Dependable Distributed Systems
Master of Science in Engineering in Computer Science

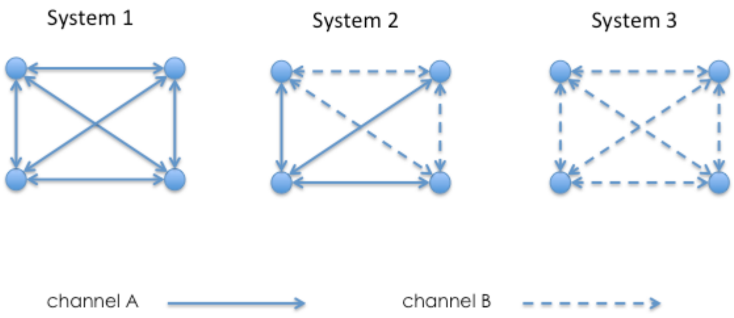
AA 2022/2023

Lecture 8 – Exercises

Ex 1: Let channel A and channel B be two different types of point-to-point channels satisfying the following properties:

- channel A: if a correct process p_i sends a message *m* to a correct process p_j at time *t*, then *m* is delivered by p_j by time $t+\delta$.
- channel B: if a correct process p_i sends a message *m* to a correct process p_j at time *t*, then *m* is delivered by p_j with probability p_{cons} ($p_{cons} < 1$).

Let us consider the following systems composed by 4 processes p_1, p_2, p_3 and p_4 connected trough channels A and channels B.



Assuming that each process p_i is aware of the type of channel connecting it to any other process, answer to the following questions:

1. is it possible to design an algorithm implementing a perfect failure detector in system 2 if only processes having an outgoing channel of type B can fail by crash?
2. is it possible to design an algorithm implementing a perfect failure detector in system 2 if any process can fail by crash?
3. is it possible to design an algorithm implementing a perfect failure detector in system 3?

For each point, if an algorithm exists write its pseudo-code, otherwise show the impossibility.

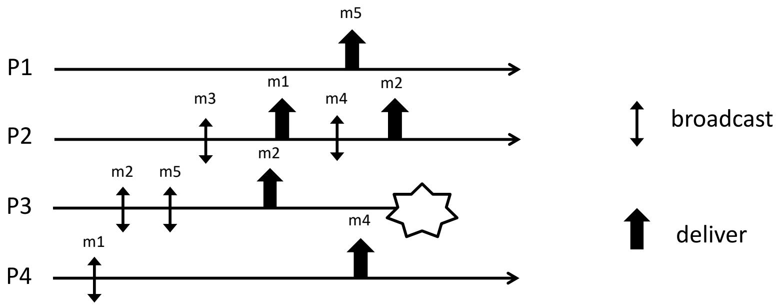
Ex 2: Consider a distributed system composed by n processes $\{p_1, p_2, \ldots, p_n\}$ that communicate by exchanging messages on top of a line topology, where p_1 and p_n are respectively the first and the last process of the network.
Initially, each process knows only its left neighbour and its right neighbour (if they exist) and stores the respective identifiers in two local variables LEFT and RIGHT.
Processes may fail by crashing, but they are equipped with a perfect oracle that notifies at each process the new neighbour (when one of the two fails) through the following primitives:

- **Left_neighbour(p_x):** process p_x is the new left neighbour of p_i
- **Right_neighbour(p_x):** process p_x is the new right neighbour of p_i

Both the events may return a NULL value in case p_i becomes the first or the last process of the line.
Each process can communicate only with its neighbours.

Write the pseudo-code of an algorithm implementing a Leader Election primitive assuming that channels connecting two neighbour processes are perfect.

Ex 3: Consider the partial execution depicted in the Figure



Answer to the following questions:

1. Complete the execution in order to have a run satisfying Uniform Reliable Broadcast.
2. Complete the execution in order to have a run satisfying Regular Reliable Broadcast but not Uniform Reliable Broadcast.
3. Complete the execution in order to have a run satisfying Best Effort Broadcast but not Regular Reliable Broadcast.

<u>**NOTE:**</u> In order to solve the exercise you can add broadcast, deliver and crash events but you cannot remove anything from the run.

Ex 4: Consider a distributed system composed by n processes $\{p_1,p_2,\ldots,p_n\}$ identified through unique integer identifiers. Processes may communicate using perfect point-to-point links. Links are available for any pair of processes.
Processes may fail by crash and each process has access to a perfect failure detector.
Modify the algorithms implementing a distributed mutual exclusion abstraction discussed during the lectures to allow them to tolerate crash failures.