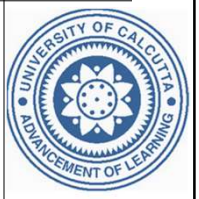
State Recording for Distributed Systems

Quest for A Consistent State Recording Algorithm



1

Naïve State Recording Algorithm

- Assumptions:
  - The system is assumed to be organized in a connected graph topology
  - An edge, often referred in this domain as a channel, connects only two neighboring nodes
  - Channels have infinite capacity

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Naïve State Recording Algorithm

1. In one atomic action, the initiator
   1.1 Records its own state;
   1.2 Sends recording messages (RM) to all the neighbors;
2. On receipt of a RM for the first time, every other process,
   2.1 Records its own state;
   2.2 Sends RMs to neighbors except from which it received the RM;

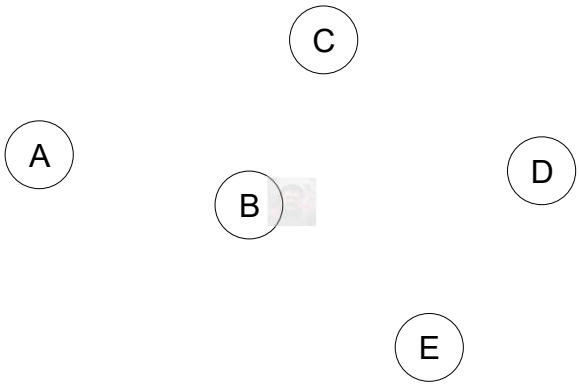
3

Naïve State Recording Algorithm

- The algorithm terminates when
  - Every process, other than the initiator, has received a Recording Message through each incoming channel;
  - No Recording Message is left in any channel.

4

How does it work?



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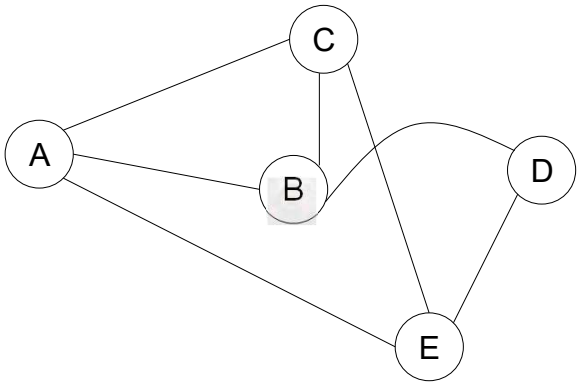
How does it work?



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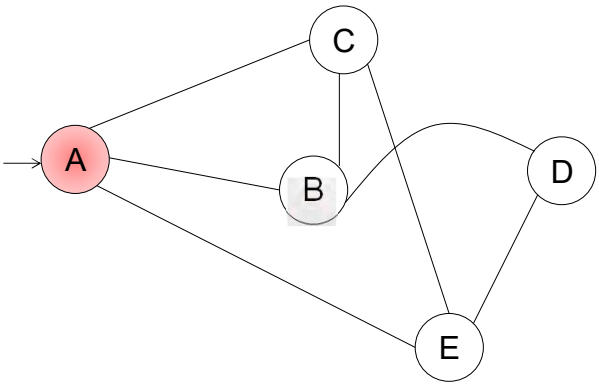

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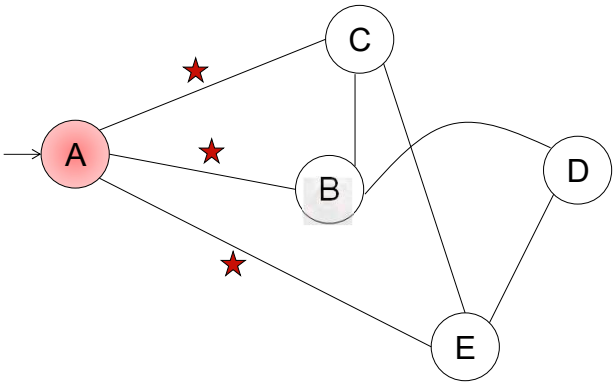

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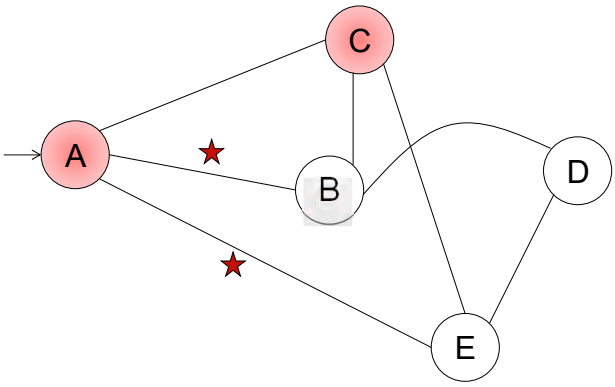

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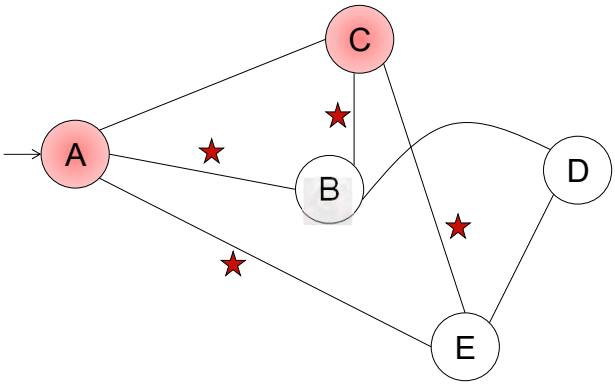

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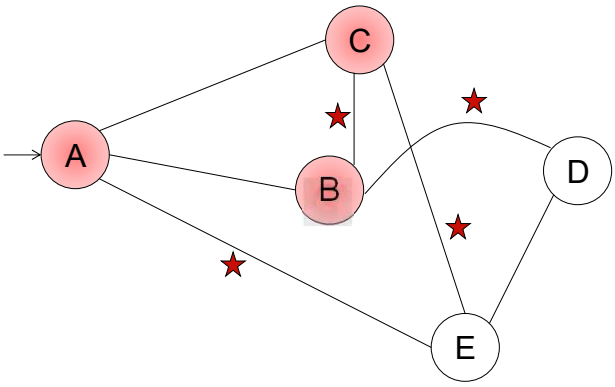

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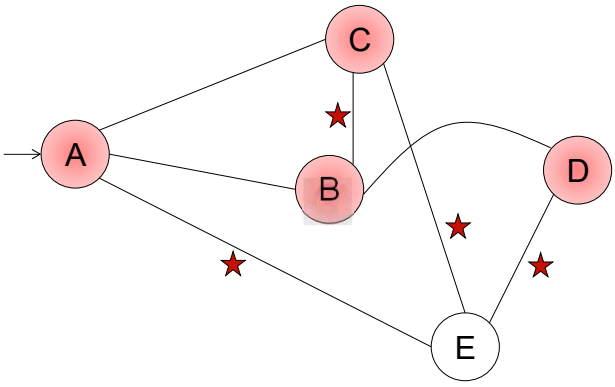

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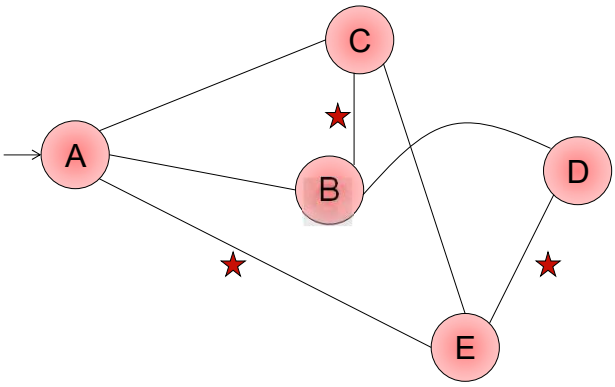

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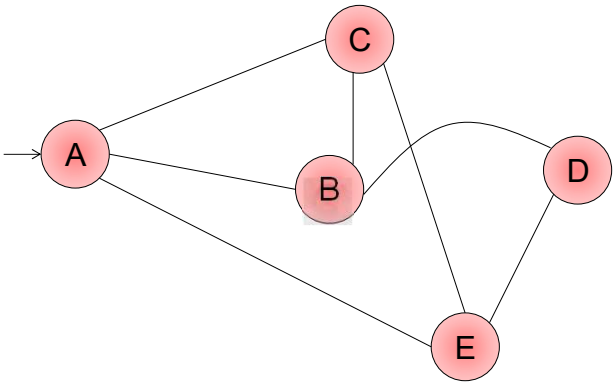

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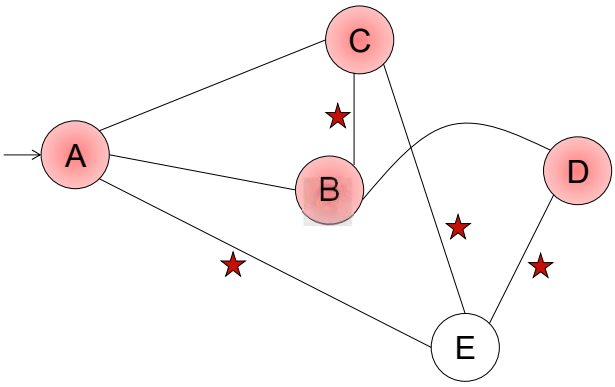
Does it ensure Consistency?



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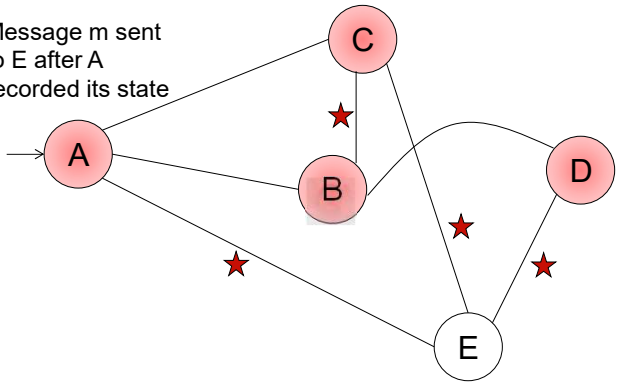
Does it ensure Consistency?

Message m sent
to E after A
recorded its state



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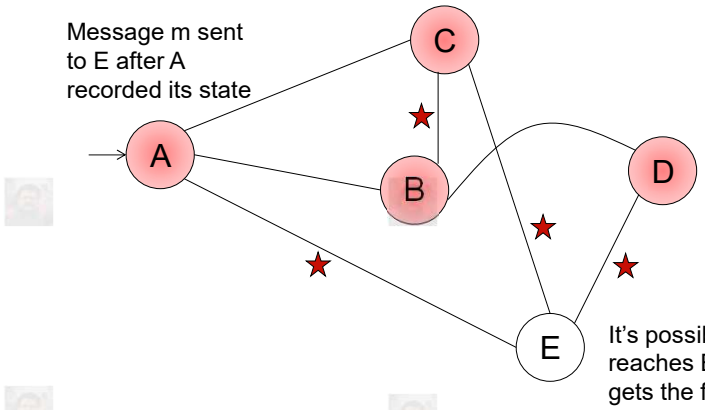

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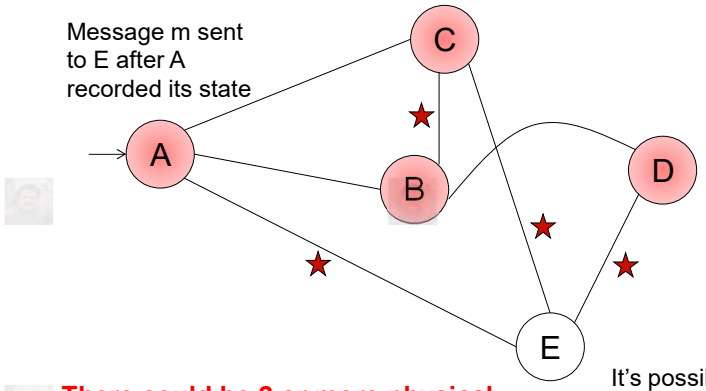
Does it ensure Consistency?



There could be 2 or more physical paths between any pair of nodes

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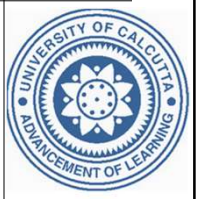
State Recording for Distributed Systems

Look for a better Algorithm



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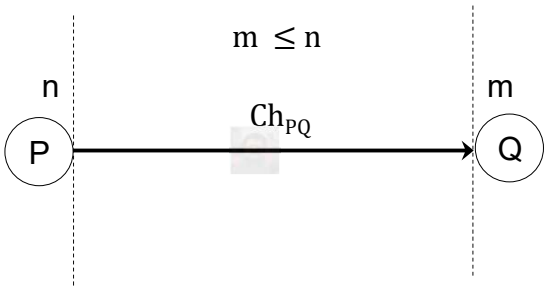
Process Channel Consistency



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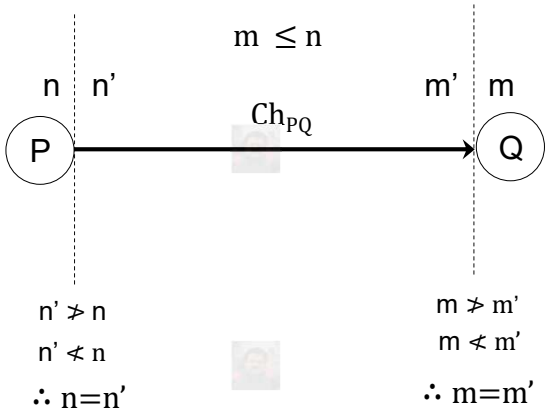
Process Channel Consistency



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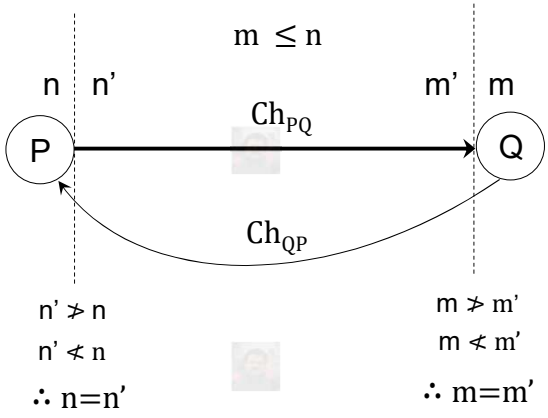
Process Channel Consistency



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Chandy-Lamport's Algorithm

- Assumptions:
  - Channels are FIFO
  - Channels are unidirectional
  - Channels have infinite capacity

Chandy-Lamport's Algorithm

1. In one atomic action, the initiator P_i
   1.1 Records its own state;
   1.2 Sends markers on all outgoing edges;
2. On receipt of the first marker, process P_k
   2.1 Records its own state;
   2.2 Sends markers on all outgoing edges;
   2.3 Records state of the channel C_{ik} through which it received the first marker as empty;

Chandy-Lamport's Algorithm

3. If recipient of marker P_k has already received a marker earlier, then

   3.1 Records state of the channel Ch_{ik} as holding the following messages:

   {Messages received over Ch_{ik}} – {Messages recorded as received over Ch_{ik}};

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Chandy-Lamport's Algorithm

- The algorithm terminates when
  - Every process, including the initiator, has recorded its state;
  - No marker is left in any channel.

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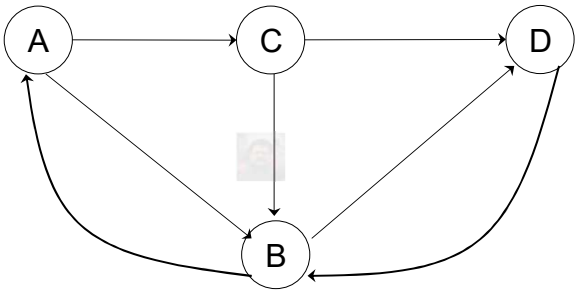
How does it work?



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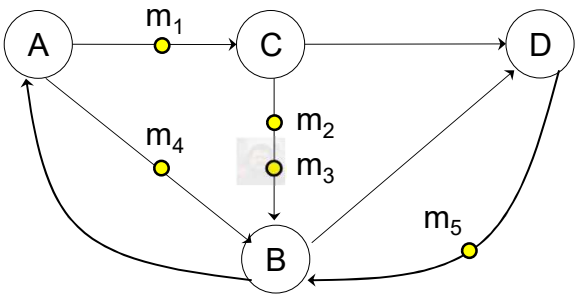

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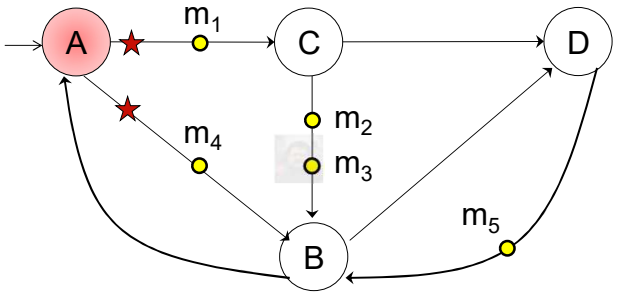

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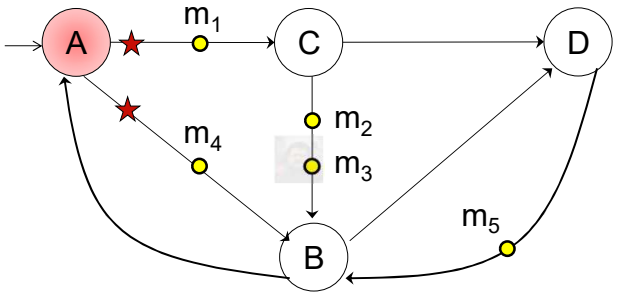
How does it work?

m_1	C
m_4	B
ϕ	



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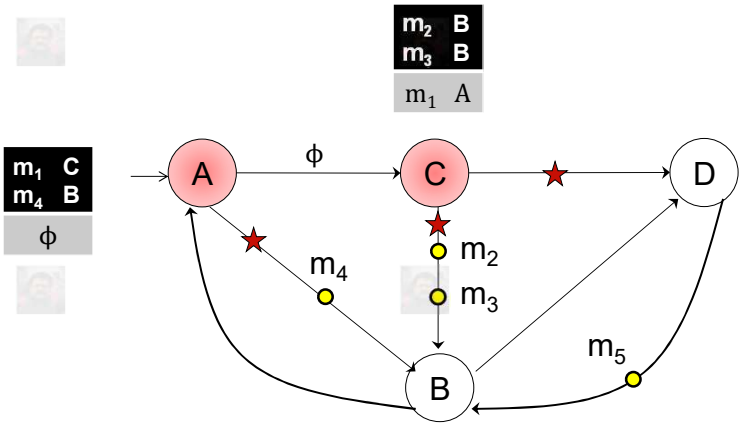

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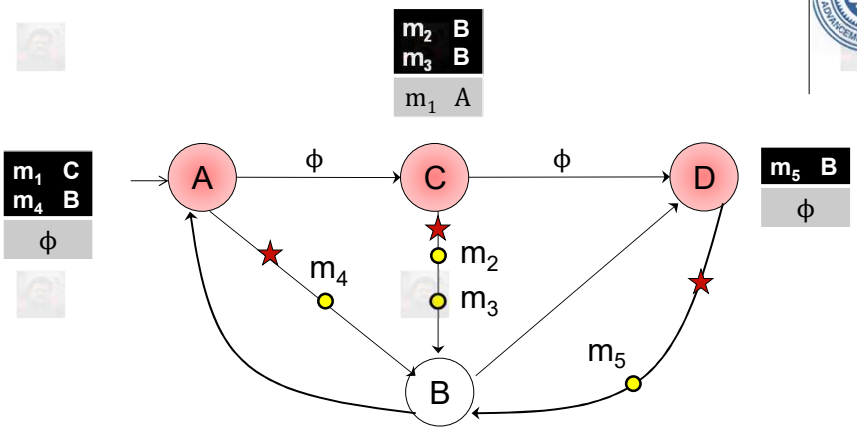

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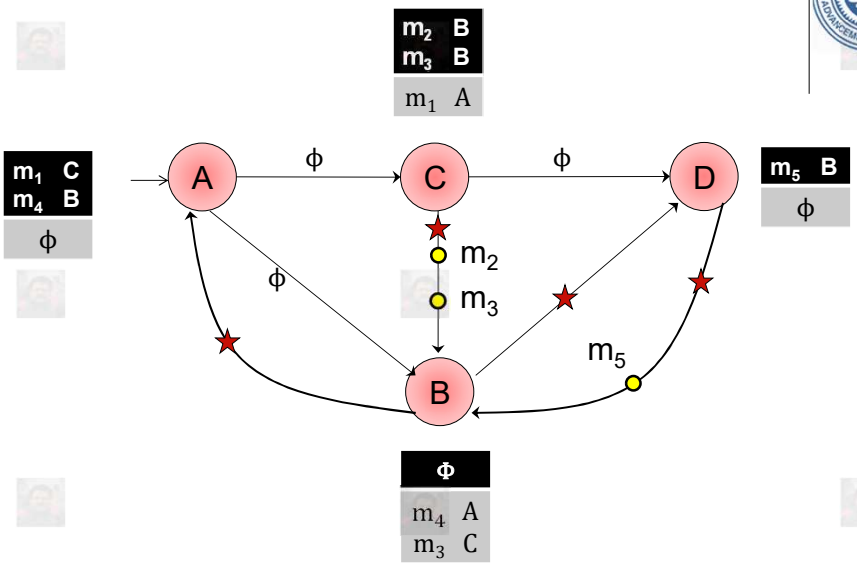

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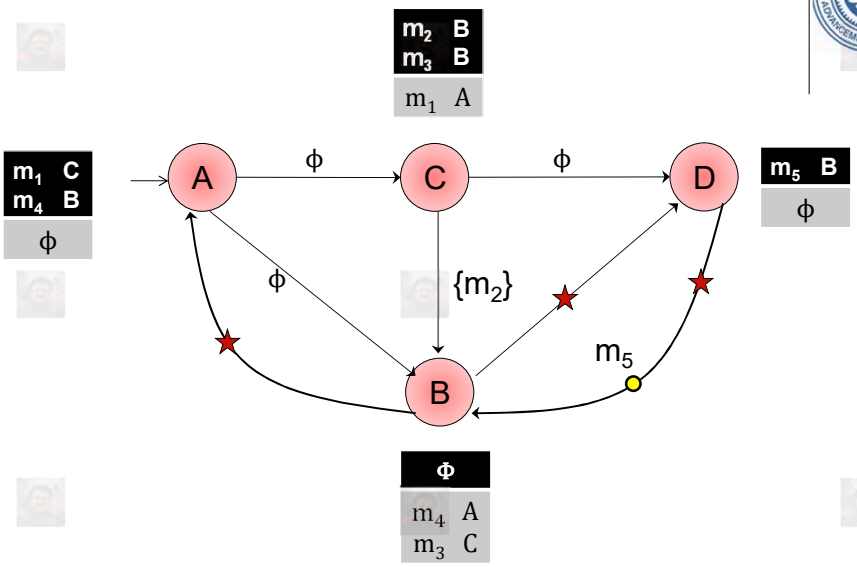

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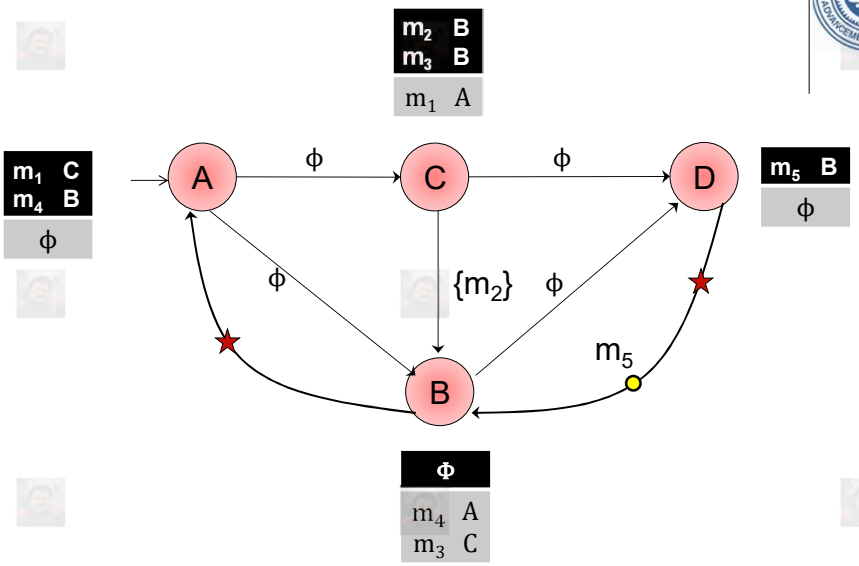

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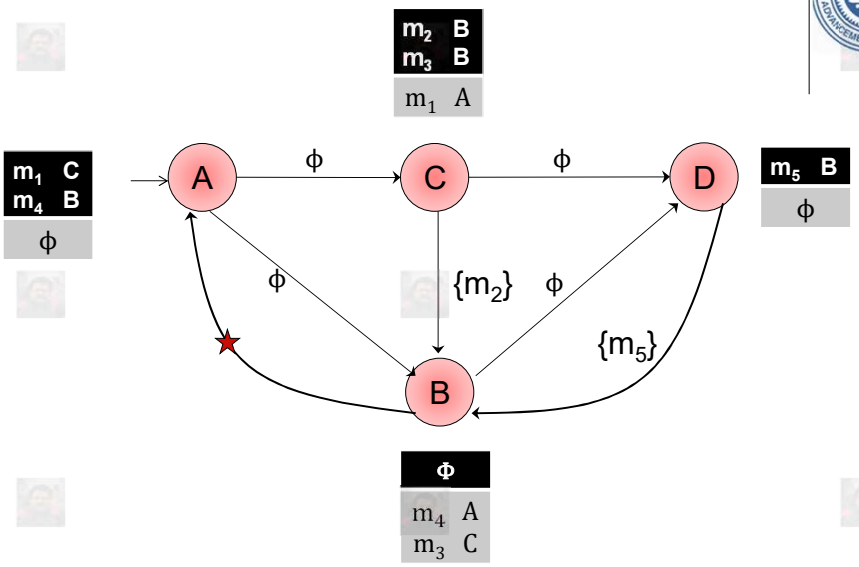

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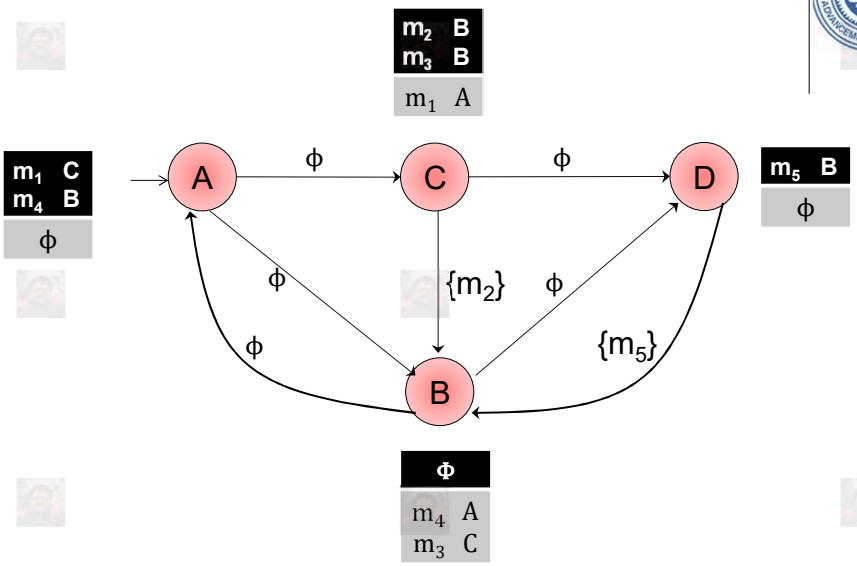
How does it work?



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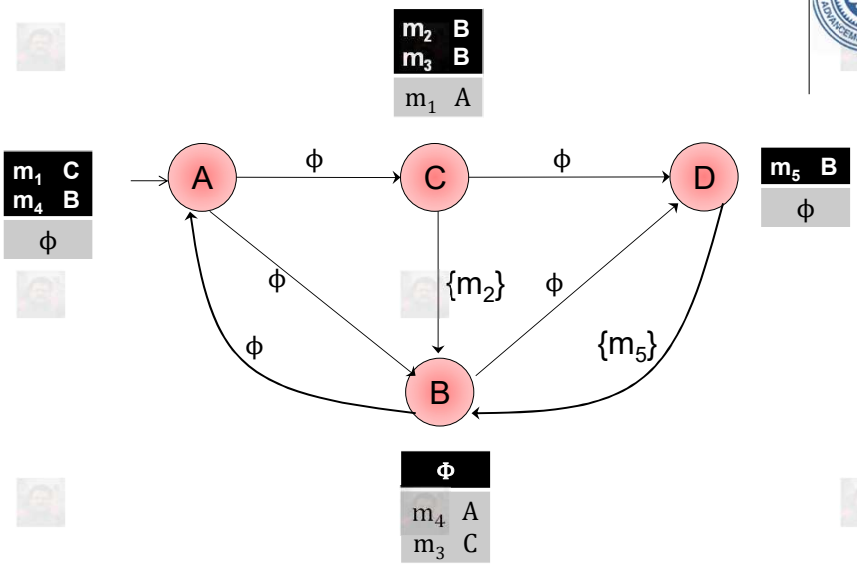
Does it ensure Consistency?



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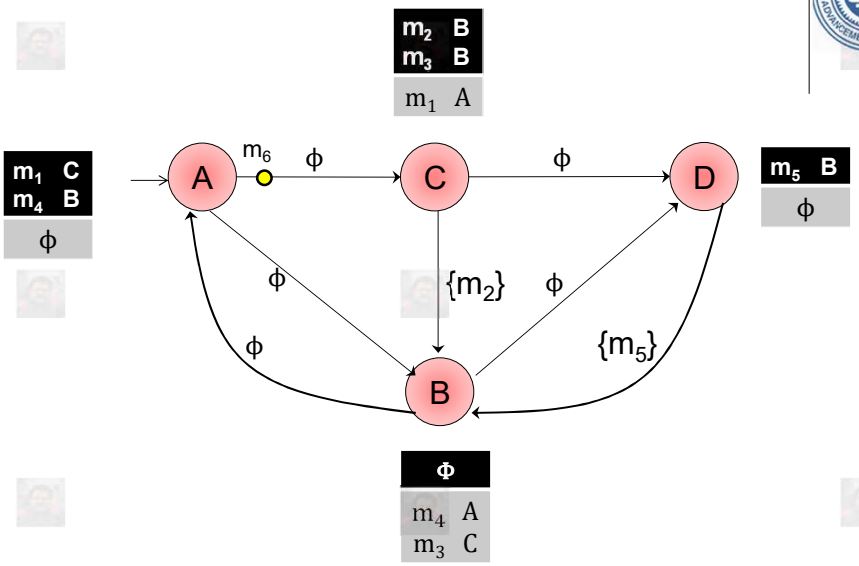

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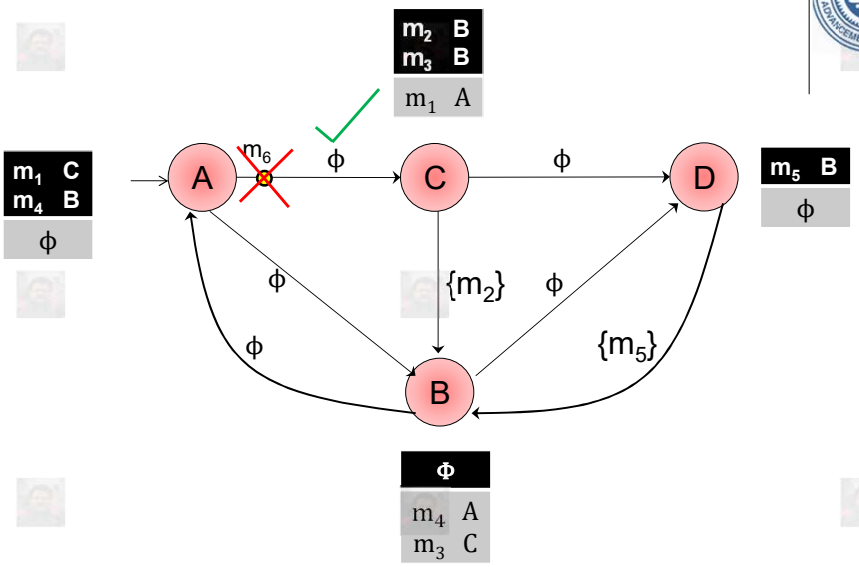

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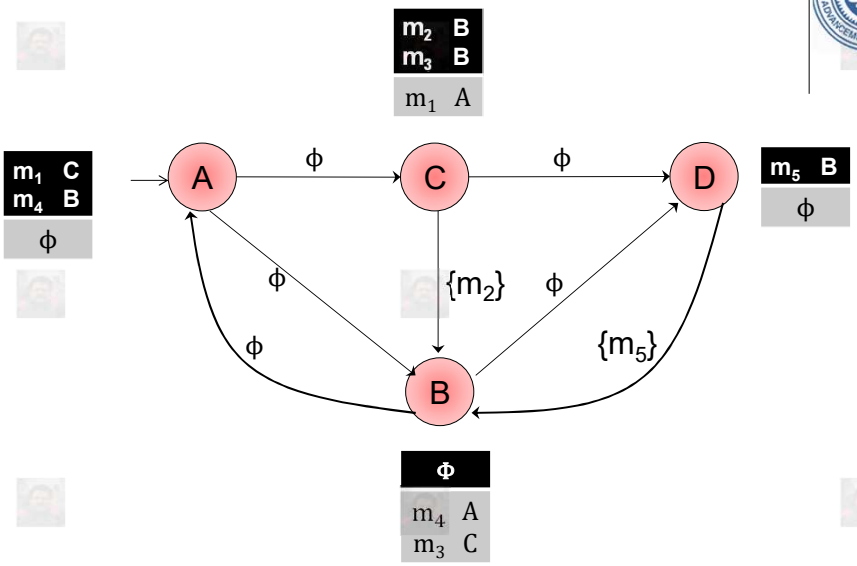

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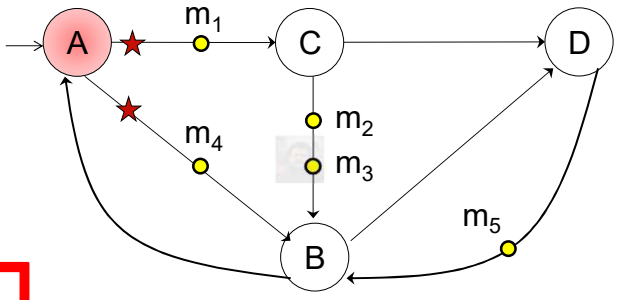
Stage 1



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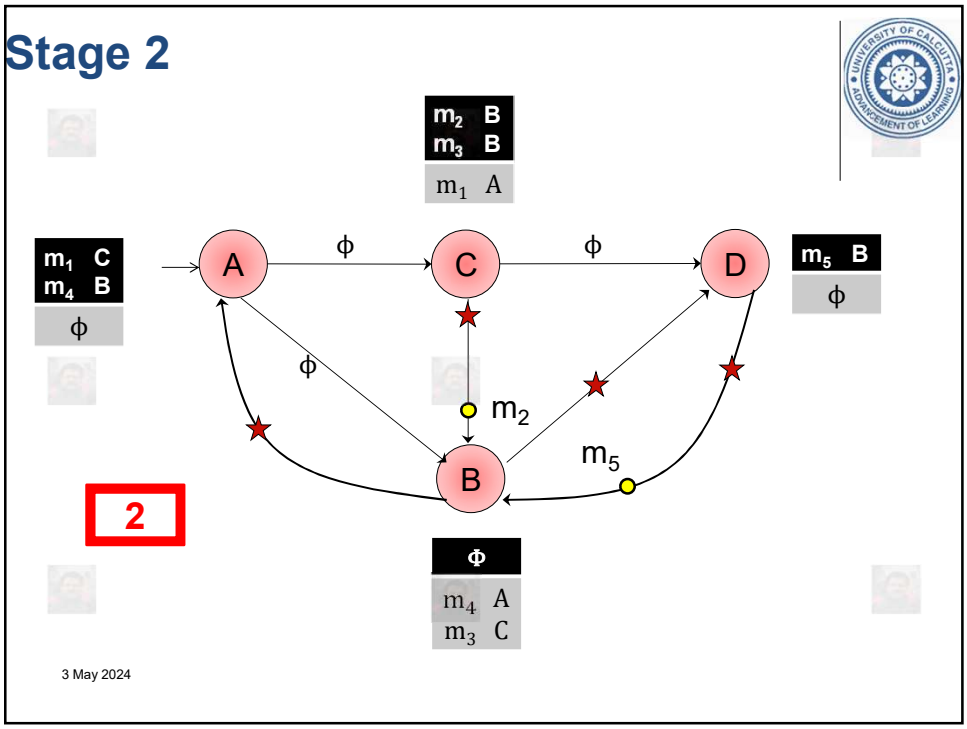
Stage 2
m2 B
m3 B
m1 A
m1 C
m4 B
ϕ
A
ϕ
C
ϕ
D
m5 B
ϕ
ϕ
m2
m5
B
2
Φ
m4 A
m3 C
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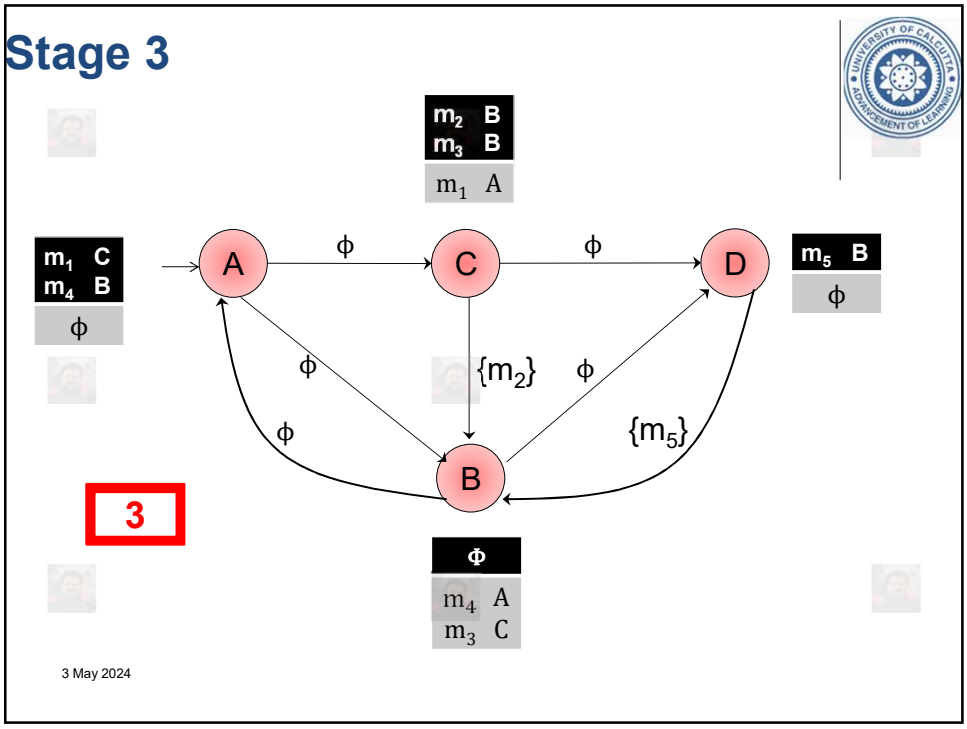
Stage 3
m2 B
m3 B
m1 A
m1 C
m4 B
ϕ
A
ϕ
C
ϕ
D
m5 B
ϕ
ϕ
{m2}
ϕ
ϕ
{m5}
B
3
Φ
m4 A
m3 C
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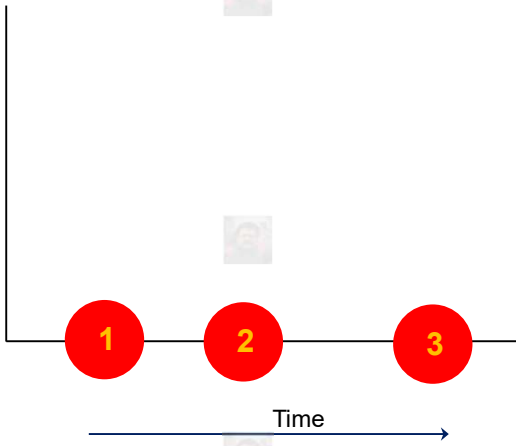
On a Timeline



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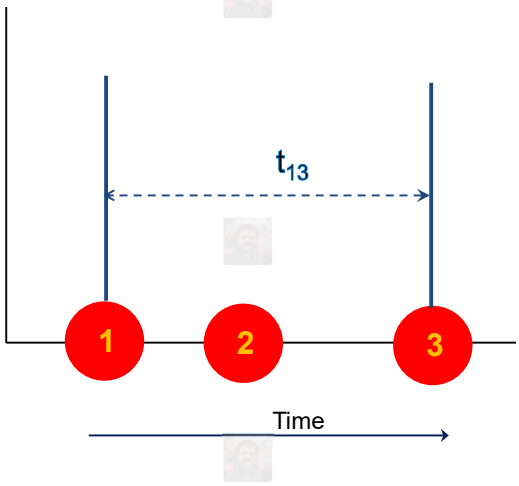
On a Timeline



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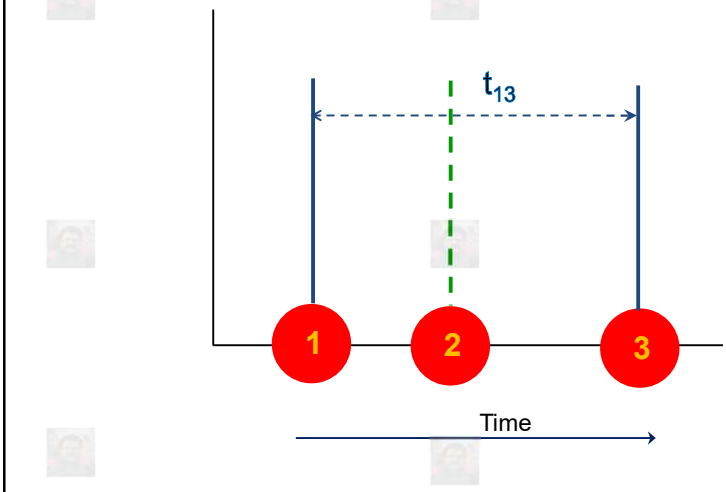
On the Time Line



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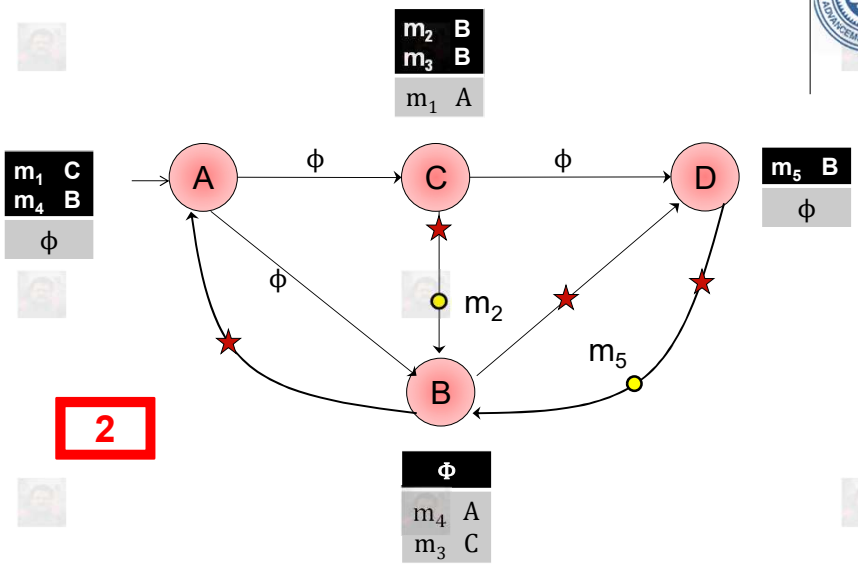
Stage 2



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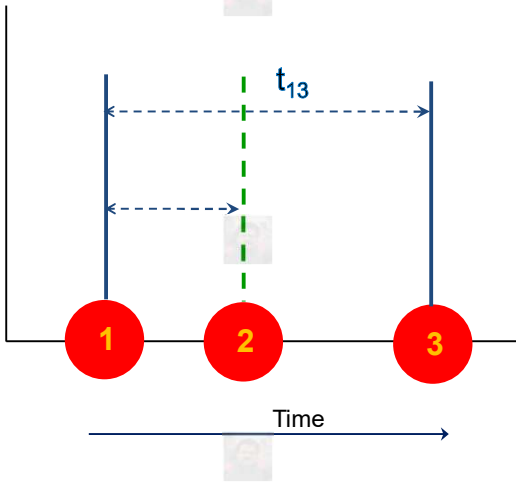
On the Time Line



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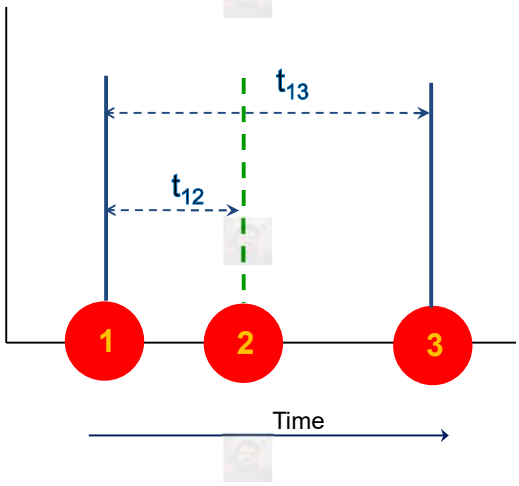
On the Timeline



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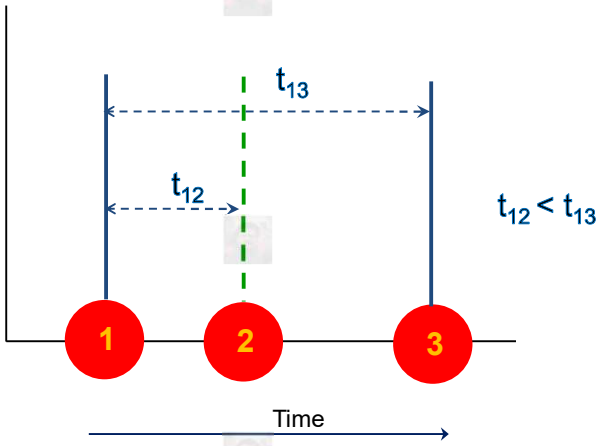
On the Time Line



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Thanks for your kind attention

Questions??

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