EC 305 : Communication Systems

<u>**Tutorial 3 :** Noise Figure, Repeater, ARQ Protocols, Basics of Cellular Communications</u>

1. Consider a cascade of N active sub-systems (i.e., each sub-system has a gain and a noise-figure), as shown in Fig 1 below. In a typical receiver, these sub-systems may be amplifiers and mixers. The input SNR is given by SNR_I = S/No where S is the signal power and N_O is the thermal noise power, and the i^{th} sub-system has a gain of G*i* and a Noise Figure of F*i*.

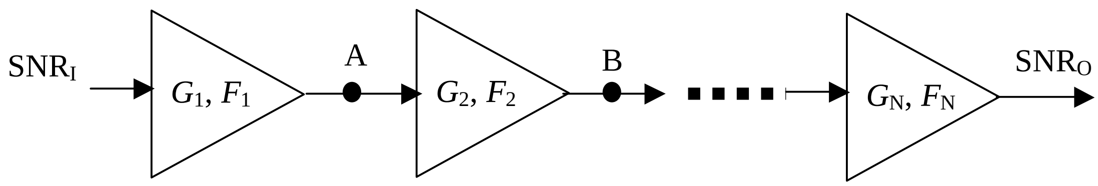
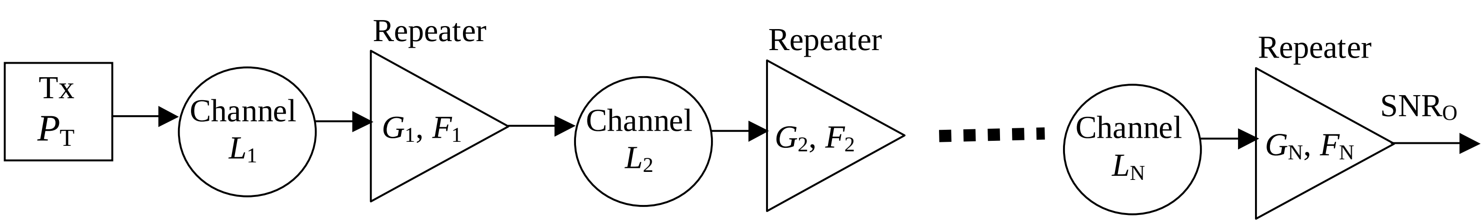


Figure 1: Typical receiver chain – cascade of different active sub-systems

(a) Get the expressions for the SNR and Resultant Noise Figure at locations A and B.
(b) Repeat this to get the expression for the output SNR_O and the overall Noise Figure (also called Fries' formula).
(c) For N=3 and input SNR=20dB, and each gain being Gi=10dB, and the noise figure of each being Fi=6dB find (i) The overall noise figure F (both, in the linear scale and the dB scale), and (ii) The output SNR in dB.

2. A signal of bandwidth 10KHz is to be transmitted over a distance of 200km over a wireline channel that has an attenuation of 2dB/km. Assume that the thermal noise PSD is –174dBm/Hz.
(a) Determine the transmit power P_T required to achieve an SNRo = 20dB at the output of the receiver amplifier that has a noise figure F=6dB. Express the desired P_T in dBm as well as in Watts. Is this reasonable?
(b) Repeat the calculation when a repeater is inserted every 10km with a gain of 20dB (to compensate the loss) and a noise figure Fi=6dB, as shown in Figure 2 below. Express the desired P_T in dBm as well as in Watts. How does it compare to (a)? Comment.

<u>*Hint:*</u> Use the fact that when $L_i = L$ and $F_i = F' \; \forall i, \mathrm{SNR}_O = \frac{1}{NLF'}\left(\frac{P_T}{kT\Delta f}\right)$

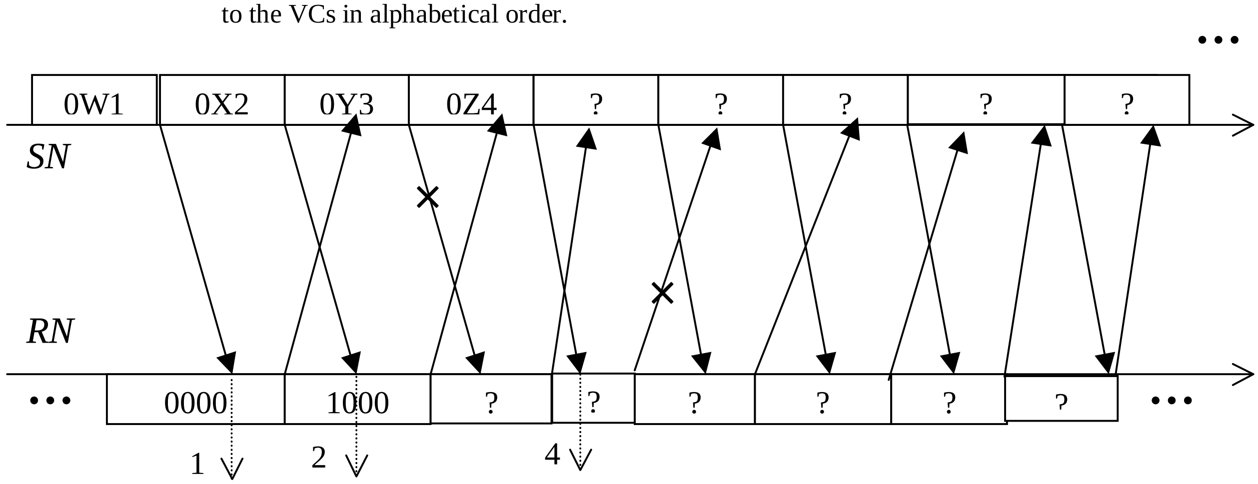


3. Consider a 10Mbps link between nodes A and B, where both nodes put out 500 bit packets. These 500 bits include a 16-bit CRC, RN, and SN, with the remaining bits making the pay-load. The round-trip time, including the propagation, processing, and buffering delays, is 1.33msecs.
(a) Design a selective repeat ARQ scheme where the window size is chosen such that the probability of reaching the edge of the window (before the first packet is acknowledged) is p^2, where p is the probability of the packet being in error. Specify the choice (and the size) of RN and SN.
(b) For the same link, design an efficient Arpanet ARQ scheme, specifying the number of control bits (excluding the CRC) that would be required in each 500 bit packet.
(c) Which of these two schemes is more efficient for $p=10^{-3}$?

4. An Arpanet ARQ scheme uses 4 virtual channels (W,X,Y,Z) with independent stop-and-wait protocols which are time-multiplexed. The SNs are specified by (SN,VCID,PKT#) where VCID is the virtual channel ID (namely, W,X,Y, or Z, and PKT# are the packet numbers from the network layer. The RN is specified by 4 bits, one bit per VCID. Further, assume that:

(i) The transmitter will re-send a lost packet in the first available opportunity, and

(ii) (ii) In there more than one VC is available, the new packet from the network layer will be assigned to the VCs in alphabetical order.



Complete the labels in the locations marked "?" in the figure above, which is consistent with the given state and the above rules.

5. Problems from "Data Networks 2nd Ed.", by Bertsekas and Gallager, Chap. 2 (pp.142-143): **2.16, 2.21, 2.22, & 2.29*.**

6. <u>Reading from "Wireless Communications – Principles & Practice"</u> 2nd Ed., by T.S. Rappaport, Chapter 3 – "The Cellular Concept – System Design Fundamentals" pp. 57 to 104. It is also recommended that you (at least) browse thro the first two chapters in this book to answer some of the problems from the text book given below.

7. Problems from "Wireless Communications 2nd Ed.", by Rappaport, Chap. 3 (pp. 97-104): **3.1, 3.4, 3.5*, 3.6, 3.7, 3.9, 3.10*, 3.11 & 3.26** (revision of Erlang-B; use tables), **3.13, 3.16, 3.22** (revision of Rx sensitivity), and **3.28***.