Engineering Design Project #1

EGN 3000 – Foundations of Engineering (Fall 2003)
Sections 005, 010, and 011 (Christensen)

Purpose: To learn how protocols are designed for reliable data communications. A *protocol* is formally defined as "the complete set of rules for reliable information exchange between same level layers."

Situation: You find the lecture in class to be boring and wish to pass a note to a friend on the other side of the room. The only way you can do this is to write your message on 3x5 cards and pass then to your neighbor (who then passes the cards to his or her neighbor in the direction of your friend and eventually the 3x5 cards may get to your friend). Your message requires multiple 3x5 cards. You would like your message to reliably arrive to your friend. The situation is that your classmates may lose, duplicate, or even alter your 3x5 cards so that your friend does not receive all the cards, receives duplicate cards, receives cards out of order, and/or receives cards with data (text) changed, added, or removed. Your classmates can only forward 3x5 cards at a rate of one per second and can only hold two cards at a time. If a card arrives when both hands are full (with other cards), the arriving card falls on the floor and is lost.

Requirements: Develop a set of rules for how the sender (you) and receiver (your friend) should handle the 3x5 cards given the constraints listed below. The set of rules should be concise, precise, and unambiguous. It is desirable that the throughput measured in cards per second received successfully (in order and without error) is as high as possible.

Constraints: The constraints for this project are:

1) You may only write one English word of data per card. Your message consists of between five to 20 English words where the ordering of the words matters (an example message is "Let's go eat ice cream after class"). You may write up to eight digits of control information per card. This control information is the key to your protocol.
2) You have no control over what the links and routers (your classmates) do to the 3x5 cards. They may lose, duplicate, delay for short or long time, or alter any of the text. You can assume that you classmates don't do this very much, but just "sometimes". This "sometimes" can be stated as a probability.
3) You have no other means of communications than the 3x5 cards (e.g., you can not talk between yourselves).

Deliverables: Your deliverables are the following:

1) A one-page description of the sender and receiver protocol. The description should cover the syntax of control information on the cards, the meaning (semantics) of the control information, and a description of how this control information is used to achieve a reliable end-to-end message transfer protocol. Your description must be sufficiently clear and unambiguous that a person not part of your group could "follow the instructions" to become either a sender or a receiver.
2) An analysis of the expected data transfer rate (in cards per second) as a function of the number of hops (classmates) between a sender and a receiver.
3) A 15-minute PowerPoint presentation and demonstration describing the problem, your protocol, and the throughput analysis. As part of this presentation, you will demonstrate your protocol with members of the audience. The instructor will select the sender and receiver.

A small prize will be given to the group with the best submission. The "best" submission will be judged on correctness and efficiency of their protocol and quality of their presentation.

Hints and ideas: Here are some hints and ideas…

- It is possible for the receiver to send cards to the sender. These cards need not contain data; they may contain only control information.
- You may assume that both the sender and receiver have an infinite supply of 3x5 cards and both have pens with which to write with.
- Both the sender and receiver can use timers to determine when something should be done.
- A means of error detection is needed to verify that a received card has not been tampered with (i.e., changed). Checksums are one means of error detection. Look-up checksums on the Internet and consider inventing a very simple checksumming scheme.
- If you cannot solve the problem as stated, make some assumptions (e.g., control cards from the receiver to the sender are never lost) and solve first the limited problem.
- A good way to describe a protocol is with a Finite State Machine (FSM). An FSM contains states and transitions. Transitions are caused by inputs or conditions and result in an output or action. The actions occur immediately. In an FSM, only one transition can be occurring at any one time. An example FSM is shown below. The states are vertical lines and the transitions are horizontal lines with inputs on top of the line and outputs below the line. In the below FSM there are three states and three transitions. Can you figure-out what the FSM is describing? A complete presentation of this FSM would carefully define and describe the states and the possible inputs and outputs of this system.