CS 6210 Spring 2021 Test 2

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Note:

1. **Write your name and GT number on each page.**
2. The test is **CLOSED BOOK** and **NOTES.**
3. Please provide the answers in the space provided. You can use scratch paper (provided by us) to figure things out (if needed) but you get credit **only** for what you put down in the space provided for each answer.
4. For conceptual questions, **concise bullets** (**not wordy sentences**) are preferred.
5. While it is NOT REQUIRED, where appropriate use figures to convey your points (a figure is worth a thousand words!)
6. **Illegible answers are wrong answers.**
7. **DON'T GET STUCK ON ANY SINGLE QUESTION…FIRST PASS: ANSWER QUESTIONS YOU CAN WITHOUT MUCH THINK TIME; SECOND PASS: DO THE REST.**

Good luck!

Question number	Points earned	Running total
1 (1 minute) (Max: 1 pts)		
2 (7 minutes) (Max: 10 pts)		
3 (7 minutes) (Max: 10 pts)		
4 (7 minutes) (Max: 10 pts)		
5 (7 minutes) (Max: 10 pts)		
6 (3 minutes) (Max: 5 pts)		
7 (3 minutes) (Max: 5 pts)		
8 (3 minutes) (Max: 5 pts)		
9 (10 minutes) (Max: 15 pts)		
10 (15 minutes) (Max: 20 pts)		
11 (7 minutes) (Max: 10 pts)		
Total (70 minutes) (Max: 61 pts)		

1. **(1 point, 1 minute)**(you get 1 point regardless of your answer)
Video hangout every week
(a) I attend all of them though I am not a fan
(b) I attend all of them and I love it
(c) I cannot attend them due to timing but watch every one of the recordings
(d) I cannot attend them due to timing but watch a few recordings for class participation points
(e) I cannot attend them due to timing and do not watch any of the recordings

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Lesson 5: Distributed Systems

2. **(10 points, 7 minutes) (Lamport's happened before relation)**
A student has implemented a distributed algorithm using Lamport's happened-before relationship to timestamp events. She is in the middle of debugging the program. She observes the following activities in the program:

P1's activities	P2's activities	P3's activities
E1: local event	E6: msg-receipt(from P1)	E10: msg-receipt(from P2)
E2: local event	E7: local event	
E3: msg-send(to P2)	E8: msg-send(to P1)	
E4: local event	E9: msg-send(to P3)	
E5: msg-receipt(from P2)		

Please help her by giving the causal relationship between the following pairs of events with reasoning. (No credit without reasoning)

(a) (2 points) E1 and E6?
(b) (2 points) E4 and E6?
(b) (2 points) E6 and E8?
(d) (2 points) E3 and E10
(e) (2 points) E5 and E10

3. **(10 points, 7 minutes) (Lamport's M.E. Algorithm)**
Lamport's mutual exclusion algorithm for a distributed system is based on happened-before relationship. It also hinges on two assumptions: (a) messages between any two nodes go in order, and (b) there is no loss of messages.

(a) What additional machinery would you need to make sure the algorithm will work correctly if the first assumption is relaxed?

(b) What additional machinery would you need to make sure the algorithm will work correctly if the second assumption is relaxed?

4. **(10 points, 7 mins) (Latency Reduction in RPC)**
Your co-worker came up with a design for a Network Interface Card (NIC) that does scatter/gather DMA. That is, it is possible to give the DMA controller a tuple in the form: {(memory address, length), (memory address, length), (memory address, length), ...}. The NIC's DMA engine will then do the needful to transfer the packet on to the network.

You are using this DMA controller to implement an efficient RPC package at the user level. Give a sketch of your design that minimizes the number of

copies for marshalling the arguments from the client. (It is sufficient to show client-side marshalling).

5. **(10 points, 7 minutes) (Active Networks)**
One could argue that Software Defined Networking (SDN) is "old wine in a new bottle".
(a) Justify this argument with a few concise bullets.
(b) With a few concise bullets, summarize the social and technology enablers that has made this wine drinkable now.

6. **(5 points, 3 minutes) (Ensemble/Nuprl)**
The authors cite features that justify the choice of OCaml as the systems programming language. Yet when it comes to optimization opportunities of the layered systems code, they point to many of these same features as the ones to circumvent to achieve good performance! Is there a contradiction? With a few concise bullets, explain why or why not.

Lesson 6: Distributed Objects and Middleware

7. **(5 points, 3 minutes) (Spring Kernel)**
You are the implementor of the "subcontract" subsystem in the Spring kernel. On the client side, you have the following API calls available to the Client-side stub: Invoke; Marshall: Unmarshall

You want to optimize the "Marshall" call to exploit the location of the server. Assume the client and server are executing on different processors of a shared memory machine.

How would you optimize marshalling the arguments of the call?

8. **(5 points, 3 minutes) (EJB)**
You have a startup to implement a portal for hotel reservations. The clients come to you over an insecure wide-area network. These are the objectives which are your "secret sauce" for the startup:

- You want to exploit parallelism across independent client requests
- You want to exploit parallelism within each client request
- You want to protect your business logic from being exposed to the wide-area Internet

You are planning to use EJB for meeting these objectives. Your N-tier solution has a Web container, an EJB container, and a Database server. To meet the design objectives:
(a) What functionalities would you put into the Web container (that interfaces with the client browsers)?

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(b) What functionalities would you put into the EJB container?

Lesson 7: Distributed Subsystems

9. **(15 points, 10 minutes) (GMS)**
(a) (5 points)
Due to memory pressure, Node N1 has paged out a **dirty** page X of a process P1 to Node N2. Node N2 is shut down for some reason. The process P1 on Node N1 page faults on X. What are the elements of the GMS design that ensures that Node N1 can satisfy the page fault for X?

(b) (5 points) (Answer True/False with justification. No credit without justification.)
The "geriatrics" algorithm decides the exact set of M pages that will be replaced in the upcoming epoch.

(c) (5 points)
A new node N3 joins the GMS system which is currently in operation. What are the steps taken in GMS to integrate N3 into the system?
(Concise bullets please).

10. **(20 points, 15 minutes) (DSM/GMS)**
(a)
CS1: a critical section governed by lock L1
CS2: a critical section governed by lock L2
Memory consistency model: LRC

In the increasing time order shown below:

- Time T1: Process P1 in CS1 produces a diff for page X: Xd1
- Time T2: Process P2 in CS1 produces a diff for page X: Xd2
- Time T3: Process P3 in CS2 produces a diff for page X: Xd3

Process P4 wishes to execute CS1.
(i) (5 points) What should happen before P4 starts executing CS1? Justify your answer.

(ii) (5 points) While inside CS1, P4 accesses page X. What should happen to ensure correct execution? Justify your answer.

(b) (5 points) (Answer True/False with justification. No credit without justification).
In Treadmarks, upon a page fault for a page X in Node N1, the DSM software on N1 broadcasts the virtual page number (VPN) of the faulting page to all the peer nodes.

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(c) (5 points)
Inspired by the material they learned, alums of OMSCS 6210 decide to design a system that combines services offered by GMS and DSM in one integrated system. Give them your sketch of a design for integrating DSM and GMS in one unified system.
(Concise bullets please.)

11. **(10 points, 7 minutes) (DFS)**
Back in 1985, Sun Microsystems built the first Network File System and dubbed it NFS and that name has stood the test of time. To this day college campuses use derivatives of NFS for serving the file system needs of its clientele.

Answer True/False with justification for each of the following questions with reference to traditional NFS. No credit without justification.

(a)
Multiple network servers can provide file system service.

(b)
The network servers for the data (actual file content) and the metadata (information about client nodes that are using the file, etc.) for a given file are not necessarily the same.

(c)
Individual files are striped across the disks of multiple network servers on the Local Area Network (LAN).

(d)
A file cached at a client may be used to serve the needs of other network clients for the same file bypassing the network server that hosts the file on its disk.