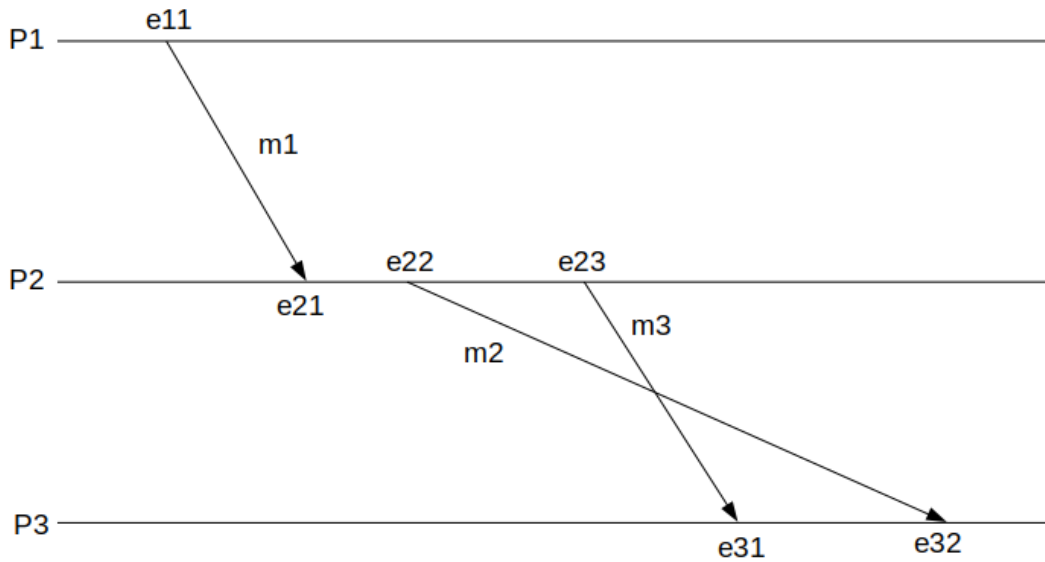


Theory Assignment 1: Clocks & Snapshots

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1. Consider the below timeline. As in Singhal-Kshemkalyanis we send only the changed values, the messages and time at the events are as follows



(All processes start with clock $[0, 0, 0]$ and increment for every event.)

$$C(e_{11}) = [1, 0, 0]$$

$$C(e_{21}) = [1, 1, 0]$$

$$C(e_{22}) = [1, 2, 0]$$

$$C(e_{23}) = [1, 3, 0]$$

$$C(e_{31}) = [0, 3, 1]$$

$$C(e_{32}) = [1, 3, 2]$$

$$m_1 = \{(1, 1)\}$$

$$m_2 = \{(1, 1), (2, 2)\}$$

$$m_3 = \{(2, 3)\}$$

Here m_2 and m_3 are not FIFO.

From m_3 , $e_{23} < e_{31}$

And $e_{22} < e_{23}$

$$\therefore e_{22} < e_{31} \implies C(e_{22}) < C(e_{31}) \text{ --- (1)}$$

But

$$C(e_{22}) \not\leq C(e_{31}), C(e_{31}) \not\leq C(e_{22})$$

$$\implies C(e_{22}) \parallel C(e_{31}) \text{ --- (2)}$$

(1) and (2) contradict. Hence Singhal-Kshemkalyanis will not work correctly if the channels are not FIFO.

2. **Modification:** Send control messages only over a spanning tree of the channels.

How it works?

- i. Assumption: Initially all nodes are made know about the topology of the systems and the spanning tree in the system.
- ii. When a node receives a marker message
 - a. Take the snapshot as described in Lai-Yang algorithm.
 - b. Send marker messages only to the outgoing channels in the spanning tree.
 - c. As in the spanning tree there is only 1 incoming edge for every node, send the snapshot to the collector as soon as we send markers to other nodes.

How $O(N)$?

- i. The number of marker messages sent are equal to the number of edges in the spanning tree, which is $N - 1$ (where N is the number of nodes). Which is $O(N)$.
- ii. Every node sends its snapshot to the collector, which is again only N messages (1 per node). Which is $O(N)$ again.

$$\therefore O(N) + O(N) = O(N)$$