DEPARTAMENTO DE ELETRÓNICA, TELECOMUNICAÇÕES E INFORMÁTICA

MESTRADO EM ENGENHARIA DE COMPUTADORES E TELEMÁTICA

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MODELAÇÃO E DESEMPENHO DE REDES E SERVIÇOS

PRACTICAL GUIDE

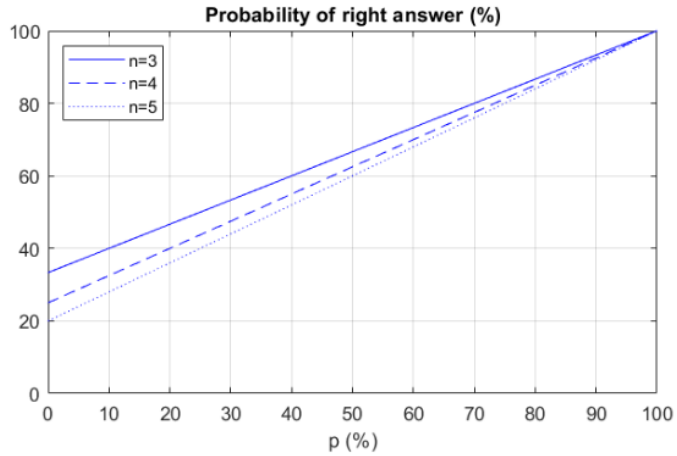
Task 1

Consider a multiple choice test such that each question has *n* possible answers and only one is correct. Assume that the student has studied a percentage p (with $0\% \leq p \leq 100\%$) of the test content. When a question addresses the content the student has studied, he selects the right answer with 100% of probability. Otherwise, the student always selects randomly one of the *n* answers with a uniform distribution.

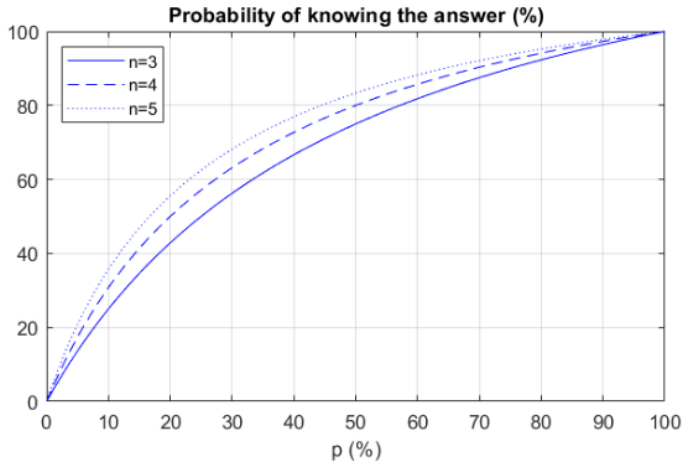
1.a. When $p = 60\%$ and $n = 4$, determine the probability of the student to select the right answer. Answer: 70%

1.b. When $p = 70\%$ and $n = 5$, determine the probability of the student to known the answer when he selects the right answer. Answer: 92.1%

1.c. Draw a plot with the same look as the plot below with the probability of the student to select the right answer as a function of the probability p (consider $n = 3, 4$ and 5). What do you conclude from these results? Answer:



1.d. Draw a plot with the same look as the plot below with the probability of the student to know the answer when he selects the right answer as a function of the probability p (consider $n = 3, 4$ and 5). What do you conclude from these results? Answer:



Task 2

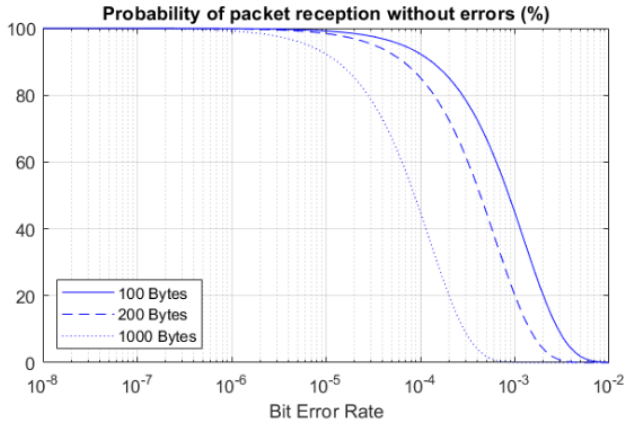
Consider a wireless link between multiple stations for data communications with a bit error rate (*ber*) of p. Assume that errors in the different bits of a data packet are statistically independent (i.e., the number of errors of a data packet is a binomial random variable).

2.a. Determine the probability of a data packet of 100 Bytes to be received without errors when $p = 10^{-2}$. Answer: 0.0322%

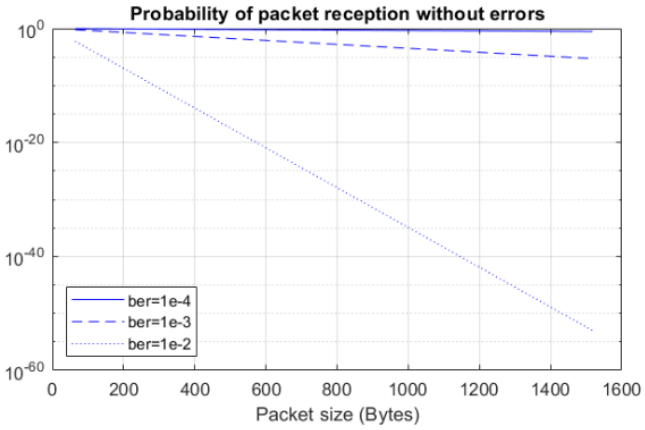
2.b. Determine the probability of a data packet of 1000 Bytes to be received with exactly one error when $p = 10^{-3}$. Answer: 0.2676%

2.c. Determine the probability of a data packet of 200 Bytes to be received with one or more errors when $p = 10^{-4}$. Answer: 14.7863%

2.d. Draw a plot using a logarithmic scale for the X-axis (use the MATLAB function `semilogx`) with the same look as the plot below with the probability of a data packet (of size 100 Bytes, 200 Bytes or 1000 Bytes) being received without errors as a function of the *ber* (from $p = 10^{-8}$ up to $p = 10^{-2}$). What do you conclude from these results? Answer:

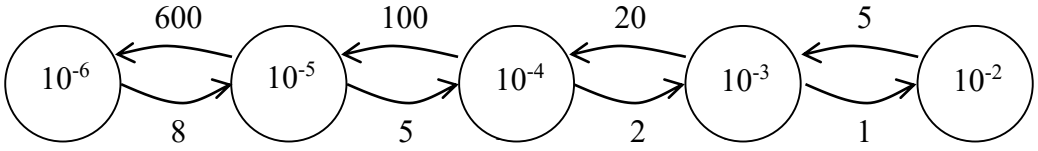


2.e. Draw a plot using a logarithmic scale for the Y-axis (use the MATLAB function `semilogy`) with the same look as the plot below with the probability of a data packet being received without errors (for $p = 10^{-4}$, 10^{-3} and 10^{-2}) as a function of the packet size (all integer values from 64 Bytes up to 1518 Bytes). What do you conclude from these results? Answer:



Task 3

Consider a wireless link between multiple stations for data communications. The bit error rate (*ber*) introduced by the wireless link (due to the variation of the propagation and interference factors along with time) is approximately given by the following Markov chain:



where the state transition rates are in number of transitions per hour. Consider that the link is in an interference state when its *ber* is at least 10^{-3} and in a normal state, otherwise. Assume that all stations detect with a probability of 100% when the data frames sent by the other stations are received with errors. Determine:

3.a. the probability of the link being in each of the five states; answer: 9.86×10^{-1} (10^{-6}), 1.31×10^{-2} (10^{-5}), 6.57×10^{-4} (10^{-4}), 6.57×10^{-5} (10^{-3}), 1.31×10^{-5} (10^{-2})

3.b. the average percentage of time the link is in each of the five states; answer: 9.86×10^{-1} (10^{-6}), 1.31×10^{-2} (10^{-5}), 6.57×10^{-4} (10^{-4}), 6.57×10^{-5} (10^{-3}), 1.31×10^{-5} (10^{-2})

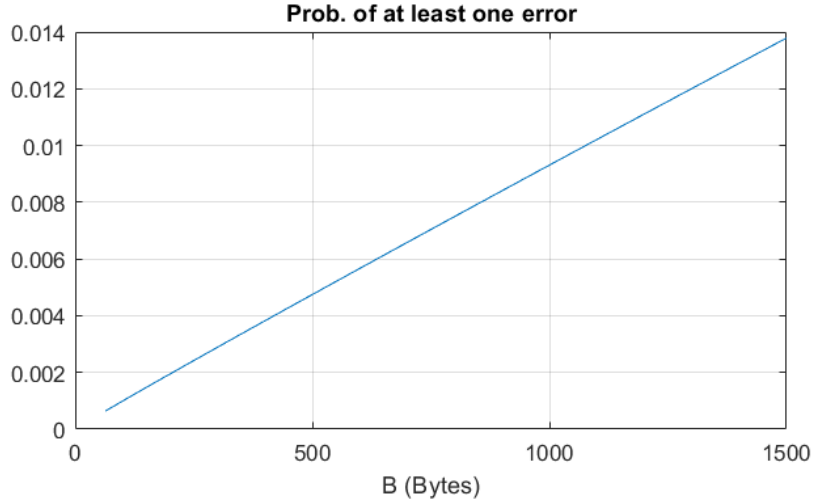
3.c. the average *ber* of the link; answer: 1.38×10^{-6}

3.d. the average time duration (in minutes) that the link stays in each of the five states; answer: 7.5 (10^{-6}), 0.10 (10^{-5}), 0.59 (10^{-4}), 2.86 (10^{-3}), 12.0 (10^{-2})

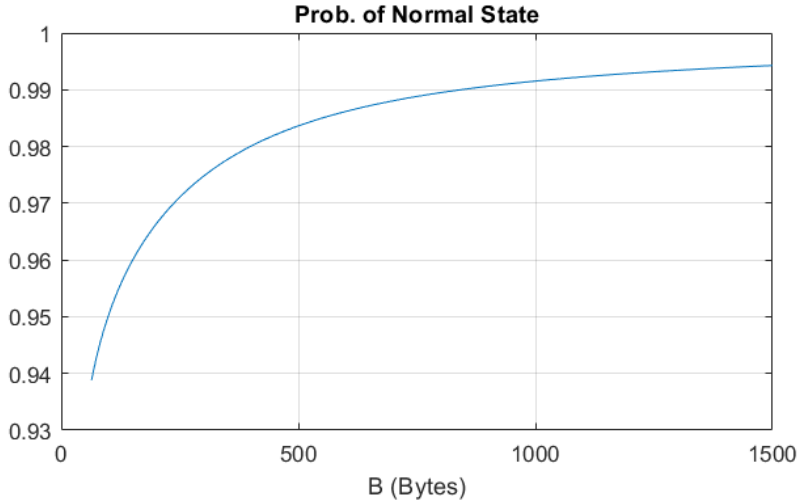
3.e. the probability of the link being in the normal state and in interference state; answer: 0.999921 (normal), 7.89×10^{-5} (interference)

3.f. the average *ber* of the link when it is in the normal state and when it is in the interference state. Answer: 1.18×10^{-6} (normal), 2.50×10^{-3} (interference)

3.g. considering a data frame of size *B* (in Bytes) sent by one source station to a destination station, draw a plot with the same look as the plot below of the probability of the packet being received by the destination station with at least one error as a function of the packet size (from 64 Bytes up to 1500 Bytes). Analyze and justify the results. Answer:



3.h. considering that a data frame of size *B* (in Bytes) sent by one source station is received with at least one error by the destination station, draw a plot with the same look as the plot below of the probability of the link being in the normal state as a function of the packet size (from 64 Bytes up to 1500 Bytes). Analyze and justify the results. Answer:



3.i. considering that a data frame of size *B* (in Bytes) sent by one source station is received without errors by the destination station, draw a plot with the same look as the plot below (use the MATLAB function `semilogy`) of the probability of the link being in the interference state as a function of the packet size (from 64 Bytes up to 1500 Bytes). Analyze and justify the results. Answer: