EE482B Advanced Computer Architecture and Organization
Midterm Exam

May 4th, 1999

(Total time = 75 minutes, Total Points = 100)

Name: (please print)______________________________

In recognition of and in the spirit of the Stanford University Honor Code, I certify that I will neither give nor receive unpermitted aid on this exam.

Signature:_______________________________________

This examination is open notes open book. You may not, however collaborate in any manner on this exam. You have 1 hour and 15 minutes to complete the exam. Before starting, please check to make sure that you have all 6 pages.

1	35	
2	20	
3	25	
4	20	
Total	100	

1. Short Answer (35 points, 5 points each)

A. When a new packet arrives at a router in a network using virtual channel flow control, what resource must be allocated to the packet?

B. To allow a single long packet to use the full bandwidth of the physical channel, what is the minimum size a virtual channel buffer can be?

C. An 8×6 mesh network uses wormhole routing, has only a single virtual channel per physical channel, and allows arbitrary minimal routes. Is this network deadlock free? (explain briefly 8-words or less).

D. An 8×6 mesh network uses wormhole routing and has two virtual channels per physical channel, one in each of two subsets, C1 and C2. At each hop along the route, a packet may use any productive (gets it closer to its destination) C2 channel and may use a productive C1 channel in the x-direction. It may only use a productive C1 channel in the y-direction if it is already at the correct x-coordinate. Is this network deadlock free?

E. A router chip has four input ports, four output ports, and 16 virtual channels per physical channel. The router currently uses a 8×4 crossbar switch internally, with two switch inputs per input port. Assuming good switch scheduling in both cases, will router performance be increased if this is increased to a 64×4 crossbar with separate switch inputs for each virtual channel?

F. Suppose you have a router with four inputs, four outputs, and 2 virtual channels per physical channel. The router uses a 4×4 crossbar switch internally. At a given point in time, the 8 input virtual channels all have traffic to forward and are connected to the following output ports (1,2;3,4;1,1;3,3). The semicolons ';' here separate the input ports. What assignment will a 'greedy' allocator make in this case? What is a good assignment?

G. Suppose you have a 4×4 mesh network that employs a CAM-based node routing table. What entries are needed at node (0,0) at the bottom left corner of the mesh?

2. Topology (20 points)

Consider a network with a mixed-radix alternating 3-cube topology with k_x=4, k_y=8, and k_z=10. This network has three dimensions. Each node has four bi-directional connections to its neighbors. A node at (x,y,z) is connected to its neighbors in the x direction (x+1,y,z) and (x-1,y,z). Nodes at even x coordinates are connected to their neighbors in the y-dimension, and nodes at odd x coordinates are connected to their neighbors in the z-dimension. The network has a different radix in each dimension, spanning k_x=4 nodes in x, k_y=8 nodes in y, and k_z=10 nodes in z.

On uniformly distributed random traffic, what is γ_{max} for this network?

3. Routing (25 points)

Consider the network from problem 2 above. Suppose the following routing algorithm is used on this network:

1. Subtract the coordinates of the present node (x,y,z) from the coordinates of the destination (x_d,y_d,z_d) to get a difference vector (Dx, Dy, Dz), and from this compute a preferred direction vector (d_x,d_y,d_z) with elements +,-, or 0.
2. If the x-coordinate is even and Dy $\neq$ 0, take one hop in the preferred direction in the y-dimension, then return to step 1.
3. If the x-coordinate is odd and Dz $\neq$ 0, take one hop in the preferred direction in the z-dimension, then return to step 1.
4. If Dx $\neq$ 0, take one hop in the preferred direction in the x-dimension, then return to step 1.
5. If at an even x and Dy = Dx = 0, and Dz $\neq$ 0, take a hop in the positive x-dimension, then go to step 1.
6. If at an odd x and Dz = Dx = 0, and Dy $\neq$ 0, take a hop in the negative x-dimension, then go to step 1.

Suggest a permutation (permutation of nodes, not necessarily bits of the node address) traffic pattern that gives the highest possible γ_{max} given this topology and routing algorithm. Describe your permutation and compute the resulting γ_{max}.

4. Flow Control (20 points)

Draw a time-space diagram for the following flow control method (method X). With method X, packets may be from 2 to 1024 flits in length. The first flit of the packet contains the destination. Packet transmission begins by sending just the first flit of the packet to the destination to establish the path (as with circuit switching). As the head flit passes each node it allocates a virtual channel and a buffer with a capacity of four flits to the packet. When the head reaches the destination, an acknowledgement with a credit to send four flits is returned to the source along the same path. When this acknowledgement reaches the source, the source sends the next four flits of the packet to the destination. When the fourth flit arrives at the destination, another acknowledgement with four credits is again returned to the source. This process continues until the tail flit reaches the destination. At this point a terminating acknowledgement is returned to the source. As this terminating acknowledgment passes each node, it frees the resources associated with the packet. Sketch the time-space diagram for sending a 9-flit packet using method X and compute the latency in terms of message length, L, and hop count, H.