Name ______________________________

Interconnection Networks
EE 7725
Midterm Examination

13 October 1995, 13:40–14:30 C. D. T.

Problem 1	________	(30 pts)
Problem 2	________	(30 pts)
Problem 3	________	(40 pts)
Exam Total	________	(100 pts)

Good Luck!

Problem 1: Consider cell $\langle 4, 413\rangle$ (cell 413 in stage 4) of a $(8,(2,3,2,3,2,3,2,3),-,\mathrm{S},\mathrm{T})$ omega network. Initially all cells are uncolored. Suppose cell $\langle 4, 413\rangle$ was colored red. Next, color red every cell in stages 3 and 4 that connect to a red cell. Repeat the coloring above until no more cells change color.

(a) List cell numbers of the red cells. (The answer can be in either decimal or mixed-radix form.) (Useful information: $413_{10} = 01120212$ in radix $(2,3,2,3,2,3,2,3)$, $413_{10} = 1120212$ in radix $(3,2,3,2,3,2,3)$, $413_{10} = 01211021$ in radix $(3,2,3,2,3,2,3,2)$, and $413_{10} = 1211021$ in radix $(2,3,2,3,2,3,2)$.) (15 pts)

(b) Prove that there are exactly five red cells when the coloring procedure above is applied to any pair of adjacent stages in this network (starting with a cell in one of the stages). (15 pts)

Problem 2: A problem with the shuffle/exchange graph is its high degree. A graph similar to the shuffle/exchange, but with a lower degree, can be obtained in the following way: replace the exchange function with a modular add. As with the shuffle/exchange graph, nodes are labeled with n-digit, radix-m numbers. The new graph also has two sets of edges, called *exchange* and *shuffle* edges. Unlike the shuffle/exchange graph, exchange edges are obtained by replacing the least-significant digit of a node label, $u_{(0)}$, by $u_{(0)} + 1 \bmod m$. (See the shuffle/exchange graph description in Note Set 1 for the notation.) Shuffle edges are obtained in the same way as in the shuffle/exchange graph. Call this graph the *shuffle-exchange lite* (SEL) graph.

(a) Write a set description ($V = \{\ldots,\ E = \{\ldots$) of the SEL graph. (8 pts)

(b) Draw an SEL graph with $m = 4$ and $n = 2$. (8 pts)

(c) What is the degree of the SEL graph? (7 pts)

(d) What is the diameter of the SEL graph? (7 pts)

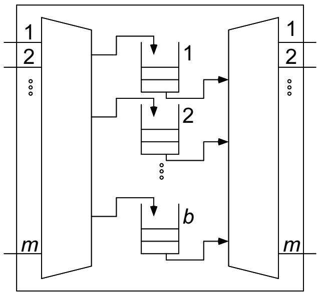
Problem 3: Answer each question below. Be brief; answers that are correct but too long may not receive full credit.

In the next two problems the effect on system performance of large queues in MIN cells is to be evaluated in two ways: using traffic model $(\mathrm{Bern}(p), 1, \mathrm{Uni}(N))$ and by using the performance model, $U(N) = \min\left\{\frac{(P/N)t_m}{t_m+t_{\mathrm{nw}}}, 1\right\}$, described in Note Set 1.

(a) For a range of values of p, when the system is offered traffic $(\mathrm{Bern}(p), 1, \mathrm{Uni}(N))$, increasing queue size will increase latency. What are those values and why does latency increase? (8 pts)

(b) The increase in latency noted above may not occur in parallel computers. Argue that the performance model is a realistic alternative to the traffic model. That is, under the performance model, increasing queue size will improve the performance of the system. Do not attempt to formally prove the argument using the utilization equation. Instead, qualitatively argue based on the system the that the equation models. (8 pts)

(c) A *middle-buffered* $m \times m$ cell contains $b < m$ queues between two crossbars; see illustration. What is the cost of this cell in crosspoints? (8 pts)



(d) Describe a situation ($e.g.$, "Message A arrives at $t = 3$ ...") in which the middle-buffered cell described above would perform better than an input-buffered cell using the same amount of total storage. Describe a situation in which the middle-buffered cell would perform worse than an input-buffered cell using the same amount of total storage. (Because the input-buffered cell uses the same amount of total storage as the middle-buffered cell, the product of the number of queues and slots per queue is the same for both cells.) Ignore crossbar contention time and control complexity. (8 pts)

(e) A system is being developed in which a new parallel program and interconnection network are being designed. It is expected that after each simulation run both the network and program will be modified. Describe and explain a situation under which 1) trace-driven simulation would be the better choice and 2) execution-driven simulation would be the better choice. (8 pts)