Prof. Dr. Annette Bieniusa
Philipp Lersch, M. Sc.

RPTU Kaiserslautern-Landau
Fachbereich Informatik
AG Softwaretechnik

Exercise 6: Programming Distributed Systems (Summer 2025)

Submission Deadline: 24.6.2025 AOE

- You need a team and a Gitlab repository for this exercise sheet.
- In your Git repository, create a branch for this exercise sheet, for example with

```
git checkout -b ex6
```

- Create a folder named "ex6" in your repository and add your solutions to this folder.
- Create a merge request in Gitlab and assign Philipp Lersch as assignee. If you do not want to get feedback on your solution, you can merge it by yourself.

1 CRDT Questions

In the lecture you started with researching CRDTs. Answer these questions to test your fundamental knowledge on CRDTs.

a) What does CRDT stand for? Do alternative long forms exist?

b) Which two major categories exist for CRDTs? How do they differ?

c) What are typical drawbacks of CRDTs?

d) What are typical benefits of CRDTs?

e) Give a short description of the CAP Theorem

f) Evaluate CRDTs in the context of the CAP Theorem

g) What properties should CRDT operations exhibit?

h) How could a state-based counter CRDT be implemented? It will only be incremented.

2 CRDT Implementations - WiP

In this section you will implement some basic CRDTs. To simplify the task at hand, we will create network agnostic implementations. These have three classes of operations

1. The initialization: Here an initial state is created and the value for the application layer is returned.
2. The operations: Operations take some input and the current state to generate an update. They do not directly modify the local state, instead they only return the update for an arbitrary transport layer.
3. The update integration: The updates from any CRDT-operation are integrate into the local and remote replica states. Each integration returns the new value for the application layer

2.1 Two Phase Set

Research and create a state-based two phase delete-wins set CRDT. It should implement the operations for adding and deleting entries. What could be changed such that deleted content can be readded?

2.2 Add Wins Set

Change the previous two phase set CRDT, such that it is operation-based and exhibits add-wins semantics. It should also implement the operations for adding and deleting entries.

2.3 Multi-Value Register

Implement a multi-value register. It should implement a set function. What should the return-value of the init and integrate update operations be?