

# COMP 360 — Homework 3

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## 1 Questions

1. The following events took place on three systems at the stated physical (time of day) times:

- System 1:
  - a – 3:00
  - b – 3:01
- System 2:
  - c – 2:55
  - d – 3:04
- System 3:
  - e – 3:03

Event *b* is the sending of a message from system 1 to 2. Event *d* is the receipt of that message. Using Lamport’s *happened-before* relation, which events happened before event *d*? Which events happened before event *e*?

2. Using the example system in the previous question, assume that all Lamport clocks are initialized to zero. What is the final value of each Lamport clock?
3. We discussed *at-most-once semantics* and *at-least-once semantics* of message delivery. Why is there no *exactly once semantics*, and how can we work around this limitation?
4. We talked about how a system can use Lamport clocks for ordering messages to be delivered to an application. Imagine that a computer has received, but not yet delivered, some messages. It has sorted them according to their timestamps. What factors should be considered in deciding *when* to deliver the messages to the application? What would constitute “too early” delivery, and how can we avoid it? Discuss in particular of relationship of timing of the delivery in relation to the balance between consistency and availability.

5. Describe how an RPC system should respond to a server's failure in the case of (a) fail-stop semantics and (b) fail-crash semantics.