DEPARTAMENTO DE ELETRÓNICA, TELECOMUNICAÇÕES E INFORMÁTICA

MESTRADO EM ENGENHARIA DE COMPUTADORES E TELEMÁTICA

ANO 2024/2025

MODELAÇÃO E DESEMPENHO DE REDES E SERVIÇOS

MINI-PROJECT 1:

PERFORMANCE EVALUATION OF POINT-TO-POINT LINKS SUPPORTING PACKET SERVICES

Assignment Description

Develop this mini-project in a group of 2 students. Implement all tasks using MATLAB to obtain all requested results. Justify all obtained results and draw all possible conclusions. Write a report with all results together with their analysis and conclusions. When requested, include in the report the developed MATLAB codes duly explained. The report must identify the elements of the group (names and Student Numbers) and must include an auto-evaluation of the percentage of the work done by each member. The report must be sent in PDF format to asou@ua.pt until 23:59 of 29th of October of 2024.

Task 1

In this task, use *Sim2* developed in Task 6 of the Practical Guide. Consider always the capacity of the link $C = 10$ Mbps and the size of the queue $f = 10.000$ Bytes. When performance parameters are estimated by simulation, present the results based on 20 runs of the simulator (with a stopping criterion of $P = 100.000$ on each run) and with 90% confidence intervals.

1.a. **(Evaluation weight: 10%)** Estimate by simulation the average packet delay and the average packet loss parameters when the bit error rate of the link is $b = 10^{-6}$ and for the arrival rate values $\lambda = 1500, 1600, 1700, 1800$ and 1900 pps. Plot the results in bar charts with the confidence intervals in error bars[1]. Justify the results and draw all relevant conclusions.

1.b. **(Evaluation weight: 10%)** Repeat experiment **1.a** considering now a bit error rate $b = 10^{-4}$. Justify the differences between these results and the results of experiment **1.a** and draw all relevant conclusions.

Calcular valores teóricos

1.c. **(Evaluation weight: 10%)** Determine the theoretical average packet loss (in %) only due to the bit error rate for $b = 10^{-6}$ and $b = 10^{-4}$. Present and explain the MATLAB code developed for these calculations. Compare these values with the results obtained in **1.a** and **1.b**. What do you conclude?

Task 2

Sim3A : Acrescentar ao Sim3 o mesmo que se fez do Sim1 para o Sim2

Consider the event driven simulator *Sim3* developed in Task 7 of the Practical Guide. Start by developing a new version of *Sim3*, named *Sim3A*, to estimate the same performance parameters as *Sim3* and to consider that the link introduces a bit error rate given by b (which should be a new input parameter of *Sim3A*).

4 casos diferente que só altera os valores de VoIP

2.a. **(Evaluation weight: 5%)** Present the developed MATLAB function of *Sim3A* highlighting and justifying the introduced changes. Using *Sim3A*, estimate all performance parameters when $\lambda = 1500$ pps, $C = 10$ Mbps, $f = 1.000.000$ Bytes, $b = 10^{-5}$ and $n = 10, 20, 30$ and 40 VoIP flows, based on 20 runs of the simulator (with a stopping criterion of $P = 100.000$ on each run) and with 90% confidence intervals.

2.b. **(Evaluation weight: 5%)** Present the simulation results of **2.a** concerning the packet loss of each service (data and VoIP) in bar charts with the confidence intervals in error bars. Justify the results and draw all relevant conclusions.

2.c. **(Evaluation weight: 5%)** Present the simulation results of **2.a** concerning the average packet delay of each service in bar charts with the confidence intervals in error bars. Justify the results and draw all relevant conclusions.

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[1] https://www.mathworks.com/help/matlab/creating_plots/bar-chart-with-error-bars.html

2.d. **(Evaluation weight: 5%)** Present the simulation results of **2.a** concerning the maximum packet delay of each service in bar charts with the confidence intervals in error bars. Justify the results and draw all relevant conclusions.

2.e. **(Evaluation weight: 5%)** Present the simulation results of **2.a** concerning the total throughput in bar charts with the confidence intervals in error bars. Justify the results and draw all relevant conclusions.

Calcular valores teóricos

2.f. **(Evaluation weight: 10%)** Determine the theoretical value of the total throughput for all cases simulated in experiment **2.a**. Present and explain the MATLAB code developed for these calculations. Compare these values with the results obtained in **2.e**. What do you conclude?

Task 3

Consider the event driven simulators *Sim3* and *Sim4* developed in Task 7 of the Practical Guide. In all experiments of this task, consider the cases of $\lambda = 1500$ pps, $C = 10$ Mbps, $f = 10.000$ Bytes and $n = 10, 20, 30$ and 40 VoIP flows. All simulation results should be based on 20 runs of the simulator with a stopping criterion of $P = 100.000$ on each run to compute the estimated values and the 90% confidence intervals.

3.a. **(Evaluation weight: 10%)** Use *Sim3* to estimate the average packet delay and average packet loss of each service (data and VoIP). Recall that in *Sim3*, both services are statistically multiplexed in a single FIFO queue. Present each of the four performance parameters in a bar chart with the confidence intervals in error bars. Justify the differences in the performance values obtained for each service and draw all relevant conclusions.

3.b. **(Evaluation weight: 10%)** Use *Sim4* to estimate the same performance parameters as in **3.a**. Recall that in *Sim4*, VoIP service has higher priority than data service. Present each of the four performance parameters in a bar chart with the confidence intervals in error bars. Justify the differences in the performance values obtained for each service, and the differences between these results and the results of experiment **3.a**. Draw all relevant conclusions.

3.c. **(Evaluation weight: 5%)** Develop a new version of *Sim4*, named *Sim4A*, to estimate the same performance parameters as *Sim4* changing the queue packet discard algorithm as follows: arriving VoIP packets are always accepted in the queue (if there is enough space) but arriving data packets are accepted in the queue only if the total queue occupation does not become higher than p (in %) of the queue size[2] (parameter p should be a new input parameter of *Sim4A*). Present the developed MATLAB function of *Sim4A* highlighting and justifying the introduced changes.

3.d. **(Evaluation weight: 5%)** Use simulator *Sim4A* to estimate the same performance parameters as in **3.a** and **3.b** for $p = 90\%$. Justify the differences in the performance values obtained for each service, and the differences between these results and the results of experiment **3.b**. Draw all relevant conclusions.

3.e. **(Evaluation weight: 5%)** Repeat experiment **3.d** considering now $p = 60\%$. Justify the differences in the performance values obtained for each service, and the differences between these results and the results of experiments **3.b** and **3.d**. Draw all relevant conclusions.

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[2] a simplified version of WRED – Weighted Random Early Discard