TSIN02 Internetworking

Exercise class 6 problems

Exercise 1: A certain transmission link can be modeled as a BSC channel with bit error $p = 10^{-5}$. Packets of 500 bytes are sent together with a strong checksum. Packets with errors are thrown away on the receiving side. Compute the theoretically obtainable efficiency if FEC is used over the link and compare it with the efficiency of using ARQ.

Exercise 2: A router in an operator-controlled network throws away 5% of all packets due to buffer overflows. It is further set to guarantee that there will be at most one packet loss in each consecutive group of 10 packets from a single user. A specific real-time protocol shall be designed based on FEC. The receiver replaces missing data with random bits.

a) Interleaving is used to spread packet loss data randomly over many transmitted packets. What is the efficiency that can be obtained with FEC assuming a BSC channel model?
b) In an attempt to make the FEC scheme better match the router behavior; a user formats his data in blocks of 10 bits. These bits are then spread out (interleaved) over 10 consecutive packets. An additional checksum bit is added to each block to enable error correction if a packet loss occurs. What is the efficiency of this scheme?

Exercise 3: Car tolls are being employed around Stockholm. To know who should pay, cameras take grayscale photos of the cars and submit them on the Internet to a central billing station. You are to design the photo delivery solution for this system. In all of the following, we ignore packet headers in the calculations, even if they are essential in practice.

a) Assume that the grayscale color of each pixel is Gaussian distributed with zero mean and variance 1. How many bits are needed using a uniform quantizer to encode a 1000 x 1000-pixel image if you accept an MSE distortion of 0.01 per pixel and we assume that the pixels are i.i.d.?

b) In practice, you quantize the pixel color values to 5 different levels. The pixels are modeled as i.i.d. with probability of the 5 different color values as $p(1) = 0.01$, $p(2) = 0.02$, $p(3) = 0.03$, $p(4) = 0.04$, and $p(5) = 0.9$. Is it possible to send these pixels with infinitely long codes and some packetization strategy, over a channel with packet loss probability $p_{loss} = 0.1$ and a transmission rate of 1 bit/pixel? Motivate your answer carefully by calculations!

Exercise 4: The Linköping Police will use a new system for real-time tracking of cars breaking the speed limit, and your company will deliver the system. Cameras take grayscale photos of

the cars and submit them on the Internet to a central car tracking server. To make the system real-time, yet robust, you will employ error concealment. You interleave the data in two packets by putting every odd pixel in packet 1, and every even pixel in packet 2. Thousands of pixels are put in packet 1 and 2, and you thereafter continue to put odd pixels in packet 3 and even pixels in packet 4, and so on. We assume no quantization distortion, and that a single packet is lost. We assume quantization distortion to be negligible and model the image as an auto-regressive process

$$x_n = ax_{n-1} + u_n$$

where u_n is a zero-mean Gaussian variable with variance 1, and a = 0.7. What is the error concealment MSE with and without interleaving if we use prediction from the most recent pixel in the packet before the lost packet?

Exercise 5: Consider coding for a network with packet losses with loss bursts following the Gilbert-Elliott process, i.e., the probability of a lost packet given that the previous packet was received $P_{l/r}$=0.01, and the probability of a received packet given that the previous packet was lost $P_{r/l}$=0.3. Assume that the probability density function (pdf) of the source is zero except in the interval [0,1]. Use uniform quantization with 10 reconstruction levels and assume that we operate in the high-rate regime. We do not use any means of protection against lost packets on the network. Assume that the MSE distortion is 1 if no packet arrives at the receiver.

a) What is the stationary channel loss probability?
b) What is the distortion if the packet arrives?
c) What is the overall stationary mean MSE distortion considering the channel loss probability and the quantization distortion?