



## **NPTEL ONLINE CERTIFICATION COURSES**

### **Blockchain and its applications Prof. Sandip Chakraborty**

**Department of Computer Science &  
Engineering  
Indian Institute of Technology Kharagpur  
Lecture 28: Paxos**

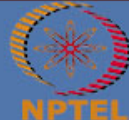
## CONCEPTS COVERED

- Paxos – CFT Consensus

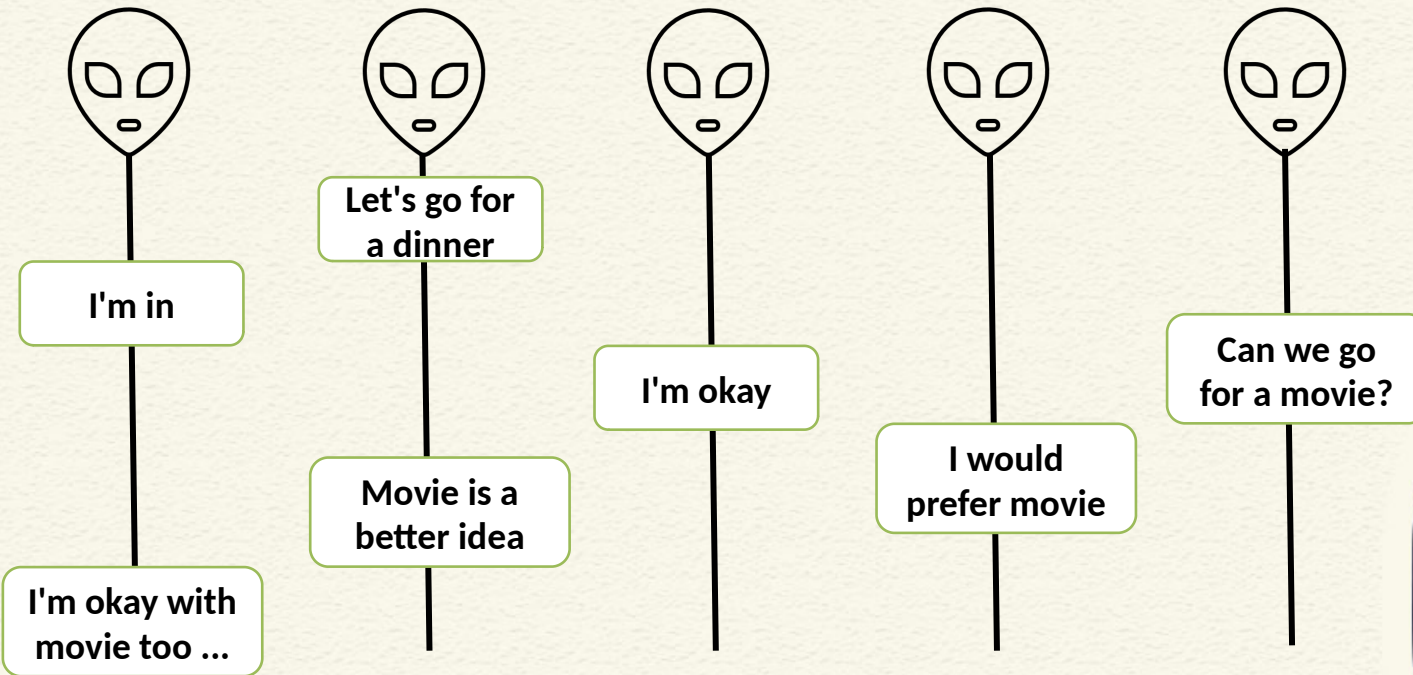


# KEYWORDS

- Paxos
- CFT



# Paxos – The Roles of Individuals





# Paxos – The Roles of Individuals

Proposer

Let's go for  
a dinner

Movie is a  
better idea

Proposer

Can we go  
for a movie?

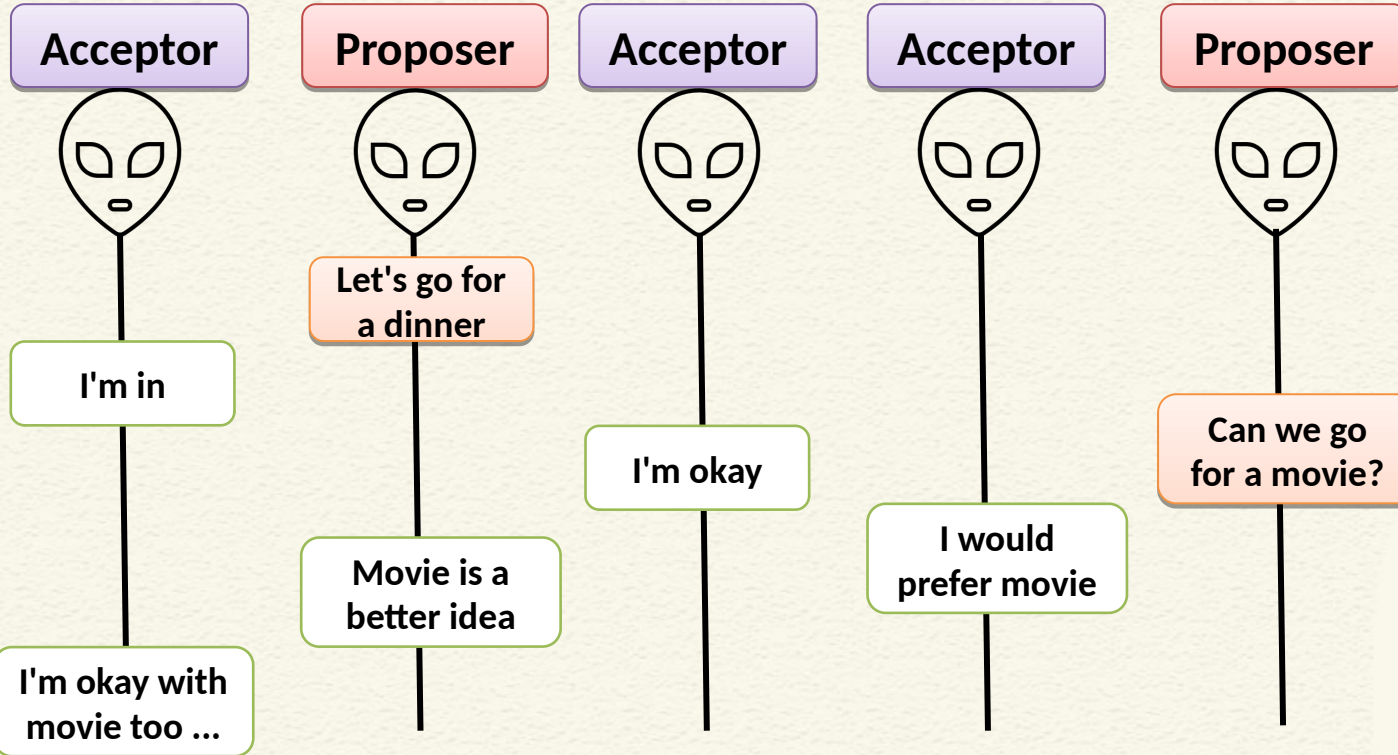
I'm in

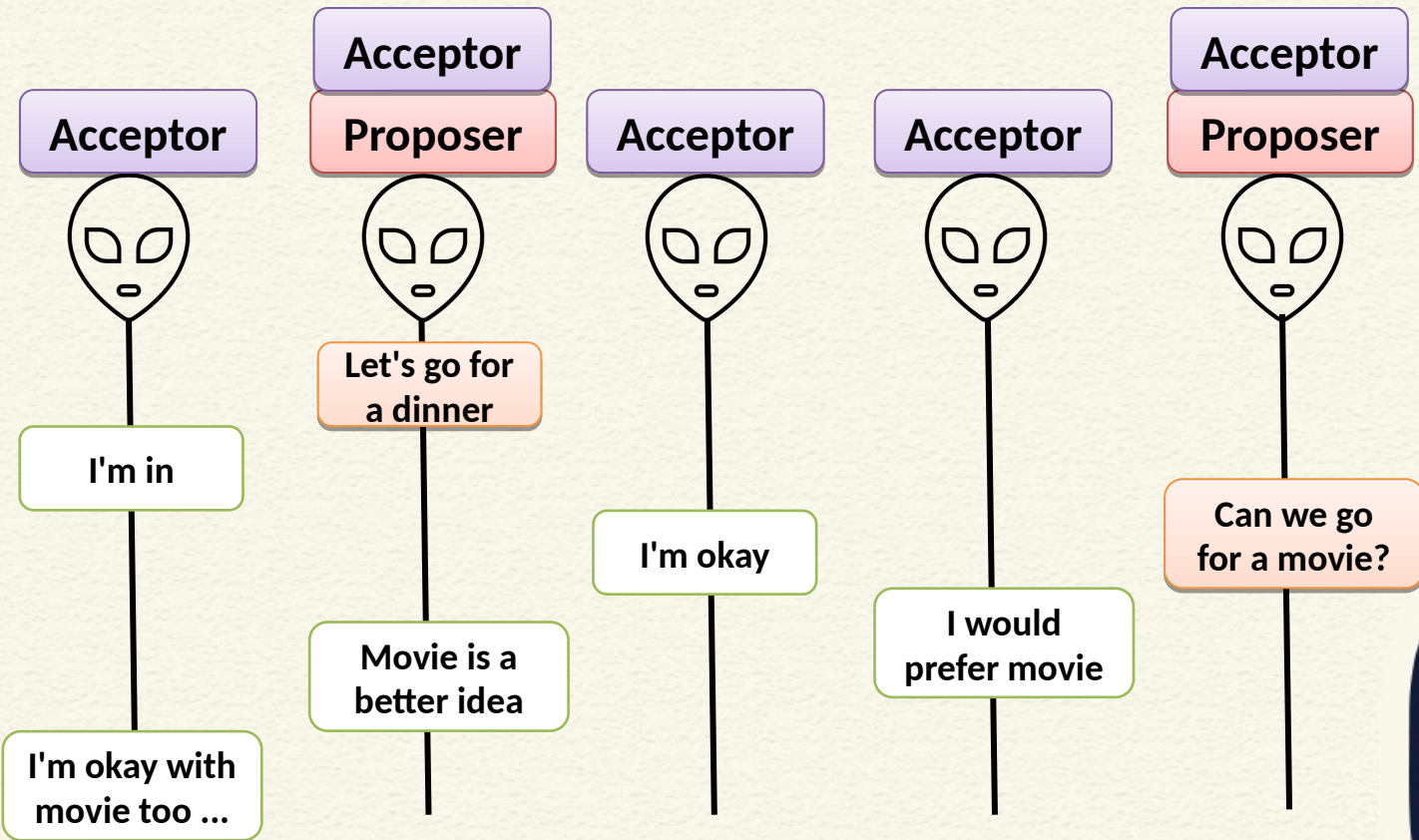
I'm okay

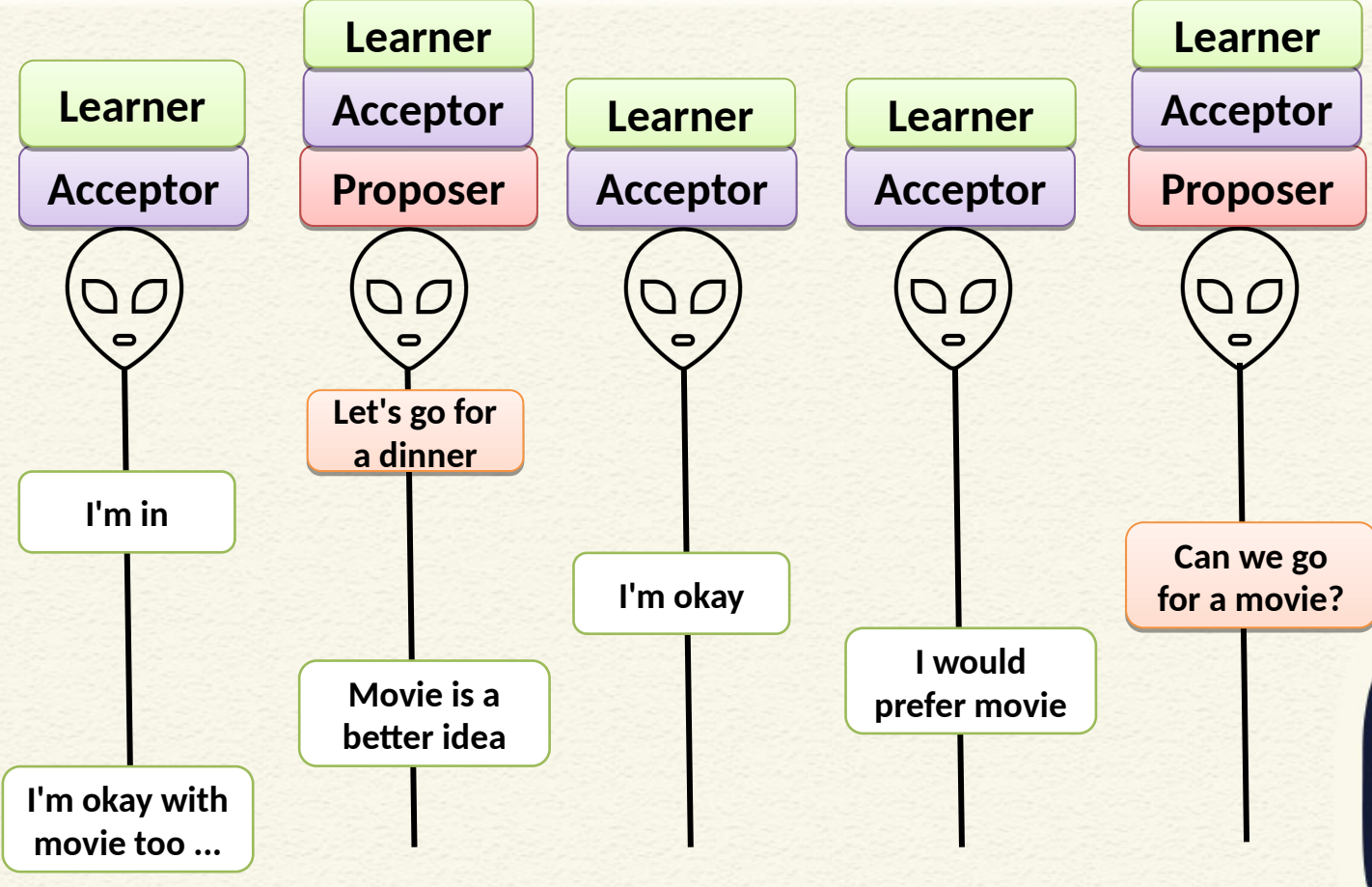
I would  
prefer movie

I'm okay with  
movie too ...

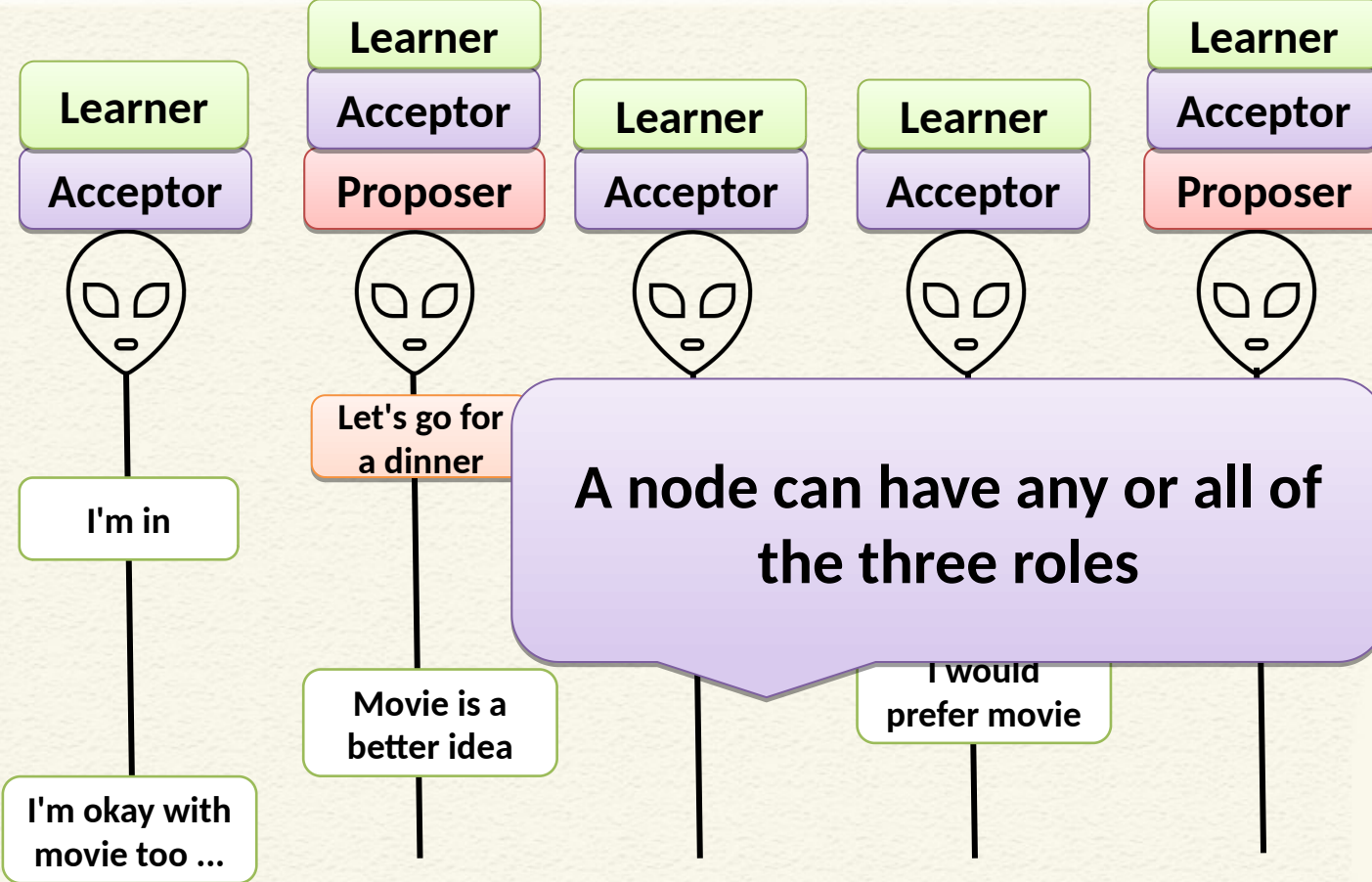
# Paxos – The Roles of Individuals

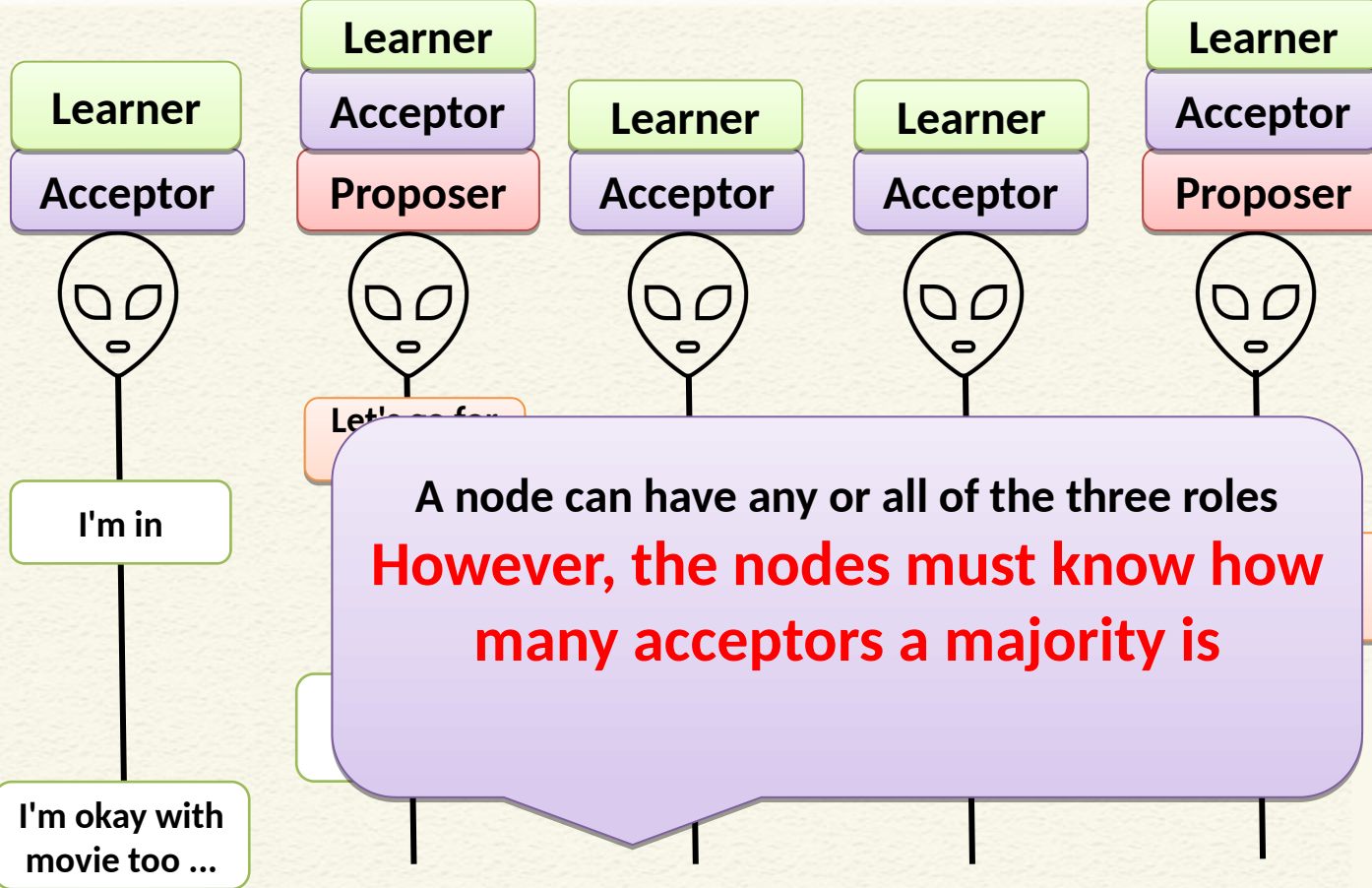


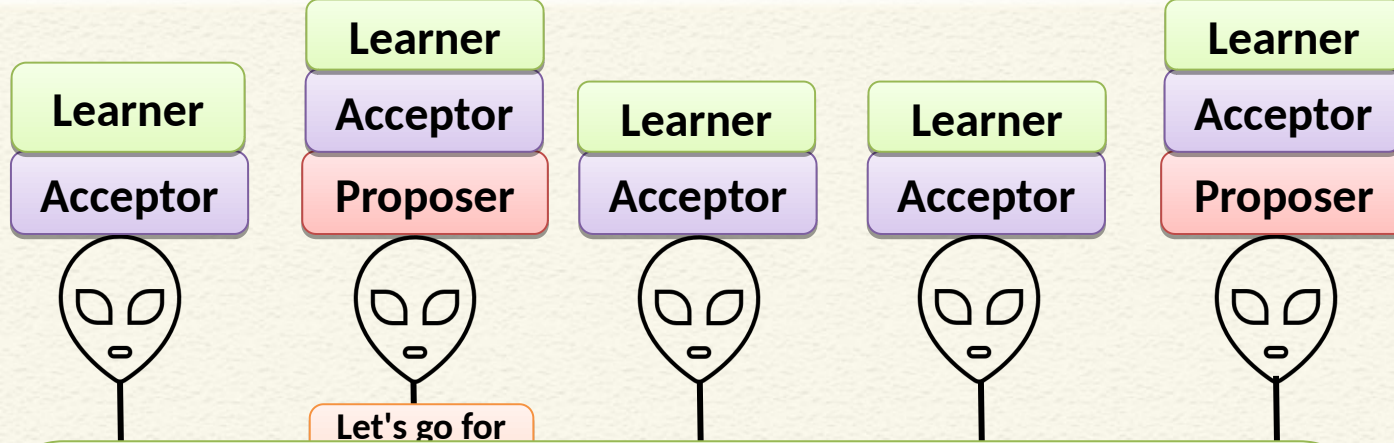












**Two majorities will always overlap in  
at least one nodes**

5 acceptors, majority = 3,

2 proposers:

To accept based on majority voting, at least one acceptor  
need to choose between one of the two proposals

# Paxos Basics

- Paxos is based on state-machine replication
  - Proposers and Acceptors maintain a state of the running epochs
  - Uses a variable  $ID_p$  where  $p$  is an epoch number – maintains the state
- A Paxos run aims at reaching a **single consensus**
  - Once a consensus is reached, Paxos cannot progress to another consensus
  - To reach multiple consensus, you need to run Paxos in rounds (Multi-Paxos)





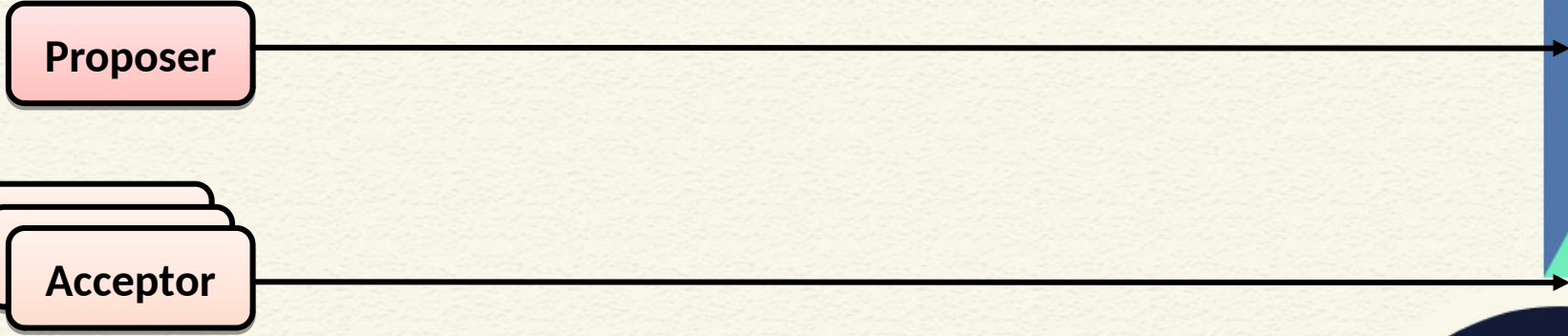
# Paxos Algorithm

Proposer

Acceptor

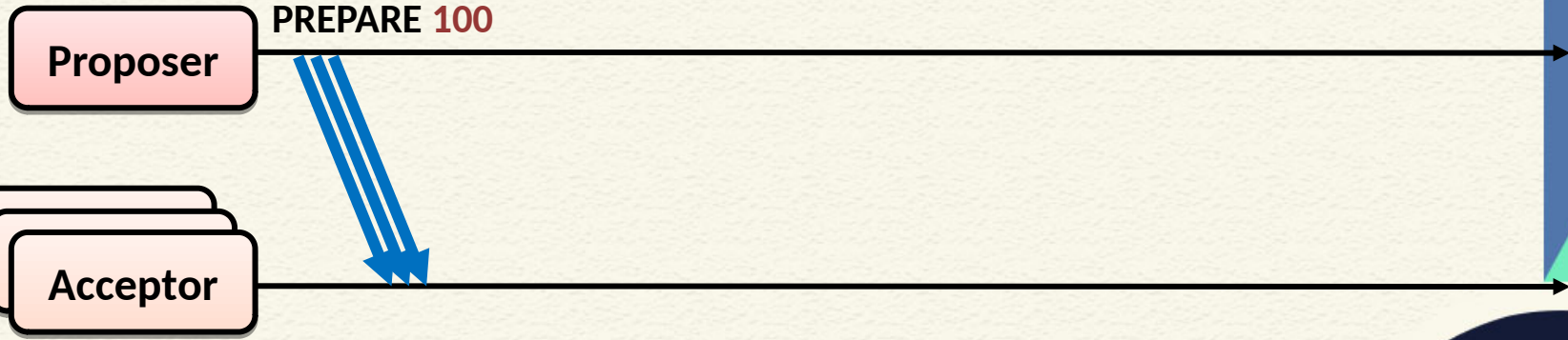


# Paxos Algorithm



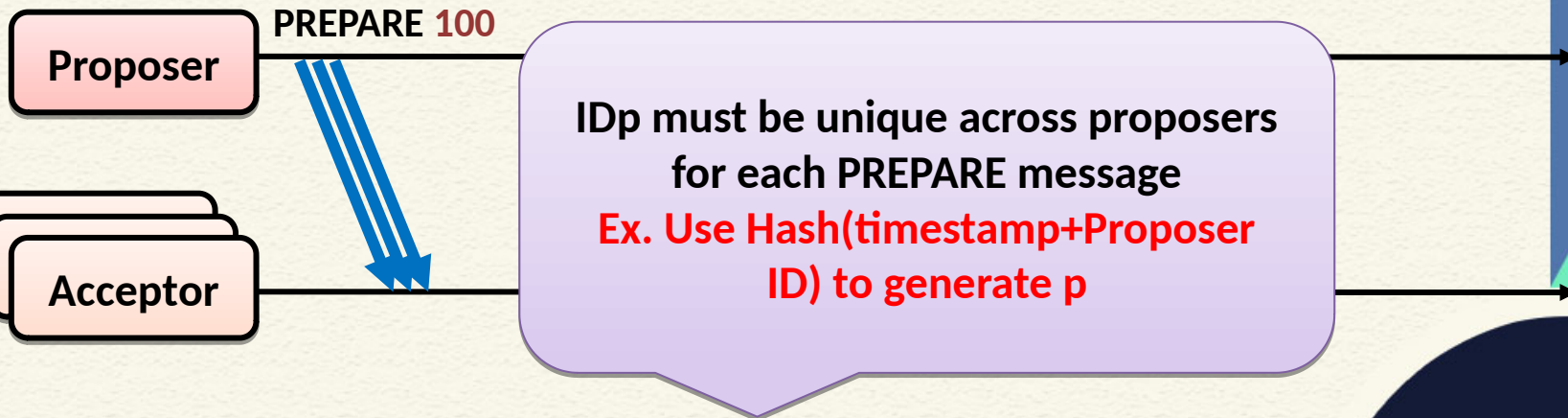
- **Proposer** wants to propose its choice (values):
  - Sends PREPARE IDp to a majority (or all) of the **acceptors**

# Paxos Algorithm



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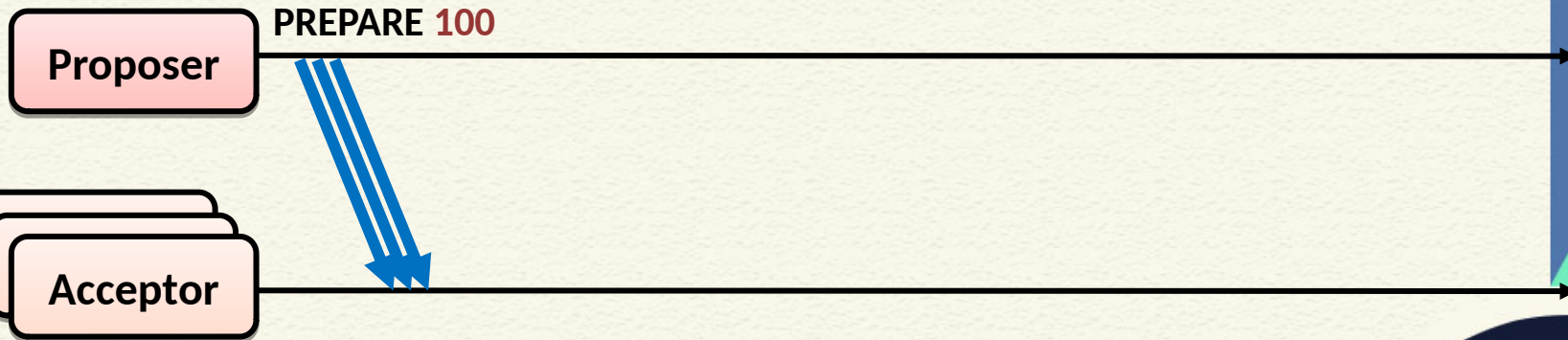
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# Paxos Algorithm



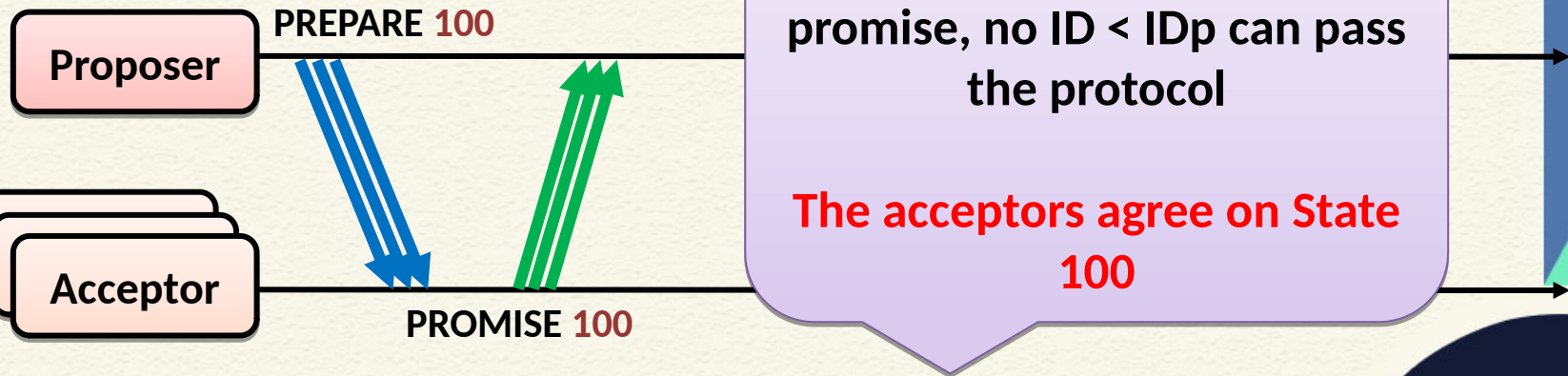
- **Acceptor** received a PREPARE message with IDp:
  - Did it promised to ignore requests with this IDp?
    - **YES:** Ignore
    - **NO:** Will promise to ignore any request lower than IDp
      - (?) Reply with PROMISE IDp

# Paxos Algorithm



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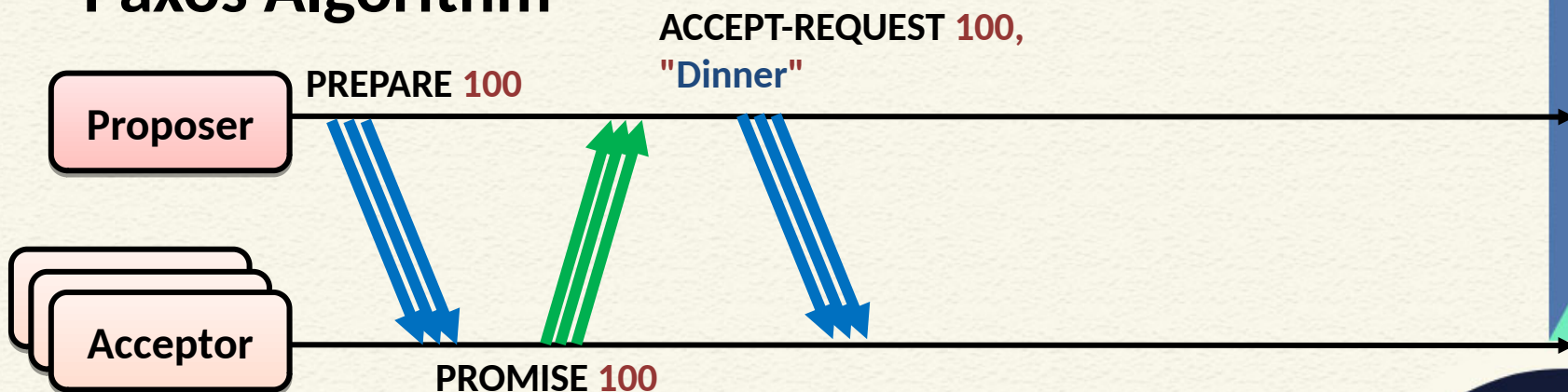
# Paxos Algorithm



- **Proposer** gets majority of PROMISE messages for a specific ID<sub>p</sub>:
  - Sends **ACCEPT-REQUEST** ID<sub>p</sub>, VALUE to a majority (or all) of **Acceptors**
  - (?) It picks any value of its choice

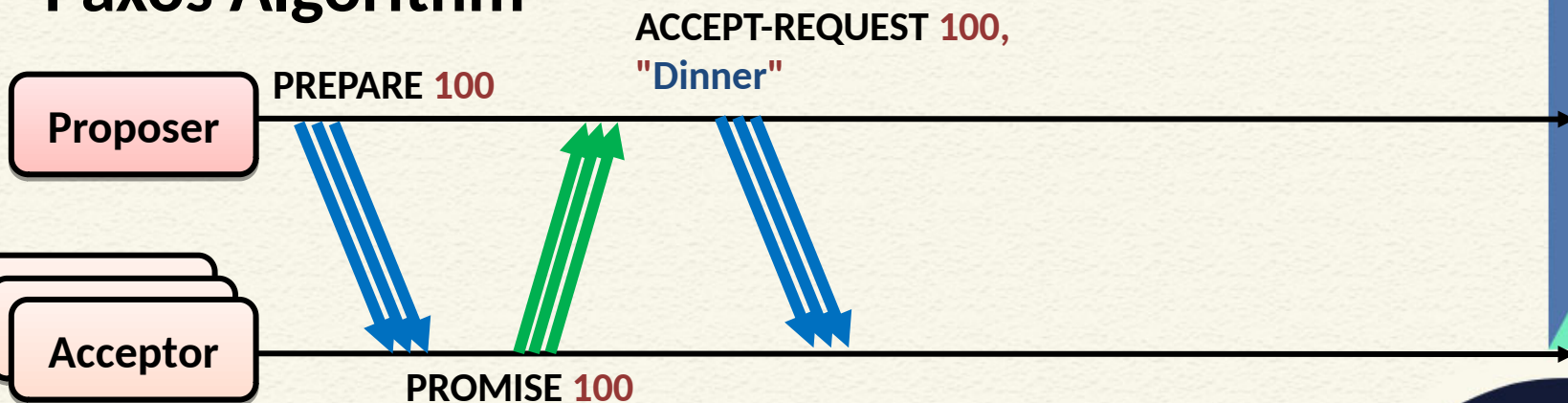


# Paxos Algorithm



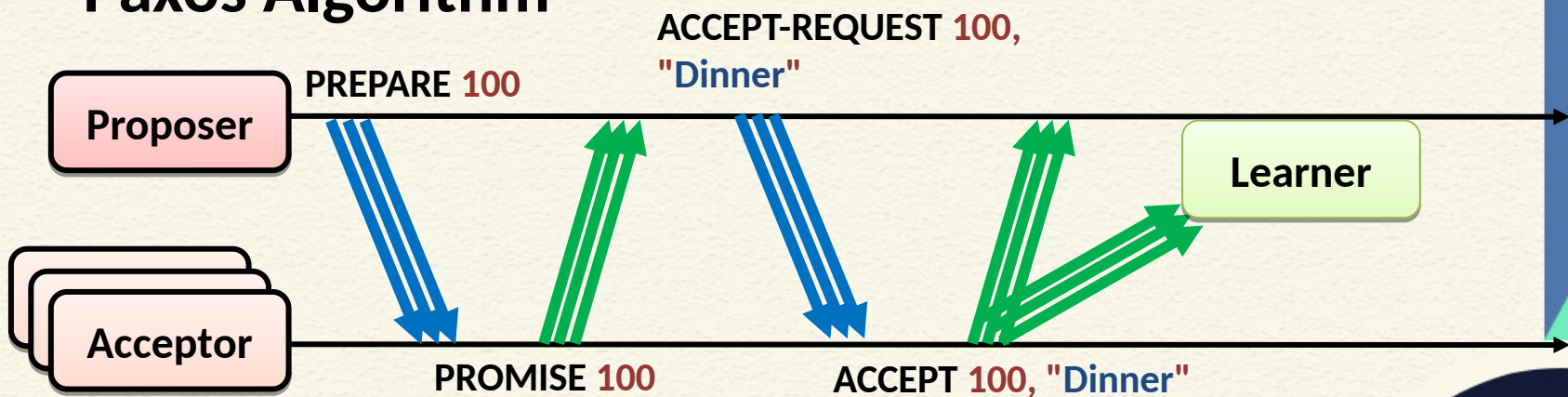
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# Paxos Algorithm



- **Acceptor** receives an **ACCEPT-REQUEST ID<sub>p</sub>, VALUE** :
  - Did it promised to ignore request with this ID<sub>p</sub>?
    - **YES:** Ignore
    - **NO:** Reply with **ACCEPT ID<sub>p</sub>, VALUE**; Also send it to all learners

# Paxos Algorithm



- **Acceptor** receives an **ACCEPT-REQUEST ID<sub>p</sub>, VALUE** :
  - Did it promised to ignore request with this ID<sub>p</sub>?
    - **YES**: Ignore
    - **NO**: Reply with **ACCEPT ID<sub>p</sub>, VALUE**; Also send it to all learners

# Paxos Algorithm

ACCEPT-REQUEST 100,  
"Dinner"

Proposer

PREPARE 100

Acceptor

Learner

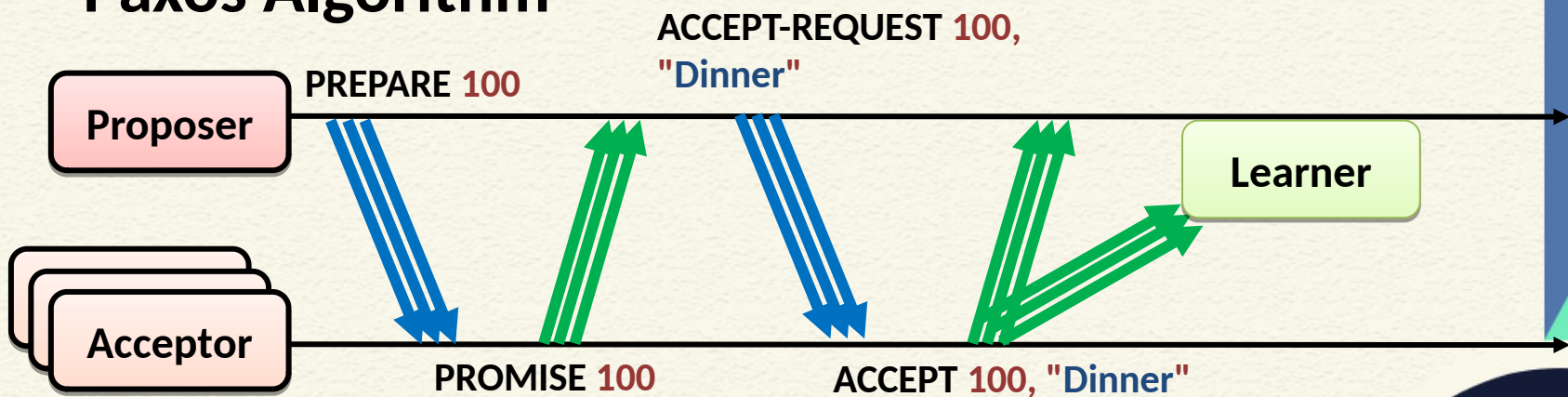
If majority of acceptors accept  
ID<sub>p</sub>, VALUE, consensus is  
reached

Consensus is reached on the  
value, not on ID<sub>p</sub>

- **Acceptor** receives a message from the proposer
  - Did it propose a value?
    - **YES:** Ignore
    - **NO:** Reply with **ACCEPT ID<sub>p</sub>, VALUE**; Also send it to all learners

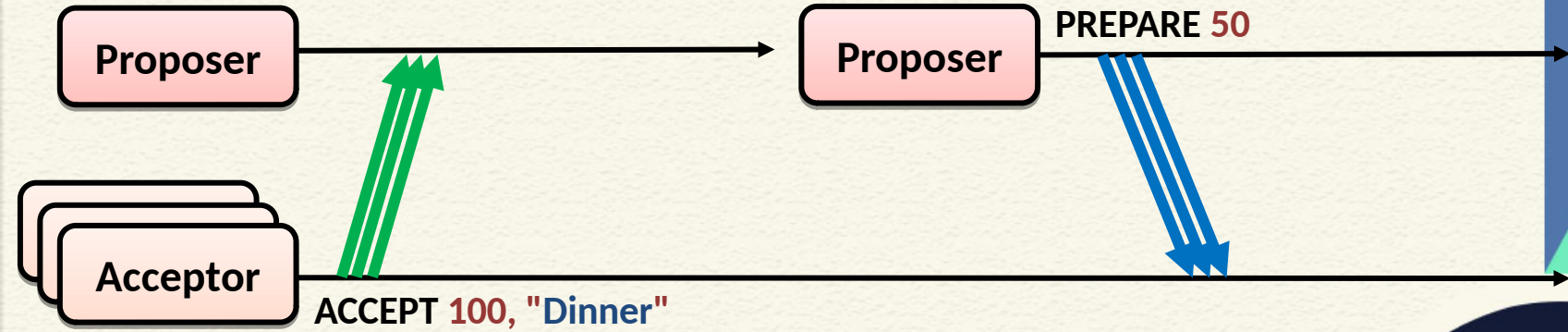


# Paxos Algorithm

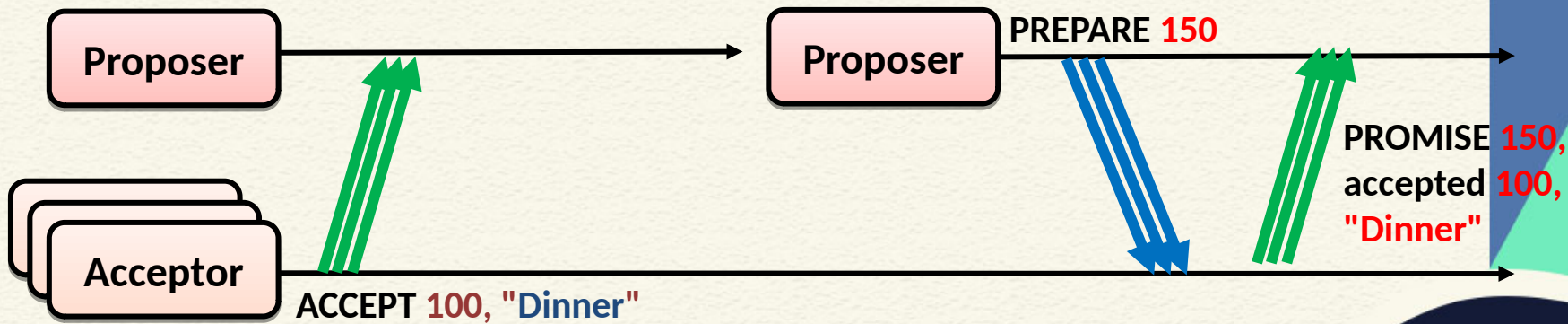


- **Proposer** or **Learner** gets ACCEPT message with IDp, VALUE:
  - If a proposer/learner gets majority of accept for a specific IDp, they know that consensus is reached for the value (not IDp).

# Paxos - Multiple Proposers

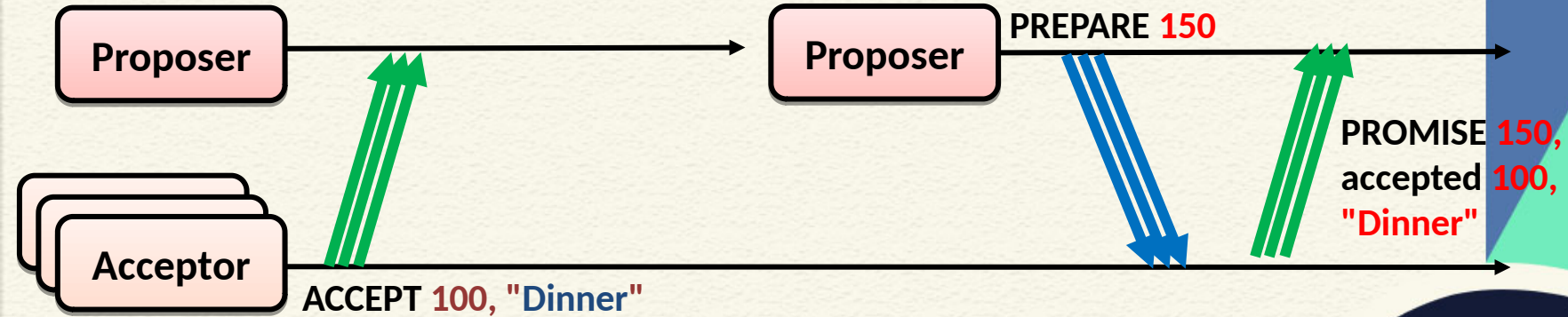


# Paxos - Multiple Proposers



- **Acceptor** received a PREPARE message with ID<sub>p</sub>:
  - Did it promised to ignore requests with this ID<sub>p</sub>?
    - **YES**: Ignore
    - **NO**: Will promise to ignore any request lower than ID<sub>p</sub>
      - Has it ever accepted anything? (Assume accepted ID = ID<sub>a</sub>)
        - **YES**: Reply with **PROMISE ID<sub>p</sub> accepted ID<sub>a</sub>, VALUE**
        - **NO**: Reply with **PROMISE ID<sub>p</sub>**

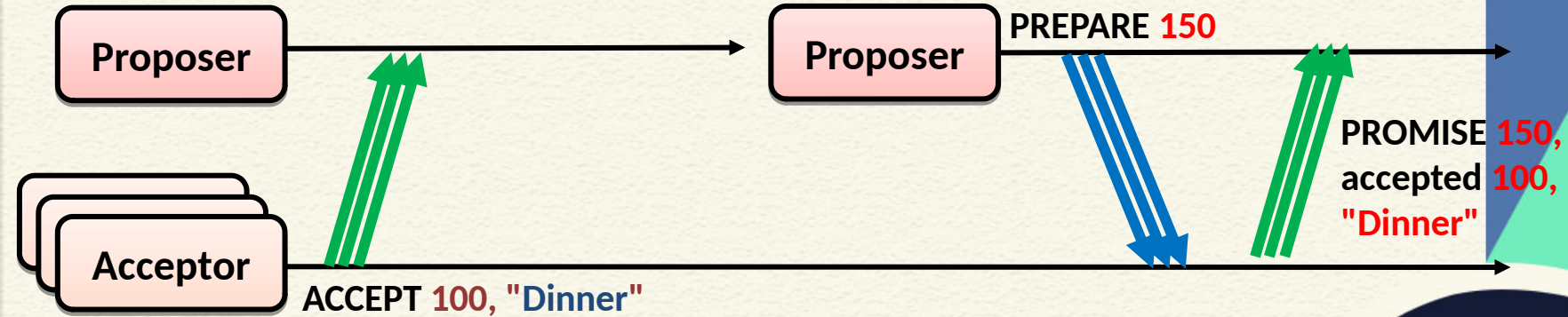
# Paxos - Multiple Proposers



What the proposer will do?

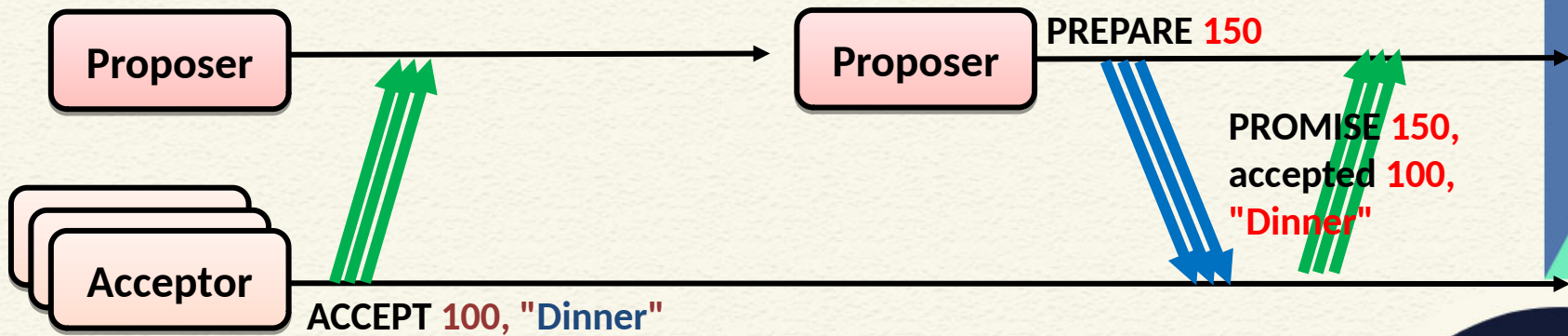


# Paxos - Multiple Proposers



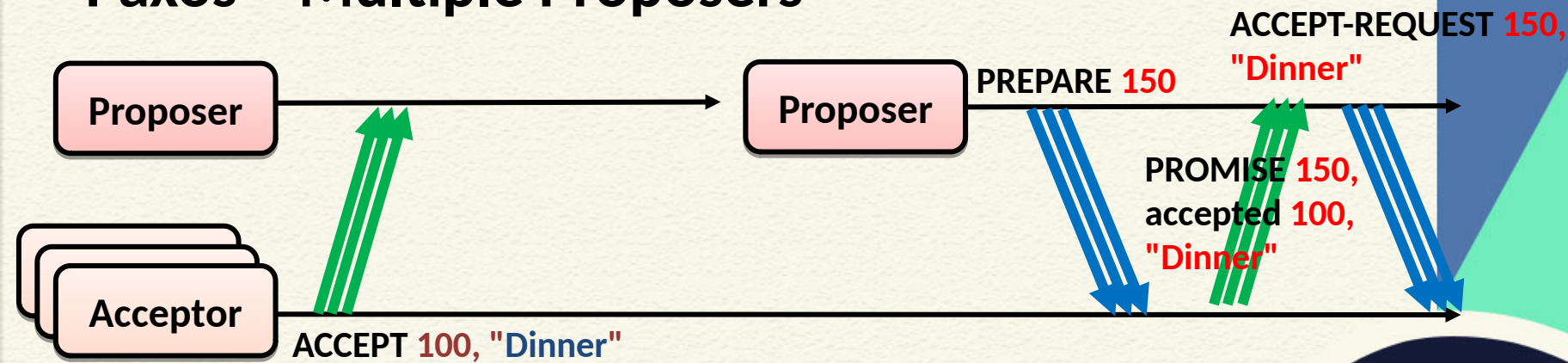
- **Proposer** gets majority of PROMISE messages for a specific IDp:
  - It sends **ACCEPT-REQUEST IDp, VALUE** to a majority (or all) of **Acceptors**
  - (?) It picks any value it wants

# Paxos – Multiple Proposers



- **Proposer** gets majority of PROMISE messages for a specific IDp:
  - It sends **ACCEPT-REQUEST IDp, VALUE** to a majority (or all) of **Acceptors**
    - Has it got any already accepted value from promises?
      - **YES:** Picks the value with the highest IDa
      - **NO:** Picks the value of its choice

# Paxos - Multiple Proposers



- **Proposer** gets majority of PROMISE messages for a specific IDp:
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# Conclusion

- Paxos works in two rounds
  - Agreement on the state (ID)
  - Agreement on the value
- **Safety and liveness of Paxos?**





*Thank  
you*

