1.

As stated in class, in a DS, processes are sending messages to each other as well to the coordinator. In a centralized token-based algorithm, it is possible that a process P1 sends a request, R1, to the coordinator and then sends a message M to P2. Furthermore, it is possible that message M in turn sends a request R2 to the coordinator. It is certainly possible that R2 could get to the coordinator before R1, even though it was sent after R1.

This does not support the liveness #3 condition that states that requests are handled in order as defined by the “happens before” relation. However, if vector timestamps are used, then order can be insured and R0 will be processed after R1 even if it gets to the coordinator first.

To illustrate, here is the diagram. P1 sends request R1 to P3. Then, P1 sends M to P2, and then P2 sends the request R2 to the coordinator.

(2, 0, 0)

(1, 0, 0)

R1

M

P1

(2, 2, 0)

R2

P2

(2, 1, 0)

B

(1, 0, 1)

P3

(2, 2, 2)

A

C

P1, P2, and P3 all start out at (0, 0, 0)

When R1 is sent, the vector timestamp is (1, 0, 0). That is, since R1 is on P1, the first element of the current vector for P1 (namely, (0, 0, 0), is incremented by 1 to give (1, 0, 0). At A, when it is received, the vector timestamp is (1, 0, 1), this is the timestamp that is sent to A. At A, the vector timestamp is (1, 0, 1). That is, since A is on Process A, the third element of the current vector for P1 is incremented by one (it was originally (0, 1, 0)), and the first and second elements are found by taking the corresponding max values between the current vector and the vector sent to from R1 and adding 1. This gives

(max(1, 0), max(0, 0), 1) which gives (1, 0, 1). The rest of the timestamps are determined similarly.

A: (1, 0, 1) B: (2, 1, 0) C(2, 2, 2)

Let V1 be the vector timestamp for when R1 gets to P3.

Let V2 be the vector timestamp for when R2 gets to P3

That is:

V1 = (1, 0, 1) and V2 = (2, 2, 2)

Is V1 < V2? Yes, since 1 < 2, and 0 < 2 and 1 < 2.

Since V1 < V2, this means that R1 happens before R2. So, if vector timestamps are applied, R1 would be processed before R2.