



Theory of Distributed Systems

Exercise Sheet 4

Due: Wednesday, 25th of May 2023, 12:00 noon

Exercise 1: Vector Clocks

(5 Points)

Prove the following Theorem from the lecture:

Fix a schedule S ; then for any e, e' , $VC(e) < VC(e')$ if and only if $e \Rightarrow_S e'$.

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

- the largest Lamport clock value in A is as small as possible, and
- the largest Lamport clock value in B is as large as possible.