L11: Two-Phase Commit

CSE 452 Winter 2016

Transactions: Motivating Example

```
send_money(user1, user2, amount) {
   Begin_Transaction();
   if (user1.balance - amount >= 0) {
      user1.balance = user1.balance - amount;
      user2.balance = user2.balance + amount;
      Commit_Transaction();
   } else {
      Abort_Transaction();
   }
}
```

ACID Guarantees

- Atomicity: all parts of the transaction execute or none (user1's decreases *and* user2's balance increases)

- Consistency: the transaction only commits if it preserves invariants (user1's balance never goes below 0)

- Isolation: the transaction executes as if it executed by itself (even if user3 is accessing user1's account, that will not interfere with this transaction)

- Durability: the transaction's effects are not lost after it executes (updates to the balances will remain forever)

What if the transaction is distributed?

- Databases are often partitioned for scalability (user1 and user2 might not share a server)
- A transaction might touch more than one partition
- How do we guarantee that all of the partitions commit the transactions or none?

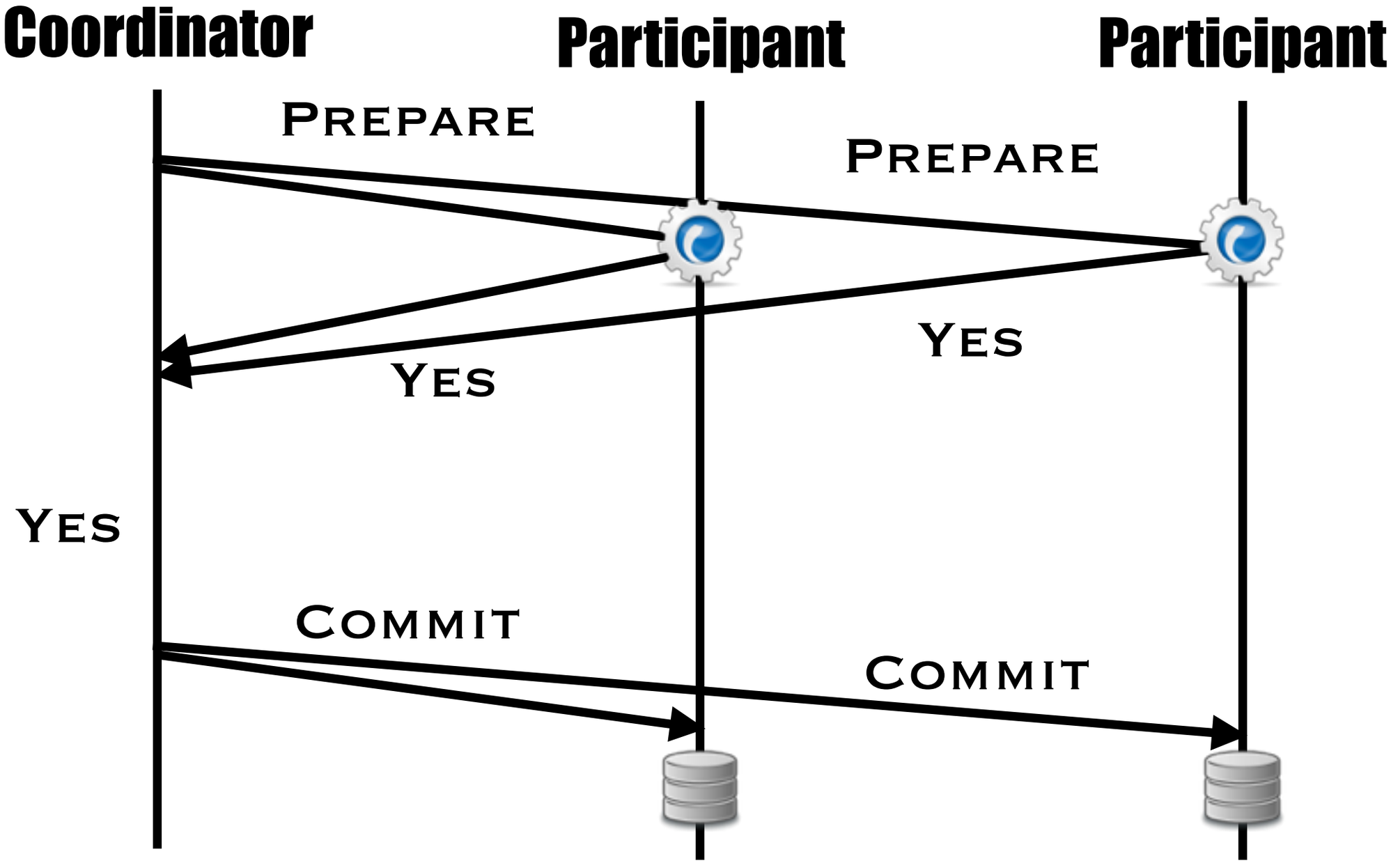
Two-Phase Commit (2PC)

- An atomic commitment protocol (ACP)
- Guarantees that participants all agree to execute a transaction or none of them will execute the transaction
- There are other ACPs: three-phase commit, etc.
- Think about why you need at least two phases …

2PC Overview

- Participants: nodes that have parts of the transaction to update
- Coordinator: node that will be responsible to running the protocol, can be a participant
- RPCs:
  - **Prepare** - the request for votes, responses **Yes** or **No**
  - **Commit** - commit the transaction
  - **Abort** - abort the transaction

The 2PC Protocol

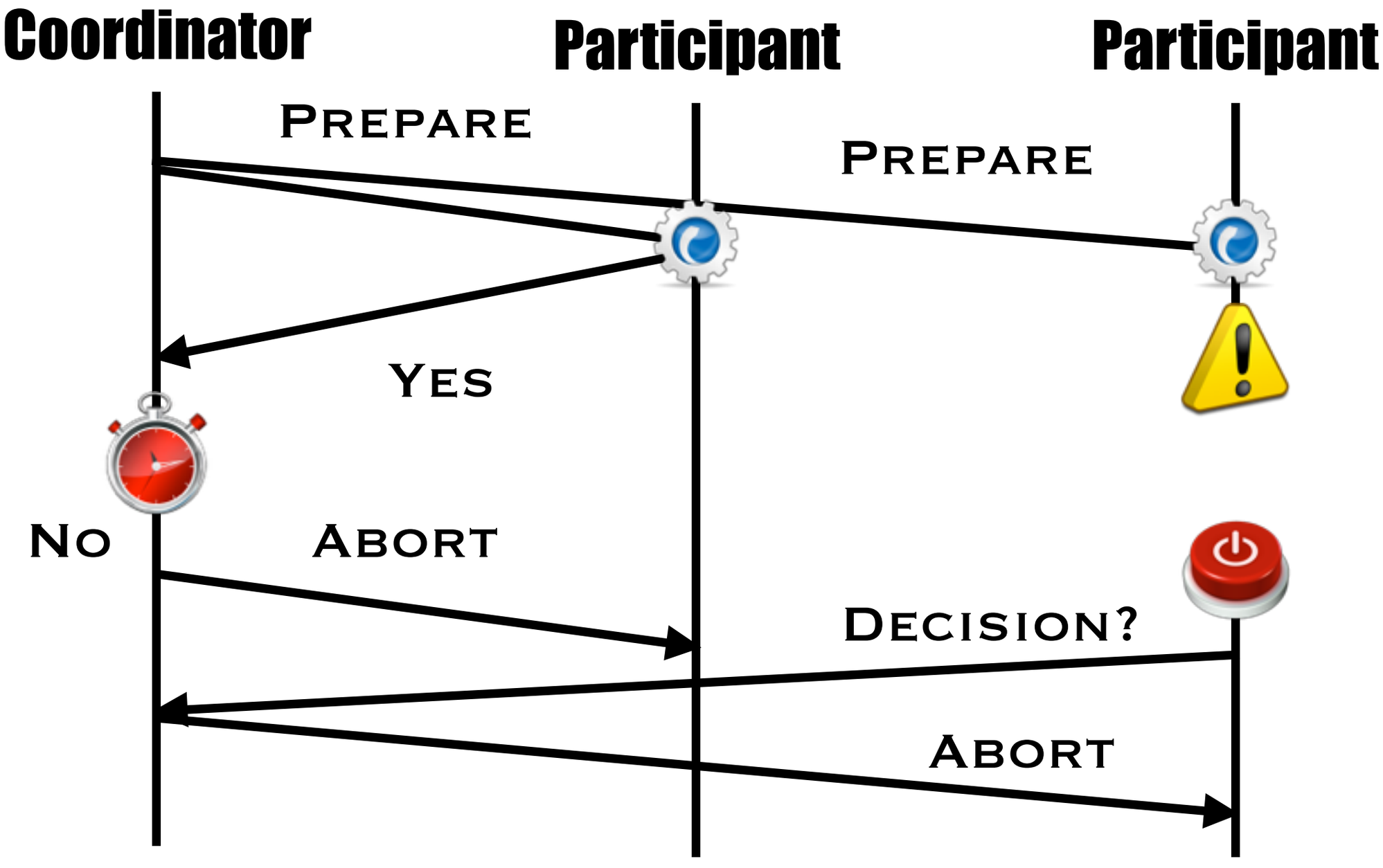


Protocol Invariants

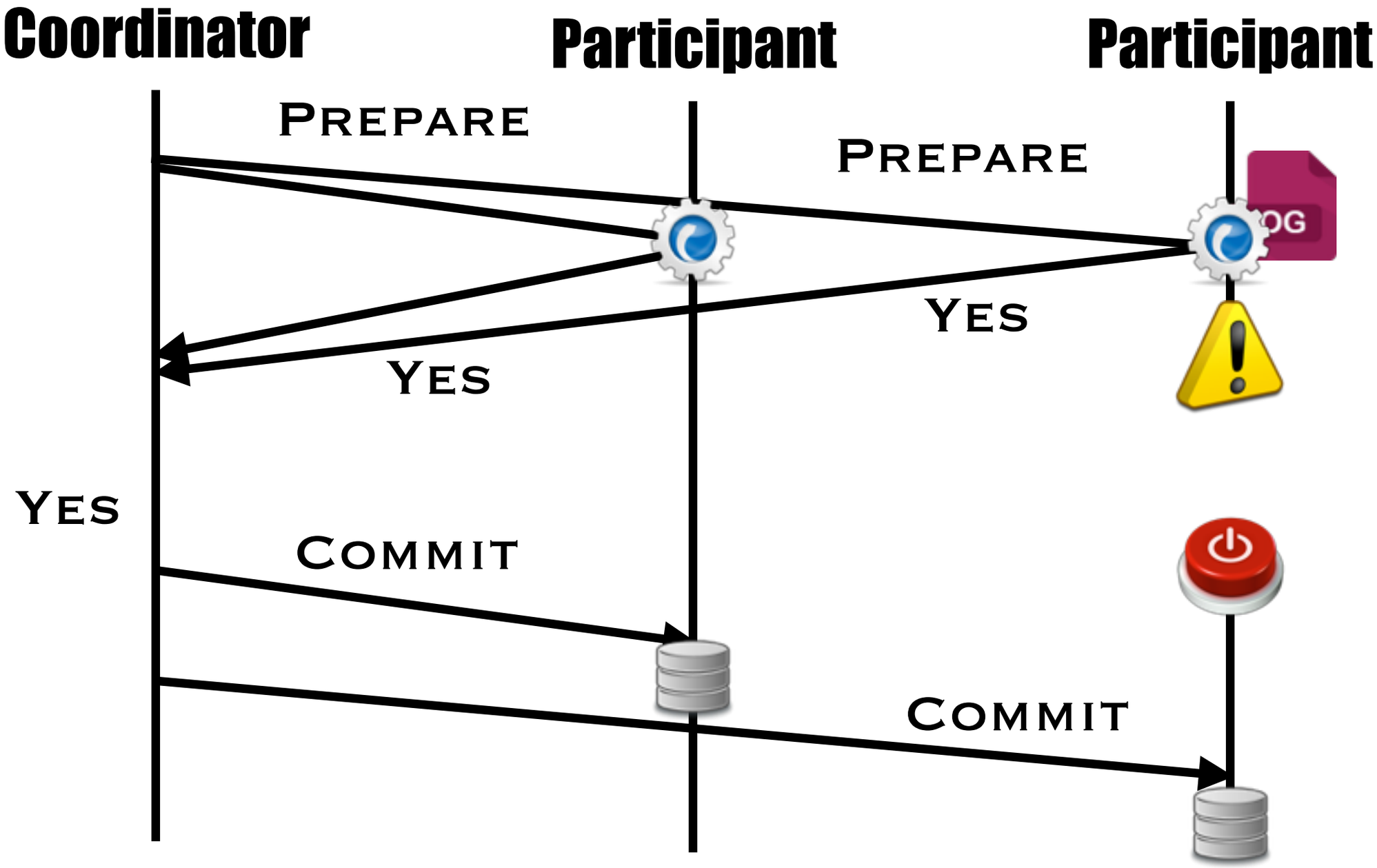
- All processes that reach a decision, reach the same one.
- A process cannot reverse its decision once it has reached one.
- The commit decision can only be reached if all participants vote **YES.**
- If there are no failures and all participants vote **YES**, then the transaction will commit.
- If failures are eventually repaired, then every process will eventually reach a decision.

Maintaining invariants with failures

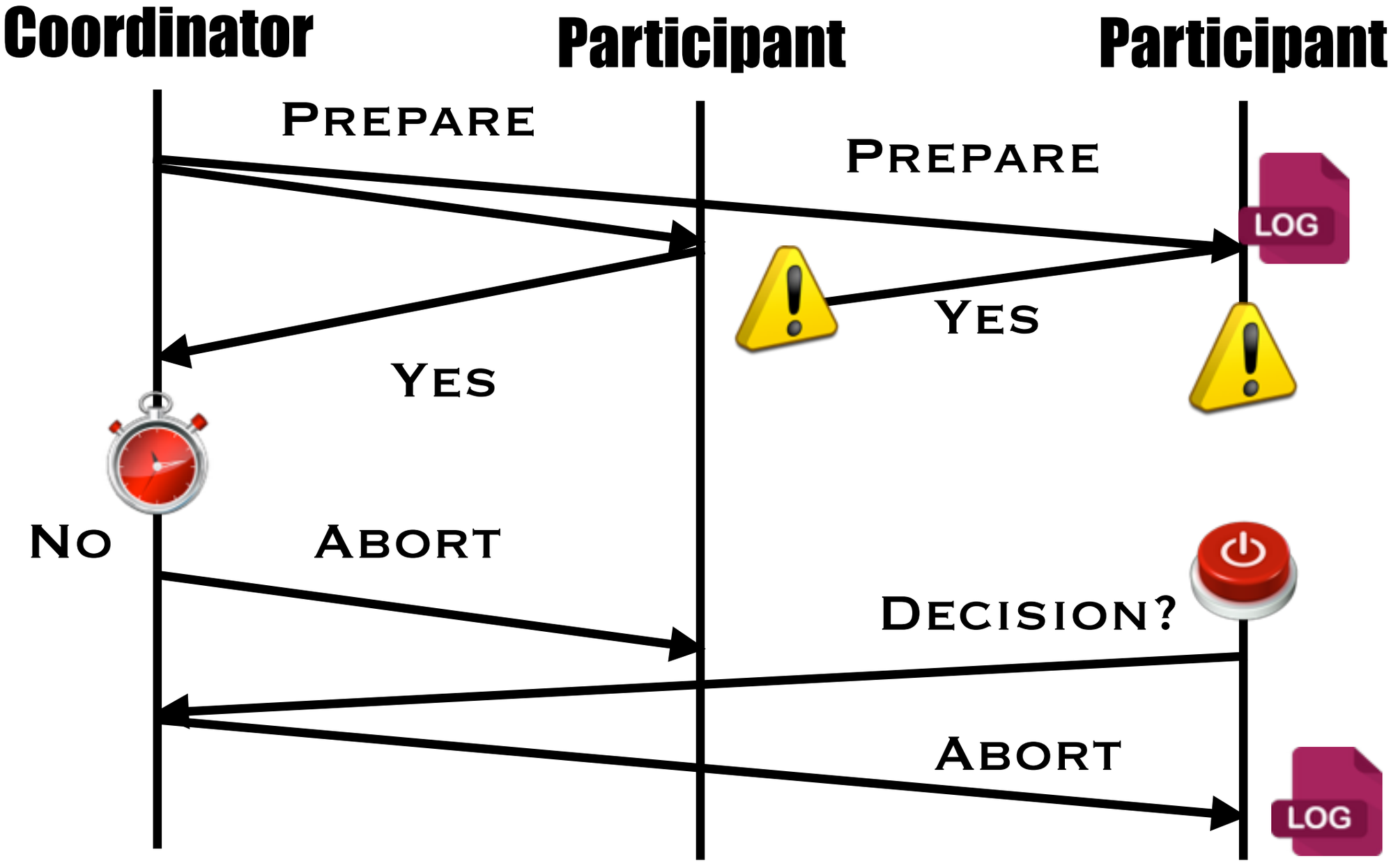
Participant failures: Before sending response?



Participant failures: After sending vote?

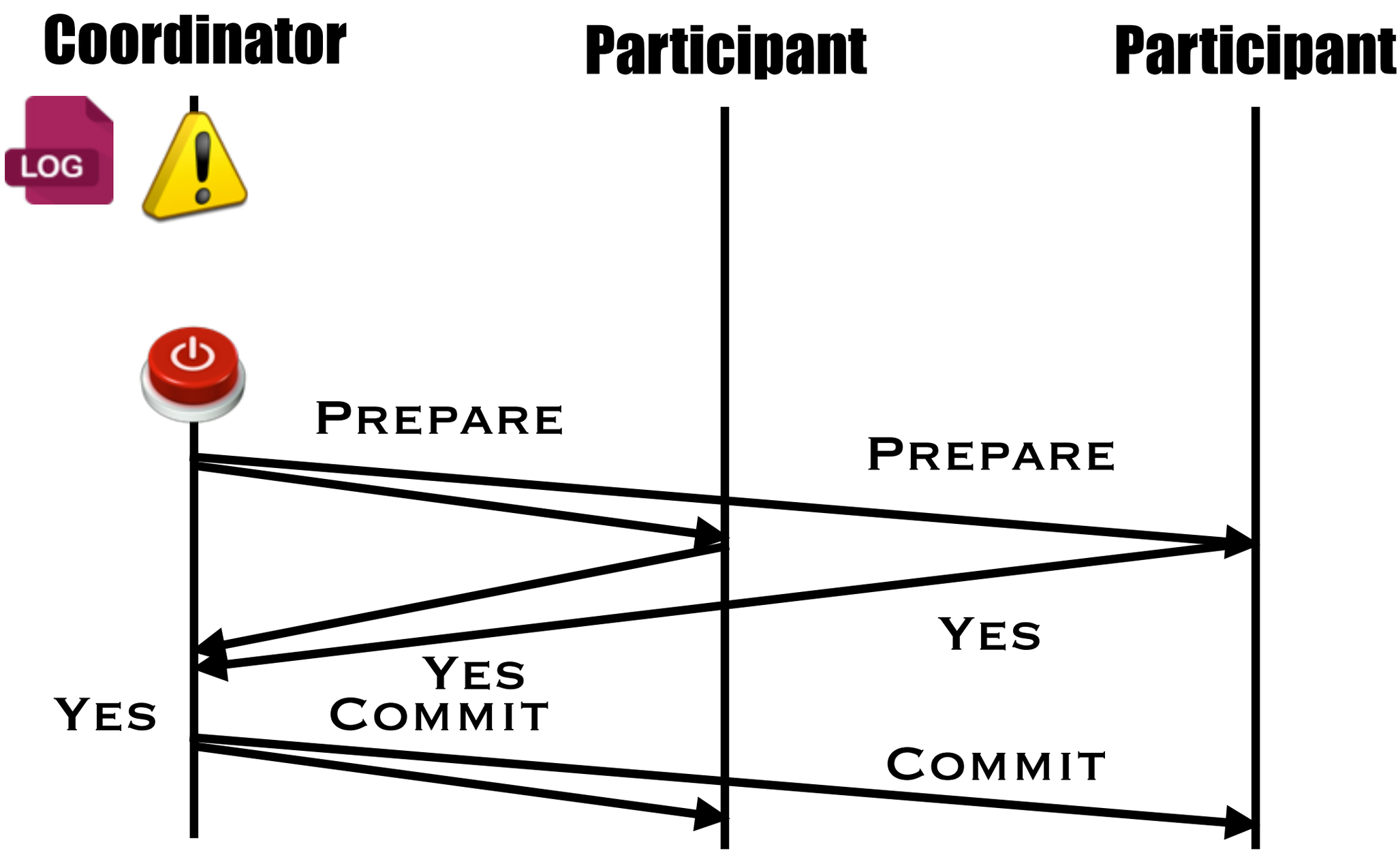


Participant failures: Lost vote?

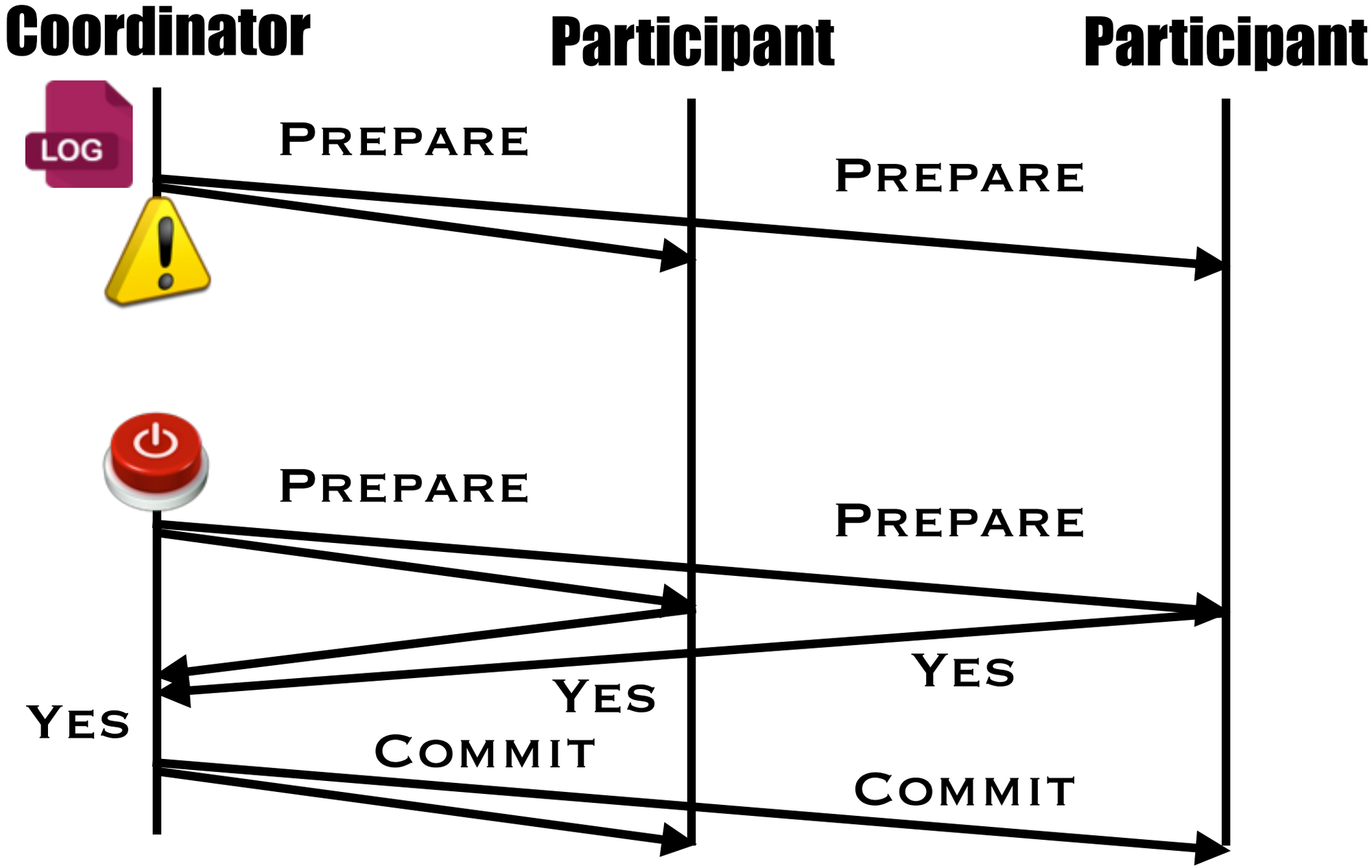


Coordinator failures

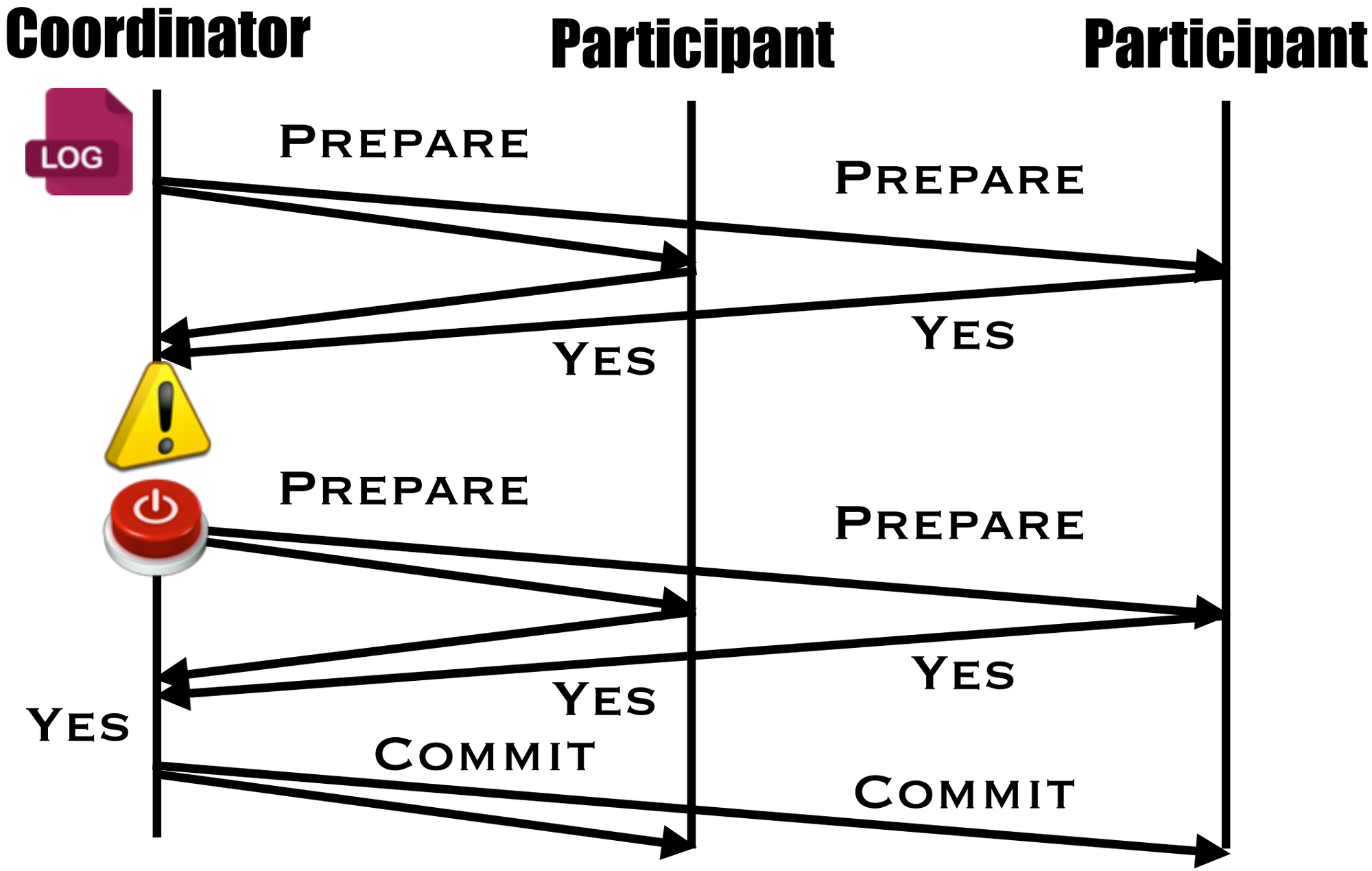
Coodinator failures:
Before sending prepare



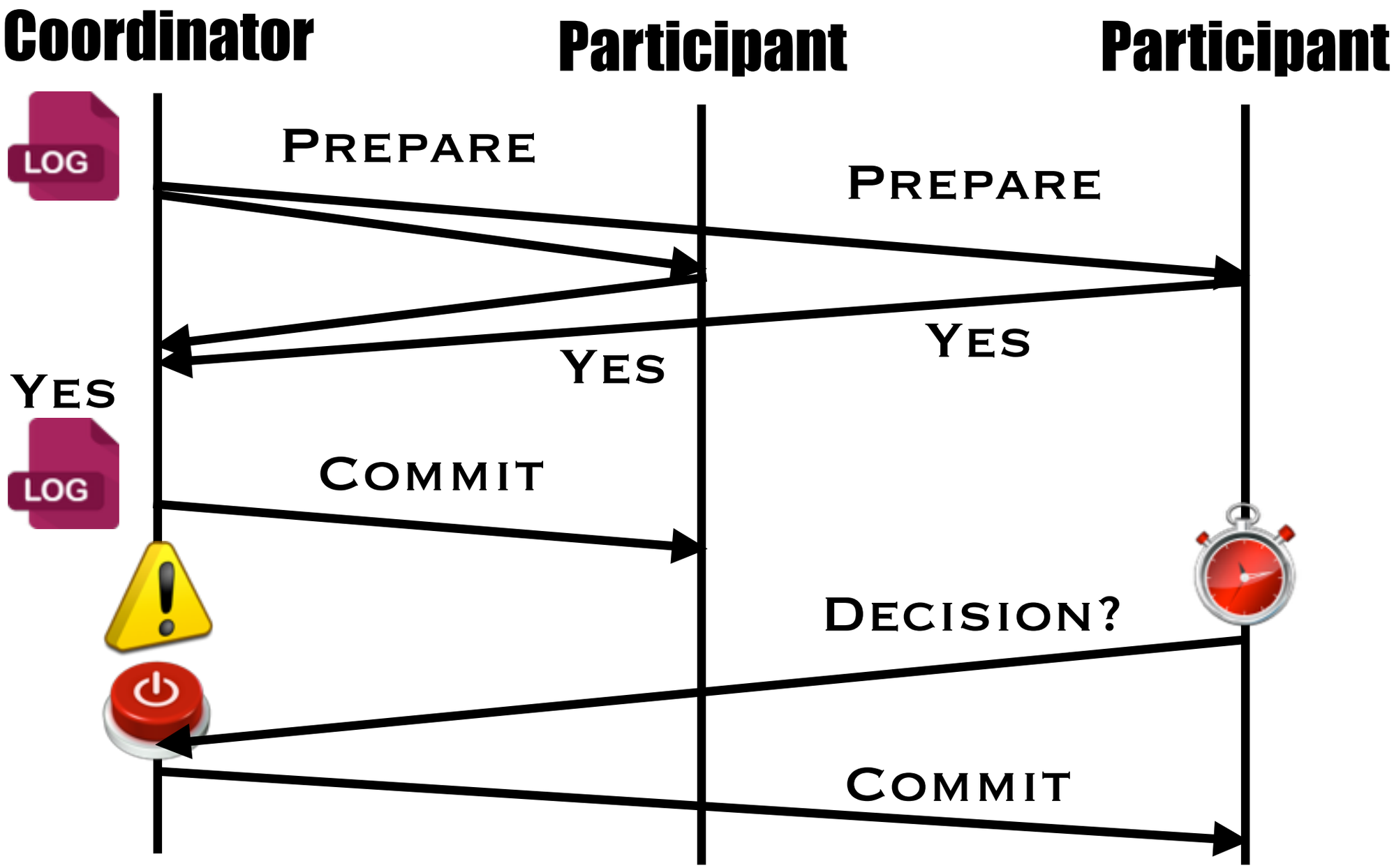
Coordinator failures: After sending prepare



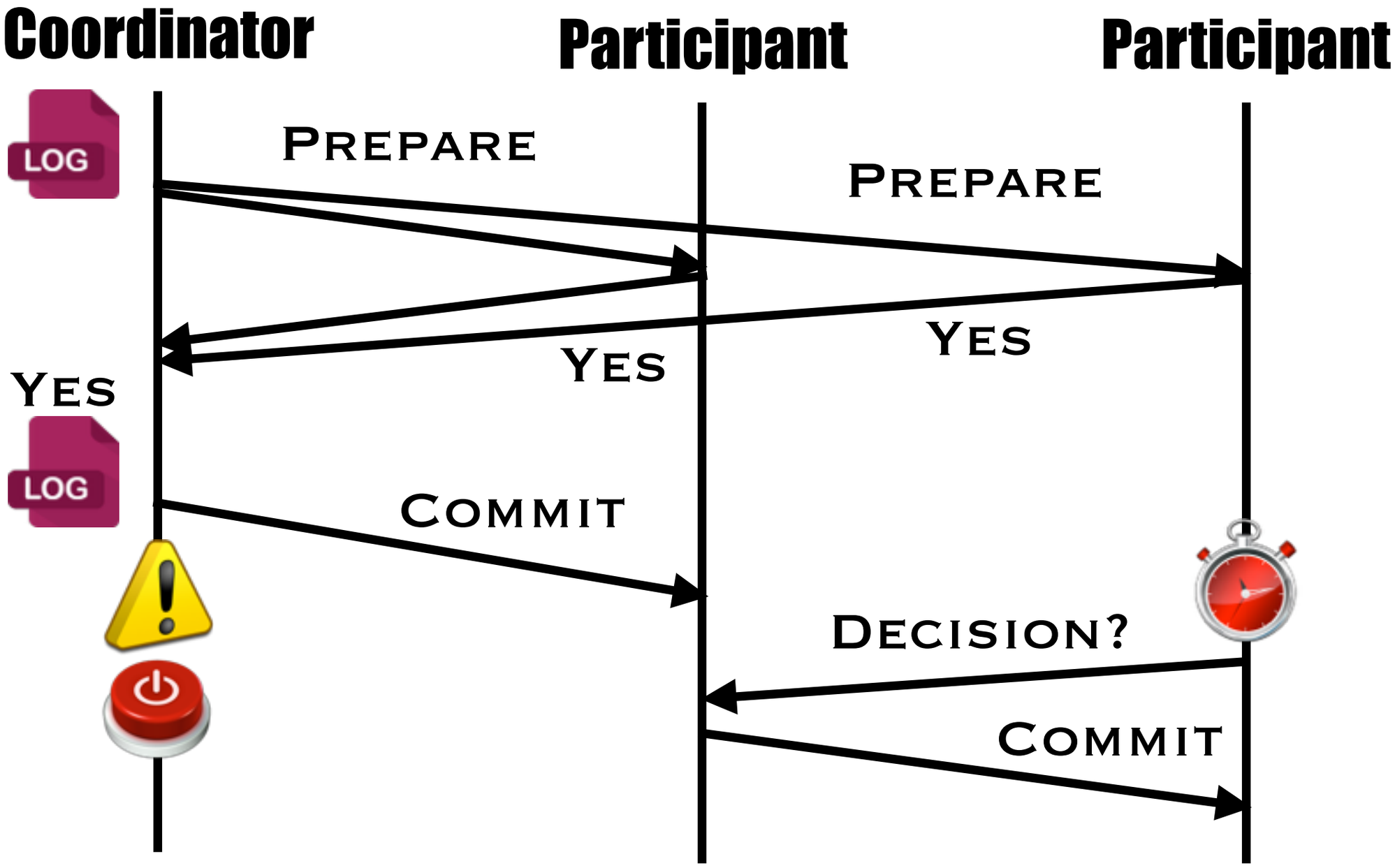
Coordinator failures: After receiving votes



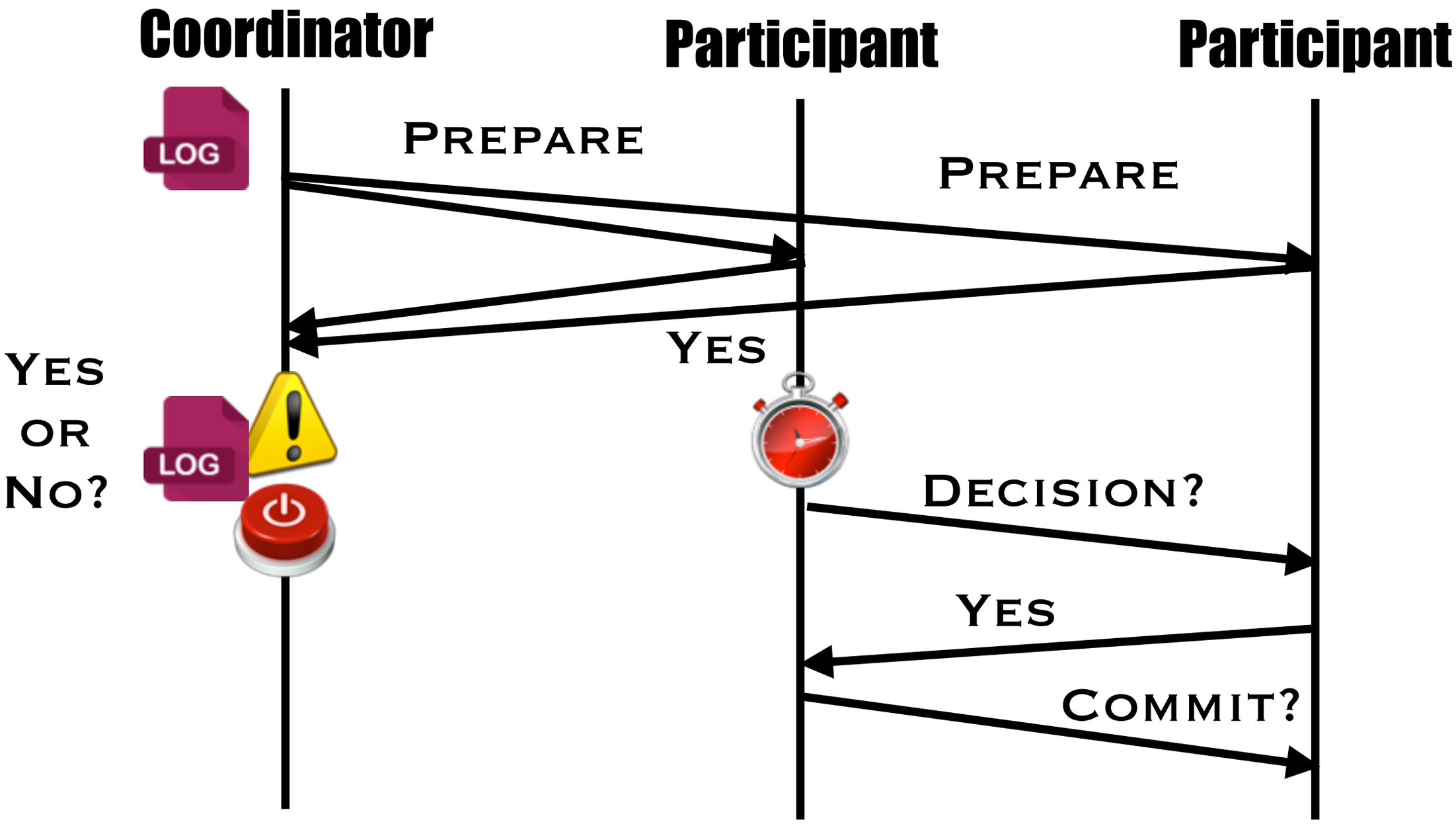
Coordinator failures: After sending decision



Do we need the coordinator?



What if we do not have the coordinator's decision?



2PC is a *blocking* protocol

- A blocking protocol is one that cannot make progress if some of the participants are unavailable (either down or partitioned).

- They have fault-tolerance but not *availability*.

- Paxos does not have this limitation (but has a variant of it).

- This limitation is fundamental (2 generals problem).