Problem Set 1: Failure Detection, Time and Ordering

1. What are the 4 desirable properties of distributed failure detectors?

2. Is it possible to provide all 4 properties (from 1 above) in lossy networks?

3. In a ring-based heartbeating protocol how many simultaneous failures can be detected and how does that depend on parameters of the protocol?

4. In failure detection why do we need to maintain two time thresholds – T_{Fail} and $T_{Cleanup}$?

5. What happens to $P_{mistake}$ (false positive rate) as T_{fail} ,$T_{cleanup}$ is increased?

6. Show that worst-case load L* (messages per member) for failure detection is

   $$L^* = \frac{\log(PM(T))}{\log(p_{ml})} \cdot \frac{1}{T}$$

   where T is desired time of detection, PM(T) is probability of mistake (false positive probability) and P_{ml} is probability of message loss.

7. What is the insight in SWIM that makes it more efficient?

8. A clock is reading 12:33:57.0 (hr:min:sec) when it is discovered to be 3 seconds fast. Explain why it is undesirable to set it back to the right time at that point and show (numerically) how it should be adjusted so as to be correct after 6 seconds has elapsed.

9. A client attempts to synchronize with a time server. It records the round-trip times and timestamps returned by the server in the table below. Which of the times in the table below should it use to set its clock? What should it set its clock to? What is the estimated accuracy w.r.t to server's clock? If minimum time to send or receive a message from the server is know to be at least 8ms, does your answer change?

Round-trip Time (ms)	Server Clock (hh:mm:ss)
24	12:43:33.456
28	12:43:35.235
22	12:43:36.124

10. If in problem 9 if it is required to sync to within 1ms of the server, is that feasible?

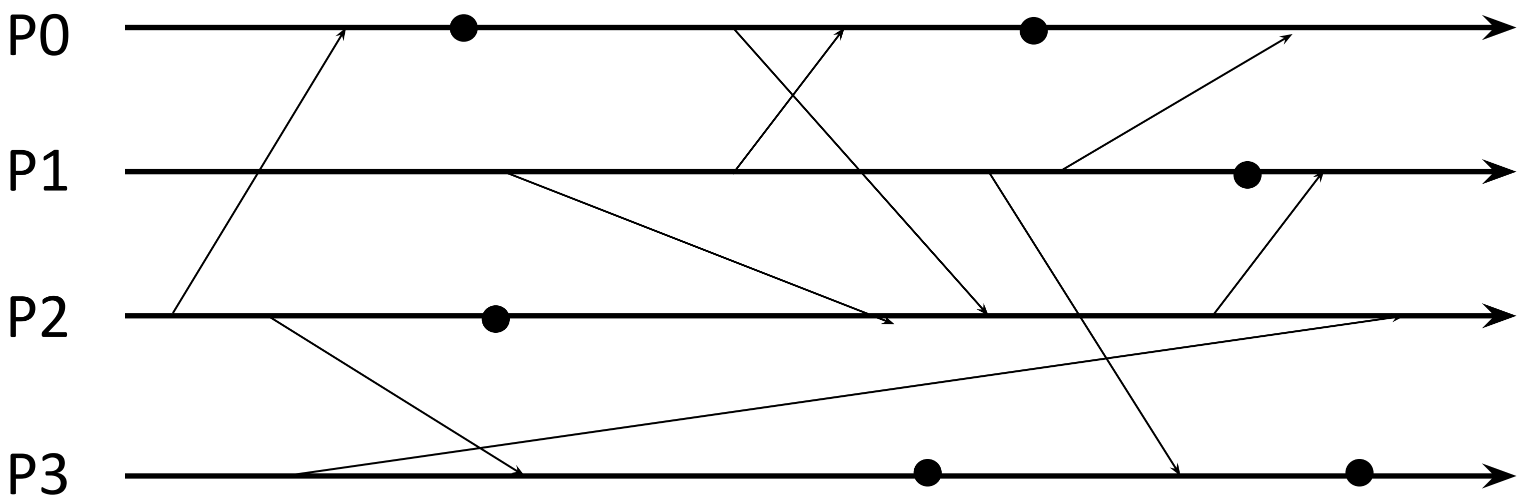
11. By considering a chain of zero or more messages connecting events e and e', and using induction, show that $e \rightarrow e'$ implies $L(e) <= L(e')$, where L(e) is the Lamport timestamp of event e.

12. Show that $V_j[i] <= V_i[i]$ where V_i is vector clock at process i.

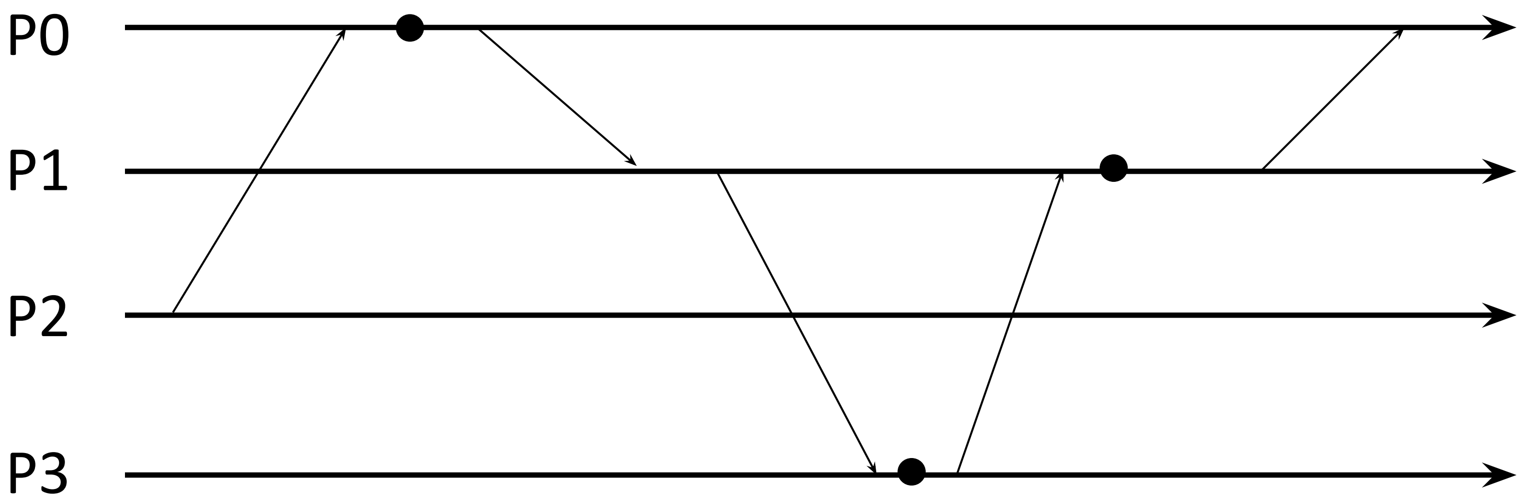
13. In a similar fashion to 11, show that $e \rightarrow e'$ implies $V(e) <= V(e')$

14. Using result from 12, show that if e and e' are concurrent that neither $V(e) <= V(e')$ nor $V(e') <= V(e)$. Thus show that if $V(e) < V(e')$ then $e \rightarrow e'$.

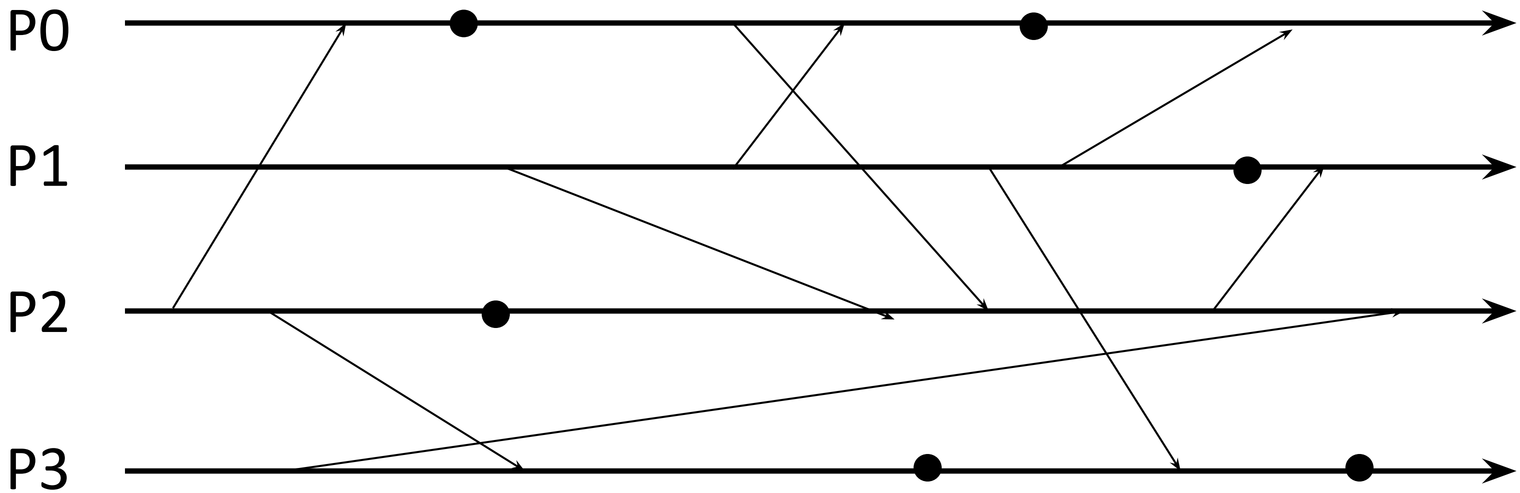
I. Mark one pair of events that are concurrent with each other.



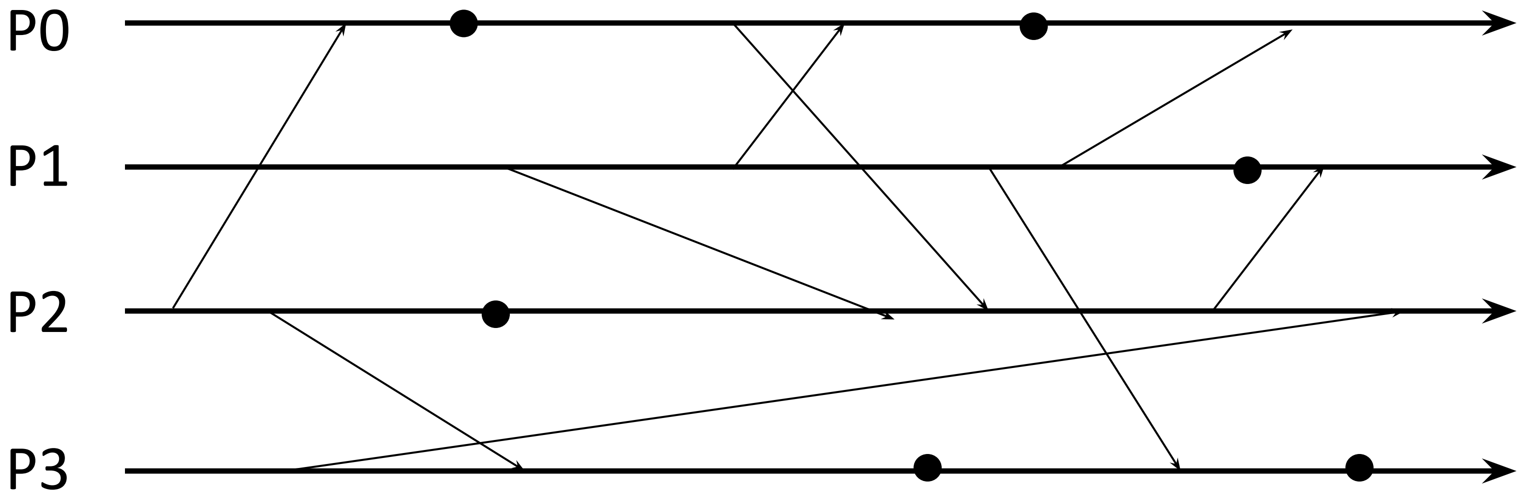
II. Mark one pair of events that are concurrent with each other.



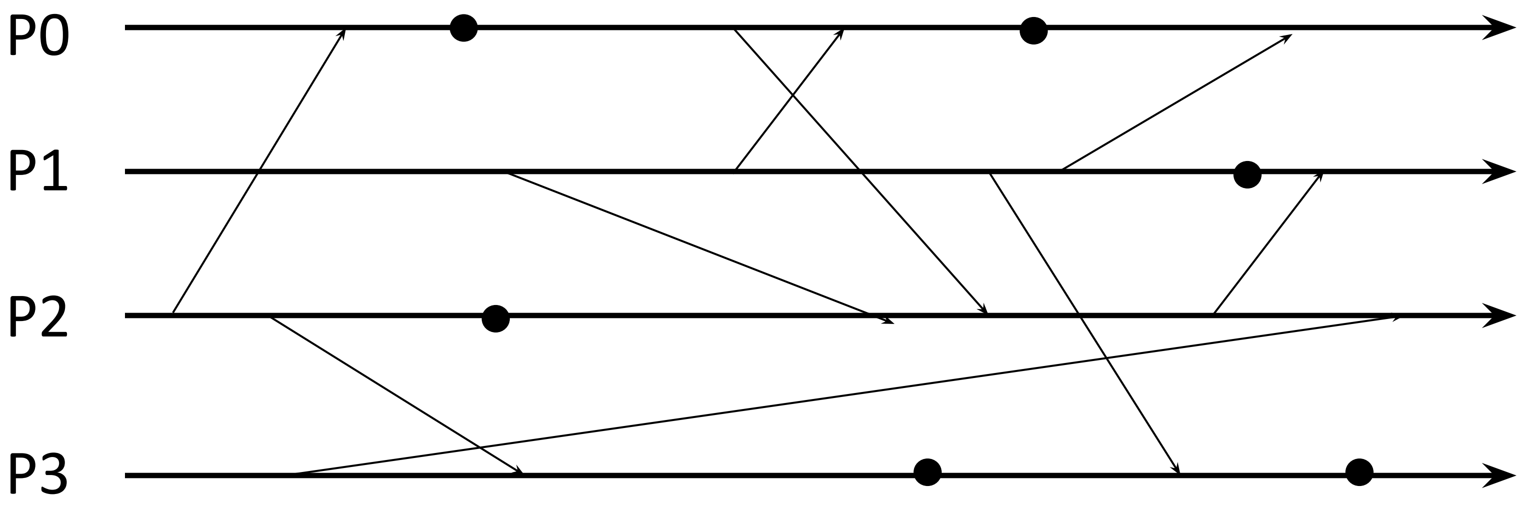
iII. Identify an event at process P2 that happens before an event at P1.



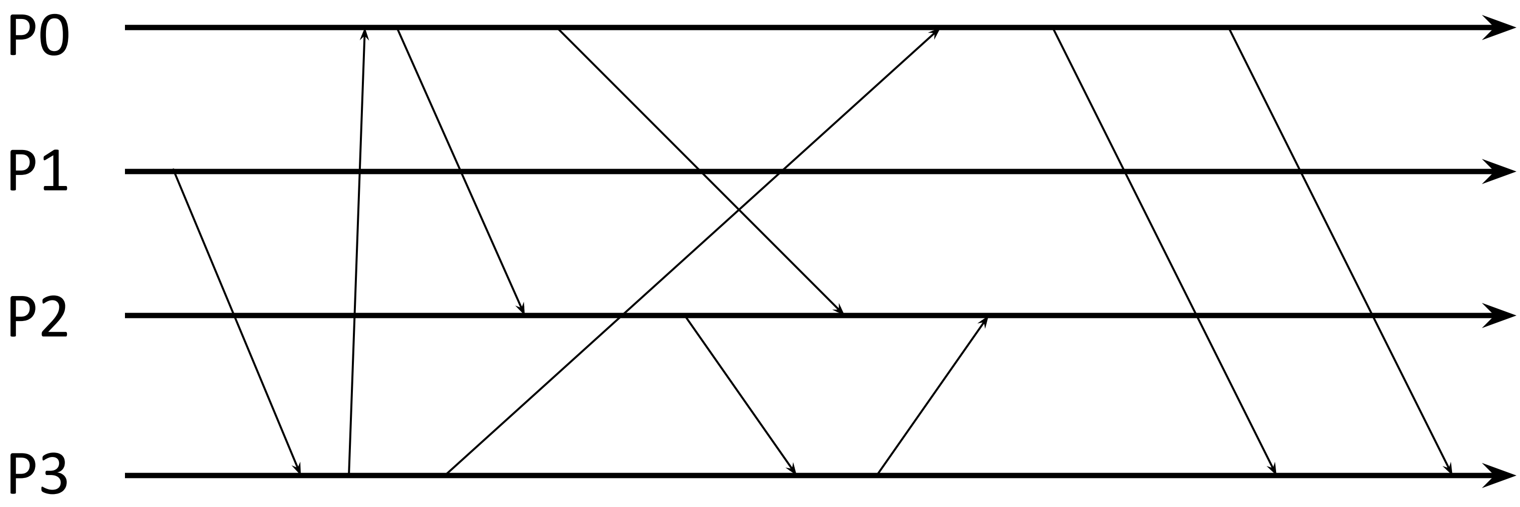
IV. Mark all Lamport timestamps on this figure for all events. All processes start with zero timestamps.



V. Mark all vector timestamps on this figure for all events.
All processes start with zero timestamps.



VI. Mark all Lamport timestamps on this figure for all events.
All processes start with zero timestamps.



VII. Mark all vector timestamps on this figure for all events.
All processes start with zero timestamps.