May 16, 2023

Final Exam Preparation Guide

ECE428 Distributed Systems

Note

- you are allowed to bring TWO pages A4 papers with handwritten or printed notes (from both sides)

Lecture 2

- define and characterize basic properties of distributed systems (message latency, bandwidth)
- synchronous vs. asynchronous systems
- failure detection, timeouts, completeness, accuracy, failure detection time

Lecture 3

- received vs. delivered messages, FIFO message channel
- two-general problem
- types of failures, failure detection for multiple processes (centralized, ring, all-to-all)
- clocks skew and drifts
- clock synchronization: internal and external, bounds for client-server synchronization
- Christian algorithm, Berkeley algorithm, NTP

Lecture 4

- event types and their ordering, happened before relationship, concurrent events
- Lamport's logical timestamps and vector logical clocks

Lecture 5

- local and global states, state changes as events
- global snapshot in asynchronous systems
- cut of events history, event history frontier, consistent and inconsistent cuts

Lecture 6

- applying Chandy-Lamport algorithm
- event history run and linearization
- global state transitions and reachability, stability
- safety and liveness as global state predicates

Lecture 7-9

- unicast vs. multicast
- basic and reliable multicast protocol
- three types of multicast ordering and their implementation including centralized sequencer, ISIS algorithm
- (spanning) tree-based multicast including flooding and gossip

Lecture 9-11

- mutual exclusion problem in single OS and distributed systems, critical section, deadlock, race conditions
- central server algorithm, ring-based algorithm, Ricart-Agrawala algorithm, Maekawa algorithm including their liveness, safety, ordering, bandwidth, client and server delays, breaking deadlock in Maekawa algorithm

Lecture 12-15

- define Leader Election, leader election in a ring, Bully algorithm and key properties (liveness, safety, worst case and best case analysis)
- handling failures in Leader Election
- define Consensus problem, basic properties (termination, agreement, integrity
- Consensus and Leader Election in synchronous vs. asynchronous systems under failures
- Paxos and Raft consensus (understand the lectures as well as check related homework problems, note that you can check out other tutorials on Blackboard, which may be more understandable)

Lecture 16

- define blockchain, how proof-of-work (PoW) is implemented, why PoW is used at all, adjusting PoW difficulty, double-spend problem, longest chain rule, how transactions are submitted and added to blockachain

Lecture 17-18

- database transactions, ACID properties
- processing concurrent transactions, serial equivalence
- pessimistic vs. optimistic concurrency control
- locks: global, per object, read-write locks, two-phase locks
- identifying and resolving deadlocks
- concurrent transactions with timestamps (read, write, commit)
- failures during transaction processing

Lecture 19

- transactions with distributed databases, ACID properties
- atomic commit, one-phase vs. two-phase commits
- locks, deadlocks and timestamps with distributed transactions

Lecture 20-22

- data sharding and replication to achieve data availability
- Google Spanner: basic architecture, Paxos and two phase commits, TrueTime for timestamps, check a presentation by Google and possibly other tutorials on Blackboard for explanations beyond lecture notes
- SQL vs. NoSQL databases
- key-value stores, distributed hash-tables
- Chord protocol (key lookup, retrieving data, values replication and node failures, stabilization after new nodes join or disappear)

Lecture 23

- MapReduce (key-value data processing, examples from lectures how it is applied to some basic problems, resource management and scheduling, fault tolerance, stragglers)

Lecture 24

- CAP theorem, when CA-CP-AP are preferred, BASE property of modern distributed datastores
- Cassandra: data partitioning, replication, reads and writes using quorums and clusters, Bloom filter, eventual consistency, consistency levels, check possibly other tutorials on Blackboard for better explanations beyond lecture notes

HOMEWORKS

- any problem or its modified version from HW1 – HW6 could appear in the examples