DEPARTAMENTO DE ELETRÓNICA, TELECOMUNICAÇÕES E INFORMÁTICA

MESTRADO EM ENGENHARIA DE COMPUTADORES E TELEMÁTICA

ANO 2023/2024

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 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 the end of 31st of October for class TP1 and until the end of 8th of November for class TP2.

Task 1

Consider the event driven simulators *Simulator1* and *Simulator2* developed in Task 5 and Task 6 of the Practical Guide.

1.a. **(Evaluation weight: 10%)** Consider the case of λ = 1800 pps and f = 1.000.000 Bytes. Run 20 times *Simulator1* with a stopping criterion of P = 100.000 at each run and compute the estimated values and the 90% confidence intervals of the average packet delay when C = 10, 20, 30 and 40 Mbps. Present the average packet delay results in bar charts with the confidence intervals in error bars[1]. Justify the results. Draw conclusions concerning the impact of the link capacity in the obtained results.

1.b. **(Evaluation weight: 10%)** Consider the system modelled by a $M/G/1$ queueing model. Determine the theoretical values of the average packet delay for all cases of **1.a**. Compare the theoretical values with the simulation results and draw conclusions.

1.c. **(Evaluation weight: 10%)** Consider the case of C = 10 Mbps and f = 1.000.000 Bytes. Run 20 times *Simulator1* with a stopping criterion of P = 100.000 at each run to compute the estimated values and the 90% confidence intervals of the average packet delay and average throughput when λ = 1000, 1300, 1600 and 1900 pps. Present the results in 2 different figures: (i) the average packet delay results and (ii) the average throughput results (in both cases, in bar charts with the confidence intervals in error bars). Justify the obtained results. Draw conclusions concerning the impact of the packet arrival rate in the obtained results.

1.d. **(Evaluation weight: 10%)** Repeat experiments **1.c** but now using *Simulator2* with $b = 10^{-5}$. Justify the obtained results. Compare these results with the previous ones and draw conclusions concerning the impact of the *ber* in the obtained results.

1.e. **(Evaluation weight: 20%)** Change both simulators to consider that the packet size is between 64 and 1518 bytes with the following new probabilities: 25% for 64 bytes, 17% for 110 bytes, 11% for 1518 bytes and an equal probability for all other values (i.e., from 65 to 109 and from 111 to 1517). Repeat experiments **1.c** and **1.d** with the new simulators. Justify the obtained results. Compare these results with the ones of **1.c** and **1.d** and draw conclusions concerning the impact of the new packet size statistics in the obtained results.

[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. Start by changing both simulators to estimate a new performance parameter: the average packet queuing delay. Use the changed versions in the next experiments.

2.a. **(Evaluation weight: 15%)** Consider the case of λ = 1500 pps, C = 10 Mbps and f = 1.000.000 Bytes. Run 20 times *Simulator3* with a stopping criterion of P = 100.000 at each run and compute the estimated values and the 90% confidence intervals of the average delay and average queuing delay of data packets and VoIP packets when n = 10, 20, 30 and 40 VoIP flows. Present the results in 4 different figures: (i) the average delay of data packets, (ii) the average delay of VoIP packets, (iii) the average queuing delay of data packets and (iv) the average queuing delay of VoIP packets (in all cases, in bar charts with the confidence intervals in error bars). Justify the obtained results. Draw conclusions concerning the impact of the number of VoIP flows in the obtained results when both services (data and VoIP) are statistically multiplexed in a single FIFO queue.

2.b. **(Evaluation weight: 15%)** Repeat experiments **2.a** but now with *Simulator4*. Justify the obtained results. Compare these results with the results of **2.a** and draw conclusions concerning the impact on the results when the VoIP service is supported with higher priority than the data service.

2.c. **(Evaluation weight: 10%)** Consider the system modelled by a $M/G/1$ queueing model with priorities. Determine the theoretical values of the average packet delay for data packets and VoIP packets in all cases of **2.b**. Compare the theoretical values with the simulation results of experiments **2.b** and draw conclusions.