Programação em Sistemas Distribuídos

2014/15

MEI/MI/MSI

Final Exam (Época normal)

January 15, 2015

Total time: 120 minutes

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.

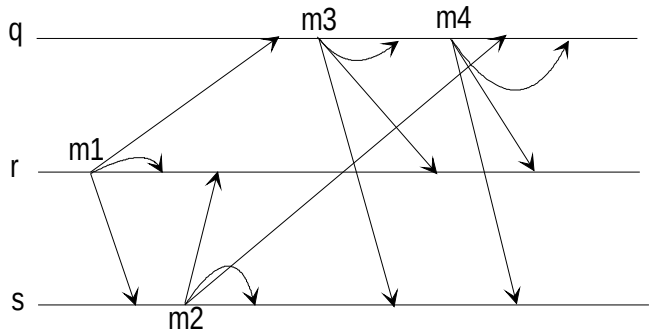
(Grading: a correct answer is awarded 0,6 points; an incorrect answer is awarded -0,2 points).

1. In comparison with a centralized system, a distributed system:

   (A) Is more manageable due to the several points of access.
   (B) Is more reliable because components can be replicated.
   (C) Is less secure.
   (D) Is less scalable.

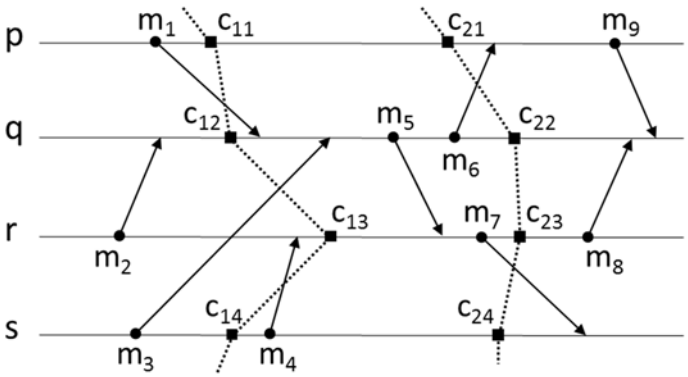
2. Consider the following figure, which illustrates a set of message exchanged between processes q, r and s (messages are delivered as soon as they are received). It is correct to say that the communication protocol:

   (A) Only preserves FIFO order.
   (B) Preserves FIFO and Causal order, but not Total order.
   (C) Preserves FIFO and Total order, but not Causal order.
   (D) Preserves FIFO, Causal and Total order.



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



4. Which of the following statements is true for the sequential consistency model:

   (A) Sequential consistency is sufficient to guarantee the state convergence of replicates registers.
   (B) To achieve sequential consistency it is enough that concurrent accesses to replicated registers are FIFO ordered.
   (C) Sequential consistency is achieved as long as write operations are totally ordered.
   (D) To achieve sequential consistency it is necessary to use the Two-Phase Commit protocol.

5. In the Google File System:

   (A) There are several Master nodes serving client requests, for load balancing purposes.
   (B) There is a single Master node, which stores file mappings on a disk log for fault tolerance.
   (C) Files are split in chunks that are replicated in Chunk Servers using passive replication.
   (D) When a client requests a write operation, the operation is concluded as soon as one of the replicas writes all the data to disk, to achieve higher throughput.

6. Concerning the DNS and the X.500 directory services, it is true that:

   (A) The execution of functional queries is only possible in the X.500 service.
   (B) Only DNS is locally managed.
   (C) The X.500 service is not hierarchical.
   (D) The DNS service is not hierarchical.

7. In group communication:

   (A) The group management service ensures that messages are delivered to all group participants.
   (B) The group management service handles join and leave requests, as well as indications from the failure detection service.
   (C) The view synchrony property ensures that at a given time instant all group participants have the same group membership view.
   (D) The view synchrony property ensures that when a message is sent in view V, it is delivered to all processes in that view.

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

   (A) Communication is asymmetric and blocking.
   (B) A multi-threaded client is allowed to execute several concurrent RPCs.
   (C) Multi-threaded RPC servers are more reliable than single-threaded RPC servers.
   (D) Multi-threaded RPC servers require synchronization mechanisms to prevent state corruption.

9. The Message bus or Publish/Subscribe communication model is characterized by:

   (A) Allowing time and space decoupling.
   (B) Requiring stateless event brokers.
   (C) Ensuring reliable delivery of events.
   (D) Allowing events to be filtered according to FIFO or priority disciplines.

10. When using Zookeeper, the method that allows checking if a node has been previously created is:

    (A) created.
    (B) test.
    (C) exists.
    (D) check.

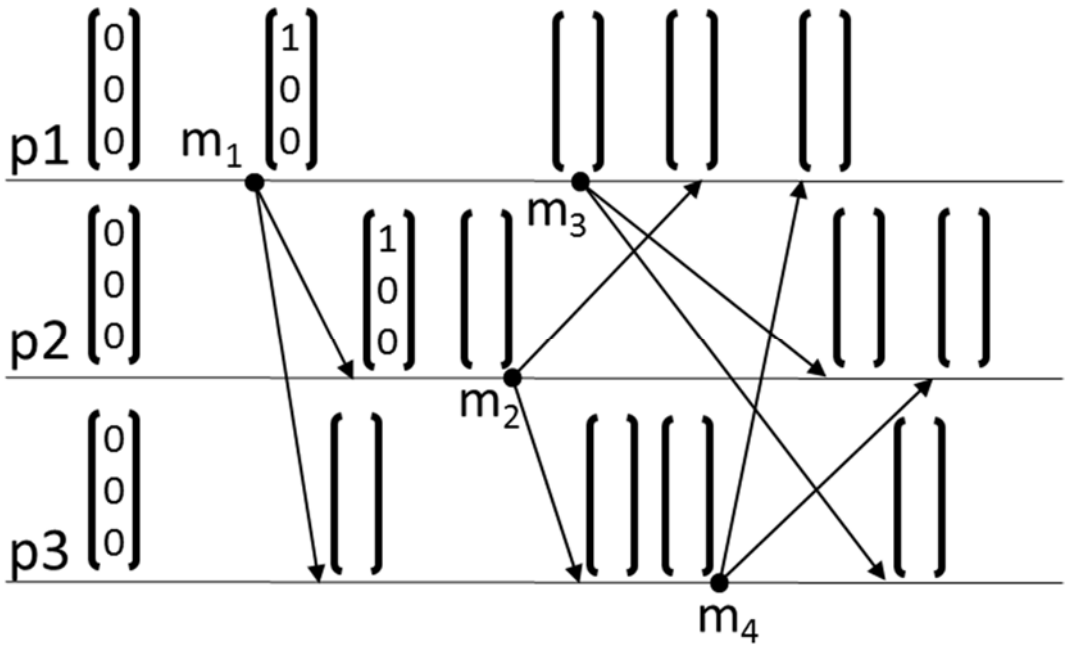
II. Development questions (14 points)

1. [1,5] Distributed systems architectures have evolved over time. Explain what led to the emergence of architectures with "fat clients" and why were these replaced, later on, by architectures based on "HTTP thin clients".

2. [1,5] Explain the difference between coordination, sharing and replication in a distributed system. Provide a representative example of each of these classes of distributed activities.

3. [1,5] The CAP (Consistency, Availability and Partition Tolerance) theorem says that it is not possible to achieve all the three properties in a distributed large-scale system. However, most existing large scale services, like Google, eBay or Facebook, seem to enjoy all them. Explain the apparent paradox.

4. [1,5] The figure represents the history of an execution with causal order based on vector clocks. However, some of the vectors are missing. Complete these vectors following the implementation rules for causal ordering with vector clocks.



5. [1] Describe in detail two advantages of passive replication in comparison with active replication, providing examples of systems or applications in which these advantages are relevant.

6. [2] In some distributed computing setting, file access is characterized by:

   - Random access to file data much more frequent than sequential access;
   - Typically small read operations (1KB data blocks)
   - Read operations more frequent than write operations (10:1 factor)
   - Typically only one writer and multiple readers
   - Small probability of repeated access to the same file in a short amount of time

   a) [1] Considering these characteristics, which of the following file systems, AFS or NFS, would be the most appropriate? Justify your answer in detail.

b) [1] Given the mentioned file access characteristics, would it be useful replicate the file server? Explain why.

7. [1,5] NTP is one of the most used time services in the Internet.

a) [0,5] What are the possible synchronization modes of NTP?

b) [1] Explain the NTP operation when the synchronization mode is based on multicast.

8. [2,5] You've been hired some company to develop a chat application to be used in the company's Intranet, only by employees. In the company they use a development framework that only provides RPC as a communication library

   a) [1] Comment on the fact that the solution must be developed using RPC. Is this a suitable approach? Are there other approaches that could be more convenient? What would you suggest to your boss?

   b) [1,5] Your boss is stubborn and insists in building the chat application with RPC. So you're left with no option. Still, you want to show that you are a very good professional and you will design the best possible architectural solution. You can make a sketch, including in it the involved entities (clients/servers), the possible interactions (requests/replies) and also indicating the operations that may be performed. Other aspects, like the use of multi-threading, are also relevant. Complement the sketch with the necessary explanations. You may use the extra space in the last blank page.

9. [1] Explain the fundamental difference between Zookeeper and a name service (like LDAP or CORBA name service).

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