain karo.

Congestion tab hota hai jab network me offered load available resources (link capacity, router buffers, processing) se zyada ho jaye, jisse queue lengths grow, delay aur packet loss badh jata hai. Congestion control reactive techniques hain jo congestion detect hone ke baad actions lete hain, jaise source rate reduce karna, window size kam karna, rerouting. TCP congestion control slow start, congestion avoidance, fast retransmit, fast recovery mechanisms se sender window dynamically adjust karta hai. Prevention policies proactive hoti hain: admission control (QoS flows ke liye), proper traffic shaping (leaky bucket, token bucket), resource reservation, fair queueing. Routers congestion indication ke liye explicit feedback (ECN bits) ya implicit signals (packet loss, increased delay) provide kar sakte hain; end systems in signals ko interpret karke apne sending rate adapt karte hain. Design ka main goal stability, high throughput, low delay aur fairness balance karna hai.

Unit 6 – Transport & Application Layer

Q16. Transport layer ke functions, multiplexing aur crash recovery explain karo.

Transport layer end-to-end communication service provide karta hai jo lower network differences se independent hota hai. Iske core functions: process-to-process addressing (port numbers), reliable data transfer (sequence numbers, ACK, retransmission), flow control, congestion control aur connection management hain. Multiplexing me multiple application processes same network connection/host interface share karte hain; demultiplexing incoming segments ko correct socket/port tak deliver karta hai (e.g., port 80 – HTTP, 25 – SMTP). Connection establishment typically handshake protocol (TCP three-way) se hota hai jahan initial sequence numbers exchange kiye jate hain; connection release orderly shutdown se hota hai jisse in-flight data loss na ho. Crash recovery issues tab arise hote hain jab endpoints ya network failures ke baad half-open connections, duplicate packets, lost ACKs handle karne hote hain; timers, sequence number space aur state machines carefully design kiye jate hain.

Q17. TCP service model, TCP protocol ka overview likho.

TCP reliable, connection-oriented, byte-stream transport protocol hai jo end hosts ke beech virtual circuit jaisa behavior provide karta hai. Service model in-order delivery, error-free data transfer, full duplex communication, flow control (sliding window) aur congestion control (slow start, AIMD) include karta hai. Three-way handshake (SYN, SYN-ACK, ACK) se connection establish hota hai; har direction me independent byte sequence numbers maintain kiye jate hain. TCP segment header me source/destination port, sequence number, acknowledgment number, flags (SYN, ACK, FIN, RST), window size, checksum, urgent pointer fields hote hain. Timeout-based retransmission, fast retransmit (triple duplicate ACK), selective acknowledgments jaisi techniques reliability improve karti hain. TCP zyada overhead but strong reliability provide karta hai, isliye web, email, file transfer, remote login jaisi applications me standard choice hai.

Q18. Application layer me DNS aur Email (architecture, message formats, transfer) explain karo.

DNS (Domain Name System) hierarchical distributed database hai jo human-readable domain names (example.com) ko IP addresses me translate karta hai. Iska architecture root servers, TLD servers (.com, .org), authoritative servers, caching resolvers par based hai; clients resolver ke through iterative/recursive queries se mappings lete hain. Email system me users Mail User Agent (MUA) jaisa client (Outlook, webmail) use karte hain; message Mail Transfer Agents (MTA) ke through mail servers ke beech SMTP protocol se forward hota hai. Message format RFC standards follow karta hai jisme header (From, To, Subject, Date, Received fields) aur body hoti hai; attachments MIME encoding se send hote hain. Retrieval ke liye POP3 ya IMAP protocols use hote hain; POP3 simple download-and-delete model, IMAP server-side folder management support karta hai. Network security ke liye authentication, encryption (TLS), digital signatures, spam filtering jaisi techniques common hain.