Fakultät IV
Betriebssysteme und verteilte Systeme
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Excercise Sheet 9

(To be processed until 19.12.)

Lecture Distributed Systems
Winter Term 2024/25

Exercise 1: Algorithm of Ricart and Agrawala

The algorithm of Ricart and Agrawala has the problem that if a process has crashed and does not respond to a request from another process to enter a critical section, the missing response is interpreted as a denial of permission. One way to easily identify crashed processes is to immediately (if necessary negatively) respond to all requests. Are there situations where even this method is not sufficient?

Exercise 2: Deadlocks - Ricart and Agrawala

A distributed system can have several independent critical sections. Suppose process 0 wants to enter the critical section A, and process 1 wants to enter the critical section B. Can the Ricart and Agrawala algorithm lead to deadlocks? Explain your answer.

Exercise 3: Programming: Ricart/Agrawala (Mandatory exercise for 6 CP, submit via moodle!)

In the archive `u09eFiles.zip`[1] on the lecture's web page you will find the implementation of a process system with several server processes. At the very start, the servers receive a message from the client containing exactly one task, which they process locally. For processing, the servers must go into a critical section in which a file (`ressource.txt`) is written.

Based on the given code, implement the Ricart and Agrawala mutual exclusion algorithm so that only one server can write to the file at a time. To do this, complete the methods `lockResource()`, `unlockResource()` and `handleMutexMessage()` in `Server.java` and add any necessary declarations and initializations. To simplify things, you can assume that a server receives only exactly one request from the client, i.e., no new request can be received while the current request is being processed.

The realization of Lamport time stamps necessary for the algorithm is already completely predefined. The sender of a message can also be determined (method `getSender()` of the class `Message`).

Test your solution with a varying number of simultaneous requests and a varying number of servers. The number of jobs can be specified at the client as a command line argument (maximum as many as there are servers).
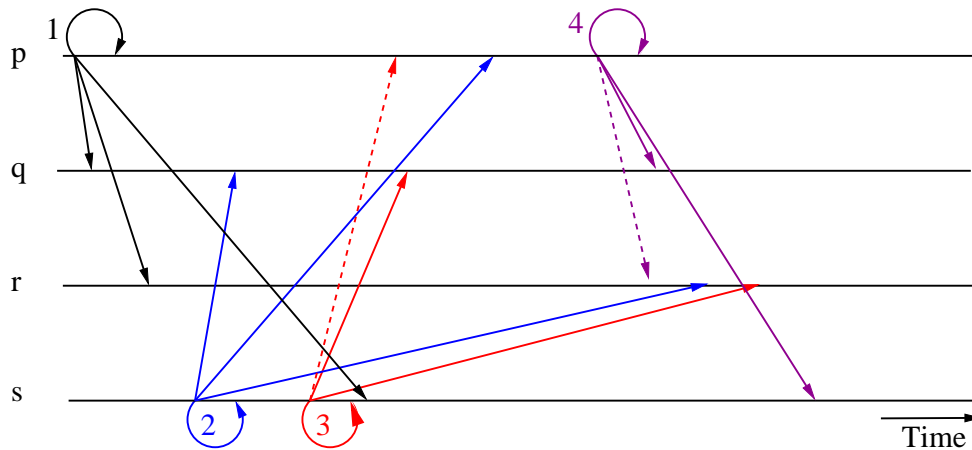
Exercise 4: Multicast Order Guarantees

In the lecture different variants for order guarantees in multicast were presented (see chapter 7.3).

a) The figure shows 4 processes (p, q, r, s) and four multicast messages.

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[1] http://www.bs.informatik.uni-siegen.de/web/wismueller/vl/vs/u09eFiles.zip

Message 4 in the example is causally dependent on message 3.

When must the delivery of the messages 3 and 4 take place, so that a FIFO order and a causal order is guaranteed for all messages? Note: You only need to draw the dashed arrows correctly. Is then also a total oder guaranteed?

b) To illustrate the multicast sorting, let's look at an "electronic blackboard" application, where users leave messages on a blackboard. Each user executes an application process for the black board. There are several discussion topics, each with its own process group. A user's process is a member of the group for the topic he is interested in, so the user only receives messages on that topic. When a user posts a message on a black board, the application multicasts it to the appropriate group.

A user X could then receive the following display from the program for the black board:

```
Bulletin board on the topic: Communication in distributed systems

Message          from                 Title of message
_____
   27            A. Bauer             UDP & TCP Communication
   28            C. Fritz             RPC Principle
   29            G. Meier             Re: UDP & TCP Communication
   30            K. Wim               RPC 1
   31            A. Bauer             Re: RPC Principle
   32            K. Wim               RPC 2
```

Note that the messages whose topics begin with *Re:* appear after the messages to which they refer.

Which sorted multicast methods are used in the application and where exactly? If the multicast were totally ordered, what can you say about the numbering in the left column?

Exercise 5: Totally Ordered Multicast

To implement totally ordered multicast with the help of a sequencer, one approach is to first pass the message to the sequencer, which assigns it a unique number and then passes it on via multicast. Name an alternative approach and compare the two solutions.

Exercise 6: Causally Ordered Multicast (Mandatory exercise for 6 CP, submit via moodle!)

Suppose a system provides reliable multicast with FIFO ordering. One could get the idea to implement a causally ordered multicast based on this as follows:

- Each message is provided with the Lamport time stamp of the send event.

- The recipient nodes deliver incoming messages to the recipient processes in an order that is consistent with the order of the timestamps.

a) Justify why this multicast is causally ordered.

b) Where is the problem with this implementation? (**Tip**: when can a message be delivered to the recipient process?) How could it be solved?

c) Justify why this multicast is not totally ordered. How could a total order be achieved?