Name ______________________________

Multistage Interconnection Networks

EE 7700-2

Final Examination

9 December 1993, 15:00-17:00

Modified for later semesters.

Problem 1	________	(25 pts)
Problem 2	________	(25 pts)
Problem 3	________	(25 pts)
Problem 4	________	(25 pts)
Exam Total	________	(100 pts)

Good Luck!

Problem 1: Consider $m \times m$ cells with the following buffer arrangements: SAFC, SAMQ, and virtual channel flow control using m virtual channels.

Part 1: Compute the cost of the switching hardware in a cell, including the crossbar and any other switching circuitry that might be needed. The answer should ignore the cost of buffering. Specify how the queues are connected to the crossbars. (17 pts)

Part 2: Describe a situation in which a cell using SAFC would block a message that a cell using virtual channel flow control would not. (8 pts)

Problem 2: Write two sets-of-permutations definitions of a rearrangeable Clos network, one for arbitrary (m, k), the other for $(2^t, k)$. The first should use the Clos network as originally defined in class. The second should take advantage of the correspondence between cells in the first and third stages of a Clos network and the related cells in a Beneš network. The answer should be in the form of a list of sets of permutations, not a composition of sets of permutations. Needless to say, Σ_{mk} is not the correct answer (even though it is the set of permutations a Clos network can satisfy). (25 pts)

The following symbol may be useful. Let a and b be integers such that $a < b$. The symbol $\Sigma_{\langle a,b\rangle}$ is the set of all permutations of symbols $a, a+1, \ldots, b-1$. For example, $\Sigma_3 = \Sigma_{\langle 0,3\rangle}$ and $\Sigma_{\langle 2,4\rangle} = \left\{ \begin{pmatrix} 2 & 3 \\ 2 & 3 \end{pmatrix}, \begin{pmatrix} 2 & 3 \\ 3 & 2 \end{pmatrix} \right\}$.

Problem 3: ***Problem based on material not covered in the 1995 semester. A problem like this will not appear on the 1995 final.*** Suppose queue $\mathcal{A}$, a queue in stage j of an omega network using 2×2 cells, is empty at $t = \tau$. Then it is certain that there was no arrival to that queue at $t = \tau - 1$. The two queues in the previous stage which connect to queue $\mathcal{A}$ through a crossbar will be called feeder queues. Then it is also certain that the head of both feeder queues did not have a message bound for queue $\mathcal{A}$ at $t = \tau - 1$. Let p_0 be the probability that a feeder queue is empty, r be the probability of an arrival to a feeder queue, and α be the probability that a feeder queue will not be empty at $t = \tau$ given that it was not empty at $t = \tau - 1$. The destinations of messages are independent and uniformly distributed.

Part 1: Find an expression for r_x, the probability of an arrival to queue $\mathcal{A}$ at $t = \tau$ given that it was empty at $t = \tau - 1$. Assume that no queue in stage j is full. (14 pts)

Part 2: Find an expression for α in terms of p_0 and r. (11 pts)

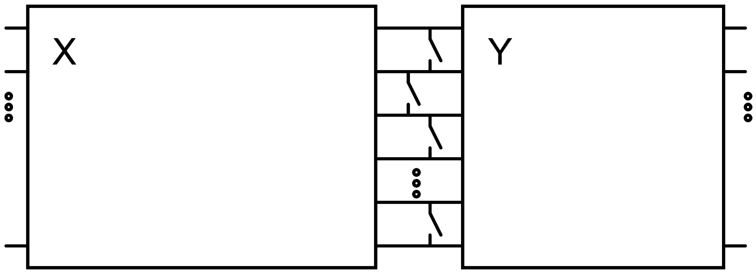
Problem 4: Answer each of the problems below and on the next page. Be concise.

Part 1: Draw the 8-input sorting network based on Batcher's odd/even merge network. (7 pts)

Part 2: ***Problem based on material not covered in the 1995 semester. A problem like this will not appear on the 1995 final.*** A problem with directory based cache coherence schemes is that the amount of memory needed for the presence vectors in the MUs is too large. A solution to the problem is the *limited directory scheme* (see the Note Set 6 glossary) in which a presence vector can hold the location of at most d cache lines. Specify one way such a system might handle $(d+1)$'st request to cache a line. (8 pts)

It's not over yet, turn to the next page.

Part 3: The network below consists of cascaded two parts, X and Y. The links connecting the two parts are connected to each other by switches. Any subset of the switches can be closed, for example, if all the switches are closed then all the links will be connected together. Specify what type of networks X and Y need to be so that this network is a generalized connector. What are the advantages and disadvantages of this network over the one described by Ofman? (10 pts)



Have a good holiday!