EE5134 – Optical Communications and Networks
CA 1 – Assignment (Sem 2, 2024-2025)
Lecturer: Assoc. Prof. Mohan Gurusamy

Instructions:

1. Answer all FOUR Questions. Each question carries 10 marks.
2. Handwritten reports shall be avoided. Use Word, Latex or any other documentation software of your choice to prepare the report.
3. Name the report as <StudentNo-EE5134-CA1> and submit at the Canvas – CA1 Reports.
4. The submission is due on Tuesday 25th March 2025.
5. The answers must be yours and in your own words. Our university views any form of cheating and plagiarism (like copying from other students or reports or web sources) very seriously. Any malpractice will be subject to disciplinary action.

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1. Consider a unidirectional WDM physical ring network with five nodes connected as $0\rightarrow1\rightarrow2\rightarrow3\rightarrow4\rightarrow0$. It is required to create six lightpaths for the node pairs P_1: <0,2>, P_2: <0,1>, P_3:<3,0>, P_4:<2,3>, P_5: <1,4>, and P_6: <4,0>.

(a) Route the lightpaths using shortest-path-first heuristic with fixed-order wavelength assignment policy, and list the path and wavelength chosen for each lightpath in the table format as shown below. Determine the number of wavelengths required.

Lightpath P_i	Path	Wavelength

(b) Develop a better heuristic with fixed-order wavelength assignment policy, and list the path and wavelength chosen for each lightpath in the table format as shown below. Your heuristic should require fewer wavelengths than that used in part (i) above. Explain the intuitive reason why your heuristic is doing better.

Lightpath P_i	Path	Wavelength

(c) It is required to route 0.3, 0.8, and 0.6 units of client traffic flows for the node pairs (0,3), (2,1) and (1,2), respectively, through shortest paths over the virtual topology. Determine the route traversed by each traffic flow and load carried by each lightpath. Tabulate the results in the format below. Calculate the congestion and average weighted number of (virtual) hops.

Traffic flow	route	hop

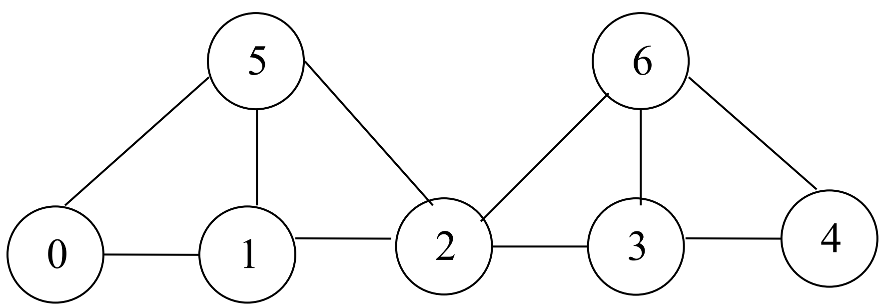
Lightpath P_i	Load

(2)

(a) "Wavelength rerouting" migrates an existing lightpath from its current wavelength to a new wavelength without changing the physical path traversed by the existing lightpath. There might be a scenario wherein a new lightpath request cannot be set up due to wavelength continuity constraint, and wavelength rerouting could be helpful to create this new lightpath by migrating some existing lightpath(s) to a new wavelength. Consider a path network $1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 6 \rightarrow 7$ with two wavelengths w_0 and w_1 ,wherein lightpath requests arrive dynamically one by one, and they use 2-hop or 3-hop physical paths. Construct a scenario of dynamically arriving lightpath requests to illustrate the benefit of wavelength rerouting. Your example should be such that you are not able to create a new lightpath, but with wavelength rerouting you are able to create it. Illustrate your example using a figure showing the lightpaths with the wavelengths routed on the above path network. Assume fixed order wavelength assignment policy.

(b) Is there any drawback or limitation of using "wavelength rerouting"? Briefly explain.

(3) Consider a WDM network with 4 wavelengths per fiber as shown in Figure below. The wavelengths are labeled w_0 through w3. The mean time to failure (MTTF) and mean time to repair (MTTR) of each link in the network are 9 and 1 unit, respectively. The MTTF and MTTR values are assumed to be independent for the links. Suppose that node 2 is provided with wavelength converters. Further suppose that only wavelength w_0 is available on links 0-5 and 5-2, no wavelength is available on links 2-6 and 6-4, and only w_2 is available on all other links.



(a) Calculate the availability of a link

(b) Which path and wavelength are chosen if it is required to set up a lightpath from node 0 to node 4 without requiring any wavelength conversion?

(c) What is the availability value for the path chosen in part Q3(b)?

(d) It is possible to improve the availability of a path by protecting one or more links, or segments on a path. What are the links and segments that can be protected on the path chosen in part Q3(b) to improve the path availability?. For each possible case of such protection, calculate the improved availability value.

(4) In an optical burst switching (OBS) network, usually, the bursts are scheduled (i.e. wavelength channels are chosen) on the outgoing link based on their arrival time and duration, at the time of arrival of their control packets. This might result in high burst loss probability, because at the time of scheduling, the pattern of bursts that arrive later is not known. One possible way to avoid such a scenario (to some extent) is to use *burst rescheduling* as discussed in the class. Another possible way to avoid such a scenario (to some extent) is to use *ordered scheduling* which schedules a burst just before its arrival time instead of making the scheduling decision at the time of arrival of the control packet.

(a) Construct an example with at most four bursts to illustrate the advantage of burst rescheduling and ordered scheduling over the usual approach. Assume an OBS network link with two wavelengths and use the Latest Available Unscheduled Channel (LAUC) scheduling algorithm. Your example should be such that burst rescheduling and ordered scheduling (both are based on LAUC) are able to schedule all the bursts, but, the usual approach (LAUC) fails to schedule at least one burst. Use the following table format to give your example. Here, CA-T, BA-T, and BD represent control packet arrival time, burst arrival time and burst duration, respectively. Show the bursts scheduled on wavelengths as a timeline diagram (as discussed in the lecture)

Burst	CA-T	BA-T	BD
B1			
B2			
B3			
B4			

(b) Same as part (i) above, but your example should be such that ordered scheduling is able to schedule all the bursts, but, the usual approach (LAUC) and burst rescheduling fail to schedule at least one burst.