Course: Computing Science

Name: Armando Eliseu Phacule

Code: 202203082

Subject: Parallel Computing

**Part 1**

**The scenario is a metro station of a refugee camp in India for 900 million people.**

**The train only accommodates 1000 people and there are only 4 rails way and 10 trains going, 10 returning**

1. **Explain the computing concepts and the parts to optimize**

What they represent in computing terms are the following.

**The 900 million people, the data in RAM.**

Represents: **Main memory (RAM) capacity**

Computing equivalent: This could be likened to a very large amount of data in main memory, perhaps in the range of several gigabytes to terabytes.

**Train accommodating 1000 people**

Represents: **Data transfer unit size**

Computing equivalent: This could be a cache line, a data bus width, or a network packet size, typically ranging from 64 bytes to a few kilobytes.

**4-rail ways.**

Represents: **Data buses or channels**

Computing equivalent: This could be multiple data buses or channels for parallel data transfer, similar to multi-channel memory architectures or multiple PCIe lanes.

**10 trains going, 10 returning**

Represents: **Bidirectional data transfer capacity**

Computing equivalent: This could represent the number of data transfer operations that can occur simultaneously in each direction, similar to how many read/write operations can be in flight at once in a memory system.

**In computing terms, this scenario might describe a system with**

- A large main memory (represented by 900 million people)

- A fixed data transfer size (1000 people per train)

- Multiple parallel data channels (4 rail ways)

- The ability to perform multiple simultaneous data transfers in both directions (10 trains each way)

**What parts to optimise**

We can **Increase train capacity**, this action will upgrade the trains to carry more people from 1000 to 2000 for instead. This can add the benefit of having more data transferred per operation, increasing the throughput.

We can **add more rail ways**, the construction of additional rail lines from 4 to 8 for example will benefit by increasing the data paths, thus reducing bottlenecks.

We can **Increase train frequency**, by running more trains in any direction, from 10 to 20 each way. As in 20 trains going, 20 trains returning can lead to higher data transfer rates, improving the overall system speed.

We can **Implement express trains** too, this would be equivalent to caching, that is creating priority trains for urgent travellers. This will give faster access to frequently travelling data.

1. **What will be the best and worst case scenario.**

**Part 2**

**Explain in computing concepts the parts on a phone that determines the efficiency and optimization for data storage, data transfer, connectivity.**

**Data Storage**

**Storage Medium**: The type and quality of the storage medium can significantly impact the read/write speeds and durability. High-end phones often use UFS (Universal Flash Storage) instead of embedded Multi-Media Card for faster performance and this suits them better.

The iPhone 7 for example, uses NAND flash storage. The quality and type of this flash memory directly affect read/write speeds. Apple uses high-quality NAND to ensure faster and more reliable performance.

**File System**: The file system can also affect how data is organized, accessed, and managed on the storage medium. Modern file systems can improve efficiency by reducing fragmentation and optimizing read/write operations.

The storage controller in the iPhone 7 manages data transfer between the CPU and the storage medium. Apple's custom-designed controllers are optimized for high performance and low latency.

**Storage Controller**: This component manages data transfer between the CPU and the storage medium. An efficient controller can improve data throughput and latency.

With iOS 10.3, Apple introduced the Apple File System (APFS) for example, which is optimized for flash storage. APFS improves efficiency by reducing fragmentation and providing faster read/write operations.

**Data Transfer**

**Memory (RAM)**: The amount and type of RAM determine how quickly data can be accessed and processed. More RAM allows for better multitasking and faster access to frequently used data.

The iPhone 7 comes with 2GB of LPDDR4 RAM. This type of RAM offers fast data access speeds and efficient power consumption, which is crucial for multitasking and handling large applications.

**CPU and GPU**: The processing power of the CPU and GPU affects how quickly data can be processed and rendered. More powerful processors can handle larger datasets and complex operations more efficiently.

**CPU (A10 Fusion Chip)**: The A10 Fusion chip in the iPhone 7 has a quad-core CPU with two high-performance cores and two high-efficiency cores. This design allows the phone to handle demanding tasks quickly while conserving energy during lighter tasks

**GPU (Graphics Processing Unit)**: The A10 Fusion chip also includes a six-core GPU, which provides fast and efficient graphics processing, enhancing the performance of games and other graphics-intensive application

**Cache Memory**: CPUs and GPUs often have multiple levels of cache that provide extremely fast access to frequently used data, reducing the time needed to fetch data from main memory.

The A10 Fusion chip for example has multiple levels of cache (L1, L2) that provide extremely fast access to frequently used data, reducing the time needed to fetch data from main memory.

**Connectivity**

**Modem and Radio Frequency (RF) Chips**: These components handle communication with cellular networks (e.g., 4G LTE, 5G). The quality and efficiency of these chips determine the speed and reliability of data transfer over mobile networks.

The iPhone 7 for example, uses Qualcomm's X12 LTE modem, supporting speeds up to 600 Mbps for downloads and 150 Mbps for uploads. This modem ensures fast and reliable cellular connectivity.

**Wi-Fi and Bluetooth Chips**: These handle wireless communication within the local area (e.g., Wi-Fi for internet access, Bluetooth for peripherals). Higher standards (e.g., Wi-Fi 6, Bluetooth 5.2) offer faster speeds and better range.

For the iPhone 7, a Broadcom BCM4357 chip for Wi-Fi and Bluetooth connectivity is used. It supports Wi-Fi 802.11a/b/g/n/ac and Bluetooth 4.2, offering fast wireless communication and low-energy Bluetooth connections.

**Antenna Design**: The design and placement of antennas within the phone impact signal strength and quality, affecting both cellular and Wi-Fi connectivity.

On the iPhone 7 it features advanced antenna design and placement to maximize signal strength and quality for both cellular and Wi-Fi connections.

**Network Protocols**: The software protocols used for data transfer (e.g., TCP/IP, HTTP/2) influence the efficiency and reliability of data communication over networks. Optimized protocols can reduce latency and improve throughput.

iOS includes optimized software protocols for efficient data transfer over networks, such as TCP/IP for internet communications and HTTP/2 for faster web browsing.

**Part 3**

**In computing concepts, explain how the hardware of a server and a phone can process 1 billion transaction and show the metrics**

To understand how the hardware of a server and a phone can process 1 billion transactions, we can break down the processes involved in each of the three types of transactions: mobile money, bank card transactions, and internet banking. And then consider the capabilities and limitations of server and phone hardware, to show metrics that illustrate their performance.

**Transactions and Processing Requirements**

**For Mobile Money**

Which is a Peer-to-peer transfers type of transaction, or for either paying bill payments or merchant payments. The Processing Requires, some Authentication, balance verification, transaction recording, and notifications.

The Data Volume of such is Moderate, as each transaction involves minimal data transfer (e.g., user IDs, amounts).

**For Bank Card Transactions**

Which is a Point-of-sale (POS) transactions, online purchases. The processing Requirements would be Authentication (PIN/biometric), fraud detection, authorization, and settlement. The Data Volume for this is on the Moderate to high side, including user data, transaction amounts, merchant information.

**For Internet Banking**

Which is a Fund transfers type of transaction for bill payments, account management.

The processing Requirements includes, User authentication (multi-factor), encryption, transaction logging, notification. With a Data Volume that is High, due to detailed account information, transfer details, and secure communications.

Now for the Server Hardware Capabilities, the server Specifications can be as following for example.

**CPU :** High-performance multi-core processors (e.g., Intel Xeon or AMD EPYC with 64 cores).

**RAM**: Large memory capacity (e.g., 1TB DDR4 RAM).

**Storage:** Fast and scalable storage solutions (e.g., NVMe SSDs, RAID arrays).

**Network:** High bandwidth and low latency connections (e.g., 100 Gbps Ethernet).

**Specialized Hardware:** Accelerators like GPUs or FPGAs for specific tasks (e.g., AI-driven fraud detection).

With the above considerations the Metrics for Server Processing would be following.

**Transactions per Second (TPS):** A high-performance server can handle hundreds of thousands to millions of TPS. For example, a server with 64 CPU cores can potentially process around 500,000 TPS.

**Latency:** Typically low, around 1-10 milliseconds for transaction processing.

**Scalability:** Servers can scale horizontally (adding more servers) to handle increased loads.

And also considering the Phone Hardware Capabilities from part 3

Phone Specifications (e.g., iPhone 7)

CPU: Dual-core high-performance cores (A10 Fusion chip).

RAM: 2GB LPDDR4 RAM.

Storage: Flash storage (up to 256GB).

Network: LTE modem, Wi-Fi 802.11ac.

The Metrics for Phone Processing would be,

**Transactions per Second (TPS):** Limited compared to servers, typically around 1,000 TPS for local processing due to limited CPU and memory resources.

**Latency:** Higher than servers, around 50-100 milliseconds due to network dependencies and lo processing power.

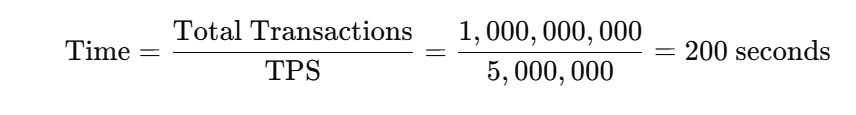
**Scalability**: Limited to the capabilities of the single device; cannot scale like a server.

**Server site processing 1 Billion Transactions**

Scenario: A cluster of 10 high-performance servers.

Processing Capability: Assuming each server can handle 500,000 TPS, the cluster can process 5 million TPS.

Time to Process 1 Billion Transactions:



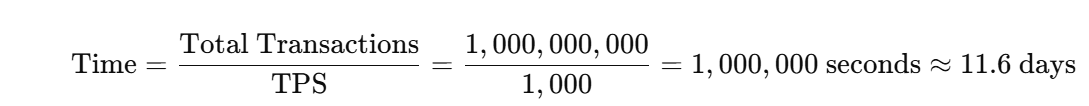
In this regard there need to be considerations in Load balancing, redundancy, and high availability to ensure continuous processing.

**Phone site**

Scenario: Processing transactions locally or through a mobile app.

Processing Capability: 1,000 TPS (limited by CPU and network latency).

Time to Process 1 Billion Transactions:



In this regard there need to be considerations in Offloading to cloud servers for heavy processing tasks, optimizing network communication, and ensuring secure transactions.

While both servers and phones can process transactions, servers are vastly more efficient and scalable. For processing 1 billion transactions:

Servers: Can complete the task in about 200 seconds with a cluster of high-performance machines.

Phones: Would take around 11.6 days due to limited processing power and higher latency.