L19: Replicated state machines

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Last Time: Two-Phase Commit

(Not to be confused with two phase locking)

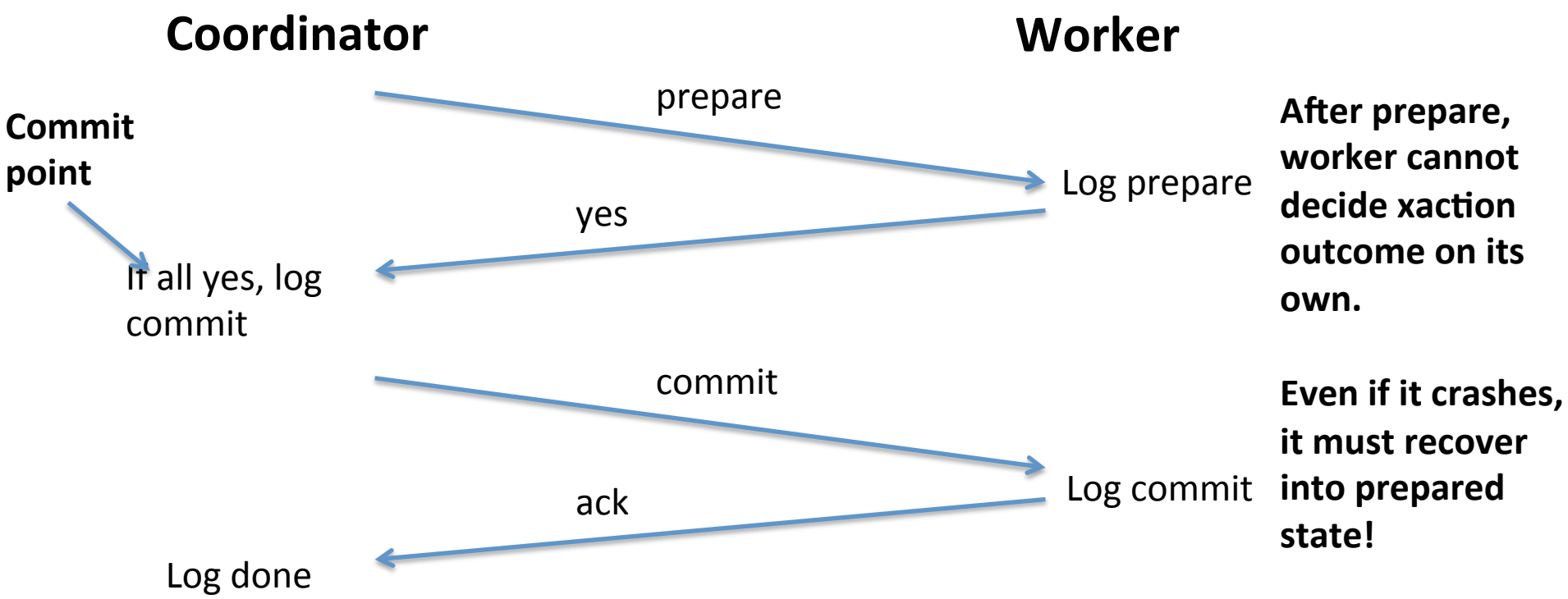
Allows transactions to be run across multiple distinct nodes (each with their own data)

Key idea:

- prepare all nodes to commit

- atomically **commit** them via a single log record

Two Phase Commit



Single-copy consistency

- Operations appear to execute as if there is only a single copy of the data

Replicated state machine

- A general approach to building consistent replicas of a server:
  - Start with same initial state
  - Provide each replica with the same input and in same order
  - Ensure all inputs are deterministic

RSM is hard in practice [comp.risks]

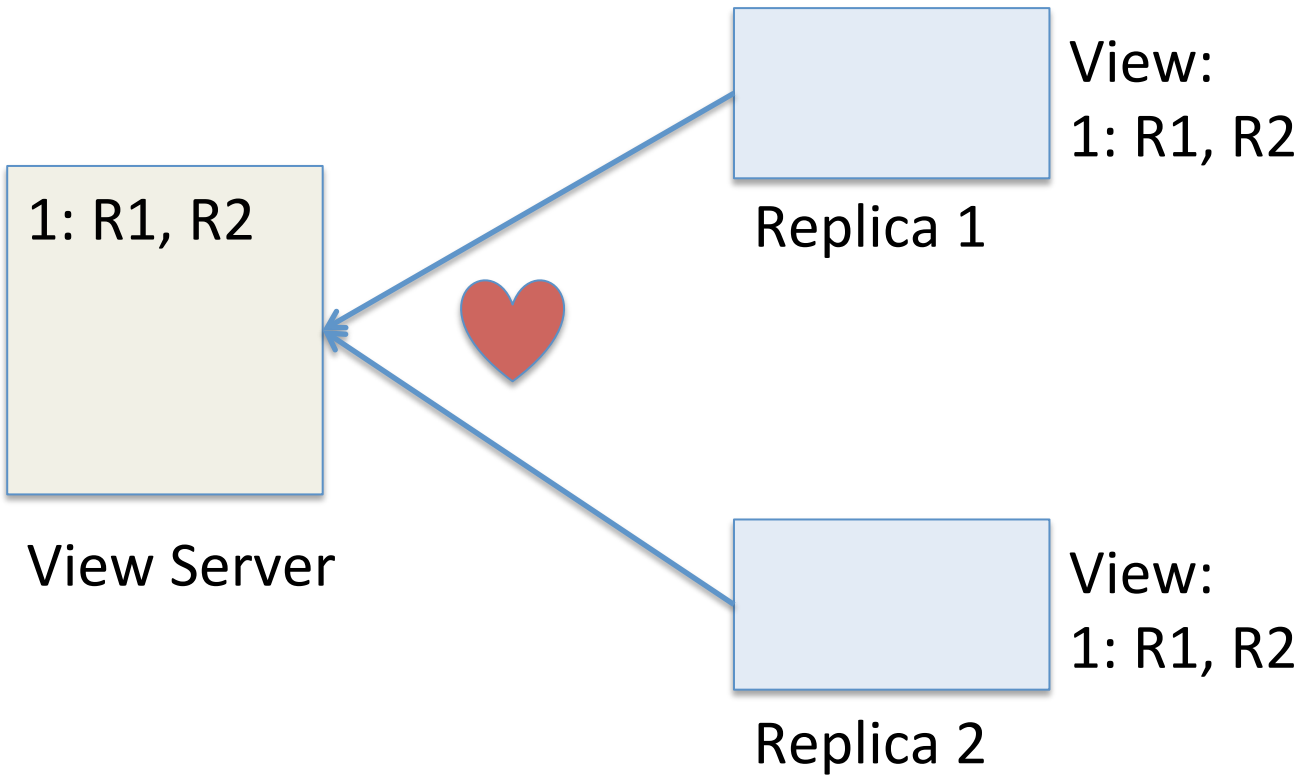
- Leap day 2012, Microsoft's Azure
  - Configuration error crashed all servers
- April 2011, Amazon's EC2
  - Replication storm exhausted all storage
- September 2010, Facebook clients
  - Clients overwhelmed database after misconfig.
- September 2009, Google's gmail
  - Request routers overloaded

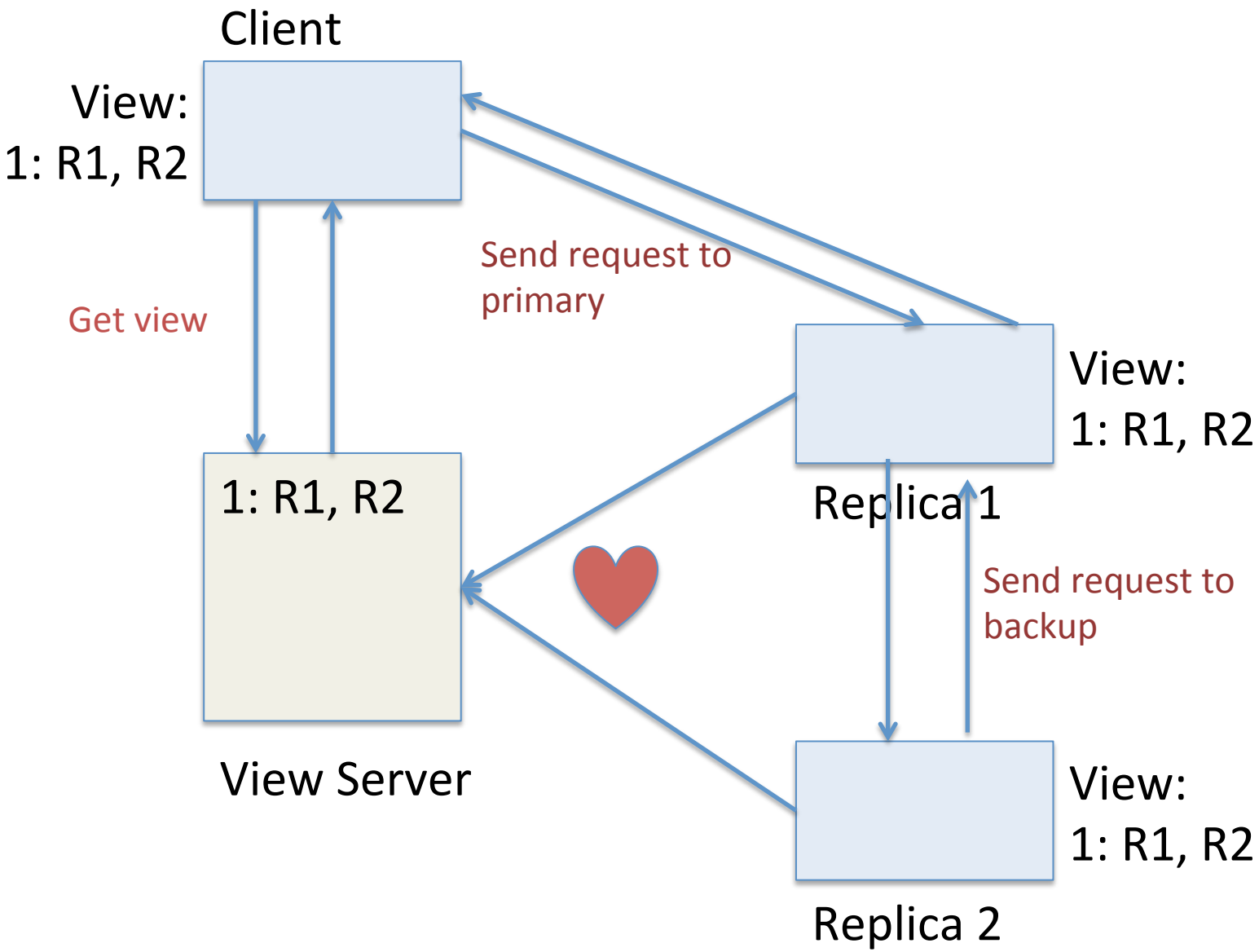
Complete outages

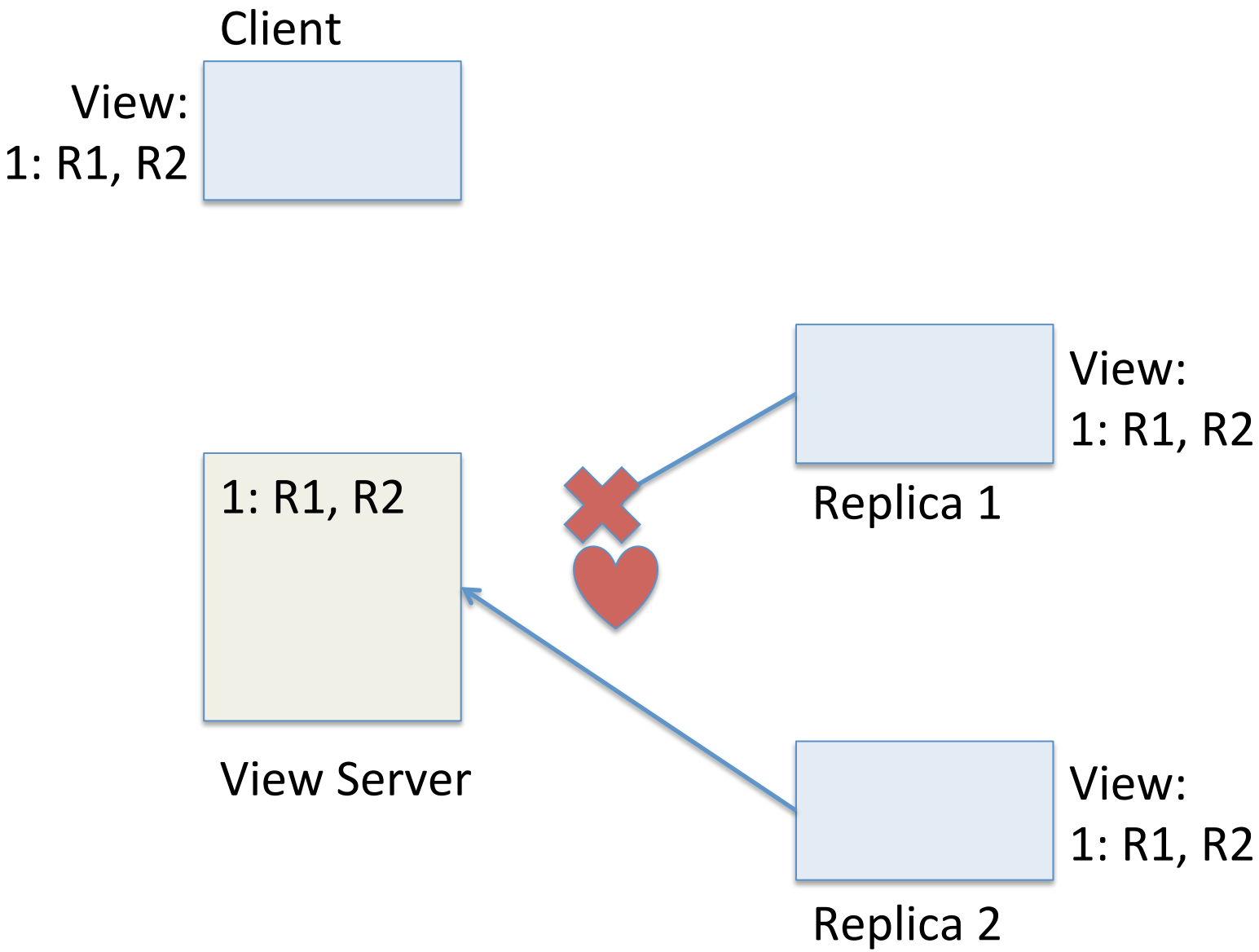
RSM with view server

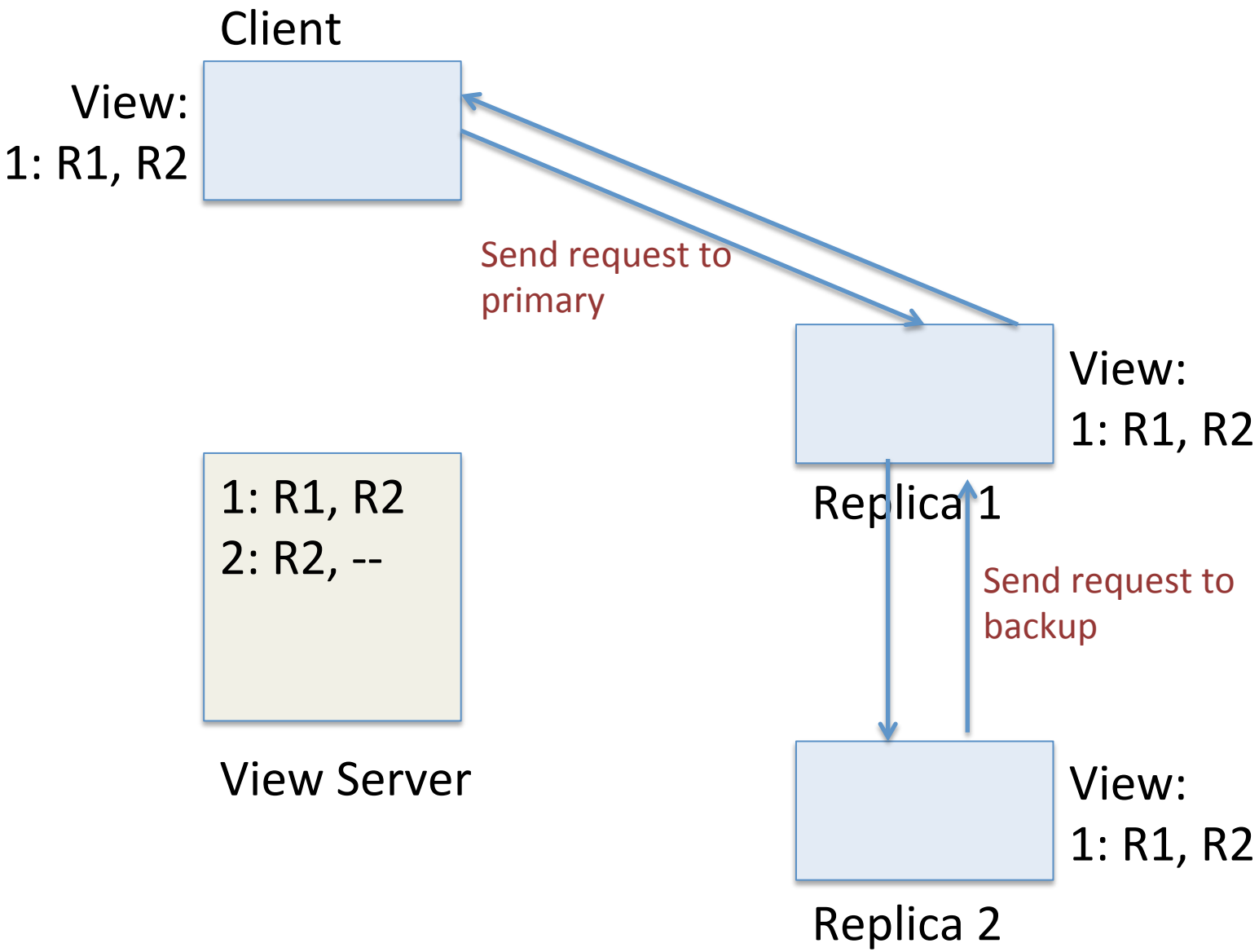
- Primary must wait for backup to accept each request
- Non-backup must reject forwarded requests
- Non-primary must reject direct client requests
- Primary in view *i* must have been primary or backup in view *i*-1
- New backups copy state from primary

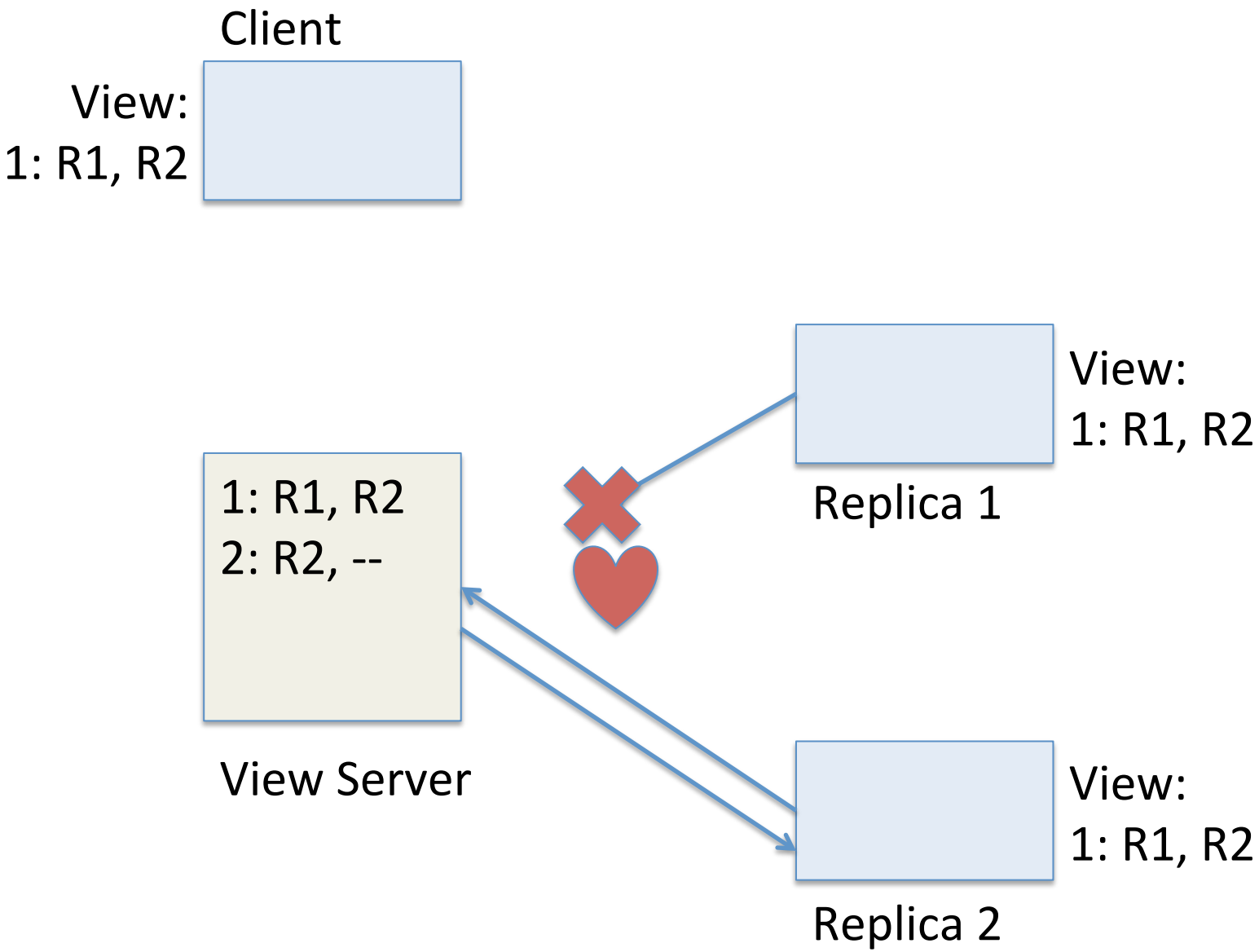
RSM w/ View Server Example

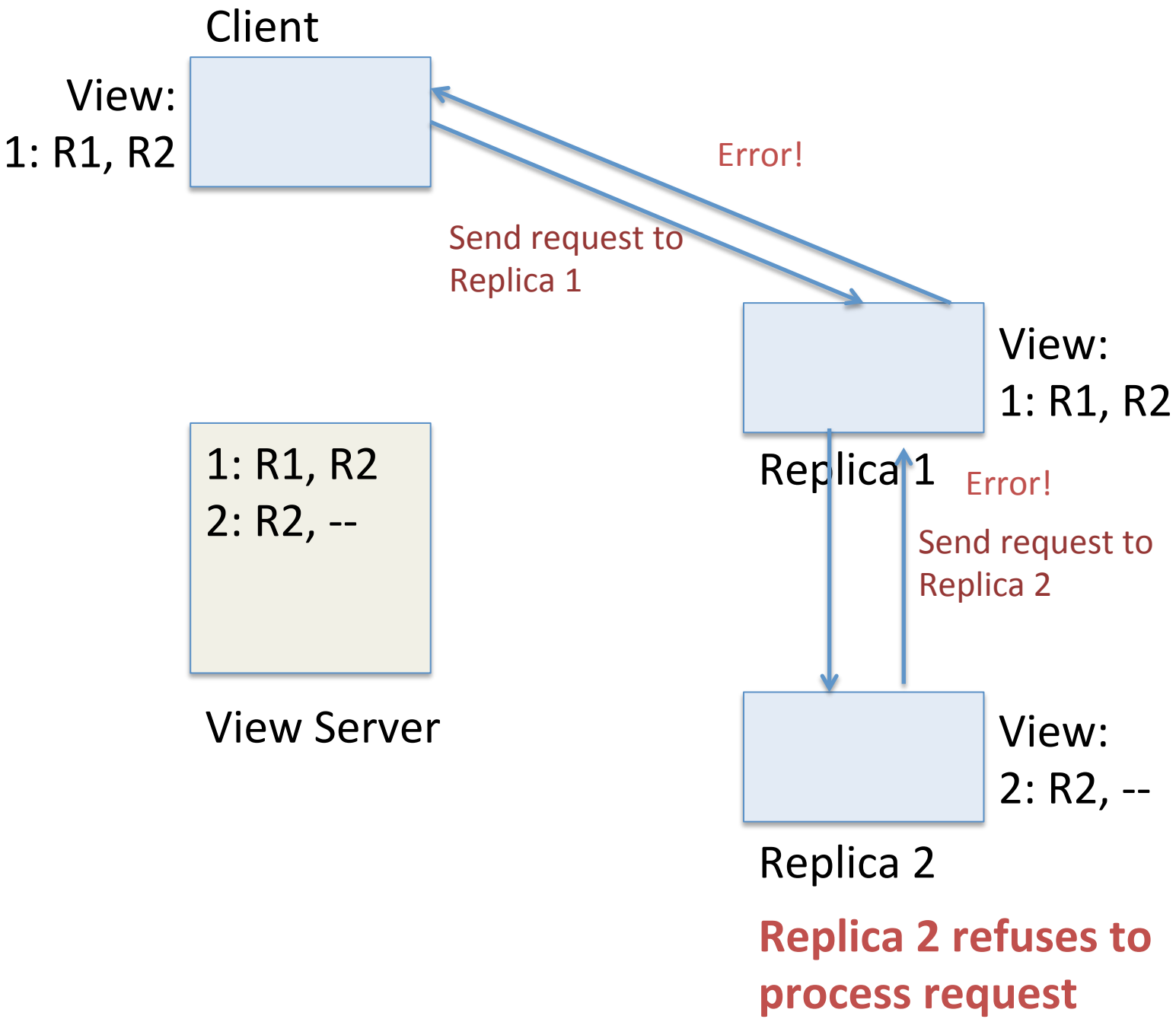


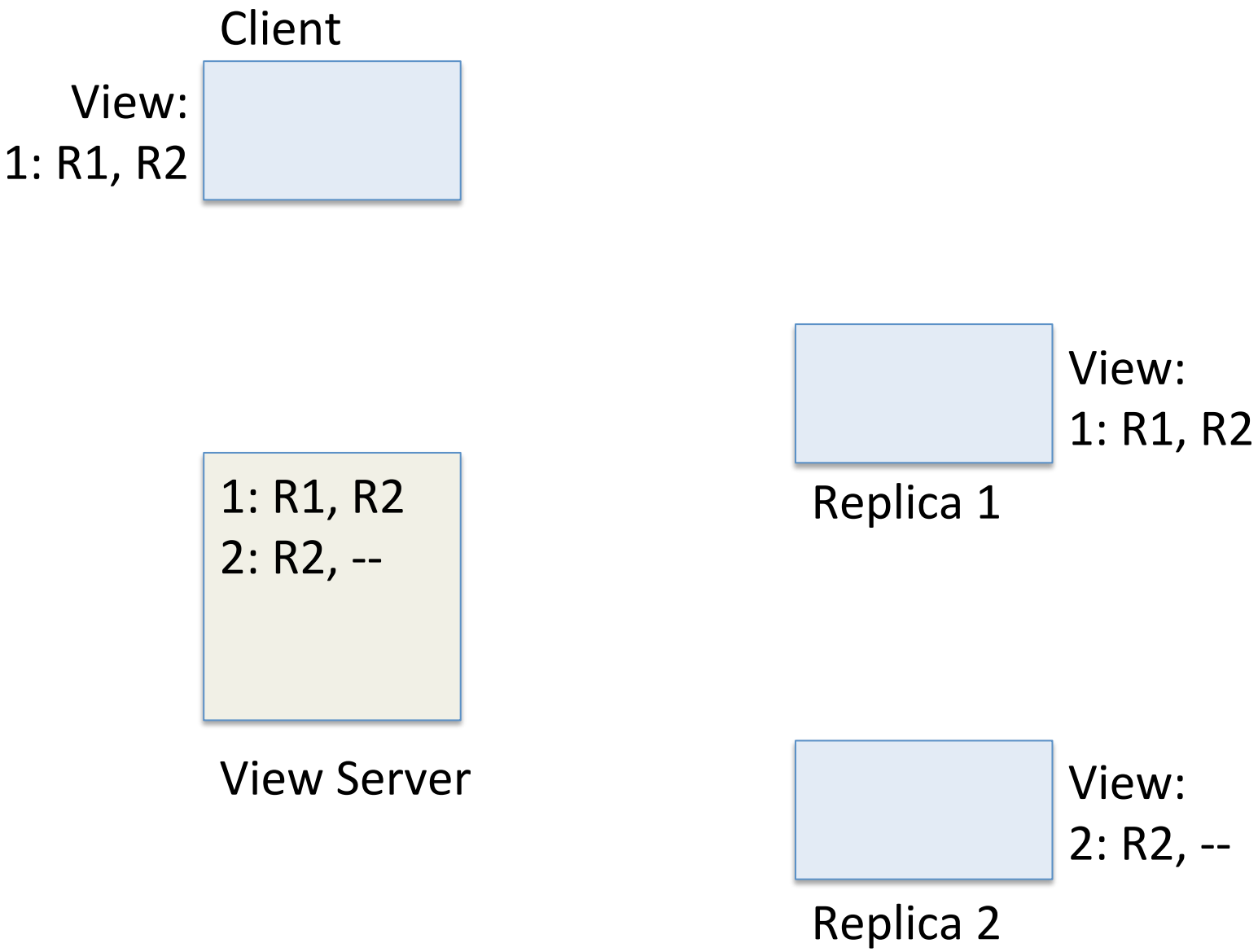

Client
View:
1: R1, R2
Get view
Send request to
primary
View:
1: R1, R2
Replica 1
1: R1, R2
Send request to
backup
View Server
View:
1: R1, R2
Replica 2

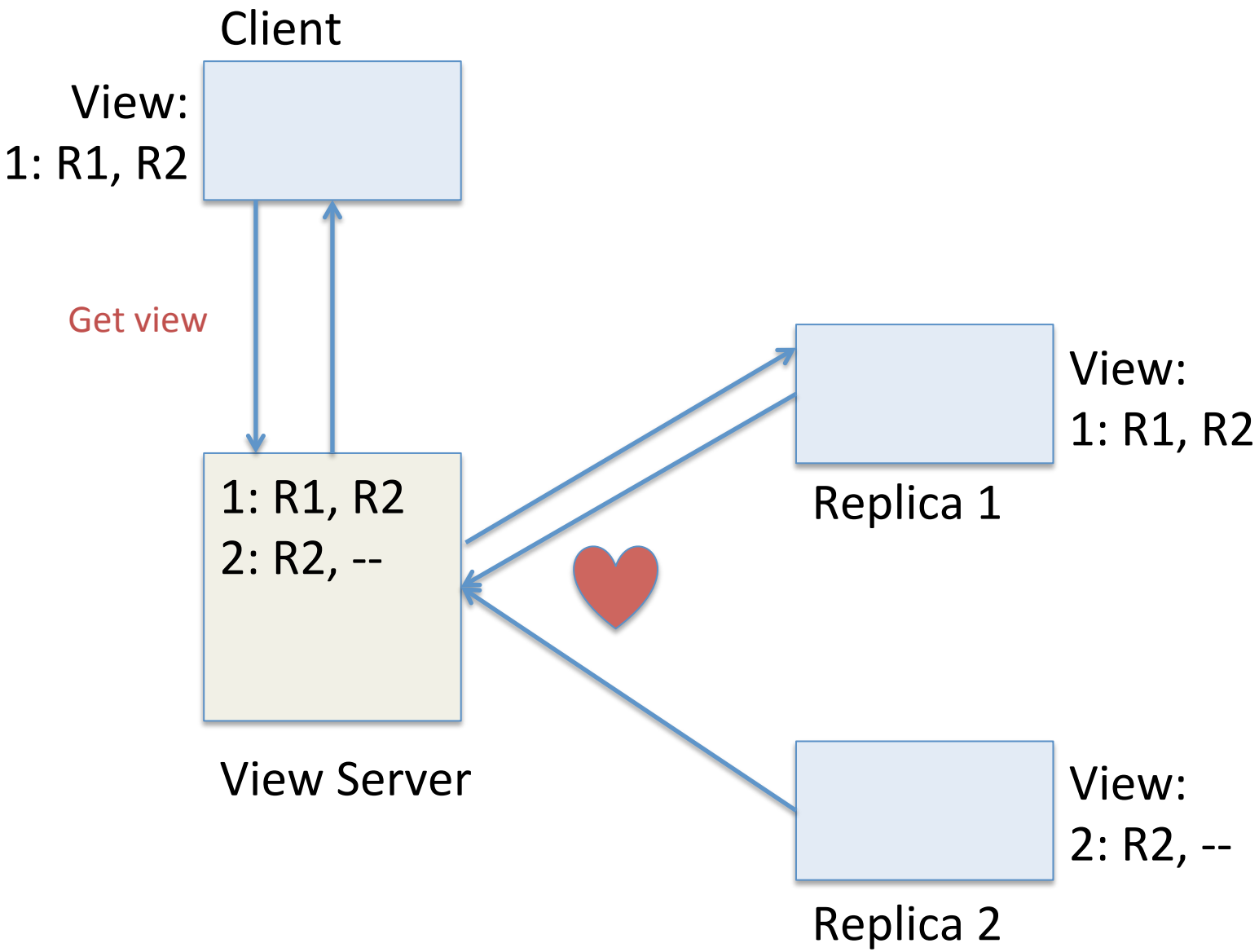

Client
View:
1: R1, R2
1: R1, R2
View Server
Replica 1
View:
1: R1, R2
Replica 2
View:
1: R1, R2

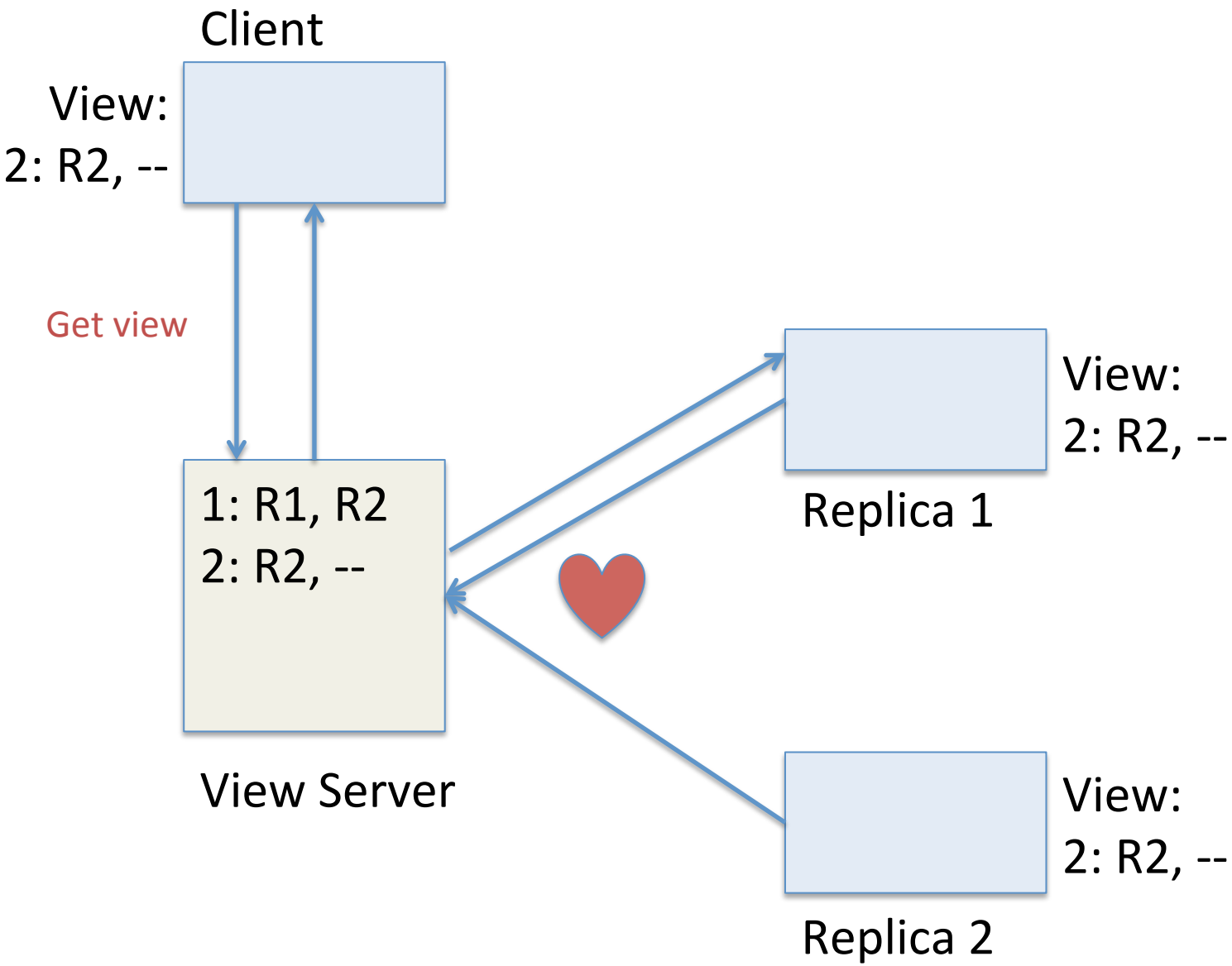

Client
View:
1: R1, R2
Send request to
primary
View:
1: R1, R2
Replica 1
1: R1, R2
2: R2, --
Send request to
backup
View Server
View:
1: R1, R2
Replica 2

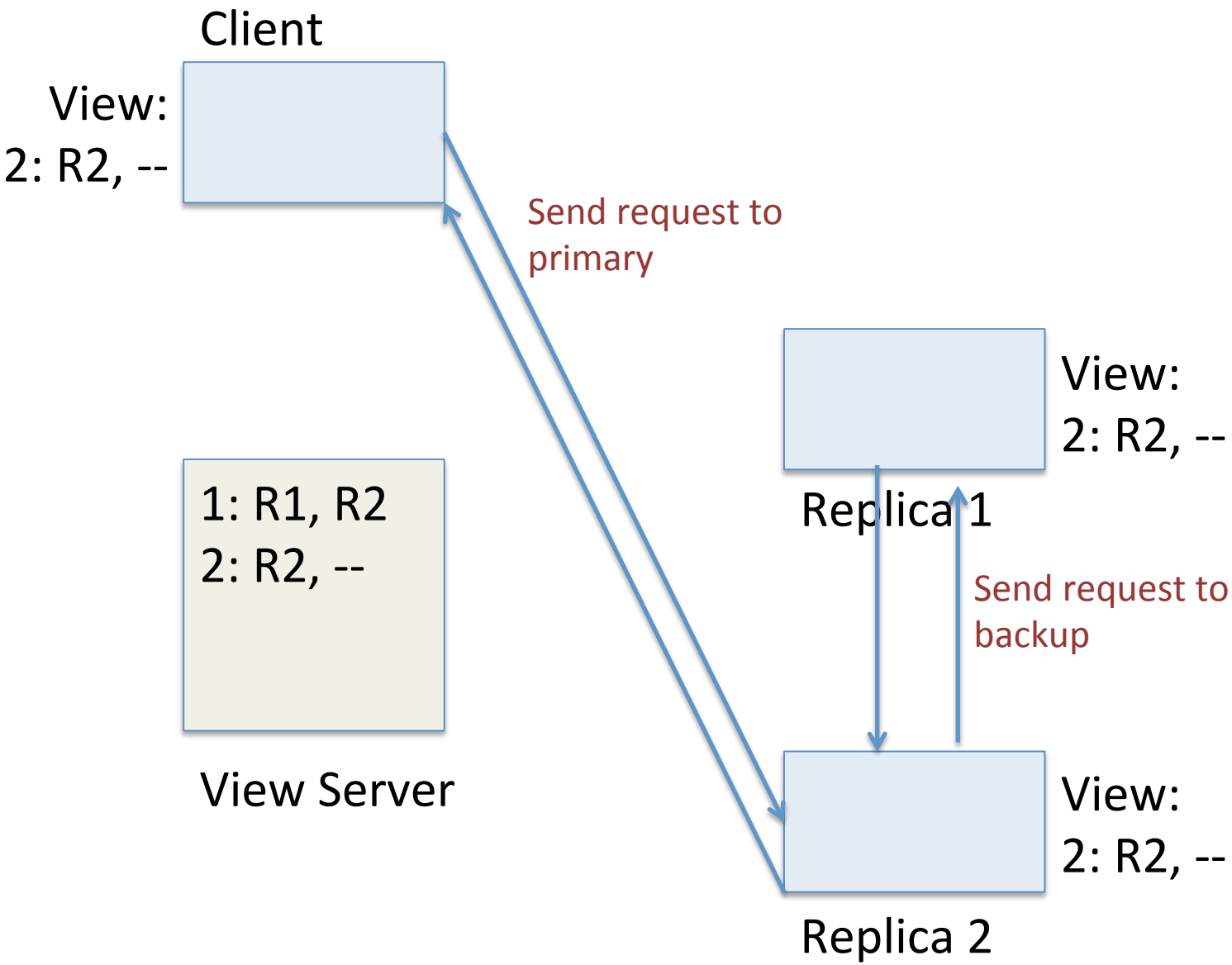

Client
View:
1: R1, R2
View:
1: R1, R2
Replica 1
1: R1, R2
2: R2, --
View Server
View:
1: R1, R2
Replica 2


Client
View:
1: R1, R2
Error!
Send request to
Replica 1
View:
1: R1, R2
Replica 1
1: R1, R2
2: R2, --
Error!
Send request to
Replica 2
View Server
View:
2: R2, --
Replica 2
Replica 2 refuses to
process request


Client
View:
1: R1, R2
1: R1, R2
2: R2, --
View Server
View:
1: R1, R2
Replica 1
View:
2: R2, --
Replica 2


Client
View:
1: R1, R2
Get view
1: R1, R2
2: R2, --
View Server
View:
1: R1, R2
Replica 1
View:
2: R2, --
Replica 2


Client
View:
2: R2, --
Get view
1: R1, R2
2: R2, --
View Server
View:
2: R2, --
Replica 1
View:
2: R2, --
Replica 2


Client
View:
2: R2, --
Send request to
primary
View:
2: R2, --
Replica 1
1: R1, R2
2: R2, --
Send request to
backup
View Server
View:
2: R2, --
Replica 2

Summary

- Single-copy consistency
- Replicated state machine
- Consensus with view server
- Wednesday: distributed consensus