MIDTERM II-Solutions

EE/TE4367 Telecommunications Switching & Transmission

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Problem 1. General, 30 points

(a) The bandwidth-distance factor of a fiber system resulting from chromatic dispersion is determined from the fiber dispersion coefficient and the spectral width of the source. *(Fill up the blank)*

(b) SONET defines optical carrier (OC) levels and electrically equivalent synchronous transport signal levels for the fiber-optic–based transmission hierarchy.

(c) What is the purpose of building SONET in ring architecture? What are two basic types of the rings?

Network Survivability

Unidirectional Ring

Bidirectional Ring

(d) Two plesiochronous digital networks, A and B, utilize cesium beam clocks accurate to ∓ 3 parts in 10^{13}. The networks are operated by independent long-distance companies and are synchronized to each other by means of a UTC signal. If a company leases a T1 line, which is terminated at one end in network A and at the other end in network B, how often must the networks be resynchronized to each other to avoid a framing bit error in the customer's T1 signal in the worst case? *Hint:* You may assume that a framing bit error occurs when the two networks are out of synchronization by $\geq 1/2$ of a T1 "bit time".

A T1 bit time = $\dfrac{1}{1.544\times10^{6}} = 6.47668\times10^{-7}$ sec/bit

6 parts in 10^{13} or 6×10^{-13} errored bits per bit transmitted

$\dfrac{6.47668\times10^{-7}}{6\times10^{-13}}$ errored bits per bit= 1.07945×10^{6} seconds per errored bit

Or, 5.39273×10^{5} seconds per errored half bit = 149.92 hrs.

Problem 2. Fiber Optics Transmission (30 points)

Optical Source			
Device Type	Wavelength (nm)	Launched Output Power (dBm)	FWHM Spectrum Width (nm)
Ge LED	1300	-19	100

Optical Detector			
Device Type	Wavelength (nm)	Launched Output Power (dBm)	Data Rate (Mbps)
inGaAs *p-i-n*	1300	-35	100

A 1300-nm, graded-index, single-mode, 100 Mbps fiber system with 0.5 dB/km loss in the fiber is to be used for a token-passing bus local area network. Assume the system uses the source-detector pair above. The BDP of the fiber is 800 Mbps-km.

(a) What is the total loss margin (or budget) of the system?

Loss Budget= -19 dBm – (- 35 dBm) = 16 dB

(b) Find the distance limit of the system.

BDP= 800 Mbps-km = D $\times$ 100 mbps

D= 8 km

(c) How many passive taps with 0.5 dB of loss can be inserted per kilometer without affecting the distance between transmitter and receiver?

$$0.5 \text{ dB/km} \times 8 \text{ km} = 4 \text{ dB loss due to fibre}$$

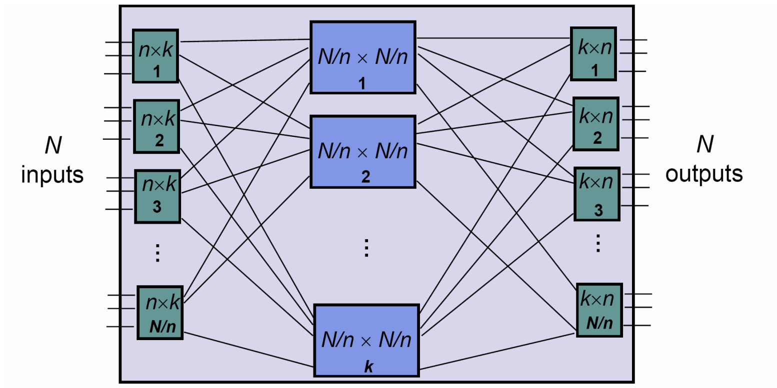
$$16 \text{ dB - } 4 \text{ dB} = 12 \text{ dB loss left}$$

$$\text{No. of taps} = \frac{12 \text{ dB}}{0.5 \text{ dB}} = 24 \text{ taps}$$

$$\text{No. of taps/km} = \frac{24}{8} = 3 \text{ taps/ km}$$

Problem 3. Multistage Switch (40 points)

You are asked to design a three-stage space switch as shown below with 256 inputs. Blocking should be less than 0.002 and the channel utilization is given as 0.1652.



(a) Find n (the size of each inlet-outlet group) if the number of N/nxN/n center-stage arrays is k=9, What is the number of inlet arrays (first stage)? ***Hint: Valid solution of n, when rounded to the closest integer, has to make N/n an integer.***

$p = 0.1652 \qquad N = 256 \qquad B = 0.002 \qquad \beta = \frac{k}{n}$

$$B = \left(1 - (1 - p')^2\right)^k \qquad p' = \frac{p}{\beta} = \frac{pn}{k}$$

$$\Rightarrow 0.002 = \left(1 - \left(1 - 0.1652 \times \frac{n}{9}\right)^2\right)^9$$

$$\sqrt[9]{0.002} = 1 - \left(1 - 0.1652 \times \frac{n}{9}\right)^2$$

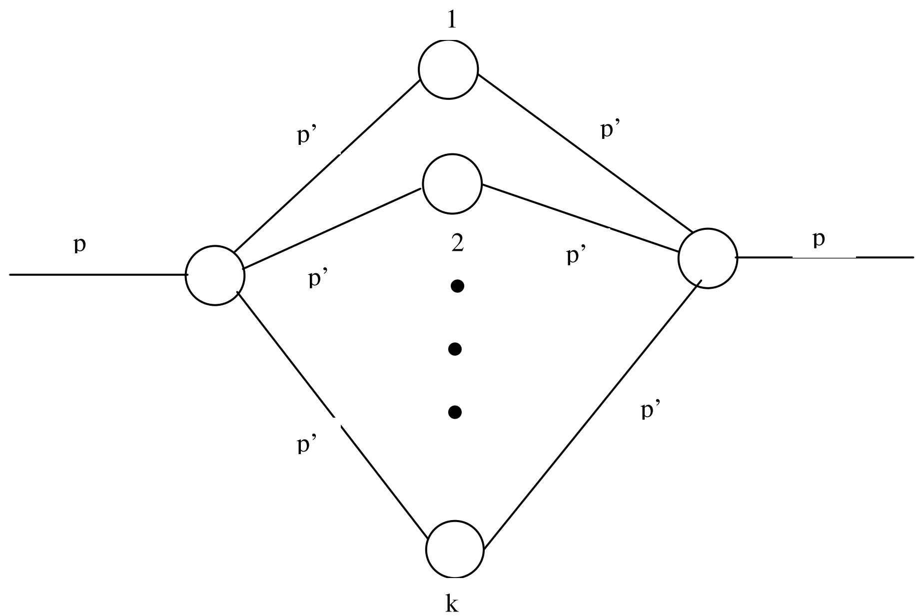
$$\Rightarrow \frac{(0.1652)^2 n^2}{81} - \frac{0.3304}{9} n + \sqrt[9]{0.002} = 0$$

$n \cong \{16, 92.95\} \qquad$ valid solution $n = 16$

$$\frac{N}{n} = \frac{256}{16} = 16 \text{ (integer)}$$

$$\therefore \frac{N}{16} = 16 \text{ inlet arrays.}$$

(b) Draw the probability of the three-stage switch described above. Carefully label probabilities on the graph.



$$p' = p\left(\frac{n}{k}\right)$$

(c) Find the total number of crosspoints required by the three-stage switched design in part (a).

$$N_x = 2 \times \frac{N}{n} \times n \times k + k \times \frac{N}{n} \times \frac{N}{n}$$

$$= 2 \times 16 \times 16 \times 9 + 9 \times \frac{(256)^2}{(16)^2} = 6912$$

(d) If a three-stage space switch is designed with n=8, what should be the value of k for a strictly nonblocking operation? Compare the complexity of this non-blocking switch to the blocking switch complexity in part (c).

$$k = 2n - 1 = 15$$

$$N_x = 2 \times 32 \times 8 \times 15 + 15 \times (32)^2$$

$$= 23040 \quad \text{(much higher than part (c))}.$$