
**DEPARTAMENTO DE ELETRÓNICA, TELECOMUNICAÇÕES E INFORMÁTICA**

**MESTRADO EM ENGENHARIA DE COMPUTADORES E TELEMÁTICA**

**ANO 2025/2026**

## MODELAÇÃO E DESEMPENHO DE REDES E SERVIÇOS

# MINI-PROJECT 1:

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

Mini-Project 1

## Assignment Rules

- Develop this mini-project in a group of 2 students.
- Implement all tasks using MATLAB to obtain all requested results.
- Write a report containing all results together with their analysis and conclusions as complete as possible.
- 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 at the first page an auto-evaluation of the percentage of the work done by each element.
- In the classes of 22nd of October (TP1) and 23rd of October (TP2), both elements of each group must attend the class and demonstrate what have already developed.
- The report must be sent in PDF format to asou@ua.pt **until 23:59 of 28th of October (TP1) and until 23:59 of 29th of October (TP2)**.

## Task 1

Consider the event driven simulator *Simulator1* used in Task 5 of the Practical Guide. In all experiments requesting simulation results, compute always the estimated values and 90% confidence intervals based in 50 runs of the requested simulator with a stopping criterion of $P = 100.000$ each run. Then, present the estimated values in bar charts and the 90% confidence intervals in error bars on the same plot [Footnote 1].

**1.a.** **(Evaluation weight: 5%)** Consider the cases $C$ = 10 Mbps, $f$ = 1.000.000 Bytes and $\lambda$ = 1100, 1300, 1500, 1700 and 1900 pps. For each case, estimate by simulation the packet average loss and the average packet delay. Present the average packet loss results in one figure and the average packet delay results in another figure. Justify these results and draw all relevant conclusions.

**1.b.** **(Evaluation weight: 5%)** Repeat experiments of **1.a** but now considering $f$ = 10.000 Bytes. Justify these results and draw all relevant conclusions. Justify also the differences between these results and the results of **1.a**.

**1.c.** **(Evaluation weight: 10%)** Develop a new version of *Simulator1*, named *Simulator1A*, to estimate 6 additional performance parameters: the average packet loss and the average packet delay of the packets whose size is one of 3 special cases: 64, 110 and 1518 Bytes. Include in the report the developed MATLAB function of *Simulator1A* highlighting and justifying the changes introduced.

**1.d.** **(Evaluation weight: 5%)** Consider the case $C$ = 10 Mbps, $f$ = 1.000.000 Bytes and $\lambda$ = 1900 pps. Using *Simulator1A*, estimate by simulation the average packet loss and average packet delay, both performance parameters for all packets and for each of the 3 special packet sizes. Present the average packet loss results in one figure and the average packet delay results in another figure. Justify these results and draw all relevant conclusions.

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

**1.e.** **(Evaluation weight: 10%)** Consider the case of **1.d** modelled by an $M/G/1$ queueing model. Develop a MATLAB script to determine the theoretical values of the average packet loss and average packet delay for all packets and for each of the 3 special packet sizes. Include in the report the developed MATLAB code duly explained. Report the obtained results, compare them with the simulation results of experiments **1.d** and draw all possible conclusions.

**1.f.** **(Evaluation weight: 5%)** Repeat experiments of **1.d** but now considering $f$ = 10.000 Bytes. Justify these results and draw all relevant conclusions. Justify also the differences between these results and the results of **1.d**.

**1.g.** **(Evaluation weight: 10%)** Develop a new version of *Simulator1A*, named *Simulator1B*, with the same input and output performance parameters of *Simulator 1A* and changing the queuing discipline to provide the following 3 priorities:

- First (i.e., highest) priority: packets with size is [1501 , 1518] in Bytes;
- Second priority: packets with size is [1001 , 1500] in Bytes;
- Third (i.e., lowest) priority: packets with size is [1 , 1000] in Bytes.

Include in the report the developed MATLAB function of *Simulator1B* highlighting and justifying the changes introduced.

**1.h.** **(Evaluation weight: 5%)** Consider the case $C$ = 10 Mbps, $f$ = 1.000.000 Bytes and $\lambda$ = 1900 pps. Using *Simulator1B*, estimate by simulation the average packet loss and average packet delay, both performance parameters for all packets and for each of the 3 special packet sizes. Present the average packet loss results in one figure and the average packet delay results in another figure. Justify these results and draw all relevant conclusions.

**1.i.** **(Evaluation weight: 5%)** Repeat experiments of **1.h** but now considering $f$ = 10.000 Bytes. Justify these results and draw all relevant conclusions. Justify also the differences between these results and the results of **1.h**.

**1.j.** **(Evaluation weight: 10%)** Justify the differences between the simulation results obtained with *Simulator1A* (in **1.d** and **1.f**) and *Simulator1B* (in **1.h** and **1.i**).

## Task 2

Consider the event driven simulator *Simulator3* developed in Task 7 of the Practical Guide. Like before, compute always the requested simulation results based in 50 runs of the requested simulator with a stopping criterion of $P$ = 100.000 each run. Then, present the estimated values in bar charts and the 90% confidence intervals in error bars on the same plot.

**2.a.** **(Evaluation weight: 5%)** Develop a new version of *Simulator3*, named *Simulator3A*, with the same output performance parameters of *Simulator3,* considering that the link introduces a bit error rate given by $b$ (which should be added as a new input parameter). Include in the report the developed MATLAB function of *Simulator1B* highlighting and justifying the changes introduced.

**2.b.** **(Evaluation weight: 5%)** Consider the cases $C$ = 10 Mbps, $f$ = 1.000.000 Bytes and $\lambda$ = 1500 pps, $b = 10^{-5}$ and $n$ = 10, 20, 30 and 40 VoIP flows. For each case and using *Simulator3A*, estimate by simulation the average packet loss of each service (data and VoIP). Present the simulation results of data service in one figure and of VoIP service in another figure. Justify these results and draw all relevant conclusions.

**2.c.** **(Evaluation weight: 5%)** For each of the cases defined in **2.b** and using *Simulator3A*, estimate by simulation the average packet delay of each service (data and VoIP). Present the simulation results of data service in one figure and of VoIP service in another figure. Justify these results and draw all relevant conclusions.

**2.d.** **(Evaluation weight: 5%)** For each of the cases defined in **2.b** and using *Simulator3A*, estimate by simulation the total throughput of the link. Justify these results and draw all relevant conclusions.

**2.e.** **(Evaluation weight: 10%)** Develop a MATLAB script to determine the theoretical value of the total throughput for each of the cases defined in **2.b**. Include in the report the developed MATLAB code duly explained. Report the obtained results, compare them with the simulation results of experiments **2.d** and draw all possible conclusions.