COMP9152 Assignment 3
Due: by email, Monday May 5

April 24, 2008

Use MCK to analyze the following scenarios. Assume that agents have synchronous perfect recall.

1. **Bit transmission:** Consider the following protocol. There are two agents, Alice and Bob. The communication channel between Alice and Bob is lossy: when a message is sent, it is either delivered immediately, or it is lost forever. Alice has a single bit of information to communicate to Bob, and she would like to guarantee that the message has been received. They proceed as follows:

   - Alice repeatedly sends her bit to Bob
   - Whenever Bob receives a message from Alice, he sends her back one copy of the same message.
   - When Alice receives from Bob a copy of the message she is currently sending (a bit), she stops sending that bit and switches to repeatedly sending the opposite bit.

   What happens to Alice and Bob's mutual knowledge of the value of Alice's original bit as they run this protocol? Is it ever the case that they get common knowledge of the value of this bit?

2. **Leader Election.** Consider a group of n agents that can pass messages in a clockwise direction around a ring. That is, agent 1 can send messages to agent 2, agent 2 can send messages to agent 3, etc, and agent n can send messages to agent 1. Initially, each agent i is randomly assigned a unique number $num(i)$ in the range $1..2n$, i.e., no two agents are assigned the same number. The *leader* is defined to be the agent with the largest number. Initially, each agent knows how many agents there are in the system (this is in fact common knowledge), but no agent knows the number of any other agent. They run a protocol to discover the number held by the leader. Consider a number of versions of this problem:

   (a) Suppose that when a message is sent, it is guaranteed to be delivered immediately. Each agent i runs the following protocol: at time 0, it sends a message to the next agent in the ring, that contains the number of agent i. Whenever agent i receives a message with a number k, it sends a message to the next agent with number $max(num(i), k)$. (This goes on forever.)

(b) Suppose that when a message is sent, it is either delivered immediately, or lost forever. Each agent i runs the following protocol: the agent has a variable that records the maximum number that it has seen. This is either its own number or a number that it received in some message. (This goes on forever.)

Use MCK to analyze these situations, and answer the following questions. Consider what happens with different numbers of agents, e.g. $n = 2, 3, 4, 5$.

(a) Consider two distinct agents i and j. What happens to the agents' mutual knowledge $(K_i K_j)^k$ of the leaders value with time in these scenarios?

(b) Is the leader's number ever common knowledge? If so, under what circumstances?

Submit a zip or tar file containing the following:

1. A report describing what experiments you performed, and your conclusions, for each question.
2. A copy of MCK scripts that you developed.

Hint: MCK does not do model checking for common knowledge formulas with respect to perfect recall. If you would like to show that it is possible for the agents to have common knowledge, then try to identify a small finite amount of historical information that the agents can store (rewrite the protocol to maintain this information) that results in them having common knowledge with respect to the observational view, which can be model checked. If you would like to claim that the agents do not get common knowledge, then either argue this theoretically, or give (non-conclusive) evidence in the form of experiments.