NATIONAL UNIVERSITY OF SINGAPORE

FACULTY OF ENGINEERING

EXAMINATION FOR

(Semester II: 2002/2003)

EE5912 – High Speed Networks

April / May 2003 - Time Allowed: 2.5 Hours

INSTRUCTIONS TO CANDIDATES:

1. This paper contains **SIX** (6) questions and comprises **SEVEN** (7) printed pages.
2. Answer any **FOUR** (4) questions.
3. All questions carry equal marks.
4. This is a CLOSED BOOK examination.

Q.1

(a) The SONET UPSR-2 architecture is designed primarily to handle single link failures. However, it can handle some cases of simultaneous multiple link failures as well. Characterize carefully the types of multiple link failure combinations that it can handle.

(10 marks)

(b) Suppose that a new SONET ring called *2-fiber unidirectional line-switched ring* (ULSR-2) with span protection is proposed as an alternative to *2-fiber bidirectional line-switched ring* (BLSR-2). A ULSR-2 uses two unidirectional rings running in the same direction. The whole capacity on the outer ring can be used by the working traffic and the whole capacity in the inner ring is reserved for rerouting the affected traffic in the event of a link failure. It uses span protection and when the working fiber between two adjacent nodes fails, the traffic is switched to the protection fiber between the same nodes. Give reasons why ULSR-2 is not a better choice than BLSR-2? (8 marks)

(c) Consider the circuit-switching network with 6 switches labeled from 0 through 5 as shown in Fig. Q.1c. Suppose that voice calls between different switches are carried by 64kbps connections. Further suppose that 100, 200, 100, and 200 calls per second are generated on the average between switch-pairs (0,4), (0,5), (1,4), and (0,1), respectively. The duration of the calls between the respective switch-pairs are given by 5, 10, 10, and 20 seconds. The acceptable blocking probability of the calls between the respective switch-pairs is at most 0.02, 0.05, 0.10, and 0.05. Use the simplified model to determine the minimum capacity required on link 2-3.

(7 marks)

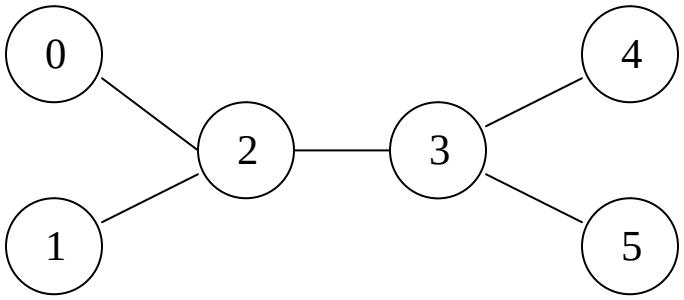

Figure Q.1c

Q.2

(a) Consider the WDM networks N1, N2, and N3. Network N1 is a single-fiber network with 6 wavelengths per fiber and the nodes do not have conversion capability. Network N2 is a single-fiber network with 6 wavelengths per fiber and all the nodes have full-degree conversion capability. Network N3 is a multi-fiber network having 2 fibers between adjacent nodes with 3 wavelengths per fiber.

(i) Let p_1, p_2, and p_3 be the connection blocking probability of networks N1, N2, and N3, respectively. What can you say about how p_1, p_2, and p_3 compare with one another? Justify your answer.

(7 marks)

(ii) Determine the blocking probability of a request for each of the networks N1, N2, and N3 when a path with 4 hops is considered for satisfying the request. A wavelength is assumed to be used on a fiber with probability 0.3. The above event is assumed to be independent of the use of other wavelengths on the link and is also independent of the use of the same and other wavelengths on other links.

(13marks)

(b) Comment on the fairness achieved by the limited alternate routing method when the load is increased from low to high.

(5 marks)

Q.3

(a) Consider a WDM node with 2 input fibers and 2 output fibers with 4 wavelengths w_0, w_1, w_2, and w_3 per fiber. Suppose that only the following two scenarios could occur.

Scenario-1

w_0 from input 1 to output 1
$w_1$from input 1 to output 1
w_2 from input 1 to output 2
w_3 from input 1 undergoes o-e-o conversion and is sent to output 2
w_0 from input 2 to output 1
w_1 from input 2 to output 1
w_2 from input 2 to output 2
w_3 from input 2 to output 2

Scenario-2

w_0 from input 1 undergoes o-e-o conversion and is sent to output 1
$w_1$from input 1 to output 2
w_2 from input 1 to output 2
w_3 from input 1 to output 1
w_0 from input 2 to output 1
w_1 from input 2 to output 2
w_2 from input 2 to output 2
w_3 from input 2 to output 1

(i) If the primary objective is to minimize the number of wavelength converters required and the secondary objective is to minimize the number of optical switches, which of the three wavelength-convertible architectures -- dedicated, share-per-node, and share-per-link -- will be your choice? Why?

(10 marks)

(ii) Give the size of the optical switches required by each of the three architectures.

(9 marks)

(b) Consider a ring network with 8 nodes and a hypercube network with 8 nodes. Which of the above two networks will benefit more by placing wavelength converters? Justify your answer.

(6 marks)

Q.4

(a) Consider the network shown in Fig. Q.4a with bidirectional links (two fibers one in each direction between the adjacent nodes). Based on a virtual topology design method it is decided to embed ring 0-1-2-3-4-0 with bidirectional links as the virtual topology. Note that there exists a unique path between a node pair in the given physical network.

(i) Develop a wavelength assignment heuristic to set up lightpaths forming the ring virtual topology. Comment on the efficiency of your heuristic.

(12 marks)

(ii) Suppose that at an instant of time, the traffic demand between node pairs (0,2), (1,4), (2,0), (3,1), and (4,3) is observed to be 1, 2, 2, 1, and 2 units, respectively. Assume that the traffic is routed over the shortest route on the virtual topology. Determine the average weighted number of hops and average lightpath load.

(8 marks)

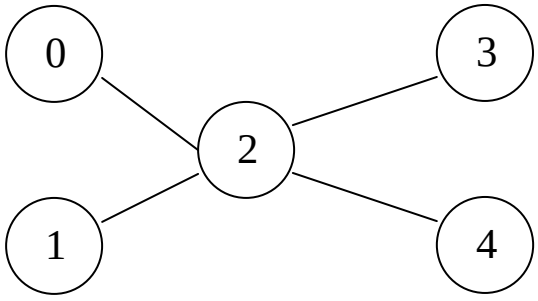

Figure Q.4a

(b) In HLDA, after providing a lightpath for node-pair pair *x*, traffic associated with *x* is updated by subtracting the traffic associated with pair *y* which has the next highest traffic. Why is this necessary?

(5 marks)

Q. 5

(a) Compare and contrast link-based protection and path-based failure dependent protection methods. Develop a simple mathematical expression to calculate the restoration time upon a link failure in terms of link propagation time, control message processing time etc. for a path-based failure dependent protection method employing backup resource sharing.

(10 marks)

(b) Suppose that a burst-switching network uses LAVF (latest available void filling) for scheduling bursts. In such a network, long bursts are more likely to be dropped than short bursts. To overcome this, two solutions are proposed. The first proposal suggests to assemble packets into short bursts at the edge router itself. The second proposal suggests to fragment a burst (whenever it is not able to fit any of the wavelengths) and possibly assign different wavelengths for the fragments. State two major drawbacks of the above proposals.

(10 marks)

(c) Under what circumstances will the performance of LAUC (latest available unscheduled channel) become significantly poorer than the void-filling scheduling algorithm LAVF? (5 marks)

Q.6

(a) Consider an ATM network with three switches labeled S1 through S3, three hosts labeled H1 through H3 and a few labeled ports as shown in Fig. Q.6a. Suppose that the following events – virtual circuit (VC) connection setup and release – take place one by one in the given order. Assume that virtual circuit identifier (VCIs) start from 0 and the lowest possible identifier is always chosen. Show the VC tables in each switch at the end of the last event. Assume that VC connections are unidirectional.

Event No.	Event	Path
1	setup	H1 – S1 – S2 – H2
2	setup	H1 – S1 – S2 – S3 – H3
3	setup	H3 – S3 – S1 – S2 – H2
4	setup	H2 – S2 – S3 – H3
5	release	H3 – S3 – S1 – S2 – H2
6	setup	H2 – S2 – S3 – S1 – H1

Q.6 (a) is continued on page 7

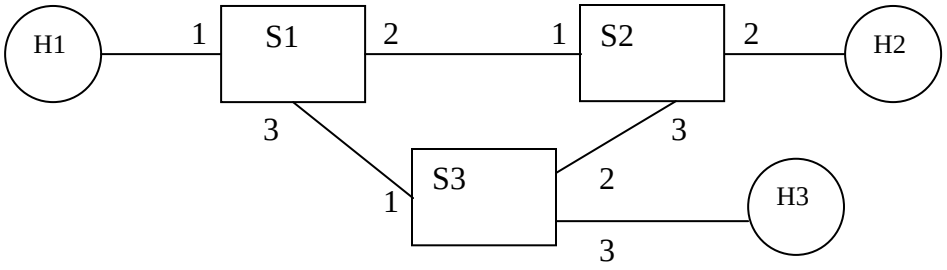

Figure Q.6a

(10 marks)

(b) Suppose that a proposal is made to use implicit congestion control instead of explicit congestion notification. The implicit congestion control method is similar to the flow or error control used in traditional networks. According to the proposal, when the destination detects the loss of a cell, it presumes that the cell was dropped by the network due to congestion. It sends a negative-ACK signal back to the source node which will then retransmit the dropped cell and possibly all subsequent cells. Explain why the above proposal does not work satisfactorily in ATM networks. To support your argument, consider a 100-Mbps VC connection traversing 1000 km through a number of switches before reaching the destination. Assume that the propagation time is 5μs/km and other delays such as processing, switching, and queuing delay are negligible.

(8 marks)

(c) Propose a mechanism that can be used by ATM switches such that if one switch loses all its state regarding the VC connections traversing through it, the source nodes of these VC connections are informed of the failure. Assume that VC connections are bidirectional.

(7 marks)

END OF PAPER