CS-451 – Distributed Algorithms

Midterm Exam

December 2^{nd}, 2019

Name: ______________________________

SCIPER number: ____________________

Time Limit: 1:45 hours.

Instructions:

- This exam is closed book: no notes, electronics, nor cheat sheets allowed.
- If you need additional paper, please ask one of the TAs. Write your name and SCIPER on *each extra page*.
- Read through each problem before starting to solve it.
- When solving a problem, do not assume any known result from the lectures, unless it is explicitly stated that you might use some known result.
- Unless a problem explicitly states otherwise, assume that processes only fail by *crashing*.

Good Luck!

Problem	Max Points	Score
1	5	
2	5	
Total	10	

1 Terminating Reliable Broadcast (5 points)

(a) *(0.5 points)* State the interface and properties of Terminating Reliable Broadcast.

(b) *(1 point)* Discuss the difference between Perfect Failure Detector and Eventually Perfect Failure Detector.

(c) *(2 points)* Is it possible to implement Terminating Reliable Broadcast, in the presence of one failure, without a Perfect Failure Detector?

- If yes, provide an algorithm that does that, and prove its correctness.
- If no, prove that doing that is impossible.

(d) *(0.5 points)* State the interface and properties of Consensus.

(e) *(1 point)* Provide an algorithm `A` that implements consensus among N processes, subject to an arbitrary number of failures, using at most N instances of Terminating Reliable Broadcast. Prove the correctness of `A`.

2 Best-Effort Broadcast (5 points)

Complexity & Latency Let `A` be a distributed, terminating algorithm. We define the following:

- The **maximum per-process communication complexity** of `A` is the maximum number of messages any process has to exchange (i.e., send + receive) throughout an execution of `A`.
- The **latency** of `A` is number of units of time `A` takes to terminate on every process, under the assumption that computation is instantaneous and the delay of every message is one time unit.

(a) *(0.5 points)* State the interface and properties of Best-Effort Broadcast.

(b) *(1.5 points)* Provide an algorithm `A` that implements Best-Effort Broadcast among N processes, subject to an arbitrary number of failures such that: the maximum per-process communication complexity of `A` if $O(N)$; the latency of `A` is $O(1)$. Prove the correctness of `A`.

(c) *(2 points)* Provide an algorithm `A` that implements Best-Effort Broadcast among N processes, under the assumption that only the sender process can crash, such that: the maximum per-process communication complexity of `A` is $O(1)$; the latency of `A` is $O(\log N)$. Prove the correctness of `A`.

(d) *(1 points)* Provide an algorithm `A` that implements Best-Effort Broadcast among N processes, under the assumption that at most $f \ll N$ of them can crash, such that: the maximum per-process communication complexity of `A` is $O(f)$; the latency of `A` is $O(\log N - \log f)$. Prove the correctness of `A`.