In Search of an Understandable Consensus Algorithm - Raft

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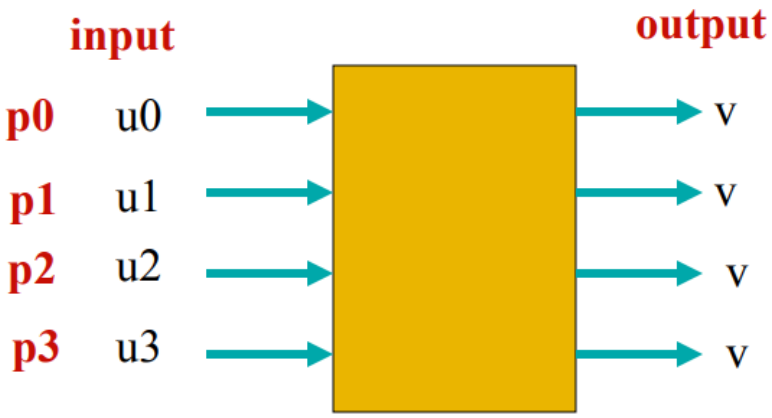
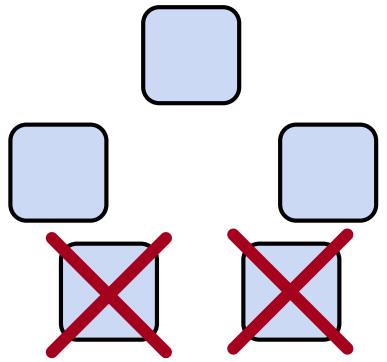
https://raft.github.io/raft.pdf

What is Consensus?

- **involves multiple servers agreeing on values**
- **Recovers from server failures autonomously**
  - Minority of servers fail: no problem
  - Majority fail: lose availability, retain consistency



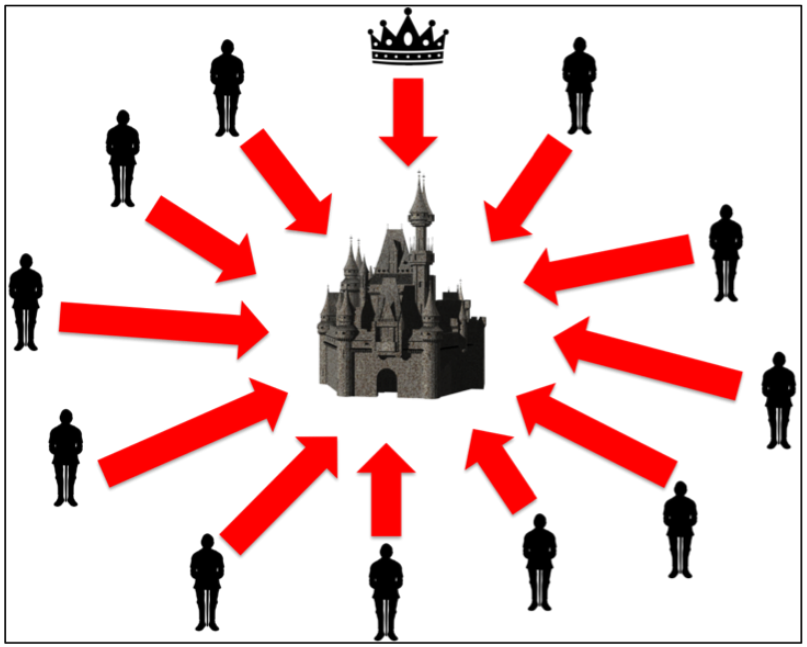


Servers

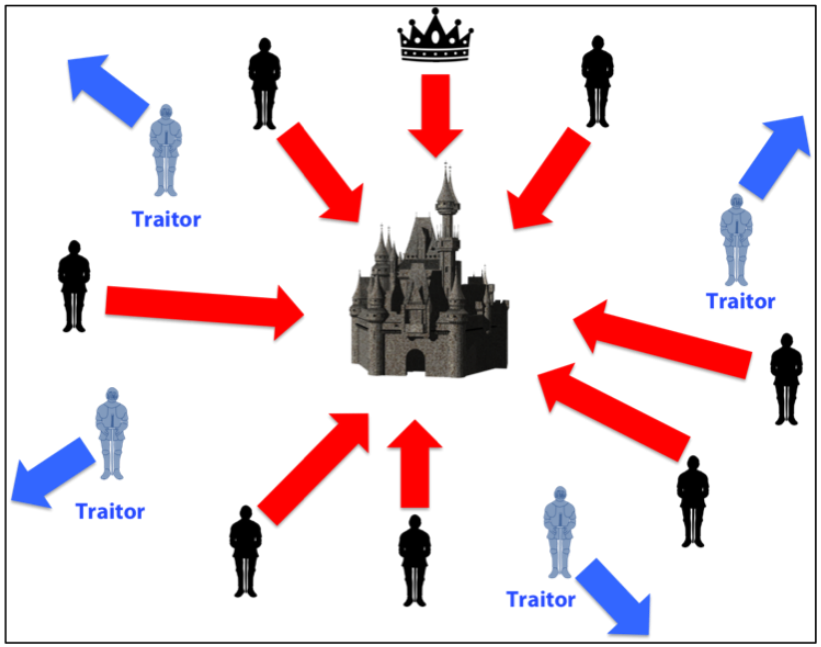
- **Key to building consistent storage systems**

Paxos? Too complicated!

- *Leslie Lamport, 1989*
- **Byzantine Generals Problem**



Coordinated Attack Leading to Victory



Uncoordinated Attack Leading to Defeat

- **Paxos: a consensus algorithm to solve it**
  - But… too difficult to be understood & implemented

Method: Design a new algorithm

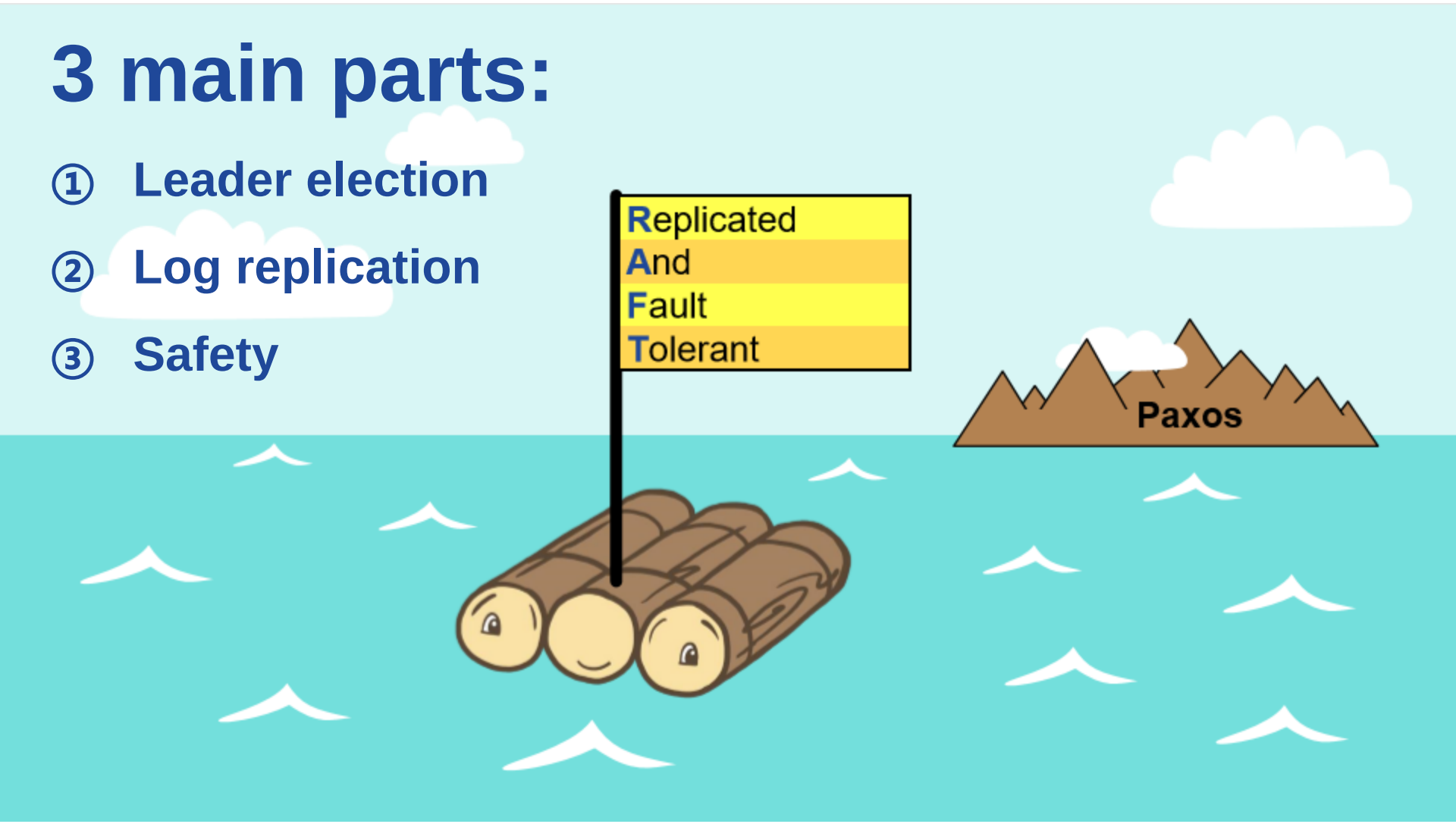
- **Named Raft**
- **Design for Understandability**
- **Define a better algorithm for building real systems**
  - Must be correct, complete, and perform well
  - Must also be understandable
- **Be easier to understand than Paxos**
  - Fundamentally different decomposition than Paxos
  - Less complexity

3 main parts:

① Leader election

② Log replication

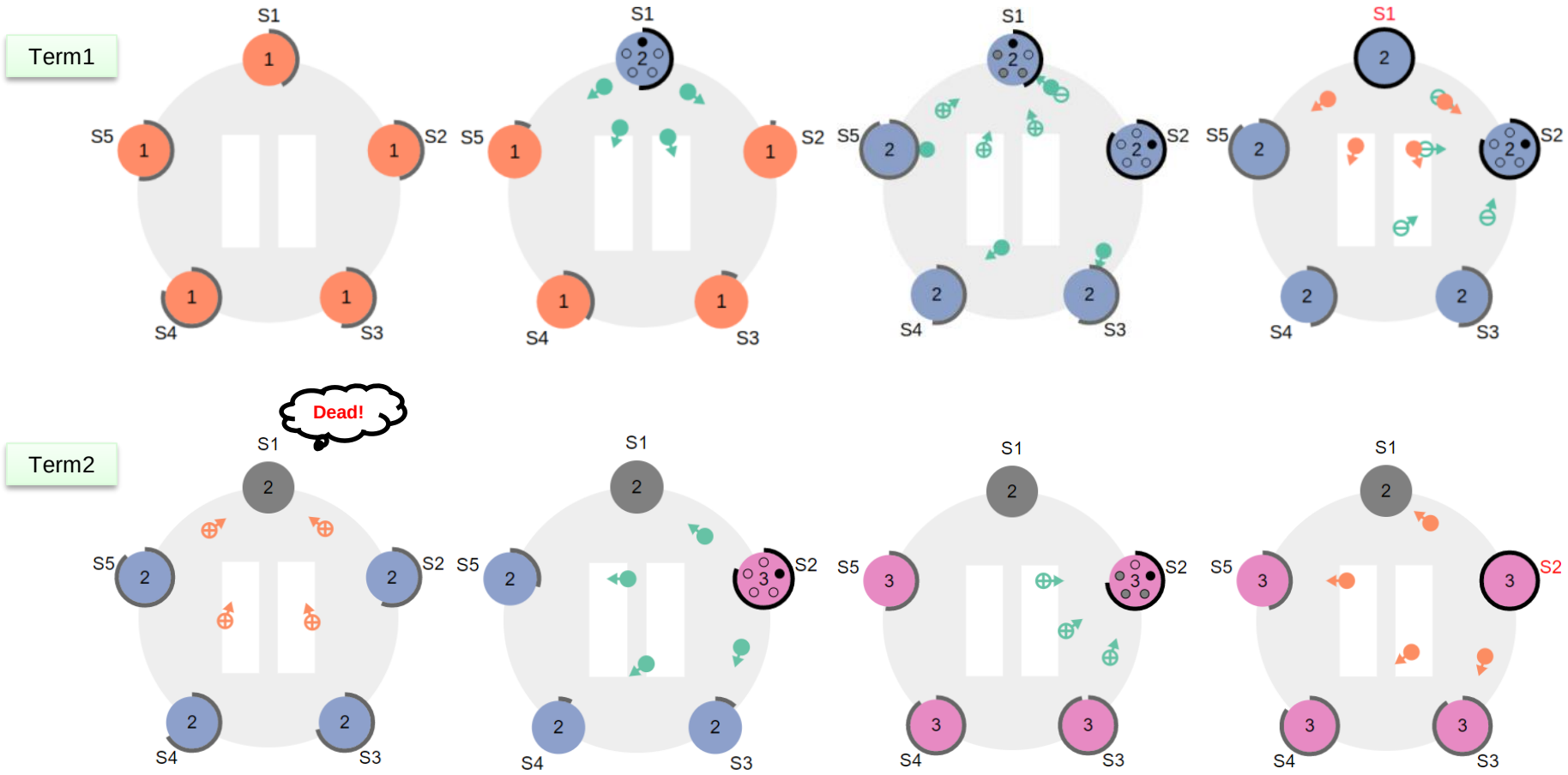
③ Safety



1. Leader election

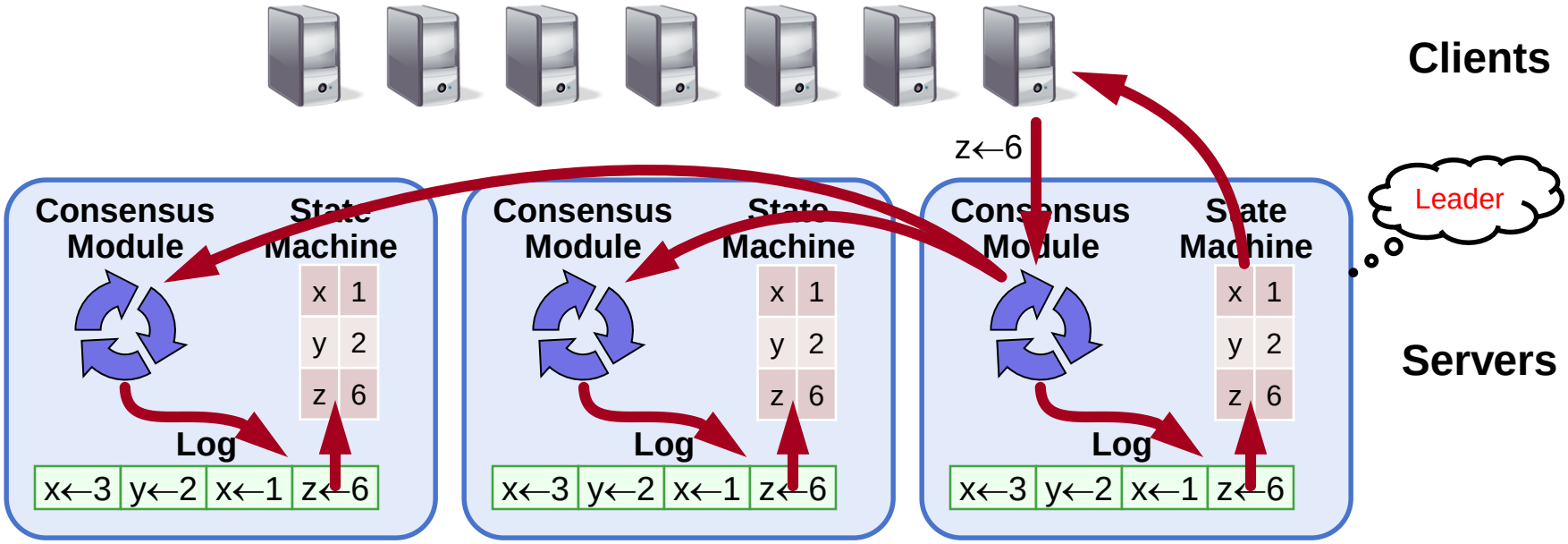
- **Select one of the servers to act as cluster leader**
- **If the leader is crashed, choose a new one**

$\geq \frac{1}{2}$ votes



2. Log replication

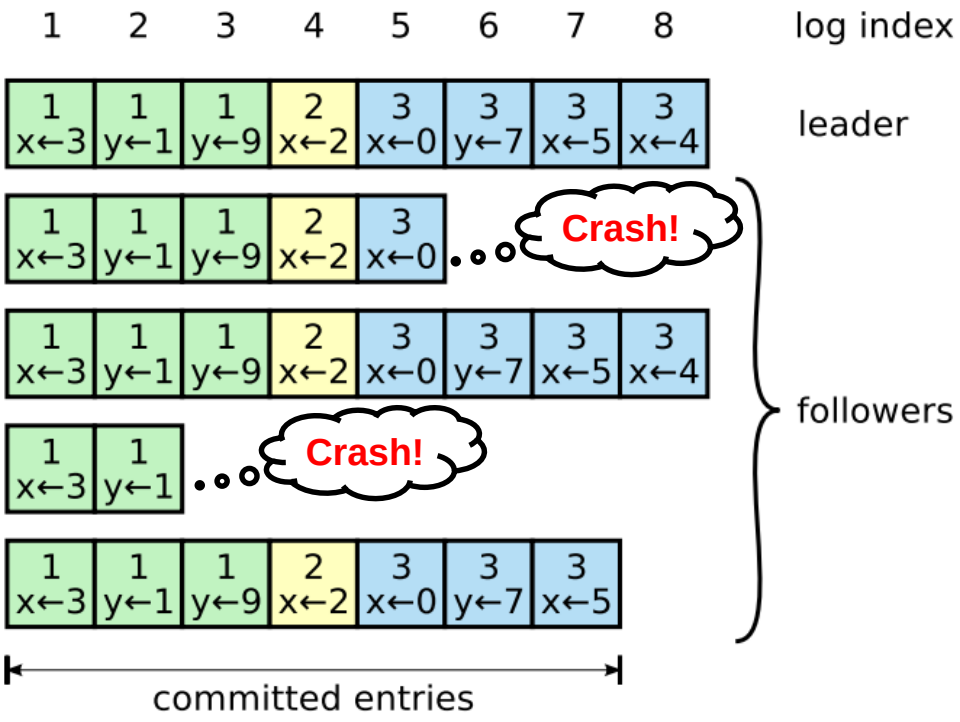
- **Replicated State Machines**



- **Replicated log ⇒ replicated state machine**
  - All servers execute same commands in same order
- **Consensus module ensures proper log replication**
- **Node crashes / Leader changes ⇒ replication may be wrong!**

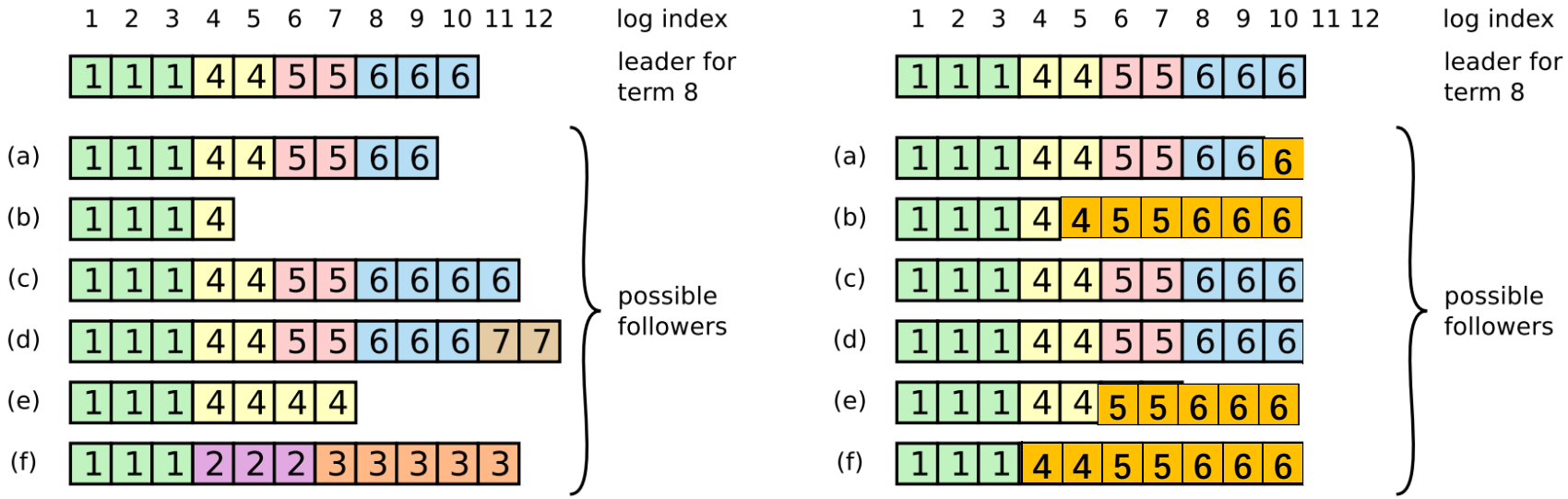
2. Log replication

- **Node crashes**
- **Safely replication**
  - More than half of nodes have replicated logs
  - then leader commits



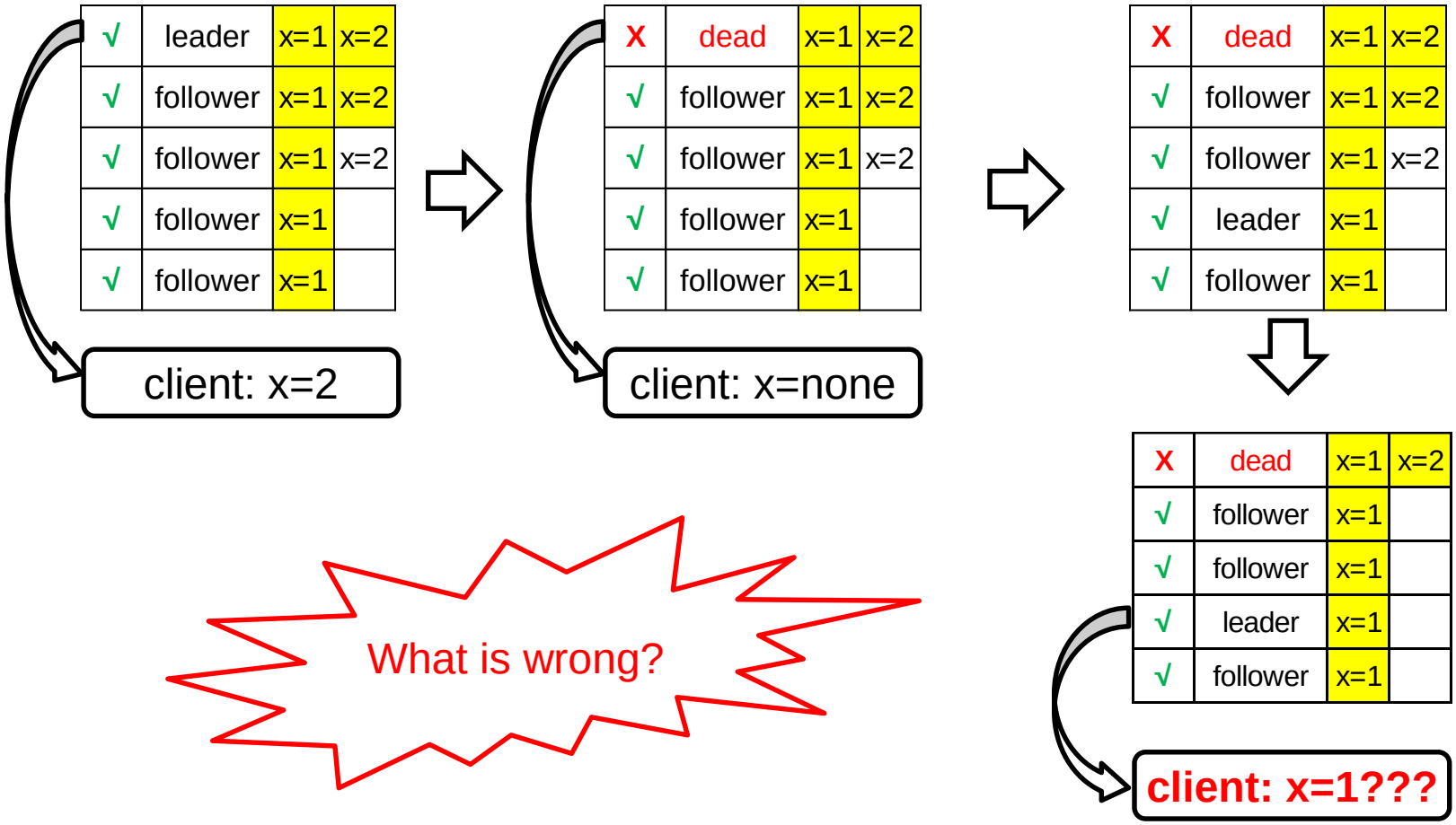
2. Log replication

- **Leader changes**
- **Find the last common log from the end to the front**
- **Force followers to replicate different logs!**



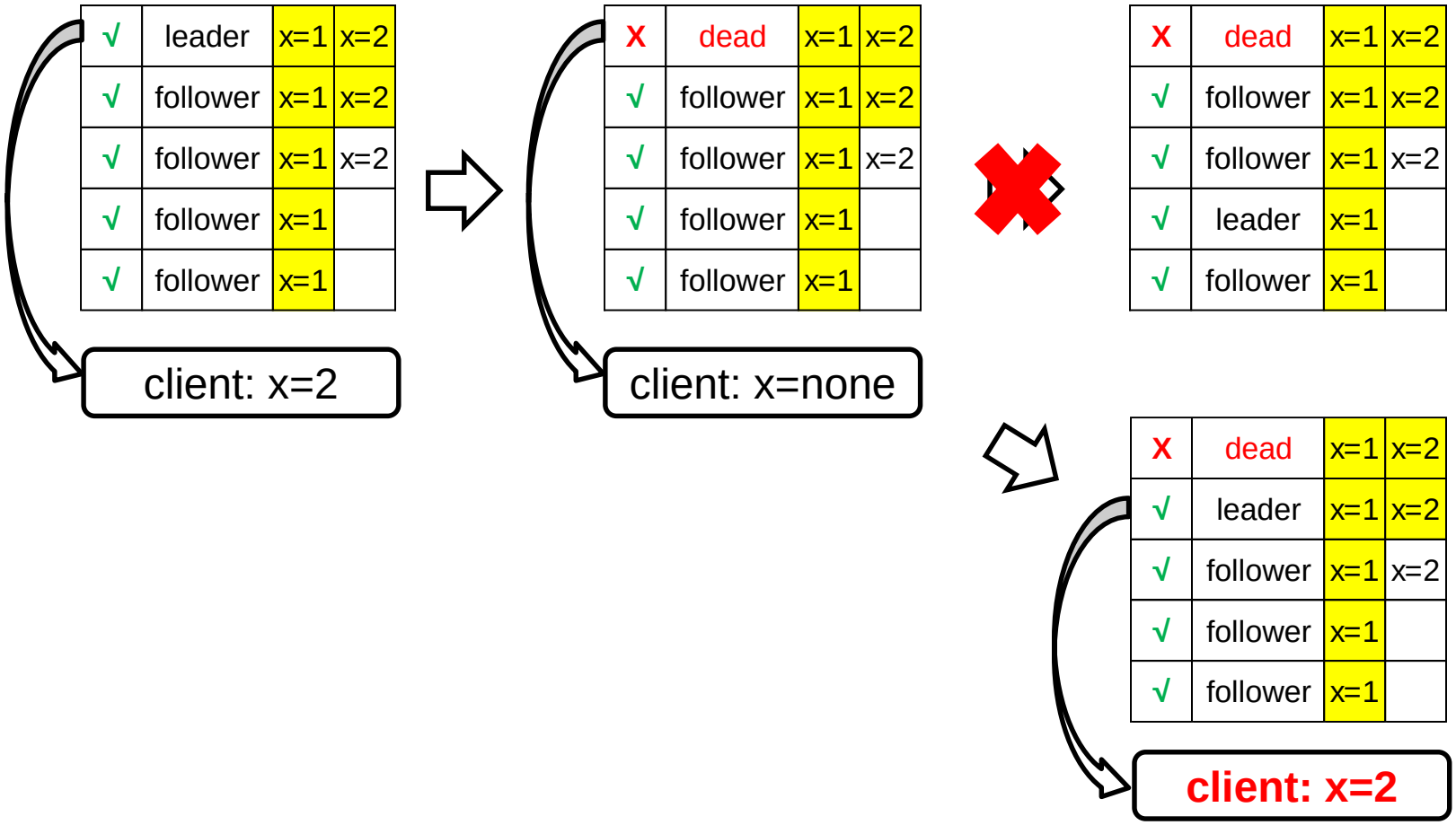
3. Safety

- **Hidden error of execute**
  - each node executes the same commands in the same order?



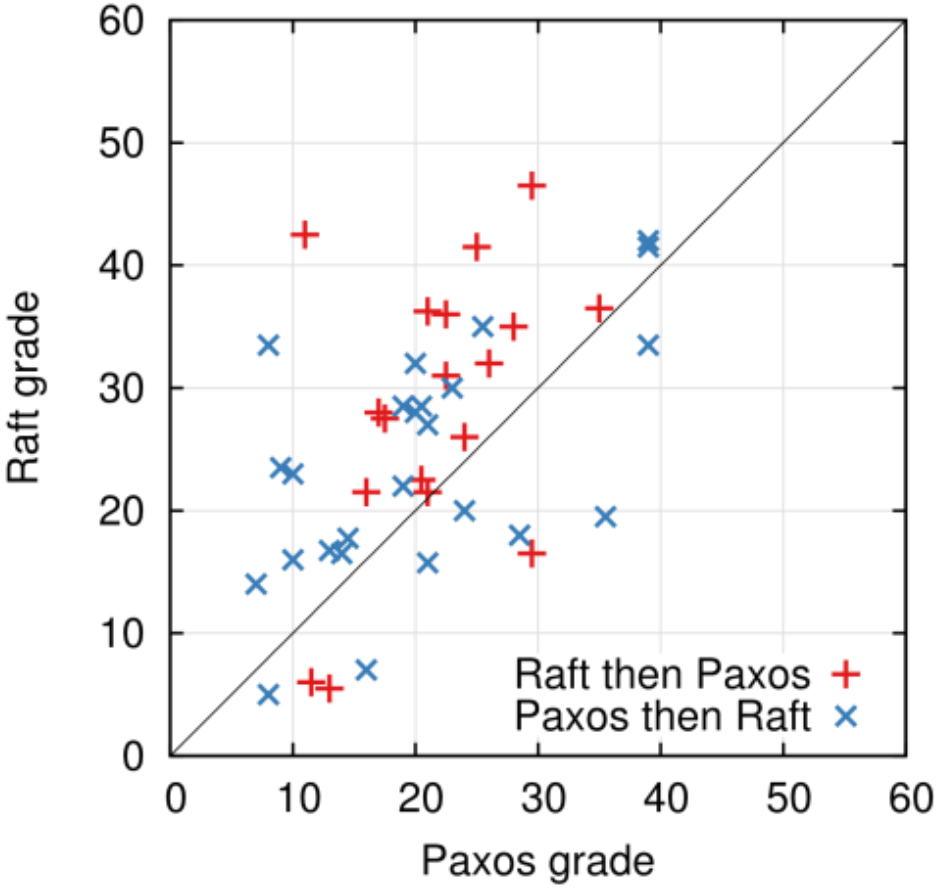
3. Safety

- **Node with <u>smaller committed log number</u> cannot be elected as leader**

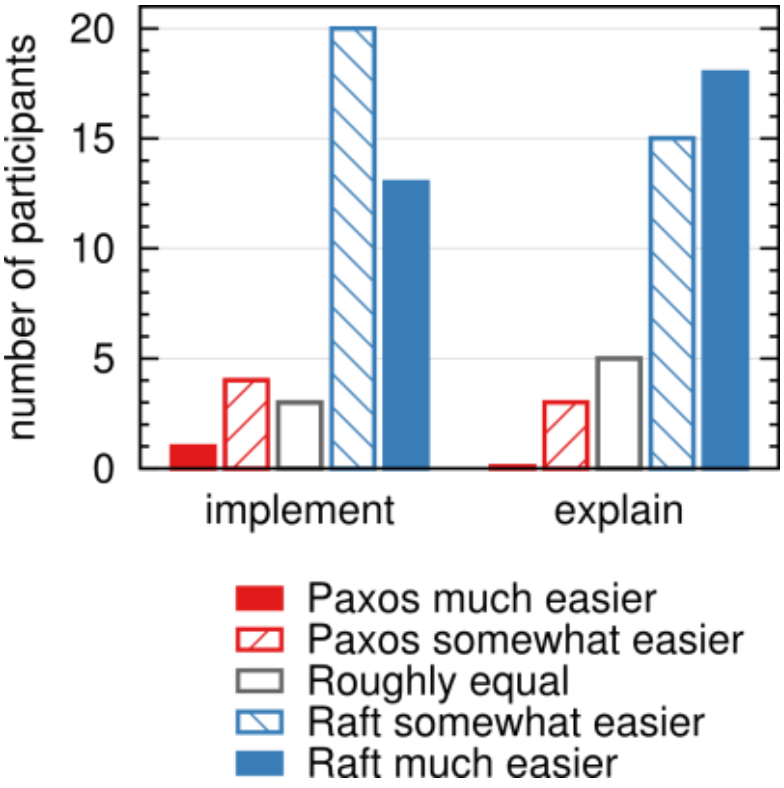


Result: Raft User Study

Quiz Grades

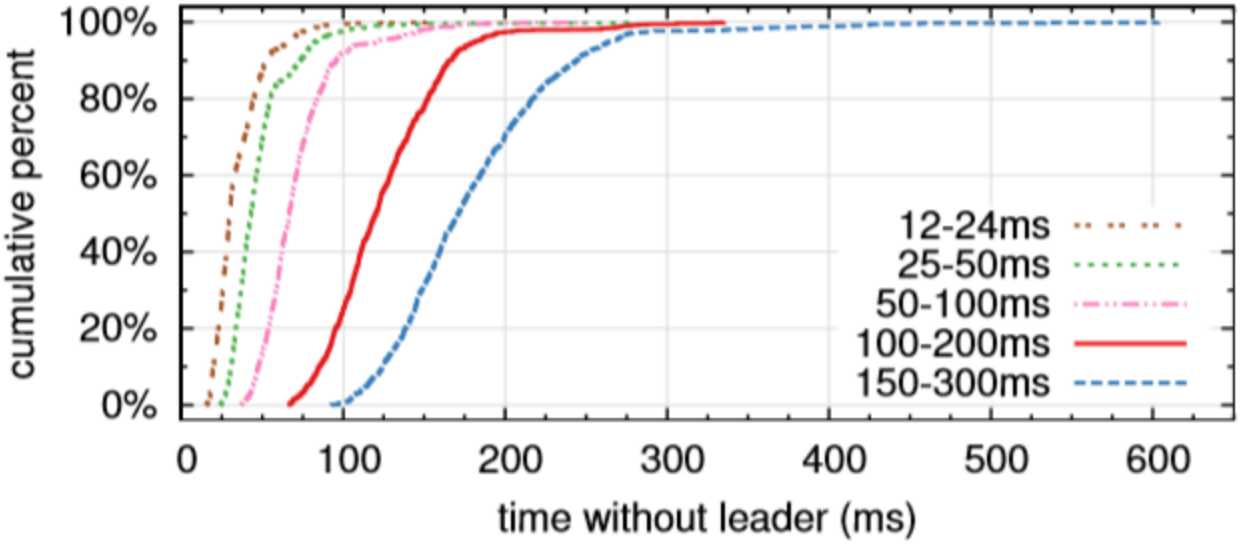


Survey Results



Result: Performance

- **The time to detect and replace a crashed leader.**
- **“x-y ms” means election timeout.**
  - Downtime can be reduced by reducing the election timeout.



- **Recommendation**
  - Use a conservative election timeout such as 150–300ms
  - Avoid unnecessary leader changes

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Questions