Subject Name Solutions

4351602 – Summer 2025

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Explain working of POP protocol.

Solution

POP (Post Office Protocol) is an email retrieval protocol that downloads emails from server to client device.
Working Process:

Step	Action	Description
1	Connection	Client connects to POP server on port 110
2	Authentication	User provides username and password
3	Download	Emails downloaded to local device
4	Deletion	Emails deleted from server after download

- **Download-based**: Emails stored locally on client device
- **Offline access**: Can read emails without internet connection
- **Single device**: Best suited for single device access

Mnemonic

"POP Downloads Once Permanently"

Question 1(b) [4 marks]

Compare OSI model with TCP/IP model.

Solution

Comparison between OSI and TCP/IP networking models:

Aspect	OSI Model	TCP/IP Model
Layers	7 layers	4 layers
Approach	Theoretical model	Practical implementation
Development	ISO standard	DARPA project
Complexity	More complex	Simpler structure

Key Differences:
- **Layer count**: OSI has 7 layers vs TCP/IP's 4 layers
- **Real-world usage**: TCP/IP widely implemented, OSI mostly theoretical
- **Protocol independence**: OSI is protocol-independent, TCP/IP is protocol-specific
- **Header overhead**: OSI has more overhead due to additional layers

Mnemonic

"OSI Seven Theoretical, TCP Four Practical"

Question 1(c) [7 marks]

Explain protocols working at each layer in TCP/IP models.

Solution

TCP/IP model consists of 4 layers with specific protocols at each layer:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Application Layer] {-{-}{} B[Transport Layer]}
    B {-{-}{} C[Internet Layer]}
    C {-{-}{} D[Network Access Layer]}

    A1[HTTP, HTTPS, FTP, SMTP, POP, IMAP, DNS] {-{-}{} A}
    B1[TCP, UDP] {-{-}{} B}
    C1[IP, ICMP, ARP, RARP] {-{-}{} C}
    D1[Ethernet, WiFi, PPP] {-{-}{} D}
{Highlighting}
{Shaded}
```

Layer-wise Protocol Functions:

Layer	Protocols	Function
Application	HTTP, FTP, SMTP, DNS	User interface and services
Transport	TCP, UDP	End-to-end communication
Internet	IP, ICMP, ARP	Routing and addressing
Network Access	Ethernet, WiFi	Physical transmission

Protocol Details:

- **HTTP/HTTPS**: Web communication and secure web communication
- **TCP**: Reliable, connection-oriented data transfer
- **UDP**: Fast, connectionless data transfer
- **IP**: Packet routing and addressing
- **ARP**: Maps IP addresses to MAC addresses

Mnemonic

"Applications Transport Internet Networks Always"

Question 1(c OR) [7 marks]

Briefly explain OSI model with all its layers and functionality of each layer

Solution

OSI (Open Systems Interconnection) model has 7 layers for network communication:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Application Layer] {-{-}{} B[Presentation Layer]}
    B {-{-}{} C[Session Layer]}
    C {-{-}{} D[Transport Layer]}
    D {-{-}{} E[Network Layer]}
    E {-{-}{} F[Data Link Layer]}
```

```
    F {-{-}{} G[Physical Layer]}
{Highlighting}
{Shaded}
```

Layer Functions:

Layer	Name	Function	Protocols
7	Application	User interface	HTTP, FTP, SMTP
6	Presentation	Data formatting, encryption	SSL, JPEG, MPEG
5	Session	Session management	NetBIOS, RPC
4	Transport	End-to-end delivery	TCP, UDP
3	Network	Routing	IP, ICMP
2	Data Link	Frame transmission	Ethernet, PPP
1	Physical	Bit transmission	Cables, Radio waves

Key Features:
- **Modular design**: Each layer has specific responsibilities
- **Protocol independence**: Layers can use different protocols
- **Standardization**: Universal networking reference model

Mnemonic

"All People Seem To Need Data Processing"

Question 2(a) [3 marks]

Give the difference between ARP and RARP protocols.

Solution

ARP and RARP are address resolution protocols with opposite functions:

Aspect	ARP	RARP
Full Form	Address Resolution Protocol	Reverse Address Resolution Protocol
Purpose	IP to MAC address mapping	MAC to IP address mapping
Direction	Logical to Physical	Physical to Logical
Usage	Normal network communication	Diskless workstations

Working Process:
- **ARP**: "I know IP address, need MAC address"
- **RARP**: "I know MAC address, need IP address"
- **Cache**: Both maintain address tables for efficiency

Mnemonic

"ARP Asks Physical, RARP Requests IP"

Question 2(b) [4 marks]

Explain working of IMAP protocol.

Solution

IMAP (Internet Message Access Protocol) manages emails on server for multiple device access.
Working Process:

Step	Action	Description
1	Connection	Client connects to IMAP server (port 143/993)
2	Authentication	Login with credentials
3	Folder Access	Browse email folders on server
4	Synchronization	Changes sync across all devices

Key Features:
- **Server-based**: Emails remain on server
- **Multi-device**: Access from multiple devices
- **Synchronization**: Changes reflected everywhere
- **Selective download**: Download only needed emails

Advantages:
- **Storage efficiency**: Server manages storage
- **Accessibility**: Access from anywhere
- **Backup**: Server provides automatic backup

Mnemonic

"IMAP Internet Messages Always Present"

Question 2(c) [7 marks]

Explain Three-tier architecture of mobile computing with appropriate diagram.

Solution

Three-tier architecture separates mobile computing into distinct layers:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Presentation Tier{br/{}Mobile Devices] {-}{-}{} B[Application Tier{}br/{}Application Server]}
    B {-{-}{} C[Data Tier{}br/{}Database Server]}

    A1[Smartphones{br/{}Tablets{}br/{}Laptops] {-}{-}{} A}
    B1[Business Logic{br/{}Processing{}br/{}API Services] {-}{-}{} B}
    C1[Database{br/{}File Systems{}br/{}Data Storage] {-}{-}{} C}
{Highlighting}
{Shaded}
```

Tier Details:

Tier	Components	Responsibilities
Presentation	Mobile devices, UI	User interface and interaction
Application	App servers, middleware	Business logic and processing
Data	Databases, storage	Data management and storage

Architecture Benefits:

- **Scalability**: Each tier can scale independently
- **Maintainability**: Separate concerns for easier updates
- **Security**: Data protection through tier separation
- **Performance**: Distributed processing reduces load

Communication Flow:

- **User request**: Presentation → *Application* → *Data*
- **Response**: Data → *Application* → *Presentation*
- **Processing**: Application tier handles business logic

Mnemonic

"Presentation Applies Data Processing"

Question 2(a OR) [3 marks]

Explain the limitation of Stop-and-wait data link layer protocol.

Solution

Stop-and-wait protocol has several performance limitations:
Major Limitations:

Limitation	Description	Impact
Low Efficiency	Waits for ACK before next frame	Poor bandwidth utilization
High Delay	Round-trip delay for each frame	Slow data transmission
Error Sensitivity	Single error stops transmission	Reduced reliability

Performance Issues:

- **Bandwidth waste**: Link remains idle during wait time
- **Timeout problems**: Lost ACK causes unnecessary retransmission
- **Sequential processing**: Cannot send multiple frames simultaneously

Mnemonic

"Stop Waits, Bandwidth Wastes"

Question 2(b OR) [4 marks]

Explain Advantages of IPV6 over the older IPV4 addressing scheme.

Solution

IPv6 provides significant improvements over IPv4:
Key Advantages:

Feature	IPv4	IPv6
Address Space	32-bit (4.3 billion)	128-bit (340 undecillion)
Header	Variable length	Fixed 40 bytes
Security	Optional IPSec	Built-in IPSec
Configuration	Manual/DHCP	Auto-configuration

Major Benefits:

- **Unlimited addresses**: Solves address exhaustion problem
- **Better performance**: Simplified header processing
- **Enhanced security**: Mandatory encryption support
- **Mobility support**: Better mobile device connectivity

Additional Features:

- **Quality of Service**: Built-in QoS support
- **Multicast**: Improved multicast capabilities
- **No fragmentation**: Routers don't fragment packets

Mnemonic

"IPv6 Improves Performance, Security, Addresses"

Question 2(c OR) [7 marks]

Enlist types of networks available in mobile computing. Explain one of them in detail.

Solution

Types of Mobile Networks:

Generation	Technology	Speed	Features
2G	GSM, CDMA	64 Kbps	Voice + SMS
3G	UMTS, CDMA2000	2 Mbps	Data services
4G	LTE, WiMAX	100 Mbps	High-speed internet
5G	New Radio (NR)	10 Gbps	Ultra-low latency

Detailed: 4G LTE Network

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Mobile Device] {-{-}{} B[eNodeB{}br/{}Base Station]}
    B {-{-}{} C[Mobility Management Entity{}br/{}MME]}
    B {-{-}{} D[Serving Gateway{}br/{}S{-}GW]}
    D {-{-}{} E[Packet Data Network Gateway{}br/{}P{-}GW]}
    E {-{-}{} F[Internet/External Networks]}
    C {-{-}{} G[Home Subscriber Server{}br/{}HSS]}
{Highlighting}
{Shaded}
```

4G LTE Features:

- **High Speed**: Up to 100 Mbps download, 50 Mbps upload
- **Low Latency**: Less than 10ms for real-time applications
- **All-IP Network**: Packet-switched architecture
- **Advanced Antenna**: MIMO technology for better coverage

Architecture Components:

- **eNodeB**: Enhanced base station with advanced features
- **MME**: Manages mobility and authentication
- **Gateways**: Handle data routing and external connectivity

Applications: Video streaming, online gaming, IoT connectivity

Mnemonic

"4G LTE: Long Term Evolution"

Question 3(a) [3 marks]

Explain types of Routing.

Solution

Routing determines path for data packets across networks:
Types of Routing:

Type	Description	Example
Static	Manual route configuration	Administrative setup
Dynamic	Automatic route discovery	RIP, OSPF protocols
Default	Fallback route for unknown destinations	Gateway of last resort

Routing Categories:
- **Distance Vector**: Uses hop count (RIP)
- **Link State**: Uses network topology (OSPF)
- **Hybrid**: Combines both approaches (EIGRP)

Selection Criteria:
- **Shortest path**: Minimum hops or distance
- **Load balancing**: Distribute traffic evenly
- **Fault tolerance**: Alternative routes for failures

Mnemonic

"Static Dynamic Default Routes"

Question 3(b) [4 marks]

What is Subnetting and supernetting?

Solution

Subnetting and supernetting manage IP address allocation efficiently:
Comparison:

Aspect	Subnetting	Supernetting
Purpose	Divide large network	Combine small networks
Direction	Top-down approach	Bottom-up approach
Mask	Longer subnet mask	Shorter subnet mask
Result	Multiple smaller subnets	Single larger network

Subnetting Process:
- **Borrowing bits**: Take bits from host portion
- **Create subnets**: Multiple network segments
- **Reduce broadcast**: Smaller broadcast domains

Supernetting Process:
- **Combine networks**: Merge adjacent networks
- **Route aggregation**: Single routing entry
- **Reduce routing table**: Fewer routing entries

Benefits:
- **Subnetting**: Better network management, security
- **Supernetting**: Simplified routing, reduced overhead

Mnemonic

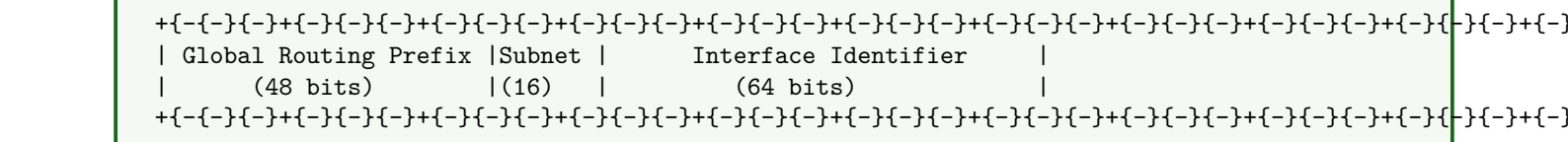
"Subnetting Splits, Supernetting Sums"

Question 3(c) [7 marks]

Explain IPV6 Addressing. Why need of IPV6 migration?

Solution

IPv6 addressing uses 128-bit addresses to solve IPv4 limitations:
IPv6 Address Structure:



Address Format:

Component	Size	Purpose
Global Prefix	48 bits	ISP allocation
Subnet ID	16 bits	Organization subnets
Interface ID	64 bits	Device identification

Address Types:

- **Unicast**: One-to-one communication
- **Multicast**: One-to-many communication
- **Anycast**: One-to-nearest communication

Need for IPv6 Migration:
Critical Issues:

Problem	IPv4	IPv6 Solution
Address Exhaustion	4.3 billion addresses	340 undecillion addresses
NAT Complexity	Required for connectivity	End-to-end connectivity
Security	Add-on feature	Built-in IPSec
Mobile Support	Limited	Native mobility

Migration Benefits:

- **Unlimited growth**: Supports IoT expansion
- **Simplified configuration**: Auto-configuration features
- **Better performance**: Optimized header structure
- **Enhanced security**: Mandatory encryption

Migration Challenges:

- **Dual-stack**: Running both IPv4 and IPv6
- **Translation**: IPv4-IPv6 interoperability
- **Training**: Staff education requirements

Mnemonic

"IPv6 Infinite Possibilities, Enhanced Security"

Question 3(a OR) [3 marks]

Determine valid IPv4 address from below. If it is a valid IPv4 address then find its class, Network ID and Host ID. If it's an invalid IPv4 address, then give a reason.

a. 192.108.102.101 b. 80.54.256.14

Solution

Analysis:

Address	Validity	Class	Network ID	Host ID	Reason
192.108.102.101	Valid	Class C	192.108.102.0	0.0.0.101	All octets ≤ 255
80.54.256.14	Invalid	-	-	-	Third octet = $256 > 255$

Address a: 192.108.102.101

- **Valid**: All octets within range (0-255)
- **Class C**: First octet 192 (192-223 range)
- **Default mask**: 255.255.255.0 (/24)

Address b: 80.54.256.14

- **Invalid**: Third octet is 256
- **Rule violation**: Each octet must be 0-255
- **Correction**: Replace 256 with valid value (0-255)

Mnemonic

"Each Octet Maximum 255"

Question 3(b OR) [4 marks]

Write Short note on Network Address Translation.

Solution

NAT translates private IP addresses to public IP addresses for internet access:
NAT Process:

Step	Direction	Translation
Outbound	Private → *Public*	Internal IP mapped to public IP
Inbound	Public → *Private*	Public IP mapped back to internal IP

NAT Types:

```
NAT Types
  Static NAT (1:1 mapping)
  Dynamic NAT (Pool mapping)
  PAT/NAPT (Port translation)
```

Benefits:

- **IP conservation**: Multiple devices share one public IP
- **Security**: Hides internal network structure
- **Cost reduction**: Fewer public IP addresses needed
- **Flexibility**: Easy internal network changes

Limitations:

- **End-to-end connectivity**: Breaks direct communication
- **Protocol issues**: Some protocols don't work through NAT
- **Performance**: Additional processing overhead

Mnemonic

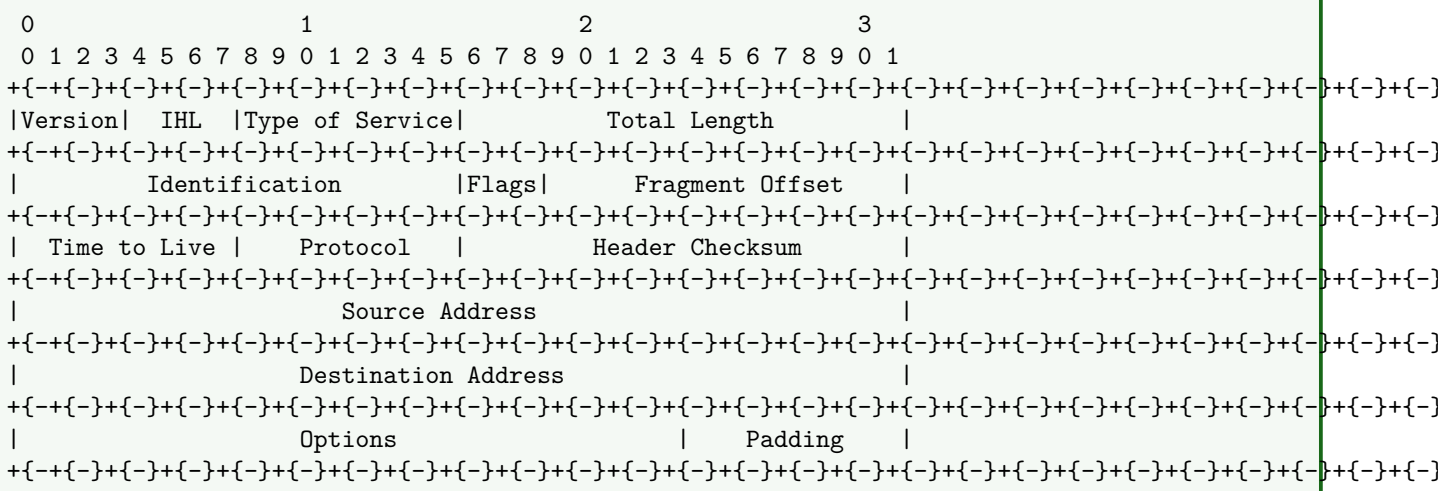
"NAT Networks Address Translation"

Question 3(c OR) [7 marks]

Explain IPV4 Datagram Header in detail.

Solution

IPv4 header contains essential information for packet routing:



Header Fields:

Field	Size	Purpose
Version	4 bits	IP version (4 for IPv4)
IHL	4 bits	Header length in 32-bit words
Type of Service	8 bits	Quality of service
Total Length	16 bits	Total packet size
Identification	16 bits	Fragment identification
Flags	3 bits	Fragmentation control
Fragment Offset	13 bits	Fragment position
TTL	8 bits	Maximum hops before discard
Protocol	8 bits	Next layer protocol
Checksum	16 bits	Header error detection
Source Address	32 bits	Sender IP address
Destination	32 bits	Receiver IP address

Key Functions:

- **Routing**: Source and destination addresses
- **Fragmentation**: Handle large packets
- **Error detection**: Header checksum
- **Quality control**: Type of service field

Important Values:

- **Protocol**: TCP=6, UDP=17, ICMP=1
- **Flags**: Don't Fragment, More Fragments
- **TTL**: Prevents infinite loops

Mnemonic

"Version IHL Service Length Identify Fragment TTL Protocol Check Source Destination"

Question 4(a) [3 marks]

Explain working of Indirect TCP.

Solution

Indirect TCP splits TCP connection to handle mobile network challenges:
Architecture:

Component	Role	Location
Mobile Host	TCP client	Mobile network
Base Station	TCP proxy	Fixed network
Fixed Host	TCP server	Wired network

Connection Split:
- **Connection 1**: Mobile Host $\leftrightarrow$ *BaseStation*
- **Connection 2**: Base Station $\leftrightarrow$ *FixedHost*
- **Proxy function**: Base station acts as TCP proxy

Working Process:
- **Data flow**: Mobile $\rightarrow$ *BaseStation* $\rightarrow$ *FixedHost*
- **ACK handling**: Base station manages acknowledgments
- **Handover**: Connection maintained during movement

Advantages:
- **Wireless optimization**: Handles wireless link issues
- **Mobility support**: Seamless handover capability
- **Error recovery**: Better handling of wireless errors

Mnemonic

"Indirect TCP Through Proxy"

Question 4(b) [4 marks]

Write Short note on Stop and Wait ARQ Protocol.

Solution

Stop and Wait ARQ ensures reliable data transmission with error detection and correction:
Protocol Operation:

Step	Action	Purpose
Send	Transmit frame with sequence number	Data delivery
Wait	Wait for acknowledgment	Confirm receipt
Timeout	Retransmit if no ACK	Handle lost frames
ACK	Send acknowledgment for received frame	Confirm delivery

Error Handling:

```
Sender                    Receiver
  |                         |
  |{-{-}{-}{-} Frame 0 {-}{-}{-}{-}{-}{-}{-}{-}{-}{-}|}
  |                         |{-{-}{-}{-} ACK 0}
  |{{-}{-}{-}{-} ACK 0 {-}{-}{-}{-}{-}{-}{-}{-}{-}{-}|}
  |                         |
  |{-{-}{-}{-} Frame 1 {-}{-}{-}{-}{-}{-}{-}{-}{-}| (Lost)}
  |                         |
  |{-{-} Timeout, Retransmit {-}{-}|}
  |{-{-}{-}{-} Frame 1 {-}{-}{-}{-}{-}{-}{-}{-}{-}|}
  |                         |{-{-}{-}{-} ACK 1}
  |{{-}{-}{-}{-} ACK 1 {-}{-}{-}{-}{-}{-}{-}{-}{-}{-}|}
```

Features:

- **Sequence numbers**: 0 and 1 alternation
- **Timeout mechanism**: Handles lost frames/ACKs
- **Duplicate detection**: Prevents duplicate acceptance
- **Flow control**: Receiver controls transmission rate

Limitations:

- **Low efficiency**: Only one frame in transit
- **Bandwidth waste**: Idle time during waiting

Mnemonic

"Stop Send, Wait ACK, Repeat"

Question 4(c) [7 marks]

Explain Communication Middleware in detail.

Solution

Communication middleware provides abstraction layer between applications and network services:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Mobile Applications] {-{-}{} B[Communication Middleware]}
    B {-{-}{} C[Network Services]}

    B1[Message Passing{br/{}RPC{}br/{}Event Handling] {-}{-}{} B}
    C1[TCP/IP{br/{}Wireless Protocols{}br/{}Network APIs] {-}{-}{} C}
{Highlighting}
{Shaded}
```

Middleware Types:

Type	Function	Example
Message-Oriented	Asynchronous messaging	Message queues
RPC-based	Remote procedure calls	CORBA, RMI
Event-driven	Event notifications	Publish-subscribe
Stream-oriented	Continuous data flow	Multimedia streams

Core Services:
Communication Services:
- **Message routing**: Efficient message delivery
- **Protocol conversion**: Different protocol handling
- **Buffering**: Temporary message storage
- **Synchronization**: Coordinated communication

Reliability Services:
- **Error detection**: Message integrity checking
- **Retransmission**: Failed message recovery
- **Duplicate elimination**: Prevent message duplication
- **Ordering**: Maintain message sequence

Mobile-Specific Features:
- **Location transparency**: Hide mobility from applications
- **Disconnection handling**: Manage network interruptions
- **Bandwidth adaptation**: Adjust to network conditions
- **Power management**: Optimize battery usage

Architecture Benefits:
- **Abstraction**: Hide network complexity
- **Portability**: Application independence from network
- **Scalability**: Support growing number of devices
- **Interoperability**: Different system communication

Examples:
- **CORBA**: Distributed object communication
- **Message Queues**: Asynchronous messaging
- **Web Services**: HTTP-based communication

Mnemonic

"Middleware Manages Mobile Communication"

Question 4(a OR) [3 marks]

Explain Handover management in mobile IP.

Solution

Handover management maintains connectivity when mobile device moves between networks:
Handover Process:

Phase	Action	Purpose
Detection	Monitor signal strength	Identify need for handover
Decision	Select target network	Choose best network
Execution	Switch to new network	Complete handover

Types of Handover:
- **Horizontal**: Same technology networks
- **Vertical**: Different technology networks
- **Hard**: Break-before-make
- **Soft**: Make-before-break

Management Components:
- **Signal monitoring**: Continuous signal assessment
- **Network discovery**: Available network identification
- **Decision algorithm**: Optimal network selection

Performance Metrics:
- **Handover delay**: Time to complete switch
- **Packet loss**: Data lost during handover
- **Signaling overhead**: Control message cost

Mnemonic

"Handover Helps Maintain Mobility"

Question 4(b OR) [4 marks]

Explain key functions of Communication Gateways.

Solution

Communication gateways enable interoperability between different network systems:
Key Functions:

Function	Description	Benefit
Protocol Translation	Convert between protocols	Interoperability
Data Format Conversion	Transform data formats	Compatibility
Security Enforcement	Apply security policies	Protection
Load Balancing	Distribute traffic	Performance

Gateway Services:
Protocol Services:

- **Multi-protocol support**: Handle various protocols
- **Translation efficiency**: Fast protocol conversion
- **Standards compliance**: Follow protocol specifications

Security Services:

- **Authentication**: Verify user identity
- **Authorization**: Control access permissions
- **Encryption**: Protect data transmission
- **Firewall**: Filter malicious traffic

Performance Services:

- **Caching**: Store frequently accessed data
- **Compression**: Reduce data size
- **Traffic shaping**: Manage bandwidth usage
- **Quality of Service**: Prioritize critical traffic

Management Features:

- **Monitoring**: Track gateway performance
- **Configuration**: Flexible setup options
- **Logging**: Record activity and errors

Mnemonic

"Gateways Grant Protocol Interoperability"

Question 4(c OR) [7 marks]

Explain Process of mobile IP.

Solution

Mobile IP enables device mobility while maintaining IP connectivity:

```
sequenceDiagram
    participant MN as Mobile Node
    participant HA as Home Agent
    participant FA as Foreign Agent
    participant CN as Correspondent Node
```

```
MN{-FA: Agent Solicitation}
FA{-MN: Agent Advertisement}
MN{-HA: Registration Request}
HA{-MN: Registration Reply}
CN{-HA: Data Packet (Home Address)}
HA{-FA: Tunneled Packet}
FA{-MN: Data Packet}
```

Mobile IP Components:

Component	Role	Function
Mobile Node	Moving device	Maintains connectivity
Home Agent	Home network router	Forwards packets
Foreign Agent	Visited network router	Local delivery
Care-of Address	Temporary address	Current location

Registration Process:
Phase 1: Agent Discovery

- **Advertisement**: Agents broadcast availability
- **Solicitation**: Mobile node requests agent info
- **Selection**: Choose appropriate foreign agent

Phase 2: Registration

- **Request**: Mobile node registers with home agent
- **Authentication**: Verify mobile node identity
- **Binding**: Create care-of address binding
- **Confirmation**: Registration acknowledgment

Phase 3: Packet Delivery

- **Interception**: Home agent intercepts packets
- **Tunneling**: Encapsulate and forward packets
- **Decapsulation**: Foreign agent extracts packets
- **Local delivery**: Forward to mobile node

Tunneling Mechanism:

```
Original Packet: [IP Header|Data]
                 Dest: Home Address

Tunneled Packet: [New IP Header|Original Packet]
                 Dest: Care{-of Address}
```

Key Features:

- **Transparency**: Applications unaware of mobility
- **Triangle routing**: Indirect packet delivery
- **Location privacy**: Hide actual location
- **Seamless handover**: Maintain connections

Challenges:

- **Triangle routing**: Inefficient packet path
- **Ingress filtering**: Firewall compatibility
- **Security**: Authentication and encryption

Mnemonic

"Mobile IP: Discover Register Tunnel Deliver"

Question 5(a) [3 marks]

List advantages of WPANs.

Solution

WPAN (Wireless Personal Area Network) provides short-range connectivity benefits:
Key Advantages:

Advantage	Description	Benefit
Low Power	Minimal battery consumption	Extended device life
Low Cost	Inexpensive implementation	Affordable deployment
Easy Setup	Simple configuration	User-friendly

Technical Benefits:

- **Short range**: 10-30 feet coverage reduces interference
- **Ad-hoc networking**: No infrastructure required
- **Device mobility**: Move freely within range
- **Automatic discovery**: Devices find each other automatically

Application Advantages:

- **Personal devices**: Connect phones, tablets, headphones
- **IoT integration**: Smart home device connectivity
- **File sharing**: Quick data transfer between devices
- **Peripheral connection**: Wireless keyboards, mice

Security Benefits:

- **Limited range**: Reduced eavesdropping risk
- **Encryption**: Built-in security protocols
- **Pairing**: Authenticated device connections

Mnemonic

"WPANs: Wireless Personal Area Networks"

Question 5(b) [4 marks]

Explain steps of packet delivery in mobile IP.

Solution

Mobile IP packet delivery involves multiple steps to reach mobile devices:
Packet Delivery Steps:

Step	Process	Location
1. Transmission	Send packet to home address	Correspondent Node
2. Interception	Capture packet for mobile node	Home Agent
3. Tunneling	Encapsulate and forward	Home to Foreign Agent
4. Delivery	Extract and deliver packet	Foreign Agent to Mobile

Detailed Process:

```
CN {-{-}{-}{-}{-}{-} HA {-}{-}{-}{-}{-}{-} FA {-}{-}{-}{-}{-}{-} MN}
   (1)     (2,3)    (4)

Step 1: Normal IP routing to home network
Step 2: Home Agent intercepts packet
Step 3: Tunnel packet to care{-of address  }
Step 4: Foreign Agent delivers to mobile node
```

Tunneling Mechanism:

- **Encapsulation**: Add new IP header with care-of address
- **Forwarding**: Route through internet to foreign network
- **Decapsulation**: Remove tunnel header at foreign agent
- **Local delivery**: Standard delivery to mobile node

Mnemonic

"Correspondent Home Foreign Mobile"

Question 5(c) [7 marks]

Briefly Explain architecture of WLAN with diagram.

Solution

WLAN (Wireless Local Area Network) architecture provides wireless connectivity within local area:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Distribution System{br/{}Wired Backbone] {-}{-}{} B[Access Point 1]}
    A {-{-}{} C[Access Point 2]}
    A {-{-}{} D[Access Point 3]}

    B {-{-}{} E[BSS 1{}br/{}Basic Service Set]}
    C {-{-}{} F[BSS 2{}br/{}Basic Service Set]}
    D {-{-}{} G[BSS 3{}br/{}Basic Service Set]}

    E {-{-}{} H[Wireless Stations]}
    F {-{-}{} I[Wireless Stations]}
    G {-{-}{} J[Wireless Stations]}

    K[ESS {- Extended Service Set] {-}{-}{} A}
{Highlighting}
{Shaded}
```

WLAN Components:

Component	Function	Coverage
Station (STA)	Wireless device	Individual device
Access Point (AP)	Wireless hub	Basic Service Set
Basic Service Set (BSS)	Single AP coverage	Local area
Extended Service Set (ESS)	Multiple BSS	Large area

Architecture Types:
Ad-hoc Mode:
- **Independent BSS**: No access point required
- **Peer-to-peer**: Direct station communication
- **Limited range**: Single hop communication
- **Temporary networks**: Conference, meeting rooms

Infrastructure Mode:
- **Access Point**: Central coordination
- **Distribution System**: Connect multiple APs
- **Roaming support**: Move between BSS areas
- **Internet connectivity**: Gateway to external networks

Key Features:
- **Mobility**: Move within coverage area
- **Scalability**: Add more access points
- **Interoperability**: IEEE 802.11 standards
- **Security**: WPA/WPA2 encryption

Services Provided:
- **Association**: Connect to access point
- **Authentication**: Verify user credentials
- **Data delivery**: Reliable frame transmission
- **Power management**: Battery optimization

Standards:
- **802.11a**: 5 GHz, 54 Mbps
- **802.11b**: 2.4 GHz, 11 Mbps
- **802.11g**: 2.4 GHz, 54 Mbps
- **802.11n**: MIMO, 600 Mbps
- **802.11ac**: 5 GHz, 1 Gbps+

Mnemonic

"WLAN: Wireless Local Area Network"

Question 5(a OR) [3 marks]

Explain 5G mobile network features in detail.

Solution

5G provides revolutionary mobile network capabilities:
Key Features:

Feature	Specification	Benefit
Speed	Up to 10 Gbps	Ultra-fast downloads
Latency	Less than 1ms	Real-time applications
Density	1M devices/km^2	Massive IoT support

Technical Capabilities:
- **Enhanced Mobile Broadband**: High-speed internet access
- **Ultra-Reliable Low Latency**: Critical applications
- **Massive Machine Communication**: IoT device connectivity

Advanced Technologies:
- **Millimeter waves**: Higher frequency bands
- **MIMO**: Multiple antenna systems
- **Network slicing**: Virtual network partitions
- **Edge computing**: Distributed processing

Applications:
- **Autonomous vehicles**: Real-time control
- **Smart cities**: Connected infrastructure
- **Industrial IoT**: Factory automation

Mnemonic

"5G: Fifth Generation Great Speed"

Question 5(b OR) [4 marks]

Explain how DHCP works in a mobile network context.

Solution

DHCP (Dynamic Host Configuration Protocol) automatically assigns IP addresses in mobile networks:
DHCP Process in Mobile Networks:

Step	Message	Purpose	Direction
1	DHCP Discover	Find DHCP server	Client → *Broadcast*
2	DHCP Offer	Offer IP address	Server → *Client*
3	DHCP Request	Request specific IP	Client → *Server*
4	DHCP ACK	Confirm assignment	Server → *Client*

Mobile Network Challenges:

```
Mobile DHCP Process:

Device moves: Network A  Network B

Network A          Network B
DHCP Server        DHCP Server
    |                  |
    |{-{-} Release       |}
    |                  |
    |              Discover |
    |               Offer {-{-}|}
    |              Request |
    |               ACK {-{-}{-}{-}|}
```

Mobile-Specific Features:

- **Fast handover**: Quick IP assignment during movement
- **Lease renewal**: Extend IP address validity
- **Conflict resolution**: Handle duplicate addresses
- **Location update**: Notify network of device location

Configuration Information:

- **IP address**: Unique network identifier
- **Subnet mask**: Network boundary definition
- **Default gateway**: Router for external communication
- **DNS servers**: Domain name resolution

Advantages in Mobile Context:

- **Automatic configuration**: No manual setup required
- **Address conservation**: Reuse addresses efficiently
- **Mobility support**: Seamless network transitions

Mnemonic

"DHCP: Discover Offer Request ACK"

Question 5(c OR) [7 marks]

Explain Bluetooth technology with a neat figure of its protocol stack.

Solution

Bluetooth provides short-range wireless communication for personal devices:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Applications] {-{-}{} B[Application Layer]}
    B {-{-}{} C[L2CAP{}br/{}Logical Link Control]}
    C {-{-}{} D[HCI{}br/{}Host Controller Interface]}
    D {-{-}{} E[Link Manager Protocol{}br/{}LMP]}
    E {-{-}{} F[Baseband Layer]}
    F {-{-}{} G[Radio Layer]}

    H[RFCOMM{br/{}Serial Port] {-}{-}{} C}
    I[SDP{br/{}Service Discovery] {-}{-}{} C}
    J[OBEX{br/{}Object Exchange] {-}{-}{} B}
{Highlighting}
{Shaded}
```

Protocol Stack Layers:

Layer	Function	Purpose
Radio	Physical transmission	2.4 GHz ISM band
Baseband	Media access control	Time division duplex
LMP	Link management	Connection establishment
HCI	Host-controller interface	Hardware abstraction
L2CAP	Logical link control	Packet segmentation
Applications	User services	File transfer, audio

Technical Specifications:
Physical Layer:

- **Frequency**: 2.4 GHz ISM band
- **Hopping**: 79 frequency channels
- **Modulation**: Frequency shift keying
- **Power classes**: 1mW to 100mW

Network Topology:

```
Bluetooth Piconet:

    [Slave 1]
        |
[Slave 2]{-{-}{-}[Master]{-}{-}{-}[Slave 3]}
        |
    [Slave 4]

Max 8 devices per piconet
Master controls communication
```

Connection Types:

- **SCO**: Synchronous Connection-Oriented (voice)
- **ACL**: Asynchronous Connection-Less (data)
- **eSCO**: Enhanced SCO (improved voice)

Security Features:

- **Authentication**: Device identity verification
- **Authorization**: Service access control
- **Encryption**: Data protection (E0 algorithm)
- **Key management**: Security key exchange

Bluetooth Versions:

Version	Speed	Range	Features
1.x	1 Mbps	10m	Basic connectivity
2.x	3 Mbps	10m	Enhanced data rate
3.x	24 Mbps	10m	High-speed option
4.x	1 Mbps	50m	Low energy (BLE)
5.x	2 Mbps	240m	Improved range/speed

Applications:

- **Audio streaming**: Headphones, speakers
- **File transfer**: Documents, photos
- **Input devices**: Keyboards, mice
- **Health monitoring**: Fitness trackers

Advantages:

- **Low power**: Battery-friendly operation
- **Easy pairing**: Simple device connection
- **Interoperability**: Universal standard
- **Cost-effective**: Inexpensive implementation

Mnemonic

"Bluetooth: Radio Baseband LMP HCI L2CAP Applications"