Distributed Systems 09/02/2018
Corso di Laurea Magistrale in Ingegneria Informatica

☐ **5 Credits** ☐ **6 out of 12 Credits (not passed CNS yet)**

☐ **6 Credits** ☐ **6 out of 12 Credits (passed CNS)**

(tick the appropriate box above – write clear below)

Family Name_____Name_____Student ID_____

Ex 1: Describe primary-backup and active replication schemes. In particular, discuss for both schemes the possible failure scenarios and how they can be managed.

Ex 2: Consider a distributed system composed of N processes p_1, p_2, … p_N, each having a unique identifier myID. Initially, all processes are correct (i.e. correct={ p_1, p_2, … p_N }). Consider the following algorithm:

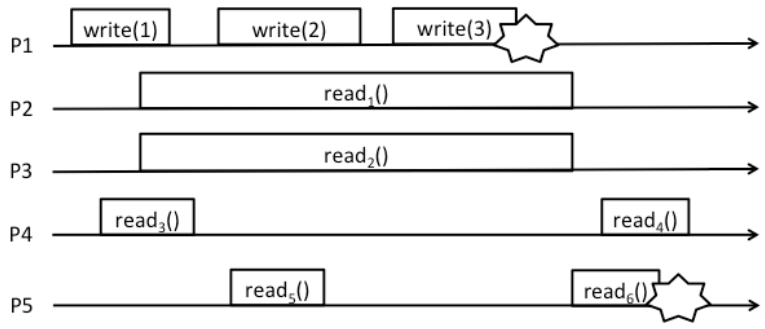
```
upon event Xbroadcast(m)
        sn = sn+1;
        ∀ p ∈ correct
                pp2pSend ("MSG", m, sn, myId);

upon event pp2pReceive ("MSG", m, sn, i)
        if ((m ∉ delivered) ∧ (<sn, i> > lastDelivered))
                trigger XDeliver (m);
                delivered = delivered ∪ {m};
                lastDelivered = <sn, i>;

upon event crash (p_i)
        correct = correct / {p_i}
```

Let us assume that: (i) links are perfect, (ii) the failure detector is perfect and (iii) initially local variables are initialized as follows sn=0, delivered =∅, e lastDelivered=<0, ->.
Answer to the following questions:

1. Does the `Xbroadcast()` primitive implement a Reliable Broadcast, a Best Effort Broadcast or none of the two?
2. Considering the ordered broadcast communication primitives discussed during the lectures (FIFO, Causal, Total), explain which ones can be satisfied by the `Xbroadcast()` implementation.

Provide examples to justify your answers.

Ex 3: Consider the execution depicted in the following figure and answer the questions



1. Define ALL the values that can be returned by read operations (Rx) assuming the run refers to a regular register.
2. Define ALL the values that can be returned by read operations (Rx) assuming the run refers to an atomic register.

Ex 4: Consider a distributed system composed of N processes p_1, p_2, … p_N, each having a unique identifier myID. Processes are arranged in a k-ary tree and each process just knows[1] its father (if any) and its children (if any).
Each process maintains locally a value $v \in \{0,1\}$.

1. Assuming that processes are not going to fail, write the pseudo-code of an algorithm that is able to compute and report to the issuing process the sum of all the values stored by processes.
2. Assuming that the system is synchronous with message delivery times bounded by δ and negligible computation time, discuss what happen to the algorithm (both in terms of termination and validity of the computed average) when one Byzantine process is in the network.

According to the Italian law 675 of the 31/12/96, I authorize the instructor of the course to publish on the web site of the course results of the exams.

Signature: _____

[1] Assume that father and children are stored respectively in two local variables FATHER and CHILDREN.