A Very Simple Discrete-Event Simulation (using AnyLogic)

MIT Center for Transportation & Logistics

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Problem: Boarding Pass Kiosks at Logan

Emaití Airlines wants to install several automated kiosks at Logan Airport, for passengers to print their boarding passes.

Passengers are expected to arrive at a rate of 30 per hour.

The area has capacity for about sixteen passengers to wait in line for a kiosk to become available.

Once at the kiosk, it takes the passengers on average 5 minutes to print their boarding pass, with minimum of half a minute and maximum of 15 minutes.

The kiosks are rather expensive, and come in pairs, so they must be installed in multiples of two.

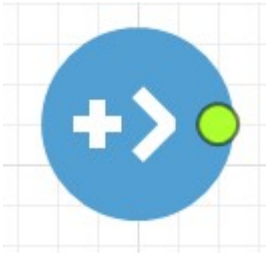
If they want their passengers to wait in queue on average less than 1 minute, how many kiosks should Emaití install?

01 - Create a new model

- Open AnyLogic in your computer
- Click on “Create a model” or on New > Model
- Select the location of the model in your computer
- Give the model a name
- Specify the time unit for the model: *minutes*, in our case

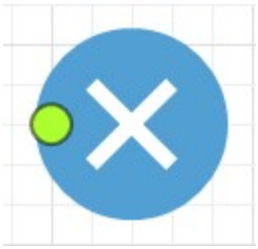
02 – Create a **Source** for passengers

- We want to simulate passengers arriving to use the kiosks at a rate of 30 passengers per hour.
- In the Palette, select the “Process Modeling Library”, and look for the **Source** icon.
- Drag the source into the **Main** area.
- Go into Properties, and rename the source ‘FrontDoor’ or some other name that you want.
- Specify that arrivals are defined by **Rate**, with an arrival rate of **30 per hour**.



03 – Create a **Sink** for passengers to exit

- We want to simulate passengers leaving to go to the boarding gates when they are done using the kiosks.
- In the Palette, in the Process Modeling Library, look for the **Sink** icon. Drag the sink into the **Main** area.
- Rename the sink ‘ToGates’ or some other name.
- Connect the source and the sink with a connector: double click the green dot on the source and then click the green dot on the sink.



04 – Specify the length of the simulation

We want the simulation to run for as long as we can get it to run, as fast as we can get it to run. AnyLogic's personal learning edition allows us to have up to 50 thousand 'agents', so we will not be able to run the simulation beyond 100 thousand minutes given the arrival rate of 30 per hour.

- Click on the **Projects** tab.
- Click on Simulation: Main.
- In **Execution mode**, specify "Virtual time"
- In **Stop**, select "Stop at specified time"
- In **Stop time**, type 90000 (this will give us 90K minutes)

05 – Run the model

- Click on the green play icon (**Run**)
- Click on the **Run** button.
- Wait for the simulation to run.

You should see that:

- ~45 thousand passengers entered through the source
- The exact same number of passengers exited via the sink

What is the distribution at the source?

- When we created the source, we stated that arrivals were *defined by rate*, with an arrival rate of 30 per hour. This means that, on average, there are 30/60 = 0.5 arrivals per minute.
- However, this does not mean that the arrivals occur as clockwork, one every two minutes. While keeping the arrivals at an average of 30 per hour, the software simulates a variability in the time between arrivals.
- This 'inter-arrival time' is randomly chosen using a probability distribution known as the **exponential** distribution, with an average of 2 minutes between arrivals (or 1/30 hours between arrivals).

Experiment #1: Redefine the source

- For you to experience first hand the validity of this, let's redefine the source in terms of the inter-arrival time.
- Go to Main, and click on the Source.
- Go to Properties, and change the arrival rate to:

0.5

…and change the units to minutes. This specifies that the source should have, on average, 0.5 arrivals per minute, which is the same as 30 arrivals per hour, since 30/60=0.5

- Run the model. Compare the result to the one before. Notice that the number of passengers is the same.

Experiment #2: Redefine the source

- Now, redefine the source in terms of inter-arrival time.
- Go to Main, and click on the Source.
- Go to Properties, and change the way the arrivals are defined. Instead of Rate, select “Interarrival time”.
- As the value for the Interarrival time, type:

exponential(0.5)

…and change the units to minutes. This specifies that the source has on average 0.5 arrivals per minute, with an exponential distribution.

- Run the model. Compare the result to the one before. Notice that the number of passengers is the same.

06 – Create a **Delay** for kiosk use

- In our discrete-event simulation, using the kiosk is included as a delay before passengers can proceed.
- In the Palette, in the Process Modeling Library, look for the **Delay** icon. Drag the delay into the **Main** area, at some point between the source and the sink.
- Rename the delay 'UseKiosk' or some other name.
- Define the delay time using a triangular distribution:

  triangular(0.5, 5, 15)

- …in minutes.

06 – Create a **Delay** (continued)

- The **capacity** of the delay tells us how many people can use the kiosks at the same time.
- For now, let's make this value equal to 10, to specify that we want to allow up to ten people using the kiosks at the same time. For now, this is the same as saying that we have ten kiosks available. This value will change, as we try different number of kiosks in the solution.
- Specify a capacity of:

10

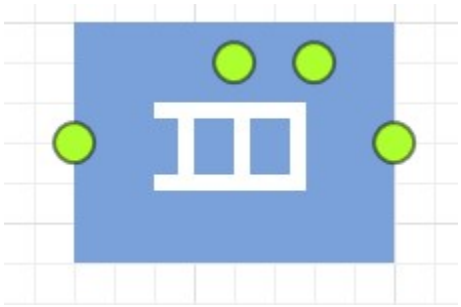
Experiment #3: Are we there yet?

- What would happen if you tried to run the model now?

07 – Create a **Queue** for waiting

- The passengers need a space to wait until the kiosk is available for them to use. This is called a queue.
- In the Palette, in the Process Modeling Library, look for the **Queue** icon. Drag the queue into the **Main** area, at some point between the source and the delay.
- Rename the queue ‘KioskLine’ or some other name.
- Define the queue capacity as:

16



08 – Run the model

- Click on the green play icon (**Run**)
- Click on the **Run** button.
- Wait for the simulation to run.

You should see that:

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- The exact same number of passengers exited via the sink

09 – Let's measure time in the queue

- We want to know how long people wait in the queue. For this, we will use time measure start and end markers.
- In the Palette, in the Process Modeling Library, look for the **Time Measure Start** icon.
- Drag it into the **Main** area, at some point between the source and the queue.
- Rename it 'stk' (for 'start time kiosk') or anything else you want..

09 – Let's measure time (continued)

- In the Palette, in the Process Modeling Library, look for the **Time Measure End** icon.
- Drag it into the **Main** area, at some point between the queue and the delay. Rename it 'etk' (for 'end time kiosk') or anything else you want.
- Click on this Time Measure End icon, and go to Properties.
- Specify stk as TimeMeasureStart blocks, by clicking on the plus sign.

10 – Run the model

- Click on the green play icon (**Run**)
- Click on the **Run** button.
- Wait for the simulation to run.

When the simulation is done:

- Click on the icon of the Time Measure End block (etk).
- A yellow window will open, that shows the minimum, average and maximum waits in the queue, among other information. Notice that the mean wait in the queue is around ~0.001 minutes. This is for the current capacity of 10 kiosks, and is really small.

Question: How many kiosks?

- Even though our model is still very primitive, it is good enough for us to answer the key question of the problem: how many kiosks should we install if we want the average waiting time to be less than 1 minute?
- Since the current average waiting time in the queue is much smaller than 1 minute, let's try with less kiosks. What if we had 8, 6, 4, or 2 kiosks? Change the capacity of the delay from 10 to these other values.
- For a capacity of 8, the mean wait in queue is ~0.02 min
- For a capacity of 6, the mean wait in queue is ~0.3 min
- For a capacity of 4, we get an error when we run. (Why?)
- The answer to the question is: We should install 6 kiosks.