BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI

WORK INTEGRATED LEARNING PROGRAMMES

COURSE HANDOUT

Part A: Content Design

Course Title	DISTRIBUTED COMPUTING
Course No(s)	SS ZG526
Credit Units	
Course Author	
Version No	V1
Date	08/02/2018

Course Description

Course Objectives

No	Objective
CO1	This course will cover various hardware architectures for building distributed systems, and their communication models.
CO2	This will help students understand the design aspects of various software applications that can be deployed on various distributed systems.
CO3	This will provide an understanding of the complexities and resource management issues that are critical in a large distributed system.
CO4	This course will cover algorithmic aspects of building/designing distributed systems in domains like IoT, P2P, Cluster, Grid computing etc.

Text Book(s)

No	Author(s), Title, Edition, Publishing House
T1	Ajay D. Kshemkalyani, and Mukesh Singhal “Distributed Computing: Principles, Algorithms, and Systems”, Cambridge University Press, 2008 (Reprint 2013).

Reference Book(s) & other resources

No	Author(s), Title, Edition, Publishing House
R1	John F. Buford, Heather Yu, and Eng K. Lua, “P2P Networking and Applications”, Morgan Kaufmann, 2009 Elsevier Inc.
R2	Kai Hwang, Geoffrey C. Fox, and Jack J. Dongarra, “Distributed and Cloud Computing: From Parallel processing to the Internet of Things”, Morgan Kaufmann, 2012 Elsevier Inc.

Content Structure

No	Title of the Module	References
M1	**Introduction to Distributed Computing** • Introduction to Distributed computing • Motivation, Multiprocessor Vs Multicomputer Systems • Distributed Communication Model; RPC • Design issues and challenge	T1 (Chap.1)
M2	**Logical Clocks & Vector clocks** • A framework for a system of logical clock • Scalar time, Vector time. • Implementation of Logical and Vector clocks, Efficient implementation of Vector clocks. • Physical Clock synchronization: NTP	T1 (Chap.3)
M3	**Global state and snapshot recording algorithms** • System model and definitions • Snapshot recording algorithms for FIFO channels • Snapshot recording algorithms for non-FIFO channels • Necessary and sufficient conditions for consistent global snapshots • Classifications and basic concepts • Elementary graph algorithms, Synchronizers • Maximal Independent set, and Connected dominating set	T1 (Chap.4 & 5)
M4	**Message ordering and Termination detection** • Message ordering paradigms • Group Communication • Protocols for ensuring Causal order of messages • Total order • Application level multicast • Termination detection using distributed snapshots • Termination detection using weight throwing • A spanning-tree based termination detection algorithm	T1 (Chap.6)
M5	**Distributed Mutual Exclusion** • Introduction and Preliminaries • Assertion based: Lamport's algorithm, and Ricart-Agrawala's algorithm • Assertion based: Maekawa's algorithm • Token based: Suzuki-Kasami's broadcast based algorithm • Token based: Raymond's tree based algorithm •	T1 (Chap.9, 10)
M6	**Deadlock detection** • Models of distributed deadlock • Chandy-Misra-Haas deadlock detection for AND model • Chandy-Misra-Haas deadlock detection for OR model • Deadlock resolution	
M7	**Consensus and Agreement Algorithms** • Problem definition • The Byzantine agreement and other consensus problems • Overview of Results • Agreement in failure-free system (synchronous or asynchronous) • Agreement in (message-passing) synchronous systems with failures	T1 (Chap.14)
M8	**Peer-to-Peer computing and Overlay graphs** • Introduction • Data indexing and Overlays • Unstructured Overlays • Structured Overlays: CHORD DHT • Design issues of P2P overlays • Security concerns from P2P networks • Mitigating security risks in P2P networks	T1 (Chap.18)

M9	**Cluster Computing & Grid Computing** • Cluster development trends • Design objectives of Computer clusters • Cluster organization and resource sharing • Node architecture and MPP packaging • Cluster system interconnects • Hardware, software and Middle ware support • GPU Clusters for massive parallelism • Cluster job and resource management • Grid architecture and service modeling • Grid resource management and brokering	R2 (Chap.2, 7)
M10	**Internet of Things** • IoT for Ubiquitous computing, RFID, Sensors and ZigBee technologies, • Applications of IoT (smart buildings, cyber-physical systems) • Graph theoretic analysis of social networks; Facebook, and Twitter case studies	R2 (Chap.9)

Learning Outcomes:

No	Learning Outcomes
LO1	Understanding of middleware platforms like RPC(Sun RPC, Java RMI, etc) for implementing communication models over distributed systems.
L02	Understanding the need of Logical clocks and their usages in building distributed systems and its' components.
LO3	Understanding of Mutual exclusion primitives, Agreement protocols, and deadlock handling scenarios in distributed systems.
LO4	Understanding of search, storage, communication, efficiency and other related issues in paradigms like P2P, Cluster, Grid, and IoT.

Part B: Contact Session Plan

Academic Term	Second Semester 2020-2021
Course Title	DISTRIBUTED COMPUTING
Course No	SS ZG526
Lead Instructor	BARSHA MITRA

Glossary of Terms

1. Contact Hour (CH) stands for a hour long live session with students conducted either in aphysical classroom or enabled through technology. In this model of instruction, instructor ledsessions will be for 22 CH.
    a. Pre CH = Self Learning done prior to a given contact hour
    b. During CH = Content to be discussed during the contact hour by the course instructor
    c. Post CH = Self Learning done post the contact hour
2. Contact Hour (CS) stands for a two-hour long live session with students conducted either in aphysical classroom or enabled through technology. In this model of instruction, instructor ledsessions will be for 11 CS.
    a. Pre CS = Self Learning done prior to a given contact session
    b. During CS = Content to be discussed during the contact session by the course instructor
    c. Post CS = Self Learning done post the contact session
3. RL stands for Recorded Lecture or Recorded Lesson. It is presented to the student through anonline portal. A given RL unfolds as a sequences of video segments interleaved with exercises

4. SS stands for Self-Study to be done as a study of relevant sections from textbooks and referencebooks. It could also include study of external resources.
5. LE stands for Lab Exercises
6. HW stands for Home Work.
7. M stands for module. Module is a standalone quantum of designed content. A typical course is delivered using a string of modules. M2 means module 2.

Teaching Methodology (Flipped Learning Model)

The pedagogy for this course is centered around flipped learning model in which the traditional class-room instruction is replaced with recorded lectures to be watched at home as per the student's convenience and the erstwhile home-working or tutorials become the focus of classroom contact sessions. Students are expected to finish the home works on time.

Contact Session Plan

- Each Module (M#) covers an independent topic and module may encompass more than one Recorded Lecture (RL).
- Contact Sessions **(2hrs each week)** are scheduled alternate weeks after the student watches all Recorded Lectures (RLs) of the specified Modules (listed below) during the previous week
- In the flipped learning model, Contact Sessions are meant for in-classroom discussions on cases, tutorials/exercises or responding to student's questions/clarification--- may encompass more than one Module/RLs/CS topic.
- Contact Session topics listed in course structure (numbered CSx.y) may cover several RLs; and as per the pace of instructor/students' learning, the instructor may take up more than one CS topic during each of the below sessions.

Detailed Structure

Introductory Video/Document: *<< Introducing the faculty, overview of the course, structure and organization of topics, guidance for navigating the content, and expectations from students>>*

- Each of the sub-modules of **Recorded Lectures** (RLx.y) shall delivered via **30 – 60mins videos** followed by:
- **Contact session** (CSx.y) of 2Hr each for illustrating the concepts discussed in the videos with exercises, tutorials and discussion on case-problems (wherever appropriate); contact sessions (CS) may cover more than one recorded-lecture (RL) videos.

Course Contents

<From content structure in Part A of this document. Detail the plan of delivery across each contact hour or each contact session. 1 contact session = 2 contact hours>

Time	Type	Description	References
M1: Introduction to Distributed Computing			
Pre-CH/CS	RL1.1	Introduction - introduction to Distributed computing in terms of various hardware and software models	
	RL1.2	Multiprocessing and Multi computing System, Distributed System Design Issues	
	RL1.3	Distributed Communication Model (RPC)	

During CH/CS	CH/CS 1	Review of different communication models Review of Design issues and Challenges for building distributed systems	
Post-CH/CS	HW/Lab		
Lab Reference	Module 1 Lab Capsule		
M2: Logical Clocks & Vector Clocks			
Pre-CH/CS	RL2.1	Distributed Computational Model and Logical Clocks.	
	RL2.2	Lamport Logical Clocks	
	RL2.3	Vector Clocks	
During CH/CS	CH/CS 2	Review of logical clocks. Review Lamport logical and vector clocks examples	
Post-CH/CS	HW/Lab		
Lab Reference	Module 2 Lab Capsule		
M3: Global state and snapshot recording algorithms			
Pre-CH/CS	RL3.1	Global States, Principles to use to record the global states	
	RL3.2	Chandy Lamport global state recording Algorithm for FIFO channels and Lai yang Algorithm for non-FIFO channels	
During CH/CS	CH/CS 3	Review of recording global state Review of algorithms Chandy Lamport global state recording Algorithm and Lai yang Algorithm for FIFO and non-FIFO channels	
Post-CH/CS	HW/Lab		
Lab Reference	Module 3 Lab Capsule		
M4: Message ordering and Termination detection			
Pre-CH/CS	RL4.1	Casual Ordering of messages; Birman Schipher Stephenson (BSS) Algorithm with Example	
	RL4.2	Schipher Eggli Sandoz (SES) Protocol for casual ordering with example	
During CH/CS	CH/CS 4	Review of Birman Schipher Stephenson (BSS) Algorithm Review of Schipher Eggli Sandoz (SES) Algorithm with examples	
Post-CH/CS	HW/Lab		
Lab Reference	No Lab		
M5: Distributed Mutual Exclusion			
Pre-CH/CS	RL5.1	Distributed Mutual Exclusion; Centralized Algorithm	
	RL5.2	Lamport DME Algorithm with Examples	
	RL5.3	Ricart Agrawala DME Algorithm with Example	
	RL5.4	Maekawa's DME Algorithm with Example	

	RL5.5	Token Based DME, Broadcast Based Algorithm; Suzuki Kasami Algorithm	
	RL5.6	Raymond's Tree Based Algorithm	
During CH/CS	CH/CS 5	Review of DME algorithms like, Lamport. Ricart Agrawala, Maekawa's and Raymond Tree based algorithms with example Review of previous Modules Quiz-1	
Post-CH/CS	HW/Lab		
Lab Reference	Module 5 Lab Capsule		
M6: Deadlock Detection			
	RL6.1	Deadlocks in distribution system	
	RL6.2	Chandy Misra Haas(CMH) Algorithm for AND Model (Edge Chasing)	
	RL6.3	Chandy Misra Haas(CMH) Algorithm for OR Model (Diffusion Computation)	
During CH/CS	CH/CS 6	Review of Chandy Misra Haas algorithms for deadlock. Assignment Announcement	
Post-CH/CS	HW/Lab		
Lab Reference	Module 6 Lab Capsule		
M7: Consensus and Agreement Algorithm			
Pre-CH/CS	RL7.1	Agreement Algorithm	
	RL7.2	Oral Message Algorithm	
	RL7.3	Applications of Byzantine Algorithm	
During CH/CS	CH/CS 7	Review of Agreement and OM algorithms	
Post-CH/CS	HW/Lab		
Lab Reference	Module 7 Lab Capsule		
M8: Peer to Peer Computing and Overlay graphs			
Pre-CH/CS	RL8.1	Introduction , P2P Architecture	
	RL8.2	Design of Unstructured peer to peer networks	
	RL8.3	Design of structured peer too peer networks	
	RL8.4	Security Solutions for threats in P2P networks	
During CH/CS	CH/CS 8	Review of deign of structured and unstructured P2P network	
Post-CH/CS	HW/Lab		
Lab Reference	Module 8 Lab Capsule		
M9: Cluster computing, Grid Computing			
Pre-CH/CS	RL9.1	Cluster computing Introduction	

	RL9,2	Design Components of cluster computers	
	RL9.3	Grid Computing Introduction	
During CH/CS	CH/CS 9	Review of Cluster computing, grid computing	
Post-CH/CS	HW/Lab		
Lab Reference	Module 9 Lab Capsule	Provide the lab capsule name or number	
M10: Internet of Things			
Pre-CH/CS	RL number	RL description	
	RL9.4	IoT ; IoT Architecture	
During CH/CS	CH/CS 10	Review of IoT Architecture and Technologies Review of Previous Modules Assignment Evaluation Quiz-2	
Post-CH/CS	HW/Lab		
Lab Reference	Module 10 Lab Capsule		

Lab Details

Lab No	Lab Objective	Lab Sheet/Capsule Access URL	Content Reference
1	To understand Remote procedure call in client server environment.	Module 1 Labcapsule	
2	To understand Lamport clock to determine order of events in distributed system	Module 2 Labcapsule	
3		Module 3 Labcapsule	
4		Module 5 Labcapsule	
5	To understand Lamport’s distributed mutual exclusion algorithm	Module 6 Labcapsule	
6	To understand Byzantine agreement algorithm to determine tolerance of systems to faulty nodes	Module 7 Labcapsule	
7	To understand Peer2Peer distributed applications	Module 8 Labcapsule	
8	To understand the concept of clustered network can be implemented over HTTP/	Module 9 Labcapsule	

	HTTPS protocol		
9	A security system that sends an email once an intrusion is detected	Module 10 Labcapsule	

Select Topics and Case Studies from business for experiential learning

Topics No.	Select Topics/Case Studies in Syllabus for experiential learning	Access URL

Evaluation Scheme

Legend: EC = Evaluation Component

No	Name	Type	Duration	Weight	Day, Date, Session, Time
EC-1	Quiz-1		*	5%	February 1-15, 2021
	Quiz-2		*	5%	March 1-15, 2021
	Assignment		*	10%	April 1-15, 2021
EC-2	Mid-Semester Test	Closed Book	2 hours	30%	Saturday, 06/03/2021 (AN) 2 PM – 4 PM
EC-3	Comprehensive Exam	Open Book	3 hours	50%	Saturday, 01/05/2021 (AN) 2 PM – 5 PM

Note *- Evaluation components can be tailored depending on the proposed model.*

Important Information:

Syllabus for Mid-Semester Test (Closed Book): Topics in CS 1-5.
Syllabus for Comprehensive Exam (Open Book): All topics given in plan of study
Evaluation Guidelines:

1. For Closed Book tests: No books or reference material of any kind will be permitted. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
2. For Open Book exams: Use of prescribed and reference text books, in original (not photocopies) is permitted. Class notes/slides as reference material in filed or bound form is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
3. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam. The genuineness of the reason for absence in the Regular Exam shall be assessed prior to giving permission to appear for the Make-up Exam. Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course handout, attend the lectures, and take all the prescribed evaluation components such as Assignment/Quiz, Mid-Semester Test and Comprehensive Exam according to the evaluation scheme provided in the handout.