BUSI 2710

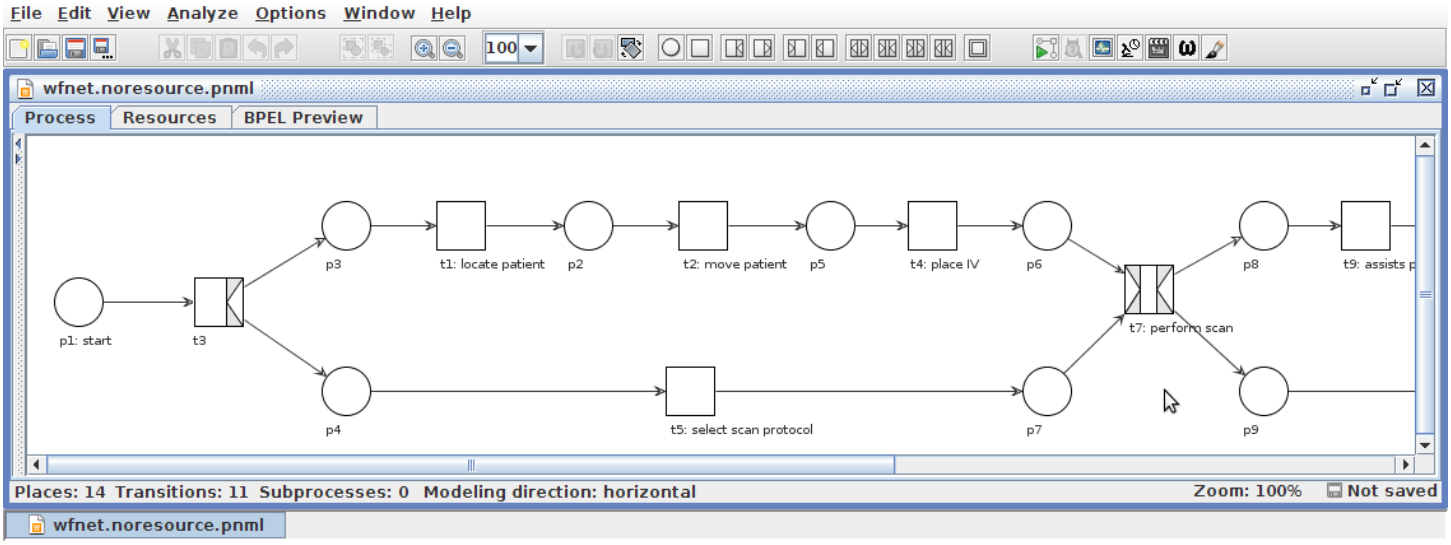
Computer Lab Exercises: Process Simulation with WoPeD

Class 20

Reading: Harvard Business School Case KEL592: “Body Scans and Bottlenecks: Optimizing Hospital CT Process Flows” by Sunil Chopra, Scott Flamm, and Sachin Waikar.

Exercise 1 (Process Model)

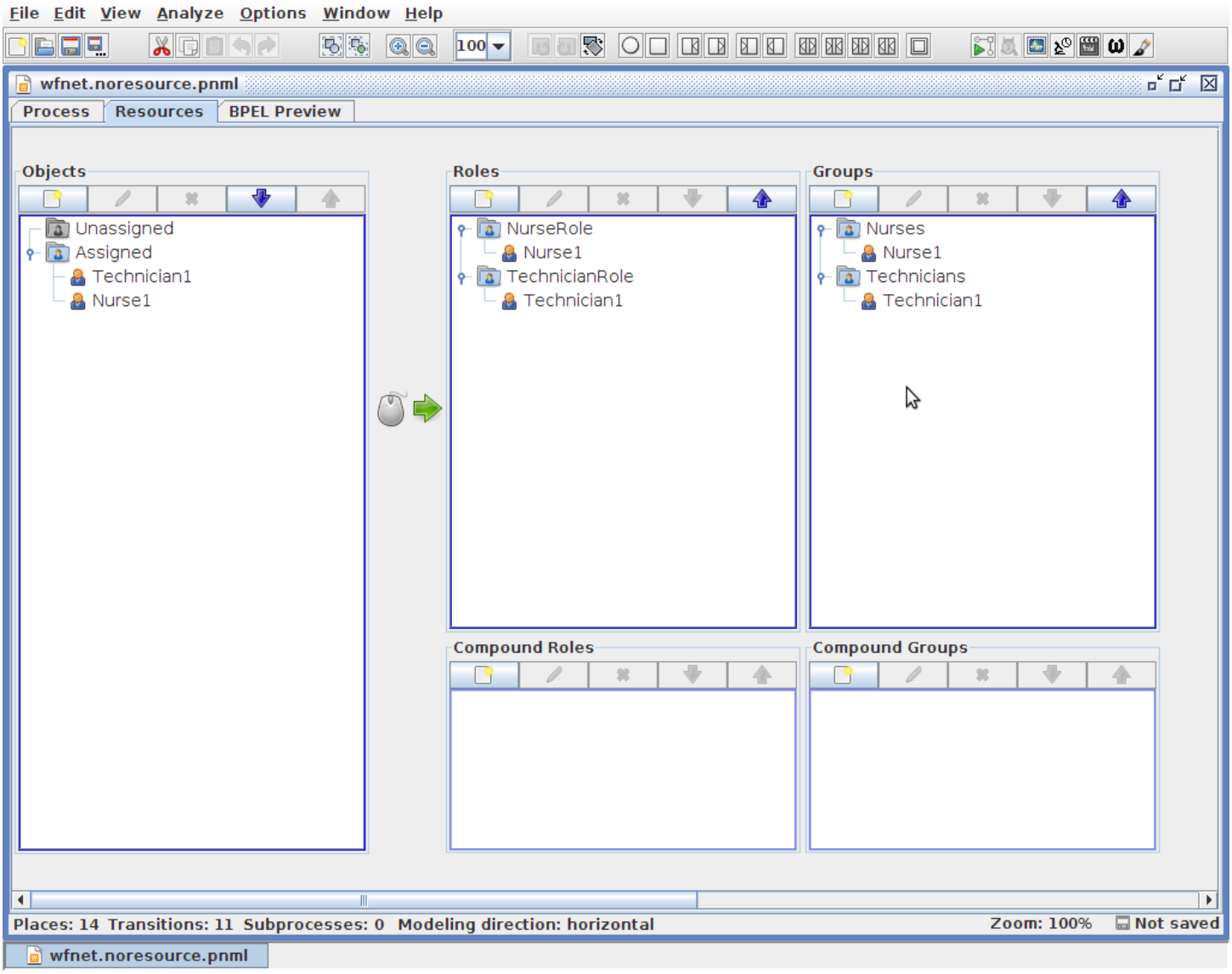
Using the description of the process steps in the case on page 2, draw a process model as a Workflow net using the WoPeD software



Exercise 2 (Resources)

Swith to the resources tab of your WoPeD model

You need to add roles as well as groups for the technician and the nurse in WoPed. You also need to create at least one technician and one nurse object and assign them to the corresponding roles and groups. You can assign objects to roles and groups by “drag-and-drop”. The end result should look like the following:

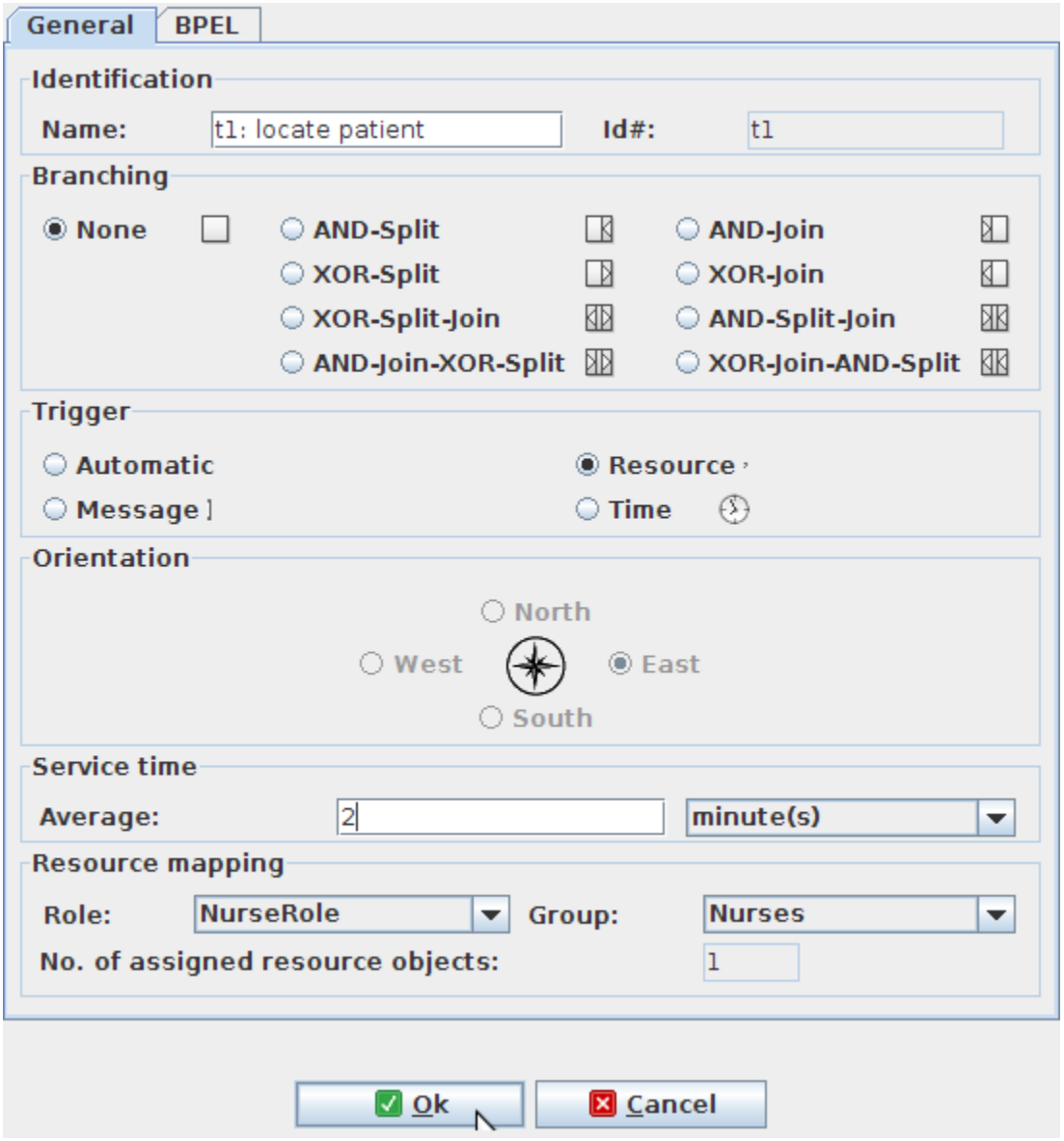


Exercise 3 (Resource Usage)

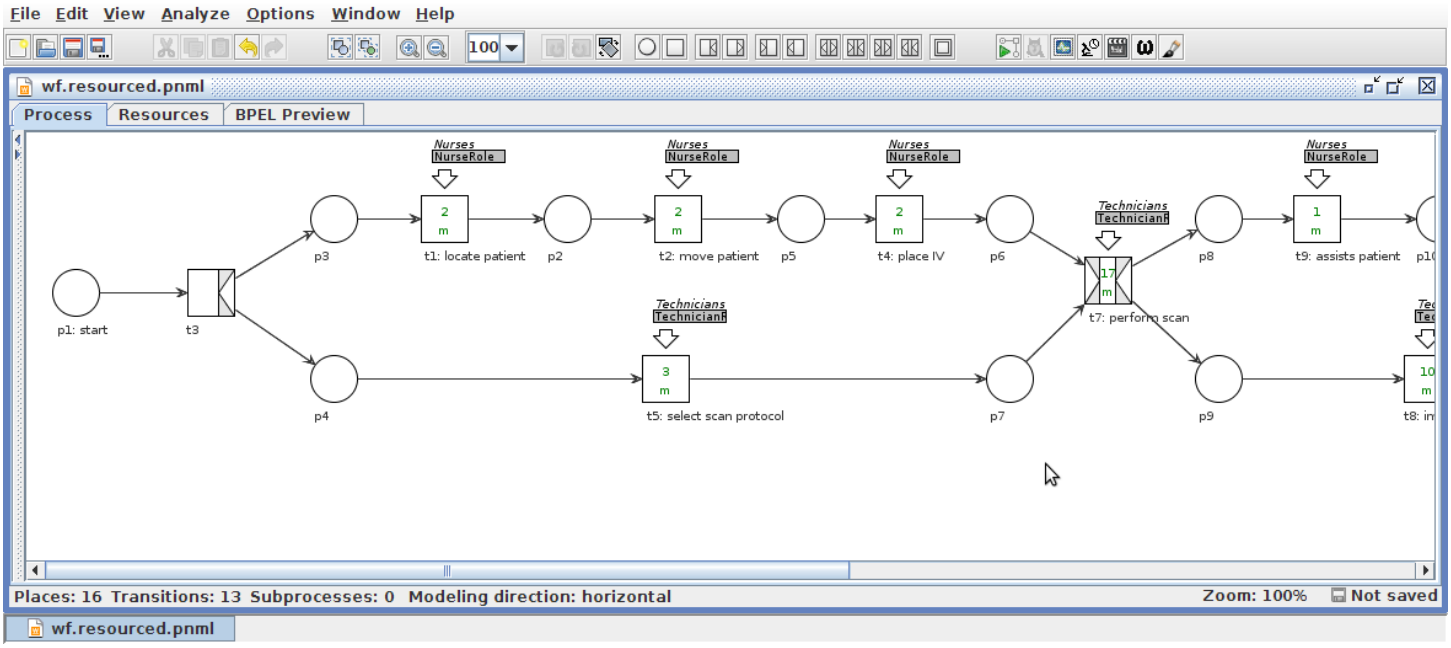
Switch back to the process tab in WoPed. For each transition that represents a task to be carried out by either the nurse or the technician, right click, and select “Properties”. Do the following:

- Select “Resource” for trigger. This means that the transition fires when it is enabled and a resource is available.
- Specify the average service time. See the case description (page 2) for these
- Specify both the role and group from which the resource is to be assigned.

The screenshot below shows an example:

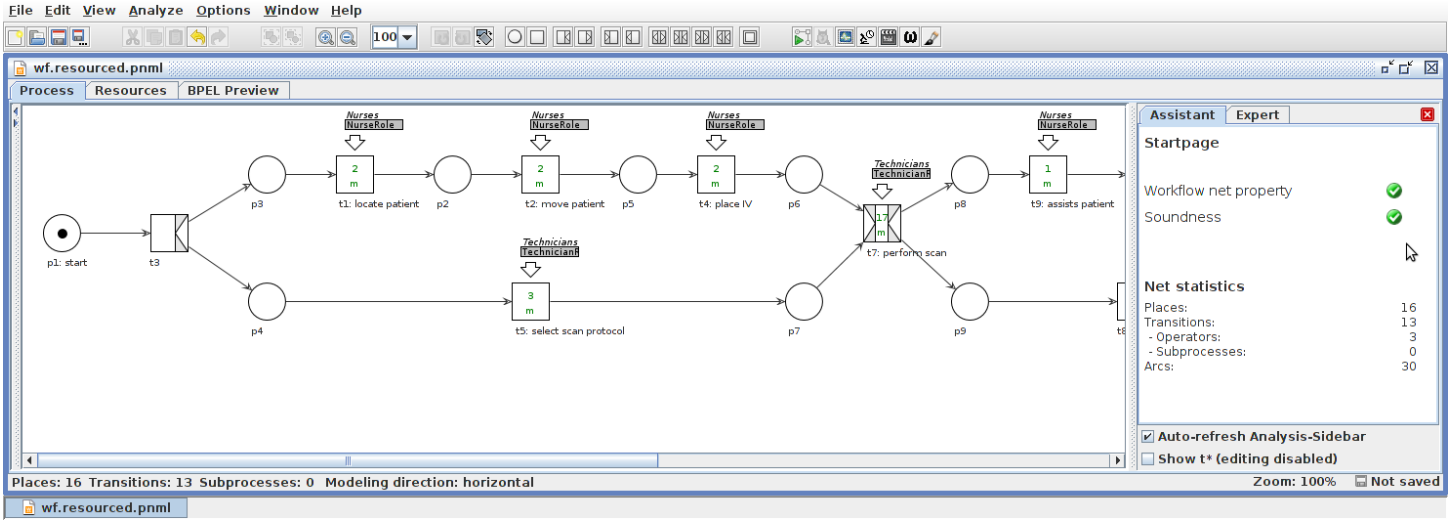


Once you are done assigning resource usages to all relevant transitions, you process model will look similar to the one below:



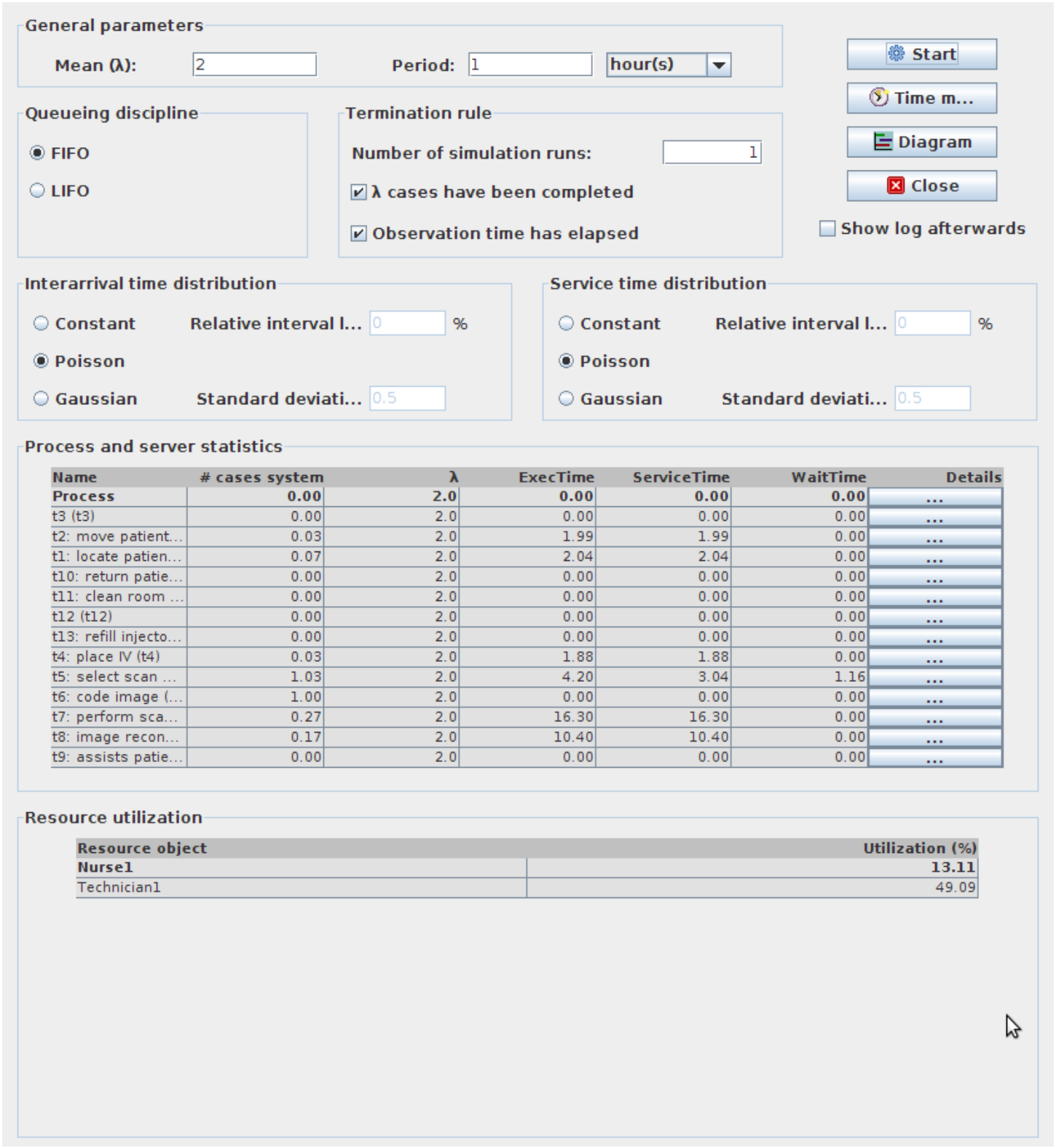
Exercise 4 (Model Verification)

Place a single token on the initial/start place and verify the correctness of your model using the “Semantic Verification” feature. You should have a sound workflow net, as indicated below. If you do not, use the information in the “Assistant” or “Expert” tab to guide you to correct the model.



Exercise 5 (Quantitative Simulation)

Click on the button for “Quantiative Simulation”. You should see the following dialog screen:



Name	# cases system	λ	ExecTime	ServiceTime	WaitTime	Details
Process	**0.00**	**2.0**	**0.00**	**0.00**	**0.00**	...
t3 (t3)	0.00	2.0	0.00	0.00	0.00	...
t2: move patient...	0.03	2.0	1.99	1.99	0.00	...
t1: locate patien...	0.07	2.0	2.04	2.04	0.00	...
t10: return patie...	0.00	2.0	0.00	0.00	0.00	...
t11: clean room ...	0.00	2.0	0.00	0.00	0.00	...
t12 (t12)	0.00	2.0	0.00	0.00	0.00	...
t13: refill injecto...	0.00	2.0	0.00	0.00	0.00	...
t4: place IV (t4)	0.03	2.0	1.88	1.88	0.00	...
t5: select scan ...	1.03	2.0	4.20	3.04	1.16	...
t6: code image (...	1.00	2.0	0.00	0.00	0.00	...
t7: perform sca...	0.27	2.0	16.30	16.30	0.00	...
t8: image recon...	0.17	2.0	10.40	10.40	0.00	...
t9: assists patie...	0.00	2.0	0.00	0.00	0.00	...

Resource object	Utilization (%)
Nurse1	**13.11**
Technician1	49.09

In the “General Parameters” section, the “Mean” value is the average number of cases per simulation period. The duration of the simulation period can be set in the “Period” field. To begin, we will keep the simulation simple and **set the “Mean” to 1** and **set the Period to 1 hour**.

In the “Queuing discipline” section, you can set how the different cases that “wait” at a place are selected when the transition fires next. FIFO means “first in, first out”, i.e. they are worked on in the order in which they arrive. LIFO means “last in, first out”, i.e. the latest arrival is selected first.

In the “Termination rule” setting, you can determine how many simulation runs you wish to make. This is important because the arrival time of cases to the process, as well as the service time for the transitions may be probabilistic, rather than constant. To begin, we will keep the simulation simple and **set the number of simulation runs to 1, untick the box “lambda cases have been completed” and tick the box “observation time has elapsed”**

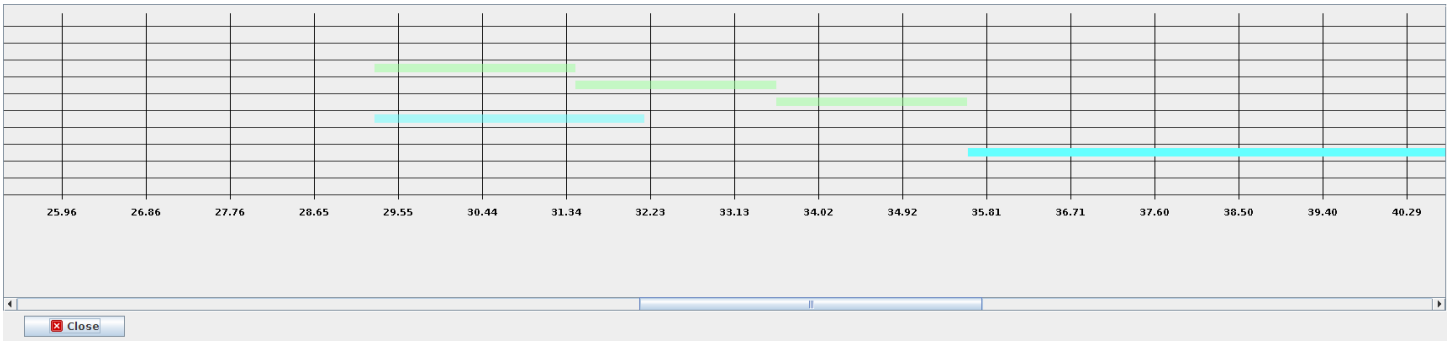
In the “Interarrival time distribution” you can select the time between the arrival of cases. You can either make this constant, or probabilistic. A constant interarrival time is unrealistic, and a common assumption is that of a Poisson-distributed interarrival time.

In the “Service time distribution” you can select how the time that a transition takes is calculated, based on the timing information you have provided for each transition. Again, a constant service time is unrealistic, and a common assumption is that of a Poisson-distributed service time.

When you **click the “Start” button**, a dialog box about the progress of the simulation will briefly appear. Once the simulation is done, the sections “Process and server statistics” and “Resource utilization” have the results fo the simulation.

Exercise 6 (Evaluating the Simulation Results)

Select the “Diagram” button to show a diagram of when each transition was active throughout the one hour period we examined. Notice that the resources involved are colour-coded in different colours.



Depending on the arrival time of the cases, it may be the case that neither of the two cases has been completed yet. For example, the first case may have arrived only after about a half hour and the second case later still.

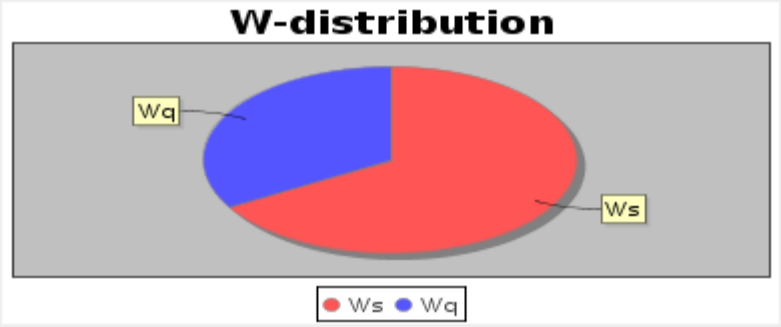
The service time shown in the table “Process and server statistics” is the *average* time duration for with that transition was actively serving a case. The wait time is the *average* time during which a case had to wait for resources for this transition. The execution time is always the sum of service and wait time. Note that the service times are not exactly as you specified them, but will only be so *on average*.

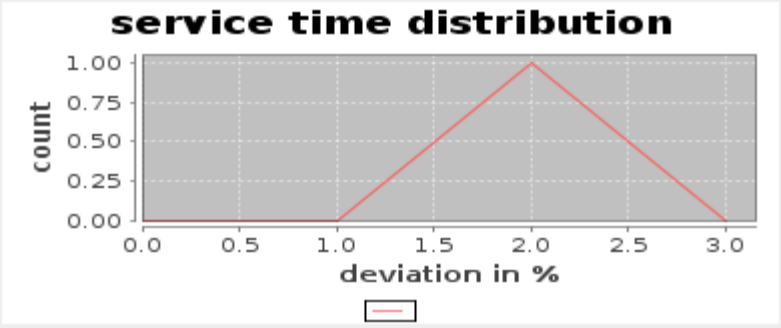
The resource resource utilization table provides the resource utilization for the resources over the entire simulation period. This may be relatively low in the first case, where we only had one or two cases for the one hour period.

Exercise 7 (Increasing Simulation Complexity)

For the next simulation, **increase the "Mean" setting to 5** (i.e. 5 cases per hour are now arriving), click "Start" and, after the simulation finished, click the "Details" button in the table "Process and server statistics" fro the "perform scan" transition. Yours may look like the one below, although your values will likely differ.

Number of zero delays	1.00
Number of calls	2.00
Number of cases service began	2.00
Number of cases service finished	1.00
Max. length of queue	2.00
Max. number of parallel cases	1.00
Max. wait time of cases	8.80
Number served cases when simulation stopped	1.00
Number waiting cases when simulation stopped	0.00





The first figure is the number of cases for which there was no delay or wait for this activity. In a good process design, this should be high.

The next figure is the total number of cases for which this activity was carried out. In my case, even though 3 cases have begun the overall process, only two had made it to this activity before the simulation ended.

The next figure is the number of cases that this transition had begun servicing, followed by the number of cases that were finished before the simulation ended.

The maximum length of the queue is the maximum number of cases waiting for service for this activity over the simulation duration.

The maximum number of parallel cases is necesarily 1, as we have only provided a single technician, i.e. we cannot perform two scans at the same time, as we never have the required resources.

The maximum wait time for a case for this activity in minutes should be very low for a good process design with adequate capacities.

The pie chart shows you graphically the proportion of waiting and service time, while the service time distribution chart shows you how the service time varied for how many cases.

Exercise 8 (Scenario Analysis)

Now that you know what the output of the simulation means, you should be able to do various experiments, similar to the scenarios we examined for this case in the earlier class:

- Implement a new scanner, for which the scanning only takes 2.5 minutes on average, the image reconstruction only takes 2 minutes on average, and the preparation time is 1 minute.
- Shorten some of the tasks for the nurse
- Move some of the tasks from the nurse to the technician
- Add a second nurse: For this, you will need to create another “nurse object” in the resources tab and assign it to the nurse role and nurse group.

How do utilization, wait times, and service times change with each of these scenarios?