PARALLEL & DISTRIBUTED COMPUTING

PART-A

Q-1

A. Identify and explain key security concerns when implementing middleware in an online banking system.
B. Justify how the role of middleware in maintaining ACID (Atomicity, Consistency, Isolation, Durability) properties.
C. Design a Middleware Solution: Suppose you are developing a distributed system for an online banking application. Apply middleware models to design a secure and efficient communication mechanism between multiple bank branches.

Q-2

A. Describe the concept of race conditions and explain how they can lead to data inconsistency in multi-user environments.
B. Justify how timestamp-based mechanisms manage concurrent transactions and prevent anomalies like lost updates and dirty reads.
C. Process Synchronization Mechanism: Design a scenario where multiple users are trying to access and update a shared database in a distributed system, apply different synchronization techniques to prevent race conditions.

Q-3

A. Describe how GPUs handle parallelism differently from traditional CPUs and why they are preferred for large-scale image processing.
B. Analyze the speedup achieved by parallel execution of image transformations compared to sequential CPU-based methods.
C. Design and implement a parallel algorithm using CUDA for processing large-scale image datasets. Explain how your solution improves performance compared to traditional CPU-based processing

Q-4

A. Design a system that uses data replication techniques such as primary-backup or quorum-based replication to ensure high availability despite node failures.
B. **Implement a check pointing mechanism where system states are periodically saved so that computations can resume from the last checkpoint after a failure.**
C. **Analyze the overhead introduced by replication, check pointing, and recovery mechanisms and their effect on overall system latency and throughput.**

Q-5

A. Implement a directory-based cache coherence mechanism that minimizes unnecessary coherence traffic and reduces memory access delays.
B. Analyze how the proposed protocol reduces cache miss rates and improves CPU performance.

C. Propose a novel hybrid approach that dynamically switches between snooping and directory-based coherence depending on workload characteristics.

Q-6

A. Justify how techniques like rate limiting, priority queues, and load balancing help maintain system stability.

B. Design a message-passing protocol that leverages message queues to balance load and prevent bottlenecks in a high-speed distributed environment.

C. Designing a Distributed Messaging System: Create a new message-passing protocol for high-speed communication in a distributed computing environment. Explain how it ensures low latency and high reliability.

Q-7

A. Develop a thread pool mechanism where multiple worker threads pick up tasks from a shared queue to balance the workload effectively.

B. Analyze how different task allocation strategies influence response time and resource utilization.

C. Building a POSIX Thread-Based Application: Create a multithreaded application using POSIX threads that demonstrates load balancing in a distributed system. Provide a sample code structure.

Q-8

A. Explain how HDFS ensures fault tolerance and load distribution to handle massive datasets efficiently.

B. Develop a scenario where YARN dynamically allocates resources to improve parallel execution efficiency in a large-scale cluster.

C. Scalability Analysis: Assess the scalability of Apache Hadoop in handling big data workloads. What are its strengths and limitations when compared to other distributed frameworks?

Q-9

A. Describe why some e-commerce functionalities (e.g., real-time payments) require strong consistency while others (e.g., product listings) can tolerate eventual consistency.

B. Apply sharding techniques and evaluate how they affect consistency, latency, and scalability in a global e-commerce database.

C. Evaluating Consistency Models: In a distributed database system, evaluate different consistency models (strong consistency, eventual consistency, etc.) and justify which model is most suitable for an e-commerce platform.

Q-10

A. A distributed system consists of multiple nodes communicating over a network. If one node fails, how does this impact system performance and reliability?

B. **Implement an efficient synchronization mechanism to ensure consistency while minimizing delays in distributed communication.**

C. Design a middleware model that enhances communication efficiency between heterogeneous distributed systems.