Introduction to IT Systems (4311602) - Winter 2024 Solution

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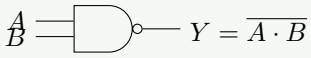
Question 1

Question 1(a) [Explain NAND logic gate. marks]

3

Solution

NAND gate is a universal logic gate that produces output 0 only when all inputs are 1. It is effectively an AND gate followed by a NOT gate.



Truth Table:

A	B	$Y = \overline{A \cdot B}$
0	0	1
0	1	1
1	0	1
1	1	0

- **Universal Gate**: Can implement any logic function (AND, OR, NOT).
- **Low Power**: Requires fewer transistors in CMOS IC design.

Mnemonic

NOT AND = NAND

Question 1(b) [Draw AND logic Gate using NOR Gate only. marks]

4

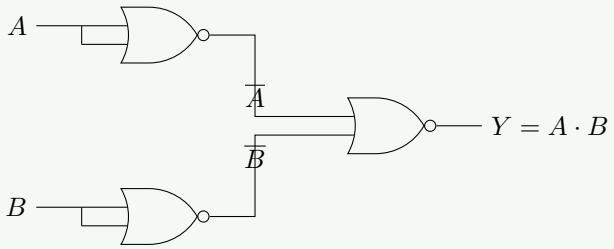
Solution

AND gate can be implemented using NOR gates by applying De Morgan's theorem: $A \cdot B = \overline{\overline{A} + \overline{B}}$.

Implementation Steps:

1. Create NOT A using NOR gate (A NOR $A = \overline{A}$).
2. Create NOT B using NOR gate (B NOR $B = \overline{B}$).
3. Feed $\overline{A}$ and $\overline{B}$ into a third NOR gate to get $\overline{\overline{A} + \overline{B}} = A \cdot B$.

Circuit Diagram:



Mnemonic

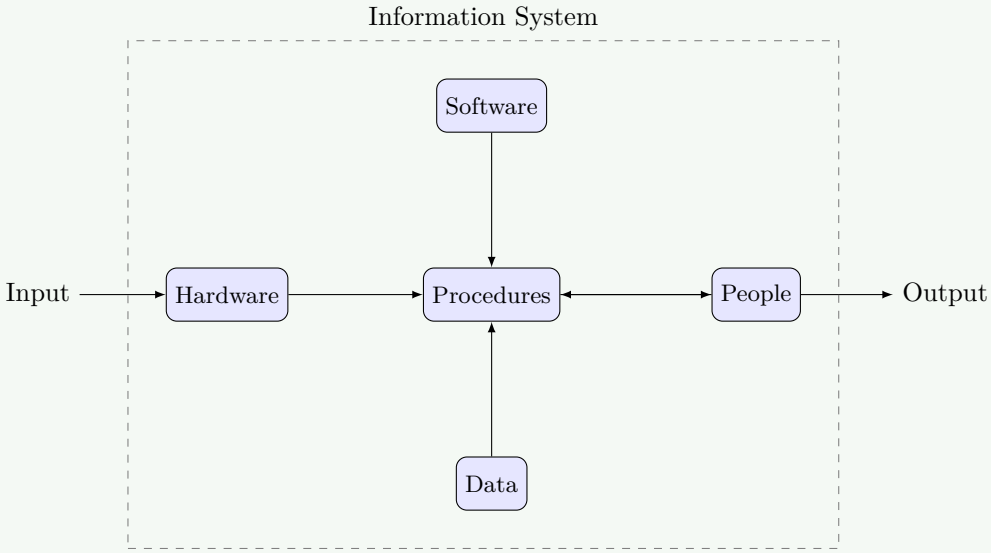
Double inversion gives original function

Question 1(c) [Explain components of Information System with diagram. marks]

7

Solution

Information System consists of five key components working together to process data into useful information.
System Diagram:



Components:

Component	Description	Examples
Hardware	Physical devices	CPU, Memory, Keyboards
Software	Programs and applications	OS, Applications, Utilities
Data	Raw facts and figures	Numbers, Text, Images
Procedures	Rules and instructions	User manuals, SOPs
People	Users and operators	End users, IT staff

Mnemonic

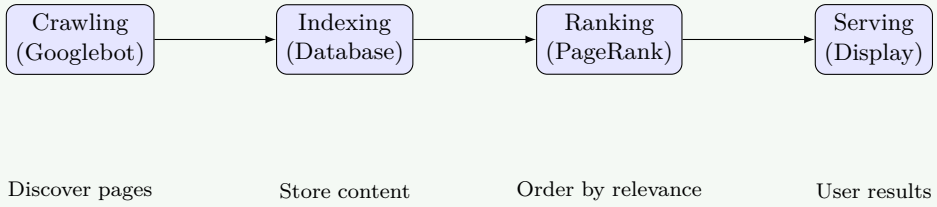
Hardware Supports Data Processing People

Question 1(c) OR [Explain the working of Google Search Engine with example. marks]

7

Solution

Google Search Engine uses complex algorithms to find and rank web pages based on user queries.
Working Process:



Key Components:
- **Crawling**: Spiders/bots browse the web to discover new and updated pages.
- **Indexing**: Analyzing text, images, and video files on pages and storing them in the large database.
- **Ranking**: Using algorithms (like PageRank) to determine the highest quality answers.
- **Serving**: Returning relevant results to the user's query.

Example Search:
- **Query**: "Introduction to IT Systems"
- **Process**: Google checks index for "Introduction", "IT", "Systems".
- **Result**: Educational sites (GTU, TutorialsPoint) ranked higher due to relevance and authority.

Mnemonic

Crawl Index Rank Serve

Question 2

Question 2(a) [Convert $(16.75)_{10} = (\quad)_8$ marks]

3

Solution

Converting decimal 16.75 to octal requires separate conversion of integer and fractional parts.
1. Integer Part (16): Divide by 8

Division	Quotient	Remainder
$16 \div 8$	2	0
$2 \div 8$	0	2

Read remainder from bottom to top: $(20)_8$
2. Fractional Part (0.75): Multiply by 8

$$0.75 \times 8 = 6.00 \rightarrow \text{Integer } 6$$

Read integer from top to bottom: $(.6)_8$
Final Answer:

$$(16.75)_{10} = (20.6)_8$$

Mnemonic

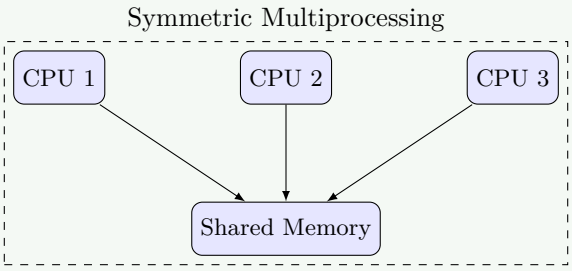
Divide integer, Multiply fraction

Question 2(b) [Explain Multiprocessing Operating System. marks]

4

Solution

Multiprocessing OS manages multiple processors (CPUs) working simultaneously to execute processes.
Architecture:



Key Features:

- **Parallel Processing**: Multiple tasks run at the same time.
- **Reliability**: If one CPU fails, others can take over (Fault Tolerance).
- **Throughput**: Increased number of processes completed per unit time.
- **Shared Resources**: CPUs share memory, bus, and I/O.

Mnemonic

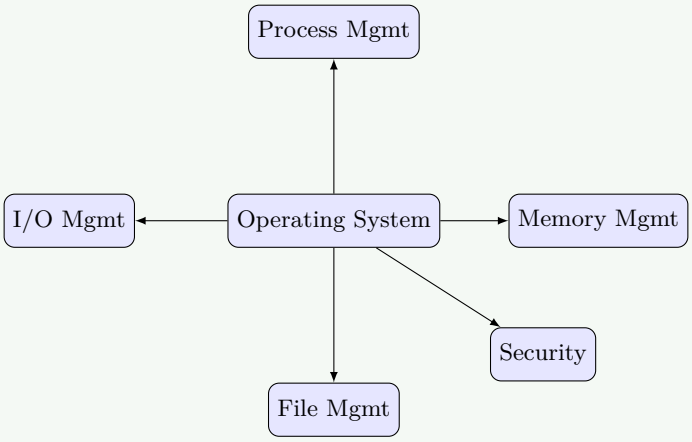
Multiple Processors Process Parallel

Question 2(c) [Define Operating System. List out and Explain the functions of Operating System. marks]

7

Solution

Definition: An Operating System (OS) is system software that manages computer hardware and software resources and provides common services for computer programs.
Core Functions:



Detailed Functions:

1. **Process Management**: Creation, scheduling, and termination of processes. Example: Multitasking.
2. **Memory Management**: Allocation and deallocation of RAM to processes. Example: Virtual Memory.
3. **File Management**: Organizing data into files and directories. Example: NTFS, EXT4.
4. **I/O Management**: Managing communication with devices via drivers. Example: Printer spooling.
5. **Security**: protecting system from unauthorized access. Example: User login.

Mnemonic

Process Memory Files Input-Output Security

Question 2(a) OR [Convert $(1111111.11)_2 = (\quad)_{10}$ marks]

3

Solution

Converting binary to decimal using positional weights (2^n).
Binary: `1111111.11`
Calculation:

$$1 \times 2^6 = 64$$
$$1 \times 2^5 = 32$$
$$1 \times 2^4 = 16$$
$$1 \times 2^3 = 8$$
$$1 \times 2^2 = 4$$
$$1 \times 2^1 = 2$$
$$1 \times 2^0 = 1$$
$$1 \times 2^{-1} = 0.5$$
$$1 \times 2^{-2} = 0.25$$

Sum: $64 + 32 + 16 + 8 + 4 + 2 + 1 + 0.5 + 0.25 = 127.75$
Final Answer:

$$(1111111.11)_2 = (127.75)_{10}$$

Mnemonic

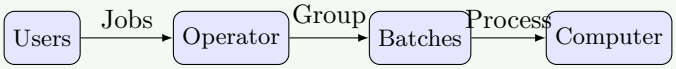
Powers of Two add Together

Question 2(b) OR [Explain Batch Operating System. marks]

4

Solution

Batch OS processes jobs in groups (batches) without user interaction during execution. Similar jobs are grouped together for efficiency.
Working Model:



Characteristics:
- **No Interaction**: User cannot interact with the job once submitted.
- **Job Queue**: Jobs are executed sequentially (FIFO).
- **Efficiency**: Reduces setup time by grouping similar tasks.

Mnemonic

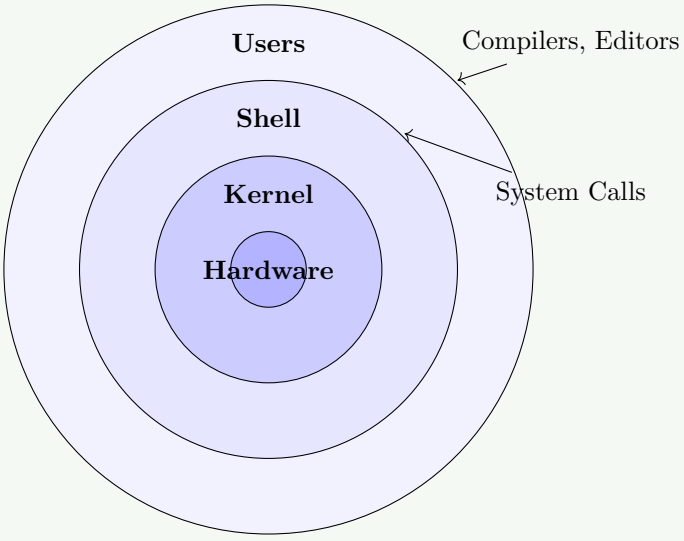
Batch Jobs Queue Automatically

Question 2(c) OR [Explain Architecture and modes of Linux System with Diagram. marks]

7

Solution

Linux follows a monolithic kernel architecture where the kernel manages all system resources.
System Architecture:



Operating Modes:
1. **User Mode**: Applications run here with restricted access. They cannot access hardware directly.
2. **Kernel Mode**: Critical OS code runs here with full access to hardware and memory.

Key Components:
- **Kernel**: Core of the OS, manages CPU, memory, and devices.
- **Shell**: Interface between user and kernel (CLI).
- **Utilities**: Basic programs like `cp`, `ls`, etc.

Mnemonic

Users call Kernel for Hardware

Question 3

Question 3(a) [Differentiate between Open-source Software and Proprietary Software. marks]

3

Solution

Comparison Table:

Aspect	Open-source Software	Proprietary Software
Source Code	Freely available	Closed and protected
Cost	Usually free	Commercial license required
Modification	Can be modified	Cannot be modified
Examples	Linux, Firefox	Windows, MS Office
Support	Community-based	Vendor-provided

Mnemonic

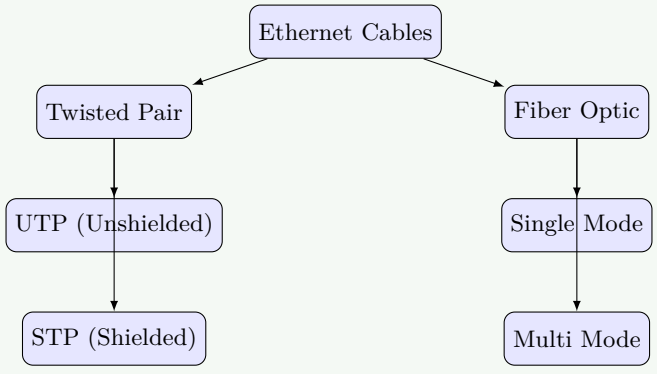
Open Shares, Proprietary Protects

Question 3(b) [Explain Ethernet Cable. marks]

4

Solution

Ethernet cable is the standard wired networking medium for LAN connections.
Cable Types:



Specifications:

- **Cat 5e**: 1 Gbps, 100m.
- **Cat 6**: 10 Gbps, 55m.
- **Connector**: RJ-45 for twisted pair.

Mnemonic

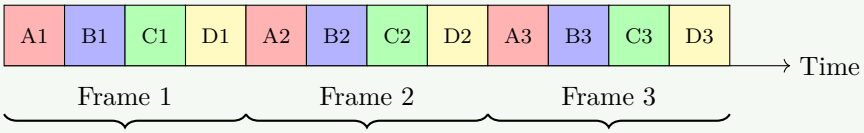
Twisted pairs Carry Digital Data

Question 3(c) [Explain Time Division Multiplexing with diagram. marks]

7

Solution

TDM allows multiple signals to share a single transmission medium by allocating distinct time slots to each signal.
TDM Process:



System Components:
1. **Multiplexer (MUX)**: Combines input signals into frames.
2. **Time Slots**: Fixed duration intervals allocated to channels.
3. **Demultiplexer (DEMUX)**: Separates the combined signal at receiver.

Mnemonic

Time Divides Multiple Signals

Question 3(a) OR [Differentiate between Hard Real Time and Soft Real Time Operating System. marks]

3

Solution

Comparison Table:

Aspect	Hard Real Time	Soft Real Time
Deadline	Absolute; must be met	Flexible; preferred
Failure Impact	Catastrophic (System Failure)	degraded performance
Examples	Air Traffic Control, Pacemaker	Video Streaming, Gaming
Response	Guaranteed max time	Best effort

Mnemonic

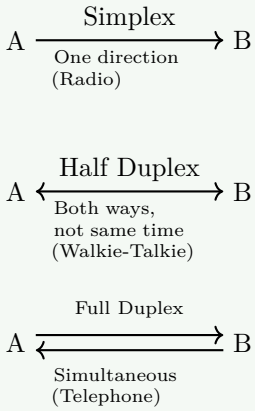
Hard requires Precision, Soft allows Flexibility

Question 3(b) OR [Explain Transmission Modes. marks]

4

Solution

Transmission modes define the direction of data flow between two devices.



Summary:

- **Simplex**: Unidirectional (Keyboard to CPU).
- **Half Duplex**: Bidirectional but one at a time.
- **Full Duplex**: Bidirectional and simultaneous.

Mnemonic

Simplex Single, Half switches, Full flows Both

Question 3(c) OR [List out types of Analog Modulation. Explain Amplitude Modulation with diagram. marks]

7

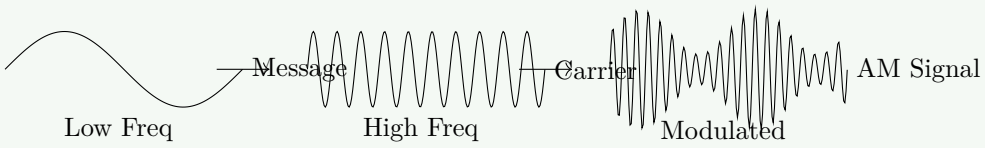
Solution

Types of Analog Modulation:

1. Amplitude Modulation (AM)
2. Frequency Modulation (FM)
3. Phase Modulation (PM)

Amplitude Modulation (AM): The amplitude of the high-frequency carrier wave is varied in accordance with the instantaneous amplitude of the message signal.

Process Diagram:



Characteristics:

- **Modulation Index** (m): Depth of modulation, usually $0 \leq m \leq 1$.
- **Bandwidth**: $2 \times f_m$ (Twice the message frequency).
- **Equation**: $s(t) = A_c[1 + m\cos(\omega_m t)]\cos(\omega_c t)$.

Mnemonic

Amplitude Varies with Message

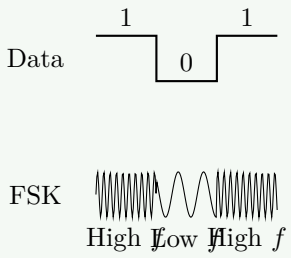
Question 4

Question 4(a) [Draw Diagram of FSK AND PSK. marks]

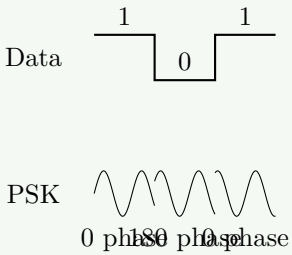
3

Solution

1. Frequency Shift Keying (FSK): Frequency changes based on bit (0 or 1).



2. Phase Shift Keying (PSK): Phase changes by 180° on bit transition.



Mnemonic

FSK changes Frequency, PSK changes Phase

Question 4(b) [If number of links in mesh topology are 45 than find maximum number of required nodes. marks]

4

Solution

Formula for Mesh Topology Links:

$$L = \frac{n(n-1)}{2}$$

Where n = number of nodes.
Given: $L = 45$.
Calculation:

$$45 = \frac{n(n-1)}{2}$$
$$90 = n(n-1)$$
$$n^2 - n - 90 = 0$$

Solving Quadratic Equation: $(n-10)(n+9) = 0$
Since nodes cannot be negative, $n = 10$.
Answer: Maximum number of nodes is **10**.

Mnemonic

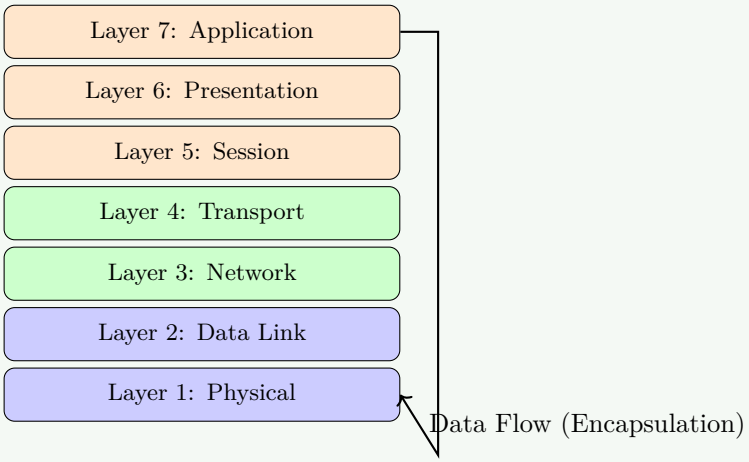
n nodes need n(n-1)/2 links

Question 4(c) [Explain OSI Model with diagram. marks]

7

Solution

OSI (Open Systems Interconnection) model defines seven layers for network communication.
OSI Layer Stack:



Layer Functions:

Layer	Function	Protocol/Device
7. Application	User Interface	HTTP, FTP
6. Presentation	Formatting, Encryption	JPEG, SSL
5. Session	Connection Control	RPC
4. Transport	End-to-end delivery	TCP, UDP
3. Network	Routing (IP Addressing)	Router, IP
2. Data Link	Error detection, MAC	Switch, Ethernet
1. Physical	Bit transmission	Hub, Cable

Mnemonic

All People Seem To Need Data Processing

Question 4(a) OR [Explain Classful IPv4 addressing scheme with example. marks]

3

Solution

Classful Addressing: Divides IP space into 5 classes (A-E).

Class	Range	Use	Format
A	1 - 126	Large Networks	N.H.H.H
B	128 - 191	Medium	N.N.H.H
C	192 - 223	Small (LAN)	N.N.N.H
D	224 - 239	Multicast	-
E	240 - 255	Research	-

Example: Class C: `192.168.1.10`

- Network ID: `192.168.1`
- Host ID: `10`
- Subnet Mask: `255.255.255.0` (/24)

Mnemonic

A for All, B for Business, C for Company

Question 4(b) OR [If number of nodes in mesh topology are 11 than find minimum number of required links. marks]

4

Solution

Formula: $L = \frac{n(n-1)}{2}$
Given: $n = 11$ nodes.
Calculation:

$$\begin{aligned} L &= \frac{11(11-1)}{2} \\ &= \frac{11 \times 10}{2} \\ &= \frac{110}{2} \\ &= 55 \end{aligned}$$

Answer: 55 links are required.

Mnemonic

Every node connects to Every other

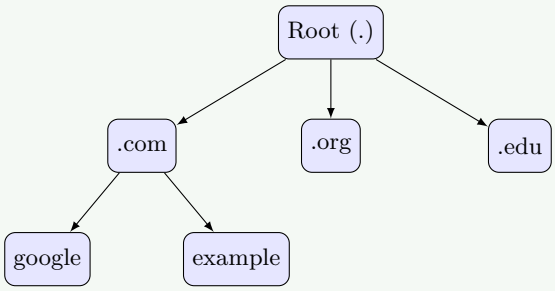
Question 4(c) OR [Explain domain name system (DNS) with diagram. marks]

7

Solution

DNS translates human-readable domain names (example.com) into IP addresses (93.184.216.34) needed for network routing.

DNS Hierarchy:



Resolution Process Steps:

1. **Query**: Client asks "What is IP of google.com?"
2. **Local DNS**: Checks cache. If missing, asks Root.
3. **Root Server**: Directs to '.com' TLD server.
4. **TLD Server**: Directs to 'google.com' Authoritative name server.
5. **Authoritative**: Returns actual IP address.

Record Types:

- **A**: IPv4 Address.
- **AAAA**: IPv6 Address.
- **MX**: Mail Server.

Mnemonic

Domains Need Systematic name-to-address translation

Question 5

Question 5(a) [Explain the need of IPv6. marks]

3

Solution

Need for IPv6: Developed to solve IPv4 address exhaustion.

Feature	IPv4	IPv6
Address Space	4.3 Billion (2^{32})	340 Undecillion (2^{128})
Security	Optional (IPSec)	Built-in (IPSec)
Configuration	Manual/DHCP	Auto-configuration (SLAAC)
Mobility	Limited	Efficient Mobile IP support

- **IoT Support**: Endless addresses for smart devices.
- **Efficiency**: Simplified header for faster routing.

Mnemonic

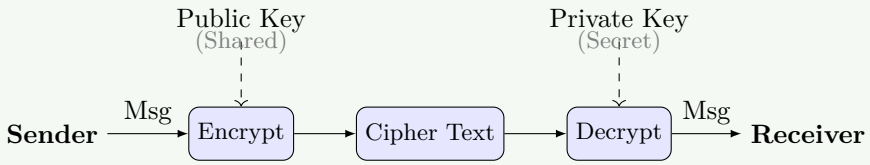
IPv6 provides Infinite addresses for Internet growth

Question 5(b) [Explain confidentiality using Asymmetric Key encryption. marks]

4

Solution

Asymmetric Encryption uses a pair of keys: a **Public Key** for encryption and a **Private Key** for decryption.
Confidentiality Process:



Explanation:
1. Receiver generates key pair. Shares Public Key.
2. Sender encrypts message using Receiver's Public Key.
3. Only Receiver's Private Key can decrypt it.

Mnemonic

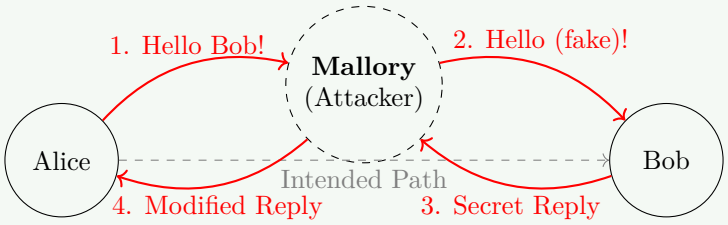
Public locks, Private unlocks

Question 5(c) [Explain man-in-middle attack with example. marks]

7

Solution

Man-in-the-Middle (MiTM): An attacker intercepts and possibly alters communication between two parties without their knowledge.
Attack Visualization:



Real-world Example (Public WiFi):
1. **Scenario**: User connects to fake WiFi "Free_Airport_WiFi".
2. **Interception**: Attacker sees all unencrypted traffic.
3. **Theft**: Passwords and bank details stolen.

Prevention: Use HTTPS, VPNs, and verify certificates.

Mnemonic

Mallory Intercepts Messages between Alice and Bob

Question 5(a) OR [Give the name of OSI model layers with respect to the following devices. 1. Repeater 2. Router 3. Switch marks]

3

Solution

Device Layer Mapping:

Device	OSI Layer	Function
Repeater	Layer 1 (Physical)	Regenerate signal strength
Switch	Layer 2 (Data Link)	Filter/Forward frames by MAC
Router	Layer 3 (Network)	Route packets by IP

Mnemonic

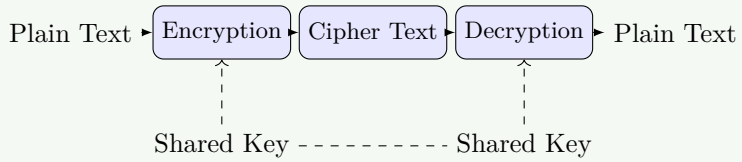
Repeaters work Physically, Switches link Data, Routers route Networks

Question 5(b) OR [Explain confidentiality using Symmetric Key encryption. marks]

4

Solution

Symmetric Encryption uses a **single shared key** for both encryption and decryption.
Process Flow:



Pros/Cons:

- **Speed**: Very fast (AES, DES).
- **Risk**: Key distribution is difficult (if key is stolen, data is lost).

Mnemonic

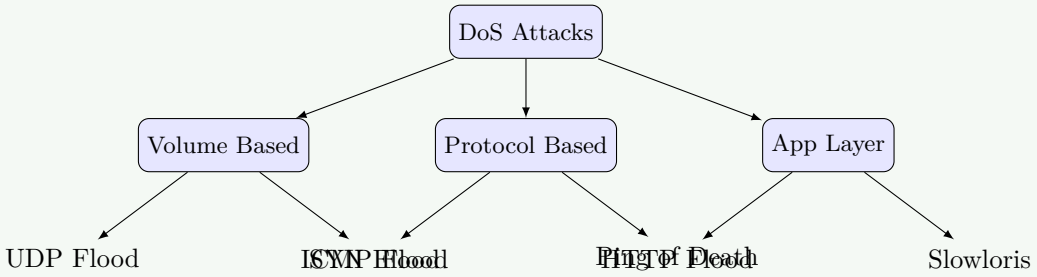
Same key Encrypts and Decrypts

Question 5(c) OR [Explain denial of service attack with example. marks]

7

Solution

DoS (Denial of Service) attack floods a target with traffic to make it unavailable to legitimate users.
Attack Types Hierarchy:



Attack Categories:

Type	Method	Target	Impact
Volume-based	Flood with traffic	Bandwidth	Network congestion
Protocol-based	Exploit protocol weakness	Server resources	Service unavailability
Application-based	Target application layer	Application server	Service degradation

Real-world Example - DDoS on E-commerce:

- **Target**: Online shopping website during sale season.
- **Method**: Botnet of 10,000 infected computers.
- **Attack**: Each bot sends 100 requests per second.
- **Result**: 1 million requests/second overwhelm servers.
- **Impact**: Website crashes, customers cannot purchase, revenue loss.

Common DoS Techniques:

- **SYN Flood**: Exploits TCP handshake process.
- **UDP Flood**: Sends large number of UDP packets.
- **Ping of Death**: Oversized ping packets crash systems.
- **Slowloris**: Keeps connections open to exhaust server.

Defense Strategies:

- **Rate Limiting**: Restrict requests per IP address.
- **Firewall Rules**: Block suspicious traffic patterns.
- **DDoS Protection**: Use services like CloudFlare or AWS Shield.
- **Load Balancing**: Distribute traffic across multiple servers.

Business Impact:

- **Revenue Loss**: Customers cannot access services.
- **Reputation Damage**: Users lose trust in reliability.
- **Operational Cost**: Resources spent on mitigation.

Mnemonic

Deny service by Overwhelming with requests