DISTRIBUTED SYSTEMS

1. KEY INDICATORS

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2. OBJECTIVES OF THE COURSE

Distributed computing systems are at the heart of any information systems today. The course aims to provide students with a clear characterization of concurrency in a distributed system considering the characteristics of this system such as failures, unpredictable latency and the absence of a global clock. Then we analyze the main system models and abstractions for communication and synchronization explaining FLP impossibility results and the CAP theorem. Finally, we provide the basic concepts of peer-to-peer and cloud computing with examples from real systems.

3. ACQUIRED ABILITIES

The student will be able to design systems and distributed algorithms over different system models such as synchronous, asynchronous and partially synchronous distributed system. Understanding which problems are solvable, and which are not, on top of a distributed system with some synchrony assumption. Students will also have the ability to abstract systems and platforms in models easier to treat. Understanding the relationship between application requirements and system models is also an ability that students acquire with the course.

4. PROGRAM OF THE COURSE

TOPICS	
INTRODUCTION	Fundamental Concepts of a Distributed Systems: hardware, software and communication technologies. From system specification to system implementation
	From Concurrent to Distributed Systems.
BASIC ABSTRACTIONS	Processes: events, histories, failures, distributed computations, distributed algorithms, safety and liveness properties.
	System models : Sinchronous, Asynchronous, Eventually synchronous
	Point-to-point communication channels : fair loss, stubborn, perfect.
	Failure detectors: perfect failure detectors, eventually perfect failure detectors, leader elections with failure detectors.
	Clock Synchronization: Physical clock synchronization, logical clock synchronization.
DISTRIBUTED COMPUTATIONS	Ordering events: happened-before relation, vector and logical clocks. Application of Logical Time: Causal Communication.
SYNCHRONIZATION	Registers: non-atomic operations, specification (safe, regular, atomic), basic protocols
	Consensus: definition, FLP impossibility result, non-uniform flooding

	consensus, uniform flooding consensus, rotating coordinator protocol. Application of consensus: Total order protocol, non-blocking atomic commitment.
COMMUNICATION	Specification and Protocols: non-uniform (regular) Reliable Broadcast, uniform reliable broadcast, Causal Broadcast, Total Order Broadcast, hierarchy of total order broadcast. Probabilistic broadcast.
REPLICATION	Software Replication : Primary backup, active replication.
INFORMATION DIFFUSION	Publish/Subscribe Systems. Communication paradigm, event routing, SIENA.
CAP THEOREM	Scalabiliy argument, NOSQL systems, CAP theorem, CP System: Google BigTable, AP System: Dynamo, the Google Infrastructure

5. REFERENCES

[T1] R. Guerraoui, L. Rodriguez, "Introduction to reliable distributed computing", Springer, 2006.
[T2] George Coulouris, Jean Dollimore and Tim Kindberg, Gordon Blair "Distributed Systems: Concepts and Design (5th Edition)". Addison - Wesley, 2012.
[S] Slides
Suggested Readings
[T3] Mullender "Distributed Systems", Addison - Wesley, 2002.
[T4] Tanembaun, Van Steen, "Distributed Systems: Principles and Paradigms"

6. COURSE WEBSITE

http://www.dis.uniroma1.it/~baldoni/