University of Freiburg
Dept. of Computer Science
Prof. Dr. F. Kuhn
S. Faour, P. Schneider

Theory of Distributed Systems
Exercise Sheet 4

Due: Wednesday, 19th of May 2021, 12:00 noon

Exercise 1: Happens Before in Shared Memory *(5 Points)*

Consider n processors and m shared variables. Every processor can access every shared variable with atomic read and write operations (i.e., a process can either read from or write to a shared variable and the system guarantees that such accesses of different processes to the same variable happen atomically). Define a happens before relation similar to the one for message passing.

Exercise 2: Unique Maximal Cut Preceding a Given Cut *(5 Points)*

Given a schedule S with *some* cut C. Show that there is a unique, maximal consistent cut C' of S which precedes the cut C.

Remarks: A cut C' precedes C if $C' \subseteq C$. A cut is maximal with respect to a given property if it contains the most events among all cuts with that property.

Exercise 3: Happens Before Relation *(5 Points)*

Let S be a schedule with events a, b, and c. Show that if $a \not\Rightarrow_S b$ and $a \not\Rightarrow_S c$ holds, then there exists some causal shuffle S' of S in which b and c occur before a.

Exercise 4: Logical Clocks *(5 Points)*

You are given a clique graph on n nodes. Find two executions A and B, in which each node sends exactly one message to every other node, such that

a) the largest Lamport clock value in A is as small as possible, and

b) the largest Lamport clock value in B is as large as possible.