DEPARTAMENTO DE ELETRÓNICA, TELECOMUNICAÇÕES
E INFORMÁTICA

MESTRADO EM ENGENHARIA DE COMPUTADORES E TELEMÁTICA

ANO 2021/2022

MODELAÇÃO E DESEMPENHO DE REDES E SERVIÇOS

MINI-PROJECT 1:

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

Mini-Project 1

Assignment Description

Develop this mini-project in a group of 2 students. Implement all tasks using MATLAB to obtain the requested numerical results. Justify all obtained results and take all possible conclusions. Write a report with all results together with their analysis and conclusions. Include in the report all developed MATLAB codes duly explained. The report must be sent in PDF format to asou@ua.pt until 14th of December of 2021.

Task 1

Consider the event driven simulator *Simulator1* used in Task 5 of the Practical Guide.

1.a. Consider the case of C = 10 Mbps and f = 1.000.000 Bytes. Run *Simulator1* 50 times with a stopping criterion of P = 10000 each run and compute the estimated values and the 90% confidence intervals of the average delay performance parameter when λ = 400, 800, 1200, 1600 and 2000 pps. Present the average packet delay results in bar charts with the confidence intervals in error bars[1]. Justify the results and take conclusions concerning the impact of the packet rate in the obtained average packet delay.

1.b. Consider the case of λ = 1800 pps and C = 10 Mbps. Run *Simulator1* 50 times with a stopping criterion of P = 10000 each run and compute the estimated values and the 90% confidence intervals of the average delay and packet loss performance parameters when f = 100.000, 20.000, 10.000 and 2.000 Bytes. Present the average packet delay results in one figure and the average packet loss results in another figure (in both cases, in bar charts with the confidence intervals in error bars). Justify the results and take conclusions concerning the impact of the queue size in the obtained average packet delay and average packet loss.

1.c. Consider the case of λ = 1800 pps and f = 1.000.000 Bytes. Run *Simulator1* 50 times with a stopping criterion of P = 10000 at each run and compute the estimated values and the 90% confidence intervals of the average delay performance parameter when C = 10, 20, 30 and 40 Mbps. Present the average packet delay results in bar charts with the confidence intervals in error bars. Justify the results and take conclusions concerning the impact of the link capacity in the obtained average packet delay.

1.d. Consider that the system is modelled by a $M/G/1$ queueing model. Determine the theoretical values of the average packet delay using the $M/G/1$ model for all cases of **1.c**. Compare the theoretical values with the simulation results of experiments **1.c** and take conclusions.

implementar o modelo MG1: ja pediu isto nas tarefass dos guioes práticos…

1.e. Develop a new version of *Simulator1* to estimate 3 additional performance parameters: the average packet delay of the packets of size 64, 110 and 1518 Bytes, respectively. Consider the case of λ = 1800 pps and f = 1.000.000. Run the new version of *Simulator1* 50 times with a stopping criterion of P = 10000 at each run and compute the estimated values and the 90% confidence intervals of the 3 new average delay performance parameters when C = 10, 20, 50 and 100 Mbps. Present the average packet delay results in bar charts with the confidence intervals in error bars. Justify these results and the differences between them and the results of **1.c**. Take conclusions concerning the impact of the link capacity in the obtained average packet delay of packets with different sizes.

Text

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

Task 2

Consider the event driven simulators *Simulator3* and *Simulator4* developed in Task 7 of the Practical Guide.

2.a. Consider the case of λ = 1500 pps, C = 10 Mbps and f = 1.000.000 Bytes. Run *Simulator3* 50 times with a stopping criterion of P = 10000 each run and compute the estimated values and the 90% confidence intervals of the average delay performance parameter of data packets and VoIP packets when n = 10, 20, 30 and 40 VoIP flows. Present the average data packet delay results in one figure and the average VoIP packet delay results in another figure (in both cases, in bar charts with the confidence intervals in error bars). Justify the results and take conclusions concerning the impact of the number of VoIP flows in the obtained average packet delay of each service when both services (data and VoIP) are statistically multiplexed in a single FIFO queue.

2.b. Repeat experiment **2.a** but now with *Simulator4*. Justify these results and the differences between them and the results of **2.a**. Take conclusions concerning the impact of the number of VoIP flows in the obtained average packet delay of each service when VoIP service is supported with a priority which is higher than the data service.

2.c. Consider that the system is modelled by a $M/G/1$ queueing model with priorities. Determine the theoretical values of the average data packet delay and average VoIP packet delay using the $M/G/1$ model for all cases of **2.b**. Compare the theoretical values with the simulation results of experiments **2.b** and take conclusions.

ver se o modelo teorico é uma boa aproximassao ou nao do modelo real….

2.d. Consider the case of λ = 1500 pps, C = 10 Mbps and f = 10.000 Bytes. Run *Simulator3* 50 times with a stopping criterion of P = 10000 each run and compute the estimated values and the 90% confidence intervals of the average delay and packet loss performance parameters of data packets and VoIP packets when n = 10, 20, 30 and 40 VoIP flows. Present the results of each of the 4 performance parameters (average data packet delay, average VoIP packet delay, data packet loss and VoIP packet loss) in different figures (in all cases, in bar charts with the confidence intervals in error bars). Justify the results and take conclusions concerning the impact of the number of VoIP flows in the obtained average packet delay and packet loss of each service when both services (data and VoIP) are statistically multiplexed in a single FIFO queue of small size.

2.e. Repeat experiment **2.d** but now with *Simulator4*. Justify these results and the differences between them and the results of **2.d**. Take conclusions concerning the impact of the number of VoIP flows in the obtained average packet delay and packet loss of each service when VoIP service is supported with a priority which is higher than the data service and the queue is of small size.

2.f. Develop a new version of *Simulator4* to consider that VoIP packets are always accepted in the queue (if there is enough space) but data packets are accepted in the queue only if the total queue occupation does not become higher than 90% (a simplified version of WRED – Weighted Random Early Discard). Repeat experiment **2.e** but now with the new version of *Simulator4*. Justify these results and the differences between them and the results of **2.e**. Take conclusions concerning the impact of the number of VoIP flows in the obtained average packet delay and packet loss of each service when (i) VoIP service is supported with a priority which is higher than the data service and (ii) the packet acceptance in the queue is differentiated.

so aceito um pacote de dados se a ocupacao da fila de espera nao ultrapassar os 90%… pelo menos 10% é dedicada a pacotes VoIP