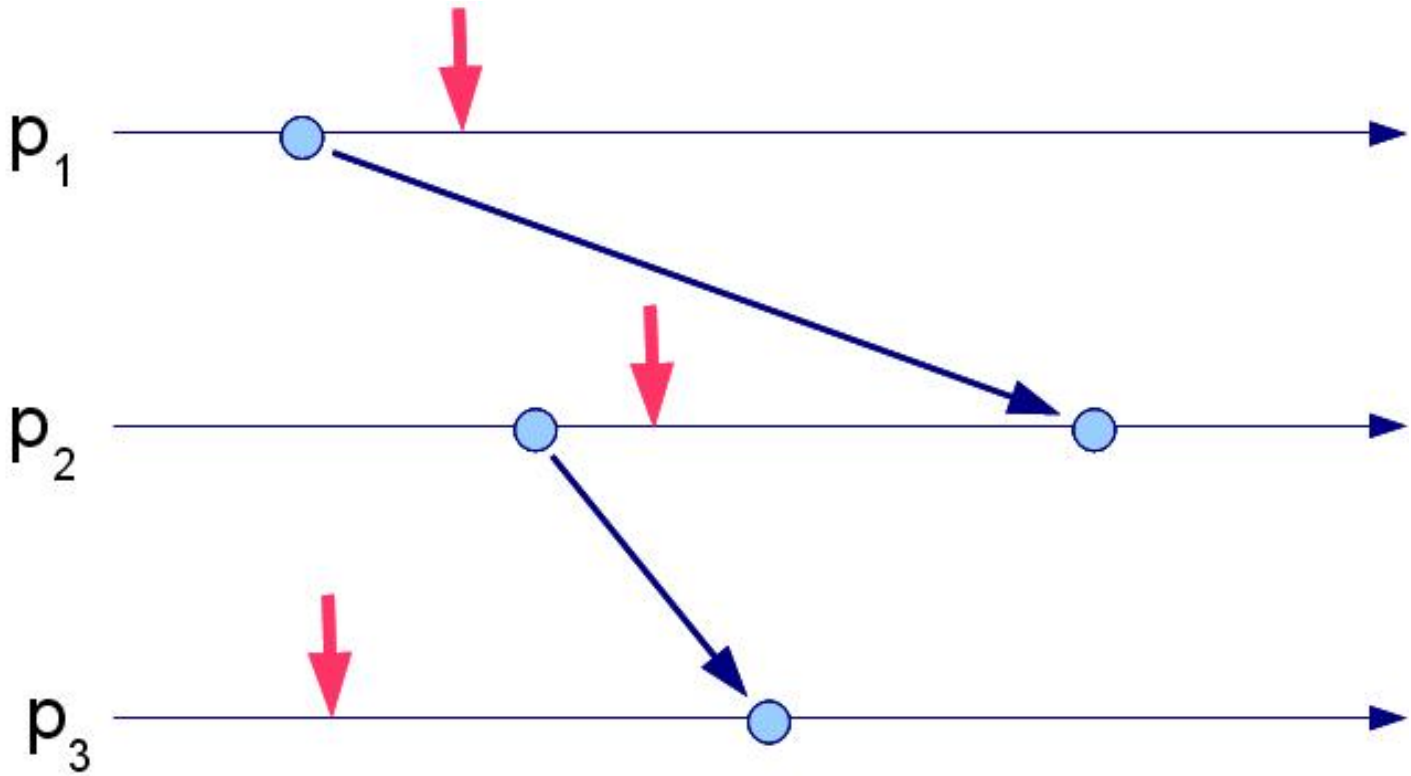
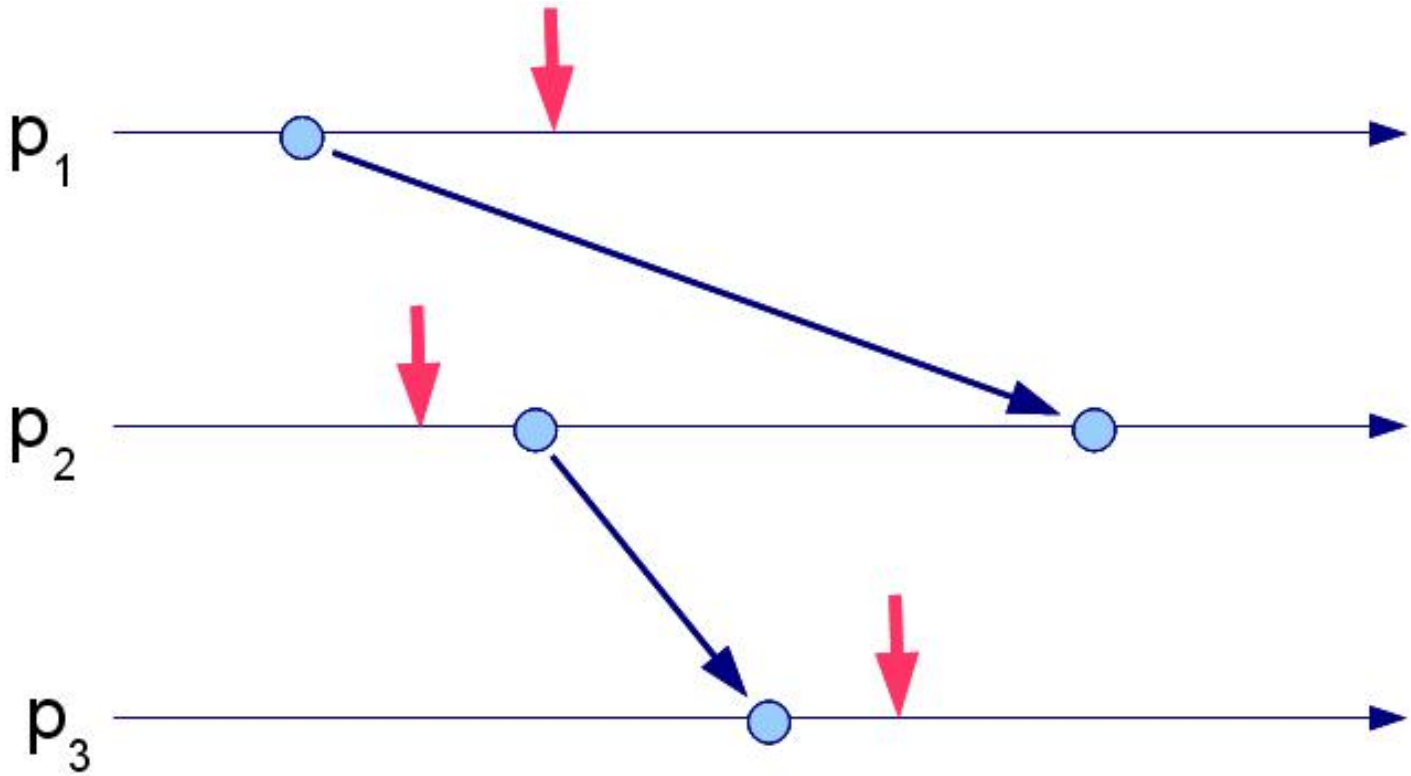
Snapshot - shot of distributed computation

consistent shot

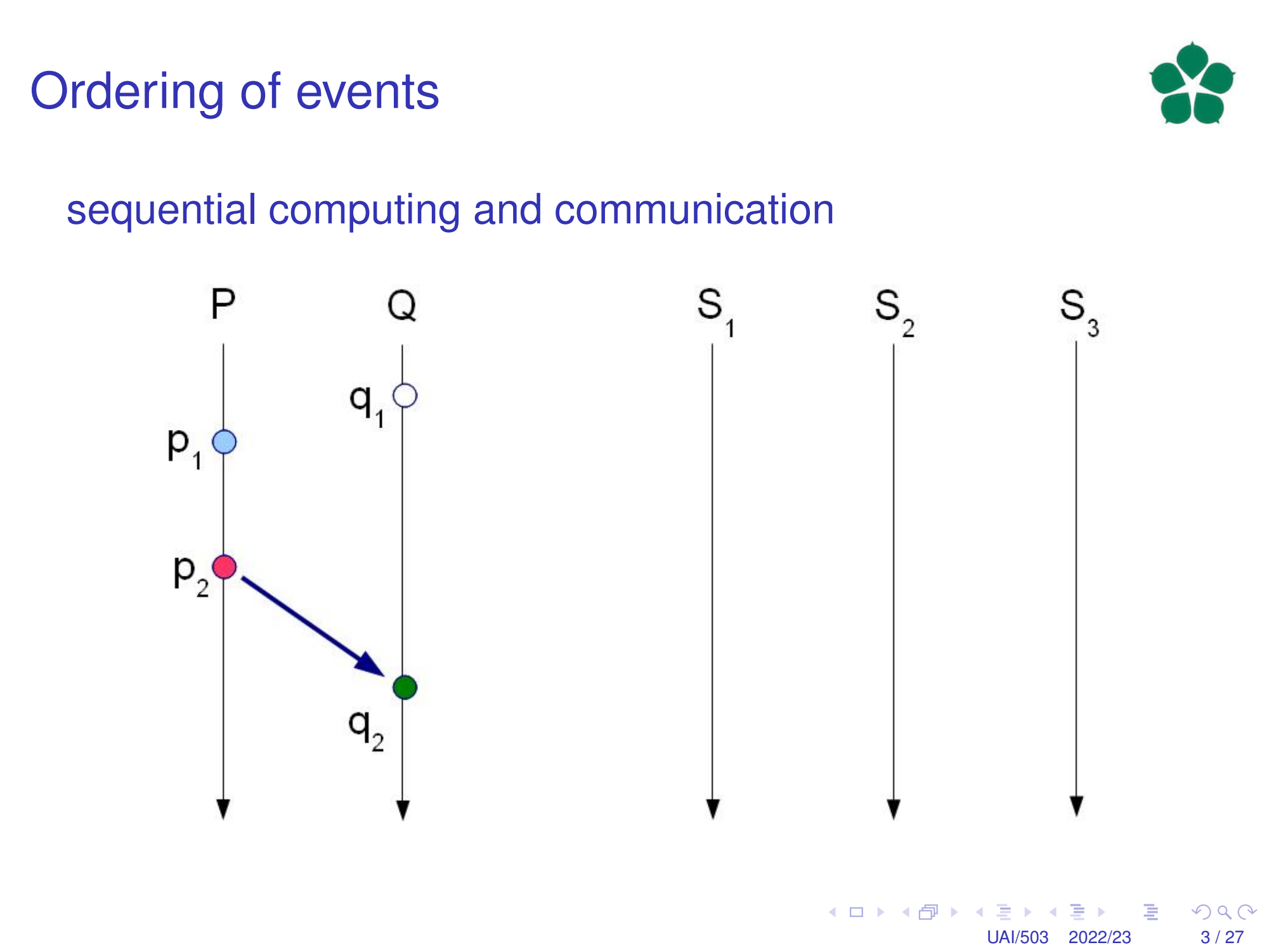


Snapshot - shot of distributed computation

inconsistent shot

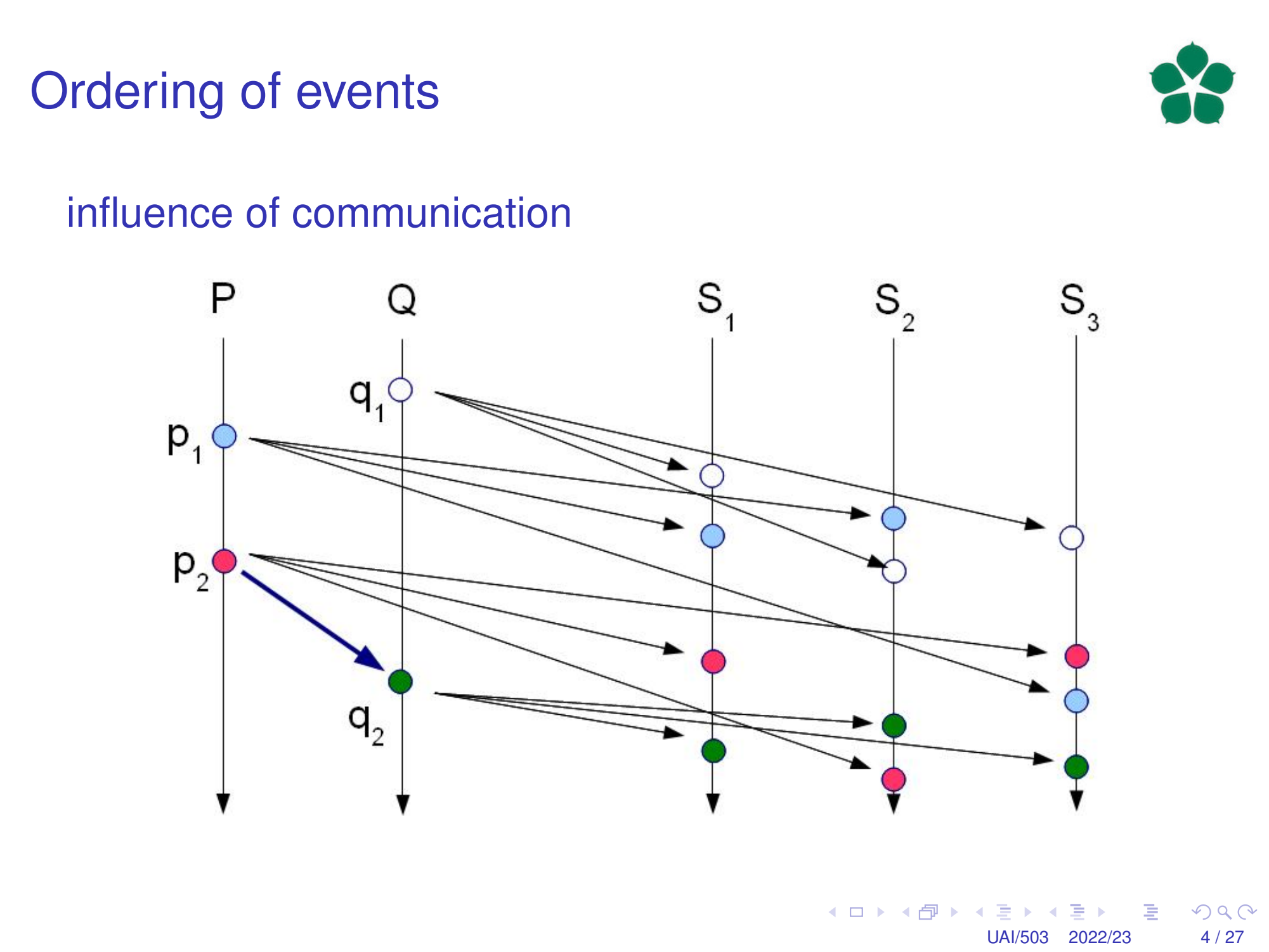


Ordering of events



sequential computing and communication

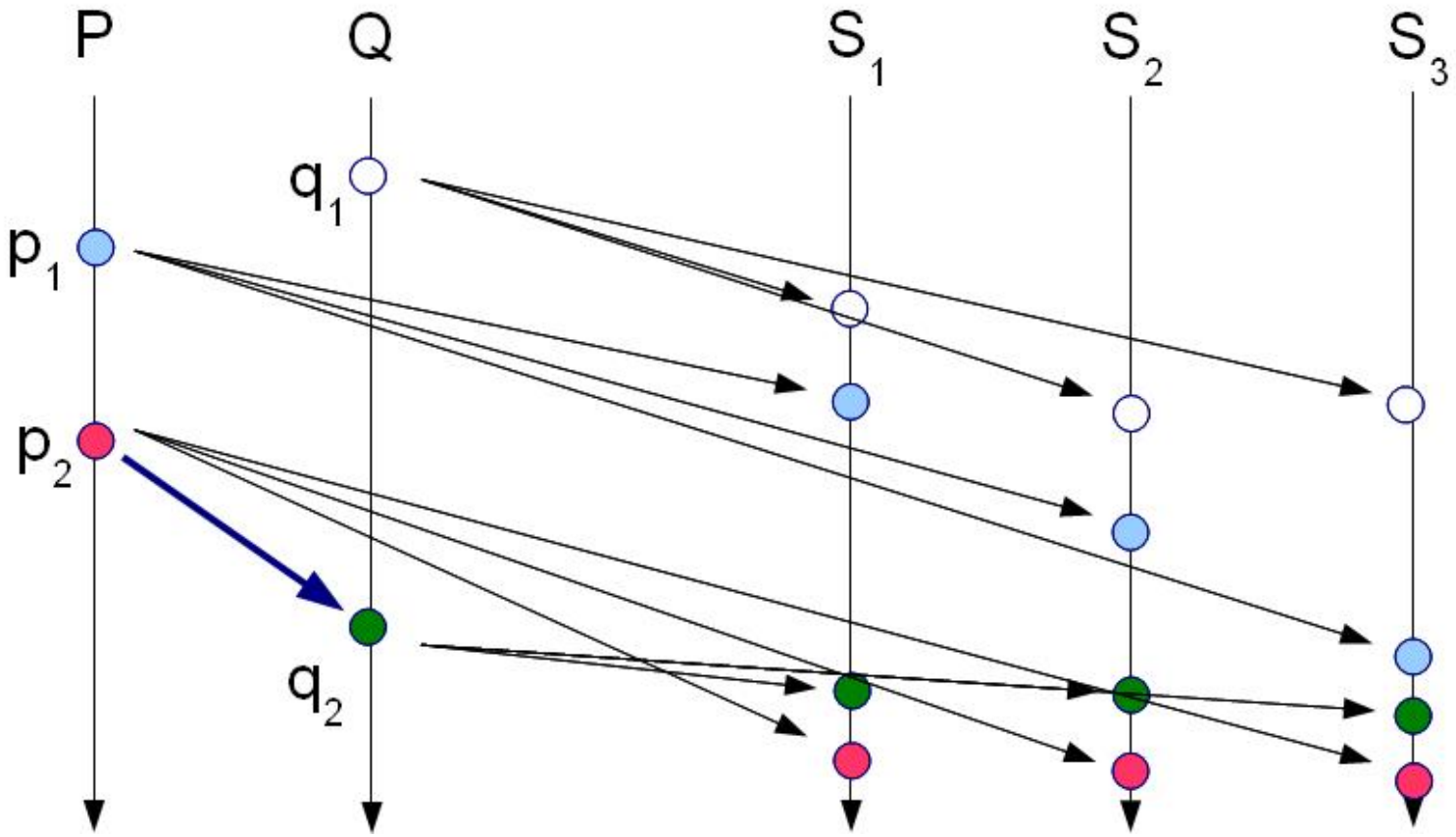
Ordering of events



influence of communication

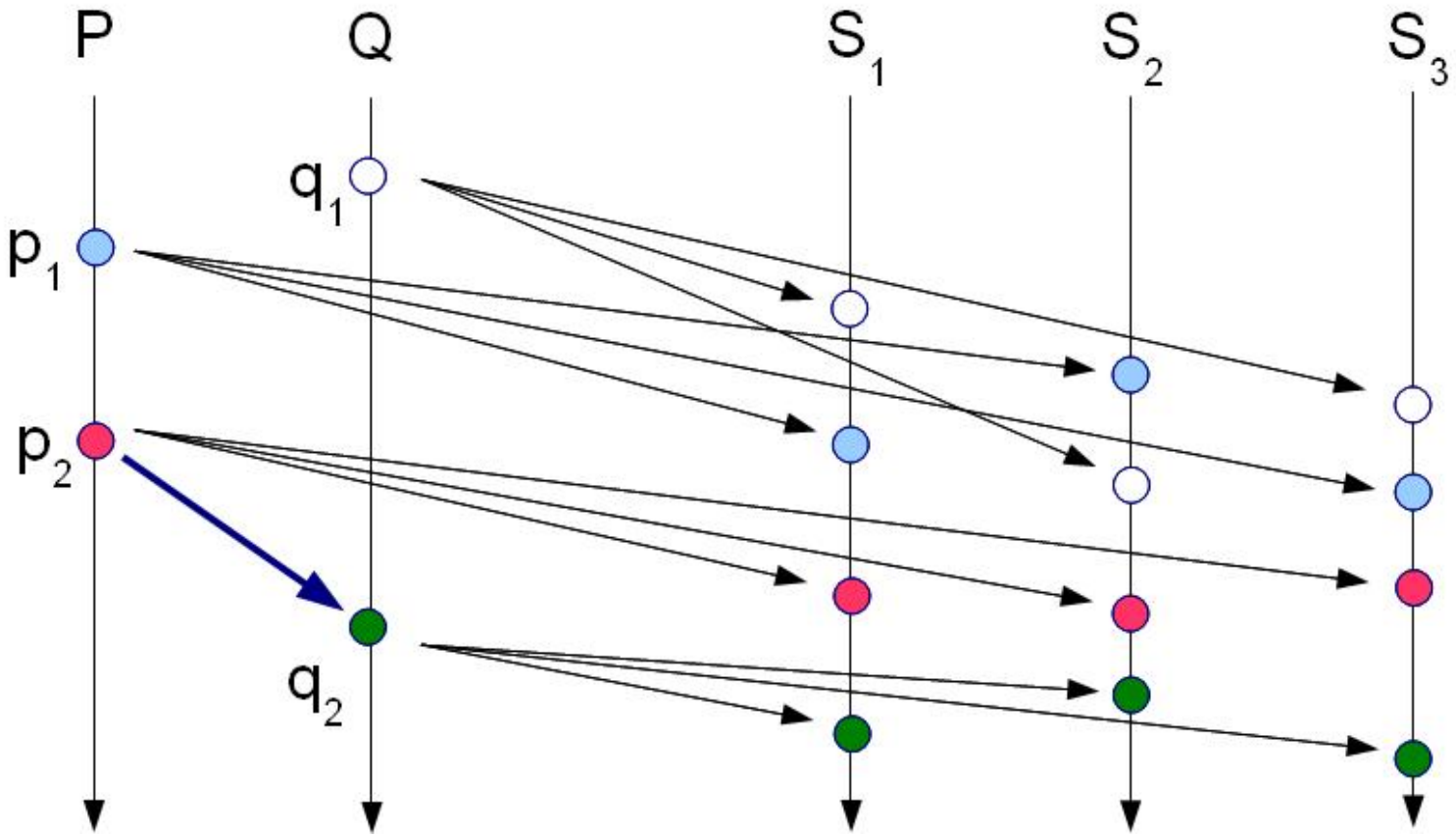
Ordering of events

full ordering



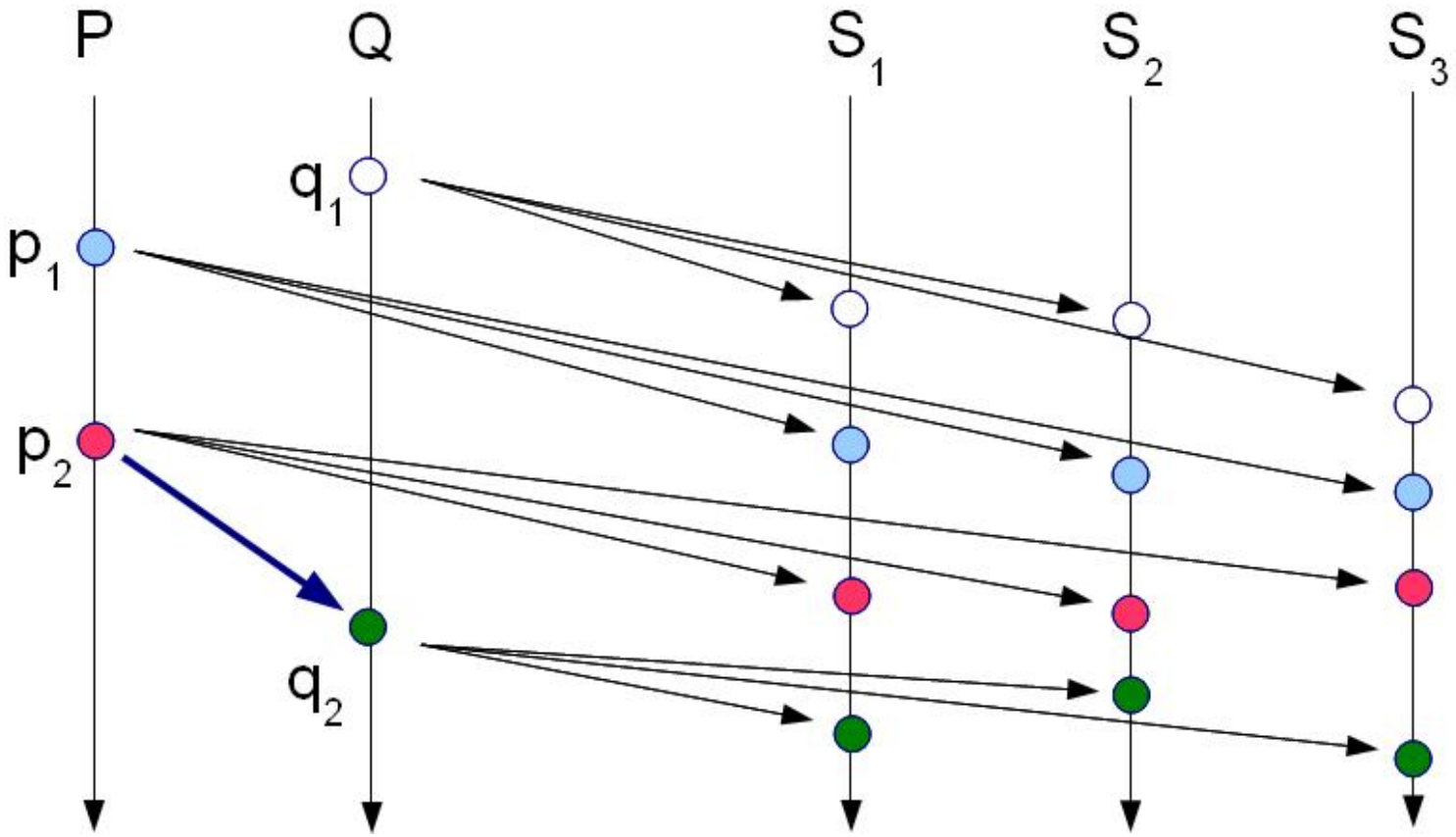
Ordering of events

causal ordering



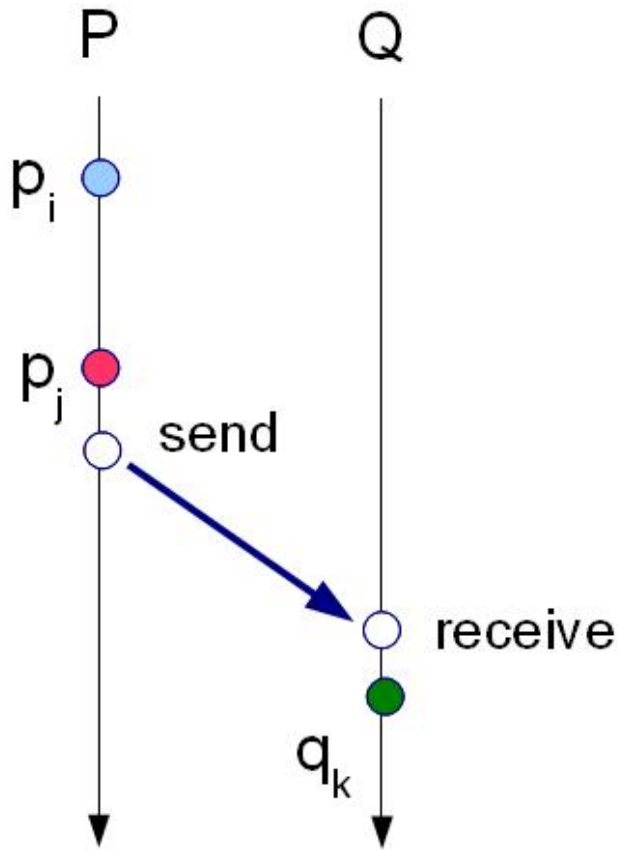
Ordering of events

full and causal ordering



Logic clock

relation



Interprocess

$$p_i \xrightarrow{!} p_j$$

communication

$$p_j \xrightarrow{!} q_k$$

Logic clock

relation

transitive

$$(a \rightarrow b) \wedge (b \rightarrow c) \Longrightarrow a \rightarrow c$$

asymmetric

$$(a \rightarrow b) \not\Leftrightarrow (b \rightarrow a)$$

concurency

Df: $\quad (a \not\rightarrow b) \wedge (b \not\rightarrow a)$

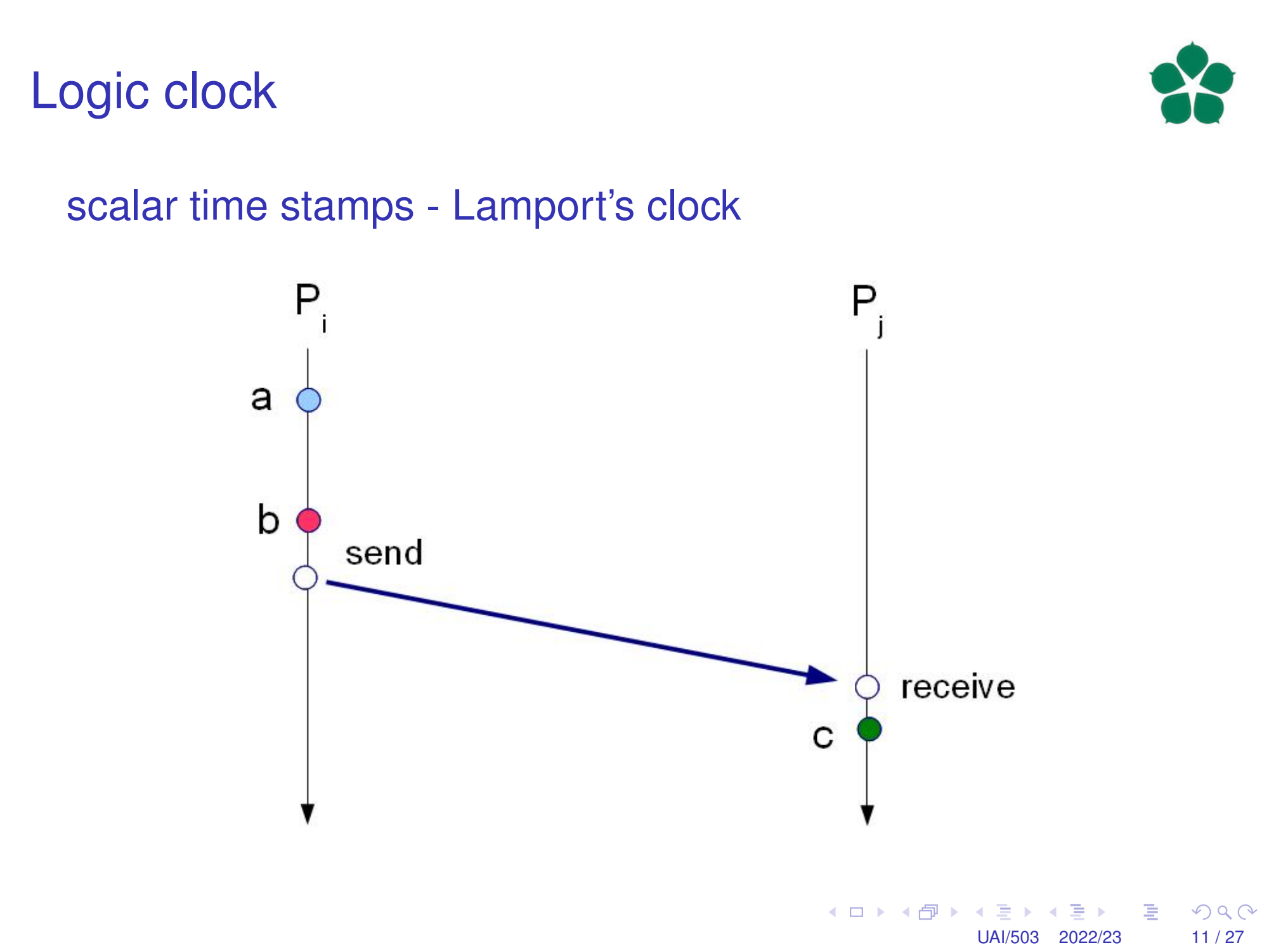
Logic clock

scalar time stamps - Lamport's clock

Df: $C : a \rightarrow C(a)$

$$\forall a, b : a \rightarrow b \Rightarrow C(a) < C(b)$$

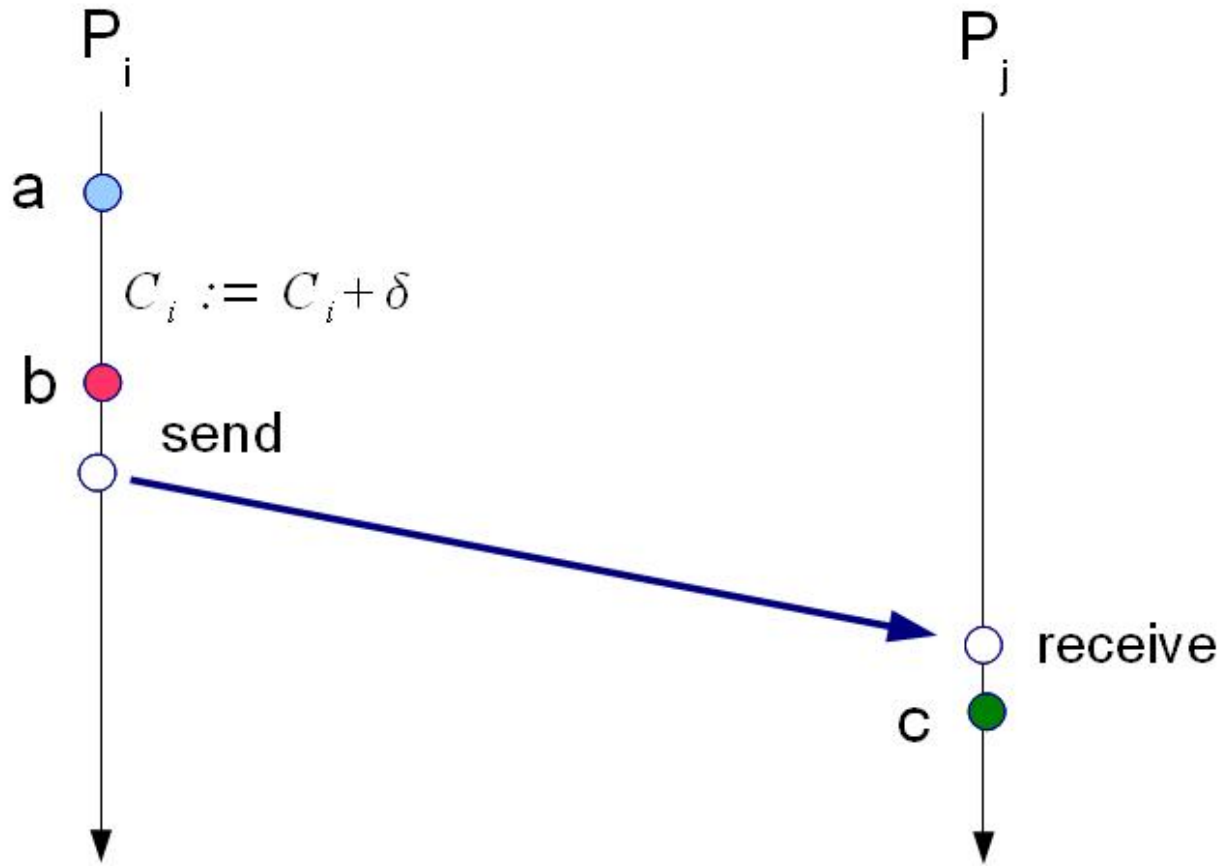
Logic clock



scalar time stamps - Lamport's clock

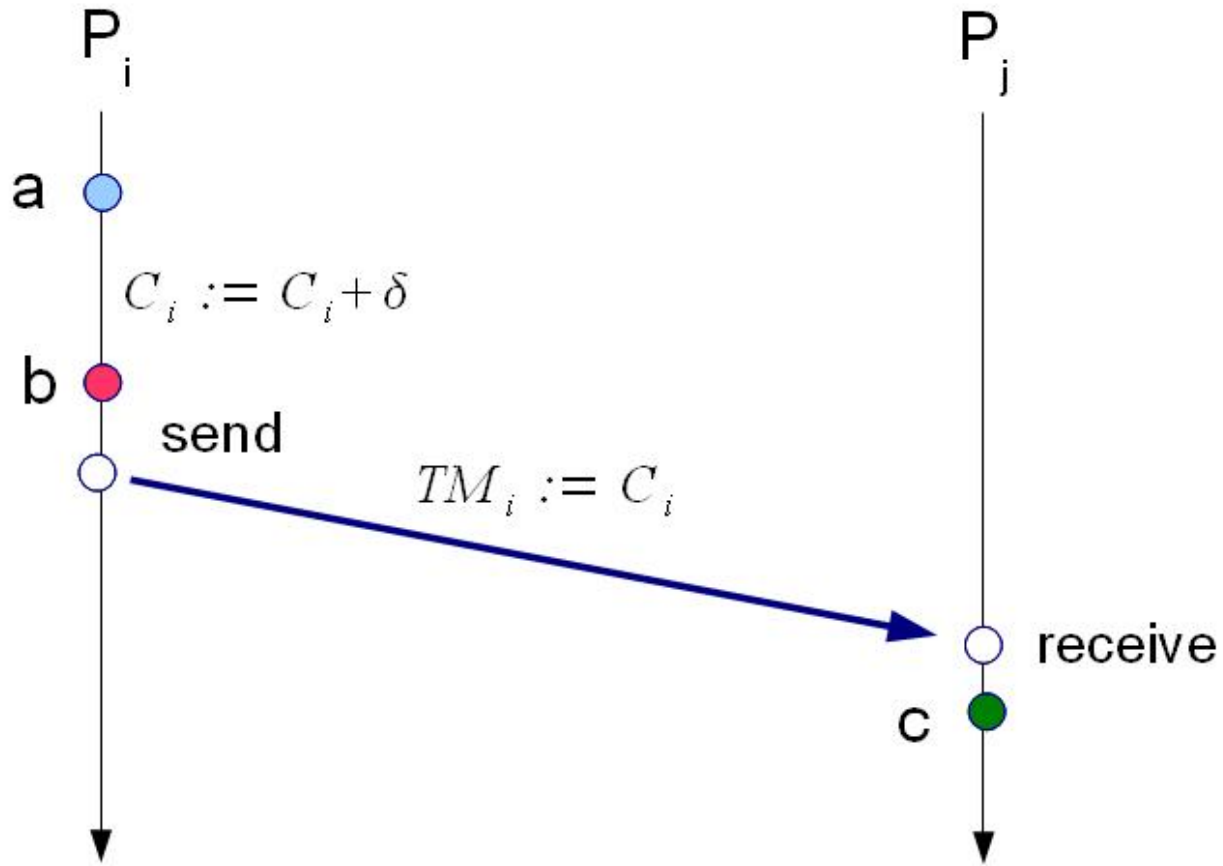
Logic clock

scalar time stamps - Lamport's clock

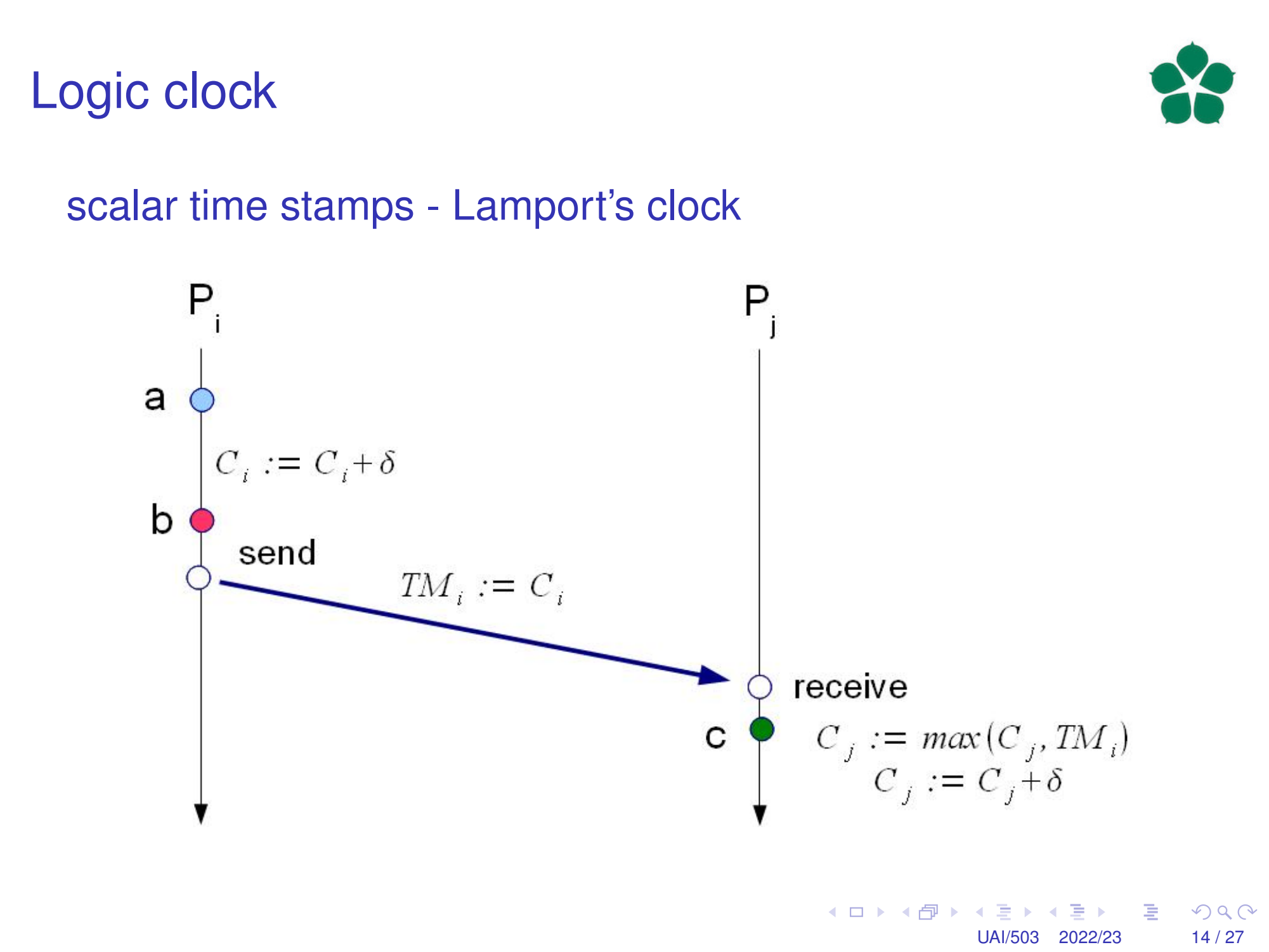


Logic clock

scalar time stamps - Lamport's clock



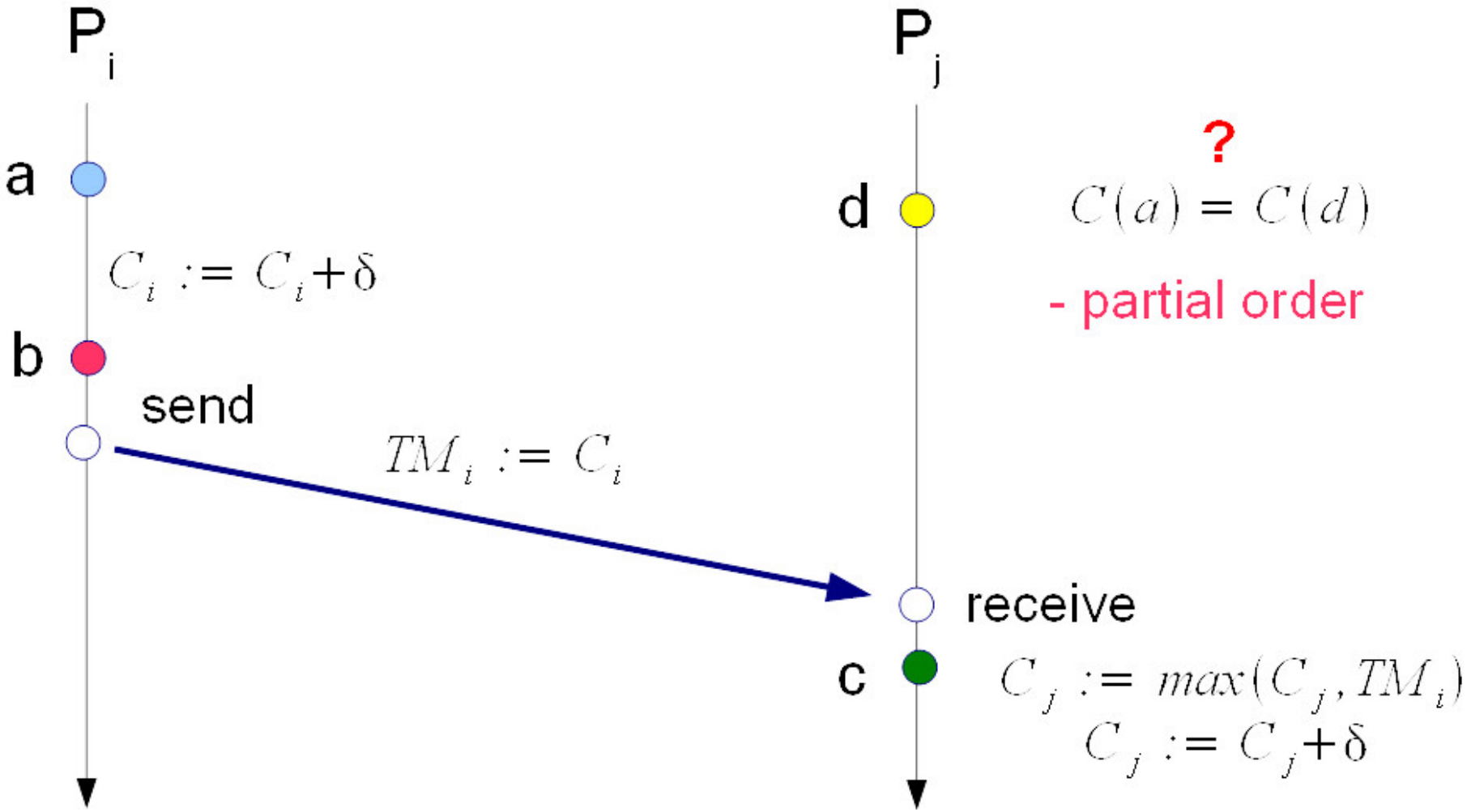
Logic clock



scalar time stamps - Lamport's clock

Logic clock

scalar time stamps - Lamport's clock



Logic clock

scalar time stamps - Lamport's clock

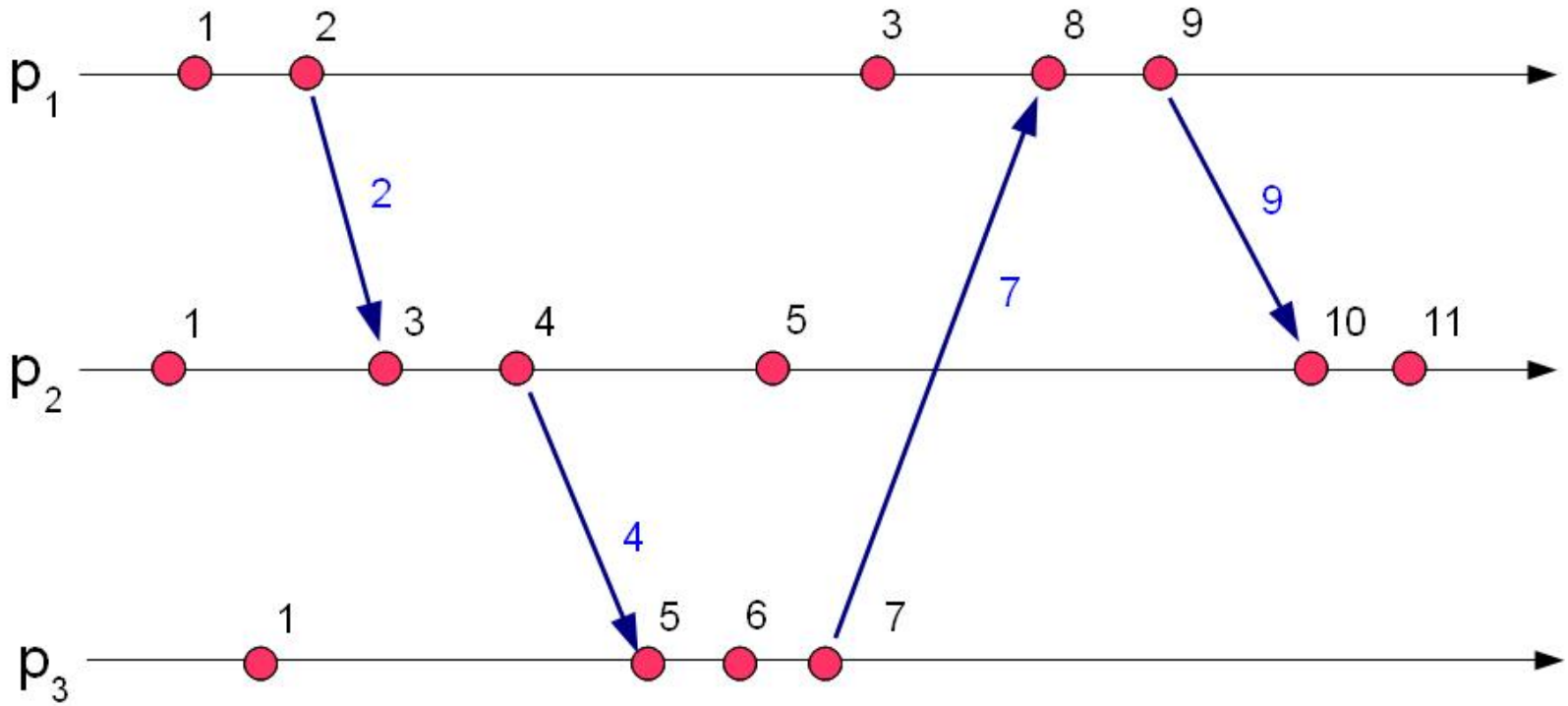
completion to full ordering

$a \Rightarrow b$

1. $C(a) < C(b)$
2. $(C_i(a) = C_j(b)) \wedge (i<j)$

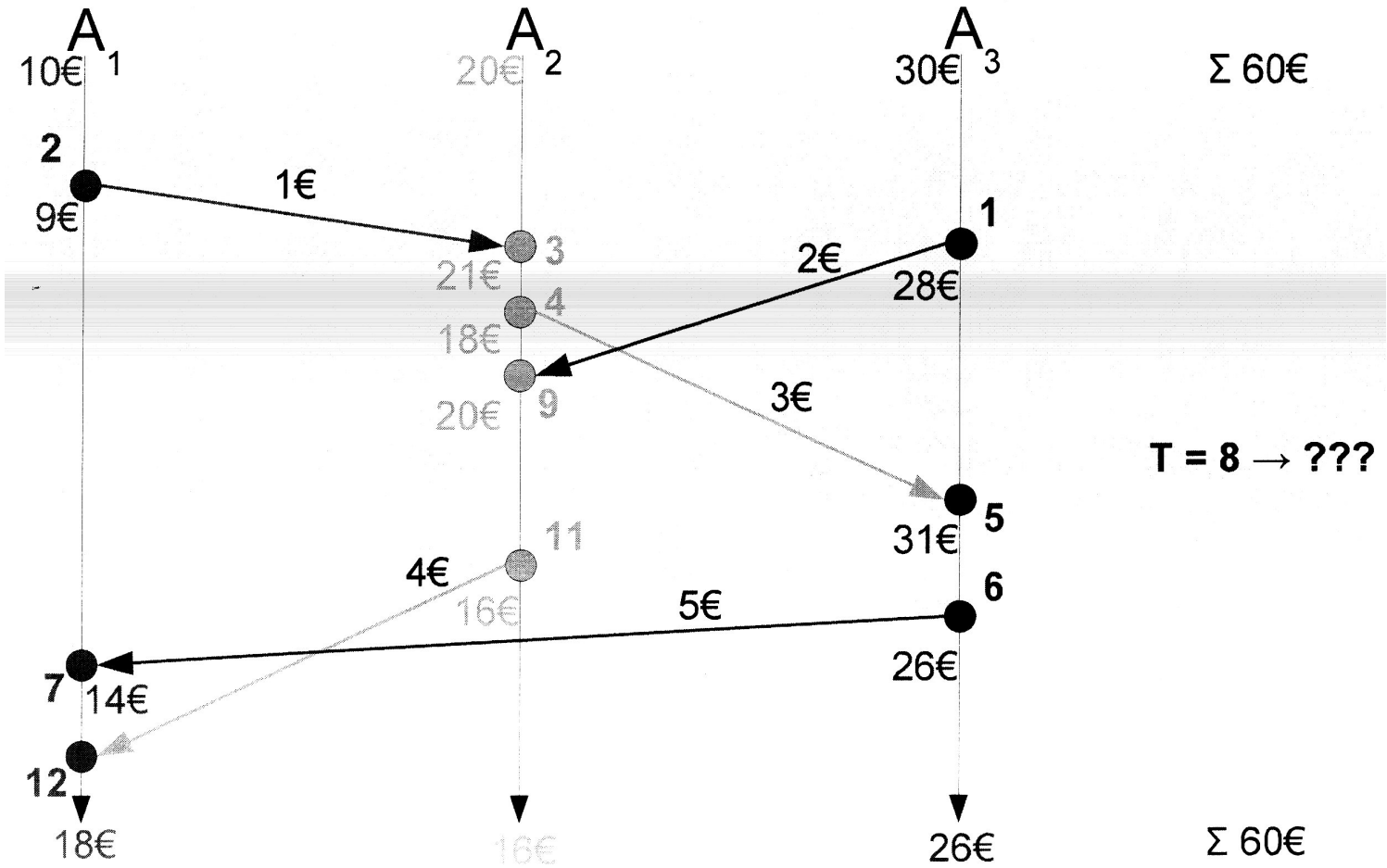
Logic clock

scalar time stamps - Lamport's clock



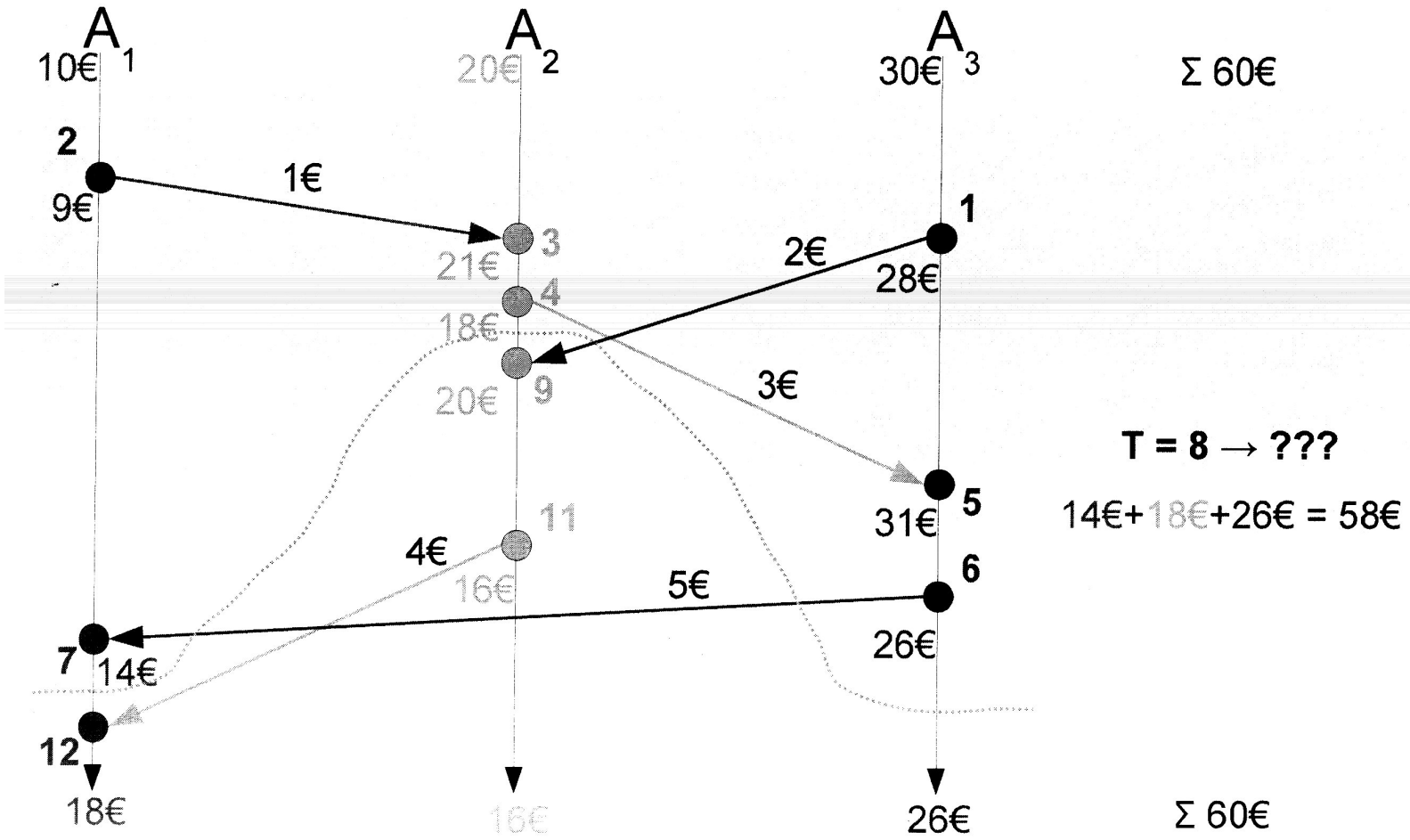
Logic clock

usage in banking



Logic clock

usage in banking



Logic clock

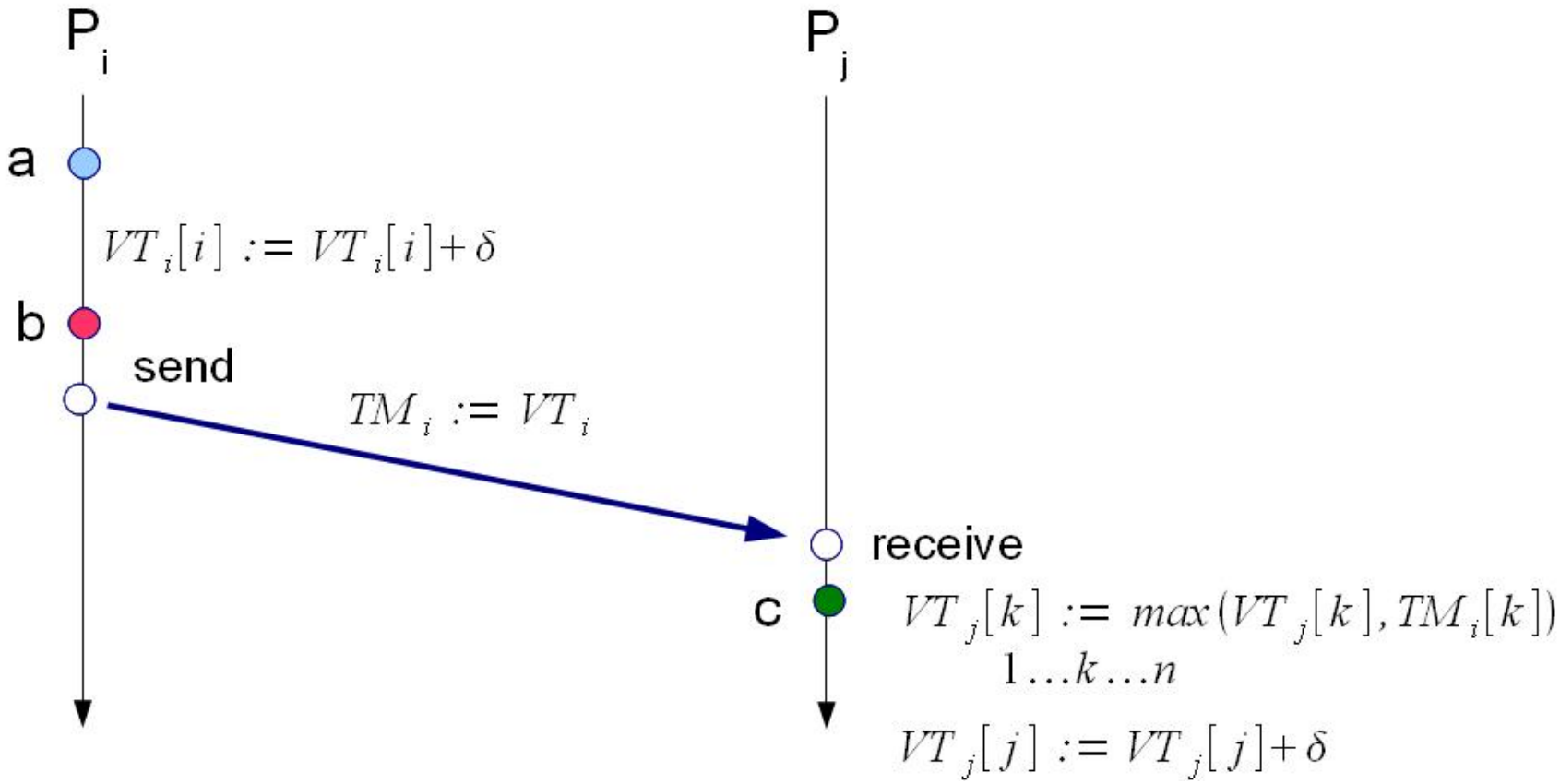
scalar time stamps - Lamport's clock

no strong consistency

$$C(a) < C(b) \qquad \not\Rightarrow \qquad a \rightarrow b$$

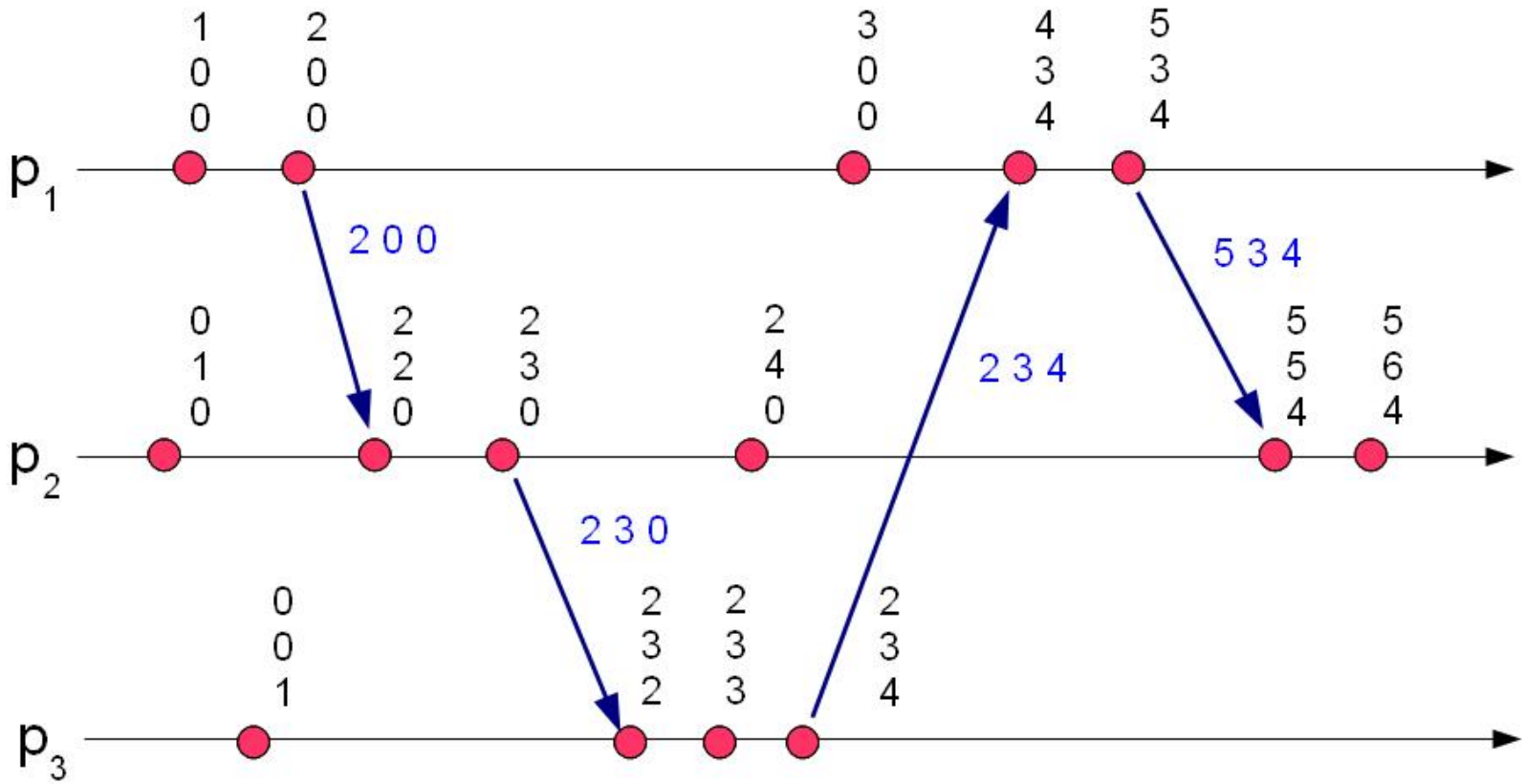
Logic clock

vector time stamps - vector clock



Logic clock

vector time stamps - vector clock



Logic clock

vector time stamps - vector clock

isomorphism

events ordering $\Leftrightarrow$ ordering of time stamps

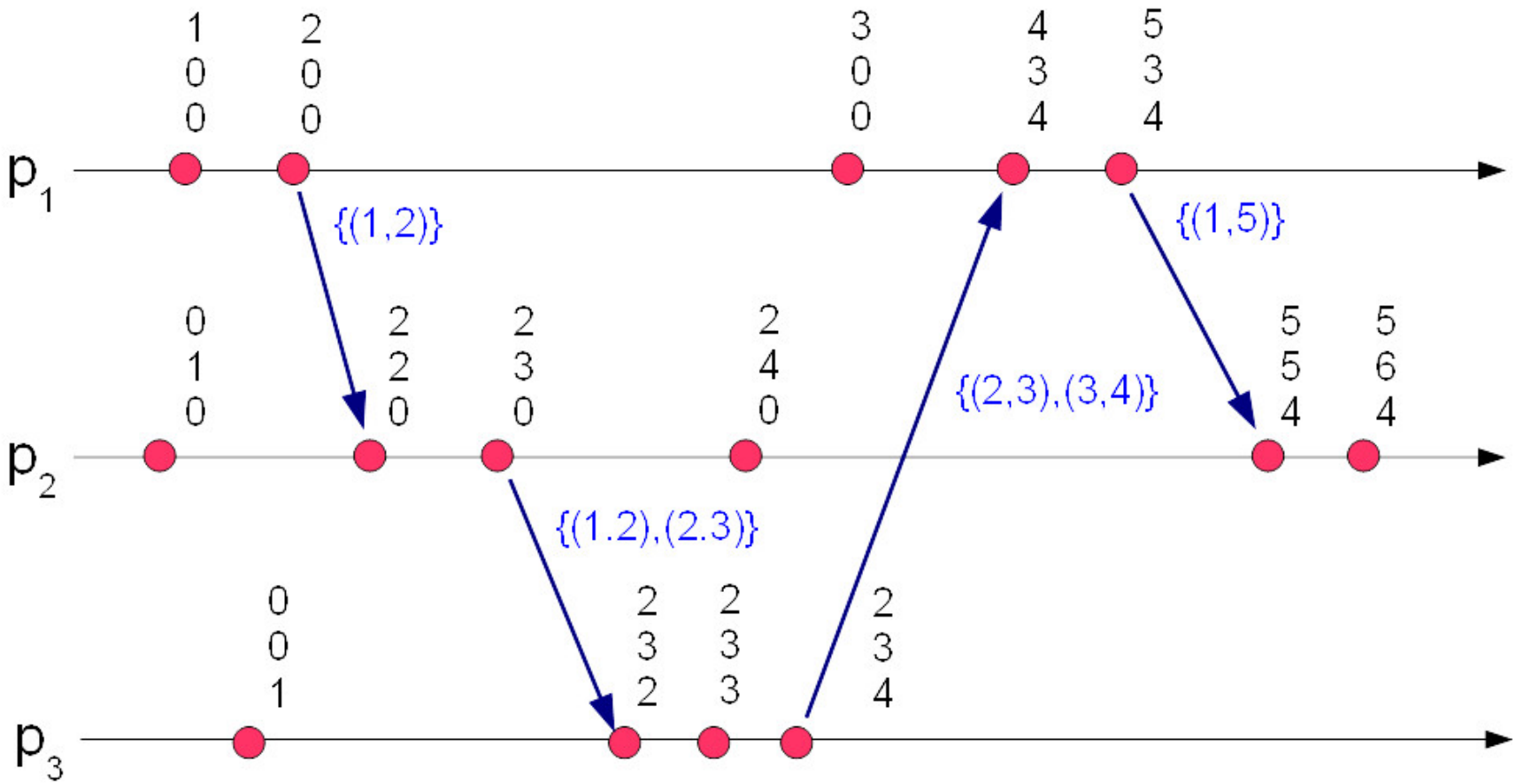
$$h \rightarrow k \quad \Leftrightarrow \quad VT_h < VT_k$$
$$\forall_{1 \leq i \leq n} \left(VT_h[i] \leq VT_k[i] \right)$$

usage

establishing of replicated data consistency

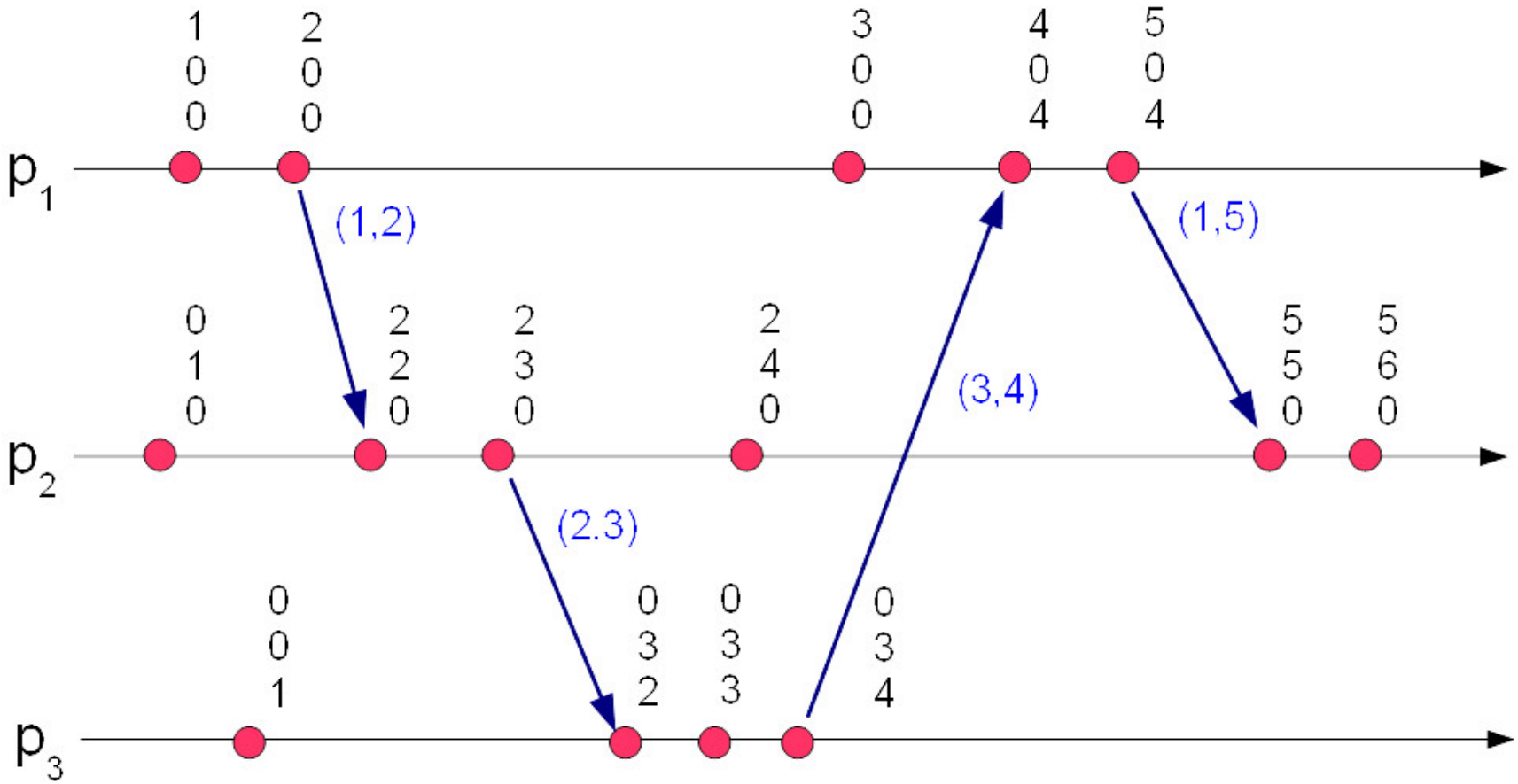
Logic clock

Singhal-Kshemkalyani's differential technique



Logic clock

Fowler-Zwaenepoel's direct-dependency technique



information about causal relations in processes

Logic clock

matrix time stamps - tensor clock

matrix

the process has full information about knowledge of its local time in other processes

$$min_{\forall(k,l)}\ [mt_i[k,l])] \quad \geq \quad t_i$$

usage

establishing of replicated data robustness for processor faults