Understanding the Raft Consensus Algorithm

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Outline

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- Types of Fault Tolerance:
  - **Byzantine Fault Tolerance (BFT):** Deals with nodes behaving arbitrarily or maliciously.
  - **Crash Fault Tolerance (CFT):** Deals with nodes that might crash but do not exhibit malicious behavior.

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- Raft is a consensus algorithm designed for managing a replicated log.
- It ensures that a distributed system's nodes agree on a sequence of operations, even with failures.
- Raft is known for being easier to understand compared to Paxos.

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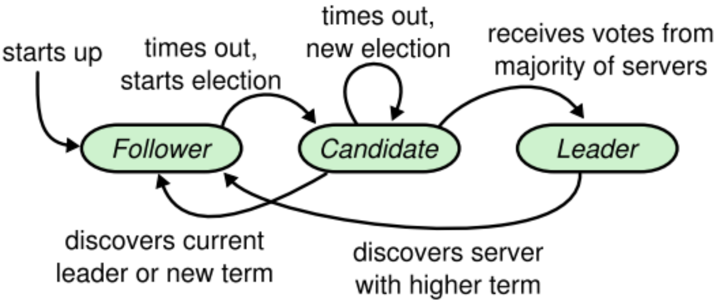
- **Commitment:** After a majority of servers replicate the log entries, they are committed.
- **Failure Handling:** If the leader fails, a new election is initiated.

Overview (Continued)



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- **lastApplied:** Index of the highest log entry applied to the state machine.

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  - **lastLogTerm:** Term of candidate's last log entry.
- Nodes reply **False** if the term is less than **currentTerm**.
- If **votedFor** is null or matches the candidate, and the candidate's log is at least as up-to-date, grant the vote.

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- Followers randomly generate a timeout. If they don't receive a heartbeat, they become candidates and initiate a re-election.

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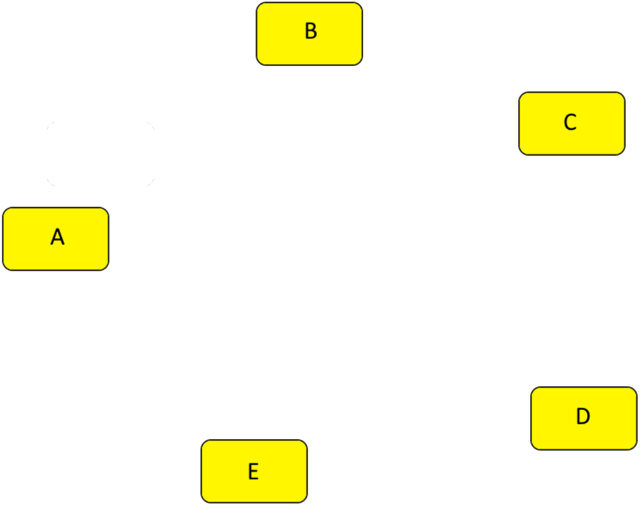
  - If **leaderCommit ¿ commitIndex**, set **commitIndex = min(leaderCommit, index of last new entry)**.
- After the leader receives a majority of **Trues**, it requests everyone to commit the latest entry to their state machine.

Example



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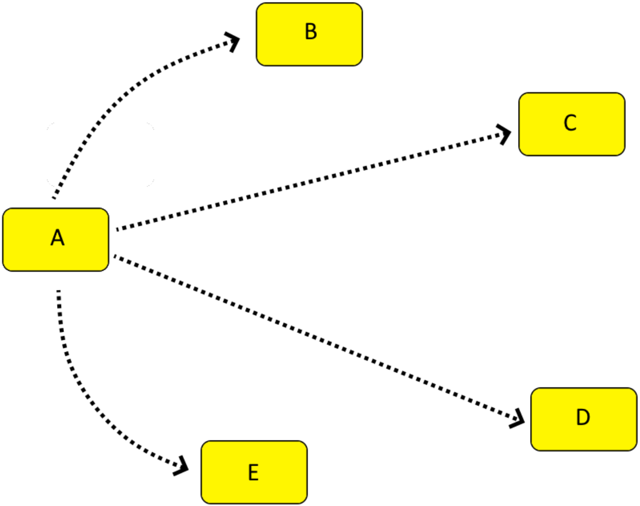

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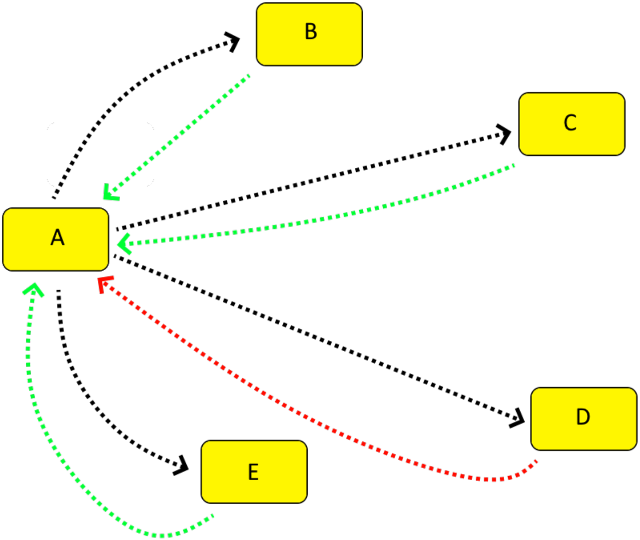

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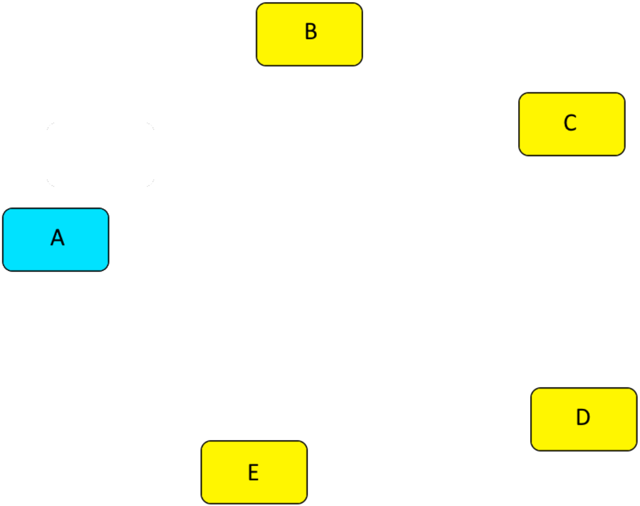

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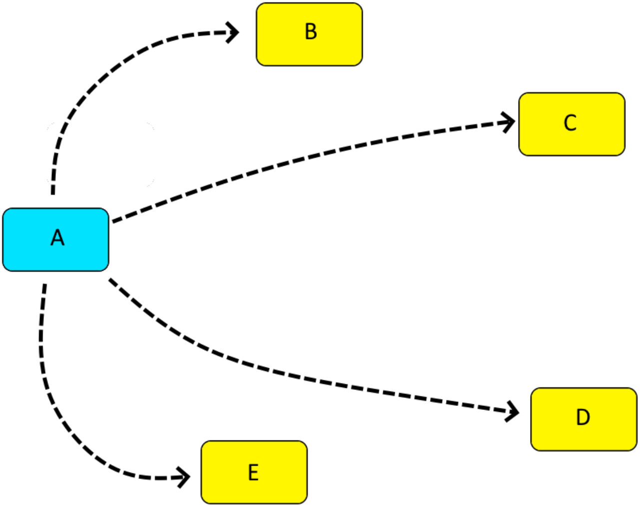

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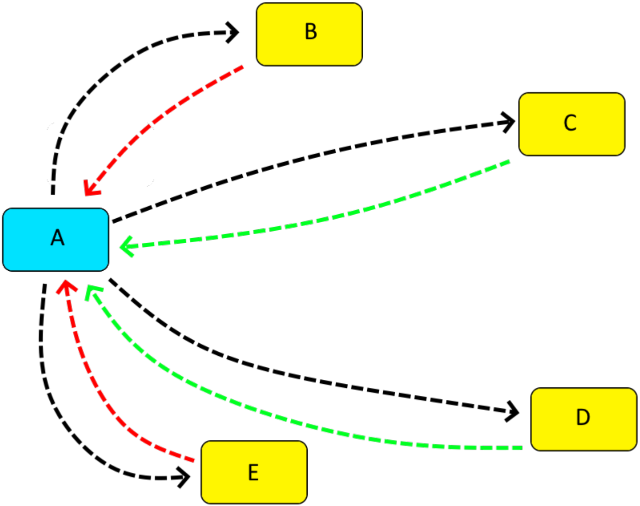

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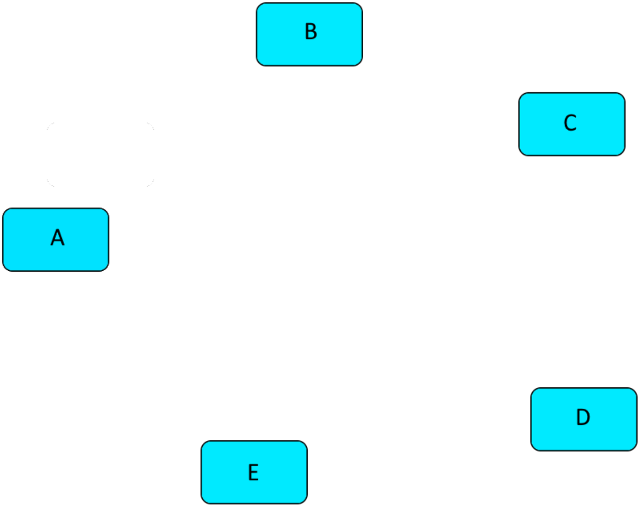

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- **Log Matching:** Logs are identical up to a certain point.
- **Leader Completeness:** Committed entries are preserved.
- **State Machine Safety:** No conflicting committed entries.
- **Leader Election Guarantee:** Only the most up-to-date candidate can be elected.

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  - Before committing: Follows the protocol for a crashed follower.

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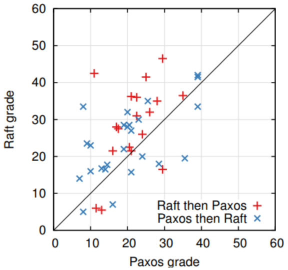

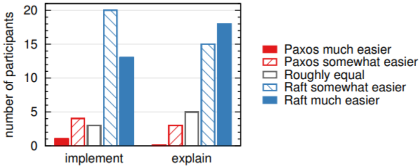

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- The protocol is designed to be easy to understand and robust in the face of failures.

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- Investigate different crash failure scenarios to find more invariants to check.

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Thank You!