Innopolis University

SYSTEM AND NETWORKING ENGINEERING

Distributed Systems

READING QUESTIONS 5

Coordination. Consistency and replication.

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Readings:

- **[DS]** Chapters 6, 7. Distributed systems: principles and paradigms, Andrew S. Tanenbaum, Maarten Van Steen

Questions:

1. Consider the processes in Fig. 6.14 [1] have continued execution and process P_1 currently having $VC_1 = [1, 2, 0]$ receives a message m from process P_2, $ts(m) = [2, 1, 1]$. What information does P_1 have, and what will it do when receiving m?
   Answer:
   P_1 adjusts $VC_1[k]$ to $max\{VC_1[k], ts(m)[k]\}$ for each k. Consequently,

   $$VC_1[0] = max\{1, 2\} = 2$$

   $$VC_1[1] = max\{2, 1\} = 2$$

   $$VC_1[2] = max\{0, 1\} = 1$$

   Process P_1 will update its clock to $VC_1 = [2, 2, 1]$ and deliver message m to the application layer.

2. What would happen with the Ricart and Agrawala algorithm if a process crashes? Discuss.
   Answer:
   If any process fails, it will not be able to respond to requests. This silence will be interpreted as a denial of permission, thereby blocking all subsequent attempts of all processes to enter any of their respective critical areas. The requesting process thinks that it is alive, but permission will never come.

3. Many distributed algorithms require the use of a coordinating process. To what extent can such algorithms actually be considered distributed? Discuss.
   Answer:
   In distributed algorithms the processes independetly interact with each other in order to achieve a common goal. There is no fixed coordinator in distributed algorithms. Using ditrubution model the coordinator is chosen dynmically among the processes that form part of the algorithm.

4. Which of the mutual exclusion solutions discussed in class requires the fewest messages under heavy contention?
   Answer:
   The centralized algorithm is simplest and also most efficient. It requires only three messages to enter and leave a critical region: a request, a grant to enter, and a release to exit.

5. Consider a bully-based technique for electing a coordinator. What kind of failure would result in multiple coordinators being elected? Under what assumptions is this acceptable?
   Answer:
   When a process indicates that the coordinator is no longer responding to requests, he initiates the election and a new coordinator is elected. If a process that was previously not available returns and does not immediately conduct elections, then at this point we will have two coordinators in the system.

6. To achieve totally-ordered multicasting with Lamport timestamps, is it strictly necessary that each message is acknowledged? If not, show how it would work on the scenario depicted in Fig. 6.8(b) [1], where m_1 and m_2 are multicast messages.
   Answer:
   No, it is sufficient that a process reacts to an incoming message by sending its own multicast message with larger timestamp than the received message. See Figure 1

7. When using a lease, is it necessary that the clocks of a client and the server, respectively, are tightly synchronized?
   Answer:
   It is not necessary since the server will push the updates to the client, or the client will try to pull the updates when the lease expires. In any case, the client will be able to obtain a new lease, even without a tightly synchronized clock.

8. Consider a non blocking primary-backup protocol used to guarantee sequential consistency in a distributed data store. Does such a data store always provide read-your-writes consistency?
   Answer:

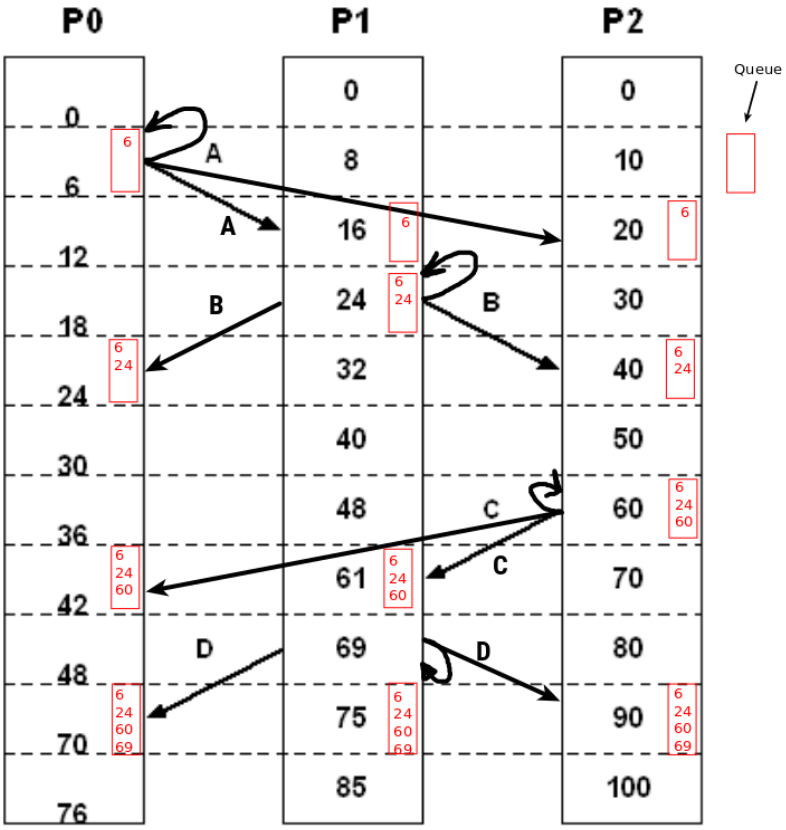

Figure 1: Lamports algorithm with multicast messages

No, in a nonblocking scheme, the client process does not know for sure that the update operation is backed up by several other servers and all processes will not always be able to see the effects of their most recent write operation.

9. A file is replicated on 5 servers. List all the combinations of read quorum and write quorum that are permitted by the voting algorithm.
Answer:
We should follow the next two constraints:

   (a) $N_R + N_W > N$

   (b) $N_W > N/2$

   Where N is number of servers, N_R is read quorum servers, and N_W is write quorum servers. The following possibilities of (N_R, N_W) are legal:

$$(1, 5)$$

$$(2, 4)$$

$$(3, 3)$$

   Because:
   $1 + 5 > 5$ and $5 > 5/2$
   $2 + 4 > 5$ and $4 > 5/2$
   $3 + 3 > 5$ and $3 > 5/2$

10. How would you characterize the consistency model of Facebook?
Answer:
Facebook is a distributed data storage model that can be accessed by clients from different locations. I think that Facebook adheres to Data-centric Consistency Model with Sequential Consistency since Facebook data store satisfies the following condition: the result of any execution is the same as if the operations (read and write) by all processes on the data store were executed in some sequential order and the operations of each individual process appear in this sequence in the order specified by its program.

References

[1] Andrew S. Tanenbaum, Maarten Van Steen. Distributed systems, Third Edition, 2017, 596 pages.