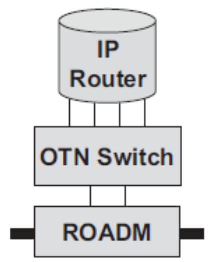
1- Explain whether the following statements are true or false.

(a) In end-to-end multiplexing, it doesn't matter if the low-rate requests are compatible.

(b) The better the granularity of the grooming switches, the higher the network efficiency.

(c) The main motivation for designing node architecture as follows is to reduce costs and power consumption.



(d) When selecting a grooming node, only nodes that are in the center of the network or on routes with heavy traffic are considered.

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2- Assume that the wavelength line rate is 100 Gb/s, and assume that the following six demands between a pair of nodes need to be multiplexed onto wavelengths Using *First Fit Decreasing* bin packing, how many wavelengths are required ?
40Gbps – 60Gbps – 80Gb/s – 40Gbps – 30Gbps – 40Gbps

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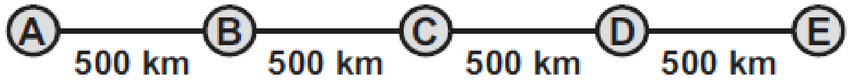
3- Consider the following network. GCs are matched according to the table below. The wavelength rate is 40Gbps and the request rates are 10Gbps, and the optical reach is 500km. State the number of regenerations before and after the grooming operation. Draw groomed paths on the network.



	source	destination	rate
GC1	B	D	**2*10G**
GC2	C	E	**2*10G**
GC3	D	E	**1*10G**
GC4	A	B	**2*10G**

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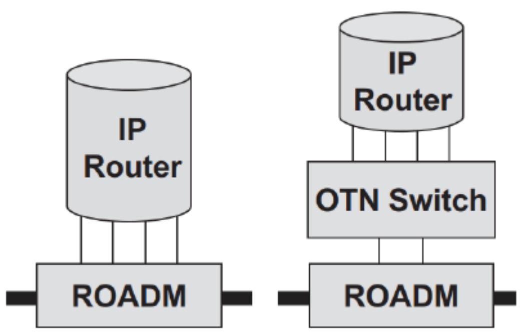
4- Consider the IP-over-OTN-over-Optical nodal architecture of Fig(a). Assume that 50 % of the traffic that enters the node remains in the optical layer; i.e., it optically bypasses both the OTN and IP layers. Of the traffic that is dropped from the optical layer, 50 % of it can bypass the IP layer; i.e., it is only groomed by the OTN switch. The remainder is delivered to the IP router. What cost ratio between the IP ports and the OTN ports justifies this architecture from a cost basis, as compared to the IP-over-Optical nodal architecture of Fig(b), where all of the non-optical-bypass traffic is delivered to the IP router? (Assume that all of the costs of the IP routers and OTN switches are in the ports. Assume that the OTN network-side ports and OTN client-side ports have the same cost.)



B **A**

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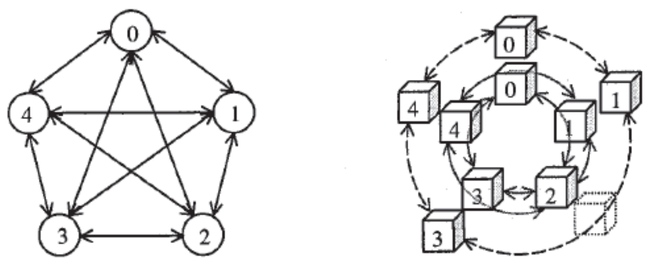
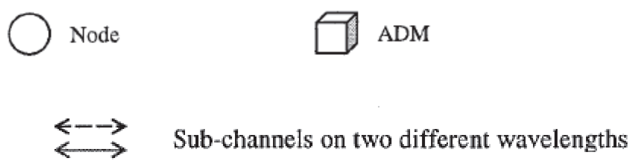
5- The following figure shows a ring network with five nodes, each with two ADMs. The grooming rate is 2 , meaning that two requests can be merged in each node and a wavelength can be assigned to them at different time slots. Each channel has two time slots. The total number of requests are 10 and all are bidirectional. Figure (b) provides an example of a wavelength allocation that ultimately uses 9 ADM (add-drop multiplexers). Can you suggest another solution for allocating wavelengths to reduce the number of ADMs used?



a **b**



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6- Assume that 135 (identical and independent) services are multiplexed onto a 100 Gb/s wavelength. Each service can be represented by an ON/OFF model, where a service is ON with probability 0.6. When the service is ON, the requested service rate is 1 Gb/s.

(a) What is the probability that the intended offered load exceeds the wavelength bit rate? Let *P* equal this probability.

(b) On average, how full is the 100 Gb/s wavelength?

(c) Next, consider the scenario where these same services are multiplexed onto 10 Gb/s wavelengths. How many services can be multiplexed onto one 10 Gb/s wavelength such that the probability that the intended offered load exceeds the wavelength bit rate is no higher than *P*?

(d) With this number of services on a 10 Gb/s wavelength, on average, how full is the wavelength?

(e) What is the statistical multiplexing gain in the 100 Gb/s scenario versus the 10 Gb/s scenario (for the level of P calculated above)?

Good luck.