Distributed Systems – 6 CFU module
A.A. 2019/2020

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Tentative Program

Topic	References
Introduction to Distributed Systems	[T1] - Chapter 1 [T2] – Chapter 1 and Chapter 2 [S]
Basic Abstractions • Distributed Computations • Abstracting Processes • Abstracting Communications • Timing Assumptions • Abstracting Time	[T1] - Chapter 2 (except Section 2.3, Sections 2.4.5-2.4.7, Sections 2.6.6, Section 2.7) [S]

Clock Synchronization
• Internal and External synchronization
• Christian's algorithm
• Berkley's algorithm
• NTP
• Happened-before relation
• Application of scalar logical clocks to the mutual exclusion
  ○ Lamport's algorithm
  ○ Ricarta-Agrawala's algorithm
	[T2] – Chapter 14 (until Section 14.4 included)
	
	[S]
	
	[R1]

Broadcast • Best Effort Broadcast • Reliable Broadcast • Uniform Reliable Broadcast • Probabilistic Broadcast	[T1] - Chapter 3 - from Section 3.1 to Section 3.4 (included) [T1] - Chapter 3 – Section 3.8 except Section 3.8.5 [S]
Consensus • Regular Consensus • FLP Impossibility Result • Uniform Consensus • Paxos Algorithm	[T1] - Chapter 5, Sections 5.1.1, 5.1.2, 5.2.1, 5.2.2 [R2] [S]
Ordered Communication Primitives • FIFO Broadcast	[T1] - Chapter 3 - from Section 3.9 (except 3.9.6)

• Causal Order Broadcast • Total Order Broadcast ○ TO Hierarchy	[T1] - Chapter 6 – Section 6.1 [R3] [S]
Registers • Regular Register • Atomic Register • Message Passing Implementatios • Transformation from (1, N) Regular to (1, N) Atomic	[T1] - Chapter 4 - until Section 4.3 [S]
Software Replication • Linearizability • Primary-backup • Active Replication	[R4] [S]
CAP Theorem	[R5] - [R6] [S]
Byzantine Fault Tolerance • Authenticated point-to-point links • Byzantine Broadcast • Byzantine Tolerant Registers • The Byzantine General Problem • State Machine Replication - PBFT	[T1] - Chapter 2 – Section 2.4.6 [T1] - Chapter 3 – Section 3.10 (except 3.10.4), Section 3.11 [T1] - Chapter 4 – Sections 4.6 and 4.7 [R10] [S]
Broadcasting Information in Multi-hop Networks • Static networks • Dynamic networks	[S] and references listed at the end of the slides
Blockchain and Distributed Ledgers	[S]

Main Text Book

[T1] - C. Cachin, R. Guerraoui and L. Rodrigues. Introduction to Reliable and Secure Distributed Programming, Springer, 2011

[S] – Slides from Lectures

Suggested Readings

[T2] - George Coulouris, Jean Dollimore and Tim Kindberg, Gordon Blair "Distributed Systems: Concepts and Design (5th Edition)". Addison - Wesley, 2012.

[R1] - Roberto Baldoni, Michel Raynal, "*Fundamentals of Distributed Computing: A Practical Tour of Vector Clock Systems*", IEEE Distributed Systems Online 3(2) (2002) https://www.computer.org/csdl/mags/ds/2002/02/o2001.pdf

[R2] - L. Lamport "Paxos Made Simple", https://www.microsoft.com/en-us/research/wp-content/uploads/2016/12/paxos-simple-Copy.pdf

[R3] - Stefano Cimmino, Carlo Marchetti, Roberto Baldoni "A Guided Tour on Total Order Specifications" WORDS Fall 2003: 187-194

[R4] - Rachid Guerraoui and André Schiper: "Fault-Tolerance by Replication in Distributed Systems". In Proceedings of the 1996 Ada-Europe International Conference on Reliable Software Technologies (Ada-Europe '96).

[R5] - Brewer "CAP twelve years later: How the "rules" have changed" http://ieeexplore.ieee.org/document/6133253/ (see NOTE above)

[R6] - Abadi "Consistency Tradeoffs in Modern Distributed Database System Design: CAP is Only Part of the Story" http://ieeexplore.ieee.org/document/6127847/ (see NOTE above)

[R10] - Leslie Lamport, Robert Shostak, and Marshall Pease "The Byzantine Generals Problem " in ACM TOPLAS 1982 Available at https://www.microsoft.com/en-us/research/wp-content/uploads/2016/12/The-Byzantine-Generals-Problem.pdf

NOTE: Use the Sapienza proxy to access this paper. Instruction on how to do it can be found here https://web.uniroma1.it/sbs/easybixy/easybixy