CSE 486/586 Distributed Systems
Concurrency Control --- 3

Steve Ko
Computer Sciences and Engineering
University at Buffalo

Recap

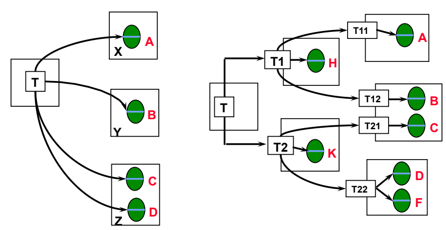
- Strict execution of transactions?
  - *Delay both their read and write operations* on an object until all transactions that previously wrote that object have either committed or aborted
- Two phase locking?
  - Growing phase
  - Shrinking phase
- Strict two phase locking?
  - Release locks only at either commit() or abort()

CSE 486/586 Administrivia

- PA3 deadline: 4/11 (Friday)
- Midterm: Next Monday

Distributed Transactions

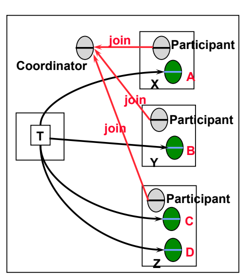
- Transactions that invoke operations at multiple servers



Flat Distributed Transaction **Nested Distributed Transaction**

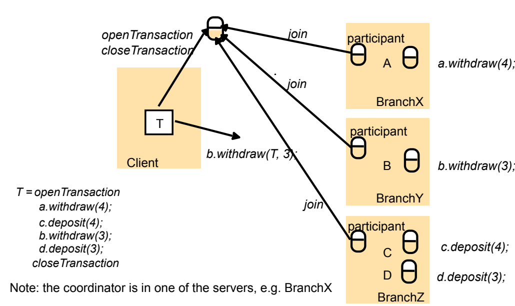
Coordinator and Participants

- Coordinator
  - In charge of begin, commit, and abort
- Participants
  - Server processes that handle local operations



Coordinator & Participants

Example of Distributed Transactions



Note: the coordinator is in one of the servers, e.g. BranchX

Atomic Commit Problem

- Atomicity principle requires that either all the distributed operations of a transaction complete, or all abort.
- At some stage, client executes closeTransaction(). Now, atomicity requires that either *all* participants (remember these are on the server side) and the coordinator commit or *all* abort.
- What problem statement is this?
  - Consensus
- Failure model
  - Arbitrary message delay & loss
  - Crash-recovery with persistent storage

Atomic Commit

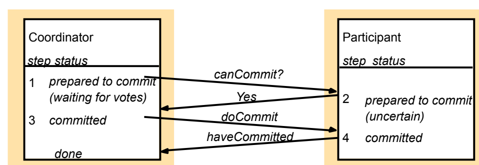
- We need to ensure *safety* in real-life implementation.
  - Never have some agreeing to commit, and others agreeing to abort.
- First cut: *one-phase commit* protocol. The coordinator communicates either commit or abort, to all participants until all acknowledge.
- What can go wrong?
  - Doesn't work when a participant crashes before receiving this message.
  - Does not allow participant to abort the transaction, e.g., under deadlock.

Two-Phase Commit

- First phase
  - Coordinator collects *a vote* (commit or abort) from each participant (which stores partial results in permanent storage before voting).
- Second phase
  - If all participants want to commit and no one has crashed, coordinator multicasts commit message
  - If any participant has crashed or aborted, coordinator multicasts abort message to all participants

Two-Phase Commit

- Communication



Two-Phase Commit

- To deal with server crashes
  - Each participant saves tentative updates into permanent storage, right before replying yes/no in first phase. Retrievable after crash recovery.
- To deal with canCommit? loss
  - The participant may decide to abort unilaterally after a timeout (coordinator will eventually abort)
- To deal with Yes/No loss, the coordinator aborts the transaction after a timeout (pessimistic!). It must announce doAbort to those who sent in their votes.
- To deal with doCommit loss
  - The participant may wait for a timeout, send a getDecision request (retries until reply received) – cannot abort after having voted Yes but before receiving doCommit/doAbort!

Problems with 2PC

- It's a blocking protocol.
- Other ways are possible, e.g., 3PC.
- Scalability & availability issues

Summary

- Increasing concurrency
  - Non-exclusive locks
  - Two-version locks
  - Hierarchical locks
- Distributed transactions
  - One-phase commit cannot handle failures & abort well
  - Two-phase commit mitigates the problems of one-phase commit
  - Two-phase commit has its own limitation: blocking

Acknowledgements

- These slides contain material developed and copyrighted by Indranil Gupta (UIUC).