Consistency --- 1

Recap

- Views?
  - Versioned membership
- View-synchronous group communication?
  - Providing group communication with a dynamic group
  - A way to design replicated state machines
  - “What happens in the view, stays in the view.”

Examples

Consistency

- Consider that this is a storage service that serves read/write requests.
- Need consistent updates to all copies of object

Consistency Question

- How do we ensure that multiple copies have the same object?
- Let’s think about this in terms of read/write operations...
  - From the client’s perspective, when do you know if an object has a new value?
  - It depends on when writes become visible to reads.
  - There are several guarantees we can provide.
    - Linearizability
    - Sequential consistency
    - Causal consistency
    - ...
  - We’ll see the first two; and later the third.

Linearizability

- What would be the strongest (and probably most natural) form of consistency?
- Linearizability
  - A read operation returns the most recent write, regardless of the clients.
  - Think of a single system read/write. What happens for a write followed by a read?
Linearizability Subtleties

• An operation takes time to finish.
  – E.g., a read op R starts at X ms and finishes at Y ms.
• A value written by a write operation becomes (physically) visible at some point during the operation.
  – E.g., a write op W starts at X ms and finishes at Y ms. At Z ms (X < Z < Y), the value gets actually written and becomes visible.
• What’s a reasonable thing to do with this?
  – If W happens at X, R happens at Y, and X < Y, then R should read what W wrote.
  – If R finishes later than W but overlaps with W, then it can read either the previous value or the value written by W.

Linearizability

• Let’s say you’re an oracle.
• Let your clients make requests (concurrent read/write).
• Let your system (with replicas) execute the requests.
• Write down the real-time execution of operations of your system. Two things to write down:
  – At what points in time each operation starts and ends.
  – Real-time precedence among operations: if A ends then B starts in real time, then A precedes B. (Caution: this is not a total order.)
• See if you can come up with an ordering of operations that meets three conditions:
  – All operations in the ordering appear one at a time as if each operation happened atomically.
  – The ordering gives the correct result as if it was done over a single copy.
  – The ordering preserves the real-time precedence of operations (i.e., the ordering written down from the above).

CSE 486/586 Administrivia

• PA3 deadline: 3/29 (Friday)
• Anonymous feedback form still available.
• Please come talk to me!
Sequential Consistency

Example
- P1: write A
- P2: write B
- P3: read B read A
- P4: read A read B

What's an interleaving that makes sense?

For understanding the intuition, rough verification of sequential consistency goes like the following.

Let's say you're an oracle
Run your system and get the result
See if you can come up with an ordering of operations where
- All operations in the ordering appear one at a time as if each operation happened atomically.
- The ordering gives the correct result as if it was done over a single copy.
- The ordering preserves the program order of each client.

Sequential Consistency

Sequential consistency is less strict.
- (Textbook definition) A replicated shared object service is sequentially consistent if for any execution (real), there is some interleaving of clients' operations (virtual) that:
  - meets the specification of a single correct copy of objects
  - is consistent with the program order in which each individual client executes those operations.

This approach does not require absolute time or a single fixed total order.
- Only that for each client the order in the sequence be consistent with that client's program order (~ FIFO).
- Linearizability implies sequential consistency.
  - Not vice-versa!
- Challenge with guaranteeing seq. cons.?
  - Ensuring that all replicas of an object are consistent.

Summary

- Consistency
  - Linearizability
  - Sequential consistency

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