

1 Two Phase Commit with Logging

Suppose we have one coordinator and three participants. It takes 30ms for a coordinator to send messages to all participants; 5, 10, and 15ms for participant 1, 2, and 3 to send a message to the coordinator respectively; and 10ms for each machine to generate and flush a record. Assume for the same message, each participant receives it from the coordinator at the same time.

1. Under proper 2PC and logging protocols, how long does the whole 2PC process (from the beginning to the coordinator's final log flush) take for a successful commit in the best case?

Solution: 130ms

Explanation:

Phase 1: $30 + 10 + 15 + 10 = 65\text{ms}$

Coordinator sends prepare message + Participant generates and flushes prepare record + max time it takes a participant to send a Yes message + Coordinator generates and flushes commit record

Phase 2: $30 + 10 + 15 + 10 = 65\text{ms}$

Coordinator sends commit message + Participant generates and flushes commit record + max time it takes a participant to send an ACK message + Coordinator generates and flushes end record

Total: 130ms

2. Now in the two-phase commit protocol, describe what happens if a subordinate receives a PREPARE message, replies with a YES vote, crashes, and restarts (All other participants also voted YES and didn't crash).

Solution: In this scenario, upon restarting, the recovery process will find that the participant is in the prepared state for the transaction. It will periodically try to contact the coordinator site to find out how the transaction should be resolved. In our scenario, the final outcome of the transaction is a commit. Because the coordinator cannot end a committed transaction until it receives final ACKS from all nodes, it will correctly respond with a COMMIT message to the inquiry. The participant will then be able to properly commit the transaction. It will write (and flush) a COMMIT record and send an ACK message to the coordinator.

3. In the two-phase commit protocol, suppose that the coordinator sends PREPARE message to Participants 1 and 2. Participant 1 sends a "VOTE YES" message, and Participant 2 sends a "VOTE NO" message back to the coordinator.
 - a. Before receiving the result of the commit/abort vote from the coordinator, Participant 1 crashes. Upon recovery, what actions does Participant 1 take 1) if we were not using presumed abort, and 2) if we were using presumed abort?
Solution: Upon recovery, Participant 1 will find a PREPARE message for this transaction in their log. In both cases, Participant 1 sends an inquiry to the coordinator for the status of this transaction and sees that the transaction aborted. Participant 1 will abort the transaction locally.
 - b. Before receiving the result of the commit/abort vote from the coordinator, Participant 2 crashes. Upon recovery, what actions does Participant 2 take 1) if we were not using presumed abort, and 2) if we were using presumed abort?
Solution:
Without presumed abort:
 Upon recovery, Participant 2 sees an abort record for this transaction in their log and sends the "VOTE NO" messages back to the coordinator.

With presumed abort:
 Upon recovery, Participant 2 may not see any log records for this transaction, and they do not need to send any messages to the coordinator.
4. In the two-phase commit protocol, suppose that the coordinator sends PREPARE messages to the participants and crashes before receiving any votes for parts (a)-(c). Assuming that we are running 2PC with presumed abort, answer the following questions.
 - a. What sequence of operations does the coordinator take after it recovers?
Solution: After the coordinator restarts, the recovery process will find that a transaction was executing at the time of the crash and that no commit protocol log record had been written (remember that the coordinator does not write any log records before sending PREPARE messages). The recovery process will abort the transaction locally (not sending an ABORT message) by undoing its actions, if any, using the UNDO log records, and writing an abort record.
 - b. What sequence of operations does a participant who received the message and replied NO before the coordinator crashed take?

Solution: If the participant sent a NO vote, it knows that the transaction will be aborted because a NO vote acts like a veto. The participant does not care if the coordinator crashes or not. It aborts the local effects of the transaction.

- c. What sequence of operations does a participant who received the message and replied YES before the coordinator crashed take?

Solution: If the participant sent a YES vote, it cannot make any unilateral decisions. If the participant notices the failure of the coordinator (for example by using a timeout), it hands the transaction over to the recovery process. The recovery process will find that it is in the prepared state for the transaction. It will periodically try to contact the coordinator site to find out how the transaction should be resolved. As we discussed above, after the coordinator recovers, it will abort the transaction and will answer "abort" upon receiving an inquiry message. The participant will then abort the transaction.

- d. Let's say that the coordinator instead crashes after successfully receiving votes from all participants, with all participants voting YES except for one NO vote. Assuming the coordinator sees no records for this transaction in its log after coming back online, how does this affect the answers to parts (a)-(c)?

Solution:

Note: the coordinator's log may contain no information about the transaction or an ABORT record (because the abort record does not need to be flushed immediately with presumed abort). In this question, we assume the coordinator crashed without flushing its ABORT log record.

No change for part (a) because the coordinator likewise sees no log records for the transaction. The recovery process will abort the transaction locally, and since there is no information about the participant IDs in the log, the coordinator cannot send abort records to the participants.

No change for part (b) - with presumed abort, even if the participant itself crashes after sending the NO vote, the participant will proceed with abort since that is the presumption given no log records.

No change for part (c) - with presumed abort, when the coordinator comes back online and sees no information about the transaction in its log, the transaction is unilaterally aborted. This change is communicated when participants who voted YES ping the coordinator to find out how the transaction should be resolved, and the coordinator will respond with an ABORT message.

Note: the number of records written/flushed to disk with presumed abort is fewer than without presumed abort. However, with successful transactions, the number of flushed records will be the same.