0- introduce yourself

Hello! My name is Samar, and I'm a 4rth year computer engineering student

I have a strong foundation in computer fundamentals with experience in web development.

I have experience in mentoring groups and explaining technical priciples

talking about the practical experience i've joined several interships and worked on several projects

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1. Networking :

What is OSI model and the difference between it and TCP|IP model

1- OSI Model (7 Layers)

Theoretical model by ISO

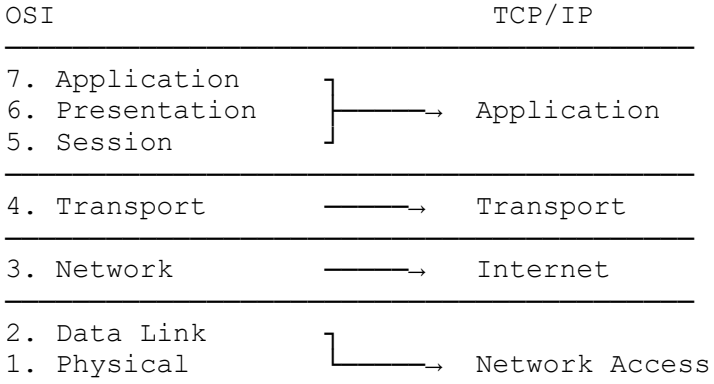
Used for teaching and troubleshooting (helps pinpoint where problems occur)

Application: User interfaces (HTTP, FTP, SMTP)
Presentation: Data formatting, encryption
Session: Maintains connections
Transport: TCP/UDP, ensures delivery
Network: IP addresses, routing
Data Link: MAC addresses, switches
Physical: Cables, signals (hardware)

2- TCP|IP Model (4 layers)

Practical model, based on real protocols

Actually used in internet communication



IP (Internet Protocol)

A unique address that identifies a device on a network
Two versions: IPv4 (e.g., 192.168.1.1) and IPv6
Allows devices to find and communicate with each other

IP vs MAC

IP Address	MAC Address
Logical address (can change)	Physical address (permanent)
Assigned by network (DHCP)	Assigned by manufacturer
Works at Network Layer (Layer 3)	Works at Data Link Layer (Layer 2)
Used for routing across networks	Used for communication within same network

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Router

Device that forwards data packets between networks
Connects your home network to the internet
Uses IP addresses to determine best path for data

Router vs Switch

Aspect	Router	Switch
OSI Layer	Layer 3 (Network Layer)	Layer 2 (Data Link Layer)
Address Used	IP Address	MAC Address
Purpose	Connects different networks	Connects devices within same network
Scope	Works across networks (WAN)	Works within a network (LAN)
Intelligence	Makes smart routing decisions	Learns which device is on which port

Example Use Connects home network to internet Connects computers in an office

Data Unit Packets Frames

DNS (Domain Name System)

Translates human-readable domain names (google.com) into IP addresses (142.250.185.46)

VPN (Virtual Private Network)

Creates encrypted, secure connection over public internet
Hides your IP address and location
Used for: privacy, security, accessing restricted content
Creates a "tunnel" for your data

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2. Computer Architecture

CPU (Central Processing Unit)

"Brain of the computer"
Executes instructions and processes data
Components: ALU (arithmetic/logic operations), Control Unit, Registers
Measured by clock speed (GHz) and cores

Operating System (OS)

Software that manages computer hardware and software resources
Interface between user and hardware
Functions: memory management, file system, process management, security
Examples: Windows, macOS, Linux, Android, iOS

Multitasking vs Multithreading vs Multiprocessing

Concept Definition Example

Multitasking Running multiple programs/processes simultaneously Listening to music while browsing web

Multithreading Multiple threads within single program running concurrently Browser loading multiple parts of webpage simultaneously

Multiprocessing Using multiple CPU cores to execute tasks in parallel Video editing using all 8 cores of processor

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Cache

Small, fast memory close to CPU
Stores frequently accessed data for quick retrieval
Levels: L1 (fastest, smallest), L2, L3 (slower, larger)
Reduces time to access data from main RAM

Caching stratigies

A. Least Recently Used (LRU)

Principle: Evict the item that hasn't been accessed (read or written) for the longest time.

Assumption: Data that was recently used is likely to be used again soon (this is called temporal locality).

Pros: Generally the most effective policy for common workloads like web browsing and CPU caches, as it adapts well to short-term usage patterns.

Cons: Requires tracking the time or order of every single access, which adds complexity and overhead.

Analogy: A crowded desk. You clear away the papers you haven't touched in hours to make room for your current work.

B. First-In, First-Out (FIFO)

Principle: Evict the item that was added to the cache first, regardless of how many times it has been accessed since.

Assumption: None, it's purely based on time of insertion.

Pros: Simplest to implement, requiring only a basic queue data structure.

Cons: Inefficient, as a highly popular (frequently used) item could be evicted simply because it was one of the first items added.

Analogy: A bus queue. The first person who got on is the first person who has to get off at the end of the line, even if they're the one person everyone else is talking to.

C. Least Frequently Used (LFU)

Principle: Evict the item that has been accessed the least number of times since it was placed in the cache.

Assumption: Data accessed infrequently is unlikely to be needed again.

Pros: Excellent for applications with very stable access patterns, as it prevents heavily used items from ever being removed.

Cons: Complex to implement (requires a counter for every item). Also, a very popular item from a week ago might have a huge count, protecting it forever, even if its usefulness has passed (cache aging).

Analogy: A library. They remove the book that has been checked out the fewest times.

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3. Coding Fundamentals

Loops :

Repeat a block of code multiple times

For Loop: Known number of iterations

While Loop: Continues while condition is true

Conditional Statements :

Execute code based on conditions

If

Break vs Continue

Break	Continue
Exits the loop completely	Skips current iteration, continues loop

Stops all remaining iterations	Only skips to next iteration

Compiler vs Interpreter

Compiler	Interpreter
Translates entire program at once	Translates line by line
Creates executable file	No executable created
Faster execution	Slower execution
Shows all errors at once	Shows errors one at a time
Examples: C, C++	Examples: Python, JavaScript

DOM (Document Object Model)

Tree structure representing HTML document
Allows JavaScript to access and manipulate HTML elements
Every element is a "node" in the tree
JavaScript can add, delete, or modify elements dynamically

Classes

Blueprint or template for creating objects

Objects

Instances created from a class

Self Keyword in Python

Refers to the instance of the class
First parameter in instance methods
Used to access attributes and methods of the object
Like saying "this specific object"

Machine Learning

Subset of AI where computers learn from data without explicit programming
System improves performance through experience
Uses algorithms to find patterns in data

Supervised vs Unsupervised Learning

Supervised Learning	Unsupervised LearningUses
labeled data (input + correct output)	Uses unlabeled data
Learns to predict outputs	Finds hidden patterns
Examples: Classification, Regression	Examples: Clustering, Dimensionality Reduction
Like learning with answer key	Like discovering patterns yourself

Malware

Malicious software designed to harm or exploit systems

Types:

Virus: Attaches to files, spreads when file is executed
Worm: Self-replicating, spreads without user action
Trojan: Disguised as legitimate software
Ransomware: Encrypts data, demands payment
Spyware: Secretly monitors user activity

Data Encoding

Converting data from one format to another
Purpose: Proper data representation and transmission
Examples: ASCII, UTF-8, Base64
Reversible - anyone can decode
Not for security, for compatibility

Encryption vs Encoding

Encryption	Encoding
For security	For compatibility
Requires key to decrypt	No key needed to decode
Hard to reverse without key	Easy to reverse
Examples: AES, RSA	Examples: Base64, UTF-8
Protects confidentiality	Ensures proper data format

1- Encryption: For Secrecy (Reversible with a Key)

Goal: To protect confidentiality. To hide the data so unauthorized people can't read it.

How it Works: It uses a secret Key (like a password) to scramble data into an unreadable message (ciphertext). The process must be reversible so the intended recipient can use their matching key to unscramble it (decrypt).

Analogy: A Locked Safe. You lock the secret document inside (encrypt), send the key to your friend, and they unlock it (decrypt).

Example Using HTTPS to secure your credit card details as they travel to a bank's server.

2- Hashing: For Integrity (One-Way Fingerprint)

Goal: To check integrity. To prove that data (like a password or a file) hasn't been changed or corrupted since it was created.

How it Works: It takes input of any size and produces a fixed-length, unique "fingerprint" (a hash value). This process is designed to be one-way—you cannot mathematically reverse the hash to get the original data.

Analogy: A Digital Fingerprint. If you change even one letter in the input, the resulting fingerprint looks completely different. Since it can't be reversed, it's safe to store for comparison.

Example: When you log in, the system takes your password, hashes it, and compares that hash to the stored hash. If they match, it verifies your identity without ever having to store your real password.

Encoding: For Compatibility (Easily Reversible)

Goal: To ensure compatibility or usability. To transform data into a common format so that different systems (like web browsers or email programs) can handle it without breaking.

How it Works: It uses a publicly known rule or table to convert data from one format to another. There is no key or secrecy involved; anyone can easily reverse the process (decode).

Analogy: A Common Language Translation. It translates complex characters (like those in a picture file) into a text-only format (like Base64) so they can safely travel over text-based systems like email.

Example: Base64 conversion, which allows images or complex binary data to be included and sent inside an email or URL link.

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Examples of Data Encoding

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1. ASCII and Unicode (Text Encoding)

This is the most basic form of encoding, translating characters we read into numbers computers understand.

Goal: To assign a unique numerical value to every letter, number, and symbol.

How it Works (ASCII): The American Standard Code for Information Interchange (ASCII) uses 7 bits to represent 128 characters.

How it Works (Unicode/UTF-8): Unicode is a modern extension that uses more bits to cover virtually all characters and emojis in every language worldwide (like Arabic, Chinese, etc.). UTF-8 is the dominant, variable-length implementation of Unicode on the web.

Example:

The capital letter 'A' is encoded as the decimal number 65.

The number 65 is encoded in binary as 01000001.

The symbol '!' is encoded as 33 (decimal).

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2. Base64 (Binary-to-Text Encoding)

Base64 is used to make complex data (like images or encrypted data) safe for transfer over text-only protocols, such as email or URLs.

Goal: To convert any binary data into a standard set of 64 printable ASCII characters (A-Z, a-z, 0-9, +, /).

How it Works: It groups every 3 bytes of original data (which is 24 bits) and represents them using 4 characters in the new Base64 alphabet.

Analogy: Turning a picture into a long, gibberish sentence so you can safely copy and paste it through text-only messenger apps.

Example:

The short word "Man" (in ASCII binary) is encoded as the Base64 string "TWFu".

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3. URL Encoding (Percent-Encoding)

This method ensures that every character transmitted in a web address (URL) is safe and unambiguous.

Goal: To replace characters that have a special meaning in a URL (like spaces or symbols) with a safe format.

How it Works: Special characters are replaced by a percent sign (%) followed by their two-digit hexadecimal code.

Example:

A space character is encoded as %20.

The character = (often used for separating keys/values) is encoded as %3D.

A query like name=John Doe becomes: name=John%20Doe (The space is encoded).

Numbers representation

System Name, Base (Radix), Symbols Used,
Place Value, Primary Use in Computing
Decimal, 10, "0, 1, 2, 3, 4, 5, 6, 7, 8, 9",
"Powers of 10 (100,101,…)", Human Interaction (Everyday use)
Binary, 2 "0, 1",
"Powers of 2 (20,21,…)", Machine Language (Internal circuitry)
Octal, 8, "0, 1, 2, 3, 4, 5, 6, 7",
"Powers of 8 (80,81,…)", Shorthand for Binary (Groups of 3 bits)
Hexadecimal, 16, "0-9, A, B, C, D, E, F",
"Powers of 16 (160,161,…)", Shorthand for Binary (Groups of 4 bits)