

**CS 425/ECE 428 Distributed Systems**

**Homework 2**

**Due by 5 p.m. on February 6, 2018.**

**Submit electronically via Compass2g.**

**PDF format preferred.**

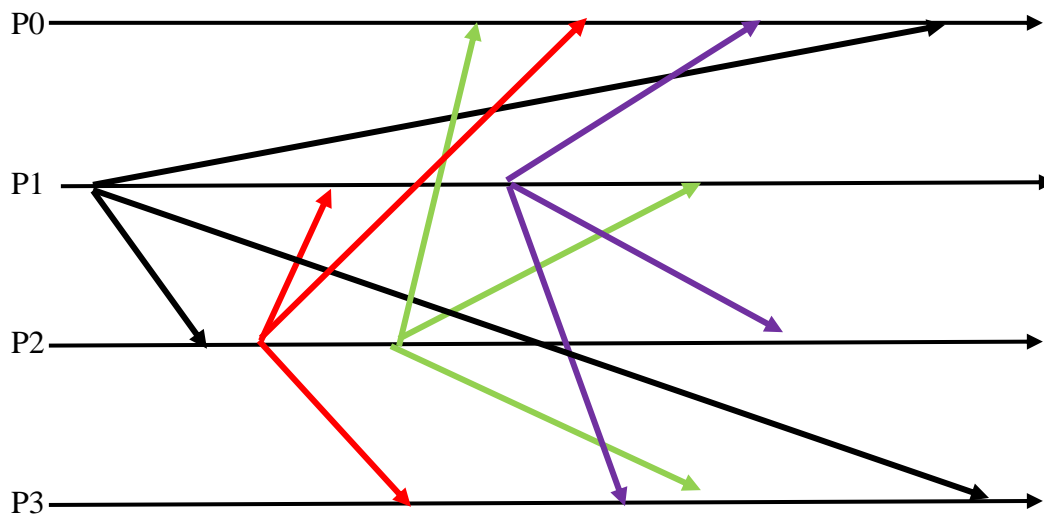
**Total 30 points**

1. Consider a pair of two NTP peers synchronizing their clocks. Server B receives server A's message M at 04:30:01 bearing a timestamp 04:30:04 and replies to it by message M'. Server A receives the message M' at 04:30:08 bearing B's timestamp 04:30:03.

- a) Estimate the offset for server B with respect to server A. (5 points)
- b) Determine the accuracy of the above estimate. (5 points)

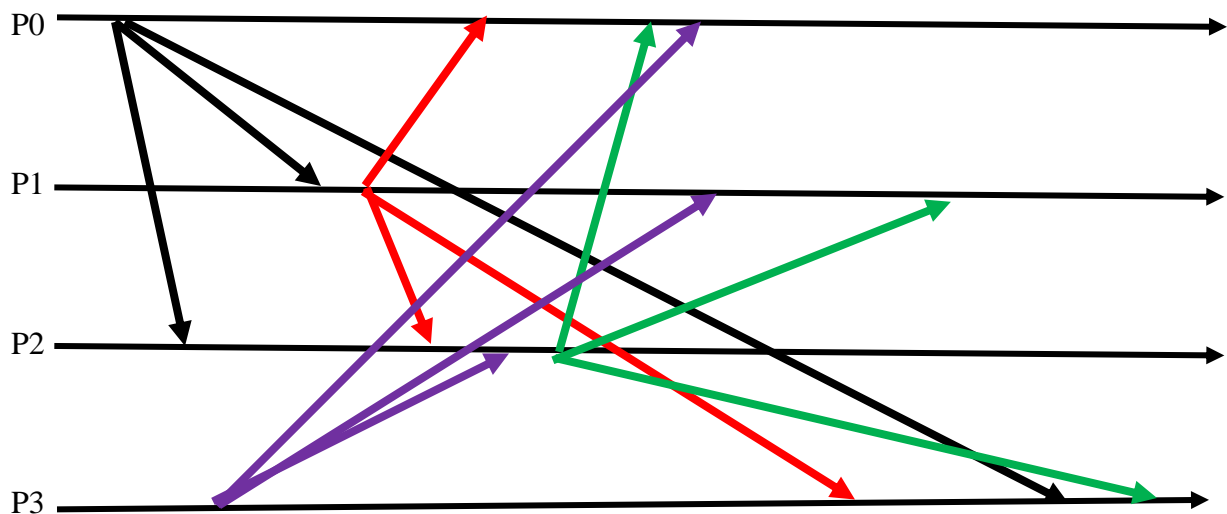
2. In the execution below, processes send messages to each other to implement **FIFO multicast**. To simplify the picture, messages sent by each process to itself are not shown, but you may assume that such messages are received instantaneously. You may draw the answer by hand, scan it, and attach in the homework, or edit the homework PDF directly.

- Identify the messages that are buffered at the processes to ensure FIFO multicast delivery. (Circle the receive event for the buffered messages to identify those messages.) (5 points)
- For each message buffered as above, determine the earliest instant of time at which the message may be delivered, while ensuring FIFO multicast. (To identify the instant of time draw an arrow that begins at the time when the message is received to the time at which the message may be delivered.) (5 points)



3. In the execution below, processes send messages to each other to implement **causally-ordered multicast**. To simplify the picture, messages sent by each process to itself are not shown, but you may assume that such messages are received instantaneously.

- Identify the messages that are buffered at the processes to ensure causally-ordered multicast delivery. (Circle the receive event for the buffered messages to identify those messages.) (5 points)
- For each message buffered as above, determine the earliest instant of time at which the message may be delivered, while ensuring causally-ordered multicast. (To identify the instant of time draw an arrow that begins at the time when the message is received to the time at which the message may be delivered.) (5 points)



**Suggested exercise:** State True or False, and if False, give a counter example. This question will not be graded, and no credit is assigned for this question.

- a) If a multicast service achieves total-ordering, then it also achieve causal ordering for the multicasts.
- b) If a multicast service achieves causal-ordering, then it also achieve FIFO ordering for the multicasts.
- c) If a multicast service achieves causal-ordering, then it also achieve total ordering for the multicasts.