

15-440/15-640: Homework 2

Due: ~~October 12, 2018~~ October 13, 2018 11:59pm (Extended)

Updated: October 12, 2018 1:15pm

Name:
Andrew ID:

1 Concurrency Control (18 points)

1. What is the major drawback of 2 phase commit protocol and explain in no more than three sentences how the 3 phase commit protocol overcomes it [6 pts].
2. How will the 3 phase commit protocol ensure correct recovery when a coordinator crashes and a recovery node takes over the transaction? Assume that there is no write ahead logging here (otherwise recovery is trivial). [6 pts]
3. How does 3 phase commit protocol handle a network partition failure? [6 pts].

2 Distributed Mutual Exclusion (25 points)

Part A (8 points)

There are 6 processes with IDs from 0 to 5. The process with ID 5 is the leader, but after some time, it crashes. Process 3 notices that the leader failed.

To elect a new leader, these processes follow the Bully Algorithm (as mentioned in class) to elect a new leader. Process 3 notices that the leader failed.

1. Process 2 starts an election. Which process(es) does 2 send an ELECTION message to? [2 pts]
2. List what processes send what messages (ELECTION, STOP, OK) until the group of processes come to consensus about electing a new leader [6 pts].

Part B (17 points)

Consider three processes. The system has totally ordered clocks by breaking ties by process ID. It uses the Ricard & Agrawala algorithm. The timestamp for each process of id i is $T(p) = 10 * L(p) + i$, where $L(p)$ is a regular Lamport clock.

Each message takes 2 'real-time' steps to get delivered. Critical section takes 2 real-time steps. Fill in the table with the messages that are being broadcast, sent, or received between the processes until all nodes have executed their critical sections. Write 'execute critical section' as the action for a node when it enters its critical section. The first three rows have been filled in for you, and the fourth row has been started. Assume that if a process receives messages from the other two processes at the same time, the message that comes from the lower process ID will be received first.

Action Types: Broadcast (B), Receive (R), Send (S), Execute Critical Section (ExCS) Initial timestamps:

P_1 : $L(p_1) = 11, T(p_1) = 111$

P_2 : $L(p_2) = 23, T(p_2) = 232$

P_3 : $L(p_3) = 9, T(p_3) = 93$

Real Time	Process	Lamport Time	Action(to/from)	Contents	Q at P1	Q at P2	Q at P3
1	1	121	B	(request 121)	121		103
	3	103	B	(request 103)			
2	2	242	B	(request 242)	121	242	103
3	1	131	R from 3	(request 103)	103	103	103
	2	252	R from 1	(request 121)	121	121	121
	2	262	R from 3	(request 103)		242	
	3	133	R from 1	(request 121)			
4	1	251	R from 2	(request 242)	121	242	103
	1	261	S to 3	(reply 103)	242		121
	2	272	S to 3	(reply 103)			242
	2	282	S to 1	(reply 121)			
	3	253	R from 2	(request 242)			
5							
6							
7							
8							
9							
10							
11							
12							
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19							

3 Logging and Crash Recovery (12 points)

1. List one advantage and one disadvantage of using checkpointing in conjunction with a log based recovery system [6 pts].
2. Assume that we are following ARIES logging and recovery protocol. Before we are able to completely recover from a crash, another crash happened. Is it possible to recover from both the crashes? Explain [6 pts].

4 Distributed Replication/Paxos (25 points)

Part A (13 points)

1. Why do we need a prepare phase in the Paxos algorithm? [3 pts]
2. Suppose one of the servers received an ACCEPT for a particular instance of Paxos (remember, each ‘instance’ agrees on a value for a particular account event), but it never heard back about what the final outcome was. What steps should the server take to figure out whether agreement was reached and what the agreed-upon value was? Explain why your procedure is correct even if there are still active leaders executing this instance of Paxos [5 pts].
3. Five servers $S1$ to $S5$ are using Basic Paxos protocol. $S1$, $S2$, $S3$ have accepted proposal 5 with a value A . Once this has happened, can $S4$ or $S5$ accept a different value B ? Provide a clear explanation [5 pts].

Part B (12 points)

Three servers $S1$, $S2$, $S3$ are using the Basic Paxos protocol. A proposer executes the protocol with an initial proposal number n and a value v_1 . But it crashes at some unknown point during or after the execution of the protocol. Can the proposer now restart and re-execute the protocol from the beginning with the same proposal number n and a different initial value of v_2 ? If yes, prove that this is safe. If no, given a scenario that shows the safety condition being violated. Your answer should be as clear and precise as possible.

5 Fault Tolerance and RAID (20 points)

You buy 20 used hard drives. Each individual hard drive has the following characteristics:

Capacity: 600 GB and MTTF: 1 year

Recalling fault tolerance from lecture, you decide to build a RAID-0 array with the disks.

1. What is the effective capacity and MTTF of the RAID-0 array? [3 pts]
2. What happens if one individual hard drive fails in the RAID-0 arrangement? [3 pts]

After a closer look at your lecture notes, you realize that a RAID-5 array might be better for storage and data durability (in addition to speed).

3. What is the effective capacity, MTTF, and MTDDL of the RAID-5 array? [3 pts]
4. What happens if one individual hard drive fails in the RAID-5 arrangement? [3 pts]
5. List one advantage and one disadvantage of mirroring (as in RAID-1) in no more than two sentences or bullet points [4 pts].
6. List one advantage and one disadvantage of having a single parity disk (with no striping of the parity disk) in no more than two sentences or bullet points [4 pts].