$\forall$ m_{ij} and m_{kj}

if send $(m_{ij}) \rightarrow$ send (m_{kj})

then recv$(m_{ij}) \rightarrow$ recv(m_{kj})

$e_1 \rightarrow e_2$

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Monsoon 2024

Distributed Systems

Quiz 1 August 26, 2024.

Instructions:

- The quiz is for 45 minutes.
- Answer all the questions. The quiz is for 25 points.
- No clarifications shall be provided during the quiz.

A global state is consistent iff it satisfies the condition that a message that is recorded as received is also recorded as sent in the state.

1. Express the conditions of causal message delivery in both words and symbols. **(Points 1.5+1.5=3)**

2. Write in words and symbols the conditions needed for a global state to be consistent. **(Points 2+2=4)**

3. Consider the algorithm of Lamport for achieving mutual exclusion using scalar time. Answer the following questions.
   a. What are the conditions needed for a process Pi to gain entry to the critical section.
   b. What are the assumptions made by the algorithm and what happens if these assumptions do not hold.
   c. Show an example of how the algorithm works with 4 processors of which at least two want to enter the critical section. Clearly mark the time at which the processors gain entry to the critical section and exit the critical section.

   (Points: 2+2+4=8)

4. Consider the following send and receive scenarios and indicate the semantics they follow with respect to being synchronous/asynchronous, or blocking/non-blocking. Justify your answers with appropriate examples.
   a. MPI Send (`MPI_Send`) and Receive (`MPI_Recv`)
   b. MPI iSend (`MPI_Isend`) and iReceive (`MPI_Irecv`)
   c. TCP send and receive
   d. UDP send and receive

   (Points: 1+1+1+1=4)

$\rightarrow e_j^y$ iff $\begin{cases} i=j \text{ and } x<y, \text{ or} \\ e_i^x \rightarrow_{msg} e_j^y, \text{ or} \\ \exists\, e_k^z \text{ in } E \text{ s.t. } e_i^x \rightarrow e_k^z \text{ and } e_k^z \rightarrow e_j^y \end{cases}$

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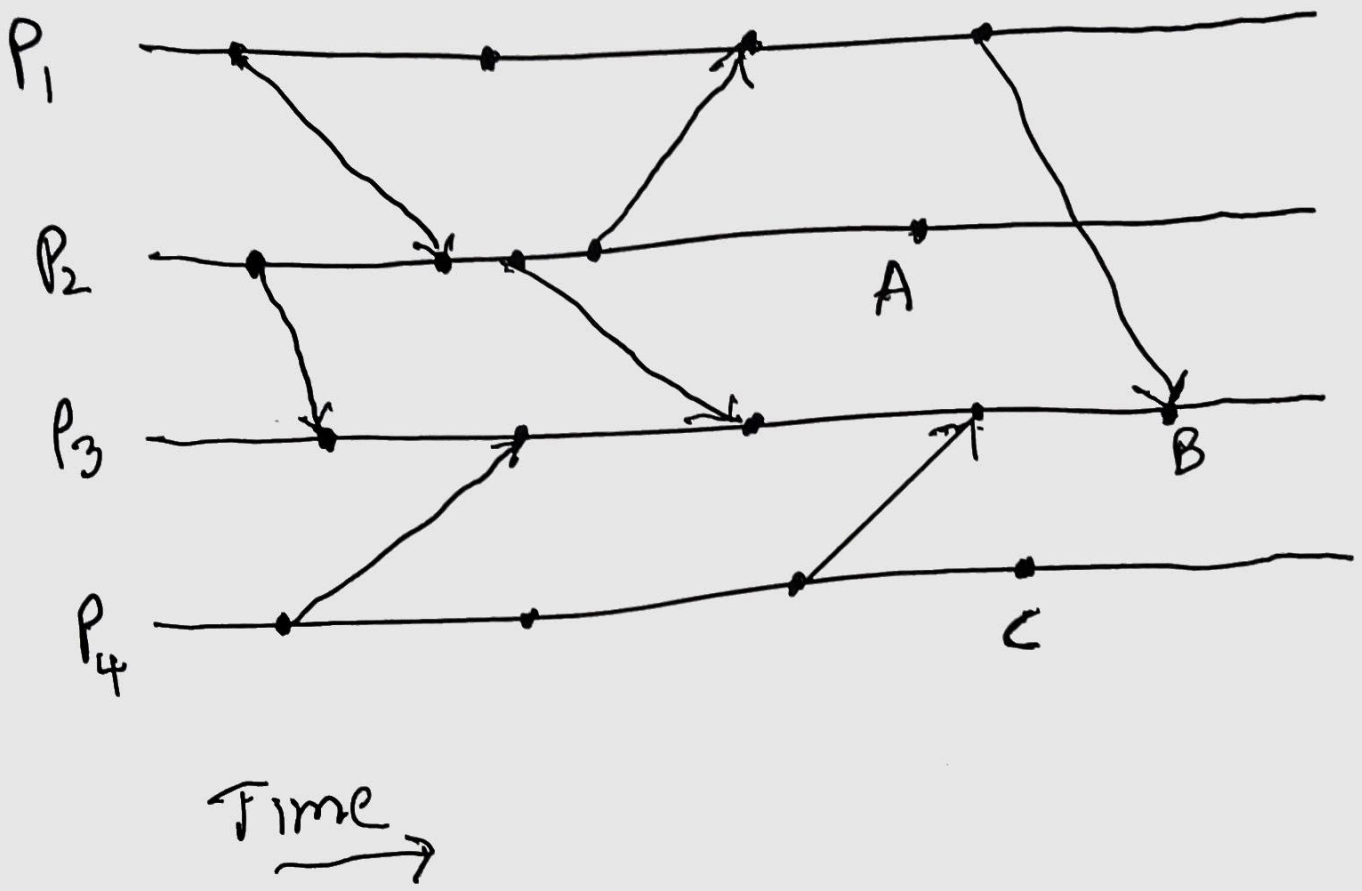
(Points: 1+1+1+1=4)

5. For the following process time diagram, answer the following questions.
   a. Find the vector time of the events labelled A, B, and C. Use an increment of 1, $d = 1$, to advance the local time.
   b. Which events are logically concurrent?
   c. Does the system indicate that the messages are delivered in causal order? Justify your answer.
   d. Is it required that all processes use the same increment, d, so that the resulting vector times are strongly consistent? Justify your answer.

(Points: 1+1+2+2=6)



$send(m_{ij}) \notin LS_i \Rightarrow recv(m_{ij}) \notin LS_j \wedge m_{ij} \notin SC_{ij}$

5. For the following process time diagram, answer the following questions.
   a. Find the vector time of the events labelled A, B, and C. Use an increment of 1, $d = 1$, to advance the local time.
   b. Which events are logically concurrent?
   c. Does the system indicate that the messages are delivered in causal order? Justify your answer.
   d. Is it required that all processes use the same increment, d, so that the resulting vector times are strongly consistent? Justify your answer.

(Points: 1+1+2+2=6)