Programação em Sistemas Distribuídos

2015/16

MEI/MI/MSI

Final Exam (Época normal)

January 14, 2016

Total time: 2h30m

Number: _____ Name: _____

Instructions (please read and follow carefully):

1. This is a closed-book, closed-notes exam.
2. **Be brief** and precise in your answers. You may be penalized for unnecessarily long answers. *Hint:* Only use the space provided. Condense your answer into its key points – avoid writing long essays! Again, you may incur penalties for long answers. So, please think before you answer.
3. The total number of points is 20.
4. Some questions may have more than one correct answer.
5. Do not spend too much time on any one question. There are some simple questions that you can answer quickly. Come back to questions you cannot answer later if necessary.
6. Try to answer every question (briefly) so as to accumulate at least partial credit.
7. A blank page is attached at the end for your use as scratch paper.

For Graders' Use Only

I. _____ / 6

II. _____ / 14

TOTAL _____ / 20

I. Multiple-choice questions (6 points)

For each question there is only one correct answer. Please circle the correct answer.

(Grading: a correct answer is awarded 0,6 points; an incorrect answer is awarded -0,2 points).

1. Distributed systems are typically characterized by:

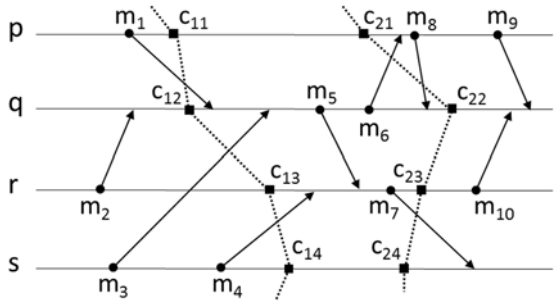
   (A) Being easily manageable.
   (B) Being homogeneous.
   (C) Having a global state.
   (D) Enjoying failure independence.

2. In a distributed system with **active** replication, message diffusion:

   (A) Can be unreliable, but with FIFO ordering.
   (B) Must be reliable, but without ordering requirements.
   (C) Must be reliable with FIFO ordering.
   (D) Must be reliable with total ordering.

3. Consider the following figure, which illustrates a set of messages exchanged between processes p, q, r and s (messages are delivered as soon as they are received). The figure also illustrates two global cuts, c1=<c_{11},c_{12},c_{13},c_{14}> and c2=<c_{21},c_{22},c_{23},c_{24}>. It is correct to say that:

   (A) Both cuts are consistent cuts.
   (B) Cut c1 is consistent and cut c2 is inconsistent.
   (C) Cut c1 is inconsistent and cut c2 is consistent.
   (D) Both cuts are inconsistent cuts.



4. Consider a distributed hash table with 128 indexed entries, to store objects with 256-bit hashes (identifiers). In this case, it is true that:

   (A) Collisions are possible because there will be 128 different identifiers for each entry.
   (B) Collisions are possible because there will be 2^{128} different identifiers for each entry.
   (C) Collisions are possible because there will be 2^{249} different identifiers for each entry.
   (D) Collisions are not possible.

5. In a distributed transactional system the mechanism that guarantees the **Isolation** property of transactions is:

   (A) Two-Phase Commit (2PC).
   (B) Two-Phase Lock (2PL).
   (C) Distributed Consensus.
   (D) Three-Phase Commit (3PC).

6. In the NFS File System:

   (A) When a client opens a file, the file is transferred from the server to the client and is stored in a memory cache.
   (B) When a client reads file data that is on the local memory cache, no data needs to be requested to the NFS server, unless it has been changed on the server.
   (C) When a client writes on a file, the local cache is updated, the data is sent to the server and all client caches containing that data are invalidated.
   (D) When a client reads file data that is not on the local cache, any server replica can be contacted to obtain the needed data.

7. The group-based communication model can be characterized as being typically:

   (A) Space coupled, time coupled and synchronized.
   (B) Space uncoupled, time uncoupled and synchronized.
   (C) Space uncoupled, time coupled and non-synchronized.
   (D) Space coupled, time uncoupled and non-synchronized.

8. Concerning RPC, which of the following sentences is **FALSE**?

   (A) Communication is symmetric and blocking.
   (B) A multi-threaded client is allowed to execute several concurrent RPCs.
   (C) The RPC failure semantics can be, for instance, *at-least-once* or *at-most-once*.
   (D) Multi-threaded RPC servers use mutual exclusion mechanisms to prevent state corruption.

9. When using NTP **multicast** to synchronize the clocks in some organization, it is true that:

   (A) The round-trip protocol is used to synchronize the clocks.
   (B) The resulting clock precision and accuracy will be better than when using other NTP synchronization methods, but the setup will be more complex.
   (C) The master node must always be above stratum 2.
   (D) All the nodes, including the master, are in the same stratum.

10. When using Zookeeper watches, it is necessary to implement the method:

    (A) watch.
    (B) callback.
    (C) process.
    (D) execute.

II. Development questions (14 points)

1. [1,5] Explain how distribution can be exploited as a strategy to improve certain security aspects in a distributed computing system.

2. [1,5] Consider a distributed system in which clocks are synchronized from the clock of master node M using the round-trip synchronization protocol. Consider also that the minimum message delivery delay is T_{Dmin}=1ms and that the deviation rate of physical clocks is, at worse, $\rho=5x10^{-5}$ (the physical clock of the master node does not deviate, is perfect).

   a) [1] If node P synchronizes its clock from M at instant t_s and receives a reply containing the master clock C_M=9h10m05s10ms from the master M at instant t_r, with t_r-t_s=12ms, determine the value $C_P(t_r)$ that will be assigned to the clock of node P at instant t_r.

   b) [0,5] Determine the maximum clock difference between the clocks of P and M, that is $|C_P - C_M|$, at time instants $t_1= t_r$ (when the clock of P is adjusted) and $t_2= t_r$+10m.

3. [1,5] Describe a protocol for message dissemination in a synchronous distributed system, which exhibits steadiness and tightness.

4. [1,5] Consider the replicated shared variable x, such that initially x=0. Three processes, p1, p2 and p3, each access a different replica to read and write the value of x. The code executed by each of the processes is the following:

p1	p2	p3
x=1;	x=2;	x=3;
a=x;	b=x;	c=x;

Considering that the replicated variable x is implemented with sequential consistency, when the three processes complete their execution is it possible to have a=3, b=2 and c=1? What about a=1, b=2 and c=3? Justify.

5. [2] A possible Distributed Shared Memory (DSM) architecture is one that implements full replication of the shared memory pages.

a) [1] Under which assumptions is this a suitable architecture? Explain why.

b) [1] Explain how it is possible to ensure sequential consistency in this DSM architecture.

6. [2] Characterize the view synchrony property of group communication systems and explain why it is so important when building distributed systems.

7. [1,5] Describe briefly the Google File System (GFS) architecture, explaining the reasons why the data flow and the control flow have been keep separate.

8. [2,5] Consider the WWStore project developed during the course.
   a) [0,5] The project was developed following a 3-tier architecture: presentation tier, application tier and data tier. Explain the role of each of the three tiers.

b) [1] The system was developed using replication and sharding mechanisms. Explain the purpose of these mechanisms in each of the layers in which they were employed.

c) [1] Consider that 6 servers were available to implement the data tier. How would you implement sharding and replication to ensure the best possible throughput and availability despite 2 server failures, explaining why your solution is the best possible.

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