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

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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()

Can We Do Better?

- What we saw was "exclusive" locks.
- Non-exclusive locks: break a lock into a read lock and a write lock
- Allows more concurrency
  - Read locks can be shared (no harm to share)
  - Write locks should be exclusive

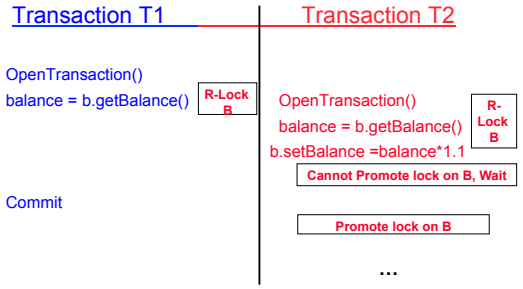
Non-Exclusive Locks

non-exclusive lock compatibility

Lock already set	Lock requested: read	Lock requested: write
none	OK	OK
read	OK	WAIT
write	WAIT	WAIT

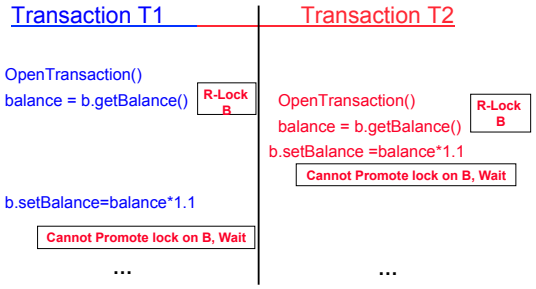
- A read lock is promoted to a write lock when the transaction needs write access to the same object.
- A read lock shared with other transactions' read lock(s) cannot be promoted. Transaction waits for other read locks to be released.
- Cannot demote a write lock to read lock during transaction – violates the 2P principle

Example: Non-Exclusive Locks



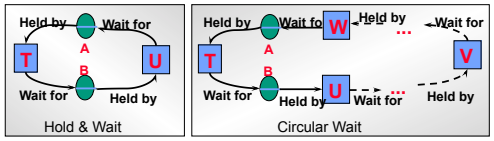
2PL: a Problem

- What happens in the example below?



Deadlock Conditions

- Necessary conditions
  - Non-sharable resources (locked objects)
  - No lock preemption
  - Hold & wait or circular wait



Preventing Deadlocks

- Acquiring all locks at once
- Acquiring locks in a predefined order
- Not always practical:
  - Transactions might not know which locks they will need in the future
- One strategy: timeout
  - If we design each transaction to be short and fast, then we can abort() after some period of time.

Extracting Even More Concurrency

- Allow writing *tentative versions* of objects
  - Letting other transactions read from the previously committed version
- Allow read and write locks to be set together by different transactions
  - Unlike non-exclusive locks
- Read operations wait only if another transaction is committing the same object
- Disallow commit if other uncompleted transactions have read the objects
  - These transactions must wait until the reading transactions have committed
- This allows for more concurrency than read-write locks
  - Writing transactions risk waiting or rejection when commit

Two-Version Locking

- Three types of locks: read lock, write lock, commit lock
  - Transaction cannot get a read or write lock if there is a commit lock
- When the transaction coordinator receives a request to commit
  - Converts all that transaction's write locks into commit locks
  - If any objects have outstanding read locks, transaction must wait until the transactions that set these locks have completed and locks are released
- Compare with read/write locks:
  - Read operations are delayed only while transactions are committed
  - Read operations of one transaction can cause a delay in the committing of other transactions

Two-Version Locking

lock compatibility

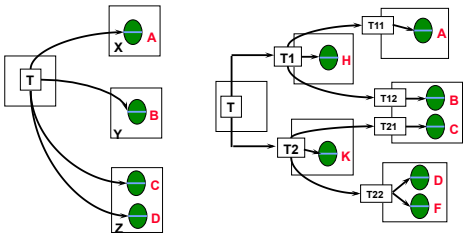
Lock already set	Lock requested read	write	commit
none	OK	OK	OK
read	OK	OK	WAIT
write	OK	WAIT	
commit	WAIT	WAIT	

CSE 486/586 Administrivia

- PA3 deadline: 3/29 (Friday)
- PA2 grading
  - Will be done sometime next week (we wanted to grade the midterm first.)
- Anonymous feedback form still available.
- Please come talk to me!

Distributed Transactions

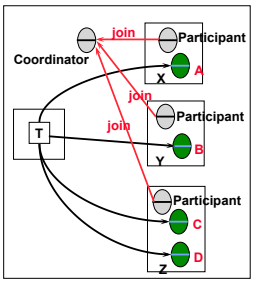
- Transactions that invoke operations at multiple servers



Flat Distributed Transaction Nested Distributed Transaction

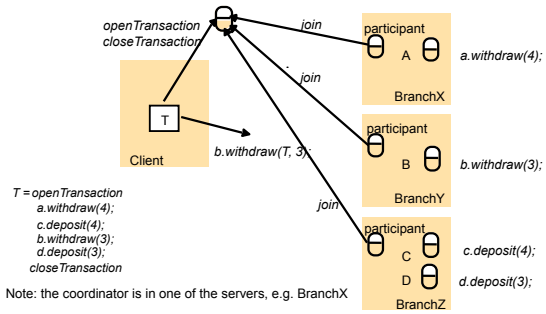
Coordinator and Participants

- 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

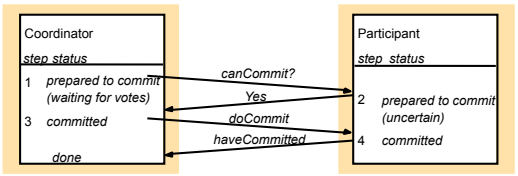
- We need to ensure *safety* in real-life implementation.
  - Never have some agreeing to commit, and others agreeing to abort.
- First cut: *one-phase commit* protocol. The coordinator communicates either commit or abort, to all participants until all acknowledge.
- What can go wrong?
  - Doesn't work 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).