

Excercise Sheet 11

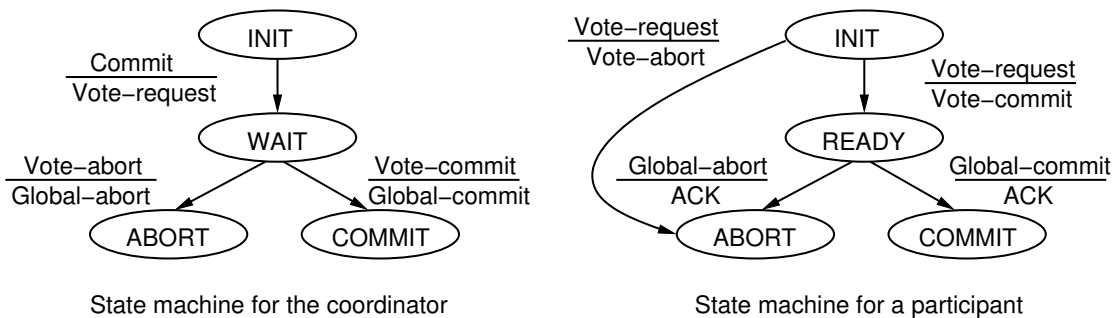
(To be processed until 22.01.)

Lecture Distributed Systems Winter Term 2025/26

Exercise 1: Two-Phase Commit

In a system where errors may occur, several problems may occur when using the basic two-phase-commit protocol. First, note that both the coordinator and the participants may have states in which they are blocking and waiting for incoming messages. So the protocol can easily fail if one process crashes, because the other processes wait indefinitely for a message from that process. The figure below shows the state machine for a coordinator and for a participant in this context. For each transition, the event (local request or incoming message) is shown on the top, while the corresponding action (outgoing message) is shown at the bottom.

Look at this diagram and name a total of three possible states in which a coordinator or participant could block.



Exercise 2: Causal Consistency

a) Show that the following execution is not causally consistent:

$P_1 : W(x)0; W(x)1$

$P_2 : R(x)1; W(y)2$

$P_3 : R(y)2; R(x)0$

b) What kind of consistency would you use to implement electronic stock trading? Explain your answer.

Compulsory Exercise 3: Quorum Protocols Submit via moodle!

The failure of network connections or the failure of a gateway computer that connects several networks with each other can result in operational subnets (partitions) whose nodes can still communicate with each other. If replicas of an object are in different subnets and changes are to be made, not all replicas can be reached and inconsistent states can result.

To solve this problem there are among other things the so-called *quorum protocols*, where each replica is assigned a certain weight (a number of votes) beforehand. In order to perform an operation, a certain sum of weights must be collected, i.e. r votes must be present for reading and w votes for writing (read quorum or write quorum).

Assume that there are N replicas in a system. Each replica is assigned a weight of 1. For the following four quorum protocols, justify whether they have a meaningful read or write quorum.

- a) $N = 10, r = 6, w = 5$
- b) $N = 10, r = 5, w = 6$
- c) $N = 10, r = 3, w = 7$
- d) $N = 10, r = 1, w = N$

Compulsory Exercise 4: Quorum-based Replication

Submit via moodle!

A file is replicated on eight servers. Name all combinations of read quorum and write quorum allowed by the voting algorithm.

Exercise 5: Replication

- a) Explain briefly why the replicas are used.
- b) Name and briefly explain the different types of replicas presented.

Exercise 6: Active Replication

For active replication to work, it is generally necessary that all operations on all replicas are executed in the same order. Is this order always required?

Compulsory Exercise 7: Evaluation of DsBox

Please provide us with feedback on the simulator for distributed systems (DsBox) that was used in the exercises. The survey is completely anonymous and can be accessed via the URL <https://umfragen.uni-siegen.de/index.php/734424?lang=en>.

Exercise 8: Any Questions?

Use the opportunity to prepare questions about the exercise sheets that you would like to discuss in the exercise lesson. You will now be able to discuss difficulties in solving the exercises and to explain possible solutions again.