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Parallel Computing exam

1. The scenario is a metro station of a refugee camp in India for 900 million. The train only accommodates 1000 people. Only 4 railways and there are 10 trains going,and 10 returning.

i) Explain the Computing concepts and the parts to optimise.

Ans:

Scenario Explanation:

- **Storage:** The 900 million people represent the total dataset to be processed, akin to data in parallel computing spread across multiple processing units.
- **RAM:** Each train accommodating 1000 people reflects the chunk of data that RAM can handle at one time, determining simultaneous processing capacity.
- **Bus:** The 4 railways resemble data buses transferring data between storage and CPUs. Optimizing bus width (number of railways) improves data transfer rates.
- **CPU:** Metro stations act as processing units where data is processed. Enhancing CPUs or scheduling can boost overall performance.
- **Processes:** With 10 trains going and 10 returning, these represent concurrent tasks. Efficient process management reduces idle times and enhances throughput.

Optimization Parts:

- **Increase Bus Width**: If possible, adding more railways (data buses) can increase the data transfer rate, reducing the time spent moving data between storage and processing units.
- **Improve Scheduling**: Optimising the schedule of trains (processes) to ensure that no train (process) is idle can improve efficiency. This could mean better load balancing and reducing bottlenecks.
- **Enhance Processing Power**: Upgrading the metro stations (CPUs) to process data more quickly can reduce overall processing time.
- **Expand RAM Capacity**: If trains could carry more people (increasing RAM), larger chunks of data could be processed at once, reducing the number of trips needed.

ii) What will be the worst and best scenario?

Worst scenario:

● **Slowdowns and Idle Time**: Congestion on trains (data buses) and delays in data transfer to and from metro stations (CPUs) can lead to inefficiency. This is similar to having restricted bandwidth in a computer system, resulting in delays.
● **Insufficient RAM:** If trains are too tiny to manage the load efficiently, more journeys will

be necessary, leading to increased total time.
● **Unbalanced load:** When certain trains (processes) are idle and others are overloaded, resources are not used efficiently. This may happen if scheduling is not optimized.

Best Scenario:

● Optimized Data flow: When data buses are fully utilized without congestion, data flow between storage and processing units becomes frictionless.
● **Adequate RAM** allows for larger data chunks, resulting in fewer trips and faster processing.
● **Efficient scheduling** guarantees that all trains (processes) are evenly loaded, reducing idle time and optimizing resource use.
● **Improved Processing Power**: Faster processing by metro stations (CPUs) improves total processing time.

Question 2

In computing, many hardware and software components affect the efficiency and optimization of data storage, data transport, and phone communication.

Data Storage

1. **Internal Storage (NAND Flash Memory)**

    - **ROM Capacity**: This is the main storage for the phone, where the operating system, apps, and user data are stored. NAND flash memory is fast and non-volatile, ensuring quick access and data retention without power.

2. **RAM (Random Access Memory)**

    - **Function**: RAM is used for temporary data storage that the CPU needs to access quickly. The amount and speed of RAM directly affect the phone's ability to handle multiple tasks simultaneously and efficiently.

3. **Storage Controller**

    - **Function**: This chip manages the flow of data between the CPU and the internal storage. A good storage controller optimizes read and write speeds and improves overall storage efficiency.

Data Transfer

1. **CPU (Central Processing Unit)**

    - **Function**: The CPU processes instructions and handles data transfer tasks. A multi-core, high-speed CPU can process more data simultaneously, improving overall performance.

2. **Internal Buses**

- **UFS (Universal Flash Storage)**: A high-speed interface used for internal data transfer between the CPU, RAM, and NAND flash memory. UFS provides faster data transfer rates compared to older technologies like eMMC.
- **PCIe (Peripheral Component Interconnect Express)**: Used in some high-end phones for even faster data transfer rates.

3. **USB Interface**

   - **USB-C**: This port is used for external data transfer and charging. USB-C supports high-speed data transfer and is reversible, making it more user-friendly.

4. **Wireless Communication Chips**

   - **Wi-Fi Chip**: Handles connections to Wi-Fi networks. The efficiency of data transfer over Wi-Fi depends on the Wi-Fi version supported by the chip (e.g., Wi-Fi 5, Wi-Fi 6).
   - **Bluetooth Chip**: Manages short-range wireless communication with other devices. Bluetooth 5.0 and later versions offer improved data transfer speeds and range.

Connectivity

1. **Modem**

   - **Function**: Connects the phone to cellular networks. Modern phones use advanced modems that support multiple generations of network technology (e.g., 4G LTE, 5G) for faster and more reliable connectivity.

2. **Network Interface Chips**

   - **Function**: Handle the phone's connections to various networks, including cellular, Wi-Fi, and Bluetooth. Advanced network interface chips support faster and more efficient data connections.

3. **SIM Card and eSIM**

   - **Function**: Manage subscriber identity and connect the phone to the mobile network. An eSIM can switch between carriers without needing a physical SIM card, offering more flexibility and potentially better connectivity.

Additional Factors

1. **Battery and Power Management**

   - **Function**: Efficient power management systems ensure that components like the CPU, RAM, and network interfaces operate optimally without draining the battery too quickly. This includes dynamic voltage and frequency scaling (DVFS) to adjust power and performance based on current needs.

2. **Thermal Management**

    - **Function**: Effective thermal management prevents overheating, which can throttle performance. Components such as heat pipes, thermal paste, and cooling systems help maintain optimal temperatures and ensure consistent performance.

Summary

In summary, the efficiency and optimization of data storage, data transfer, and connectivity in a phone are determined by a combination of hardware components and software management. These components include the internal storage, RAM, storage controller, CPU, internal buses, USB interface, wireless communication chips, modem, antenna system, network interface chips, and SIM/eSIM. Additionally, efficient battery and power management, along with thermal management, play crucial roles in maintaining optimal performance and reliability. By optimizing these components, phone manufacturers can enhance the overall user experience and performance of their devices.

<u>Qustion 3.</u>

Server Hardware

- **CPU**: 32 cores, 2.5 GHz each
- **RAM**: 256 GB
- **Storage**: SSD with 2 GB/s read/write speed
- **Network Bandwidth**: 1 Gbps

Phone Hardware

- **CPU**: 8 cores, 2.3 GHz each
- **RAM**: 8 GB
- **Storage**: Flash memory with 100 MB/s read/write speed
- **Network Bandwidth**: 100 Mbps (assuming WiFi or 4G)

<u>Calculations</u>

Let's consider a hypothetical TPS figure for both devices. Suppose the server can handle 50,000 TPS and the phone can handle 500 TPS.

Server

1. **Total Transactions**: 1 billion
2. **TPS**: 50,000

Time to process 1 billion transactions = 1,000,000,000 transactions/50,00o tps = 20,000 seconds.

Converting to hours:

20,000= 20,000/3600= 5.56 hours.

Phone

1. **Total Transactions**: 1 billion
2. **TPS**: 500

Time to process 1 billion transactions = 1,000,000,000 transactions/500tps = 2,000,000 seconds.

Converting to hours:

2,000,000= 2,000,000/3600= 555.56 hours

Hardware Utilization Metrics

Server

- **CPU Utilization**: Assuming near 100% utilization for high TPS
- **RAM Usage**: Depending on the transaction size, could use a significant portion of 256 GB
- **Storage I/O**: Continuous read/write at high speeds, close to the maximum 2 GB/s
- **Network Utilization**: High, but 1 Gbps can handle significant transaction data

Phone

- **CPU Utilization**: Near 100% utilization, but limited by lower core count and speed
- **RAM Usage**: 8 GB may be a bottleneck for high transaction processing
- **Storage I/O**: Slower read/write speeds at 100 MB/s
- **Network Utilization**: High, but limited by 100 Mbps bandwidth

Conclusion

Processing 1 billion transactions is significantly more efficient on a server than on a phone due to the server's superior hardware capabilities. The server can complete the task in about 5.56 hours, while the phone would take approximately 555.56 hours. These calculations illustrate the substantial difference in performance between these two types of hardware for high-volume transaction processing.