NOVA SCHOOL OF SCIENCE & TECHNOLOGY

Departamento de Engenharia Electrotécnica e de Computadores

Secção de Robótica e Manufactura Integrada

Description of Lab Work nº 3	
Course	**Real-Time systems / *Sistemas de Tempo Real***
Year	2024/2025
Aim	Development of real-time applications using graphical languages
Classes	2 classes x 3 hours + 6 extra hours (outside classes)
Delivery Date	**10/12/2024**

Concrete Objectives:

1. Utilization of graphical languages to model real-time systems
   a. Modeling of concurrent/simultaneous behaviors
   b. Modeling with Petri Nets

2. Application of PN modeling in a real problem.

3. Implement the real problem requirements.

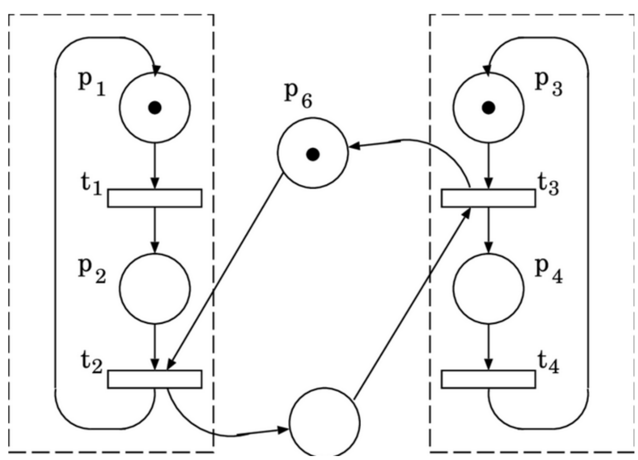
4. Fill in a questionnaire and submit the work (according to the procedures) in Moodle.

Annex 1 – Description of Work

This work aims to solve problems with real-time constraints using modeling approaches based on graphical languages, namely, Petri Nets (PN) diagrams. This work is composed of two parts, namely:

1. Model and simulate PNs of several types, learn their behavior, and recognize fundamental properties (as provided in theoretical lessons).
2. Apply the PN modeling framework in the solution of a real problem.

An example of a Petri net is shown in Figure 1:



From: https://www.researchgate.net/figure/The-producer-consumer-problem-with-finite-buffer_fig5_2830405

Figure 1 – Example of a Petri Net

1st Part - Use the HPSim tool for modeling PN and study their properties

In the first part of this work, we have the opportunity to simulate the behavior of Petri-Nets during their life cycle using HPSim software (Figure 1). After starting a simulation, we can visualize the enabling and firing of a PN' transitions and the tokens in each place. The work comprises modeling distinct PN types, exhibiting fundamental PN properties (conservative, secure, etc.).

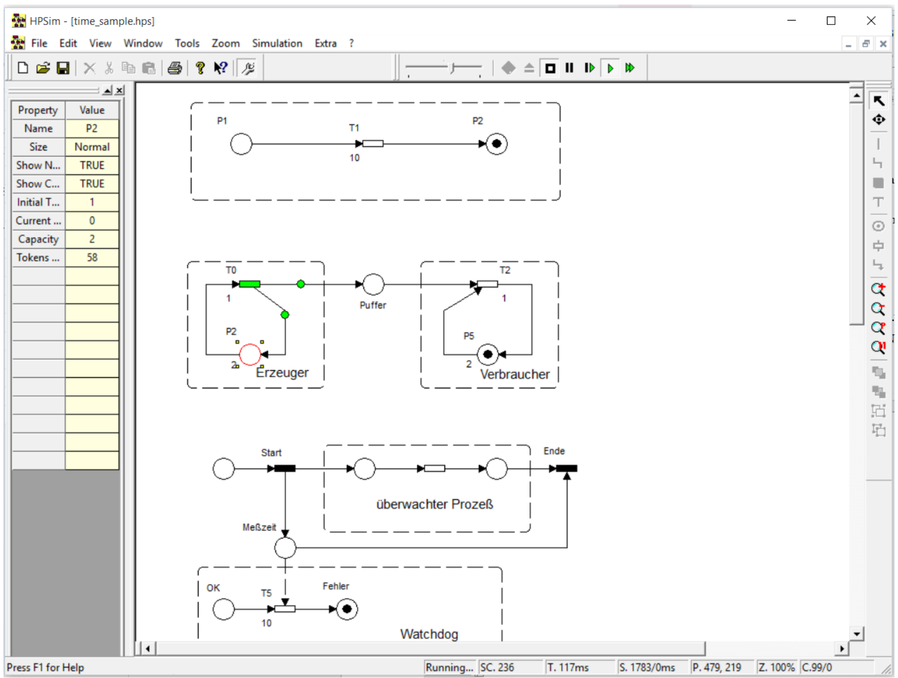


Figure 2 – The HPSim simulation tool.

2nd Part – Control a fruit Splitter

The lab work problem consists of designing a PN model and implementing a program to control the distribution of fruit to three conveyors, illustrated in Figure 2.

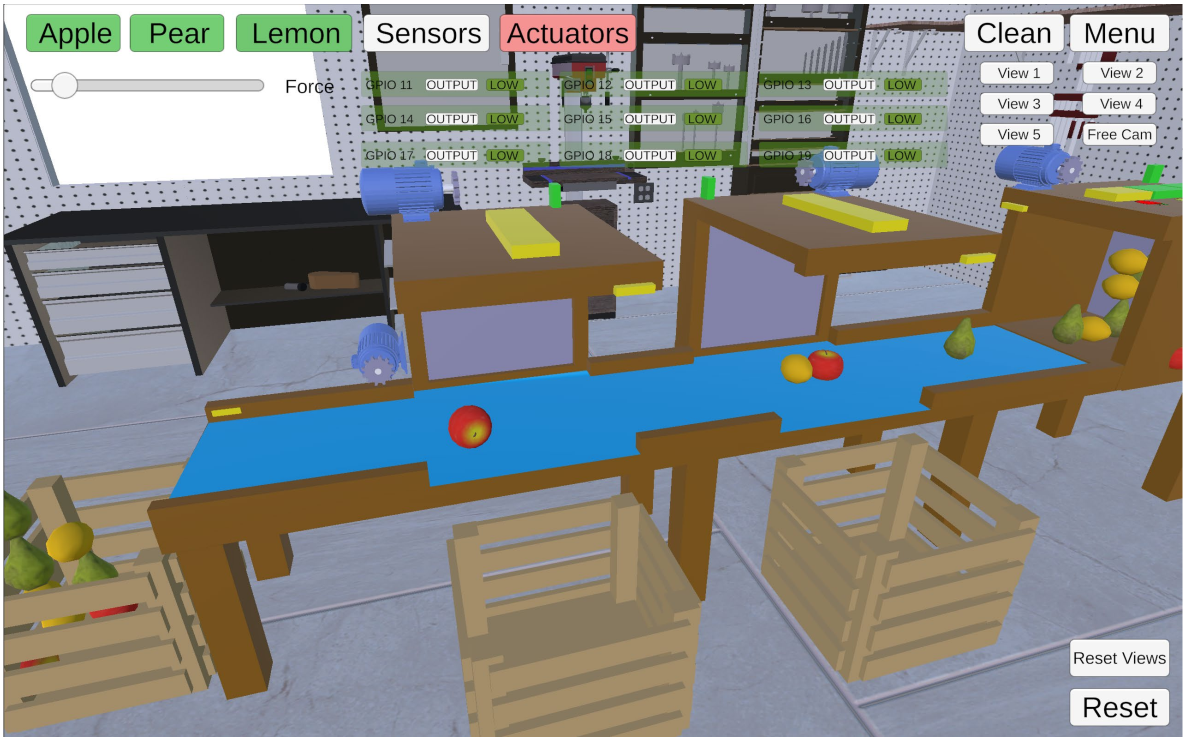
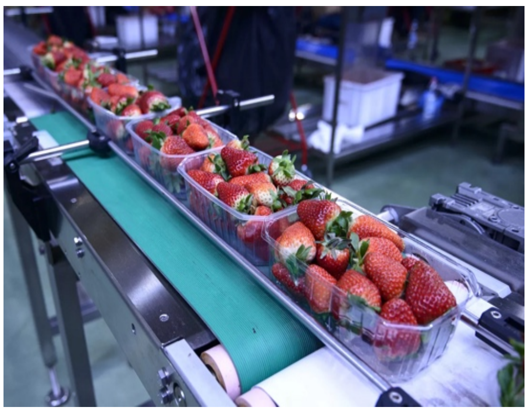


Figure 3 – The fruit splitter station kit.

The execution of this work should be subject to the following steps:

- Study the requirements of the problem (partially defined below).
- Model the problem into a Petri net diagram.

"Intra-logistics and optimisation problems are main topics in the agro-industry sector. This type of industry requires the constant movement of materials, but especially products, whether individual products (conveyor belts for eggs, fruit, legumes, etc.) or packaging with production batches (baskets or boxes with several units)."



Internal transport can be carried out in various ways, including the manual method (more traditional), using forklifts (also operated by human operators), or automatic conveyor belts, the latter being the most efficient method. Although the conveyor belt is the most efficient way to transport the product through the various stages of the process, implementing it requires synchronization with the other elements of the process, such as other machines or operators who add the product to the conveyor, those who modify the product (washing, adding labels, inspecting them, etc.), among others.

In this way, this work focuses on implementing a conveyor belt for transporting products (fruits) from one point of the factory and sorting them into specific boxes (boxes with only apples and boxes with only pears, among others). The fruit is added at the beginning of the conveyor belt, and it takes it to the point in the system where the box must be placed is located. When the fruit arrives at this part of the system, a piece of the machine moves forward, pushing the product into the respective box as shown in the figures.

The requirements that must be considered during these two parts are in the table below.

	Items
	1st Part
Functionality	R1 - Model and simulate a secure PN
	R2 - Model and simulate a conservative PN
	R2 - Model and simulate a PN with capacity places and weighted arcs
	R3 - Model and simulate a PN which starts working and enters in a deadlock state after a few iterations
	2nd Part
	R4 – Split apples to the first box
	R5 – Split pears to the second box
	R6 – Split Lemons to the third box
	R7 - Emergency stop and resume
	R8 - The UI terminal (in the python module) must provide functionality for knowing the current number of fruits in each box (pressing key “x”). It must also provide the total of boxes filled for each fruit (pressing key “y”).
	R9 - Describe your lab work in the report (STR_TP3_Report).
	R10 - Identify, from previous experiments, the different characteristics of your proposed PN for your lab work (Example, list from slide 14, STR_Lab3_1) and describe it in the report (STR_TP3_Report).
Video	
	TOTAL

<u>Classes plan for the Lab Work 3</u>

Class 1:

Introduction to *HPSim* (1st part) for training with Petri nets; Start developing the lab work (2nd part). Creation of DLL and its utilization in *HPSim* (modified version).

Class 2:

Finish developing the lab work (2nd part). Control of the fruit splitter station according to the requirements table.

Professors:

– Luis Camarinha-Matos,	cam@uninova.pt	(theoretical classes)
– Ana Inês Oliveira,	aio@fct.unl.pt	(laboratory classes)
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– Francisco Marques	fam@uninova.pt	(laboratory classes)
– Joao Rosas	p187@fct.unl.pt	(laboratory classes)

Lab work 3 submission & delivery date:

- The lab work must be submitted **only** through **Moodle** until **10.12.2024 – 23h:59m**.
- The work is submitted in **zip format**, the zip name should have the student numbers of each group member separated by '_', e.g.: 50234_51345_51734_50599.zip. The zip file must contain:
  - Report.
  - the *project*.
- It must also be filled in the **questionary** available in Moodle. In this questionnaire it is requested to submit a small video (3-5 minutes) showing the work in operation.
- The project *zip* file, the questionnaire and the video are **mandatory** components of evaluation.

Evaluation criteria

It is provided (as a guiding object) a table with the project evaluation criteria. Each item will be quoted according to the approach and quality of the generated code.

Items		Quotation
Functionality	R1 - Model and simulate a secure PN	0.50
	R2 - Model and simulate a conservative PN	0.50
	R2 - Model and simulate a PN with capacity places and weighted arcs	1.00
	R3 - Model and simulate a PN which starts working and enters in a deadlock state after a few iterations	1.00
	R4 – Split apples to the first box	2.50
	R5 – Split pears to the second box	2.50
	R6 – Split Lemons to the third box	2.50
	R7 - Emergency stop and resume	2.50
	R8 - The UI terminal (in the python module) must provide functionality for knowing the current number of fruits in each box (pressing key "x"). It must also provide the total of boxes filled for each fruit (pressing key "y").	2.00
	R9 - Describe your lab work in the report (STR_TP3_Report).	2.00
Video		3.00
	TOTAL	**20**