

Programação em Sistemas Distribuídos

2015/16

MEI/MI/MSI

Final Exam (Época Recorrência)

February 3, 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.
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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. Most distributed systems must be secure, which implies the need to ensure:

(A) Reliability, trustworthiness and availability.
(B) Confidentiality, integrity and availability.
(C) Liveness, trustworthiness, resilience.
(D) Reliability, confidentiality, safety.
2. In a distributed client/server system with passive replication of the server and with independent clients (which do not communicate with each other), message diffusion:

(A) Must be reliable with total ordering.
(B) Must be reliable with causal ordering.
(C) Must be reliable, but without ordering requirements.
(D) Can be unreliable, but with causal ordering.
3. In a distributed system clocks are periodically synchronized with an algorithm that guarantees a convergence $\delta=100\mu\text{s}$, which is executed with period $P=5\text{min}$. Knowing that the maximum rate of drift of physical clocks is $\rho=5\times 10^{-6}$, the achieved precision is:

(A) $100\mu\text{s}$.
(B) $150\mu\text{s}$.
(C) $1,6\text{ms}$.
(D) $3,1\text{ms}$.
4. Consider a distributed hash table with 512 indexed entries, to store objects with 8-bit hashes (identifiers). In this case, it is true that:

(A) Collisions are possible because there will be 256 different identifiers for each entry.
(B) Collisions are possible because there will be 2 different identifiers for each entry.
(C) Collisions are possible because there will be 504 different identifiers for each entry.
(D) Collisions are not possible.
5. In a distributed transactional system the mechanism that guarantees the consistency property of transactions is:

(A) Two-Phase Commit (2PC).
(B) Two-Phase Lock (2PL).
(C) Distributed Consensus.
(D) Total-order Broadcast.

6. The **peer-to-peer** communication model can be characterized as being typically:
- (A) Space coupled, time coupled and synchronized.
 - (B) Space uncoupled, time coupled and synchronized.
 - (C) Space uncoupled, time uncoupled and non-synchronized.
 - (D) Space coupled, time uncoupled and non-synchronized.
7. Concerning the Distributed Shared Memory (DSM) communication model, which of the following sentences is **FALSE**?
- (A) Memory distribution is transparent to clients, which “see” a centralized shared memory space.
 - (B) When a memory page is migrated to a client, another client accessing that page will block until the page is released.
 - (C) When read-replication is used to implement DSM, the consistency between replicated pages can no longer be ensured.
 - (D) When full-replication is used to implement DSM, every single write has to be broadcast to all replicas in total order, to ensure sequential consistency.
8. In the AFS File System:
- (A) When a client **opens** a file stored in AFS, the entire file is always transferred from the AFS server to the client.
 - (B) When a client **reads** data from an AFS file, the operation is always performed on a copy of the file that is in the local cache.
 - (C) When a client **writes** data on an AFS file, the file in the local cache is updated, data is sent to the server and all copies of the file in other client caches are invalidated.
 - (D) When a client **closes** a file stored in AFS, the entire file is always transferred from the client to the AFS server.
9. When using NTP in **symmetric** mode 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, the method that allows obtaining a list of the children of the node of a given path is:
- (A) getChildren.
 - (B) listNodes.
 - (C) getNodes.
 - (D) getData.

II. Development questions (14 points)

1. [2] Explain how distribution can be exploited as a strategy to improve certain performance aspects in a distributed computing system.

2. [1,5] Consider a protocol of the TDMA class, implemented in a distributed system with synchronized clocks, in which the maximum message delivery delay is bounded and known.
 - a) [0,5] Is it possible to achieve high steadiness with this protocol? Justify.

 - b) [0,5] Is it possible to achieve high tightness with this protocol? Justify.

 - c) [0,5] Is it possible to ensure total message ordering with this protocol? Justify.

3. [2] Causal ordering is fundamental in many distributed systems.
- a) [0,75] When a communication protocol is said to provide causal ordering, what does it mean?

b) [0,5] Give an example of a distributed system/application in which causal ordering is necessary.

c) [0,75] Briefly describe a possible approach to implement a causal ordering protocol.

4. [1,5] Consider the replicated shared variable x , such that initially $x=0$. Four processes, $p1$, $p2$, $p3$ and $p4$, each access a different replica to read or write the value of x . The code executed by each of the processes is the following:

$p1$
 $x=1;$

$p2$
 $x=2;$

$p3$
 $\text{print}("a",x);$
 $\text{print}("b",x);$

$p4$
 $\text{print}("a",x);$
 $\text{print}("b",x);$

Considering that the replicated variable x is implemented with **sequential consistency**, when the four processes complete their execution is it possible to have $p3$ printing the sequence $a0b2$ and $p4$ printing the sequence $a2b1$? Justify.

5. [2] Characterize the publish/subscribe communication model, describing, in particular: a) the generic interface of a publish/subscribe system and the purpose of each interface function; b) the two main approaches for routing events from publishers to subscribers.
6. [1,5] In the peer-to-peer communication model, there is an overlay network layer in between the applications and the TCP/IP network layer.
- a) [1] Explain the **purpose** of this overlay network layer, referring to the two main kinds of overlay networks: **structured** and **unstructured**.
- b) [0,5] In this context, how is the **routing stretch** metric defined, and what is its purpose?

7. [1,5] Explain carefully the solution that was devised in Cassandra to achieve high scalability.

8. [2] Consider the WWStore project developed throughout the course.

a) [1] The project was developed following a 3-tier architecture: presentation tier, application tier and data tier. Which of these tiers has more impact on the WWStore system scalability? Justify.

b) [1] The project requirements included making the WWStore service resilient to one server failure and also to the failure of all servers at the same time. Describe the fundamental aspects of the solution that should be implemented to make the service resilient to the crash of all servers.

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