More Primary/Backup

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Logistics notes

Problem set 1 posted…real soon now

- due next Friday, 9pm

Lab 1 due 9pm

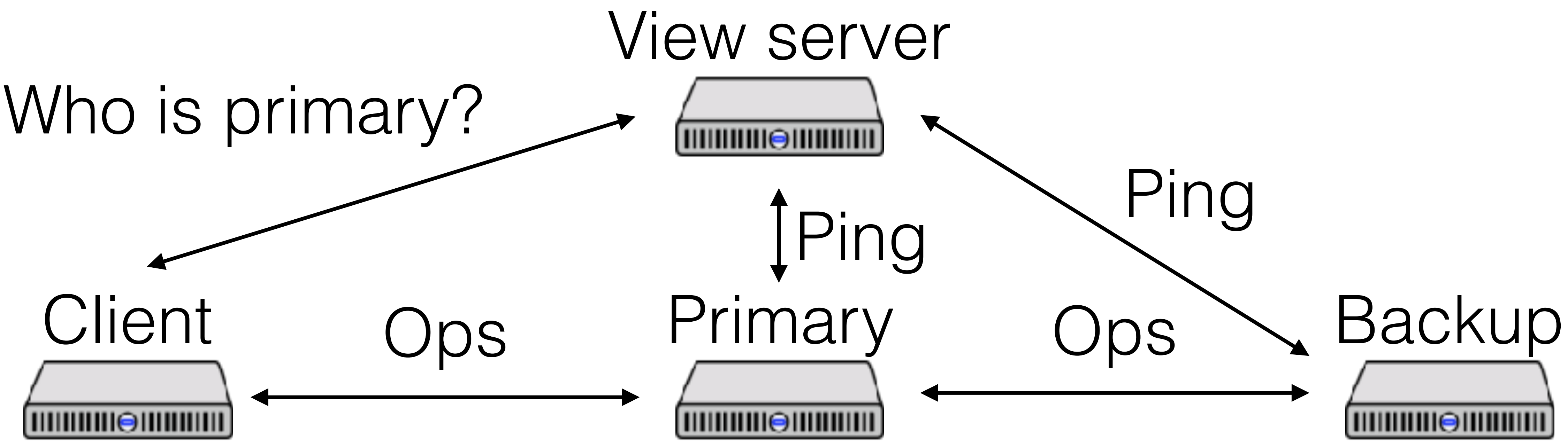
Question experiment

Today

More Primary/Backup

Intro to logical clocks

Primary/Backup Architecture



Rules

1. Primary in view *i+1* must have been backup or primary in view *i*
2. Primary must wait for backup to accept/execute each op before doing op and replying to client
3. Backup must accept forwarded requests only if view is correct
4. Non-primary must reject client requests
5. Every operation must be before or after state transfer

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Split brain

1: A, B

A is still up, but can’t reach view server

2: C, D

C learns it is promoted to primary
A still thinks it is primary

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1. Missing writes

1: A, B

Client writes to A, receives response
A crashes before writing to B

2: B, C

Client reads from B
Write is missing

2. “Fast” Reads?

Does the primary need to forward reads to the backup?

(This is a common “optimization”)

Stale reads

1: A, B

A is still up, but can’t reach view server

2: B, C

Client 1 writes to B
Client 2 reads from A
A returns outdated value

Reads vs. writes

Reads treated as state machine operations too

But: can be executed more than once

RPC library can handle them differently

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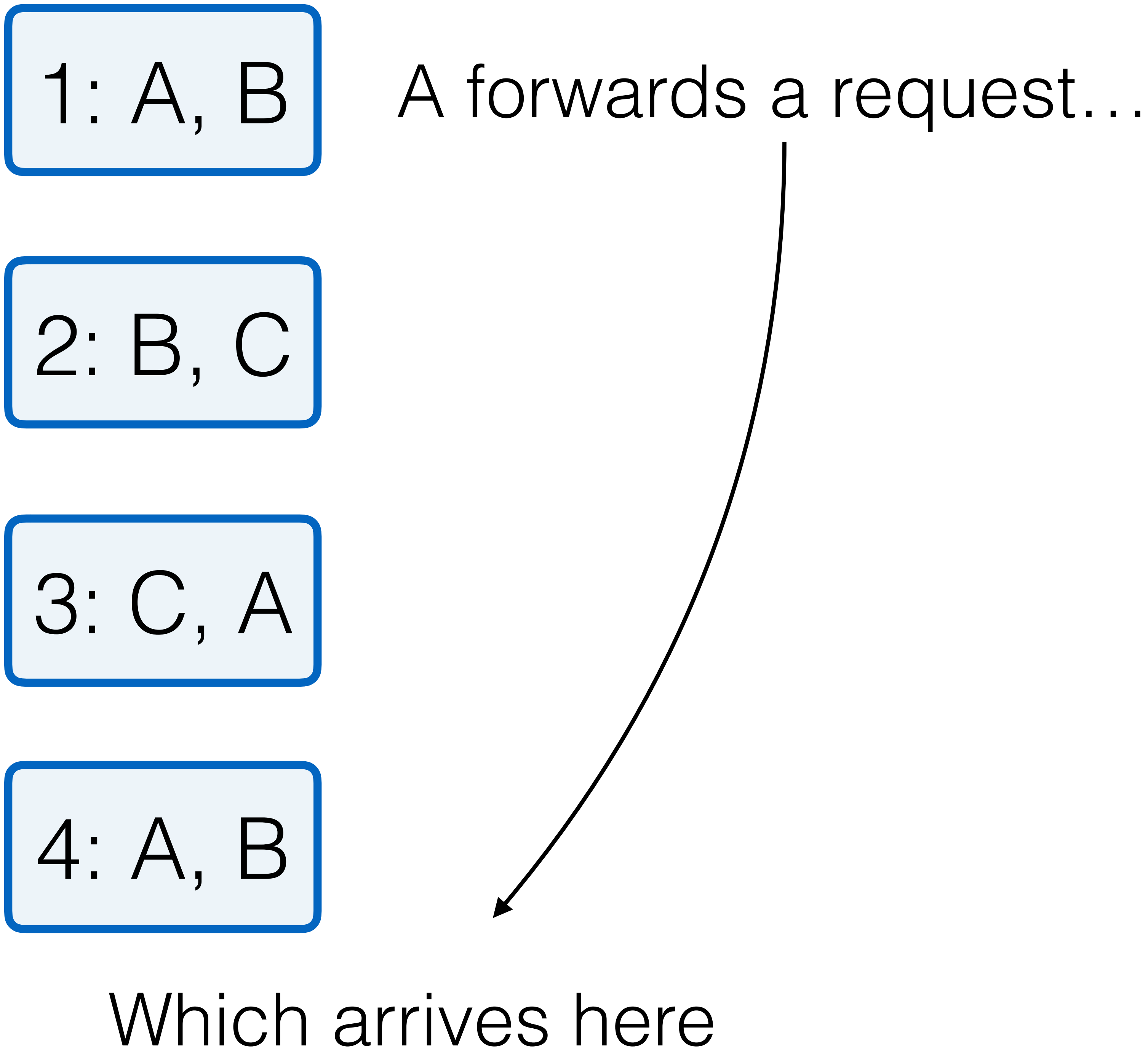
Old messages



1: A, B

2: B, C

3: C, A

4: A, B

A forwards a request…

Which arrives here

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Inconsistencies

1: A, B

2: B, C

2: B, A

Outdated client sends request to A
A shouldn’t respond!

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Inconsistencies

1: A, B

A starts sending state to B
Client writes to A
A forwards op to B
A sends rest of state to B

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Progress

Are there cases when the system can’t make further progress (i.e. process new client requests)?

Progress

- View server fails
- Network fails entirely (hard to get around this one)
- Clients can’t reach primary but it can ping VS
- No backup and primary fails
- Primary fails before ack’ing view change

State transfer and RPCs

State transfer must include RPC data

Duplicate writes

1: A, B

Client writes to A
A forwards to B
A replies to client
Reply is dropped

2: B, C

B transfers state to C, crashes

3: C, D

Client resends write. Duplicated!

One more corner case

1: A, B

View server stops hearing from A
A and B, and clients, can still communicate

2: B, C

B hasn’t heard from view server
Client in view 1 sends a request to A
What happens?
Client in view 2 sends a request to B
What happens?

Logical time

Distinct from physical time

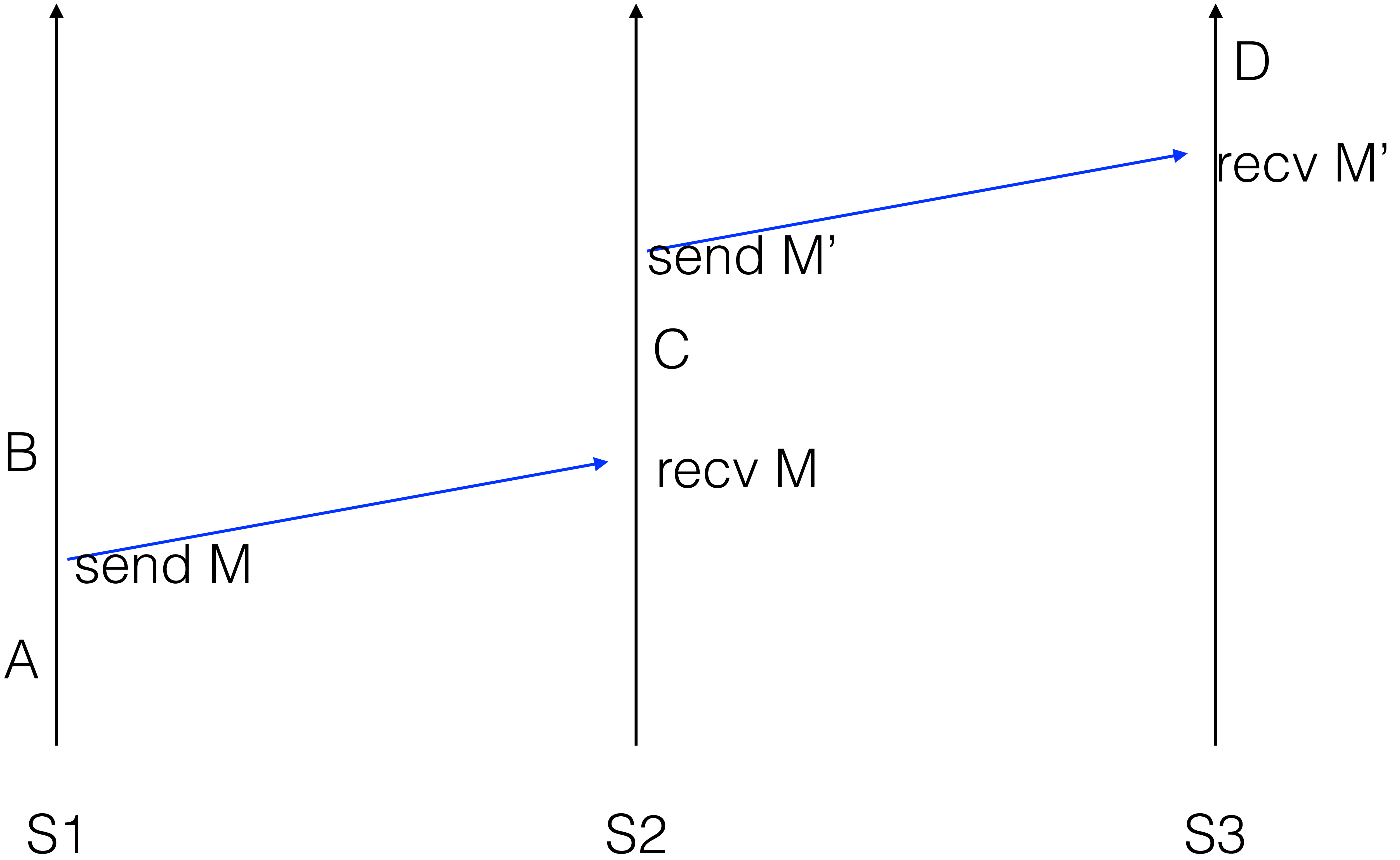
How can we order events at different nodes?

What does it mean for an event to happen before another one?

Happens-before

1. Happens at same location, earlier
2. Transmission before receipt

Space-time diagrams



Lamport clocks

Idea: timestamp on each event

When to advance timestamp, and to what?

How to implement a lock using logical clocks?

Tune in next time