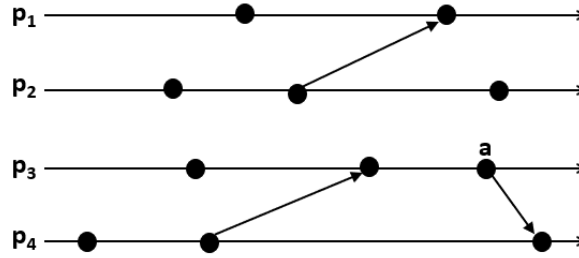


Instructions:

- (1) Submit your assignment solution as a single pdf file on moodle.
- (2) This is an individual assignment.
- (3) You may write and scan your work (pen and paper), or use tools like Word or Overleaf.

Part 1: Answer the questions given below considering the following space-time diagram of a distributed execution involving four processes.



- (1) Annotate with scalar time. [0.5 Marks]
- (2) Annotate with vector time. [0.5 Mark]
- (3) Annotate with matrix time. [1 Marks]
- (4) Give an example for a consistent cut. [0.5 Marks]
- (5) Give an example for an inconsistent cut. [0.5 Marks]
- (6) Give an example for happens-before relation between any two events. [0.5 Marks]
- (7) For the specific example you took for the consistent cut, what is the global state represented by the cut? **Clue:** If $e_i^{Max_PAST_i(C)}$ denotes the latest event at process p_i that is in the PAST of a cut C , then the **global state represented by the cut** is

$$\left\{ \bigcup_i LS_i^{Max_PAST_i(C)}, \bigcup_{j,k} SC_{jk}^{y_j, z_k} \right\}$$

where $SC_{jk}^{y_j, z_k} = \{m | send(m) \in PAST(C) \wedge rec(m) \in FUTURE(C)\}$. You may make reasonable assumptions on the contents of the channel. [1.5 Marks]

Part 2: You are provided with the following facts about a model of execution of a distributed system that uses global vector time stamps.

- (1) $(1, 1, 1, 1) \rightarrow (2, 1, 1, 1)$ is a happens-before relation.
- (2) Exactly two events occurred in each process.
- (3) Between the two events of every process, at least one event occurred in another process.
- (4) The first event occurred in the process p_2 .

Agreeing to the above facts:

- (1) Draw the space-time execution diagram annotated with global vector time stamps. (1.5 Marks)
 - (2) Draw the corresponding hasse diagram. (2 Marks)
 - (3) Draw the same space-time execution diagram annotated with matrix time. (1.5 Marks)
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