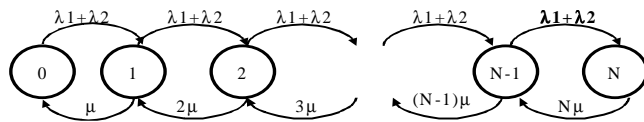
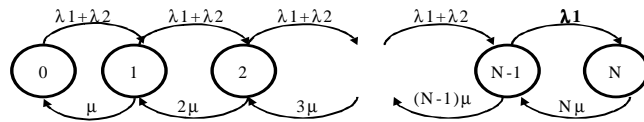


1. Assume we wish to transmit data stream at a bit-rate of 56-kbps using spread spectrum. Determine the channel bandwidth necessary when $SNR = 0.1, 0.01, \text{ and } 0.001$. If 56KHz of bandwidth was used to deliver 56 Kbps in a non-spread spectrum system, what is the minimum SNR required? (4 pts)
2. Consider a GSM system where one carrier is dedicated for CCCH, i.e., one uplink RACH and one set of downlink control channels. Assume each time slot can carry one signaling message. If there are 1,000 users/cell, and each user registers every 3 minutes, receives 3 calls/hour, and makes 3 calls/hour, determine the utilization of the PAGCH and the RACH. (6 pts)
3. Consider a single cell in a FDMA system with 8 channels. The cell needs to allocate channels to both new call originations as well as handoffs calls. If the aggregate new call arrival rate is 120/hour, the aggregate handoff call arrival rate is 24/hour, and the average call holding time is 100 seconds,
 - a) Calculate the blocking probability for new and handoff calls (they are identical) (4 pts)
 - b) If the service provider wants to provide better service to the handoff calls, one way is to use “guard” channels. In this scheme, certain number of guard channels are reserved for handoff calls only. The cell accepts both new and handoff calls until only the reserved guard channels remain unused. At this point, the cell blocks all new calls and accepts only handoff calls, thus giving handoff calls higher priority. The markov chain representing the guard channel scheme is shown in Figure (b) below where one guard channel is reserved for handoff calls (only handoff calls are admitted at state $N-1$) while, without guard channels (see Figure (a)) both new and handoff calls are admitted at all states except state N . Derive and compute the new and handoff call blocking probabilities with one guard channel. (8 pts)



(a) Single cell with new and handoff calls



(b) Single cell with new and handoff calls and 1 guard channel (reserved for handoff calls only)

4. Consider the following one-way paging network: there are 250 users/sq. mile, the network covers 30,000 square miles. Paging service is offered in regions, each of which has a square perimeter of 50 miles. A user may pay to receive pages in one, two, or three regions. When a page is to be delivered to a user, it is transmitted once in each area in which the user pays to receive the messages. For example, if a user pays to have pages delivered in 2 areas, then one page is sent in each of the two areas. Users receive on average 1.6 pages/hour.
 - a) If 20% of the users receive pages in one area, 30% receive pages in two areas, and 50% receive pages in three areas, determine average number of pages/second transmitted in each area (4 pts).
 - b) A return channel on which users may register is now added to the system. The network sends an acknowledgement to the user when it registers. Now, the pages are sent only in the area in which the user is located. If users move at an average of 10 miles/hour, determine the total downlink message rate including pages and acknowledgements to the registration messages (4 pts).