Introduction To IT Systems (4311602) - Summer 2024 Solution

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Question 1(a) [3 marks]

Define Following Term: 1. Data 2. Information 3. Knowledge

Solution

Answer:

Table 1. Data, Information, and Knowledge Definitions

Term	Definition
Data	Raw facts and figures without meaning or context
Information	Processed data that has meaning and is useful
Knowledge	Information combined with experience and understanding

- **Data**: Basic building blocks without interpretation
- **Information**: Data processed to provide meaningful context
- **Knowledge**: Information enhanced with human insight and wisdom

Mnemonic

"DIK - Data Is Knowledge's foundation"

Question 1(b) [4 marks]

Explain Primary Memory in brief.

Solution

Answer:

Table 2. Primary Memory Characteristics

Aspect	Description
Definition	Main memory that directly communicates with CPU
Access Speed	Very fast access time
Volatility	Volatile (loses data when power off)
Examples	RAM, Cache memory

- **RAM (Random Access Memory)**: Main working memory for current programs
- **Cache Memory**: Ultra-fast memory between CPU and RAM
- **Volatile Nature**: Data disappears when computer shuts down
- **Direct CPU Access**: CPU can directly read/write data

Mnemonic

"Primary is Fast but Forgetful"

Question 1(c) [7 marks]

Explain types of real time OS with example.

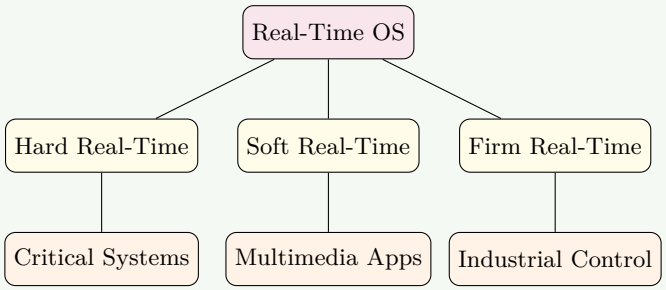
Solution

Answer:

Table 3. Real-Time Operating System Types

Type	Response Time	Examples	Use Cases
Hard Real-Time	Guaranteed deadline	QNX, VxWorks	Medical devices, Aircraft
Soft Real-Time	Best effort timing	Windows RT, Linux RT	Multimedia, Gaming
Firm Real-Time	Occasional deadline miss	Embedded Linux	Industrial control

Figure 1. Real-Time OS Types



- **Hard Real-Time**: Missing deadline causes system failure
- **Soft Real-Time**: Delayed response reduces performance but system continues
- **Deterministic Response**: Predictable timing behavior is essential

Mnemonic

"HSF - Hard, Soft, Firm timing requirements"

Question 1(c OR) [7 marks]

Describe Linux architecture and discuss the mode of the operation of Linux

Solution

Answer:

Figure 2. Linux Architecture

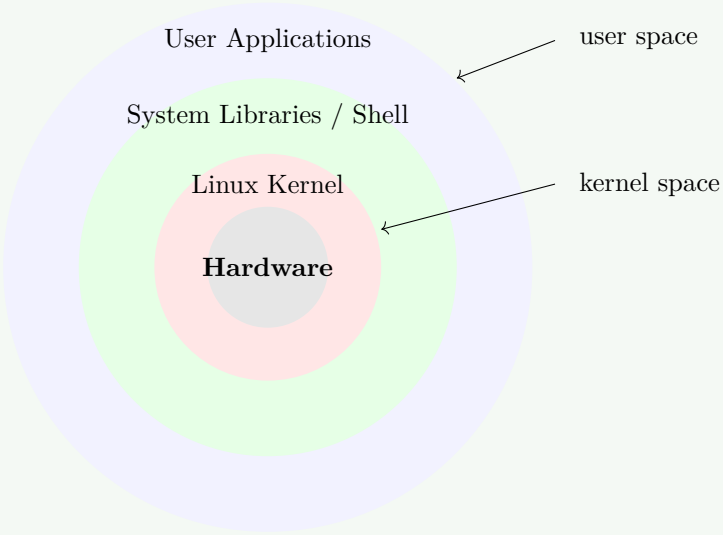


Table 4. Linux Operation Modes

Mode	Description	Access Level	Examples
User Mode	Restricted access	Limited privileges	Applications, user programs
Kernel Mode	Full system access	Complete control	Device drivers, OS functions

- **Layered Architecture**: Clear separation between user and system components
- **Mode Switching**: CPU switches between user and kernel modes
- **System Calls**: Interface for user programs to access kernel services
- **Security**: User mode prevents direct hardware access

Mnemonic

"LUSK - Linux Uses Safe Kernel protection"

Question 2(a) [3 marks]

Describe XOR gate with its truth table.

Solution

Answer:

Figure 3. XOR Gate Symbol

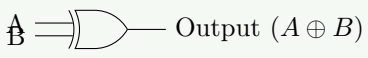


Table 5. Truth Table

A	B	Output (A ⊕ B)
0	0	0
0	1	1
1	0	1
1	1	0

- **Exclusive OR**: Output is 1 when inputs are different
- **Logic Function**: $A \oplus B = A'B + AB'$

- **Applications**: Half adder, parity checker, encryption

Mnemonic

"XOR - eXclusive OR gives 1 for different inputs"

Question 2(b) [4 marks]

Solve following. i) (4C6)16 = (_)2 = (_)10 ii) (186)10 = (_)8 = (_)2

Solution

Answer:

Table 6. Solution Summary

Conversion	Step	Result
$(\mathbf{4C6})_{16}$	Hex to Binary	$\mathbf{10011000110}_2$
	Binary to Decimal	$\mathbf{1222}_{10}$
$(\mathbf{186})_{10}$	Decimal to Octal	$\mathbf{272}_8$
	Decimal to Binary	$\mathbf{10111010}_2$

Detailed Solutions:

i) $(\mathbf{4C6})_{16} = (\mathbf{10011000110})_2 = (\mathbf{1222})_{10}$

- $4 = 0100, C = 1100, 6 = 0110$
- Combined: $010011000110 = 10011000110_2$
- Decimal: $1 \times 2^{10} + 0 \times 2^9 + 0 \times 2^8 + 1 \times 2^7 + 1 \times 2^6 + 0 \times 2^5 + 0 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0 = 1222_{10}$

ii) $(\mathbf{186})_{10} = (\mathbf{272})_8 = (\mathbf{10111010})_2$

- Octal: $186 \div 8 = 23$ rem $2, 23 \div 8 = 2$ rem $7, 2 \div 8 = 0$ rem $2 \rightarrow 272_8$
- Binary: $186 = 128 + 32 + 16 + 8 + 2 = 10111010_2$

Mnemonic

"HDB - Hex, Decimal, Binary conversions"

Question 2(c) [7 marks]

Illustrate following OS: i) Network Operating System ii) Mobile Operating System

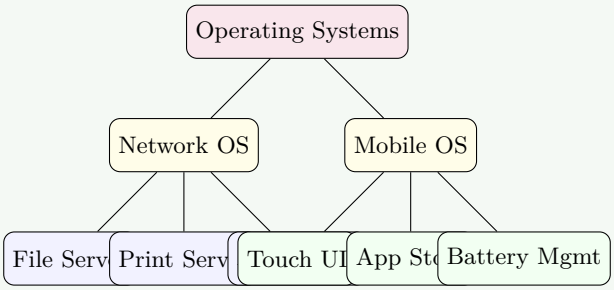
Solution

Answer:

Table 7. Operating System Comparison

Feature	Network OS	Mobile OS
Purpose	Manage network resources	Mobile device management
Examples	Windows Server, Linux Server	Android, iOS, Windows Mobile
Key Features	File sharing, printer sharing	Touch interface, battery management
Users	Multiple simultaneous users	Single user typically

Figure 4. OS Types Overview



i) Network Operating System:
- **Multi-user Support**: Handles multiple concurrent users
- **Resource Sharing**: Files, printers, applications shared across network
- **Security Management**: User authentication and access control

ii) Mobile Operating System:
- **Touch-Optimized**: Designed for finger-based interaction
- **Power Management**: Efficient battery usage
- **App Ecosystem**: Centralized app distribution and management

Mnemonic

"NOS for Networks, MOS for Mobility"

Question 2(a OR) [3 marks]

Draw Logic circuit of OR gate and NOT gate using only NAND gate.

Solution

Answer:

Figure 5. OR Gate using NAND

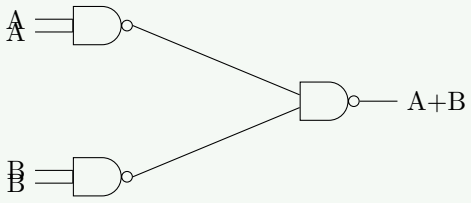


Figure 6. NOT Gate using NAND

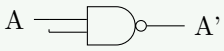


Table 8. Truth Verification Table

A	B	A'	B'	(A'·B')' = A+B
0	0	1	1	0
0	1	1	0	1
1	0	0	1	1
1	1	0	0	1

- **NAND Universal**: Can implement any logic function
- **De Morgan's Law**: $(A' \cdot B')' = A + B$

Mnemonic

"NAND is Universal - can make all gates"

Question 2(b OR) [4 marks]

i) Convert Binary number into Decimal number: (i) 11101 (ii) 10011 ii) Convert decimal number into binary number: (i) 19 (ii) 64

Solution

Answer:

Table 9. Conversion Table

Type	Number	Process	Result
Binary to Decimal	11101_2	$1 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$	$\mathbf{29}_{10}$
	10011_2	$1 \times 2^4 + 0 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$	$\mathbf{19}_{10}$
Decimal to Binary	19_{10}	Division by 2 method	$\mathbf{10011}_2$
	64_{10}	Division by 2 method	$\mathbf{1000000}_2$

Detailed Solutions:
i) Binary to Decimal:
- $11101_2 = 16 + 8 + 4 + 0 + 1 = 29_{10}$
- $10011_2 = 16 + 0 + 0 + 2 + 1 = 19_{10}$

ii) Decimal to Binary:
- $19 \div 2 = 9$ rem $1, 9 \div 2 = 4$ rem $1, 4 \div 2 = 2$ rem $0, 2 \div 2 = 1$ rem $0, 1 \div 2 = 0$ rem $1 \rightarrow 10011_2$
- $64 \div 2 = 32$ rem $0 \ldots \rightarrow 1000000_2$

Mnemonic

"Powers of 2 for Binary to Decimal"

Question 2(c OR) [7 marks]

Explain Open-source software and Proprietary software. Give at least five examples of both the types of software.

Solution

Answer:

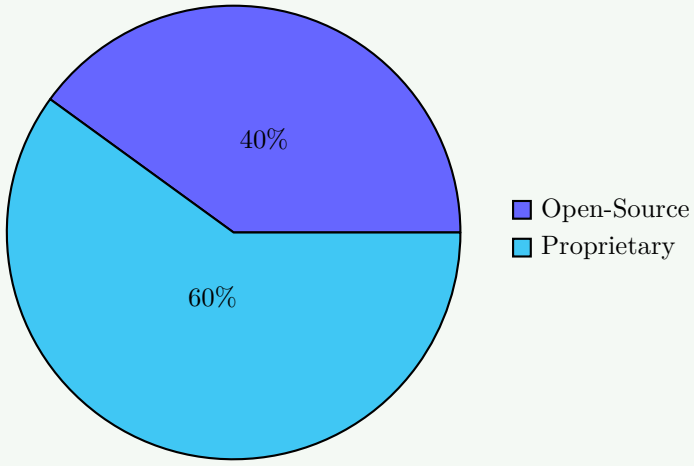
Table 10. Software Type Comparison

Aspect	Open-Source	Proprietary
Source Code	Freely available	Closed/Hidden
Cost	Usually free	Commercial license
Modification	Allowed	Restricted
Support	Community-based	Vendor support

Table 11. Software Examples

Open-Source	Proprietary
Linux	Microsoft Windows
LibreOffice	Microsoft Office
Firefox	Internet Explorer
GIMP	Adobe Photoshop
MySQL	Oracle Database

Figure 7. Software Distribution



- **Open-Source Characteristics**: Freedom to modify, Community development, Transparency
- **Proprietary Characteristics**: Commercial model, Professional support, Quality assurance

Mnemonic

"FOSS is Free, Open, Shared, Supported by community"

Question 3(a) [3 marks]

Define 1. Modulation 2. Multiplexing

Solution

Answer:

Table 12. Definition Table

Term	Definition	Purpose
Modulation	Process of varying carrier signal properties	Enable long-distance transmission
Multiplexing	Combining multiple signals for transmission	Efficient channel utilization

- **Modulation**: Changes amplitude, frequency, or phase of carrier wave
- **Multiplexing**: Allows multiple users to share same communication medium
- **Signal Processing**: Both techniques improve communication efficiency

Mnemonic

"MM - Modulation Modifies, Multiplexing Merges"

Question 3(b) [4 marks]

Explain star topology.

Solution

Answer:

Figure 8. Star Topology

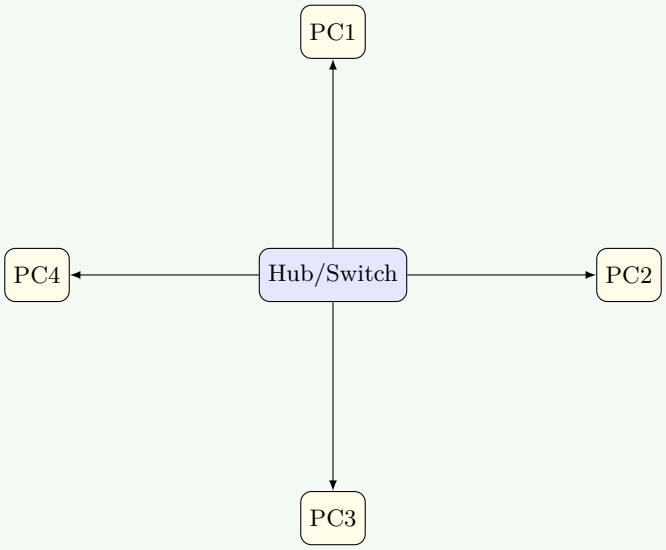


Table 13. Star Topology Features

Feature	Description
Central Device	Hub/Switch connects all nodes
Fault Tolerance	Single node failure doesn't affect others
Performance	Dedicated bandwidth per connection
Scalability	Easy to add/remove nodes

- **Central Hub**: All communication passes through central device
- **Easy Troubleshooting**: Problems isolated to individual connections
- **Higher Cost**: Requires more cable than bus topology
- **Single Point of Failure**: Hub failure affects entire network

Mnemonic

"STAR - Single point, Troubleshooting easy, All through hub, Reliable"

Question 3(c) [7 marks]

Prepare a short note on Time Division Multiplexing (TDM)

Solution

Answer:

Figure 9. Time Division Multiplexing

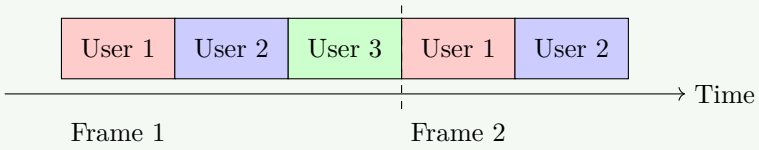


Table 14. TDM Characteristics

Feature	Description
Principle	Different users allocated different time slots
Synchronization	All devices must be synchronized
Efficiency	Full bandwidth utilization when slots filled
Applications	Digital telephone systems, T1/E1 lines

TDM Types:
- **Synchronous TDM**: Fixed time slots regardless of data availability
- **Asynchronous TDM**: Dynamic slot allocation based on demand
- **Statistical TDM**: Slots allocated on statistical basis

Advantages:
- **Fair Sharing**: Equal time allocation for all users
- **No Signal Interference**: Time-based separation prevents conflicts

Mnemonic

"TDM - Time Divides Medium fairly"

Question 3(a OR) [3 marks]

Explain Amplitude Modulation (AM).

Solution

Answer:

Figure 10. AM Signal Concept

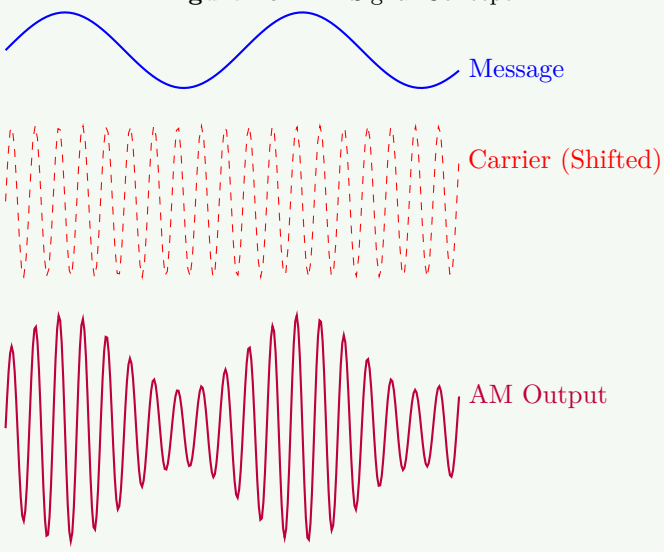


Table 15. AM Characteristics

Parameter	Description
Definition	Amplitude of carrier varies with message signal
Frequency Range	535-1605 kHz (AM radio)
Bandwidth	Twice the message signal frequency

- **Carrier Wave**: High frequency signal that carries information
- **Modulation Index**: Determines depth of amplitude variation
- **Applications**: AM radio broadcasting, aircraft communication

Mnemonic

"AM - Amplitude Modifies with message"

Question 3(b OR) [4 marks]

Describe DNS.

Solution

Answer:

Figure 11. DNS Hierarchy

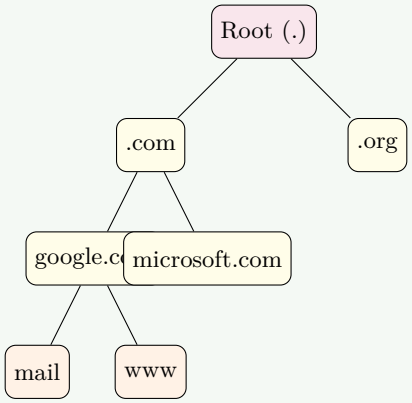


Table 16. DNS Components

Component	Function
Domain Name	Human-readable web address
IP Address	Numerical address of server
DNS Server	Translates names to IP addresses
Records	Different types (A, MX, CNAME)

- **Name Resolution**: Converts domain names to IP addresses
- **Hierarchical Structure**: Root, TLD, second-level domains
- **Distributed Database**: No single point of failure
- **Caching**: Improves performance by storing recent lookups

Mnemonic

"DNS - Domain Name System translates addresses"

Question 3(c OR) [7 marks]

Describe following 1. Serial Communication 2. Synchronous Transmission

Solution

Answer:

Figure 12. Communication Types

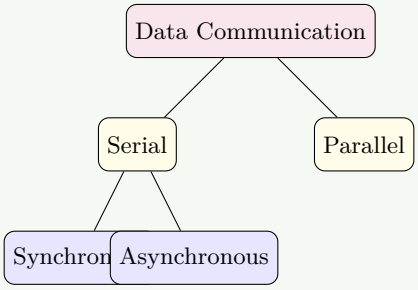


Table 17. Communication Comparison

Type	Description	Timing	Examples
Serial Communication	Data bits sent one after another	Slower but reliable	RS-232, USB, Ethernet
Synchronous Transmission	Clock signal synchronizes sender/receiver	Precise timing	HDLC, SDLC

1. **Serial Communication:**
   - **Single Wire**: Data transmitted bit by bit over single channel
   - **Cost Effective**: Requires fewer wires than parallel
   - **Long Distance**: Less susceptible to noise and interference
   - **Error Detection**: Built-in mechanisms for data integrity
2. **Synchronous Transmission:**
   - **Clock Synchronization**: Separate clock signal or embedded timing
   - **Block Transmission**: Data sent in continuous blocks
   - **Higher Efficiency**: No start/stop bits needed
   - **Complex Hardware**: Requires synchronized clocks

Mnemonic

"Serial is Sequential, Synchronous is Simultaneous"

Question 4(a) [3 marks]

Differentiate Mesh and Bus topology.

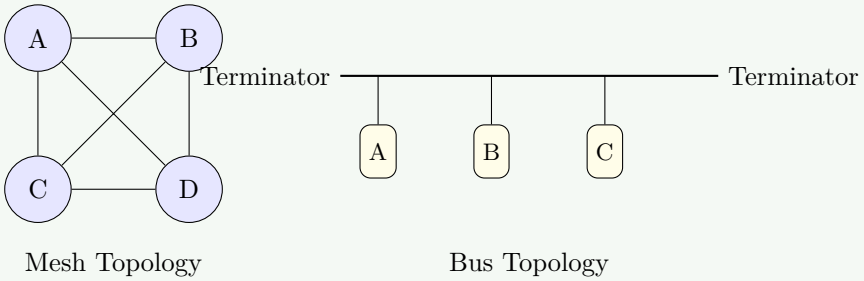
Solution

Answer:

Table 18. Topology Comparison

Feature	Mesh Topology	Bus Topology
Connection	Every node connected to every other	All nodes on single cable
Fault Tolerance	Very high	Low (single point of failure)
Cost	Very expensive	Economical
Performance	Excellent	Degrades with more nodes

Figure 13. Mesh vs Bus Topology



- **Mesh Advantages**: Redundant paths, high reliability
- **Bus Advantages**: Simple installation, cost-effective
- **Cable Requirements**: Mesh needs n(n-1)/2 connections, Bus needs single cable

Mnemonic

"Mesh is Many connections, Bus is Basic single line"

Question 4(b) [4 marks]

Compare FDM and TDM.

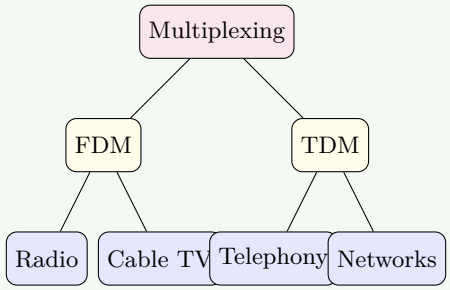
Solution

Answer:

Table 19. FDM vs TDM Comparison

Parameter	FDM	TDM
Full Form	Frequency Division Multiplexing	Time Division Multiplexing
Division Basis	Frequency bands	Time slots
Signal Type	Analog	Digital
Crosstalk	Possible between channels	No crosstalk
Synchronization	Not required	Required
Efficiency	Lower due to guard bands	Higher efficiency

Figure 14. Multiplexing Hierarchy



FDM Characteristics:

- **Frequency Separation**: Each signal allocated different frequency band
- **Simultaneous Transmission**: All signals transmitted at same time
- **Guard Bands**: Prevent interference between channels

TDM Characteristics:

- **Time Separation**: Each signal allocated different time slot
- **Sequential Transmission**: Signals transmitted one after another
- **Precise Timing**: Requires synchronized clocks

Mnemonic

"FDM uses Frequency, TDM uses Time"

Question 4(c) [7 marks]

Draw and illustrate OSI reference model.

Solution

Answer:

Figure 15. OSI Reference Model

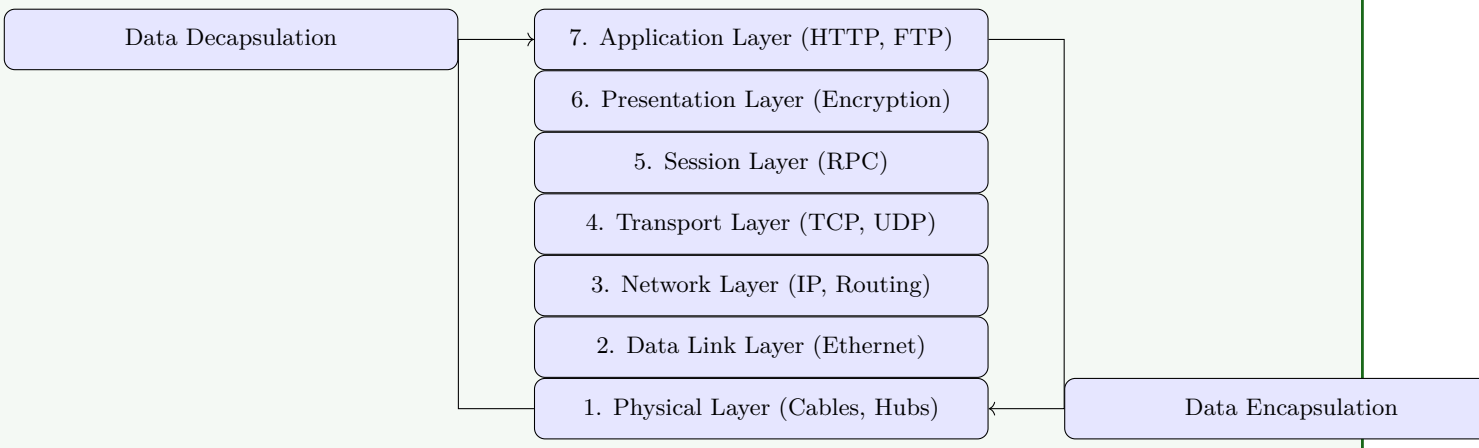


Table 20. OSI Layer Functions

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

- **Layered Architecture**: Each layer has specific responsibilities
- **Protocol Independence**: Layers can be modified independently
- **Standardization**: Common framework for network communication
- **Encapsulation**: Each layer adds its own header

Mnemonic

"All People Seem To Need Data Processing"

Question 4(a OR) [3 marks]

Describe Hub in brief.

Solution

Answer:

Figure 16. Network Hub

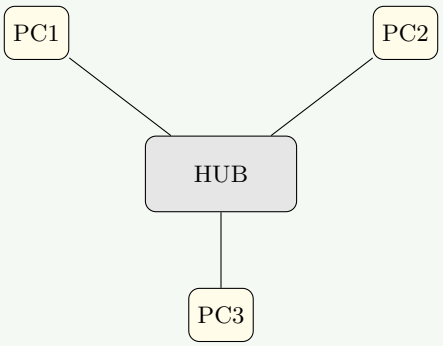


Table 21. Hub Characteristics

Feature	Description
Function	Central connection point for devices
Type	Physical layer device (Layer 1)
Data Handling	Broadcasts to all connected devices
Collision Domain	All ports share same collision domain

- **Shared Bandwidth**: All connected devices share total bandwidth
- **Half-Duplex**: Cannot send and receive simultaneously
- **Security Issues**: All devices receive all transmitted data
- **Obsolete Technology**: Replaced by switches in modern networks

Mnemonic

"Hub is Half-duplex, shares Bandwidth"

Question 4(b OR) [4 marks]

Compare STP and UTP.

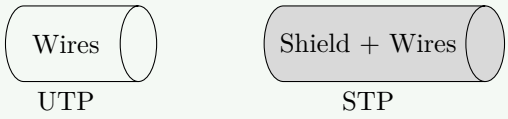
Solution

Answer:

Table 22. STP vs UTP Cable Comparison

Feature	STP (Shielded)	UTP (Unshielded)
Shielding	Metal foil/braid protection	No shielding
Cost	More expensive	Less expensive
Installation	Complex due to grounding	Simple installation
EMI Resistance	Excellent protection	Moderate protection
Applications	Industrial environments	Office environments

Figure 17. Cable Structure



- **STP Advantages**: Better noise immunity, higher data rates, secure transmission
- **UTP Advantages**: Cost effective, easy installation, flexible

Mnemonic

"STP is Shielded but Pricey, UTP is Unshielded but Popular"

Question 4(c OR) [7 marks]

Distinguish LAN, MAN, WAN.

Solution

Answer:

Figure 18. Network Types Hierarchy

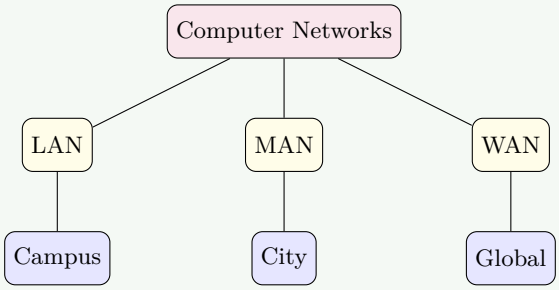


Table 23. Network Type Comparison

Parameter	LAN	MAN	WAN
Coverage	Building/Campus	City/Metropolitan	Country/Global
Speed	High (1 Gbps+)	Medium	Lower/Variable
Cost	Low	Medium	High
Ownership	Private	Private/Public	Public/Leased
Technology	Ethernet, Wi-Fi	Fiber, WiMAX	Satellite, Leased

- **LAN (Local Area Network)**: High speed, low cost, private ownership
- **MAN (Metropolitan Area Network)**: City-wide, medium speed, mixed ownership
- **WAN (Wide Area Network)**: Global coverage, public infrastructure, variable speed

Mnemonic

"LAN is Local, MAN is Metropolitan, WAN is Wide"

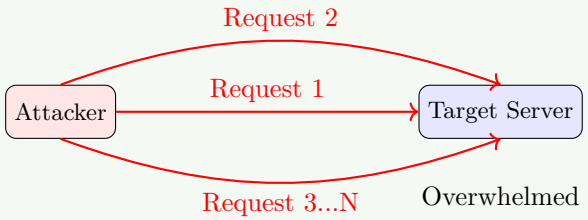
Question 5(a) [3 marks]

Explain Denial of Service Attack.

Solution

Answer:

Figure 19. DoS Attack



- **Definition**: Attack where legitimate users are unable to access information systems or devices
- **Mechanism**: Flooding the target with excess requests to overload system resources
- **Impact**: Service downtime, financial loss, reputation damage

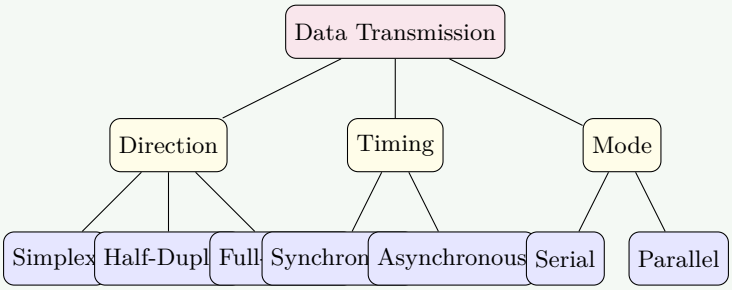
Question 5(b) [4 marks]

i) Classify data transmission ii) Write down use of Terminator in Bus Topology.

Solution

Answer:
i) Data Transmission Classification:

Figure 20. Data Transmission Types



ii) Terminator in Bus Topology:

Table 24. Terminator Functions

Function	Description
Signal Absorption	Prevents signal reflection
Impedance Matching	Matches cable impedance
Network Integrity	Maintains signal quality

- **Prevention of Reflection**: Stops signals from bouncing back
- **Signal Quality**: Maintains clean signal transmission
- **Required at Both Ends**: Bus topology needs terminators at both cable ends
- **Resistance Value**: Usually 50 ohms for Ethernet networks

Mnemonic

"Terminator Stops signal Travel"

Question 5(c) [7 marks]

Describe CIA triad.

Solution

Answer:

Figure 21. CIA Triad

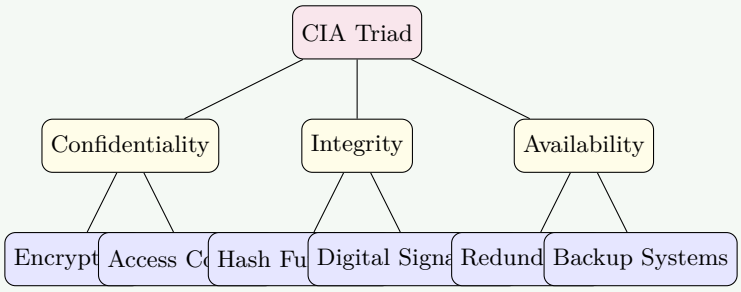


Table 25. CIA Triad Components

Component	Definition	Implementation	Threats
Confidentiality	Information secrecy	Encryption, Access control	Unauthorized disclosure
Integrity	Data accuracy and completeness	Hash functions, Digital signatures	Data modification
Availability	Information accessibility	Redundancy, Backup systems	Service disruption

Confidentiality:
- **Data Protection**: Only authorized users can access information
- **Privacy Measures**: Encryption, authentication, access controls
- **Examples**: Password protection, file permissions

Integrity:
- **Data Accuracy**: Information remains unaltered during transmission/storage
- **Verification Methods**: Checksums, digital signatures, version control
- **Examples**: Hash functions, database constraints

Availability:
- **System Accessibility**: Information and services available when needed
- **Reliability Measures**: Redundancy, fault tolerance, disaster recovery
- **Examples**: Load balancing, backup systems, UPS

Mnemonic

"CIA protects - Confidentiality, Integrity, Availability"

Question 5(a OR) [3 marks]

Define: 1. Cryptography 2. Decryption

Solution

Answer:

Table 26. Definition Table

Term	Definition	Purpose
Cryptography	Science of securing information through encoding	Protect data confidentiality
Decryption	Process of converting encrypted data back to original	Retrieve original information

- **Cryptography**: Uses mathematical algorithms to transform readable data into unreadable format
- **Decryption**: Reverse process using keys to restore original data
- **Key-based Security**: Both processes rely on cryptographic keys

Mnemonic

"Crypto Conceals, Decryption Discloses"

Question 5(b OR) [4 marks]

i) State reason why wires are twisted in twisted pair cables. ii) Identify OSI layer for: 1. Router 2. Bridge

Solution

Answer:
i) Twisted Pair Cable Design:

Table 27. Wire Twisting Benefits

Benefit	Description
Noise Reduction	Cancels electromagnetic interference
Crosstalk Prevention	Reduces signal interference between pairs
Signal Quality	Maintains better signal integrity

ii) OSI Layer Identification:

Table 28. Network Devices and OSI Layers

Device	OSI Layer	Function
Router	Layer 3 (Network)	Routing between different networks
Bridge	Layer 2 (Data Link)	Connecting network segments

- **Wire Twisting**: Each twist cancels out electromagnetic interference from adjacent wire
- **Interference Cancellation**: Noise affects both wires equally but in opposite directions
- **Router Function**: Makes routing decisions based on IP addresses
- **Bridge Function**: Forwards frames based on MAC addresses

Mnemonic

"Twisted wires Reduce interference, Router at layer 3, Bridge at layer 2"

Question 5(c OR) [7 marks]

Define Cyber Attack and explain various cyber-attacks in brief

Solution

Answer:
Cyber Attack Definition: Cyber attack is a deliberate attempt to compromise computer systems, networks, or digital devices to steal, alter, or destroy data.

Figure 22. Cyber Attack Types

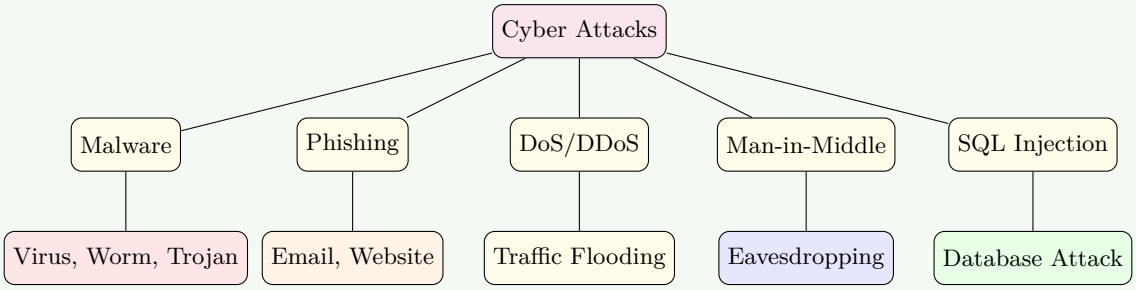


Table 29. Cyber Attack Types

Attack Type	Description	Impact	Prevention
Malware	Malicious software (virus, worm, trojan)	System corruption, data theft	Antivirus, updates
Phishing	Fraudulent emails/websites to steal credentials	Identity theft, financial loss	User awareness, email filters
DoS/DDoS	Overwhelming target with traffic	Service unavailability	Firewalls, load balancers
Man-in-Middle	Intercepting communication between parties	Data eavesdropping	Encryption, secure protocols
SQL Injection	Malicious code inserted into database queries	Database compromise	Input validation, parameterized queries

Malware Attacks:
- **Virus**: Self-replicating code that attaches to files
- **Worm**: Standalone malware that spreads across networks
- **Trojan**: Disguised malware that appears legitimate

Social Engineering:
- **Phishing**: Fake emails requesting sensitive information
- **Spear Phishing**: Targeted attacks on specific individuals
- **Baiting**: Using attractive offers to deliver malware

Network Attacks:
- **Packet Sniffing**: Capturing network traffic for analysis
- **Session Hijacking**: Taking over user sessions
- **Password Attacks**: Brute force, dictionary attacks

Mnemonic

"MPDMS - Malware, Phishing, DoS, Man-in-middle, SQL injection"