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No:- **Date:**

CSXX2831 Distributed System Design

L-T-P-Cr: 3-0-0-3

Prerequisites: Computer Architecture, Operating Systems, Computer Networks.

Course Overview: Thepurpose of this course is to cover design approaches of distributed systems (particularly, fundamental principles in design of distributed systems and middleware platforms, as well as major paradigms of distributed systems), and relate them to contemporary distributed systems.

Course Outcomes: After completing this course, students should be able to:

CO-1. *recall* distributed system terminologies, and fundamental concepts, operational principles and methods of its communication, synchronization, consistency, replication and failure recovery functionalities; [Bloom level: Remember; Mapped to: PO-1]

CO-2. *recognise* communication paradigms and architectural patterns in functioning of given distributed systems; [Bloom level: Remember; Mapped to: PO-1]

CO-3. *explain* concepts and techniques for functional/nonfunctional characteristics of architectural elements and patterns in architectural models of distributed systems; [Bloom level: Understand; Mapped to: PO-1, PO-2]

CO-4. *solve* problems on principles of multithreading, communication, naming, clock synchronization, conit, replication and checkpointing, and their performances in a given distributed system; [Bloom level: Apply; Mapped to: PO-1, PO-2, PO-3]

CO-5. *determine* nature, correctness and complexity of synchronization, coordination, consistency, consensus and availability that are supported in a given distributed system; [Bloom level: Analyze; Mapped to: PO-1, PO-2, PO-3]

CO-6. *evaluate* protocols of communication, agreement, commit, consensus and allocation in distributed systems. [Bloom level: Evaluate; Mapped to: PO-1, PO-2, PO-4, PO-5]

Syllabus:

Unit I: Lectures: 10

Introduction: Motivation for distributed systems; Characteristics of distributed systems and middleware categories; Network service requirements for distributed systems; Architectural models of distributed systems.

Interprocess communication: Multithreading models and multithreaded client/server architectures; Hardware virtualization; Code mobility; Virtual machine migration; Interprocess communication paradigms in distributed systems.

Unit II: Lectures: 10

Naming: Naming scheme and namespace; URI, URN, URL; Name resolution and DNS naming service; Naming and location services of mobile entities; Distributed garbage collection.

Synchronization: Clock synchronization; NTP and GPS; Lamport's clock and vector clock; Total-ordered and causal-ordered multicasting; Election and mutual exclusion in distributed systems.

Coordination: Coordination models; Direct and indirect coordination; Gossip based and group coordination; Publish-subscribe coordination.

Unit III Lectures: 11

Consistency: Consistency models; Data-centric and client-centric consistency; Linearizability; Sequential, causal and FIFO consistency; Eventual consistency; Monotonic read/write, read-your-writes, writes-follow-reads consistency.

Replication: Replication system architecture and functioning; Passive and active replication; Replication in gossip architecture; Consistency models and protocols in replication; Continuous consistency and conit; Replica management, placement and distribution.

Fault Tolerance: Dependability; Failure model; Failure handling and resiliency; Reliable group communication; Distributed commit and consensus.

Failure Recovery: Forward-error and backward-error recovery; Rollback and checkpointing; Message logging.

Unit IV Lectures: 11

Distributed object-based and component-based systems: Distributed objects; Object servers and adapters; Distributed components and containers.

Distributed event-based systems: Distributed event-based system architectures; Content-based communication; Matching and filtering.

Distributed web-based systems: Web service descriptions; SOAP and REST protocol; UDDI service; Web servers and web server clusters.

Distributed file systems: Distributed file system design requirements; File service architecture.

Pervasive systems: Sensor, actuator and IoT; Ubiquity; Sensor network; Context awareness.

Text/Reference Books:

1. Maarten van Steen and Andrew S. Tanenbaum, *Distributed Systems*, Third edition, 2017.
2. George Coulouris, Jean Dollimore, Tim Kindberg and Gordon Blair, *Distributed Systems: Concepts and Design*, Fifth edition, Pearson/Addison-Wesley, 2012.
3. Andrew S. Tanenbaum and Maarten van Steen, *Distributed Systems: Principles and Paradigms*, Second edition, Pearson/Prentice-Hall, 2007.
4. Joel M. Crichlow, *Distributed Systems: Computing Over Networks*, Second edition, Pearson/Prentice-Hall, 2014.
5. Sukumar Ghosh, *Distributed Systems: An Algorithmic Approach*, Chapman and Hall/CRC, 2014.
6. Arno Puder, Kay Römer and Frank Pilhofer, *Distributed Systems Architecture: A Middleware Approach*, Elsevier, 2011.
7. Ajay D. Kshemkalyani and MukeshSinghal, *Distributed Computing: Principles, Algorithms, and Systems*, Cambridge University Press, 2008.
8. PankajJalote, *Fault Tolerance in Distributed Systems*, Prentice-Hall, 1994.
9. Mukesh Singhal and Niranjan G. Shivaratri, *Advanced Concepts in Operating Systems*, McGraw-Hill, 1994.