Problem 1: Happens Before

Above is a space-time diagram. For event C, list the labeled events (A-I) that “happen before” event C, those labeled events (A-I) where C “happens before” the event, and those (A-I) that are concurrent with C.

Problem 2: Lamport Clocks

Assume that the labeled events (plus message sends and receives) are the only events, all clocks start at 0, clocks are incremented before assigning a timestamp to an event, and clocks are incremented when both sending and receiving messages. Assign every event its Lamport clock timestamp. Hint: Event A has timestamp 1 and D has timestamp 4.

Problem 3: Vector Clocks

Using the same events and assumptions, label every event with its Vector Clock value.
Problem 4: Primary Backup

In class, we suggested your solution to Lab 2 should obey certain constraints. In a sentence, explain why the constraint is needed, that is, why a violation of the constraint would cause a problem.

a) State transfer from primary to backup must include data on which RPC calls have received replies, and what the response was.
b) The backup must accept a request forwarded by the primary iff the request and the backup have the same notion of the current view.
c) The backup may accept a request forwarded by the primary even though both the request and the backup are in an old view that has since been changed by the view server.
d) On a read request (that has not been previously served), the primary must wait for the backup to accept the request before the primary can reply to the client with the data.

Problem 5: Virtual Machine Primary Backup

For the VMware virtual machine primary backup system we discussed in class, answer in a sentence:

a) What happens if the primary fails after receiving network input but before sending its log entry to backup?
b) Why can the same output be produced by both the primary and backup?