Objectives

- To discuss the different message ordering paradigms.
- To discuss Raynal-Schiper-Toueg algorithm for causal ordering.
- To discuss 3-phase distributed algorithms for total ordering.

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Message ordering paradigms

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The order of delivery of messages in a distributed system is an important aspect of system executions.

- Because it determines the messaging behavior that can be expected of the distributed program.

1. Async / Non-FIFO
2. FIFO
3. Causal Order
4. Synchronous order

Group Communication

1. Causal Order
2. Total Order

$$\text{Sync} \subset \text{CO} \subset \text{FIFO} \subset \text{Async}$$

In summary

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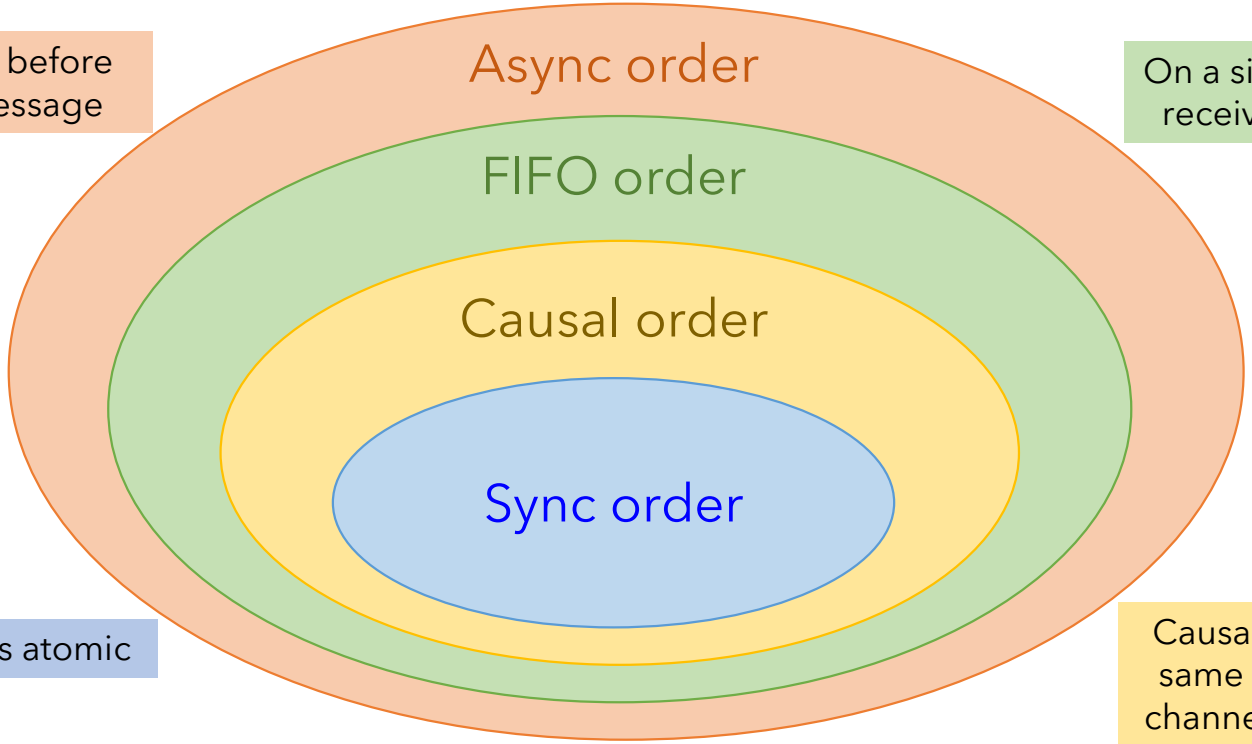
- $\text{Sync} \subset \text{CO} \subset \text{FIFO} \subset \text{Async}$

Receive happens before send for each message



On a single channel, messages are received in first-in-first-out order

Each send-receive is atomic

Causally related messages to the same destination (from differing channels) arrive in the same order

Implementing message ordering

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- Summary of approaches to implement different message ordering paradigms.

Ordering Paradigm	Implementation approach
Async order	Lamport's Scalar clock
FIFO order	Sequence numbering along each channel
Causal order	Raynal-Schiper-Toueg algorithm*
Sync order	Mutual exclusion, agreement algorithms
Total order	Three Phase Distributed algorithm*

* Will be dealt next.

Recall Total order

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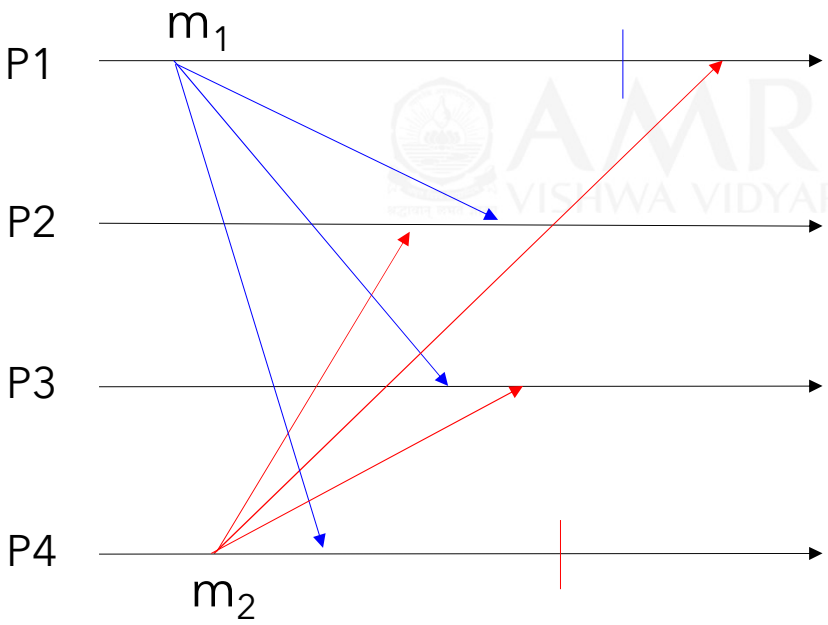
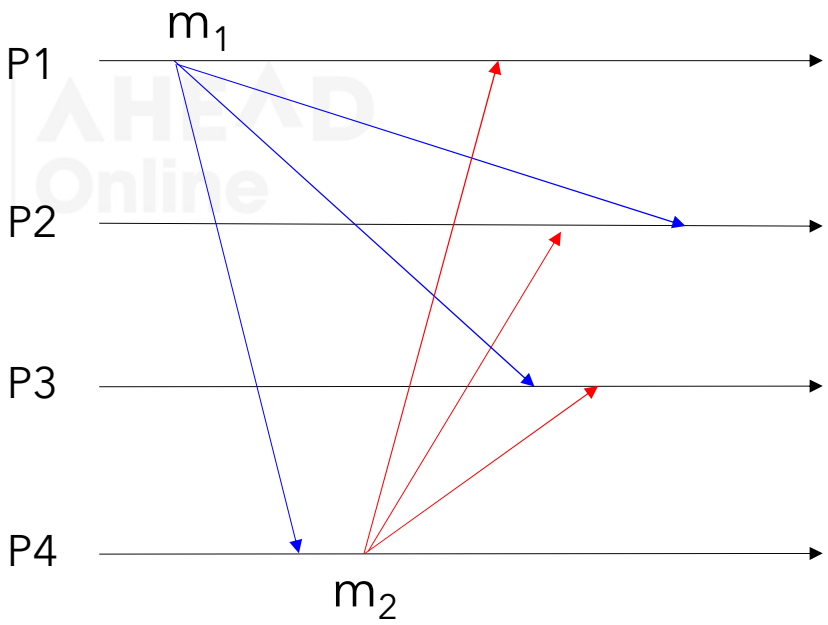
- The order of delivery to all processes must be same.
- Below scenarios depict break in total order when m1 and m2 are (i) concurrent and (ii) causally related.





Three Phase Distributed Algorithm

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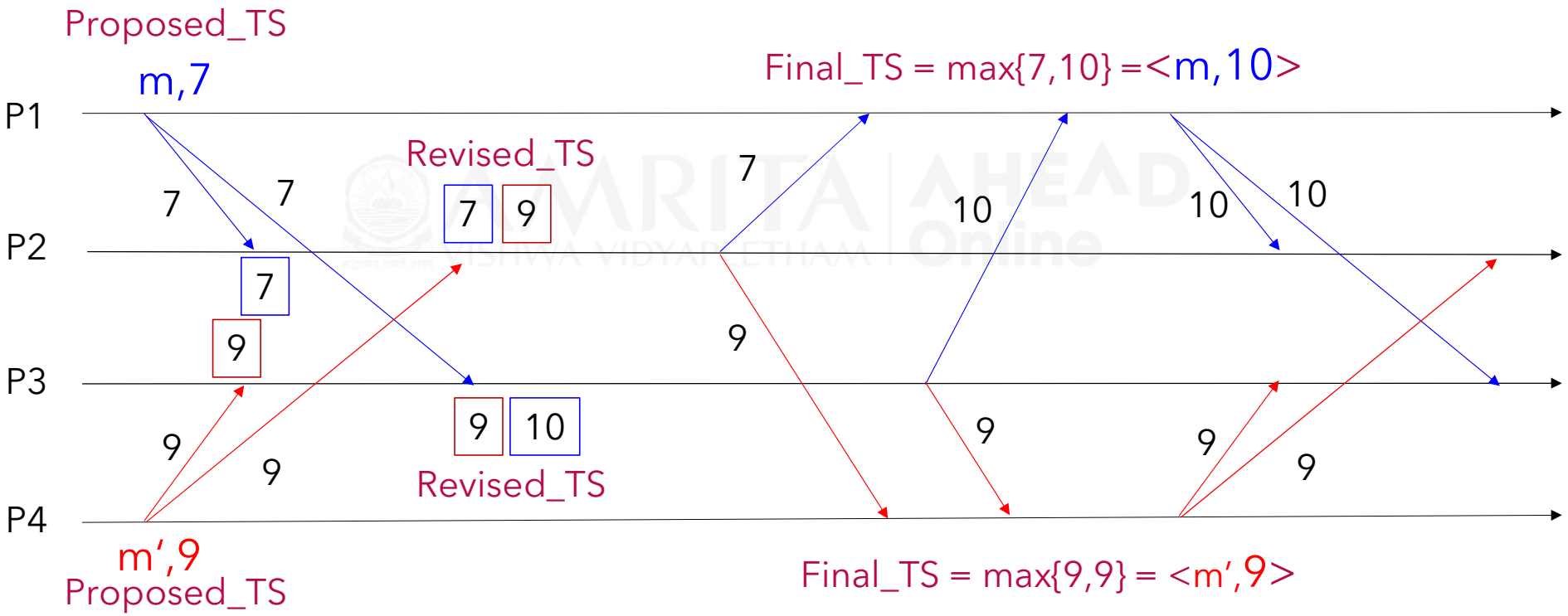
- The order of delivery to all processes must be same.



Conclusion

- We discussed different message ordering paradigms.
  - Async, FIFO, Causal, Sync
- Multicast communication
  - Causal order, Total order
- Causal ordering by Raynal-Schiper-Toueg algorithm.
- Three phase total ordering algorithm.

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