

EE 6340: Introduction to Telecommunications Networks

PROJECT 5

- Performance of coded stop-and-wait ARQ protocol.

A wireless network node sends data in the form of frames to a base station using a stop-and-wait ARQ protocol. The wireless channel between the node and the base station is subject to fading and path loss and the channel quality is expressed in terms of ratio of transmitted power to noise power, i.e., signal-to-noise ratio (SNR). To combat the noise of the wireless channel, data frames sent by the wireless node are encoded using a Rate Compatible Punctured Code (RCPC). The probability that the base station receives successfully a data frame depends on the channel SNR and on the code rate. The base station can afford to transmit acknowledgments (positive or negative) at very high power, thus the acknowledgment error probability can be considered negligible.

The objective of this project is to compare the performance of the above described system under different channel conditions and with different code rates.

1. For the above described stop-and-wait ARQ system, write the expression of the expected network latency (L), i.e., the time elapsed between the generation of the frame and the correct delivery of the frame to the base station. Assume that the data frame size is fixed and equal to F_D bits, the acknowledgment frame size is fixed and equal to F_C bits, and the probability that a data frame is not decoded successfully is equal to P_D , the data frame arrival rate at the node is λ , and the channel transmission rate is $R = 2\text{Mbps}$. Propagation time of the frames and frame losses can be considered negligible. The node buffer size is unbounded.
2. Write the expression of the expected queue length (N_q) at the node.
3. Assume that uncoded data in blocks of $N = 128$ bits arrive at the node with rate λ . The data is encoded with a RCPC code at rate R_c to form data frames (With a code rate R_c , a block of N data bits is encoded in a data frame of N/R_c bits.) Acknowledgment frames have fixed size of $F_C = 16$ bits and are not encoded. When the channel SNR is 0dB, the probability that the base station is not able to decode successfully the data frame is $P_D = 0.583$ for a RCPC code with rate $R_c = 1/2$ and $P_D = 0.171$ for a RCPC code with rate $R_c = 1/4$. **Plot #1:** plot the expected latency (L) versus the utilization factor ($\rho \in (0, 1)$) by varying λ for the two different code rates. (The arrival rate λ of uncoded data blocks should be kept the same for both cases.)
4. When the channel SNR is 20dB, the probability that the base station is not able to decode successfully the data frame is $P_D = 0.0087$ for a RCPC code with rate $R_c = 1/2$ and $P_D = 2.77 \cdot 10^{-5}$ for a RCPC code with rate $R_c = 1/4$. **Plot #2:** plot the expected latency (L) versus the utilization factor ($\rho \in (0, 1)$) by varying λ for the two different code rates. (The arrival rate λ of uncoded data blocks should be kept the same for both cases.)
5. Compare the two plots for the two different channel SNR conditions and explain why a higher code rate may not always guarantee the best performance in terms of expected latency.