CS 171 — Quiz I–January 28

Name: _____

Please Read carefully and sign below

This is an open book, open notes quiz. You must work alone. You are not allowed to discuss with your colleagues or consult any outside entity. The quiz time is 75 minutes and you will have 15 minutes to upload your answers.

Please sign or print your name below that you have read the above statement and promise to adhere to these regulations

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1. **12 points.** Consider a system with 2 processes p1 and p2. Assume event a is executed on p1 and event b is executed on p2. Give a brief justification for each question below.

   (a) Assume the logical Lamport time $L(a)$ is 10 and the logical Lamport time $L(b)$ is 17. Can you ascertain that *a happens-before b*? Why?

   (b) Assume the Logical Lamport time $L(a)$ is 17 and the Logical Lamport time $L(b)$ is 17. Can you ascertain that a and b are concurrent? Why?

   (c) Assume the Logical Total Lamport time $L(a)$ is $\langle 17, 1\rangle$ and the Logical Total Lamport time $L(b)$ is $\langle 20, 2\rangle$. Can you ascertain that *a happens-before b*? Why?

(d) Assume the Logical Total Lamport time $L(a)$ is $\langle 17, 1\rangle$ and the Logical Total Lamport time $L(b)$ is $\langle 17, 2\rangle$. Can you ascertain that a and b are concurrent? Why?

(e) Assume the Vector Time $V(a)$ is $\langle 17, 1\rangle$ and the Vector Time $V(b)$ is $\langle 19, 2\rangle$. Can you ascertain that a *happens-before* b? Why?

(f) Assume the Vector Time $V(a)$ is $\langle 17, 1\rangle$ and the Vector Time $V(b)$ is $\langle 7, 2\rangle$. Can you ascertain that a and b are concurrent? Why?

2. **4 points.** Consider any vector clock time V_i at process p_i associated with an event a and vector clock time V_j at process p_j associated with an event b. For each of the following statement, indicate if they are true or false, and **explain why**.

   (a) for all i, j, $V_i[i]$ must be greater than or equal to $V_i[j]$, $i \neq j$.

   (b) for all i, j, if $a \; happens-before \; b$, then $V_i[i]$ must be less than or equal to $V_j[i]$, $i \neq j$.

3. **6 points.** In class we discussed clock synchronization for an asynchronous systems, where we assumed that communication delays were symmetric between the clients and the time server. Consider a setting where due to congestion at the time server, the upload bandwidth is much higher than the download bandwidth. In this problem, assume you know that the speed of message delivery is on average twice as fast from the client to the time server compared to the speed of message delivery from the time server to the client (however, this is an average assumption, communication in any direction could be as small as zero).

   Using this assumption, answer the following questions using Cristian's algorithm but adapt the equations for the new network assumptions.

   (a) If the maximum clock drift of any client is +/- ρ, and the maximum time error tolerated by the application between **any client** and the **time server** is δ, then how often should a client initiate clock synchronization?

   (b) Describe what time the client should set its local clock to under these asymmetric communication assumptions.

   (c) What is the accuracy of this assignment (i.e., give error bounds to your solution in part(b))?

4. **3 points.** Consider the mutual exclusion problem as developed by Lamport, ie, one resource and n processes that need exclusive access to this one shared resource. In class, I motivated Lamport's solution by developing a centralized solution, based on a coordinator. More specifically, when a process wants to access the resource, it sends a *request* message to the coordinator. The coordinator either grants the resource by sending a *reply* or, if it has already granted the resource to another process (who has not yet released it), the request is put in a *queue*. Once a process receives a *reply*, it accesses the shared resource, and then sends a *release* message to the coordinator. When the coordinator receives a *release* message, it checks the *queue* and if there are any pending requests, it send the corresponding process a *reply* message.

   Dr Science claims that this *centralized* solution does *not* satisfy the *happens-before* relationship between mutual exclusion requests and their granting of the resource. That is if there is a *happens-before* between two different requests for the resource, then the resource is not necessarily granted in the same order in which they are made, ie, if $request_1$ by process p_1 happens before $request_2$ by process p_2 then it is not necessary that p_1 is granted the resource before p_2 is granted the resource.

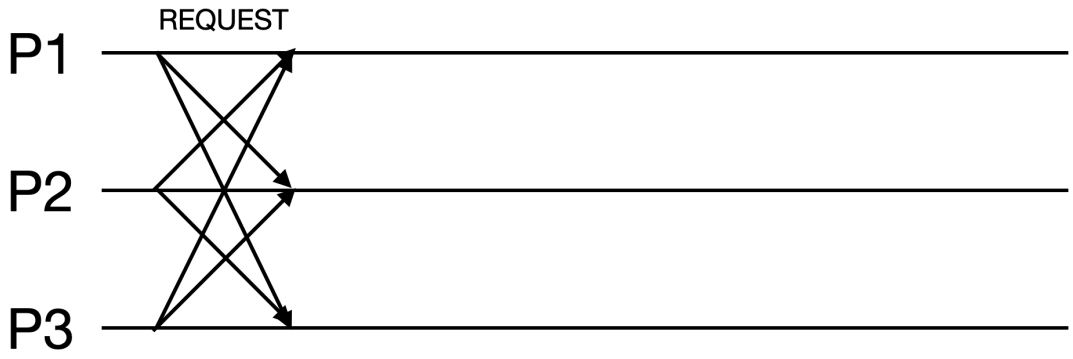
   - In support of Dr Science, show a simple example where the simple coordinator-based solution does **not** satisfy the *happens-before* relationship between *requests*.

5. **5 points.**

In class, we presented Lamport's Mutual Exclusion protocol (which consists of 3 rounds of messages: REQUEST/ACKNOWLEDGE/RELEASE).

Ricart and Agrawala simplify the original protocol as follows: A process replies with an ACKNOWLEDGEMENT only if (1) it is not requesting Mutual Exclusion or (2) if it is requesting Mutual Exclusion, its request has a timestamp higher than the request it just received.

(a) Consider a system with 3 processes p_1, p_2 and p_3. Assume all 3 processes **concurrently** attempt to acquire mutually exclusive access to a common resource. Develop in detail a scenario showing what happens and the order in which the 3 processes access the resource. For uniformity, assume all Lamport Logical Clocks are initialized to 1. Also, assume the first messages to arrive are the REQUEST message from p_1 to p_2, from p_3 to p_1 and from p_2 to p_3. Furthermore, in your scenario, assume no more REQUEST messages are sent. The rest of the actions and messages are left for you to develop. **Be sure to indicate clearly when each process accesses the resource and the final order of access**. Complete the following diagram:



(b) Does the Ricart and Agrawala protocol require FIFO channels (as Lamport's does)? Argue clearly (just a yes/no answer will receive minimal credit).

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