Beyond Introduction

Distributed Systems

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State Recording

- Local State
  - State of a component
- Global State
  - Collection of local states for all the components recorded at the same instance of time
  - Snapshot recording
- How do you ensure that same instance of time?
  - Where is the problem?

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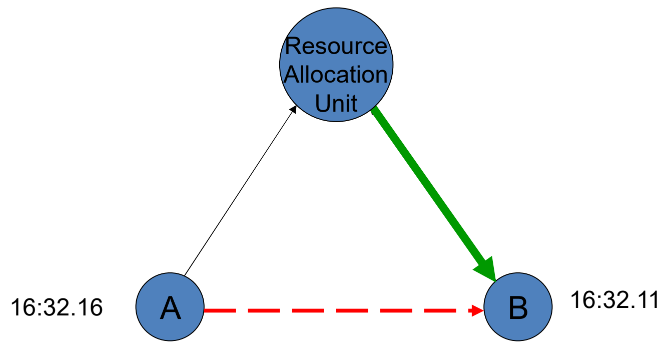
Why do we need to Time Stamp?



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Clock Model

- Every processor has its own clock
- Clocks tend to drift
- Events occurring in different nodes gets time-stamps from different clocks
- How do you the find the event order?
- What will be the CLOCK MODEL?

Mukesh Singhal and Niranjan G. Shivaratri, Advanced Concepts in Operating Systems: Distributed, Database, and Multiprocessor Operating Systems, McGraw-Hill Education Pvt Limited.

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Options with the clock

- Synchronize clocks of different nodes
  - Clocks naturally drift
  - What happens after a finite duration?
  - Synchronization of clocks involves a high overhead, but does not guarantee a full-proof solution
- Assume a Master clock in some node
  - The clock node???

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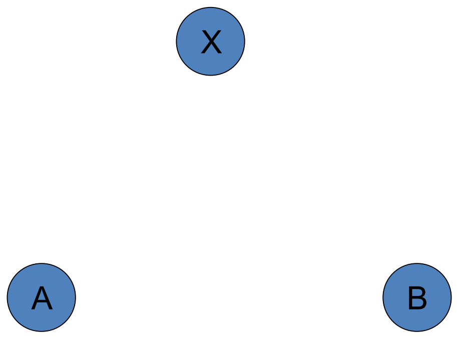
The Master Clock Option



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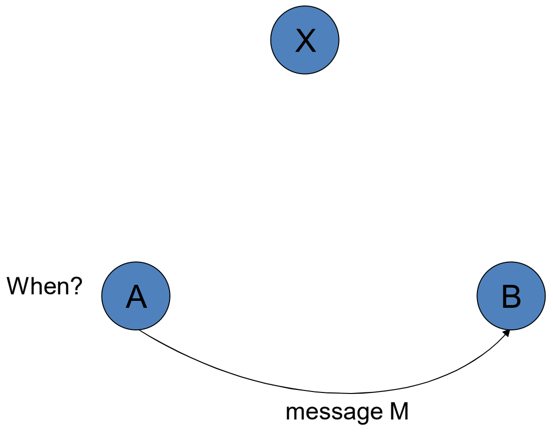
The Master Clock Option



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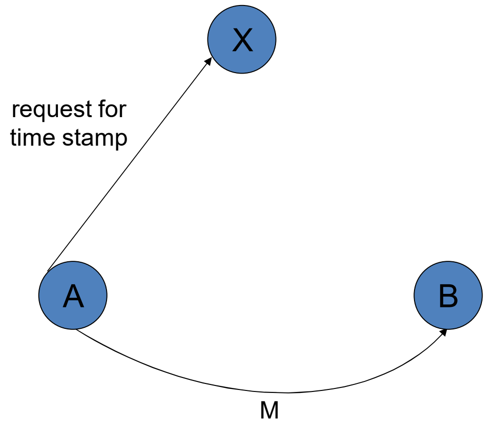
The Master Clock Option



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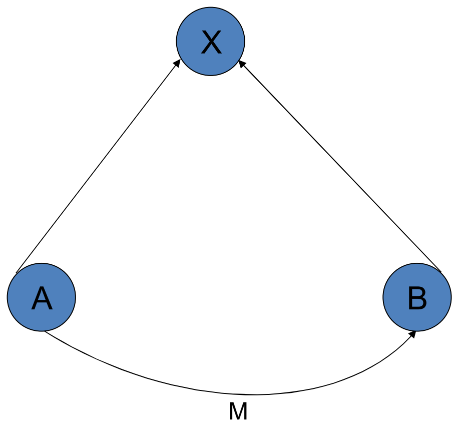
The Master Clock Option



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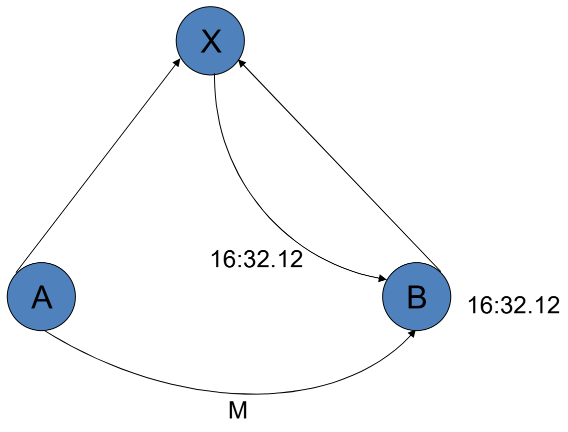
The Master Clock Option



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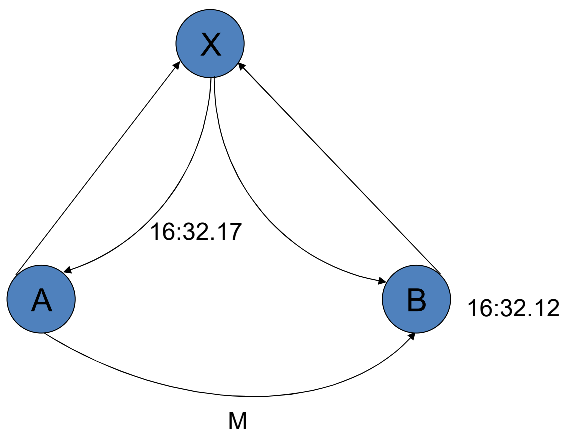
The Master Clock Option



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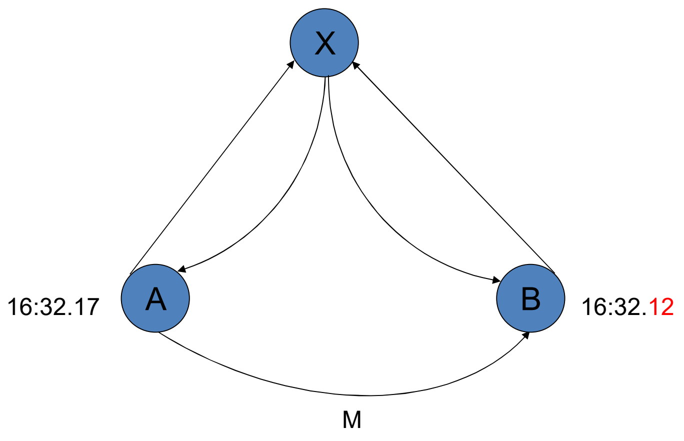
The Master Clock Option



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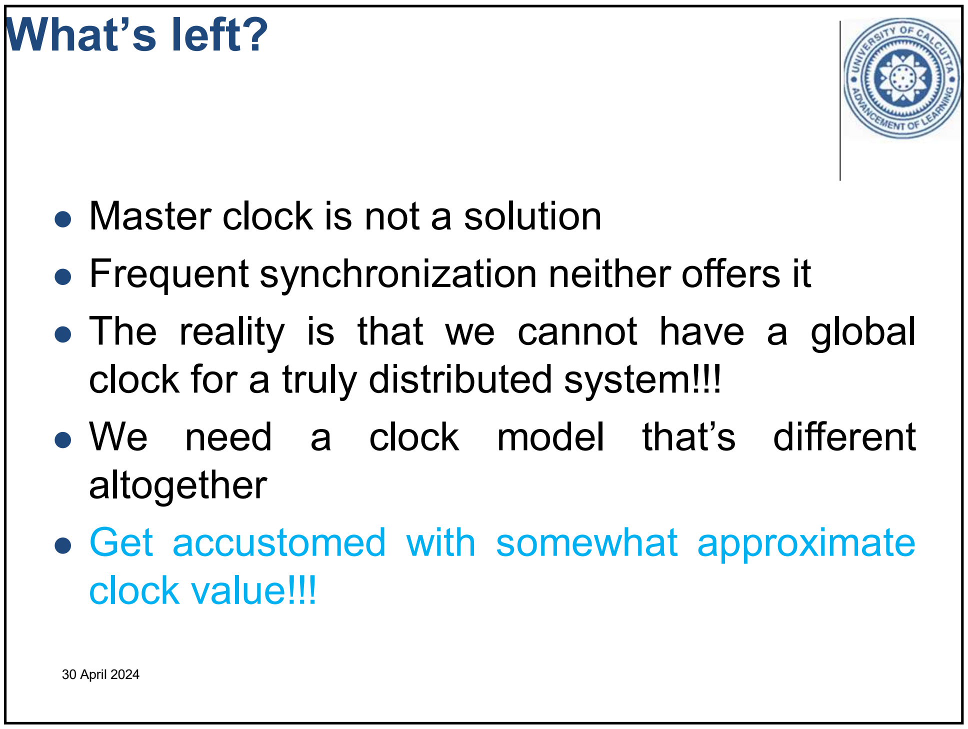

What's left?

- Master clock is not a solution
- Frequent synchronization neither offers it
- The reality is that we cannot have a global clock for a truly distributed system!!!
- We need a clock model that's different altogether
- Get accustomed with somewhat approximate clock value!!!

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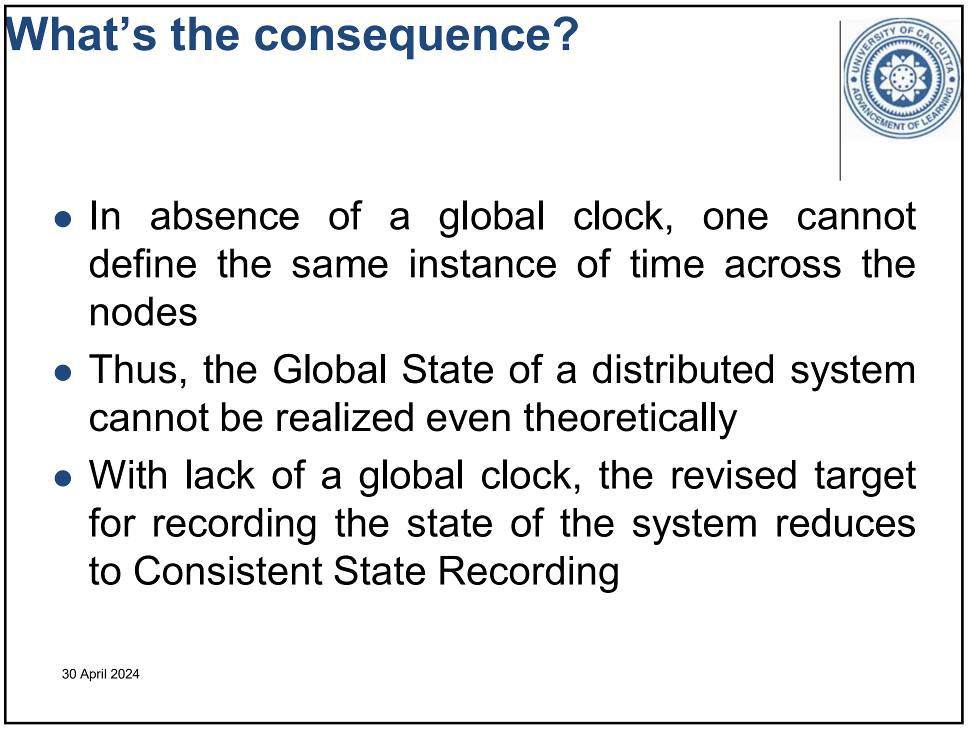

What's the consequence?

- In absence of a global clock, one cannot define the same instance of time across the nodes
- Thus, the Global State of a distributed system cannot be realized even theoretically
- With lack of a global clock, the revised target for recording the state of the system reduces to Consistent State Recording

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Cause-Effect Pair of Events

- Create a file – Open the file
- Open a file – read the file
- Send a message – receive the message
- Get inputs – process the inputs
- These had been some examples of event-pairs that are related by the cause and its effect - the effect cannot precede cause

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Consistent State

CAUSE	EFFECT	STATE
√	√	Consistent
-	-	Consistent
√	-	Consistent
-	√	Inconsistent

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Consistent State Recording

- In a consistent state recording, for every effect that has been recorded for the system, the corresponding cause must also be recorded
- This is obvious when the effect and cause are located in the same node
- When the effect and cause are in two threads in two different nodes, then a message must be sent across the two nodes

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Consistent State Recording

- Considering the message passing mode of communication for a distributed system, the condition for consistent state recording is revised as:
  - In a consistent state recording (CSR), for every message that is recorded as received, the corresponding state recording in the sender location must reflect that the message has been sent

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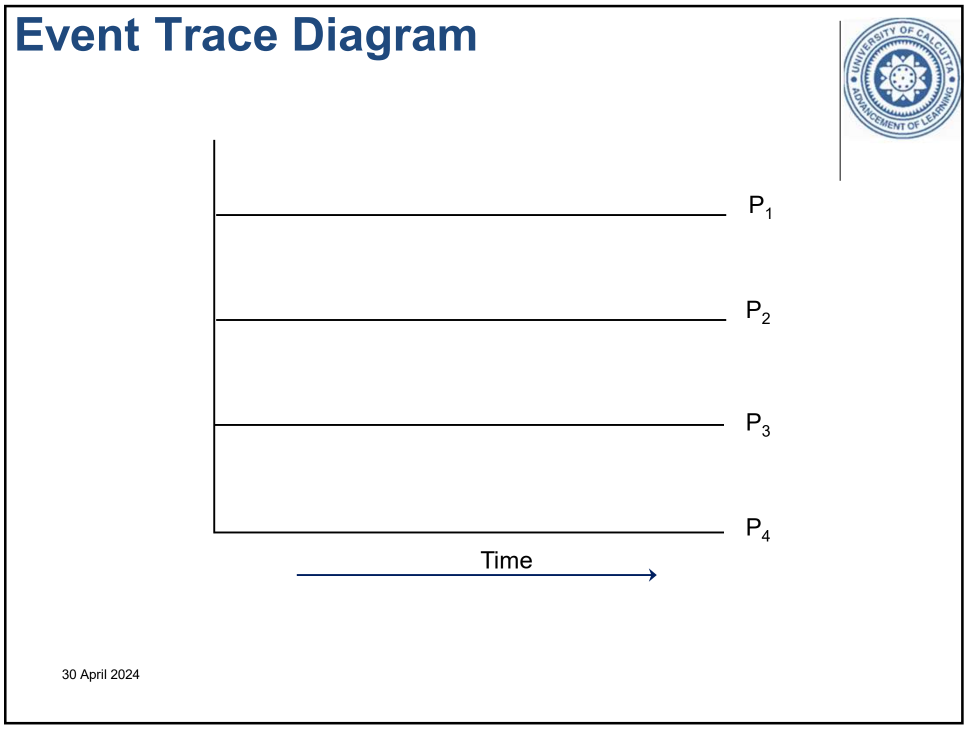
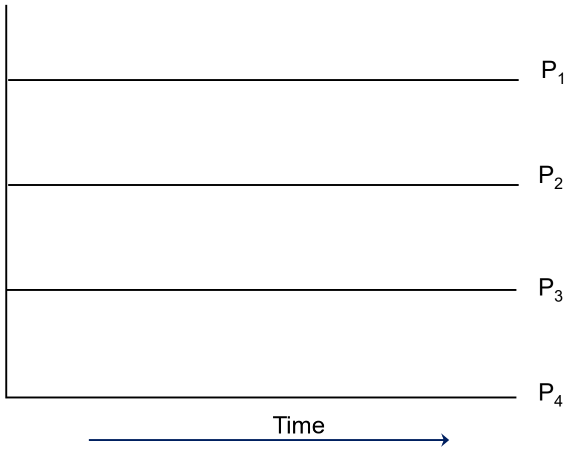


Event Trace Diagram



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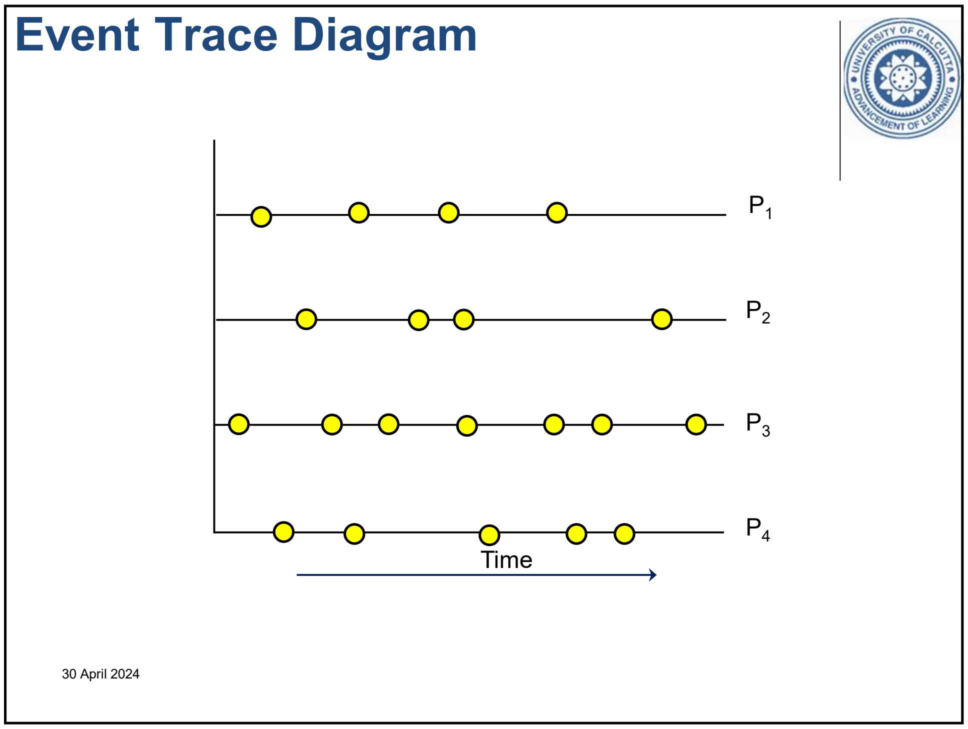
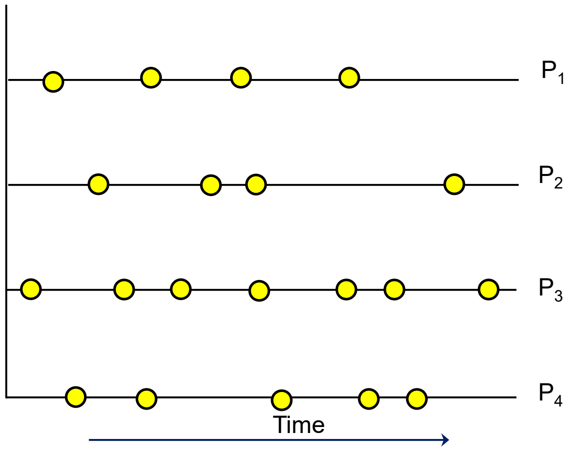


Event Trace Diagram



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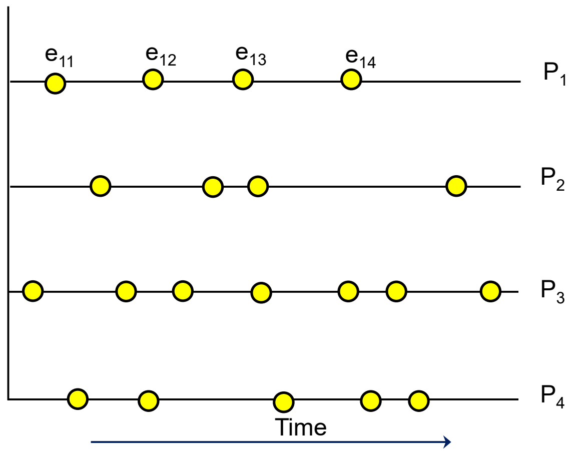
Event Trace Diagram



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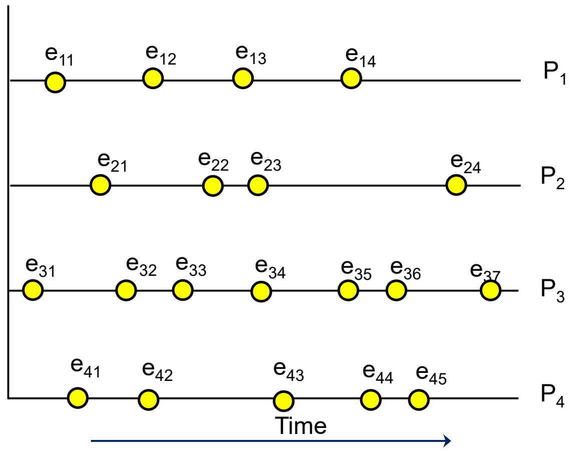
Event Trace Diagram



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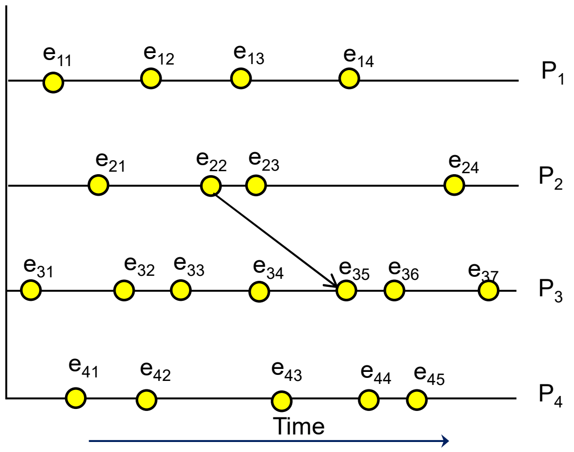
Event Trace Diagram



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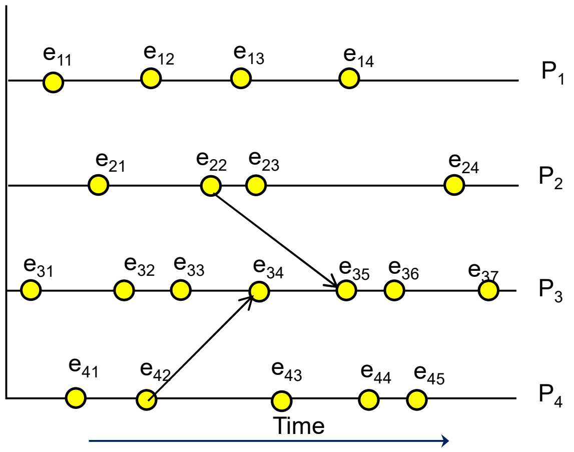
Event Trace Diagram



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Cut in Event Trace Diagram

- A cut is an imaginary line that connects the points on the time-line of an event trace diagram in which the states for different nodes are recorded

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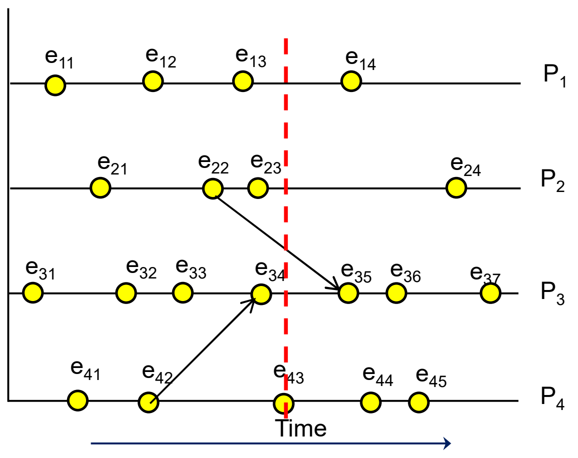
Ideal Cut for Global State Recording



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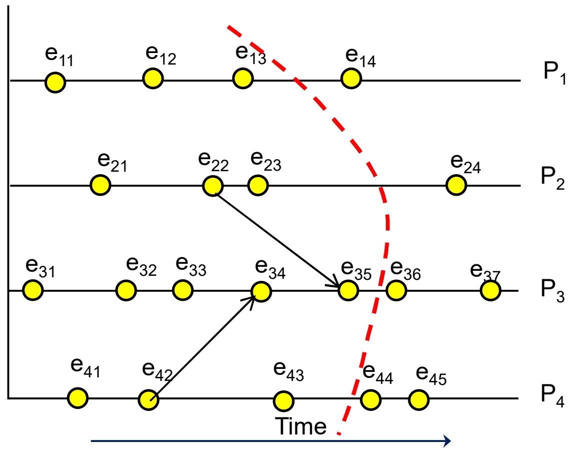
Cut 1: No Intersection



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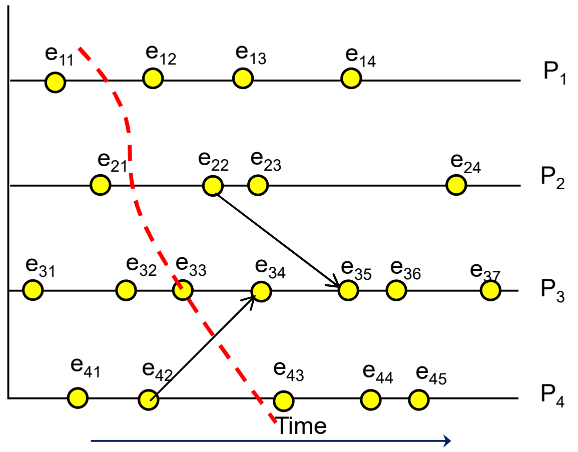
Cut 2: Forward Intersection



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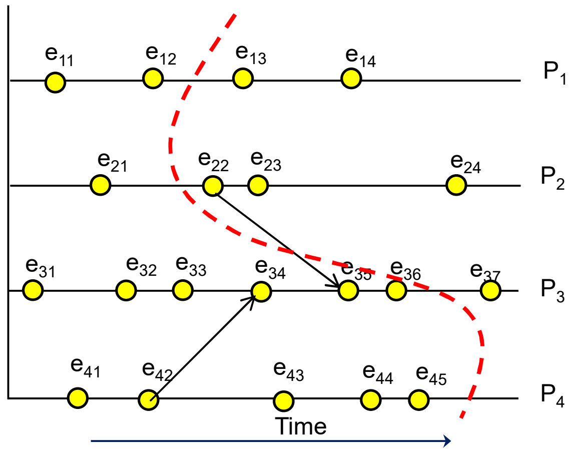
Cut 3: Backward Intersection



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Cut and Consistency

- There are four possibilities
  - Both send and receive events are in past
    - No intersection, consistent state
  - Both send and receive events are in future
    - No intersection, consistent state
  - Send is in past and receive event is in future
    - Forward intersection, consistent state
  - Receive is in past and Send is in future
    - Backward intersection, inconsistent state
    - Problem in state recording algorithm

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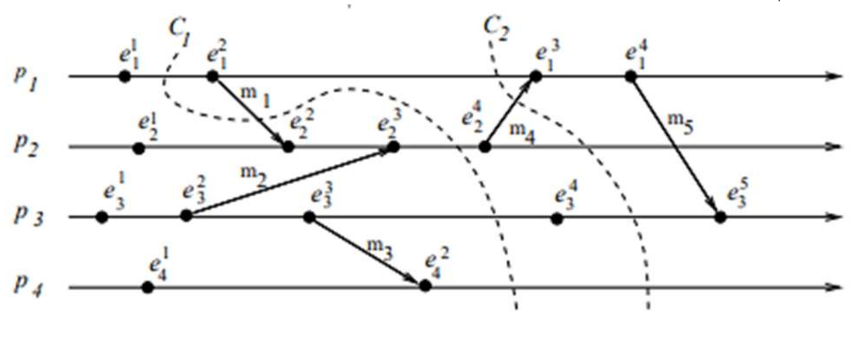
Cut 4: Scenarios



Time

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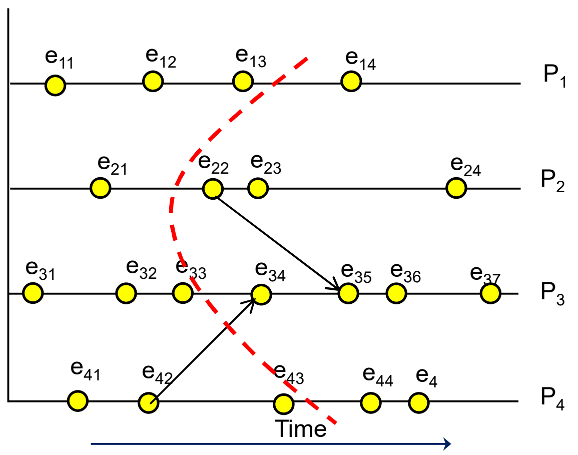
Cut 4: A Scenario



Time

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Condition of Consistency

- Two processes P_i and P_j are said to be mutually consistent if all the messages recorded as received by either of the two processes are also recorded as sent
- The state of a system is consistent if every possible pair of processes are mutually consistent

Thanks for your kind attention

Questions??