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Department of Electrical, Electronic and Computer Engineering

ERP 420 - Practical 2
Priority Queuing and Queuing Management Systems v1.1

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Contents

1 Change log

- Section 3 — Added that, specifically, preemptive **non-resume** queuing should be implemented. (8 September 2019)
- Section 3.1 — Increased the page count to 15 pages. (8 September 2019)

2 Practical objective

The objective of this practical is to investigate priority queuing and to improve the student's understanding of queuing management systems (QMS). The first phase of this practical is to extend the M/M/1 simulator developed in the previous practical by adding priority queuing. The second phase is to develop and analyse a queuing scenario, and based on this scenario propose a QMS.

3 Extending M/M/1 simulator

Expand the M/M/1 simulator developed in Practical 1 by adding priority queuing. Two types of priority should be investigated: preemptive non-resume priority[1] (the current task is interrupted and starts its service afresh upon re-entering service) and non-preemptive priority (the current task is not interrupted). These do not have to be examined for multiple workloads and a link capacity of 1 Mbps can be used.

The system should support at least 2 levels of priority, i.e. high and low priority but feel free to investigate additional priority levels. Students will have to generate their own trace files and compare both the preemptive and the non-preemptive versions with one another, and also with the original (non-preemptive) simulator developed earlier. In addition to this, two trace files (one for low and one for high priority) will be provided and students will be expected to calculate relevant queuing parameters and include them in their final reports.

Each priority level should have its own arrival rate: λ_{low} and λ_{high}. Indicate in the report how the queue length and average waiting time changes for each priority type and examine several arrival rates per level. Discuss these and any other suitable performance metrics when comparing the original, preemptive and non-preemptive versions of the simulator. Remember that the arrival times for the high and low priority streams are independent, and that they should thus be generated separately.

3.1 Report Format

The report should be a clear and concise document that highlights the theoretical aspects of the system, as well as describing the actual implementation. Marks will be deducted for poor language or spelling errors. The EPR 400 report writing standards should be followed, figures and tables must be numbered with captions (use the built in LaTeX methods to achieve this).

The report should be no longer than **15** pages. You will lose 10 % if your report exceeds the page limit. Do not start new sections on the next page but rather below the previous section.

[1] All students are required to implement preemptive **non-resume** priority queuing and compare the results to both the original simulator and the non-preemptive priority queuing implementation. Optionally, students may also implement preemptive resume priority queuing and add it to their comparison or discussion.

3.2 Report Content

The report should include the following:

- The cover page must use the template provided under ERP 420 on ClickUP. This cover page must be signed and fully completed otherwise the assignment will not be graded or regarded as submitted.
- Introduction that describes the practical
- Background on priority queuing
- Details regarding the design and implementation of the modified M/M/1 simulator
- Results of the performance comparison
- Discussion
- Conclusion

Don't have a table of contents or a list of figures or tables

4 Queuing Scenario and Queuing Management System (QMS)

4.1 Overview

This practical also requires the development and analysis of a queuing scenario and a queuing management system. Each student must prepare a presentation proposing their chosen scenario and management system. After all three group members have given their presentations, the group will be informed which proposed scenario and QMS they should proceed with for practical 3.

The purpose of a QMS is to be applied to any scenario where customers/users/packets/patients are waiting to be serviced, it enables flow management and the optimisation of the system. Before a QMS is proposed a proper identification of a queuing scenario needs to be made. Here a scenario should be developed and modelled to ensure an environment exists in which the QMS can be implemented. The student is free to propose any queuing scenario they see fit, as long as, it fulfils the complexity requirements. This is the most important part of the design process since this will be the limiting factor of the proposed QMS. The better and more thorough the scenario model, the better a QMS can be implemented and evaluated. The queuing scenario will be the main focus of the proposal and should explain as much about various parameters and restrictions as possible.

4.2 Outcomes

This section will focus on specific outcomes that will be used to evaluate the system. Thus, ensure that these outcomes are thoroughly investigated and reported on.

4.2.1 Queuing System Requirements and Classification

The queuing system requirements and classification relates to the proposal and design of the queuing scenario. Here it is important to identify and model every aspect of a scenario that you think may be important to the queuing aspect of the system, i.e. what details will help or promote the implemented QMS and determine its success. Once again the complexity of the scenario model will determine the final mark since this determines the complexity of the entire system.

Note: Pay attention to modelling the scenario with real life aspects where relevant.

4.2.2 QMS Factors and Restrictions

These factors relate specifically to the QMS, and are what define the management structure. There are a number of factors and parameters to consider in the design, thoroughly analysing these will help ensure a complete design and the required level of complexity. Each of these factors will be listed later on under **Important Aspects**.

4.2.3 QMS Implementation on an FPGA

This is how the final design will be demonstrated. The design and implementation of the QMS system will be evaluated in practical 3, but some thought as to how the system will be implemented should be given in practical 2 as well. The focus should be to use any parts of the FPGA necessary to ensure that your design is practical and can be understood, and that it can physically be shown step by step.

4.2.4 Quality of Service (QoS) Analysis

The main concern here would be to measure and evaluate performance. These include factors such as:

- Error rates
- Throughput
- Transmission delay
- Availability
- etc.

QoS is not only the measure of performance, but also implements mechanisms that allow for control of certain parameters in the system, such as throughput or prioritising. These factors and mechanisms will be dependant on the selected scenario.

4.3 Important Aspects

There are important aspects that are key during the design of the QMS, the listed and discussed aspects should be considered and used in your design. This will provide you with some guidance as to what you are expected to focus on.

Note: You are not limited to these design aspects, and any extra or outside the box thinking is encouraged.

4.3.1 System Requirements and Classification

To create a better understanding of queuing systems (scenario) it is required that the characteristics affecting performance are analysed and understood. Once the characteristics making up the queuing scenario are broken down and understood they can be used to model and classify the system. The classification relates to queuing theory and model parameters such as,

- Arrival process
- Service process
- Number of servers
- A/S/n models

Remember there are various models that can be utilised and will depend on the proposed scenario, a characteristic such as the number of queues is just one of the things that will influence this model selection.

4.3.2 Design Factors

There are several important design factors that should be focused on, it is required that the student spends some time understanding each of these factors, as well as, various possibilities for each of these factors; in order to make the best possible decision for the design of the proposed system.

1. Arrival process
    - Inter-arrival time
    - Group arrival
2. Service process
3. Number of servers
4. Number of queues
5. Number of waiting places (queuing areas)
6. Service disciplines
    - FIFO
    - LIFO
    - Shortest job first
    - Most profitable job first
    - Round Robin (RR)
    - Processor Sharing
    - Priorities
7. Information available
    - Upon choice of queue does customer know length of queue and service time?
8. Discrete / Continuous time
9. Other factors
    - Faults / Malfunctions
    - Strikes
    - Real life events affecting the system

4.3.3 Design Parameters

The parameters used in the analysis of the system queues are as follows:

- Service Discipline
- Number of servers
- Peak time (days/months/year)
- Queuing area
- Average service time
- Average waiting time
- Average time between arrivals
- Arrival rate
- Service rate
- Mean time for customers to wait and be served
- Efficiency (performance factor)

Each of the aforementioned parameters are crucial in both the design and analysis of the proposed QMS model. One of the most important characteristics of the QMS is **service discipline**, this has a direct influence on the entire design and are also closely related to the systems complexity level. It is encouraged that students read literature on these to ensure all possible approaches are covered, allowing for the relevant schemes to be selected.

Ensure that these parameters are used and evaluated in your design, any other parameters that could better the evaluation of your system are also welcome.

5 Proposal presentation

Each student should prepare a 7 minute presentation detailing their proposed queuing scenario and QMS. There will be time slots allocated for these presentations, and it is important that you stick to the time allocation. Please book the time slots individually, but ensure that group members book directly after one other. The aim of the presentations is to practice your presentation skills and to allow for immediate feedback on your proposal. After the entire group has presented their proposals, the AL will indicate which proposal should be implemented in Practical 3.

The presentation allows for the student to come up with a scenario and QMS that they would like to design and implement, as opposed to using a given scenario and QMS approach. The proposal should thoroughly explain what the intentions for Practical 3 are, including details on the selected queuing scenario and QMS. Students are encouraged to make use of the parameters and factors explained above to give a complete description of the problem and proposed solution. The presentation should contain certain key aspects such as:

- Scenario description
- System requirements and classification
- QMS Approach

  - Design Factors
  - Design Parameters
- QoS
- How will the system be implemented on the FPGA?

6 Additional Information

6.1 Submission Dates

1. Report on M/M/1 simulator
   - 20 September 2019, before 23h59.
2. Proposal presentation
   - 20 September 2019.

Failing to book a demo slot before the booking closes (exact time will be indicated using ClickUP) will result in a re-demonstration of the presentation (max 50 %). Failing to demo in your booked time slot will result in a re-demonstration of the presentation (max 50 %).

6.2 Report

Everyone is required to submit 2 soft copies of the practical report and their source code: one on ClickUp and one on the EPS (`https://eps.ee.up.ac.za/`).

Please upload a single PDF that contains your practical report, as well as your source code as an appendix, to TurnItIn (done through ClickUP). ***DO NOT*** *include the cover page/plagiarism statement in this submission.*

Please upload your report (with the cover page/plagiarism statement), and the relevant code files as an appendix, to the EPS.

Both submissions need to take place before **Friday, 20 September 2019 at 23h59**.

It is the responsibility of each student to ensure that both submissions are successful (make sure you receive both TurnItIn and EPS email receipts as proof of submission). If the student only submits on a single platform (TurnItIn or EPS), it will be treated as a non-submission.

Please feel free to email me at *up.erp420@gmail.com* if you have any questions.