LTAT.06.007 Distributed Systems

Seminar 10 - Consistency and Replication

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Quiz 10

Questions are based on the Consistency and Replication lecture

Short answers

Link to quiz – https://tinyurl.com/vxavbrg

Quiz will be available until April-20-2020:23.59
1. What are the three independent axes (Yu & Vahdat) for defining inconsistencies between replicas in continuous consistency?

1. Deviation in numerical values
   - Absolute numerical deviations
   - Relative numerical deviations

2. Deviation in staleness
   - Relate to the last time a replica was updated

3. Deviation with respect to ordering of update operations
   - Ordering of updates are allowed to be different at various replicas, as long as differences remain bounded
2. Find the order deviation and the numerical deviation at the replica A

Order deviation = 3 (A has three tentative operations pending to be committed is referred to as an order deviation)

Numerical deviation = (2, 450+70)= (2,520)-(A has not yet seen operations <6,B> and <7,B> with a total value of 450+70=520)
3. What do you mean by the sequential consistency?

The result of any execution is the same as if the (read and write) operations 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.
4. Refer to the following three concurrently executing processes. We assume that each variable is initialized to 0 in a write operation and the print statement execute read operation on two arguments from x, y, and z. Write down the prints and the signature of the following execution sequence

Prints: 101011
Signature: 101011
5. What is the working principle of the causal consistency model?

Writes that are potentially causally related must be seen by all processes in the same order. Concurrent writes may be seen in a different order on different machines.
6. In this figure, you can see there is a violation of causally consistent data store. Please indicate in which process and what actions violate the condition (name the process and the actions).

Process: P3
Actions: R(x)b and R(x)

Here we have $W_2(x)b$ potentially depending on $W_1(x)a$ because writing the value $b$ into $x$ may be a result of a computation involving the previously read value by $R_2(x)a$. The two writes are causally related, so all processes must see them in the same order.
7. What do you mean by the monotonic-read consistency model?

If a process reads the value of a data item x, any successive read operation on x by that process will always return that same or a more recent value.
8. What is the working principle of the monotonic-write consistency?

A write operation by a process on a data item x is completed before any successive write operation on x by the same process.
9. In this figure, (a) A monotonic-write consistent data store and (b) A data store that does not provide monotonic-write consistency. Briefly explain how (a) ensures monotonic-write consistency and why (b) doesn’t?

Here process $P_1$ performs a write operation on $x$ at $L_1$ (L: local data stores) presented as the operation $W_1(x_1)$. Later, $P_1$ performs another write operation on $x$, but this time at $L_2$, shown as $W_1(x_2; x_3)$. The version produced by $P_1$ at $L_2$ follows from an update by process $P_2$, in turn based on version $x_1$. The latter is expressed by the operation $W_2(x_1; x_2)$. To ensure monotonic-write consistency, it is necessary that the previous write operation at $L_1$ has already been propagated to $L_2$, and possibly updated.
10. This figure shows read-your-writes consistency. Briefly explain how it ensures the read-your-writes consistency

The effect of a write operation by a process on data item x will always be seen by a successive read operation on x by the same process.

Here the process $P_1$ performed a write operation $W_1(x_1)$ and later a read operation at a different local copy. Read-your-writes consistency guarantees that the effects of the write operation can be seen by the succeeding read operation. This is expressed by $W_2(x_1; x_2)$, which states that a process $P_2$ produced a new version of x, yet one based on $x_1$. 

\[ \begin{align*}
L1: & \quad W_1(x_1) \\
L2: & \quad W_2(x_1; x_2) \quad R_1(x_2)
\end{align*} \]
11. When it comes to content replication and placement, what are the three different types of replicas?

- **Permanent replicas**
  - Few replicas, statically configured
  - Replication across a limited number of servers on a single LAN
  - Mirroring using mirror sites geographically spread across Internet

- **Server-initiated replicas (push caches)**
  - Server keeps track of client requests
  - Dynamic migration/replication of files to servers nearby active clients

- **Client-initiated replicas (client caches)**
  - Client stores local copies of data to improve access times
  - Client caches can be shared (e.g. institutional web proxy)
12. Name three content (update) propagation protocols

- **Push-based (server-based) protocols**
  - Updated are propagated to other replicas even without their request
  - Often used between permanent and server-initiated replicas
  - When high degree consistency (identical replicas) is required
  - Efficient when read-to-update ratio is high

- **Pull-based (client-based) protocols**
  - Often used by client caches, polls server to see if update is needed
  - Efficient when read-to-update ratio is relatively low

- **Hybrid form based on lease**
  - Server pushes updates to client for a specified time
Yu and Vahdat [2000] have developed a number of protocols to tackle continuous consistency. Briefly explain how these protocols manage to keep the numerical deviation within bounds, keep the staleness of replicas within specified bounds and bounding ordering deviation.

- **Bounding numerical deviations**
  - Write operations are assigned weights
  - Each server keeps log of writes it has performed on its own local copy
  - Writes are propagated to other servers, e.g. using an epidemic protocol
  - Weights and write operations contribute to a view (state) of values at a particular server
  - A server K may advance the view of server L

- **Bounding staleness deviations with vector clocks**

- **Bounding ordering deviations by enforcing globally consistent ordering of tentative writes with primary based or quorum-based protocols**
14. This figure shows the steps involving in writing of primary based remote write protocol (primary-backup protocol). Name all the steps (W1 to W5) accordingly.

W1. Write request  
W2. Forward request to primary  
W3. Tell backups to update  
W4. Acknowledge update  
W5. Acknowledge write completed

R1. Read request  
R2. Response to read
15. Name the all steps of this primary-backup local-write protocol

W1. Write request
W2. Move item x to new primary
W3. Acknowledge write completed
W4. Tell backups to update
W5. Acknowledge update

R1. Read request
R2. Response to read
Thank You !!