UNIVERSITÄT SIEGEN

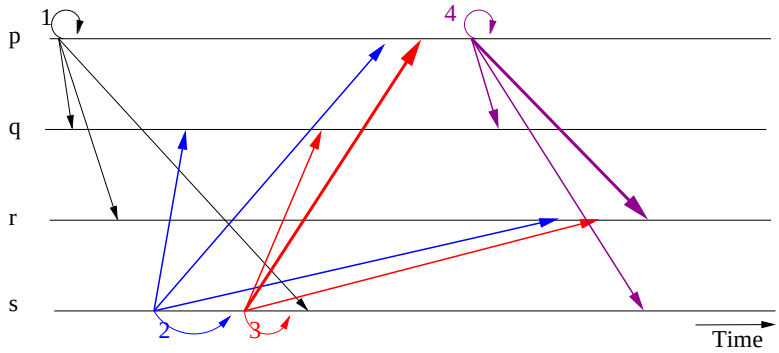
Fakultät IV
Betriebssysteme und verteilte Systeme
Prof. Dr. rer. nat. Roland Wismüller

Excercise Sheet 10
Solution

Lecture Distributed Systems
Winter Term 2025/26

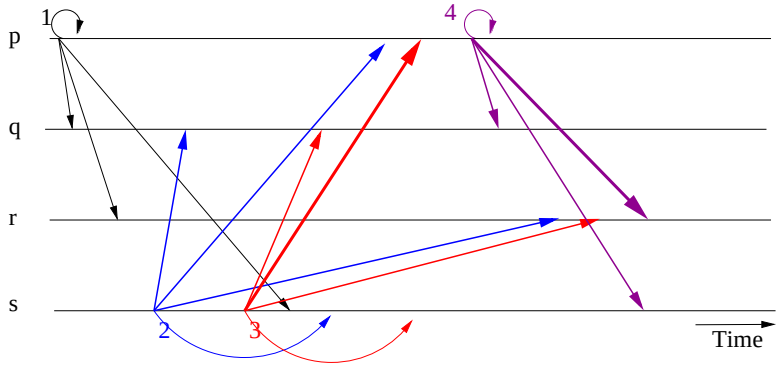
Exercise 1: Multicast Order Guarantees

a) With a causally sorted multicast, message 3 must arrive in all processes (especially process p) after message 2 (since 3 causally depends on 2). Message 4 must also arrive in all processes (especially process r) after message 3.



However, this does not guarantee total order (for example, process p: sequence 1,2,3,4; process s: sequence 2,3,1,4).

A total order would be provided if all messages from all processes were delivered in the same order.



b) For the user to receive all publications, a **reliable** multicast is required.

A **FIFO order** is required so that a user's posts, e.g. A. Bauer, are received everywhere in the same order. Users can then consistently discuss A. Bauer's "second posting". Also, the second post might refer to the first one.

A **causal order** is also needed because the messages whose topics begin with *Re:* should appear after the messages they refer to. Otherwise, delaying a message could cause the message *Re: RPC Principle* to appear before the original message *RPC Principle*.

If the multicast delivery were totally ordered, the numbering in the left column would be consistent between users. However, this is not absolutely necessary.

In practice, the USENET system, which emulates such a bulletin board, implements neither a causal nor a total order. The communication effort required for this would far outweigh its advantages.

Exercise 2: Totally Ordered Multicast

A second approach is to send the message immediately via multicast, but to postpone delivery until the sequencer has multicast a sequence number for it. This happens after the message is received by the sequencer.

A third approach is to first request a sequence number from the sequencer and then multicast the message.

The first approach (to send the operations to the sequencer) involves sending a point-to-point message with the operation and a multicast message.

The second approach requires two multicast messages: one with the operation and one with the sequence number.

The third approach costs a point-to-point message with the sequence number followed by a multicast message containing the operation.

Exercise 3: Totally Ordered Multicast / Lamport time stamps

No, it is sufficient to multicast any other message type as long as this message has a timestamp greater than that of the received message.