Large Scale Systems
CS 410 / 510

Lecture 5:

Distributed Commit Protocols

Suyash Gupta

Assistant Professor

Distopia Labs and ONRG

Dept. of Computer Science

(E) suyash@uoregon.edu

(W) gupta-suyash.github.io

UNIVERSITY OF OREGON

Assignment 1 is Out!

- **Assignment 1 is out!**
- Please work with your groups to understand the underlying system.
- Assignment 1 report **deadline** → April 16, 2026 at 11:59pm.

Useful Readings

- In general, a good practice is to read the recommended books end-to-end.

- From **Principles of Distributed Database Systems**:
  - Chapters 1, 10
  - Chapter 11.1, 11.2, 11.3, 11.6, 11.7
  - Chapters 12, and 13 (*to be covered*)

Last Class

- Last class we looked at:

- Distributed Transaction Processing
- Concurrency Control → 2PL
- Necessary actions when running a distributed transaction → Undo, Redo

Transaction Fate

- Once a distributed transaction is executed by all the participants, we need to decide whether to commit or abort the transaction.
- When will a transaction commit or abort?
- A transaction **commits** when all the participants agree.
- A transaction **aborts** when one of the participant disagrees.

Abort or Commit Decision Making

- How to decide whether to abort or commit a transaction?
- Remember, we are in a distributed setting and decisions of all the participants need to be taken into consideration.
- One participant may say commit, while other says abort.
- How should we proceed?

Commit Protocols

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- Agreement implies that somehow every partition gets a chance to vote and based on the votes a final decision is reached.
  - Every partition promises to follow this decision.

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- Commit Protocols come in several flavor:
  - Two Phase Commit, Three Phase Commit, Easy Commit, etc.

Two-Phase Commit Protocol

- First commit protocol.

- As the name suggests, in the absence of any failures, it helps participants reach an agreement in two phases.

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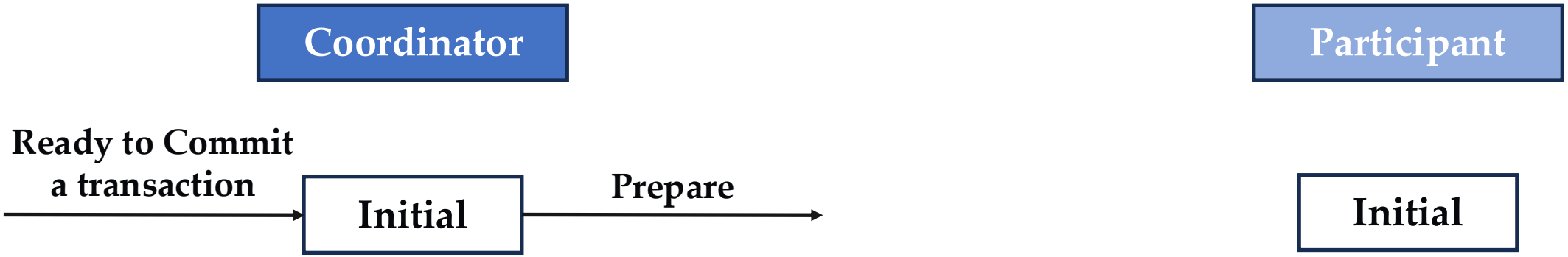
- The logic behind Two-Phase Commit (**2PC**) protocol is simple:
  - If **all the participants** agree to commit the transaction, then global decision is commit.
  - If **any one participant** decides to abort the transaction, then global decision is abort.

2PC Protocol Flow

2PC Protocol Flow

2PC Protocol Flow



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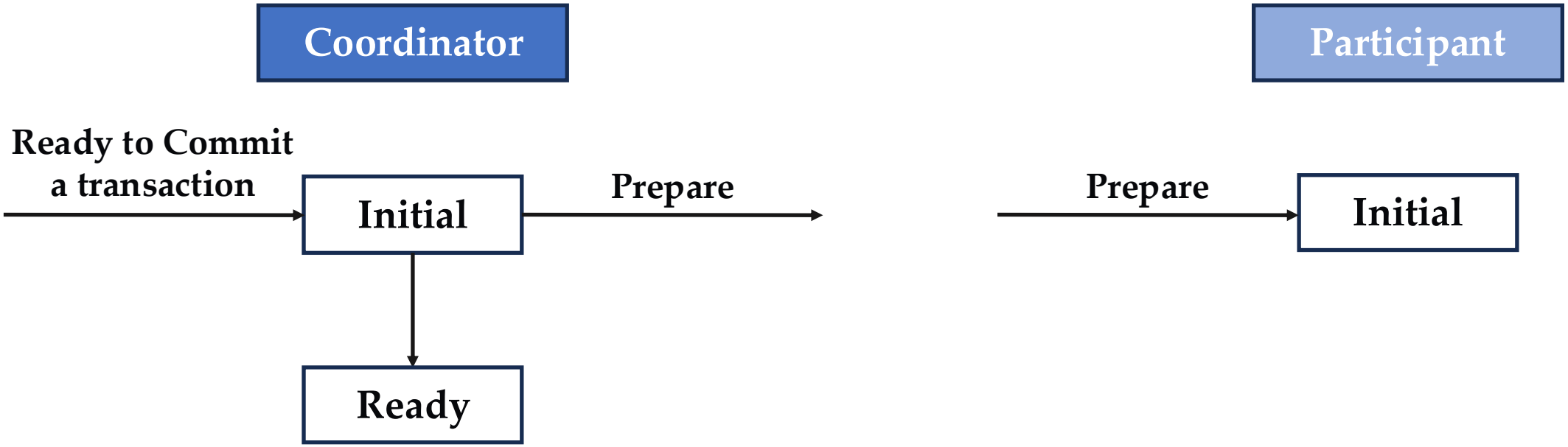

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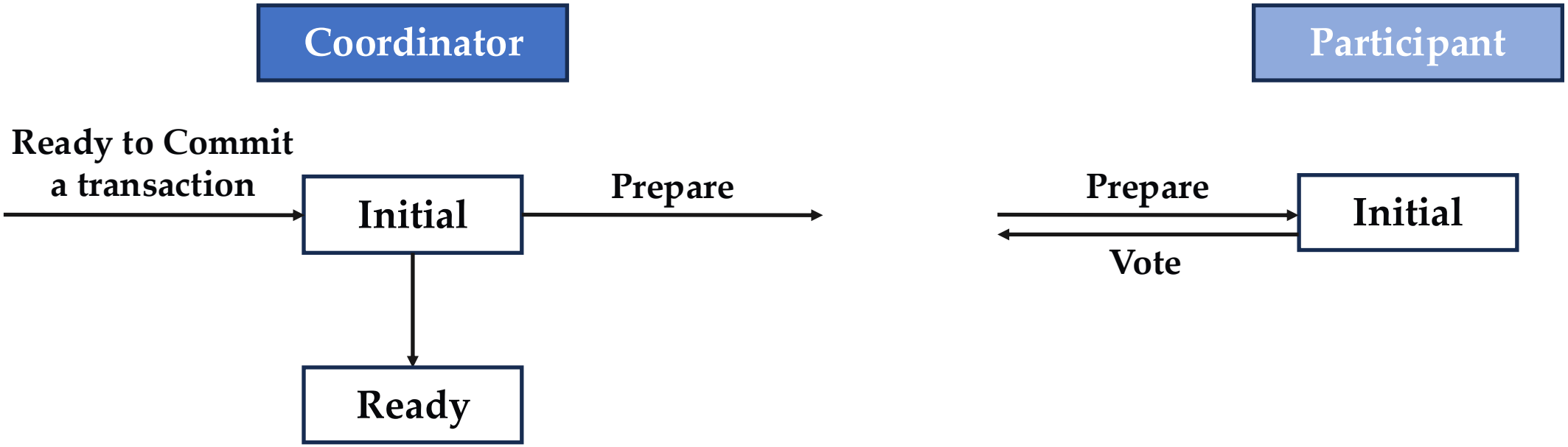

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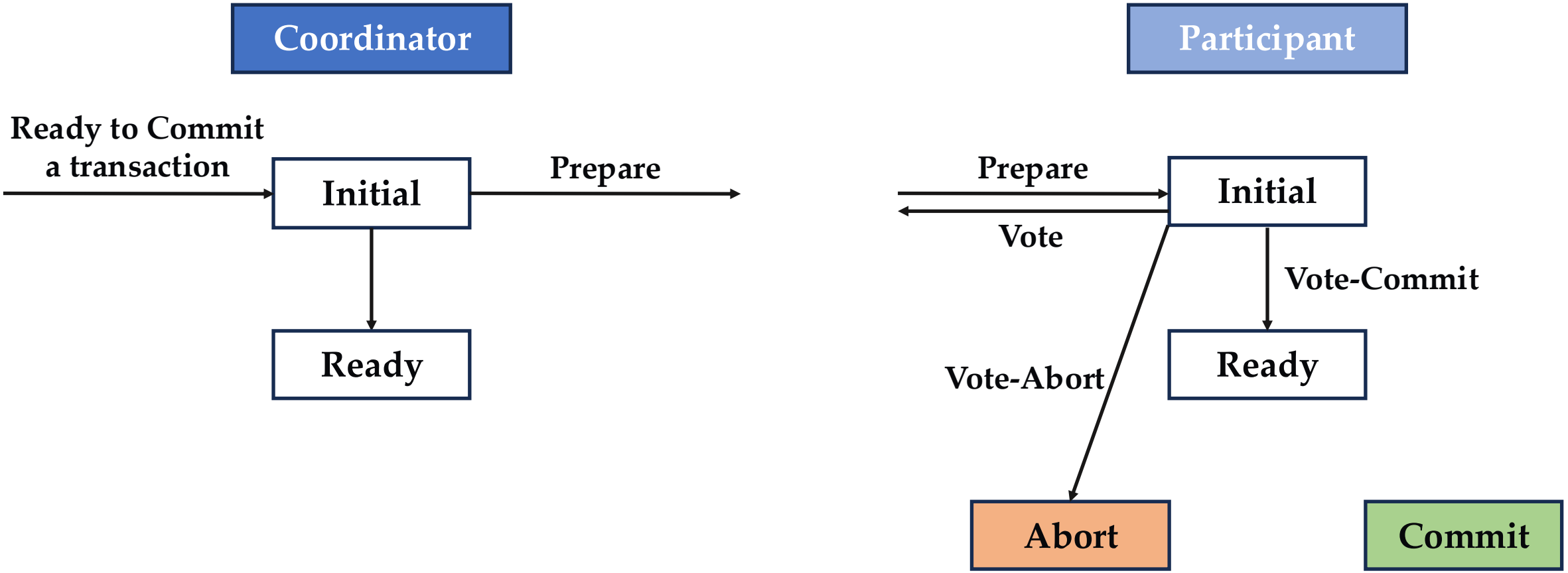

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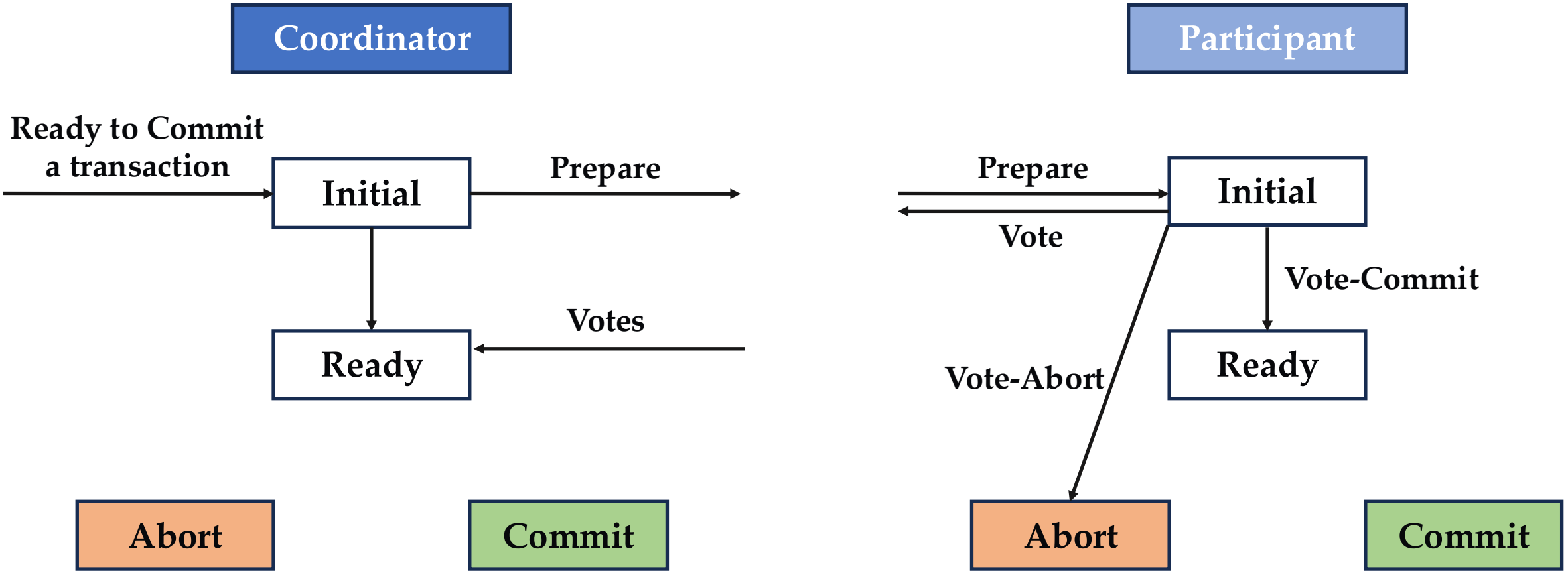

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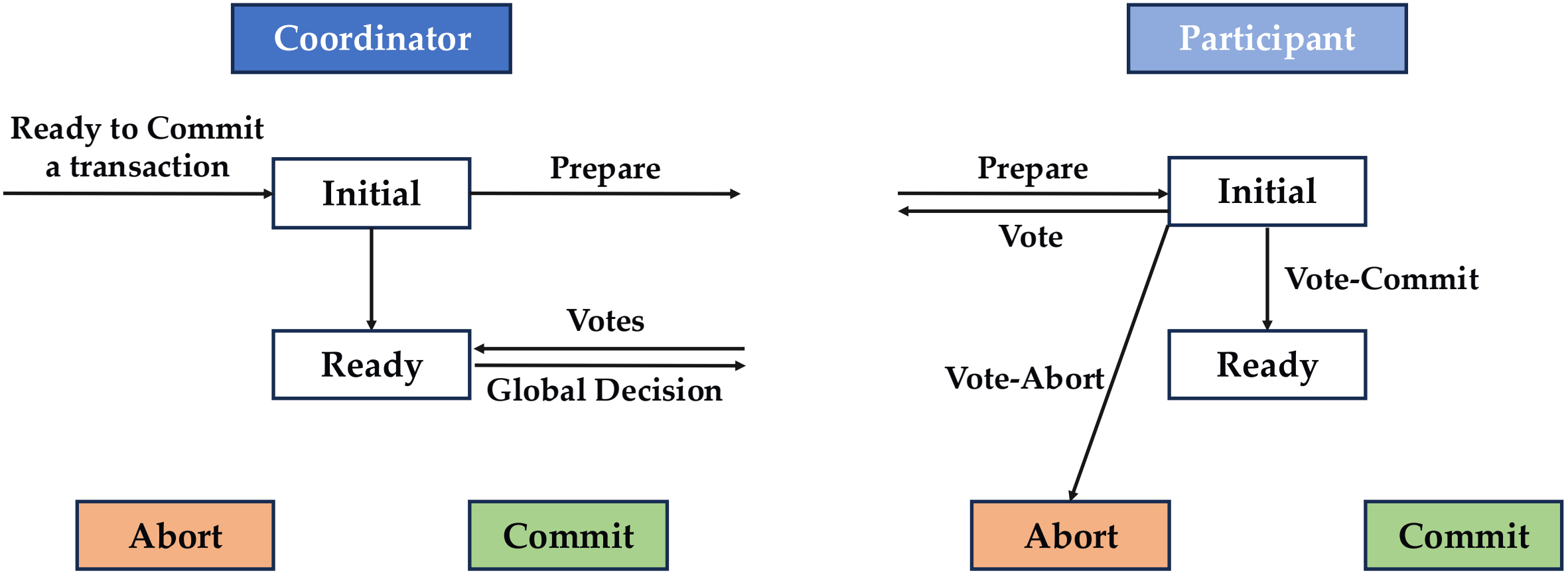

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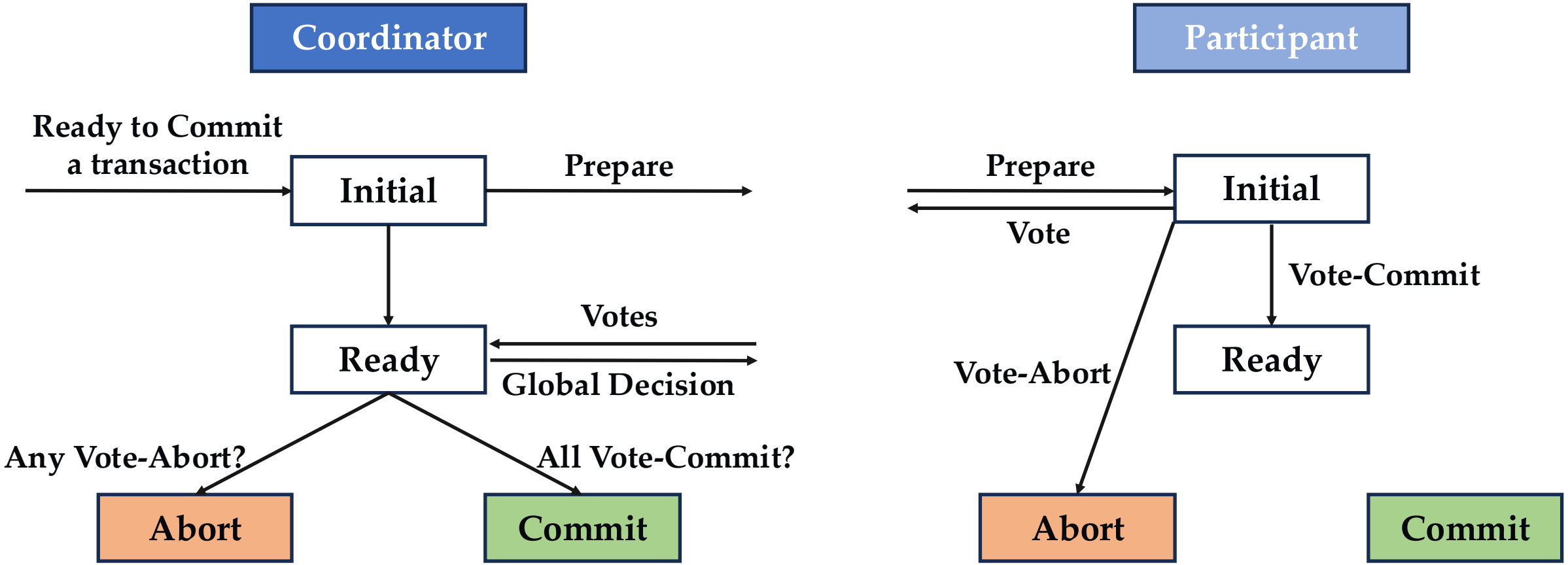

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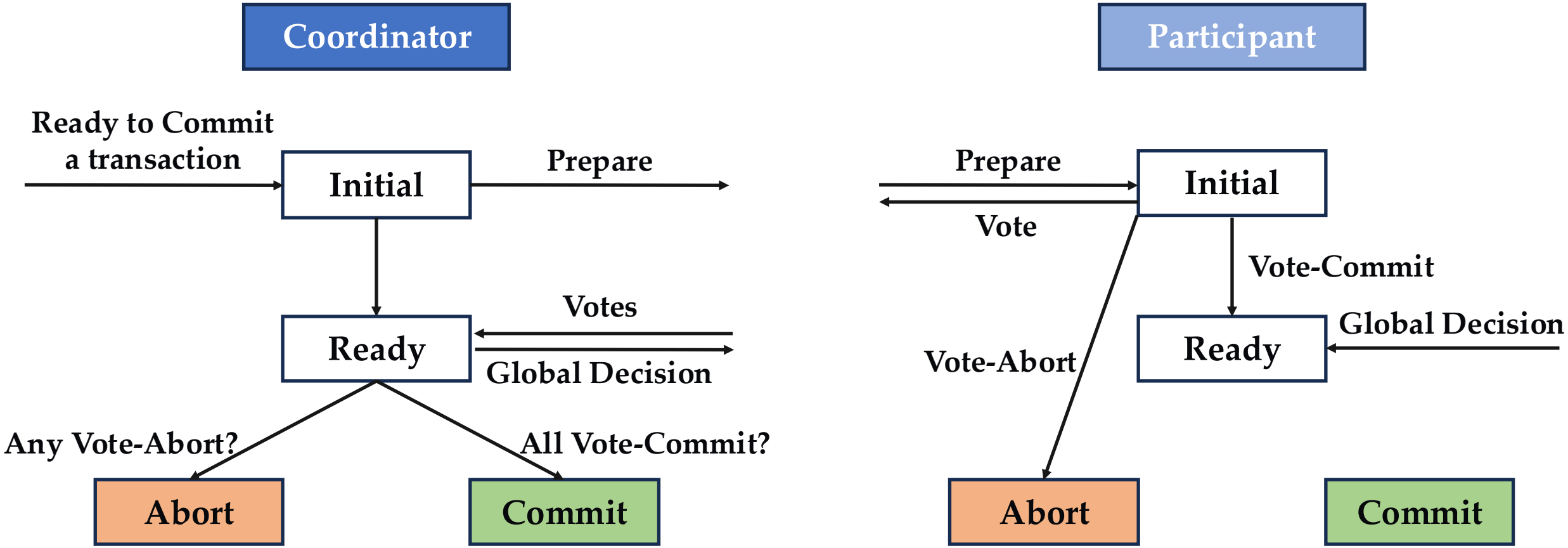

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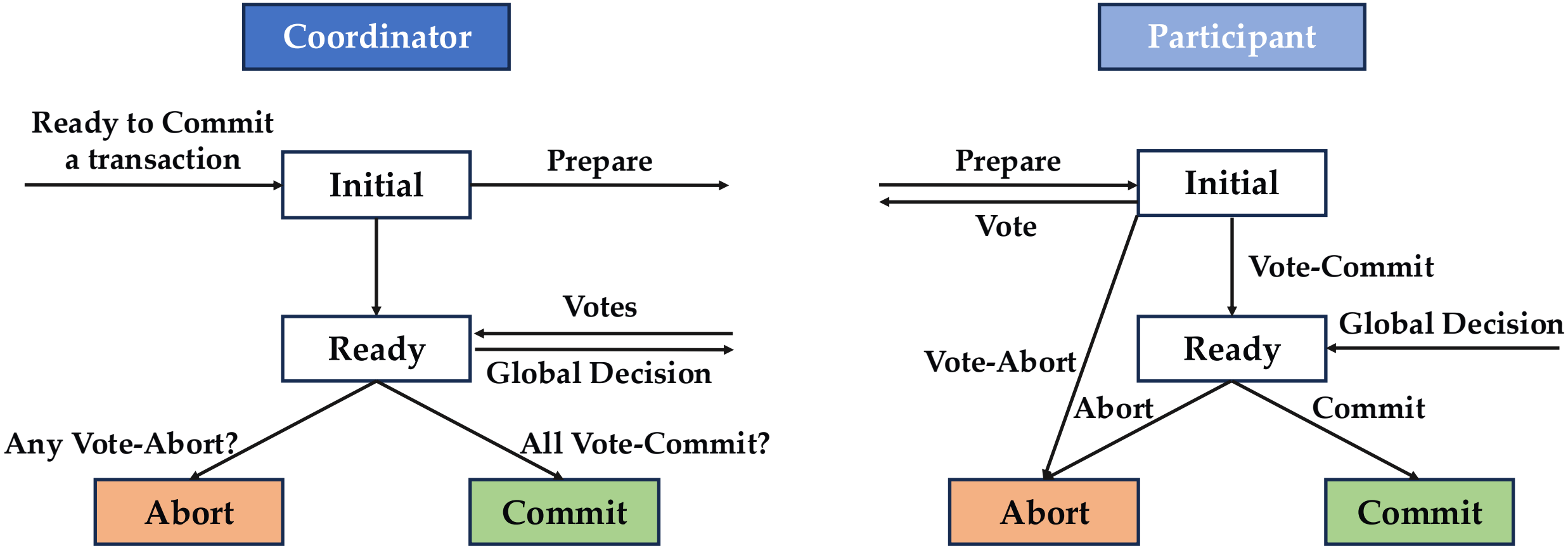

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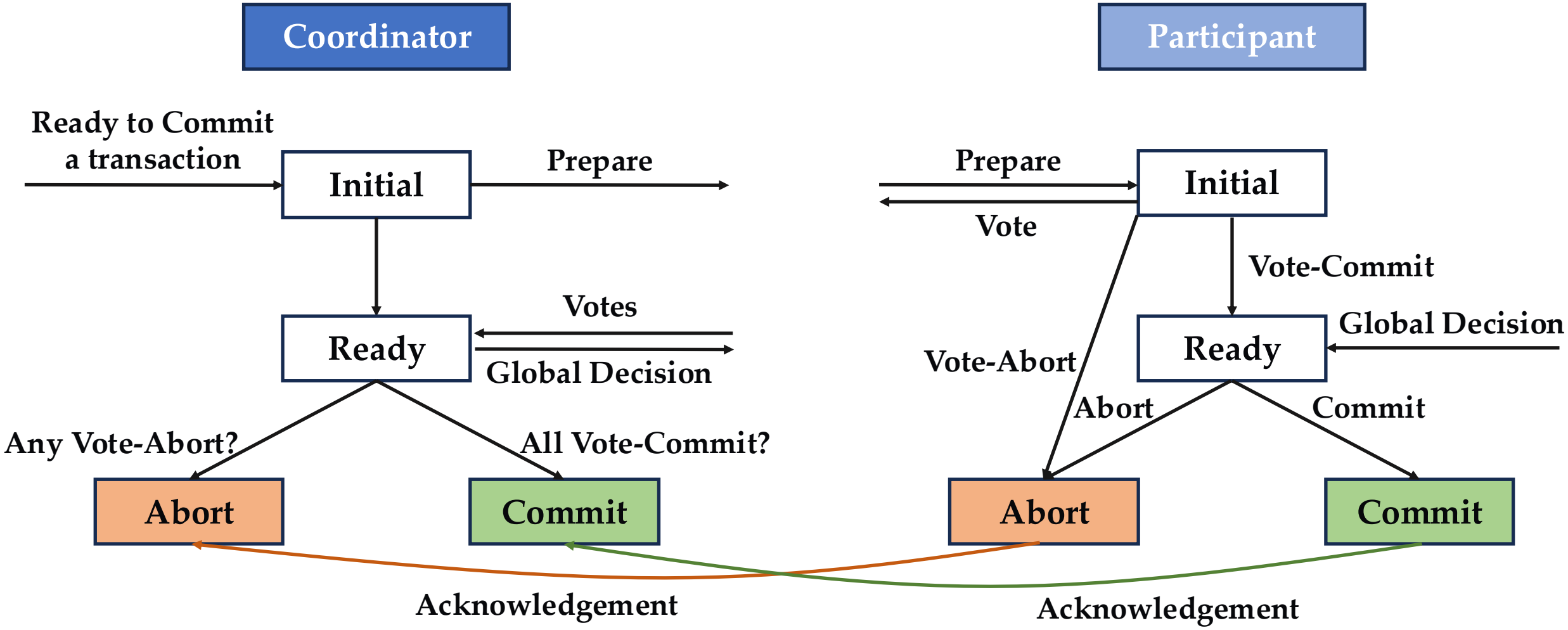
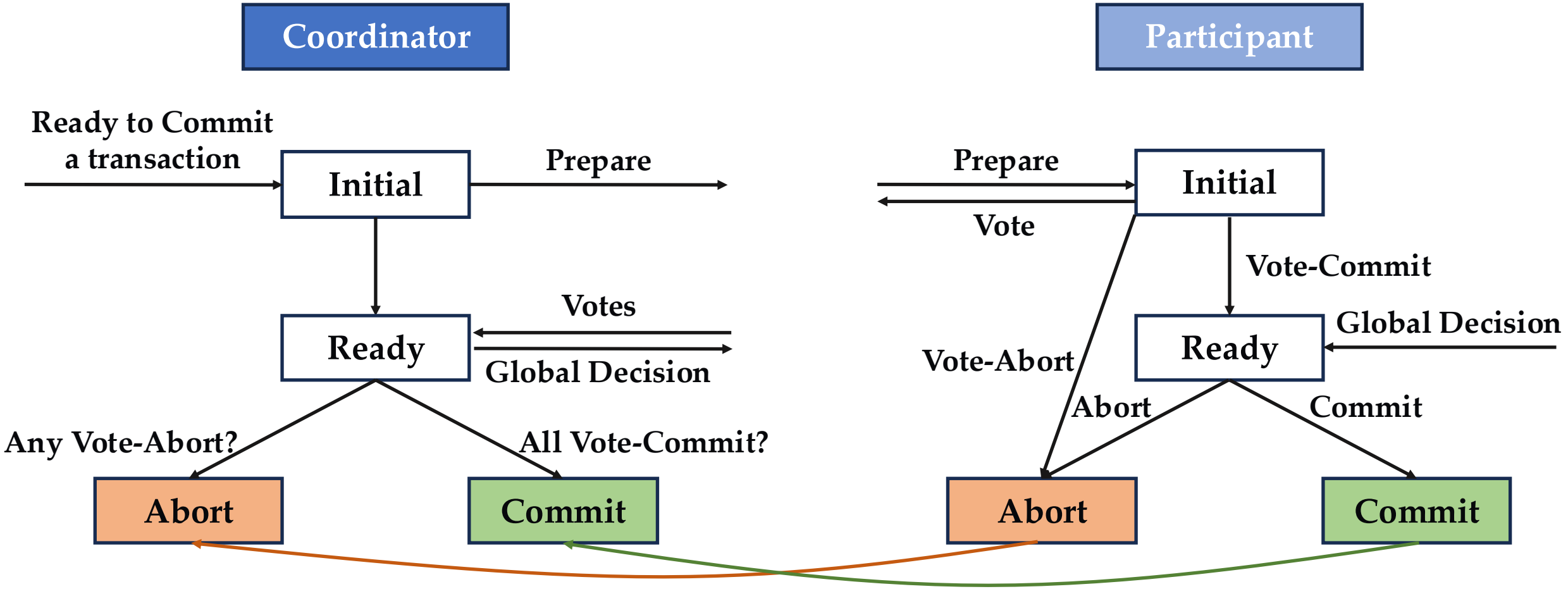


2PC Protocol Key Takeaways



- 2PC permits a participant to unilaterally abort a transaction.

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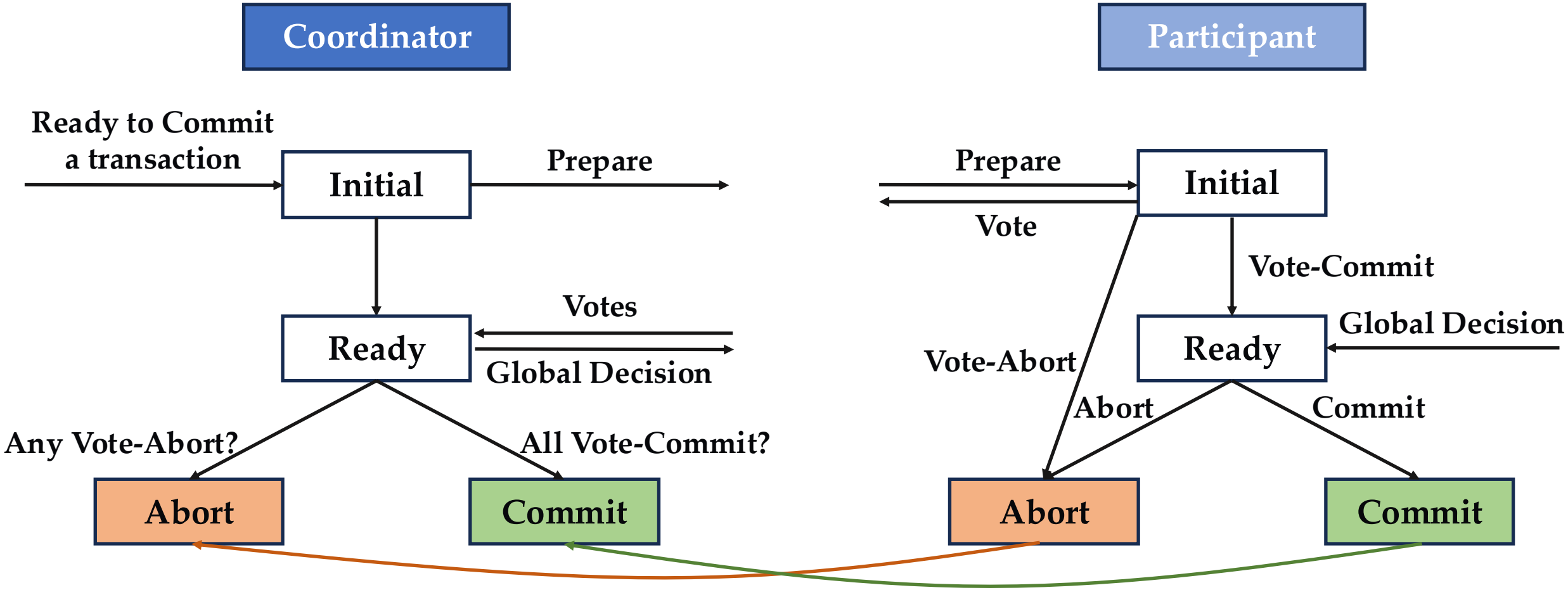

- Once a participant votes to commit or abort a transaction, it cannot change its vote.

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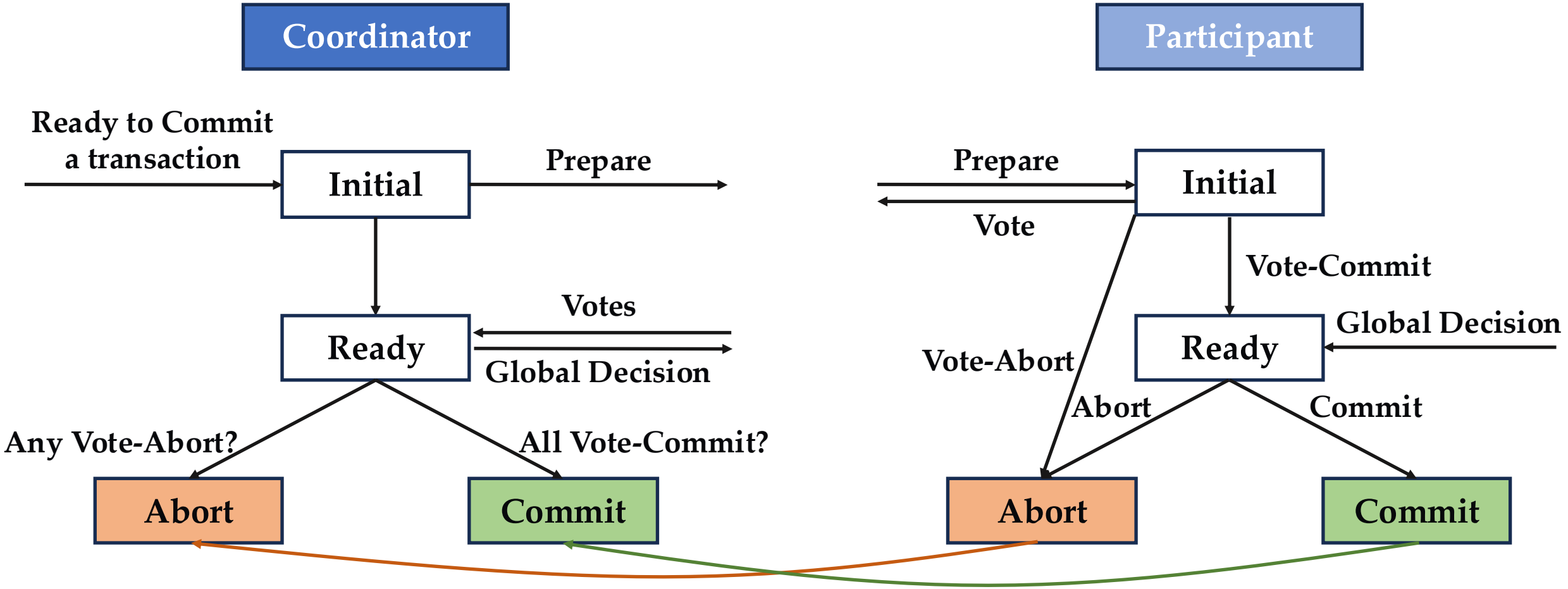

- In the Ready state, based on the global decision it receives from the coordinator, a participant can move either to abort or to commit state.

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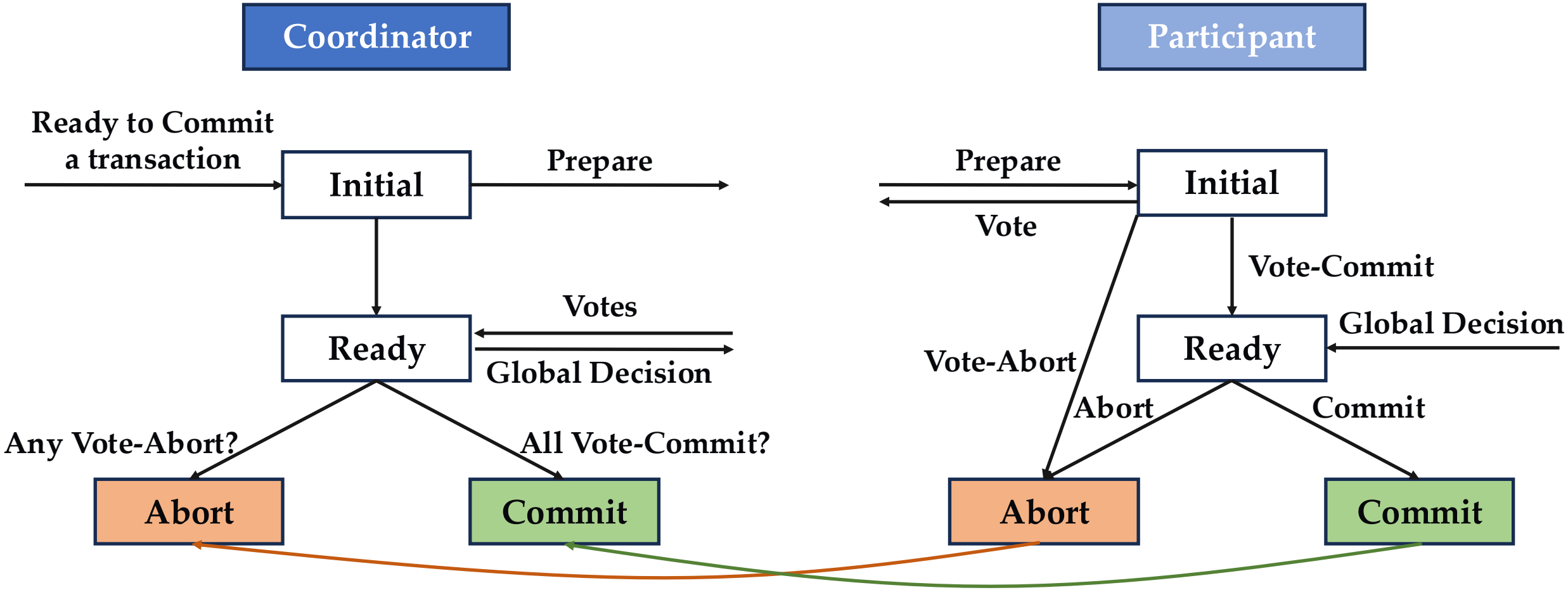

- Before sending any message or changing states, the coordinator/participants need to write an entry to the log.

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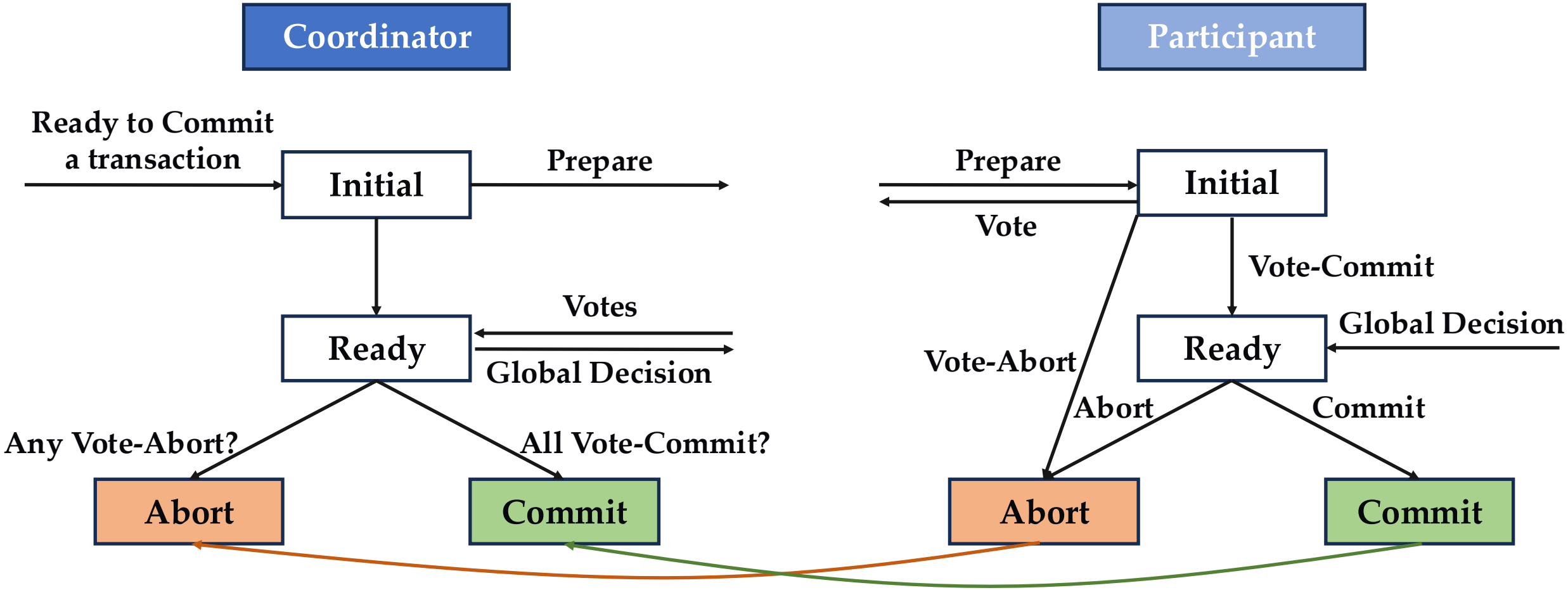

- Some states allow the coordinator/participants to exit only when they receive messages from others. How can they exit if they do not receive required messages

2PC Termination

- How can 2PC protocol manage coordinator/participant failures?

2PC Termination Protocol

- The termination protocol allows 2PC to make progress under failures.

- How to start a termination protocol?

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  - Use timers.

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  - When the timer timeouts → initiate the termination protocol.

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  - Termination protocol is a state transition protocol → allows moving across states.

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- **Timeout in Abort/Commit State:**
  - Implies that the coordinator did not receive acknowledgments from all the participants.
  - Coordinator repeatedly sends the global decision to participants that have not responded.

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- **Timeout in Ready State:**
  - Implies → participant voted to commit but has not received the global decision.
  - Cannot unilaterally make a decision, or change its own vote (to vote abort) .
  - Participant remains blocked until it hears a decision.

2PC Blocking

- Participant remaining blocked impacts system liveness!
- What can we do?

2PC Blocking

- Participant remaining blocked impacts system liveness!
- What can we do?
- Several important scenarios to consider?
  - Can participants communicate with each other?
  - Who all have failed?
  - Can unilateral decisions be made?

2PC Blocking

- If the communication is not centralized, then participants can communicate with each other and try to make progress.

- If a participant timeouts in Initial State (did not get a chance to vote) and has not received a global decision, it can unilaterally abort.
  - Post unilaterally aborting, forward the decision to everyone.

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  - New Coordinator collects all the votes and makes a decision.

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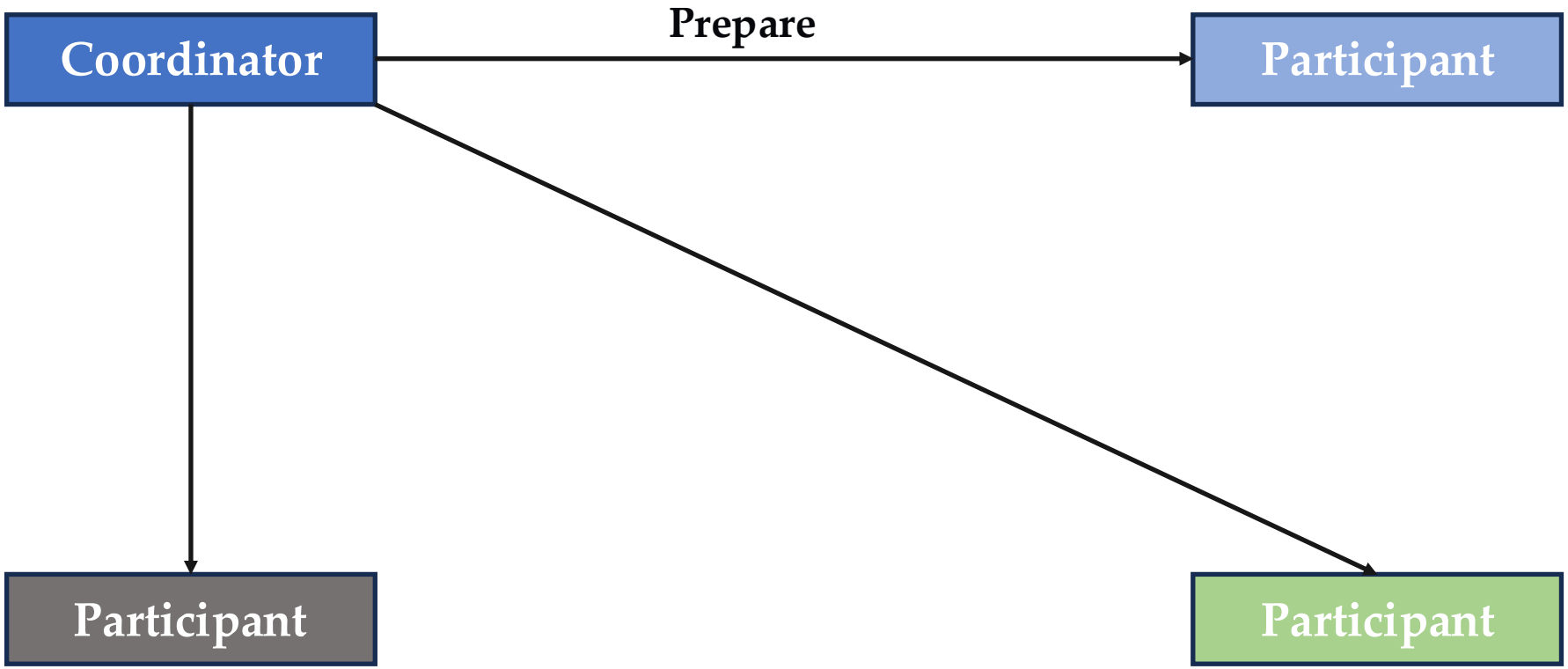

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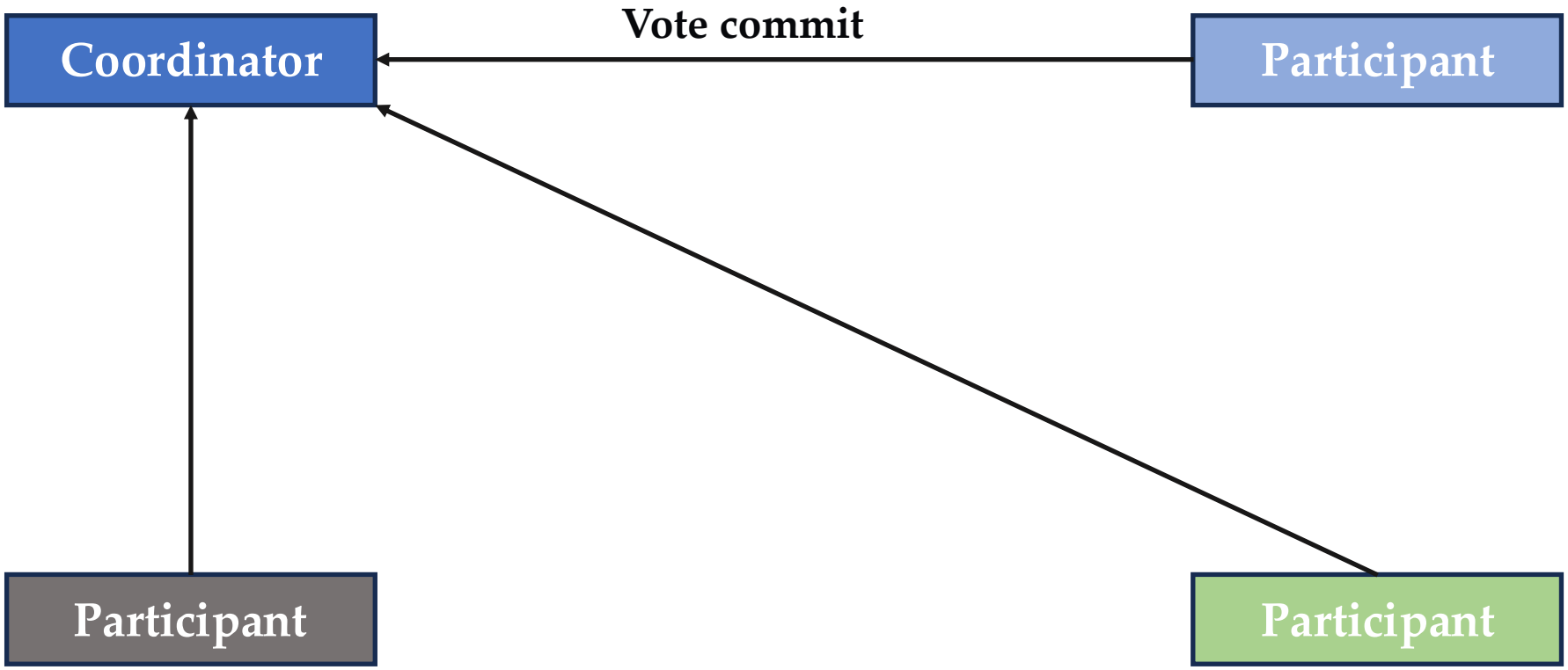

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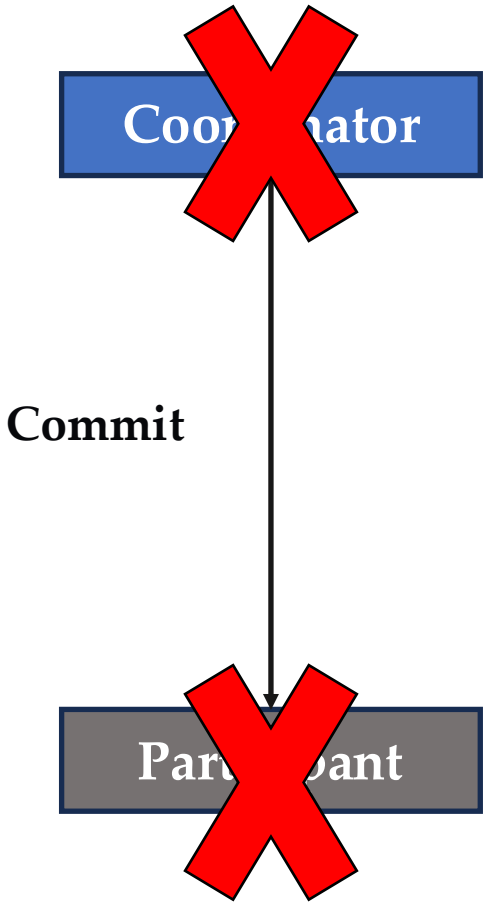

How should these participants make progress?

Any situation where 2PC always blocks?

- Thus, 2PC is termed as a blocking protocol!
- Is there any alternative?

Three Phase Commit Protocol

- The Three Phase Commit (3PC) protocol is non-blocking under node failures.

3PC Protocol Flow

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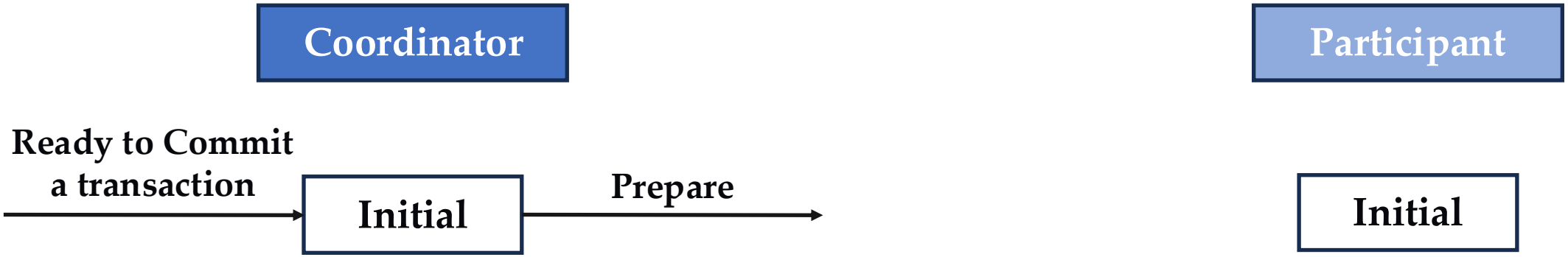

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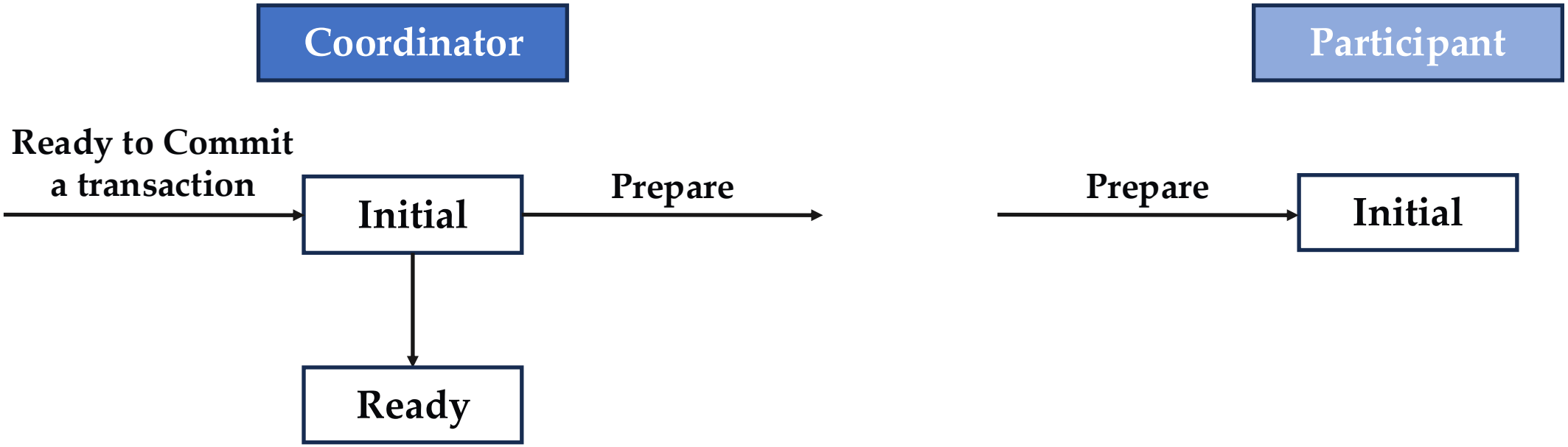

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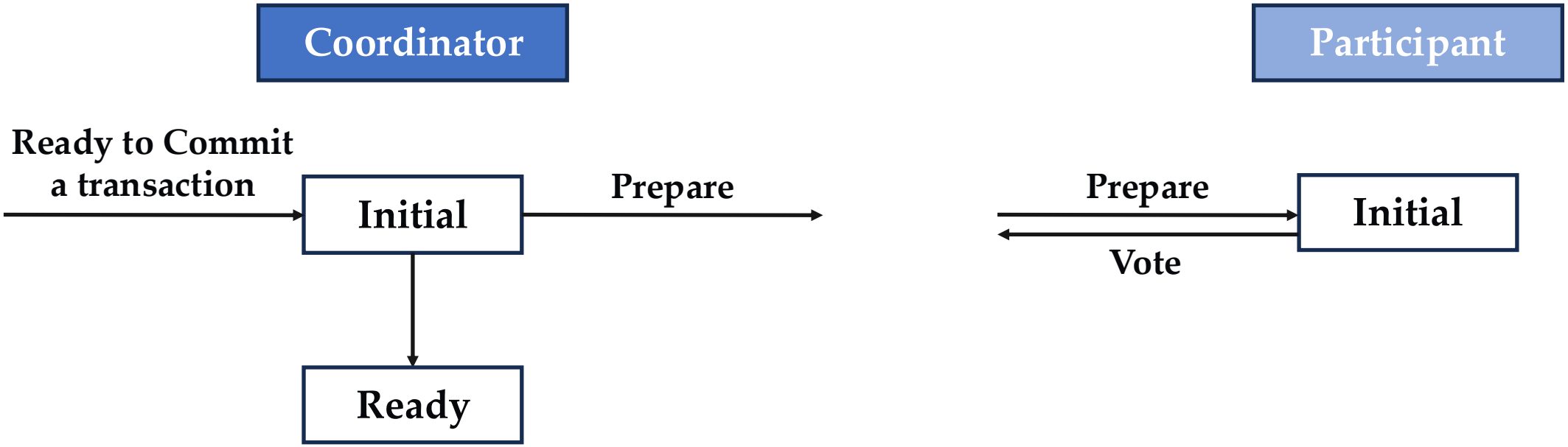

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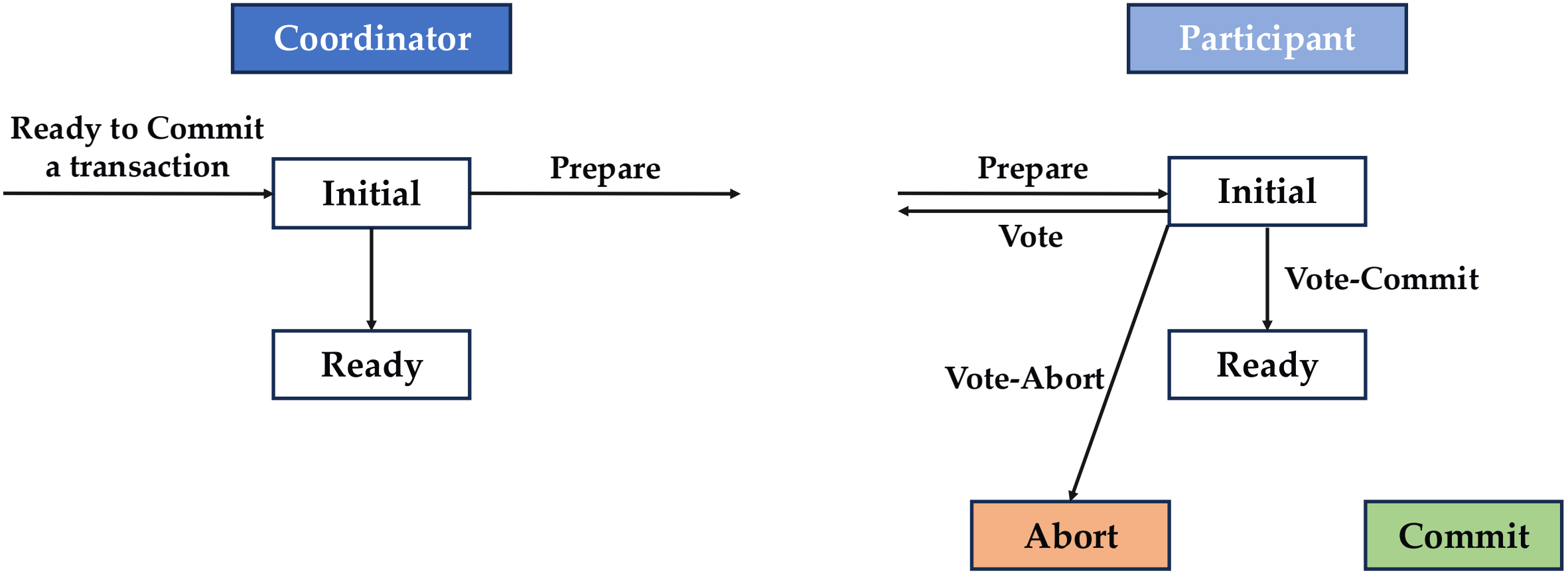

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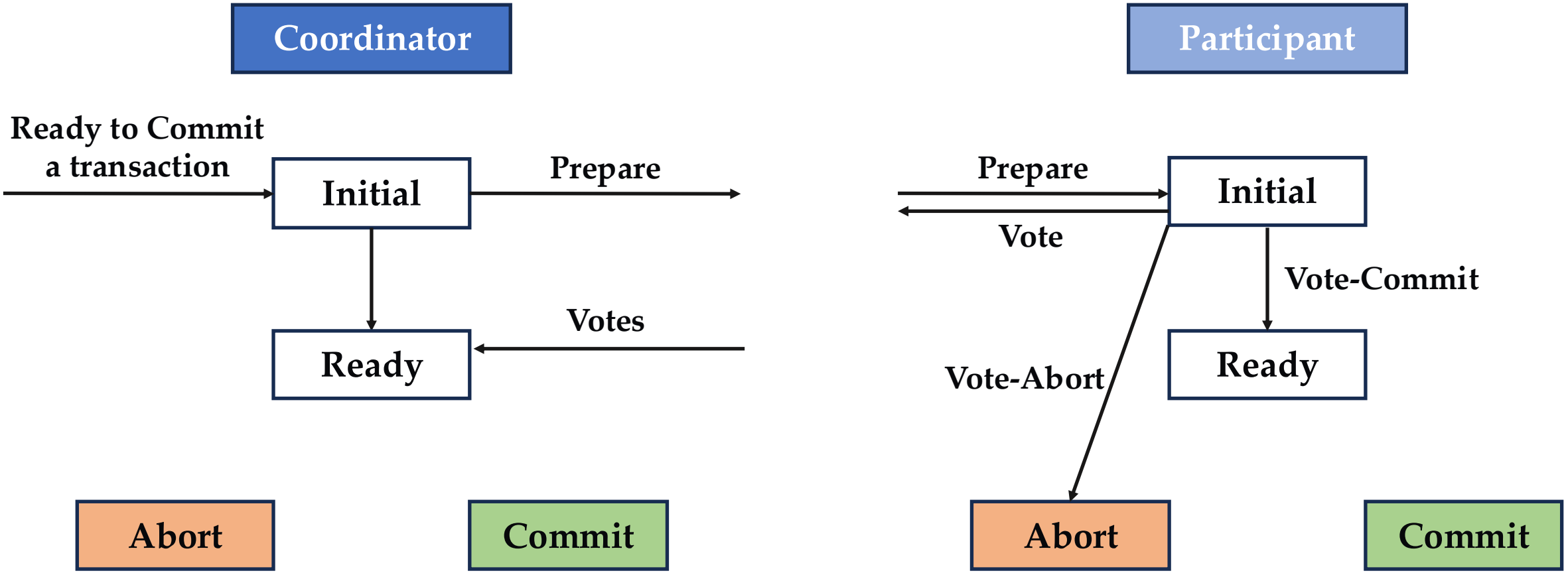

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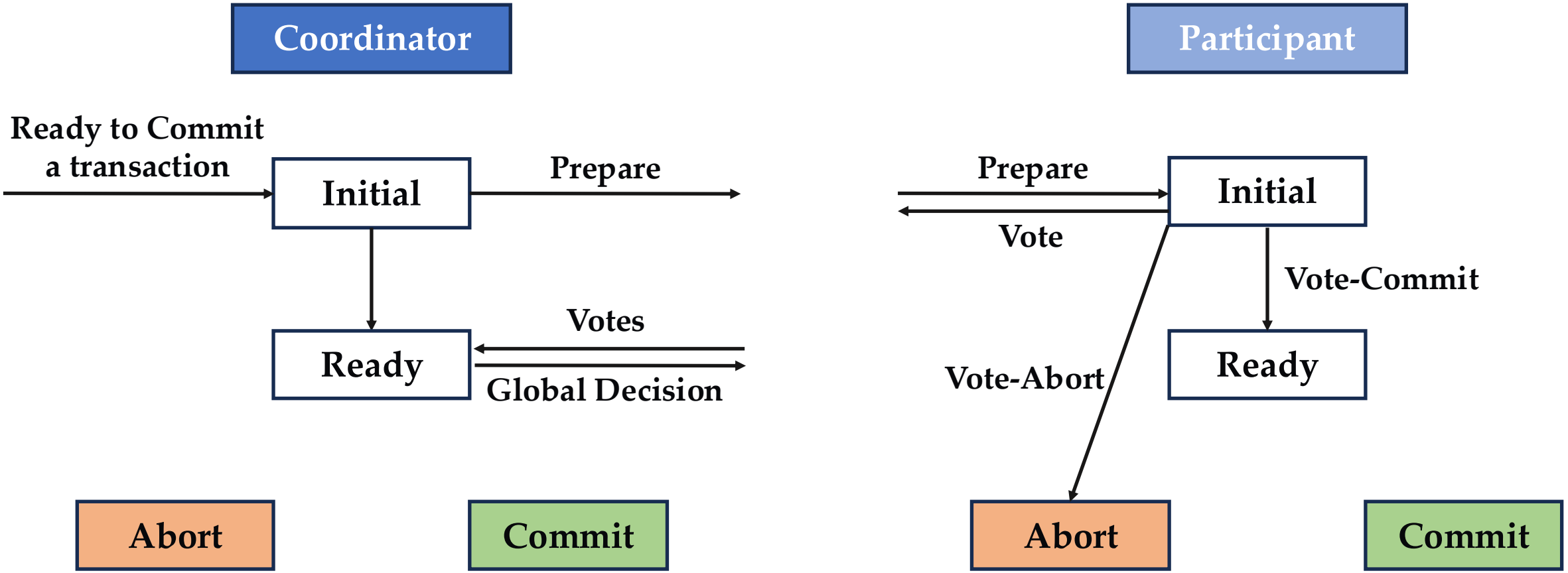

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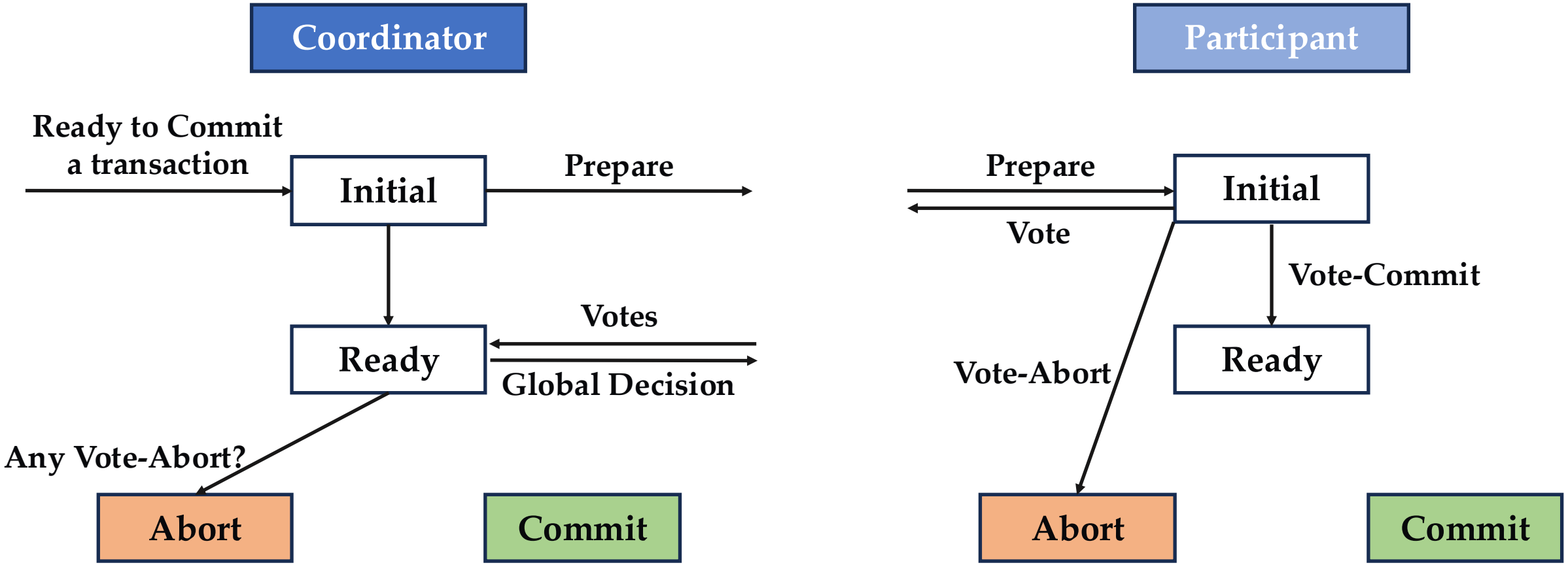

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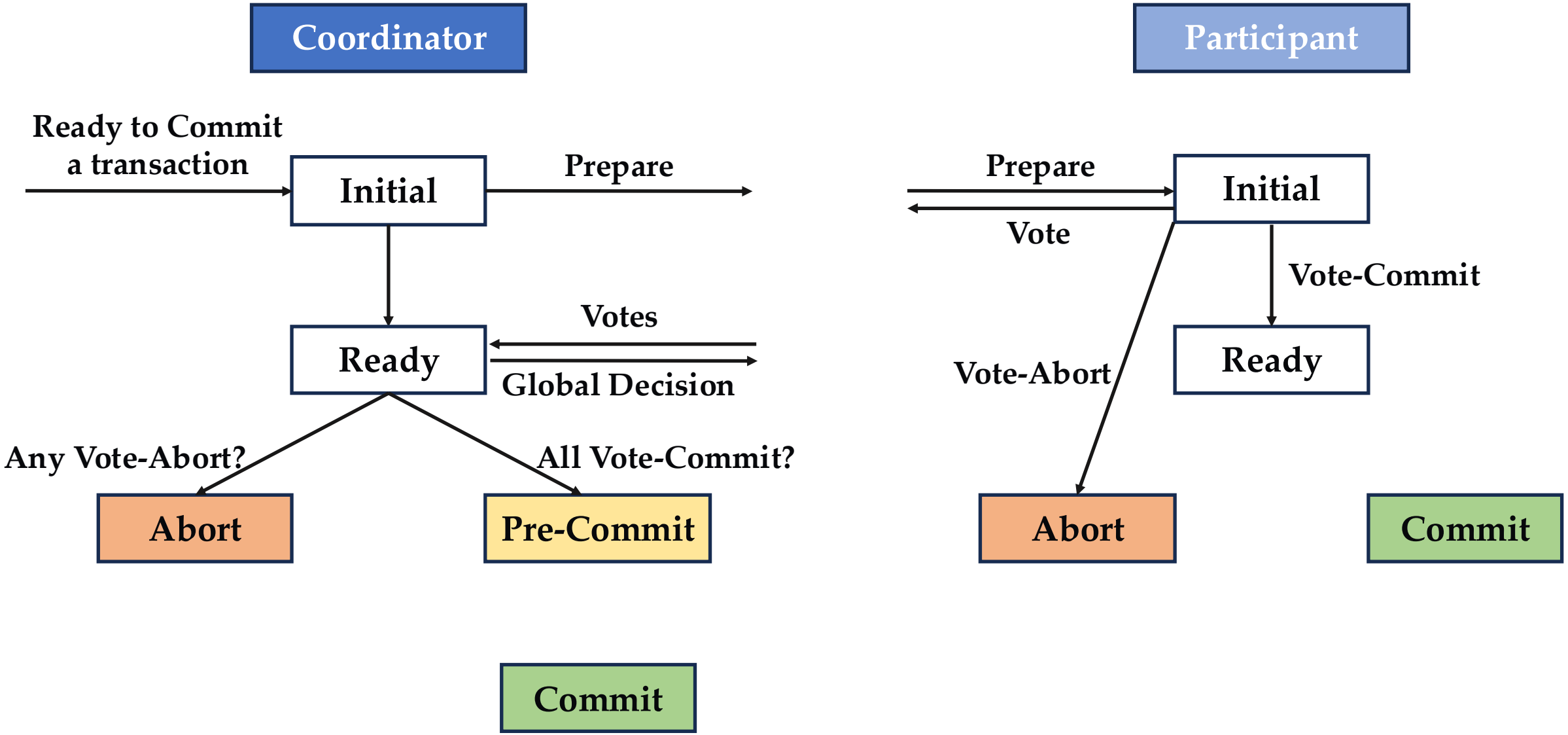

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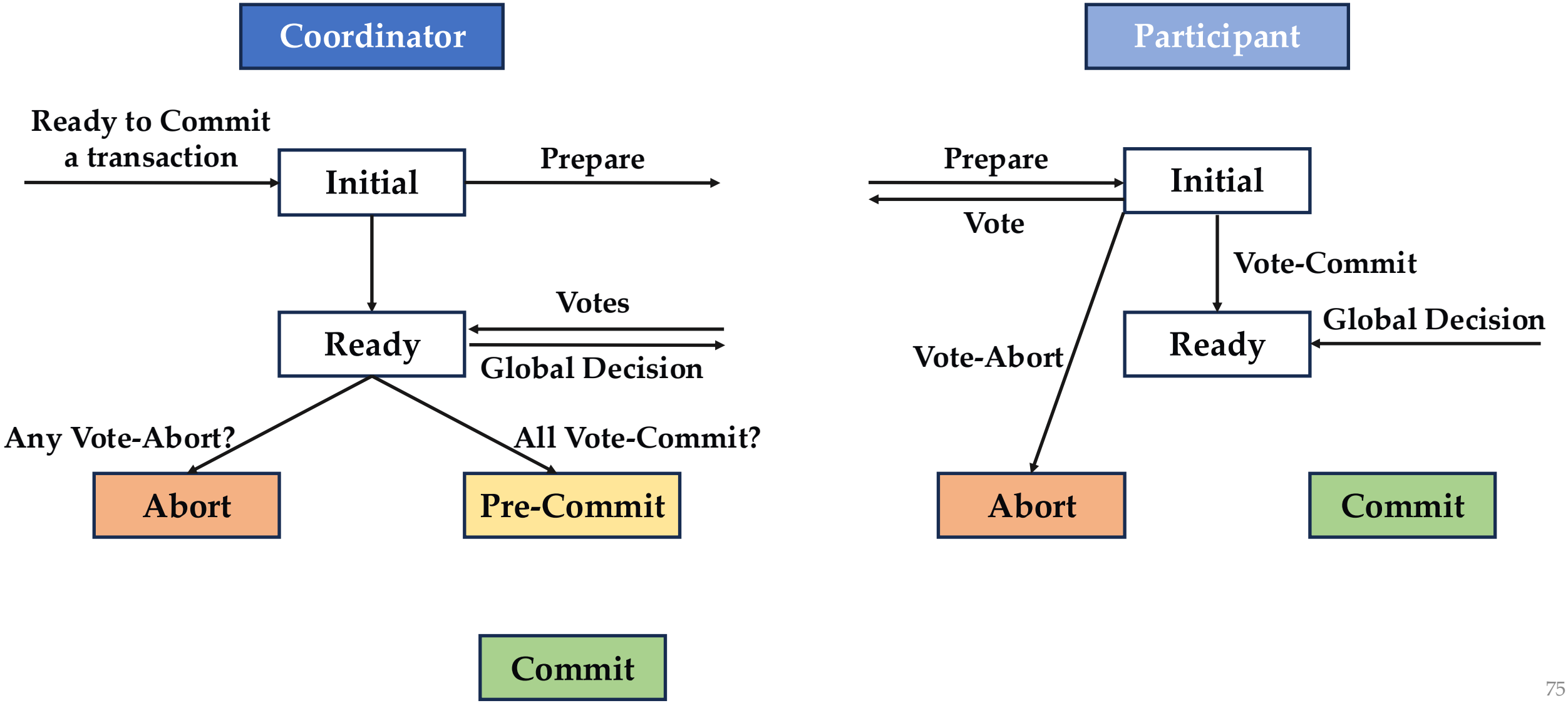

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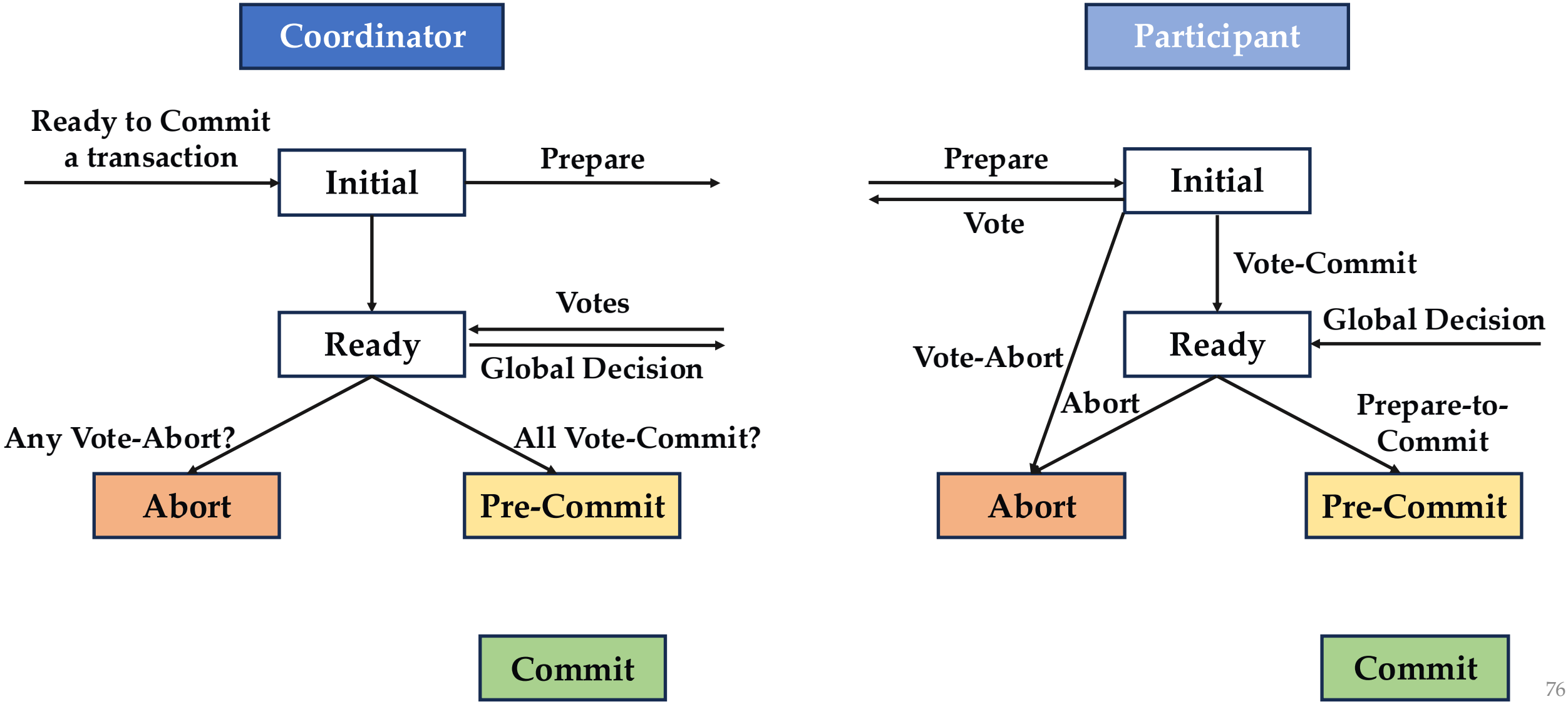

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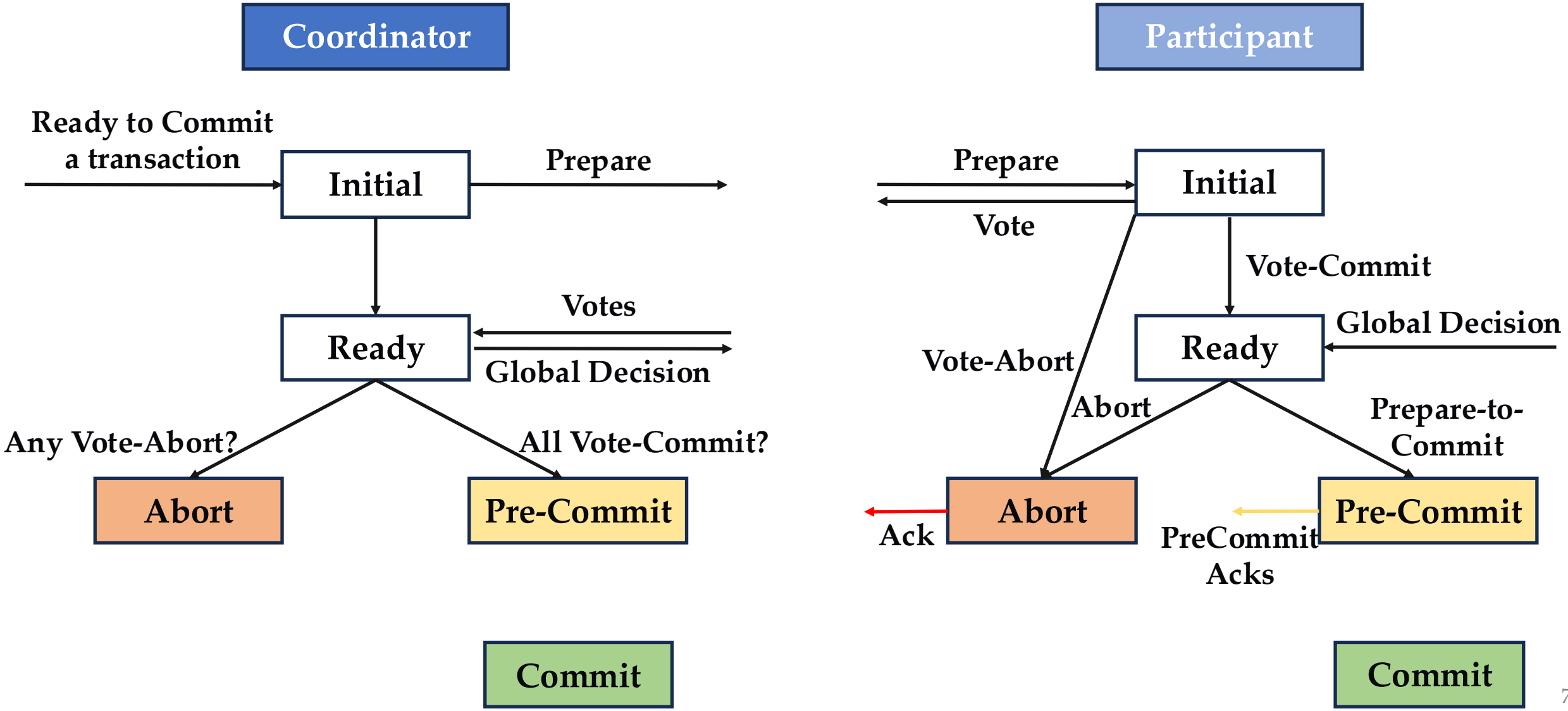

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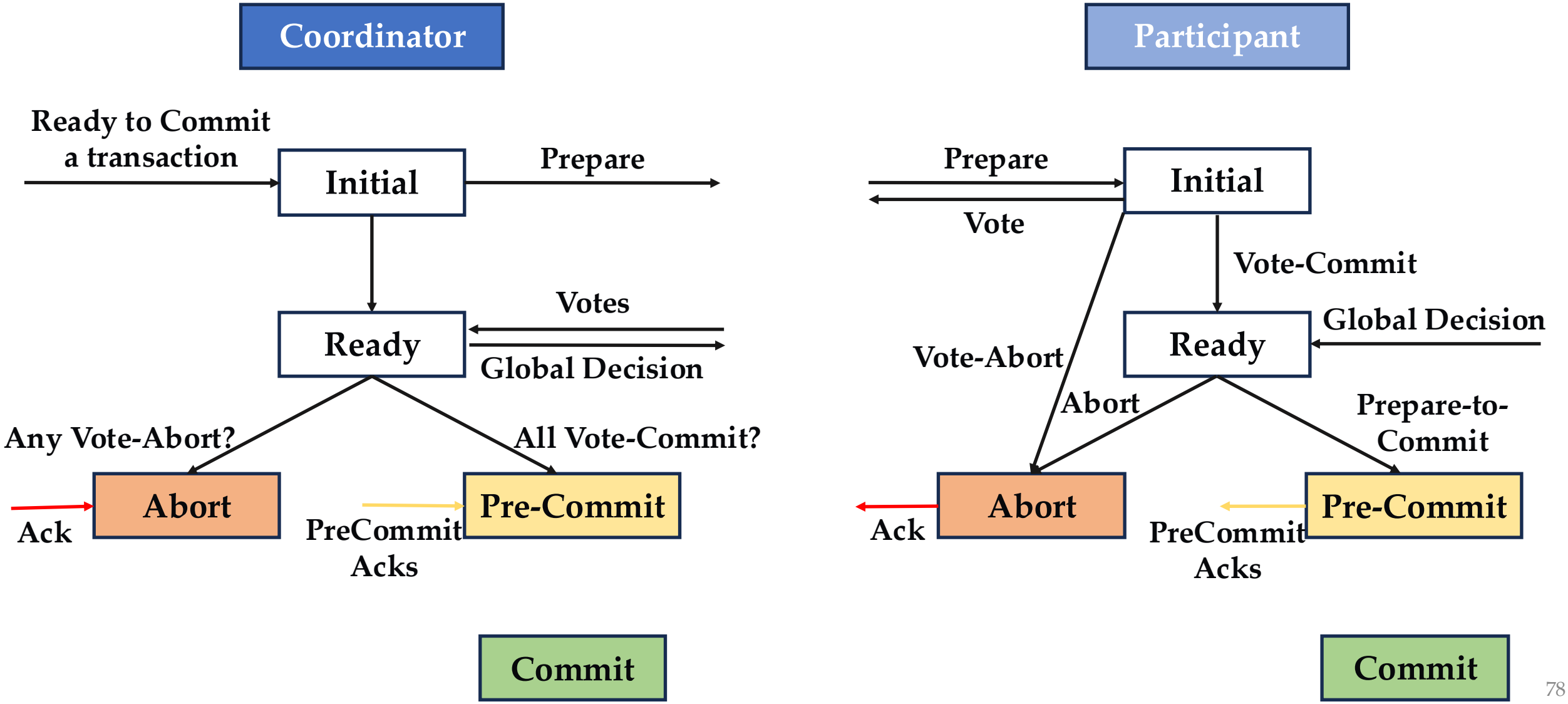

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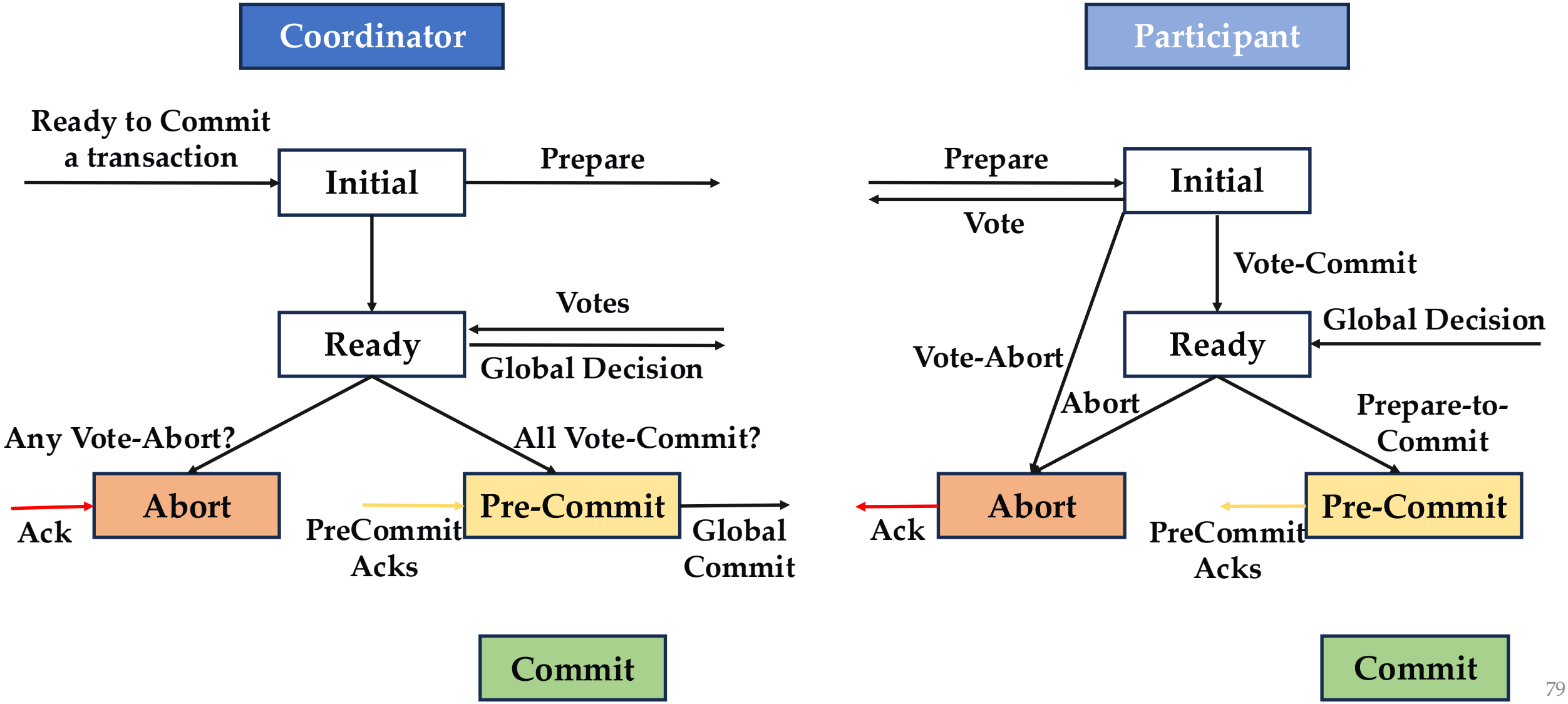

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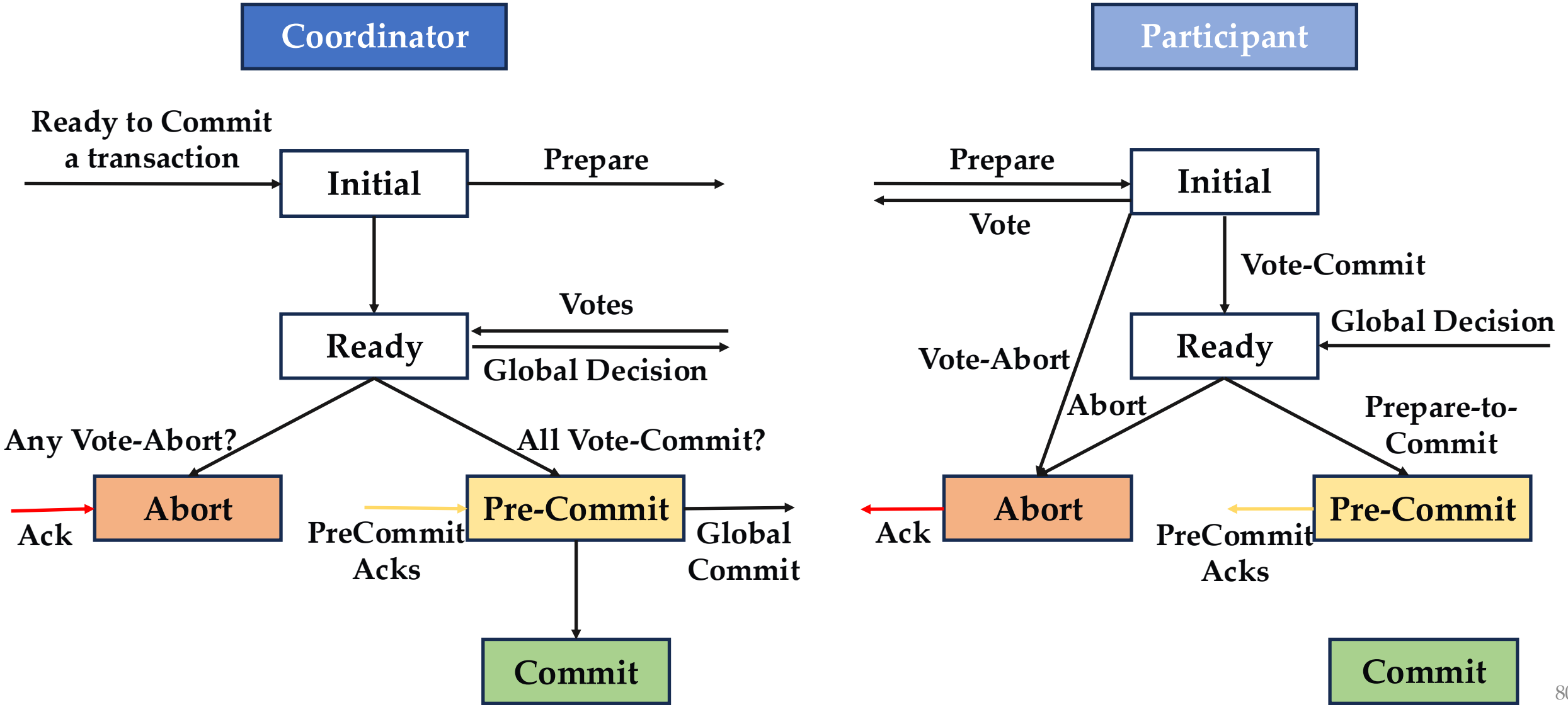

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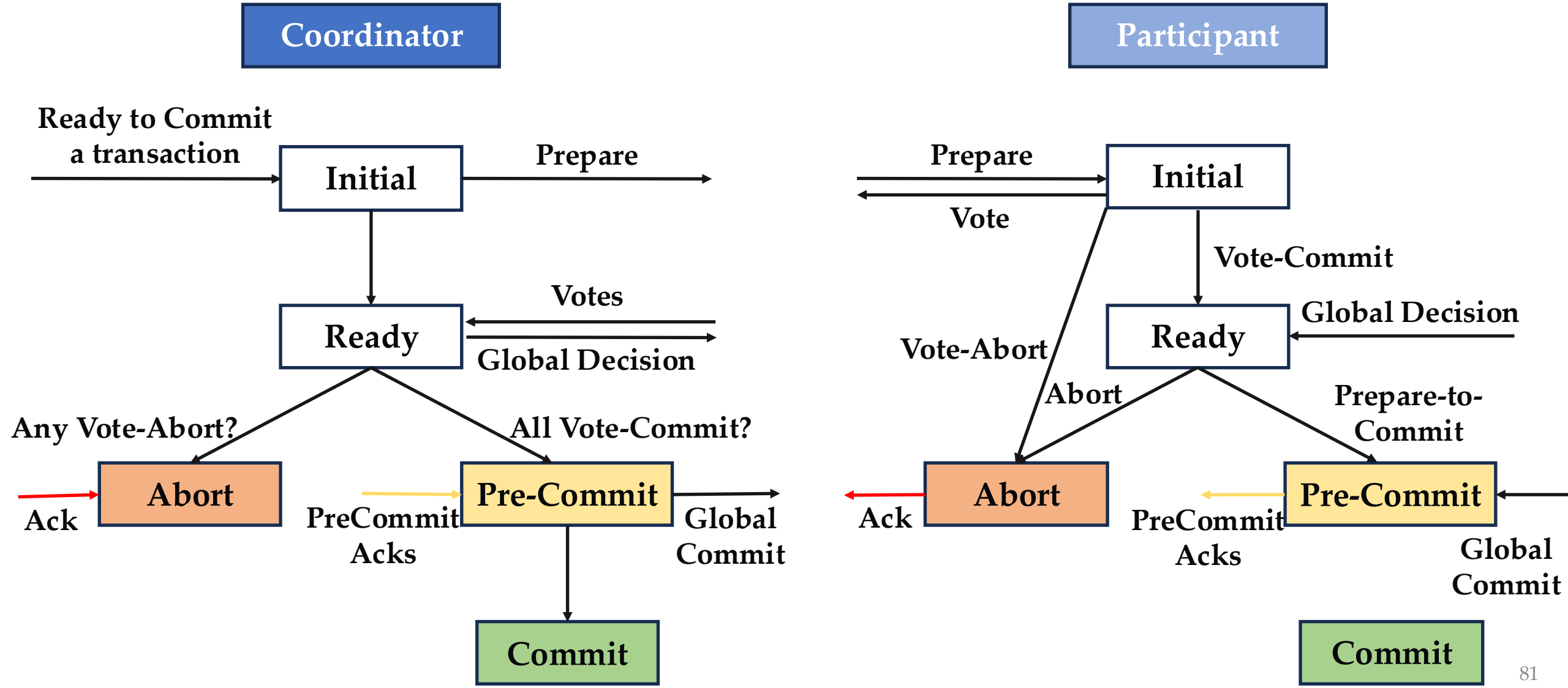

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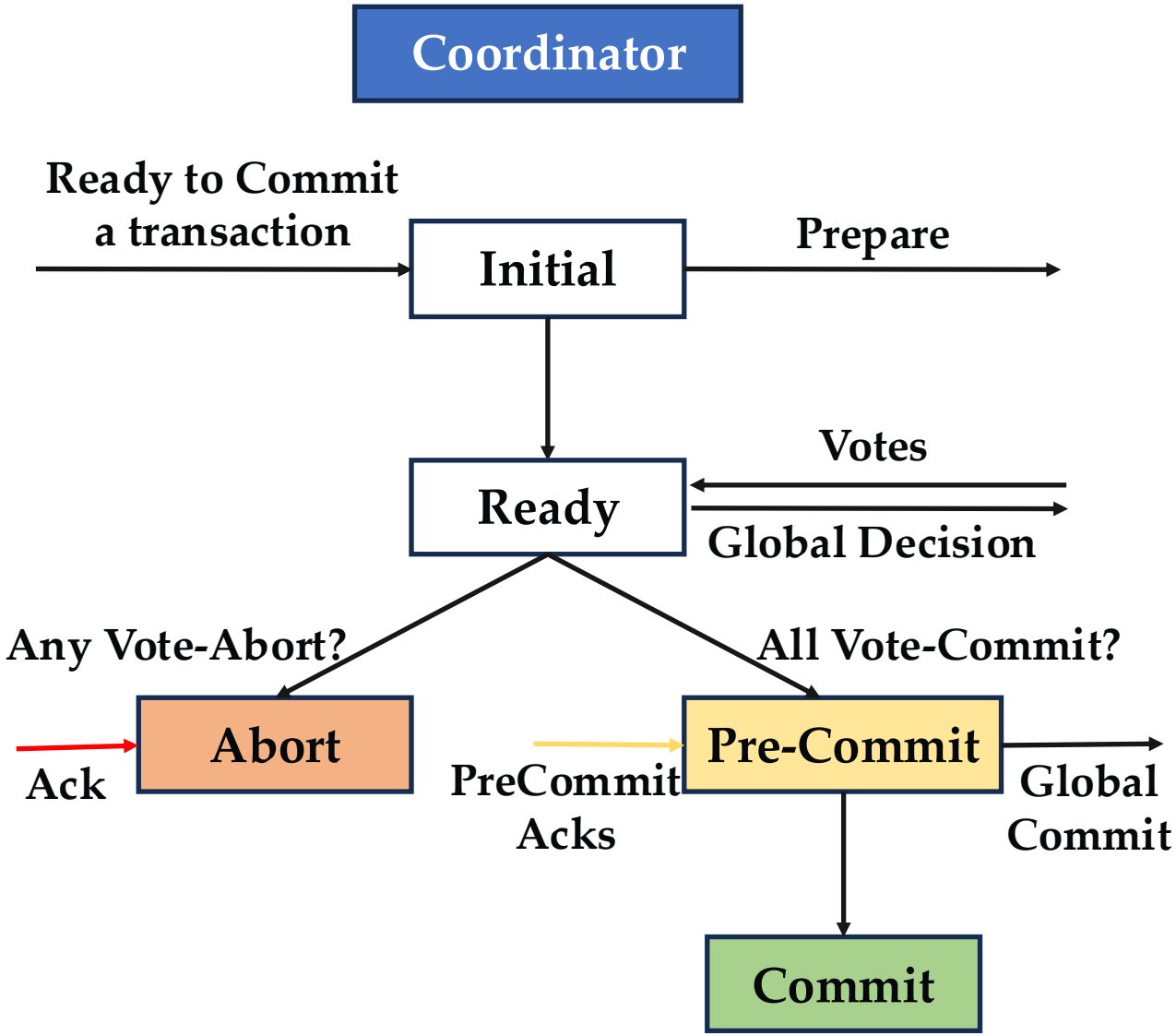

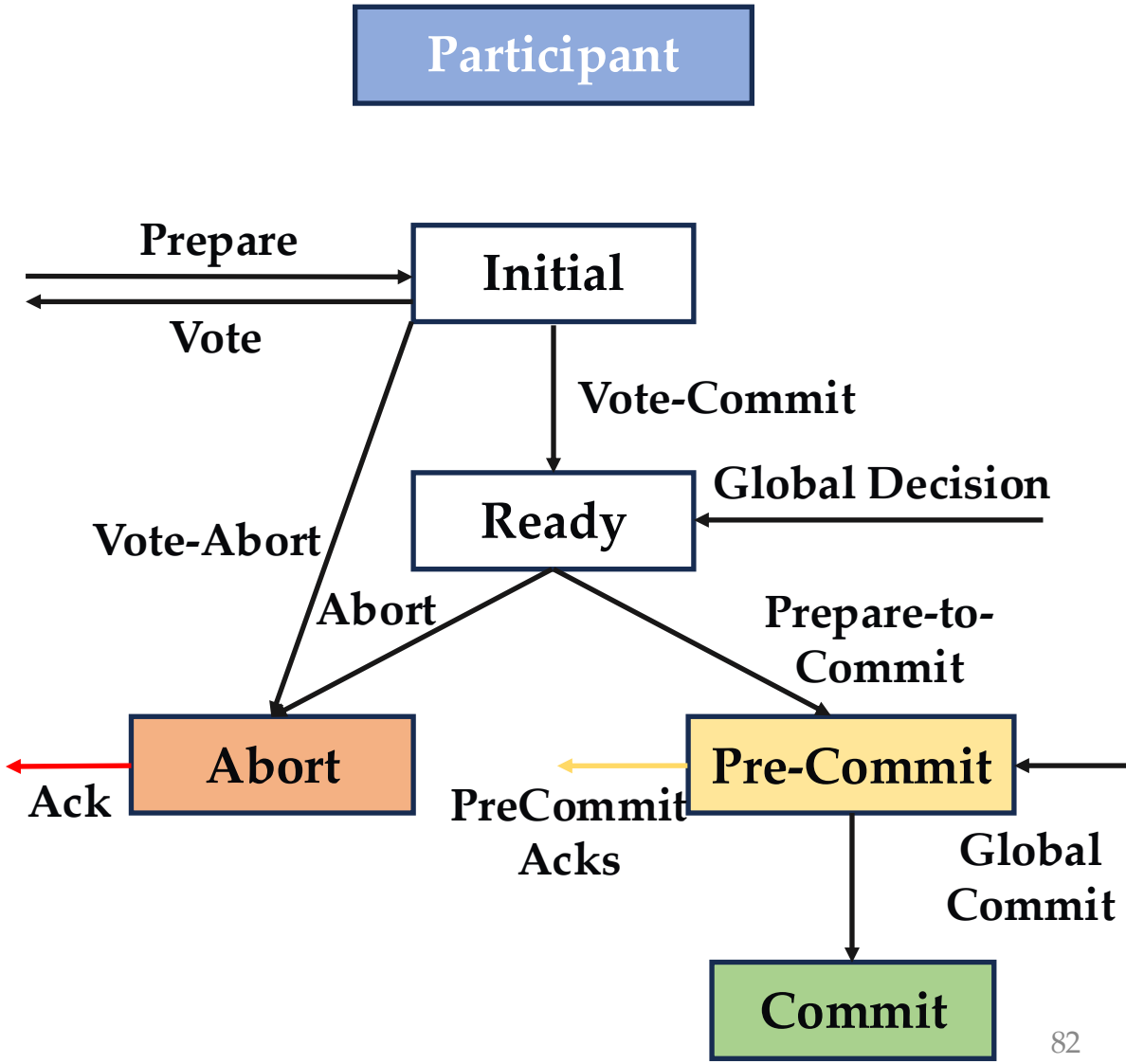

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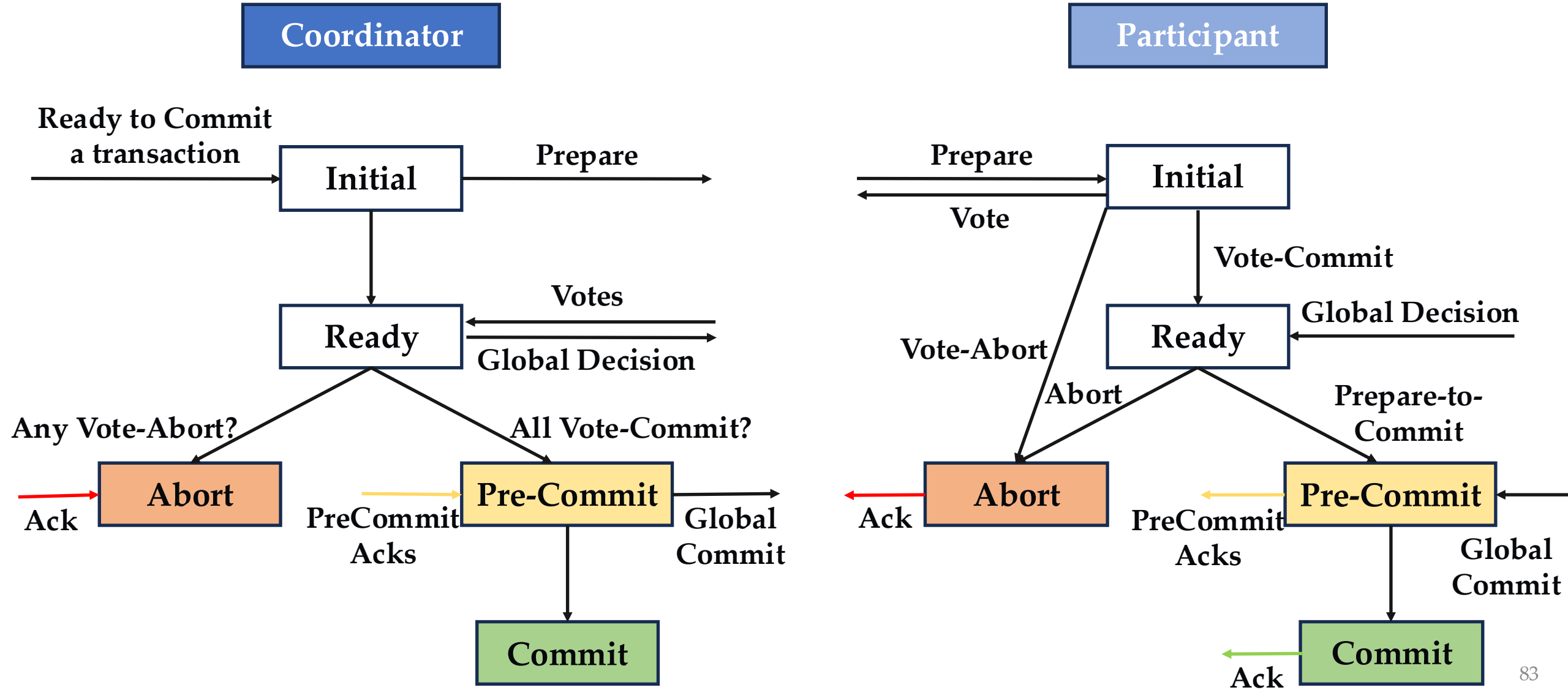

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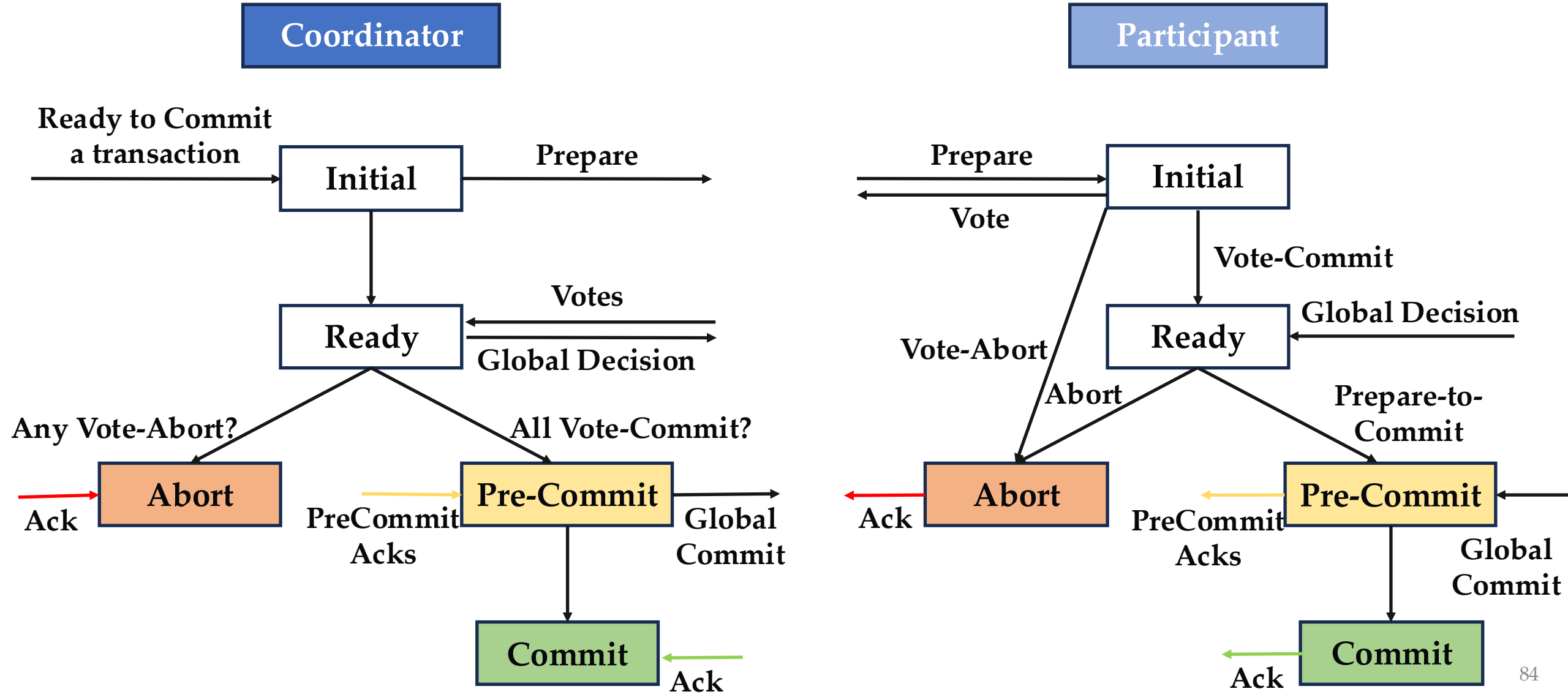

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- **Two key properties** necessary for non-blocking behavior.

  1) No state is adjacent to both a commit and an abort state.

Three Phase Commit Protocol

- So, why is 3PC protocol non-blocking?
- **Two key properties** necessary for non-blocking behavior.

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- Notice that 2PC **violates** these properties.

3PC Termination Protocol

- What changes do we need to do for the termination protocol of 3PC?

3PC Termination Protocol

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  - Coordinator timeouts in this state → Waiting for PreCommit acknowledgements from all the participants.

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3PC Termination Protocol

- **Coordinator timeout in Pre-commit State**:
  - Coordinator timeouts in this state → Waiting for PreCommit acknowledgements from all the participants.
  - Coordinator knows that all the participants are either in Ready or PreCommit state.
  - Simply re-sends Global decision and Global Commit messages.

3PC Termination Protocol

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  - Attempt to elect a new coordinator.

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