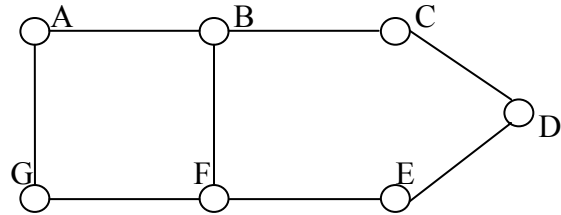


1. What are the advantages of fiber optic technology in communication systems?

2. Suppose we are given the network in the figure and have 2 wavelengths available. The following directional lightpaths have already been set up:

- A-B-C on λ_1
- C-B-A-G on λ_2
- B-F-E on λ_1
- C-D on λ_2



We wish to set up the following lightpaths in addition:

- i. C-B-F-G
- ii. E-F-G-A
- iii. A-G-F-E-D
- iv. A-B-C-D

Draw the lightpaths, preferably in color. At which nodes are wavelength converters required, and how many conversions are required at these nodes? Explain.

3. Consider the IPACT protocol with the limited service scheme, and a maximum scheduling timeslot W_{MAX} of 2500 bytes. Assume the following sequence of requests as shown in Table. Assume RTTs are constant but different for different ONUs and a $5-\mu s$ guard timeslot between data transmissions of different ONUs. The polling order starts with ONU 1.

Draw a timing diagram for a 3-ONU EPON system, similar to the timing diagram we have seen class. Give proper explanations on your diagram.

ONU	Request 1	Request 2	RTT
1	1800	1000	100
2	1500	0	200
3	3000	3000	250

4. Give the names of three wavelength assignment schemes and explain how they work.

5. The virtual topology desing formulation includes also the equation set shown on right.

- $P_{mn} = 1$ if there is a fiber link between nodes m and n, and 0 otherwise.
- $V_{ij} = 1$ if there is a lightpath between nodes i and j, and 0 otherwise.
- The binary variable p_{mn}^{ij} denotes whether the lightpath ij is routed through fiber link mn.

$$\begin{aligned}
 p_{mn}^{ij} &\leq P_{mn} \\
 p_{mn}^{ij} &\leq V_{ij} \\
 \sum_m p_{mk}^{ij} &= \sum_n p_{kn}^{ij} \quad \text{if } k \neq i, j \\
 \sum_n p_{in}^{ij} &= V_{ij} \\
 \sum_m p_{mj}^{ij} &= V_{ij}
 \end{aligned}$$

Explain each of the equations.