

Problem 1 Suppose that we have an algorithm that solves consensus in $f + 1$ rounds in a synchronous system and tolerates f crash failures. Use that consensus algorithm to solve Terminating Reliable Broadcast for crash failures in $f + 2$ rounds in a synchronous system with f crash failures. You have to present your algorithm and prove that it satisfies Termination, Agreement, Validity and Integrity.

Problem 2 Under the same assumptions of the previous problem, use the consensus algorithm to solve Terminating Reliable Broadcast for crash failures in $f + 1$ rounds in a synchronous system with f crash failures. (This is a challenging one!) As before, you have to present your algorithm and prove that it satisfies Termination, Agreement, Validity and Integrity.

Problem 3 The next question concerns *Uniform TRB*—a stronger version of TRB, where the Agreement requirement is replaced by:

Uniform Agreement If any process (whether correct or faulty) delivers a message m , then all correct processes eventually deliver m .

Consider the problem of solving Uniform TRB in a round-based system with *general omission* failures.

1. Assume that a *majority* of processes are correct, i.e. $n > 2t$. Describe a round-based algorithm that solves the above problem and prove it correct.
2. Prove that this problem cannot be solved if $n \leq 2t$. (Hint: partition the n processes into two sets of size at most t , and consider several scenarios.)

Problem 4 Complete the proof that consensus can be solved using the S failure detector.

Problem 5 Consider *Ben-Or Lite*, a modified version of Ben Or's randomized algorithm for solving Consensus in asynchronous systems in which line 12 of the algorithm is omitted. In Ben-Or Lite, a process that does not receive $n - f$ identical b values, all different from \perp , always determines its a -value for the next round by flipping a coin. Does Ben-Or Lite solve Consensus in an asynchronous system?

If so, prove Validity, Agreement, and Termination. If not provide a counterexample, i.e. an execution in which at least one of the above three properties is violated.