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# Theory of Distributed Systems

## Exercise Sheet 6

**Due:** Wednesday, 14th of June 2023, 12:00 noon

### **Exercise 1: Leader Election with Failures** *(8 Points)*

Consider the leader election problem on a complete graph in the synchronous message passing model. That is, every node has a unique ID and at end of the algorithm, every node that did not crash has to output the ID of the leader node.

Show that if at most  $f \leq n - 2$  processes fail during the protocol, at least  $f + 1$  rounds are needed to solve leader election.

### **Exercise 2: $k$ -Set Agreement with Failures** *(12 Points)*

A generalization of consensus is the  $k$ -set agreement problem: Every node has *some* input value and at the end every node has to output a value such that the following validity properties are fulfilled:

1. There must not be more than  $k$  different output values.
2. Every node that did not fail must output a value which was input of some node.

Show that on a complete graph in the synchronous message passing model with at most  $f$  node *failures*, the  $k$ -set agreement problem is solvable in  $\lfloor f/k \rfloor + 1$  rounds. Argue why that upper bound is tight.