## Exercise Session Consensus

## Exercise 1

Consider all our fail-stop consensus algorithms (Consensus Algorithm I and Consensus Algorithm II). Explain why none of those algorithms would be correct if the failure detector turns out not to be perfect.

A violation of *strong completeness* property of the perfect failure detector could lead to the violation of the *termination* property of consensus as follows. In all our fail-stop algorithms, there is at least one critical point where a process p waits to deliver a message from a process q or to detect the crash of process q. Should q crash and p never detect the crash of q, p would remain blocked forever and never decide.

Consider now *strong accuracy*. If it does not hold, our fail-stop consensus algorithms could violate the *agreement* property. It is easy to devise an execution where processes falsely suspect each other and hence decide on different values, thus violating *agreement*.

## Exercise 2

Explain why any fail-noisy consensus algorithm (one that uses a  $\diamond P$  failure detector) actually solves uniform consensus (and not only the non-univorm variant).

Consider any fail-noisy consensus algorithm that implements consensus but not uniform consensus. This means that there is an execution where two processes p and q decide differently and one of them crashes, so that the algorithm violates uniform agreement. Assume that process p crashes. With an eventually perfect failure detector, it might be the case that p has not crashed but is falsely suspected to have crashed by all other processes. Process q would decide the same as in the previous execution, and the algorithm would even violate the regular agreement property.

## Exercise 3

Explain why any fail-noisy consensus algorithm (one that uses a  $\diamond P$  failure detector) requires a majority of the correct processes. More precisely, provide a "bad run" in the case where there isn't a majority correct.

We explain this for the case of a system of four processes p, q, r, and s. Assume by contradiction that there is a fail-noisy consensus algorithm that tolerates the crash of two processes. Assume that p and q propose a value v, whereas r and s propose a different value s. Consider an execution E1 where s and s crash initially: in this execution, s and s decide s to respect the s validity property of consensus. Consider also an execution E2 where s and s crash initially: in this scenario, s and s decide s. With an eventually perfect failure detector, a third execution E3 is possible: the one where no process crashes, s and s falsely suspect s and s falsely suspect