BLOCKCHAINS

ARCHITECTURE, DESIGN AND USE CASES

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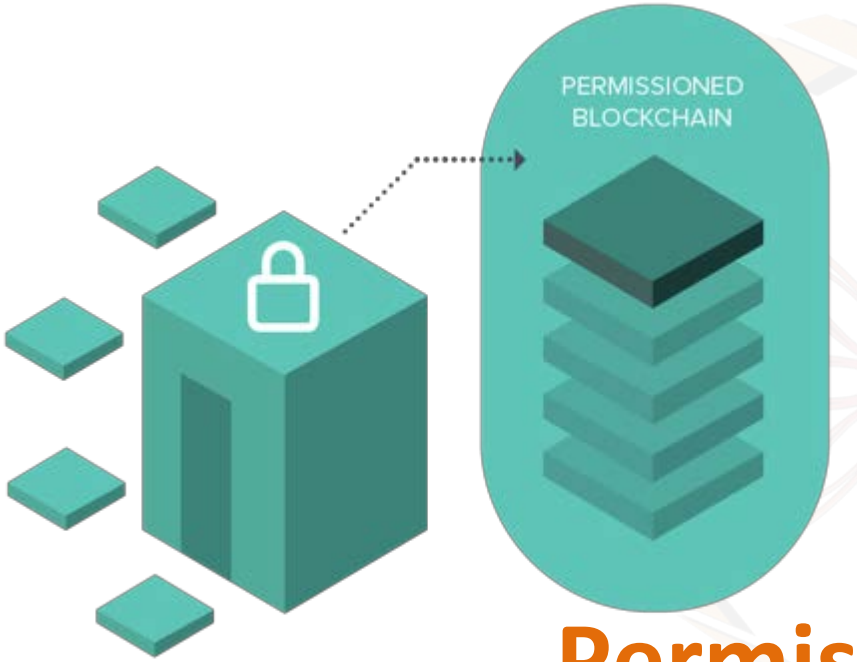


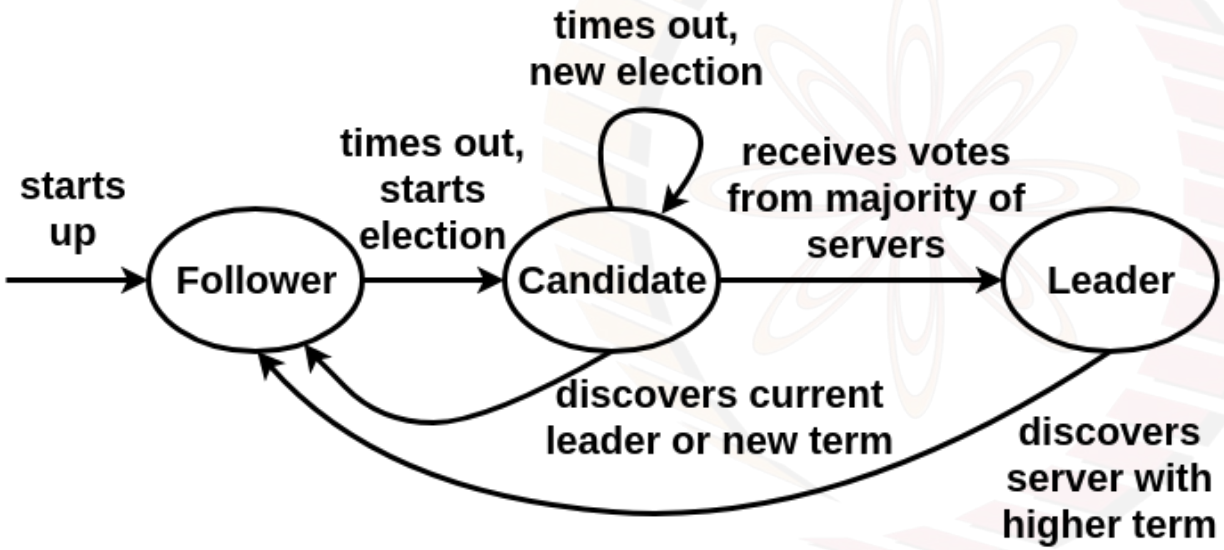
Image Source: https://nem.io/enterprise/

Permissioned Blockchain - III
Consensus Algorithms

RAFT Consensus

- Designed as an alternative to Paxos
- A generic way to distribute a state machine among a set of servers
  - Ensures that every server agrees upon same series of state transitions
- Basic idea -
  - The nodes collectively selects a *leader*; others become *followers*
  - The leader is responsible for state transition log replication across the followers

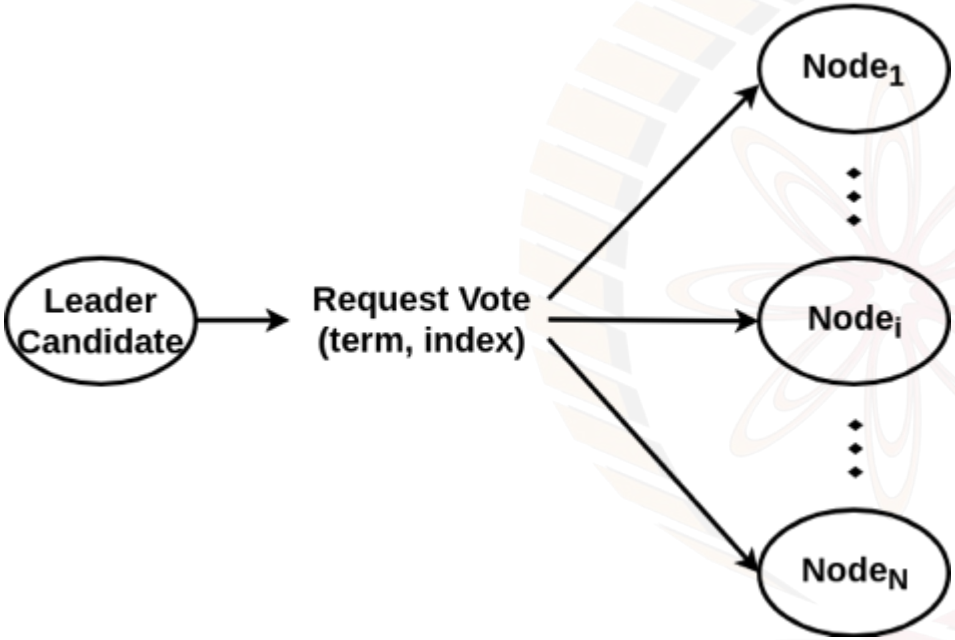
RAFT



- (re)electing a leader
- committing multiple values to the transaction log
- dealing with replicas failing

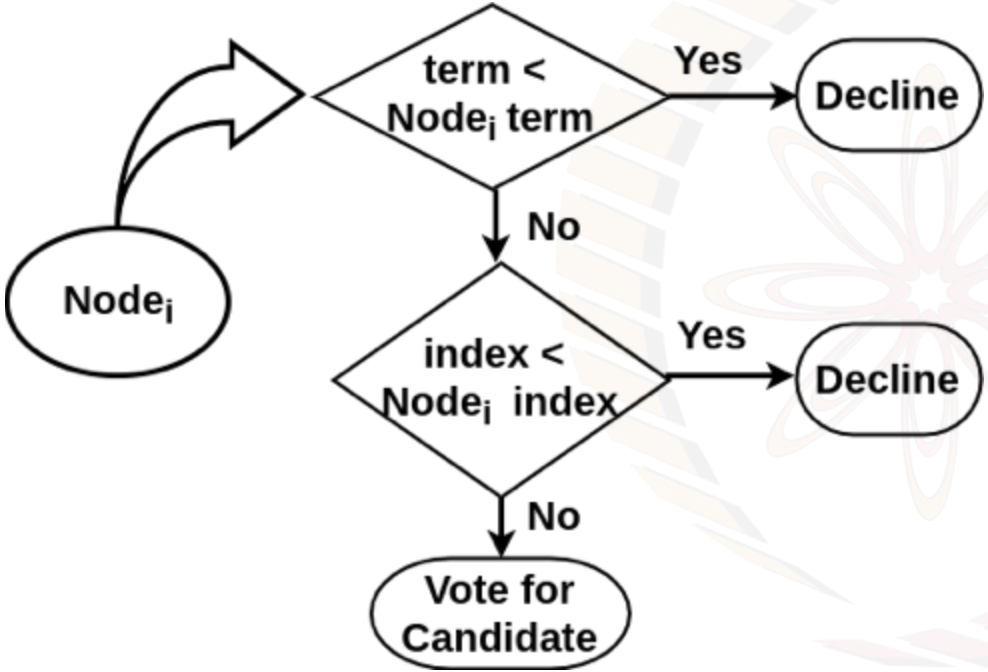
Source: Diego Ongaro and John Ousterhout, In Search of an Understandable Consensus Algorithm, Stanford University, February 22, 2014.

Electing the Leader: Voting Request



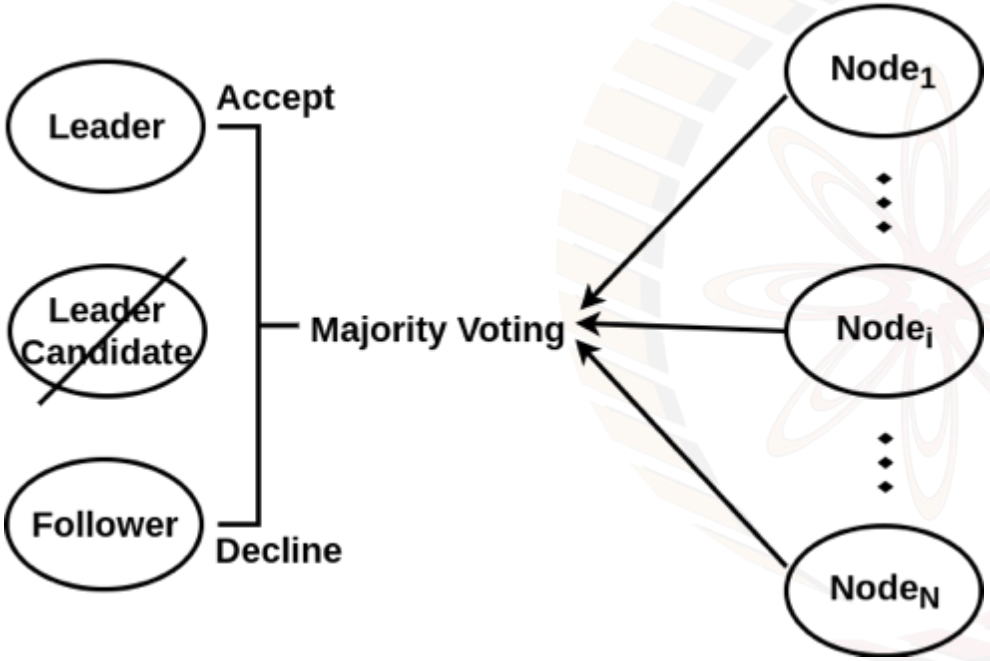
- **term:** last calculated # known to candidate + 1
- **index:** committed transaction available to the candidate

Electing the leader: Follower Node's Decision Making



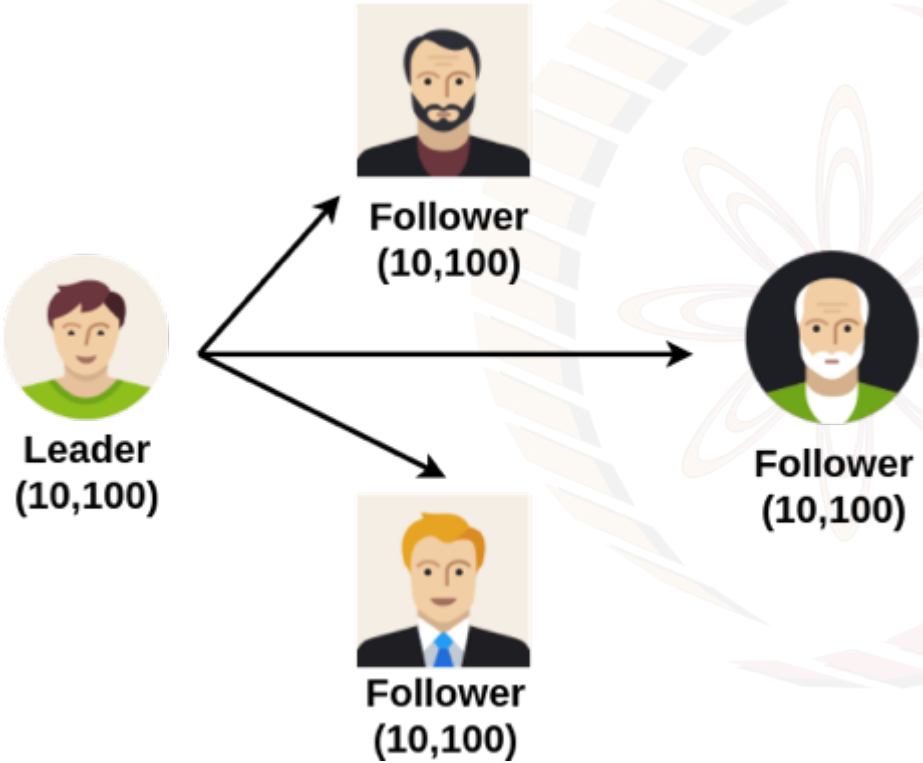
- Each node compares received term and index with corresponding current known values

Electing the leader: Majority Voting



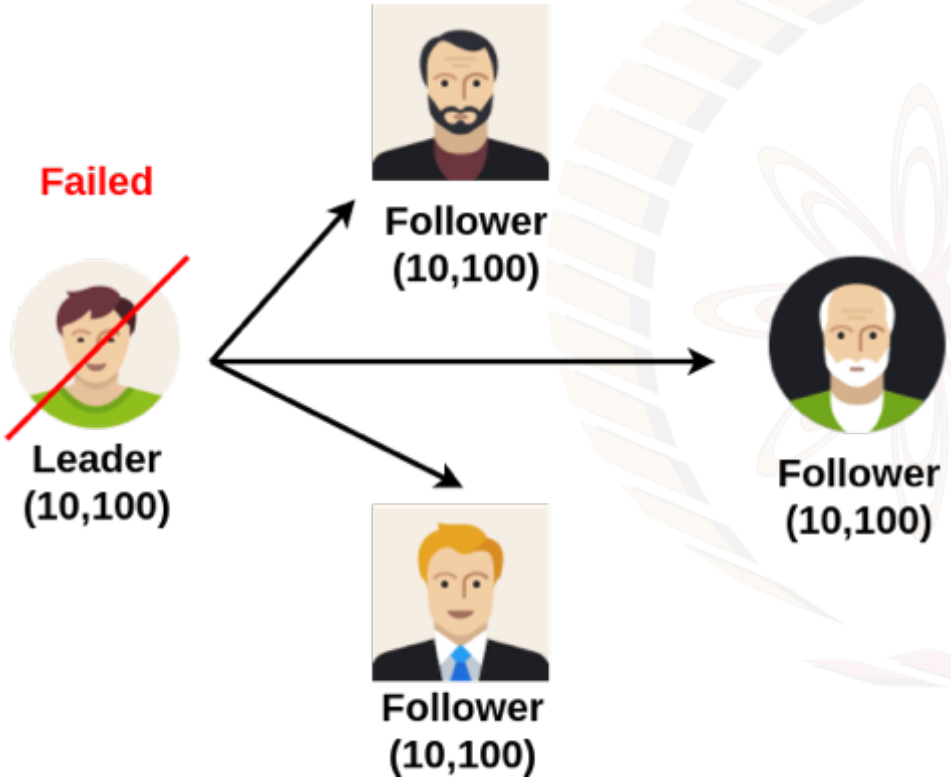
- Use of Majority voting
  - leader selection
  - commit the log entry

Multiple Leader Candidates: Current Leader Failure



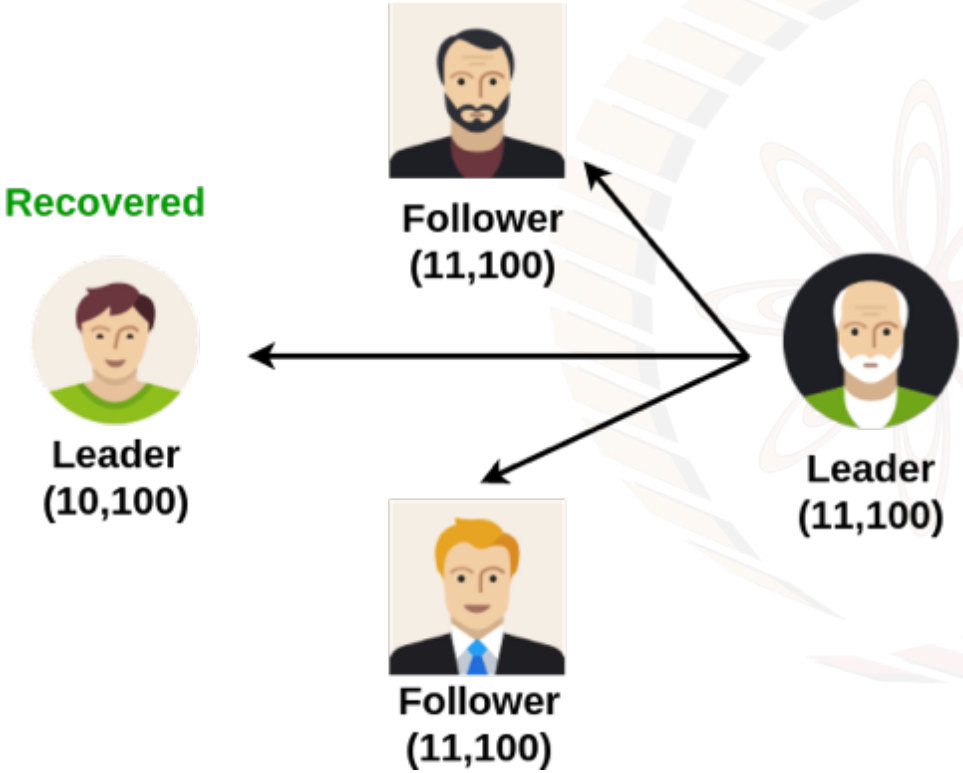
- A leader with three followers
- term: 10
- commit index: 100

Multiple Leader Candidates: Current Leader Failure



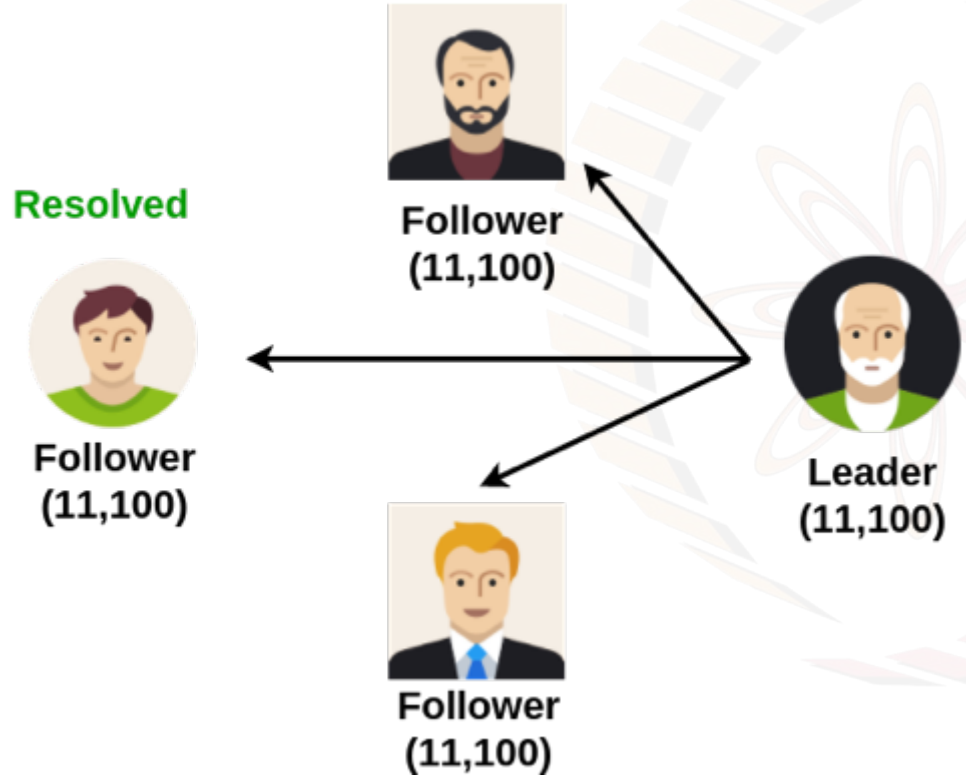
- The leader node failed

Multiple Leader Candidates: Current Leader Failure



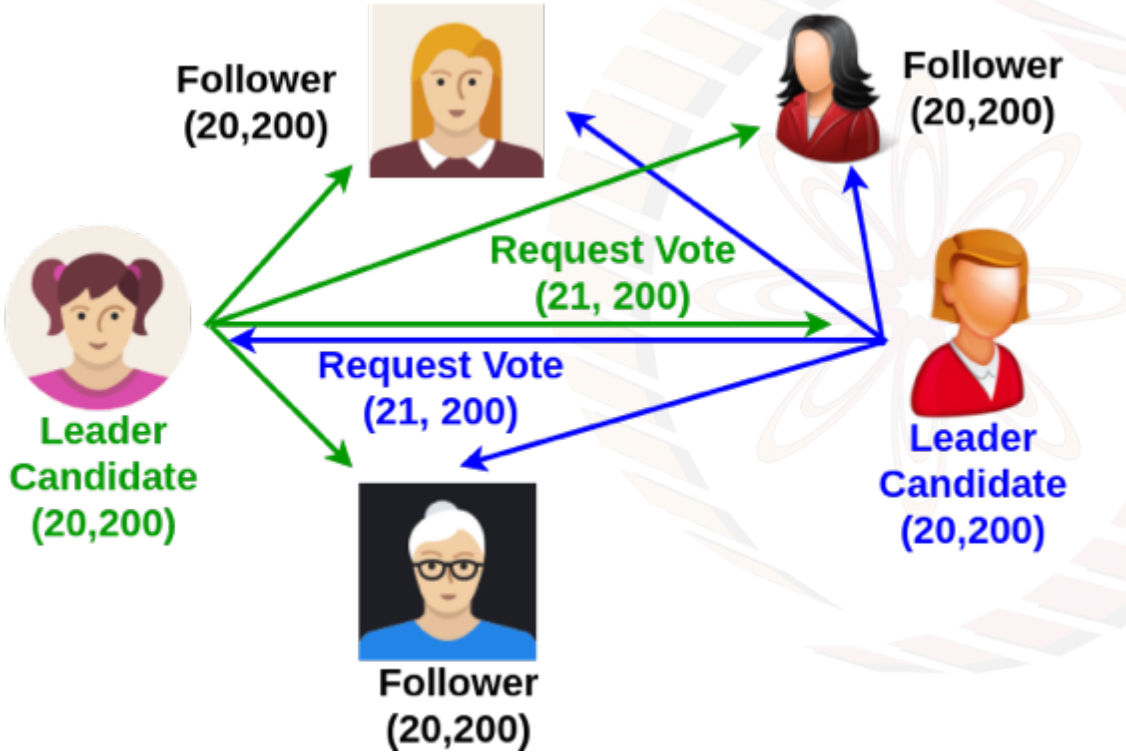
- New leader elected with term 11
- Old leader recovered

Multiple Leader Candidates: Current Leader Failure



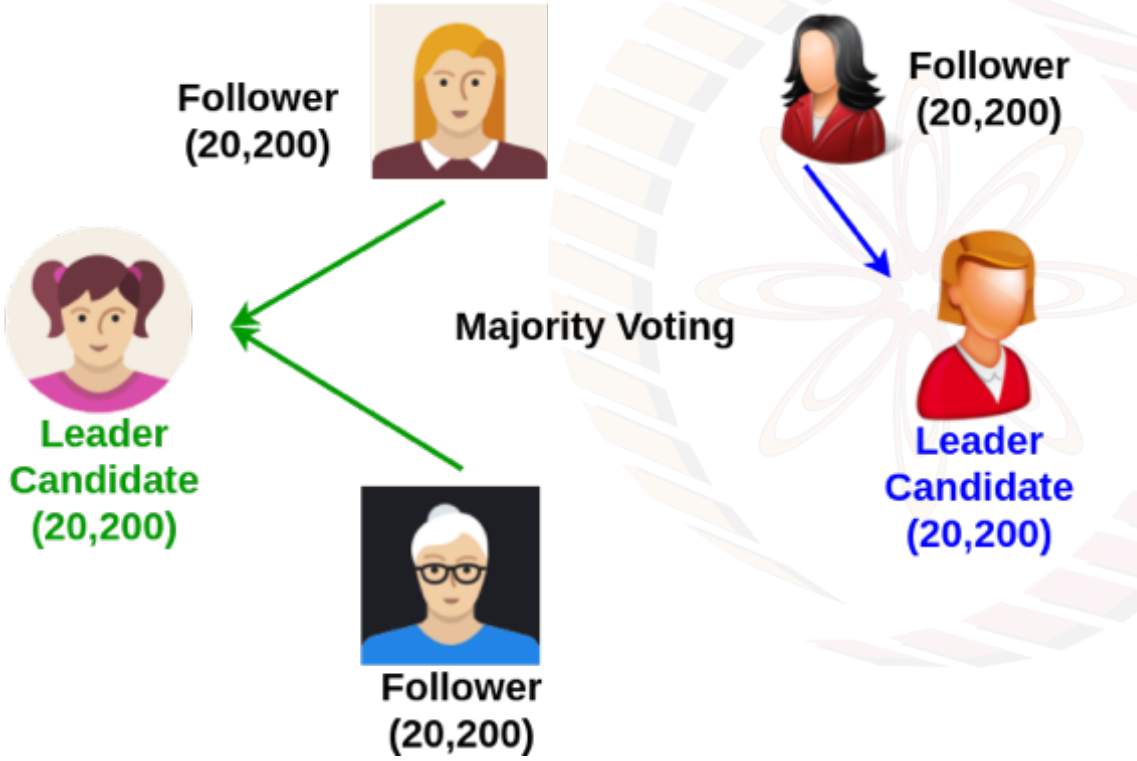
- Old leader receive heartbeat message from new leader with greater term
- Old leader drops to follower state

Multiple Leader Candidates: Simultaneous Request Vote



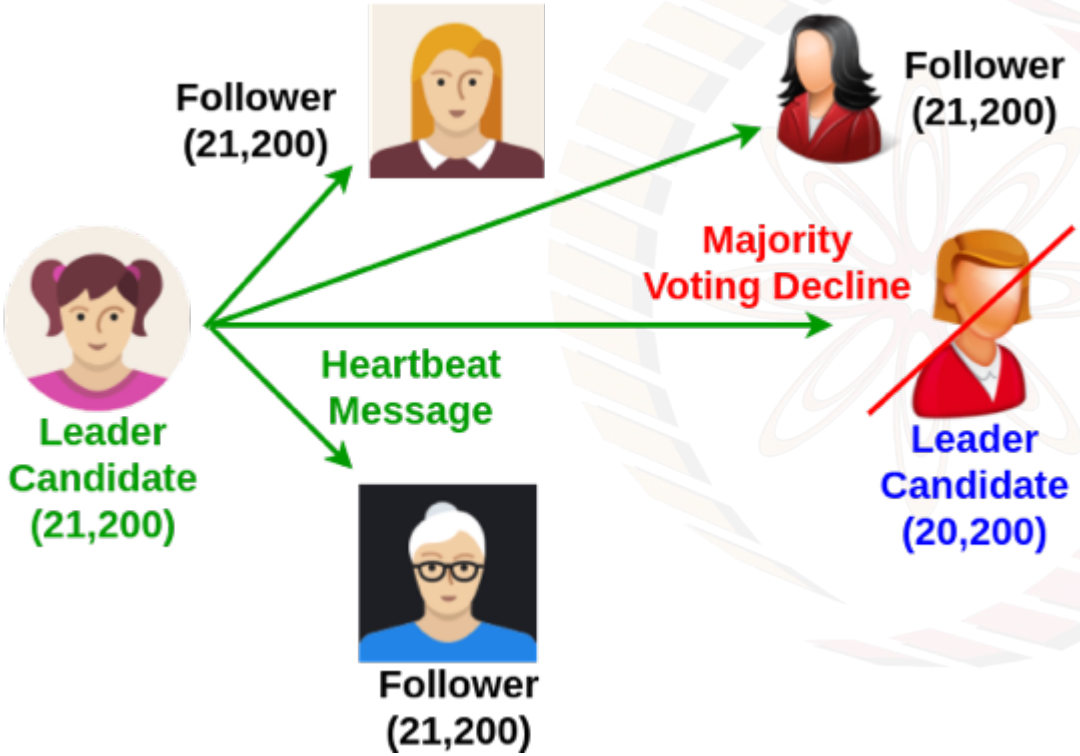
- Two nodes send Request vote message with term 21 at the same time

Multiple Leader Candidates: Simultaneous Request Vote



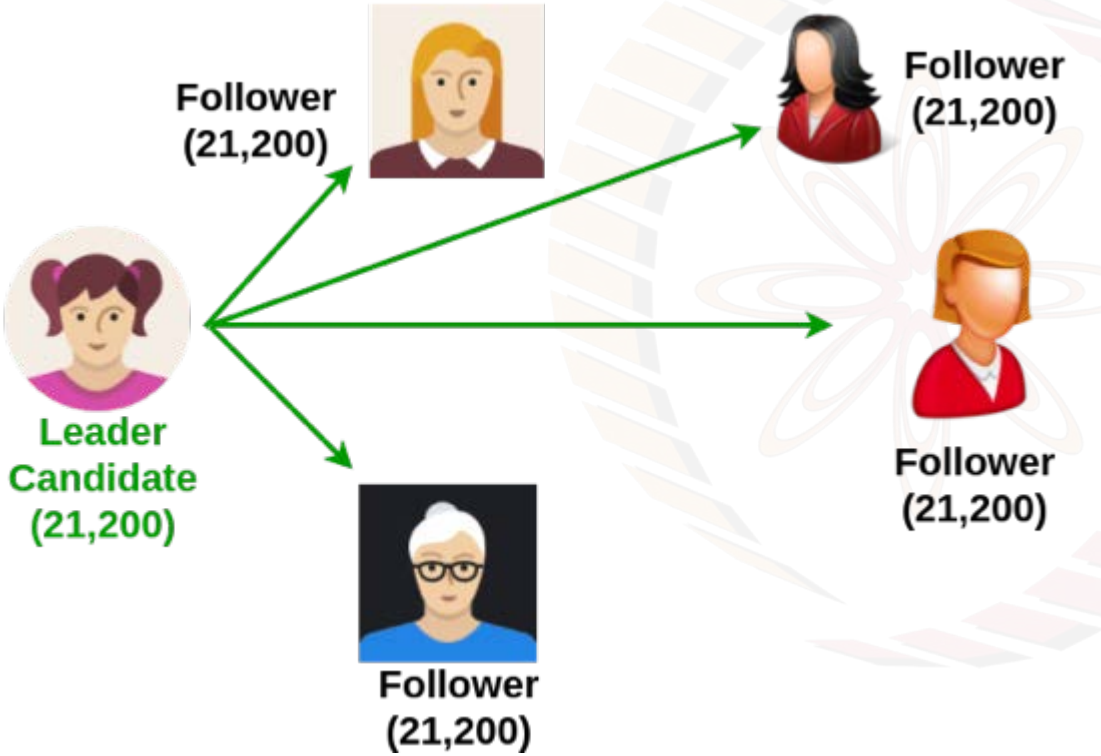
- One of them gets majority voting

Multiple Leader Candidates: Simultaneous Request Vote



- Winner sends heartbeat message

Multiple Leader Candidates: Simultaneous Request Vote



- Other leader candidate switches to follower state

Commiting Entry Log

Follower
(10,100)

Leader
(10,100)

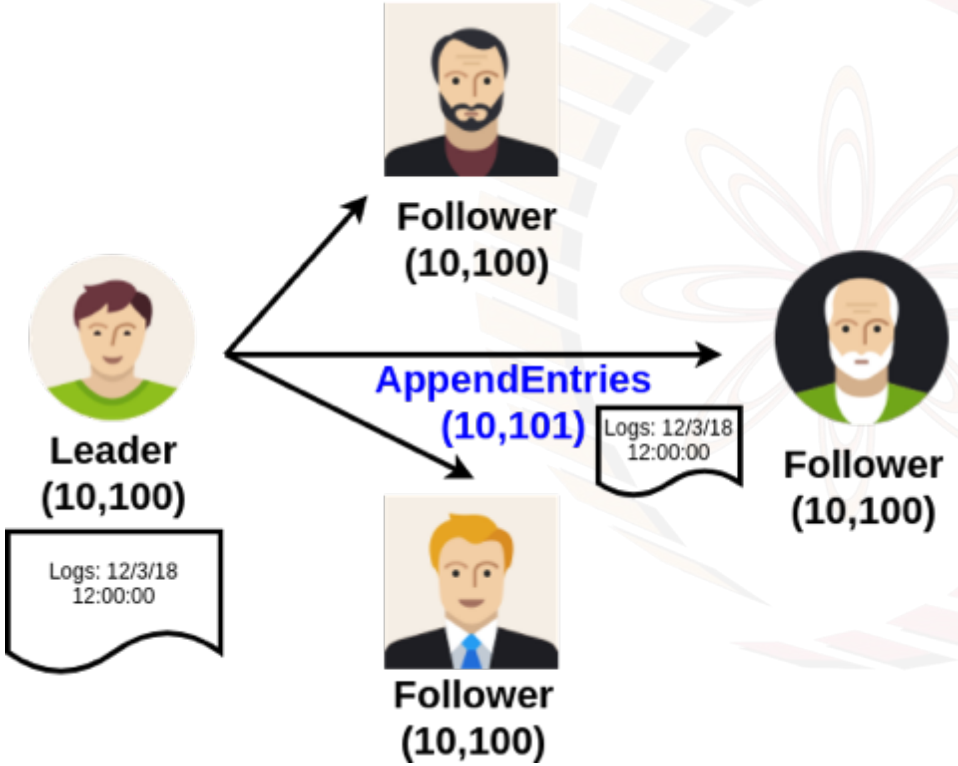
Logs: 12/3/18
12:00:00

Follower
(10,100)

Follower
(10,100)

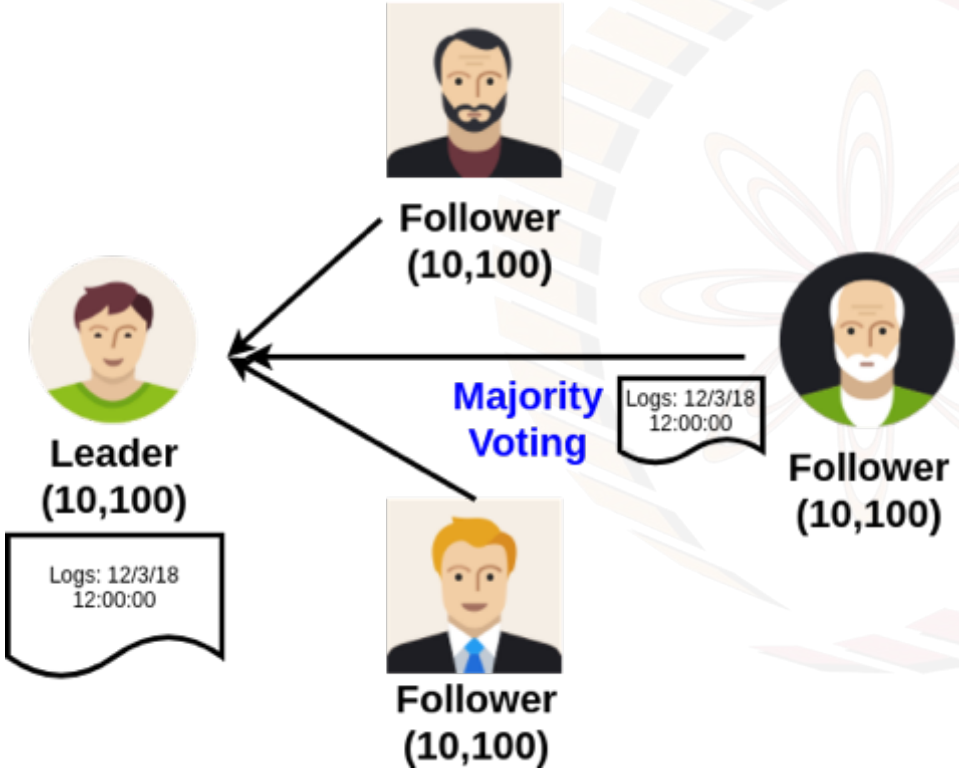
- Leader adds entry to log with term 10 and index 101

Commiting Entry Log



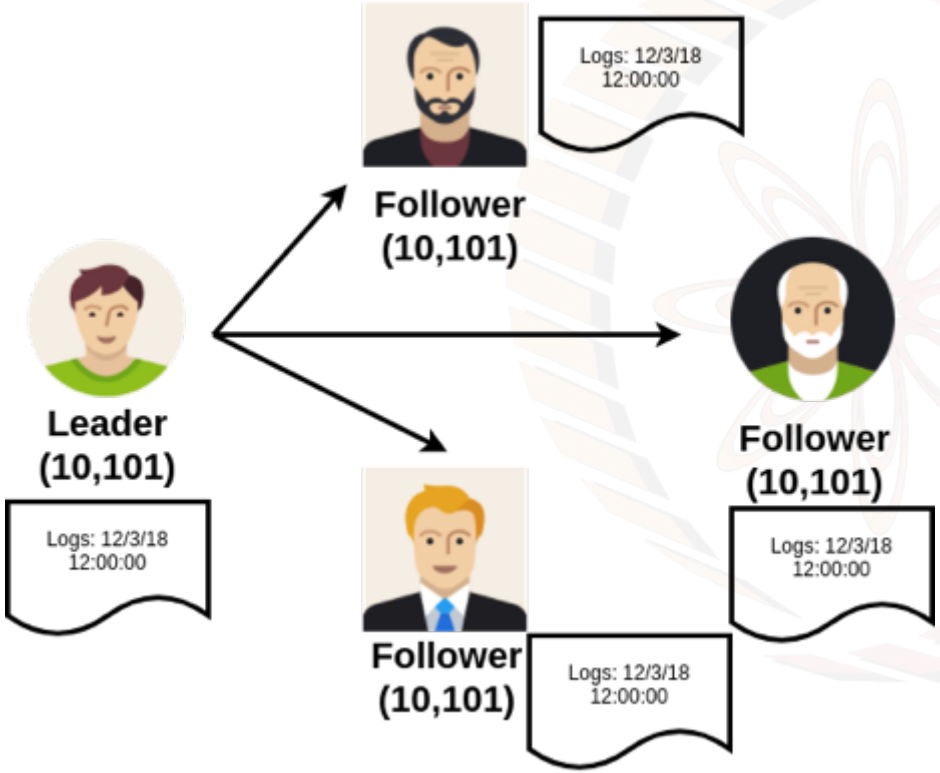
- Leader sends *AppendEntries* message to followers with index 101

Commiting Entry Log



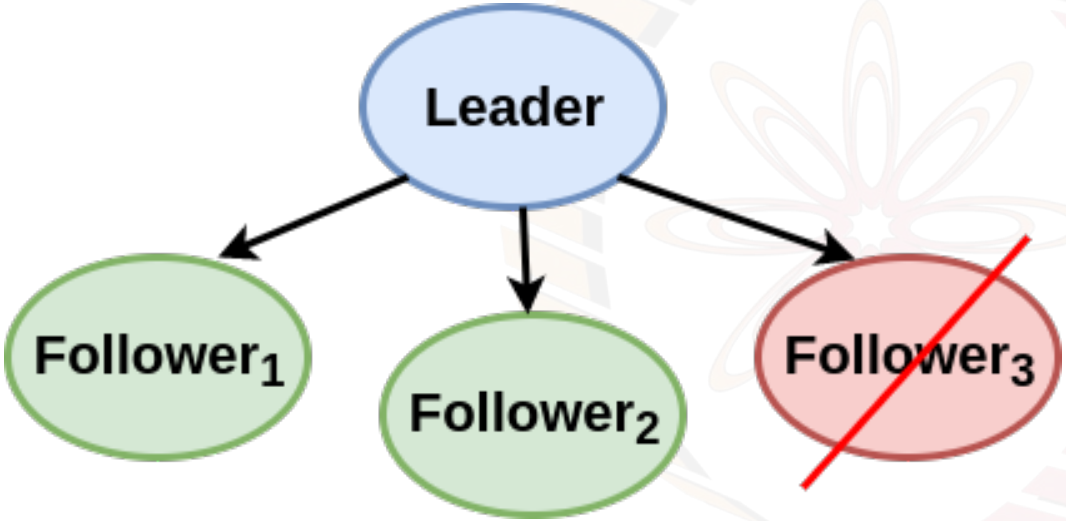
- Majority voting decides to accept or reject the entry log

Commiting Entry Log



- Successfully accept entry log
  - All leader and followers update committed index to 101

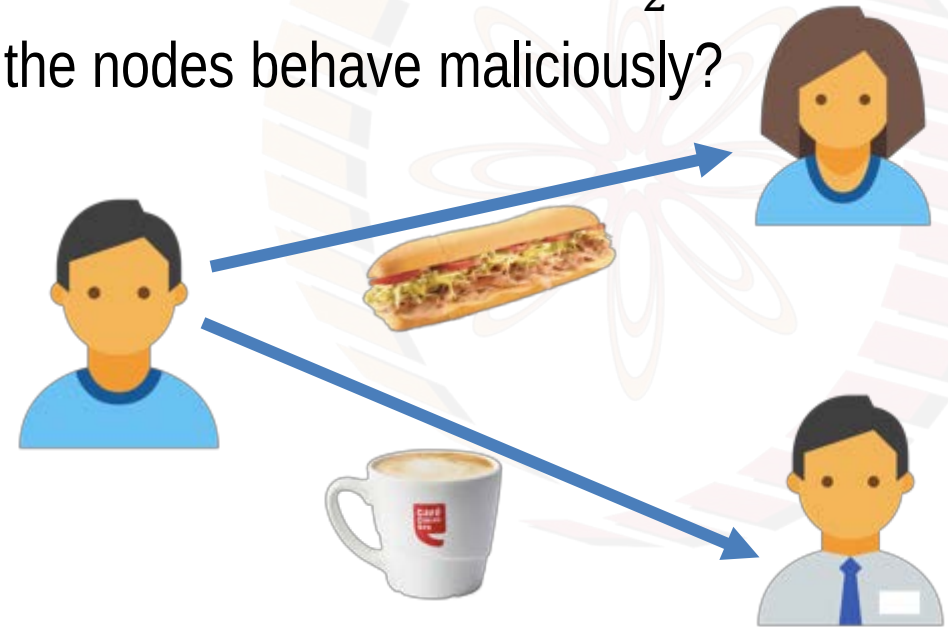
Handling Failure



- Failure of up to N/2 - 1 nodes does not affect the system due to majority voting

Byzantine Generals Problem

- Paxos and Raft can tolerate up to $\frac{N}{2} - 1$ number of crash faults
- What if the nodes behave maliciously?



Byzantine Generals Problem

Attack

Attack

Byzantine Generals Problem

Retreat

Retreat

Byzantine Generals Problem

Attack

Retreat


thank you!