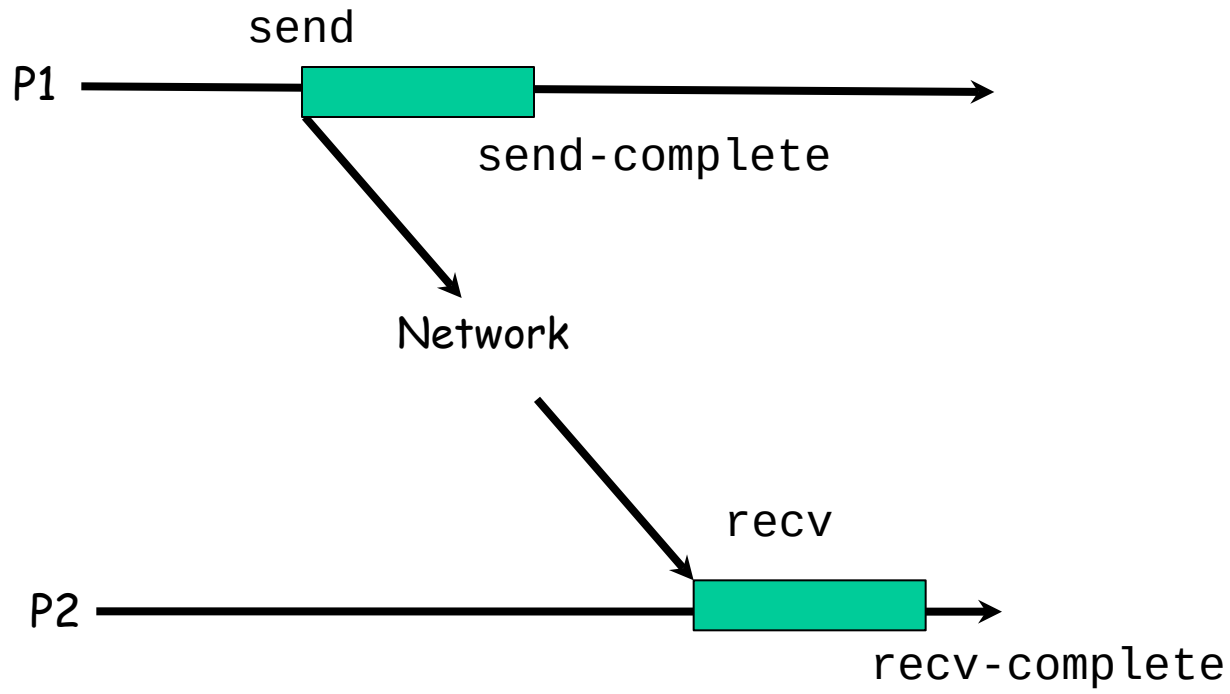
Lecture 14

- Administration

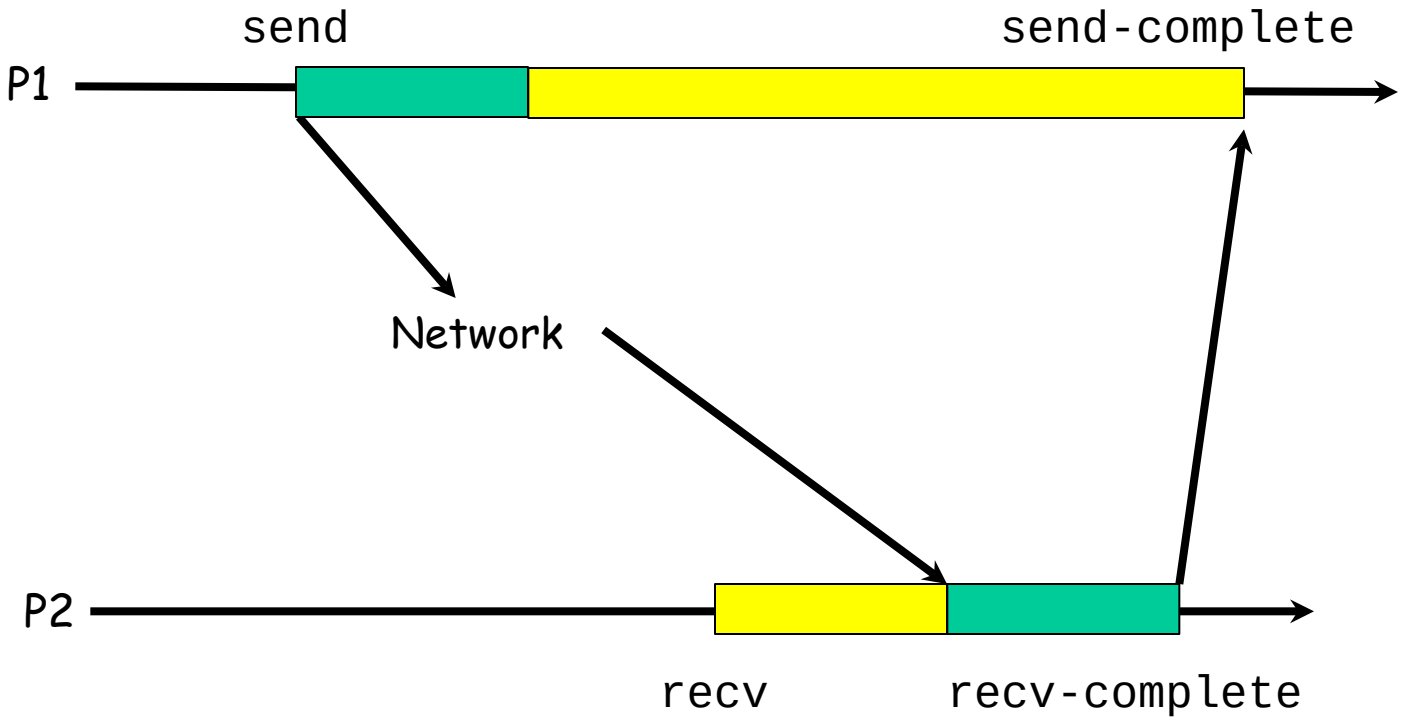
Messages

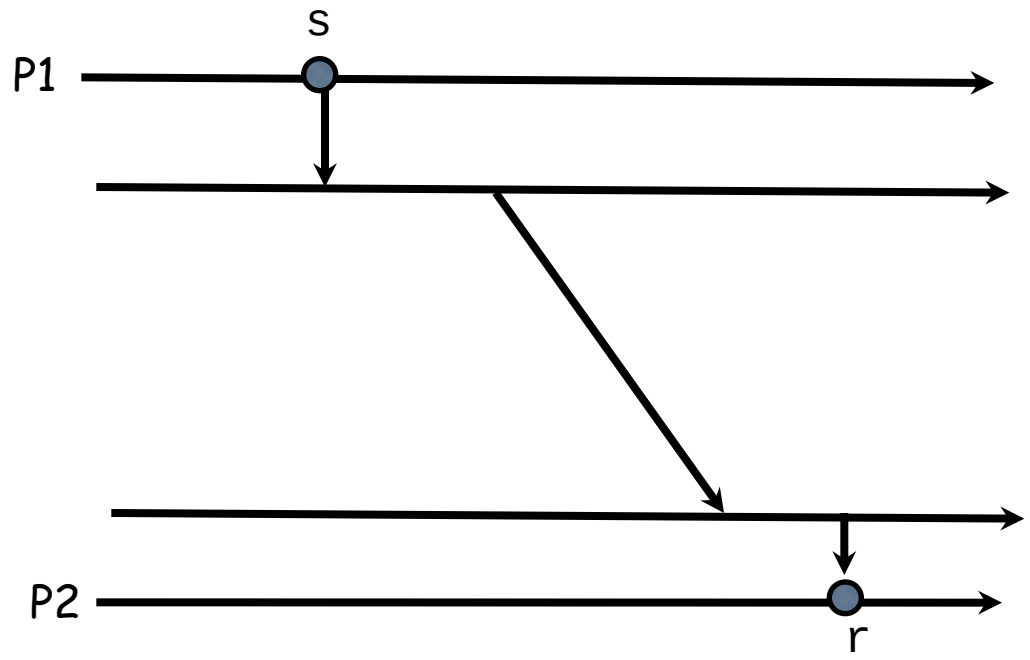
- Synchronous
- Asynchronous

Asynchronous



Synchronous

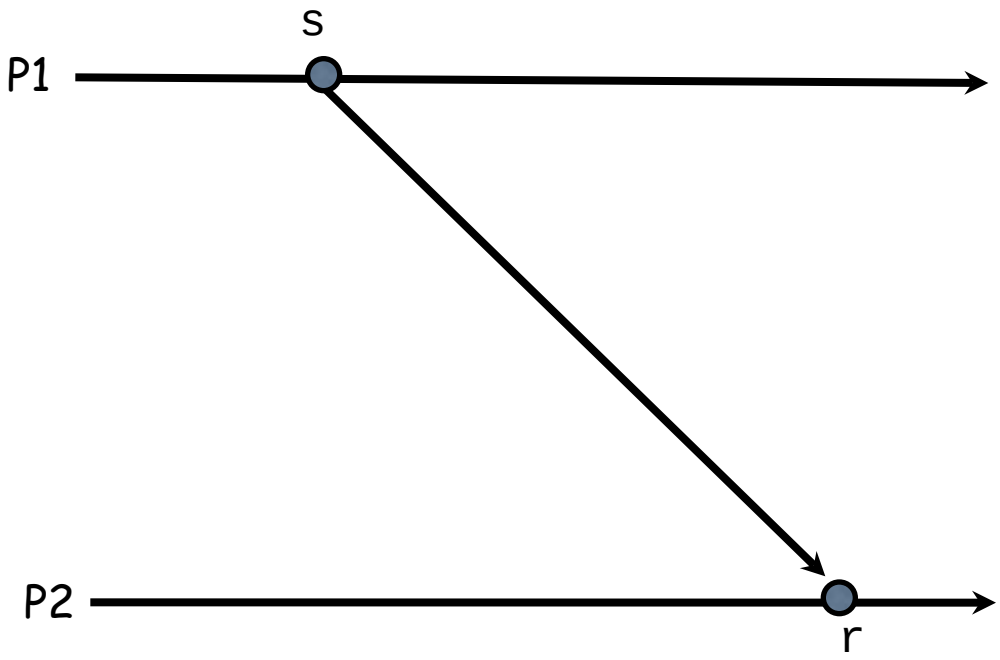



s
P1
P2
r

Blocking versus Non-blocking

Executions

- Synchronous
- Asynchronous


s
P1
P2
r

Terminology

Events in one process of an execution

$$\mathcal{H}_i \equiv e_i^1, e_i^2, e_i^3, \ldots, e_i^x, e_i^{x+1}, \ldots$$

A relation

$$send(m) \xrightarrow[msg]{} recv(m)$$

$$e_i^x \xrightarrow[msg]{} e_j^y$$

Use the following to describe the message in transit from process i to j.

m_{ij}

Terminology

Linearly ordered
By their occurrence

$$\mathcal{H}_i \equiv (h_i, \xrightarrow[i]{})$$

Ordered by causal occurrence

$$\mathcal{M} \equiv (m, \xrightarrow[msg]{})$$

Follows the flow of information

"happens before" Relation

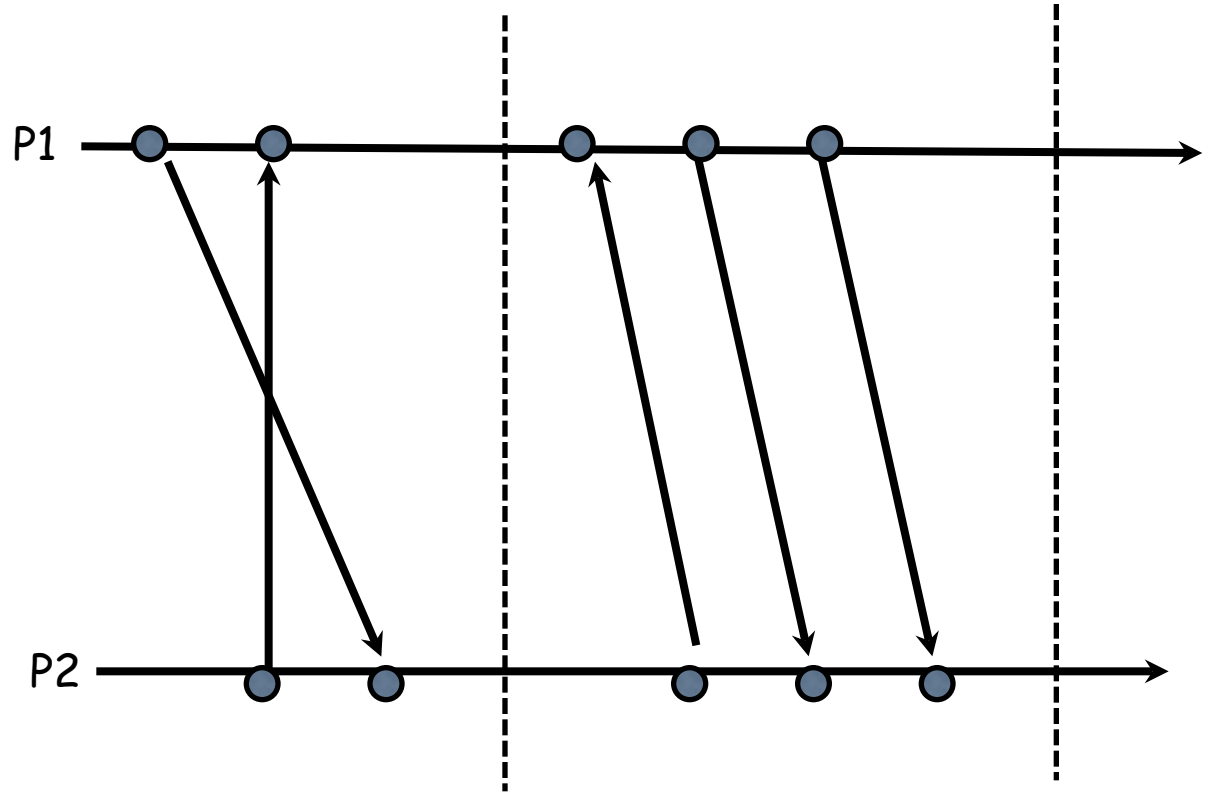
$$e_i^x \rightarrow e_j^y \Leftrightarrow \begin{cases} e_i^x \xrightarrow[i]{} e_j^y \,(i == j) \wedge (x < y) \\ e_i^x \xrightarrow[msg]{} e_j^y \\ \exists e_k^z \in H \; s.t. \; e_i^x \rightarrow e_k^z \wedge e_k^z \rightarrow e_j^y \end{cases}$$

Properties of H:

1. NOT a < a (irreflexive)
2. If a < b Then NOT b<a (asymmetric)
3. Transitive

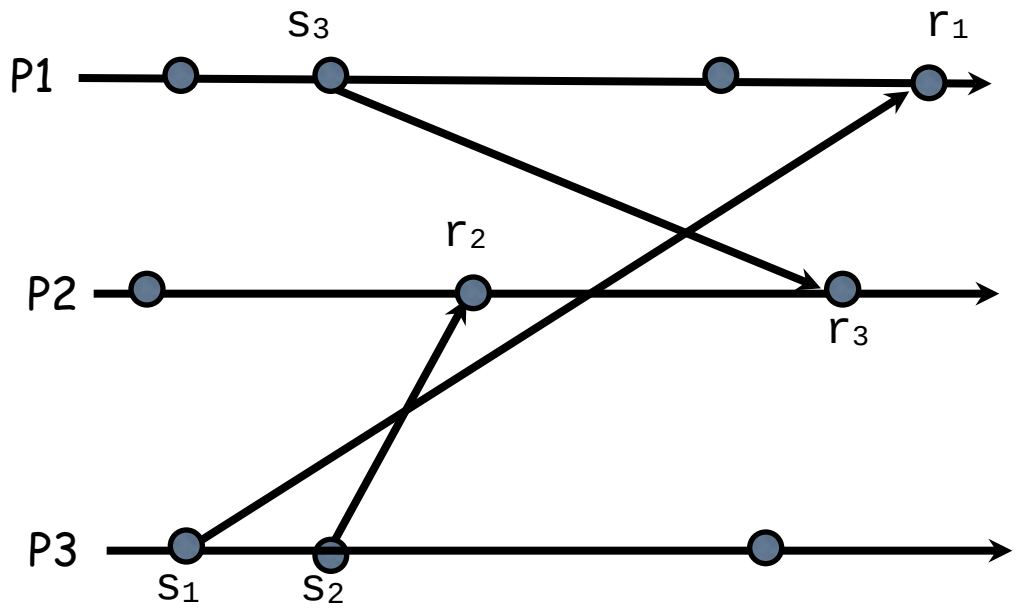
Defines a strict partial order on events (causal ordering)

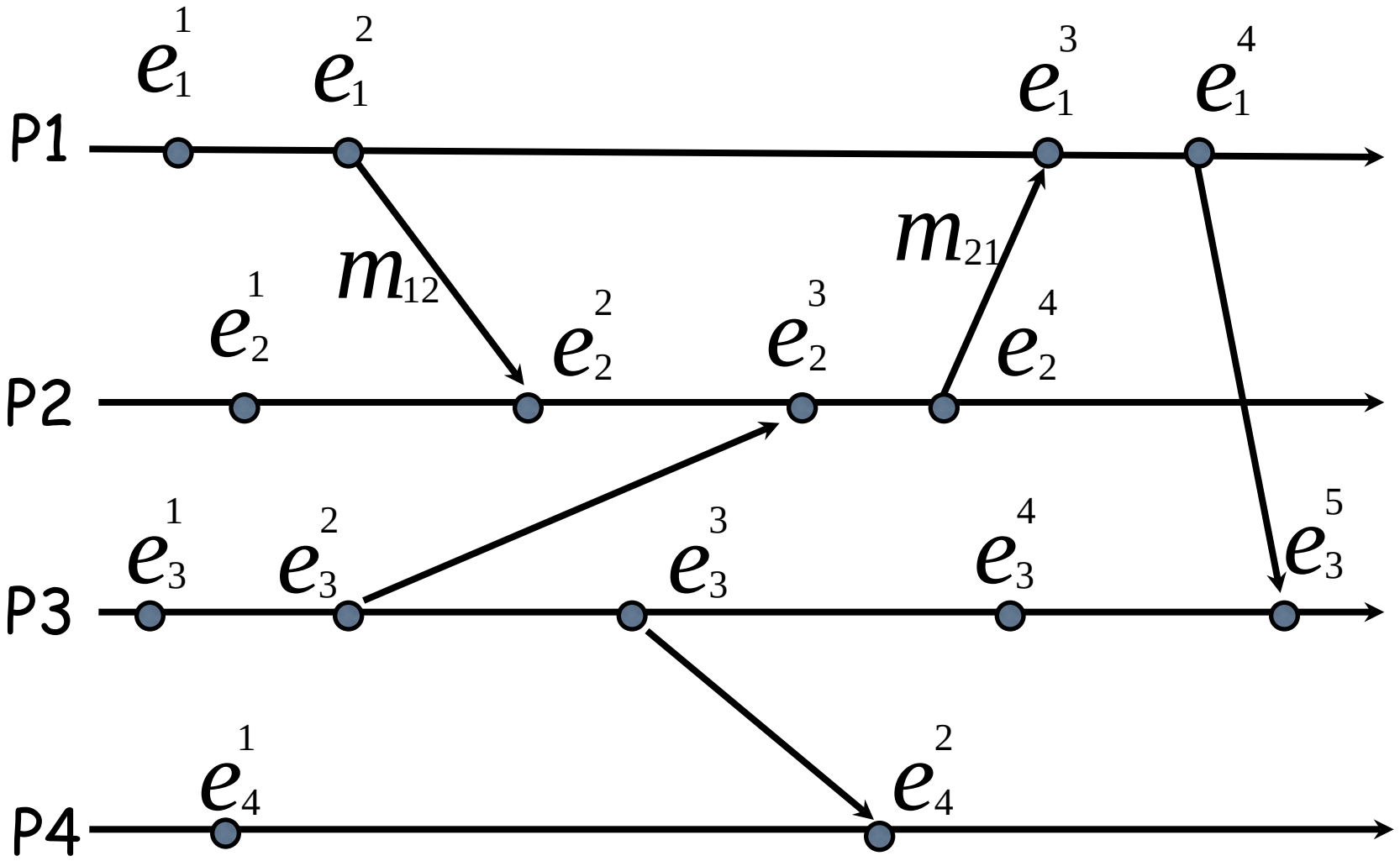
Synchronous Execution

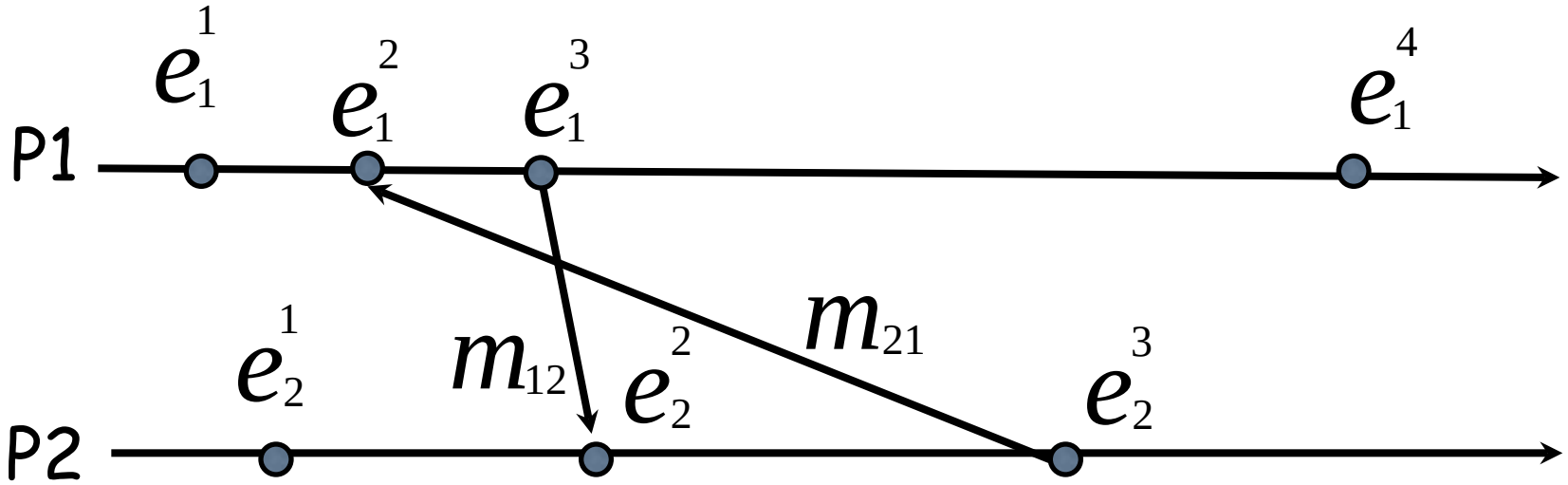


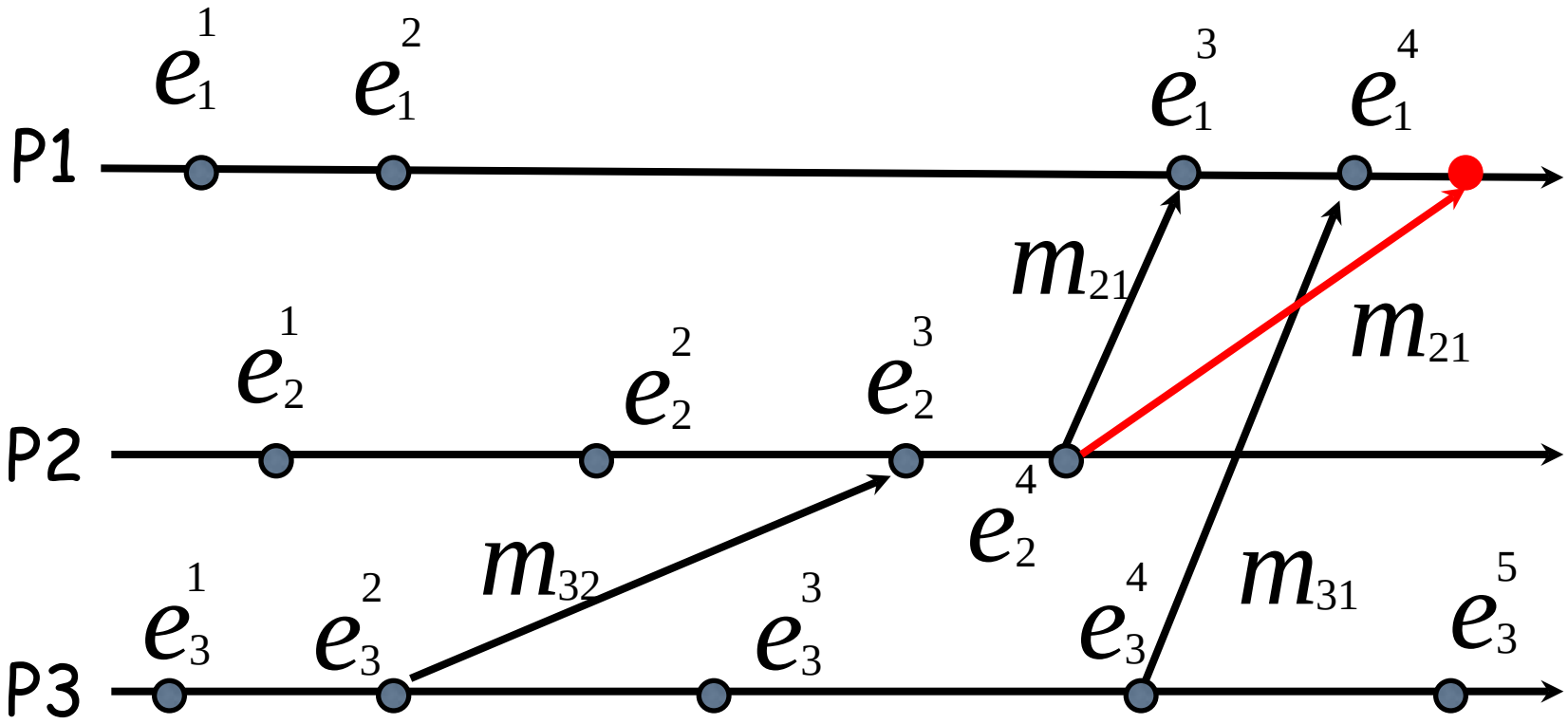
Common clock, number of rounds

Asynchronous Communication




P1
P2
P3
P4
e_1^1
e_1^2
e_1^3
e_1^4
e_2^1
e_2^2
e_2^3
e_2^4
e_3^1
e_3^2
e_3^3
e_3^4
e_3^5
e_4^1
e_4^2
m_{12}
m_{21}


e_1^1
e_1^2
e_1^3
e_1^4
P1
m_{21}
m_{12}
e_2^1
e_2^2
e_2^3
P2


P1
P2
P3
e_1^1
e_1^2
e_1^3
e_1^4
e_2^1
e_2^2
e_2^3
e_2^4
e_3^1
e_3^2
e_3^3
e_3^4
e_3^5
m_{21}
m_{21}
m_{32}
m_{31}

Communication

- Not a POSET

$$e_i^x \rightarrow e_j^y \wedge e_j^y \rightarrow e_i^x$$

- ASYNC (a POSET)

- FIFO

$$e_i^x \rightarrow e_j^y \wedge e_i^{x'} \rightarrow e_j^{y'}; e_i^x \rightarrow e_i^{x'} \Rightarrow e_j^y \rightarrow e_j^{y'}$$

- Causal Order

$$\text{send}(m_{ij}) \rightarrow \text{send}(m_{kj}) \Rightarrow \text{recv}(m_{ij}) \rightarrow \text{recv}(m_{kj})$$

- SYNC

State of Channel

All messages that have been sent but not yet received.

$$S_{ij}^{x,y} = \left\{ m_{ij} : \text{send}(m_{ij}) \leq \text{recv}(m_{i,j}) > LS_j^y \right\}$$

LS_j^y The state of process j after the occurrence of event e_j^y

Global State

$$GS = \left\{ \bigcup_{i} LS_i^{x_i}, \bigcup_{j,k} S_{jk}^{y_j, z_k} \right\}$$

Consistent or Inconsistent

Terms

- Concurrent
- Cut some Global State
- Consistent, transitless (no outstanding messages), strongly consistent (consistent and transitless)

Ordered Communication Hierarchy