Rayat Shikshan Sanstha's

KARMAVEER BHAURAO PATIL COLLEGE, VASHI

[Autonomous College]

Reaccredited by NAAC with Grade 'A+' (CGPA 3.53) | ISO 9001: 2008 Certified Institute

'Best College' Award by University of Mumbai

SIMULATION

Name :- Kisan Rajaram Pawar

Class :- MSC-cs (Part 2)

Sem :- 3rd

Roll No :- 25166009

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PRACTICAL NO: 01

Aim: Design and develop agent based model by

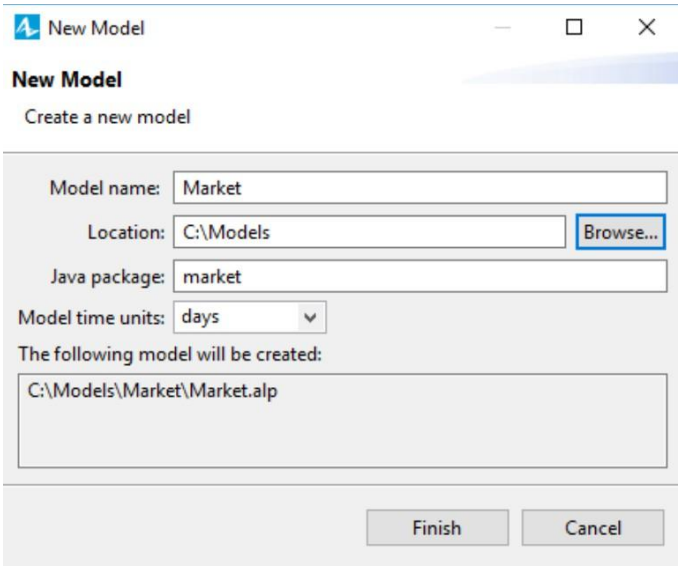
- Creating the agent population
- Defining the agent behavior
- Add a chart to visualize the model output.

[Use a case scenario like grocery store, telephone call centre etc for the purpose].

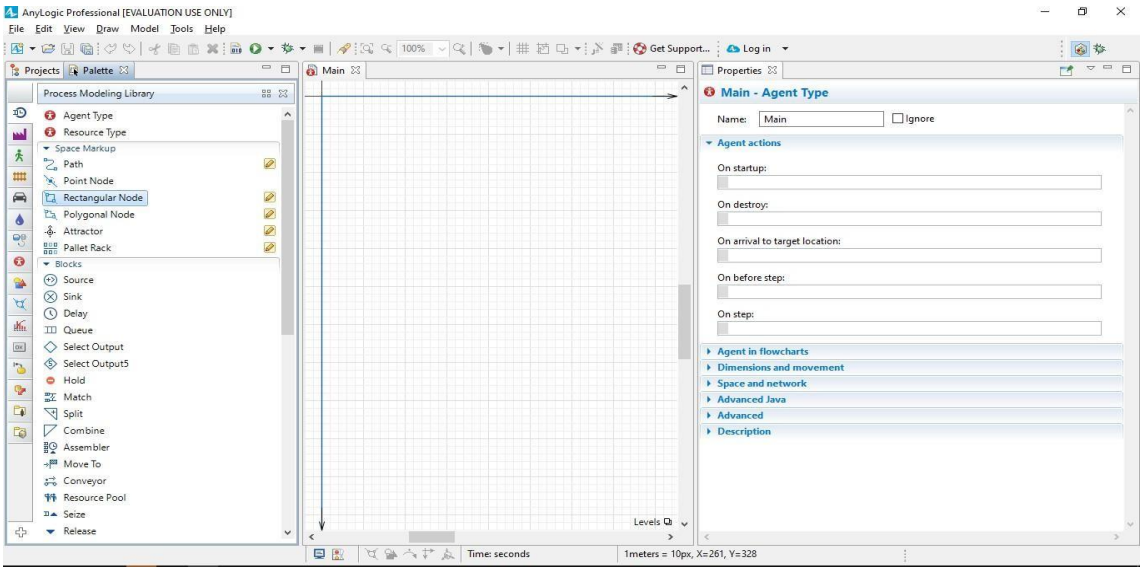
Code:

In the Model name box, enter the new model's name: Market.

In the Location box, select the folder where you want to create the model. You can browse for a folder by clicking Browse or type the name of the folder you want to create in the Location box.



Click to finish



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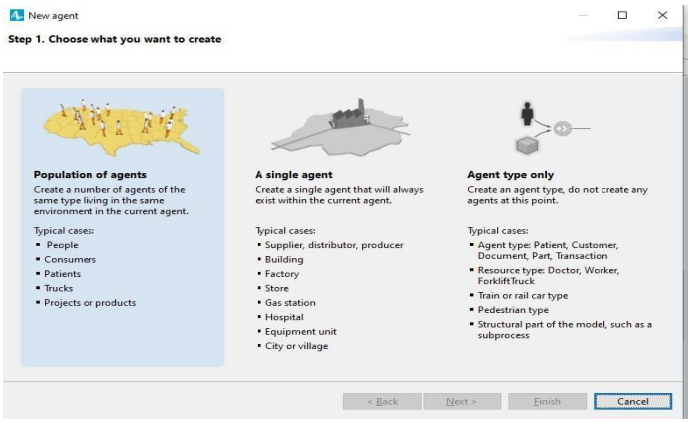
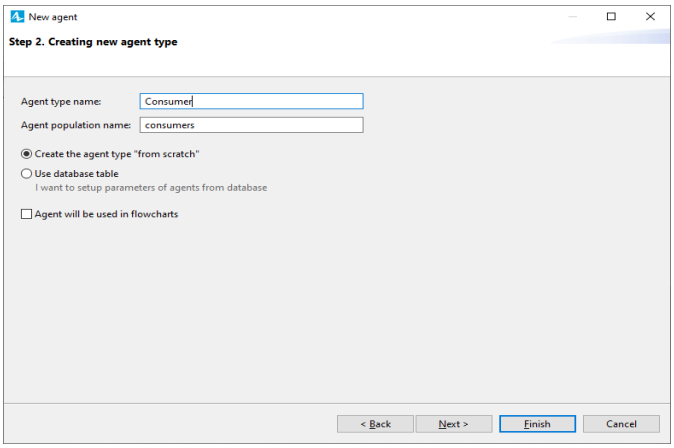
Drag the Agent from the Agent palette on to the Main diagram, and the New agent wizard will open.



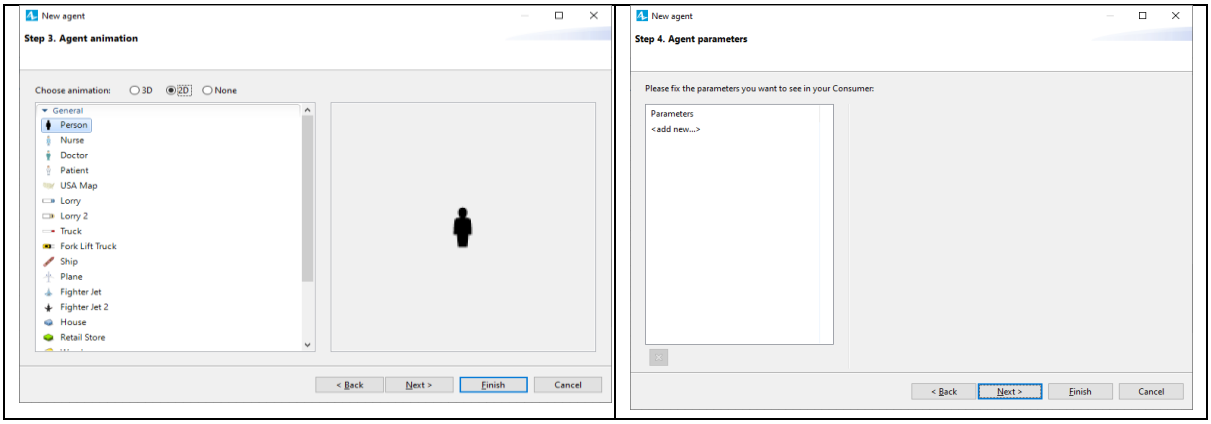
On the Step 1. Choose what you want to create page, select the option that best meets your needs. Since we want to create multiple agents of the same type, select Population of agents and click Next.10

On the Step 2. Creating new agent type page, in Agent type name box, type Consumer. The information in the Agent population name box will automatically change to consumers



Click Next.

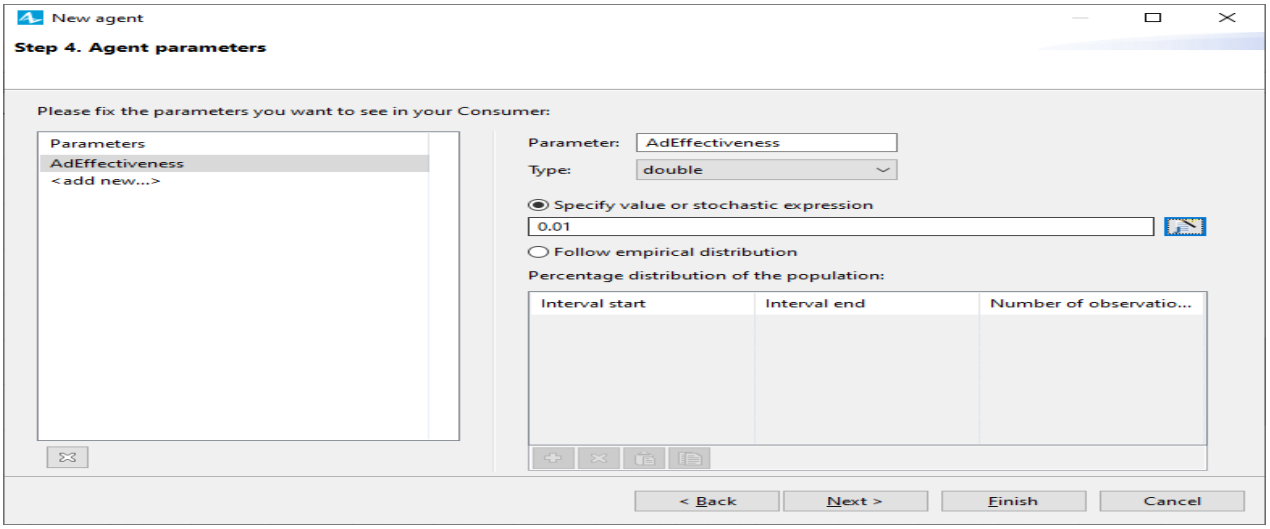
On the Agent animation page, choose the agent's animation shape. Since we're creating a simple model that uses 2D animation, choose 2D, select the General list's first item: Person, and click Next.



On the Agent Parameters page, define the agent's parameters or characteristics.

Since our model only considers advertising-related product purchases, we'll add a parameter – AdEffectiveness – to define the percentage of potential users who become ready to buy the product during a given day.

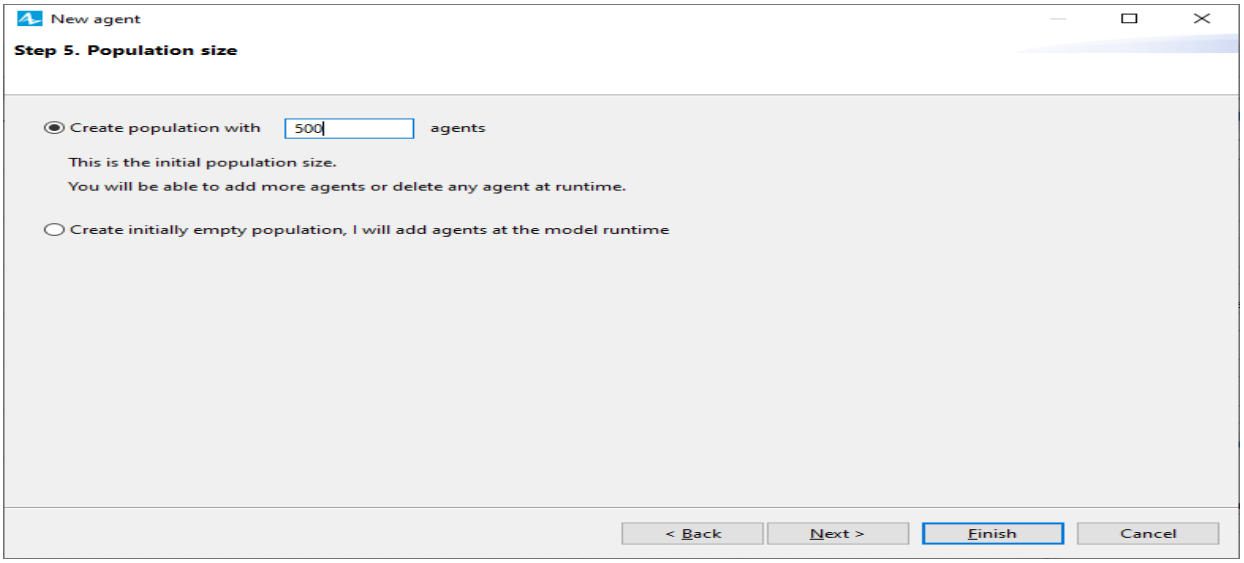
On the left section, in the Parameters table, click <add new…> to create a parameter.



Click next

On the Population size page, type 500 in the Create population with …agents box to create 500 instances of the Consumer type. Each instance in the population will model a specific agent- consumer.

While we've created our agent population, we won't see 500 Person animation figures on Main diagram. Instead, AnyLogic will use the 500 agents in the population we've called consumers to simulate the market when we run our model.



Click Next.

On the Configure new environment page, accept the default values for the environment's space type (Continuous) and both its Width and Height values (500). AnyLogic will display the agents in a 500x500 pixel rectangle.

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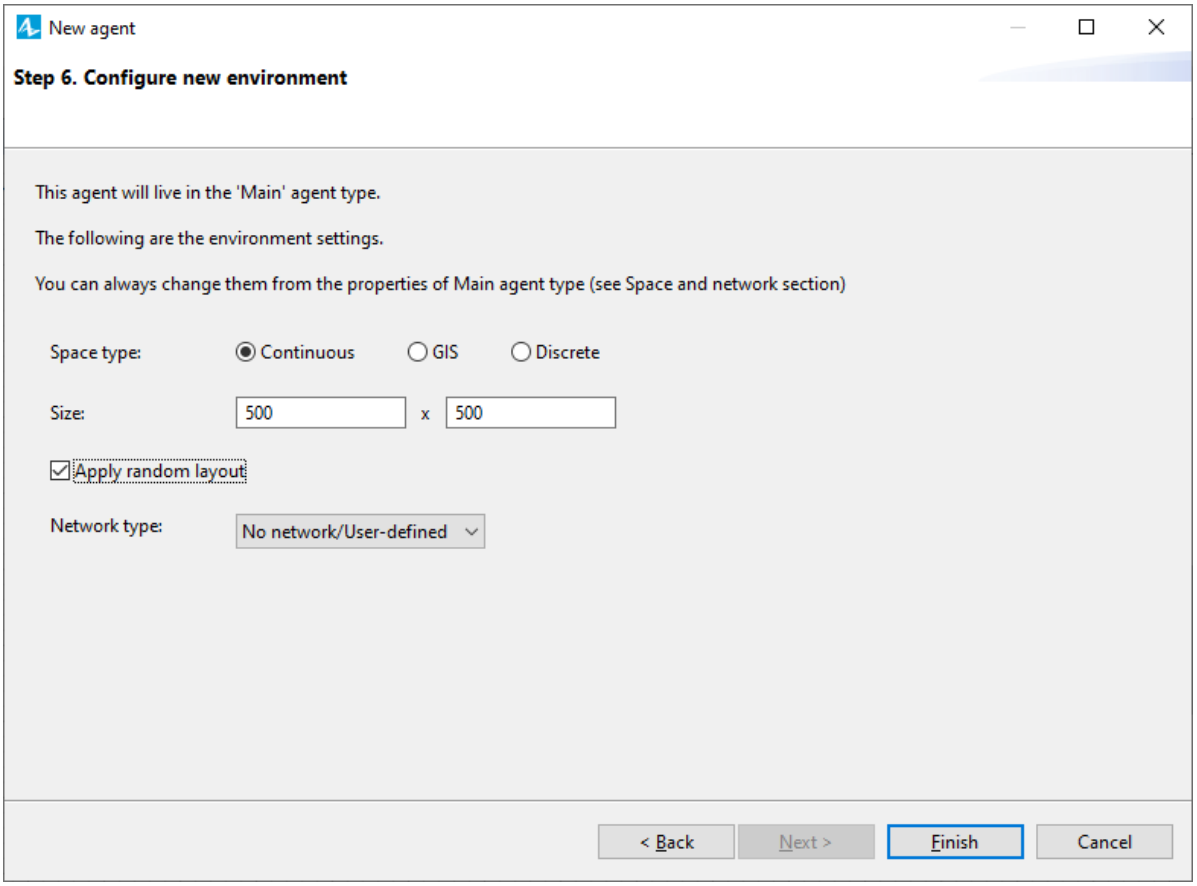
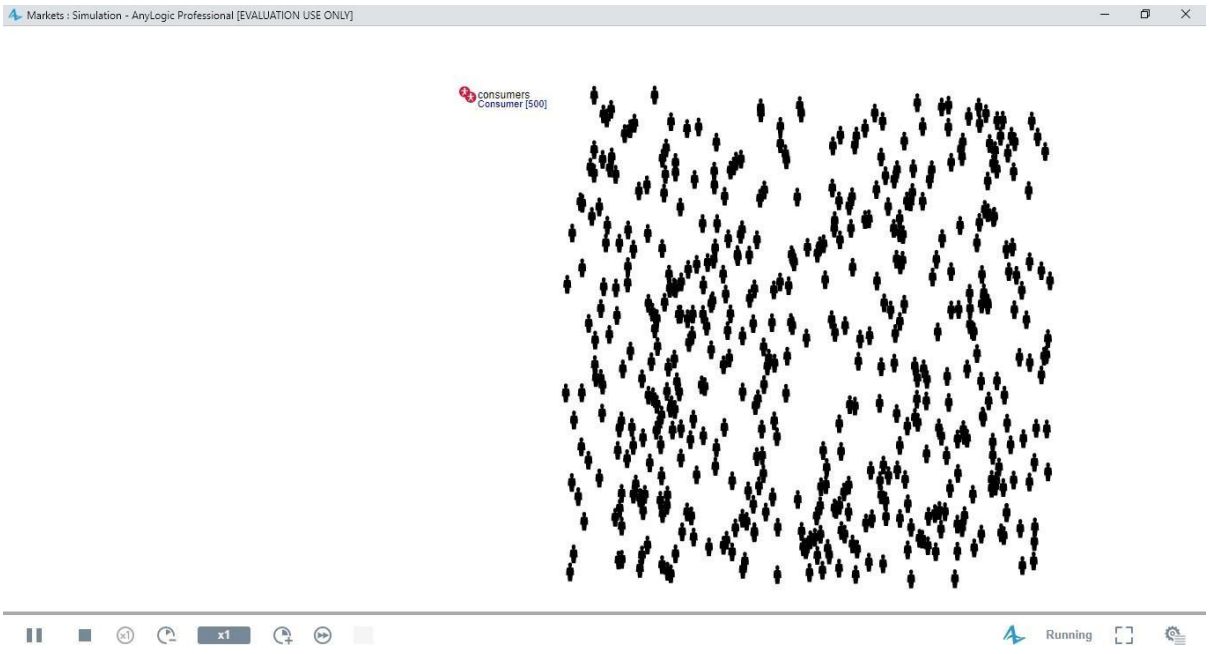
Select the Apply random layout box to randomly distribute the agents across the 500 pixel width and height we've defined. Since we don't want to create an agent network, we'll accept the default No network/User-defined network type



Click finish

Locate the Run button and click the small triangle to the right. Select the experiment you want to run. Choose Markets / Simulation from the list.



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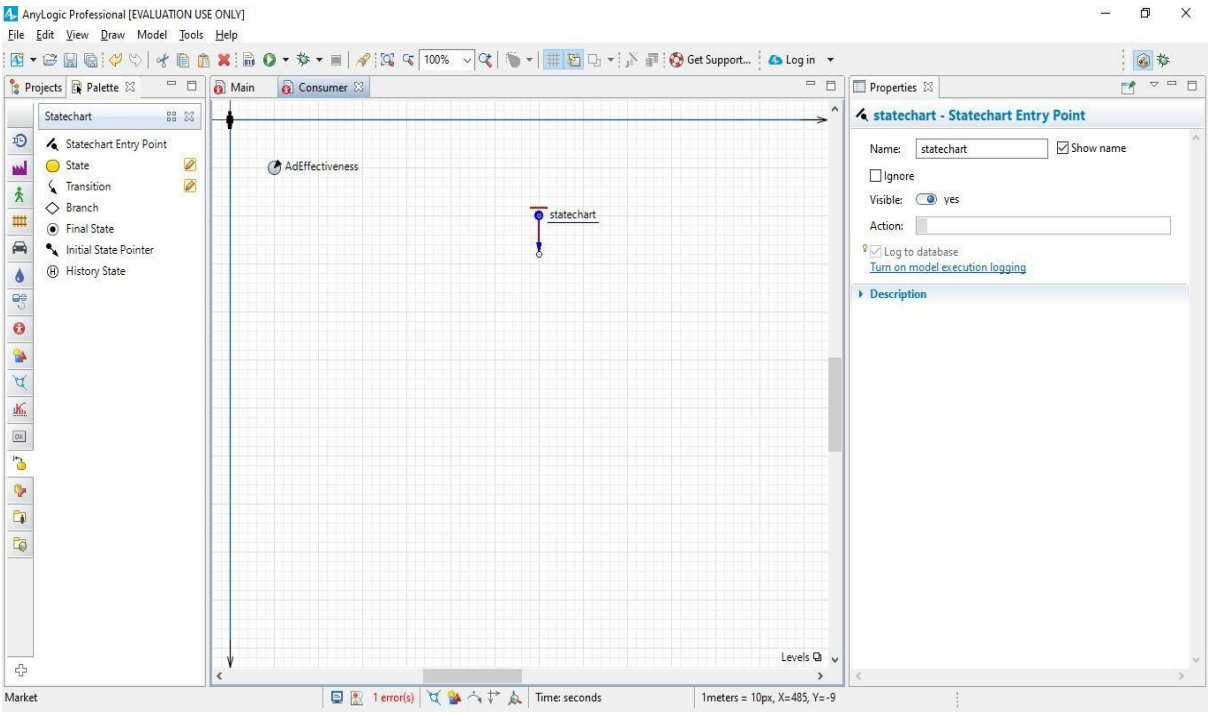
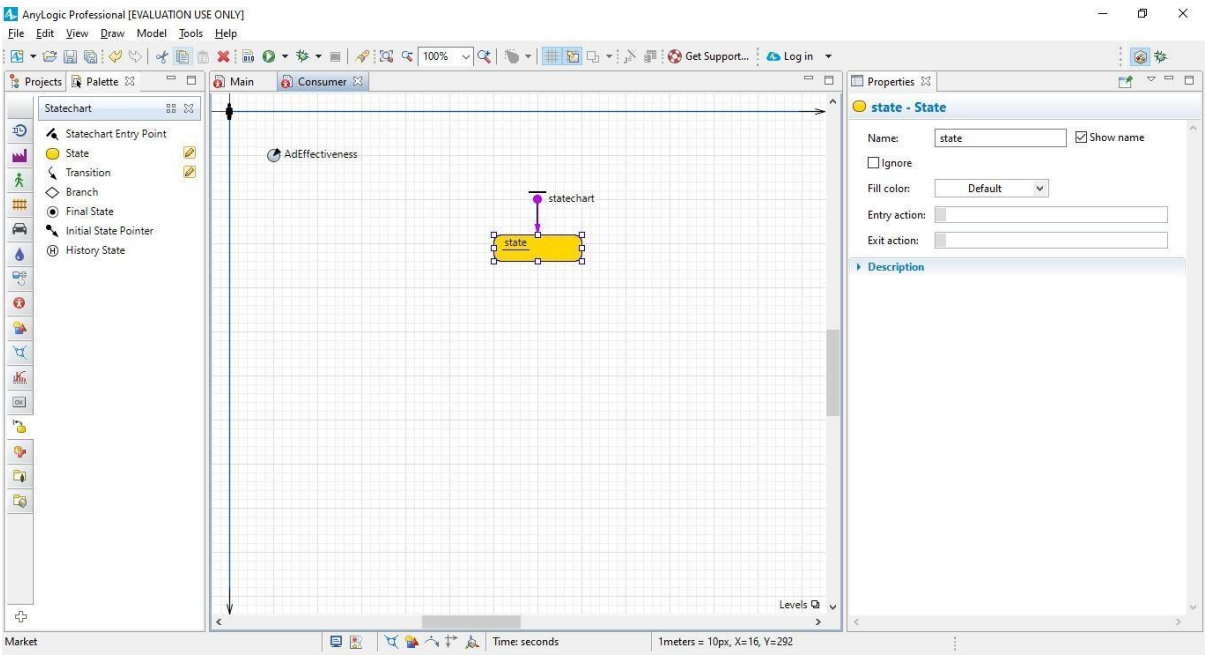
Defining Consumer Behavior

Double click on consumers a new tab of consumers open

Drag the State and Statechart Entry Point from the Statechart palette on to the graphical diagram and connect it to the statechart entry point.



Drag the State and Statechart Entry Point from the Statechart palette on to the graphical diagram and connect it to the statechart entry point.



Select the state in the graphical editor and modify its properties. Name the state PotentialUser.

Use the Fill color control to change the state's color to lavender. Type the following Java code in the state's Entry action field: shapeBody.setFillColor(lavender)

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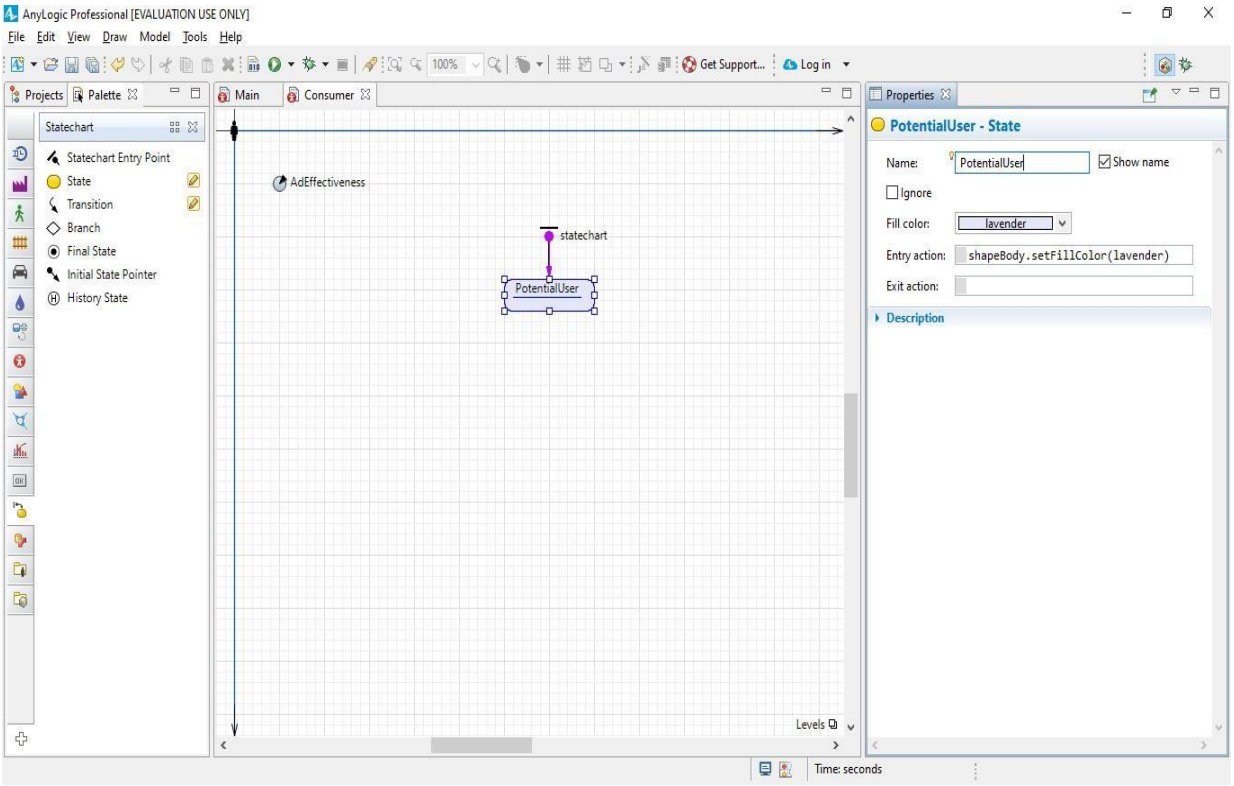


• Add another state in the consumer's statechart:

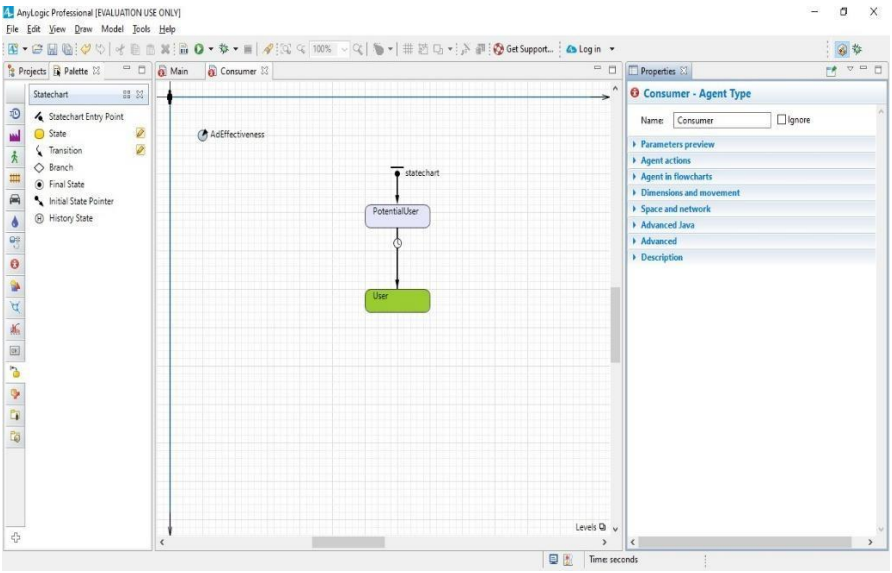
Modify the state's properties like you did earlier: Name: User

Fill color: yellowGreen

Entry action: shapeBody.setFillColor(yellowGreen);

• Draw a transition from PotentialUser to User state to model how persons purchase the product and become product users.

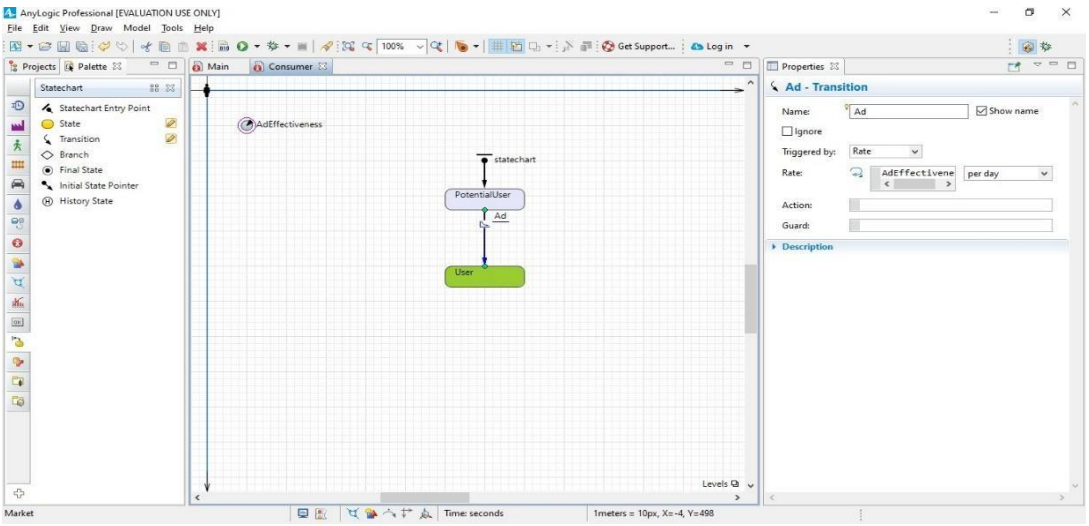
To do so, double-click the Statechart palette's Transition element (the element's palette icon should change to), click PotentialUser state, and click User.



Name the transition Ad to represent "advertising".

12. Select the Show name checkbox to display the transition's name on the graphical diagram.

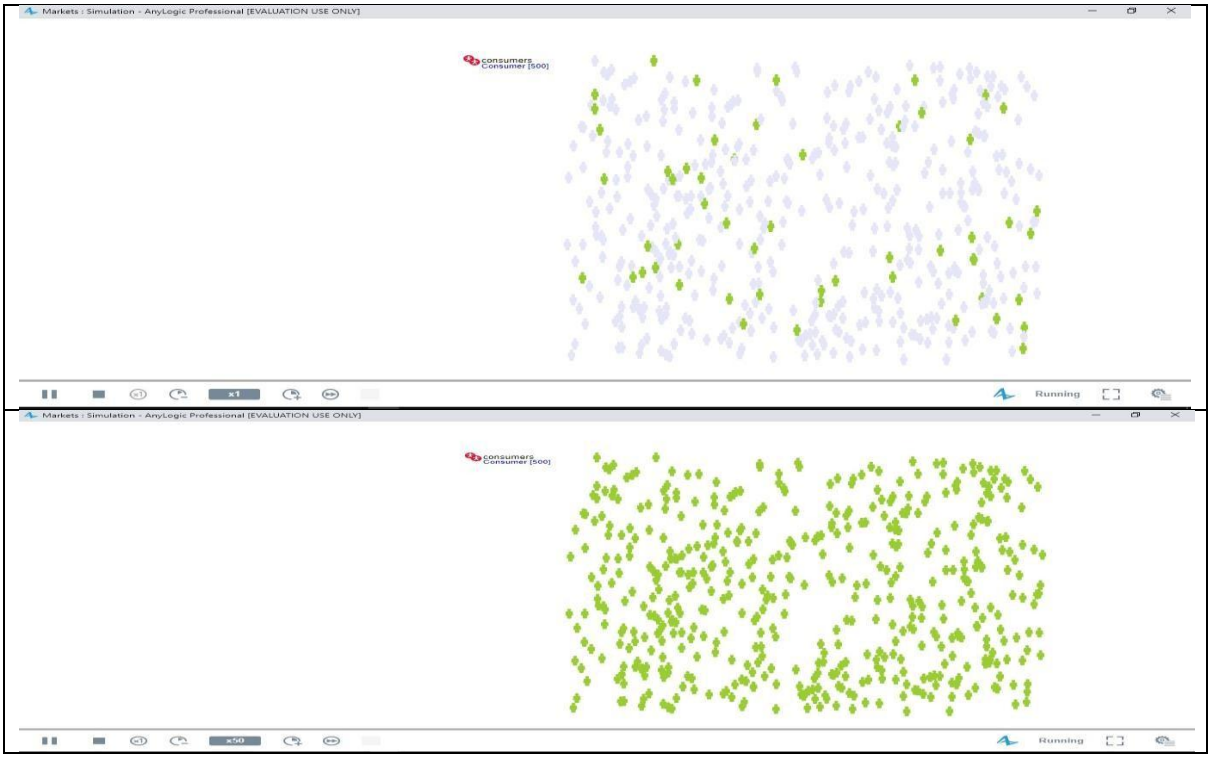
13. The transition from PotentialUser to User state will model how advertising leads the person to buy the product. In the Triggered by list, click Rate. In the Rate field, type AdEffectiveness, and then click per day.



Now, let's set up the model's time units. To tune the model setting, switch from Palette to Projects, and then click the model item in the tree (the tree's top object, Market).

In the Properties view, choose days as the Model time units.

Run the model. The population should gradually turn green – a change that represents the effect of advertising - until every consumer buys the product.

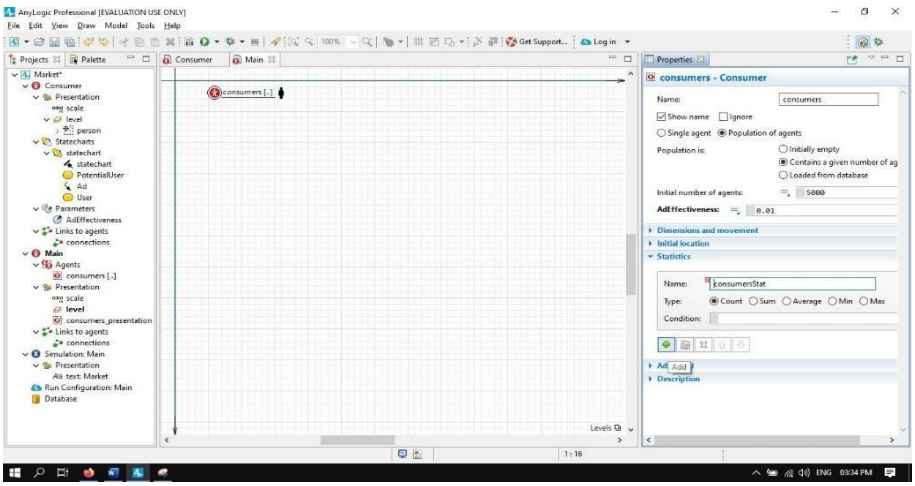


To adjust the model's execution speed, click the toolbar's Slow down or Speed up buttons. If you increase the speed to 10x – you'll see the speed at which the population turns green also increase

Adding a chart to visualize the model Output

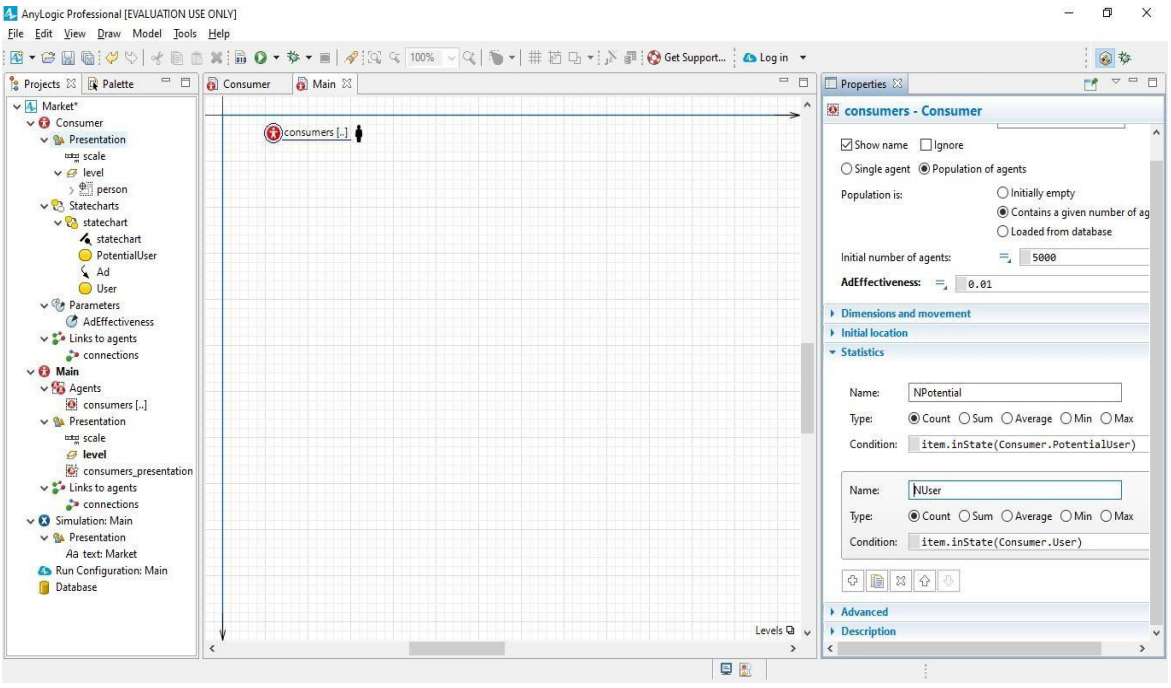
First, define a function to count potential users. To add a new function that collects statistics for agents, open the diagram of the agent type Main, select the agent population consumers, and go to the Statistics properties section.

Define the function of type Count with the Name NPotential. The statistics of type count iterates through a given population – in our case, the number of agents – to count those that meet the selected condition.



Enter item.inState(Consumer.PotentialUser) as the function Condition.

Define a second statistics function to calculate the number of product users. Name it NUser and let it count the number of agents, conforming the Condition item.inState(Consumer.User). You can duplicate the other statistics function by clicking the Duplicate button and changing its Name and the Condition.



Now, let's add a chart to show the statistics these functions collect and display the adoption process dynamics.

Open the Analysis palette and drag the Time Stack Chart from the Analysis palette on to the Main diagram to create a chart that will display the dynamics of users and potential users.

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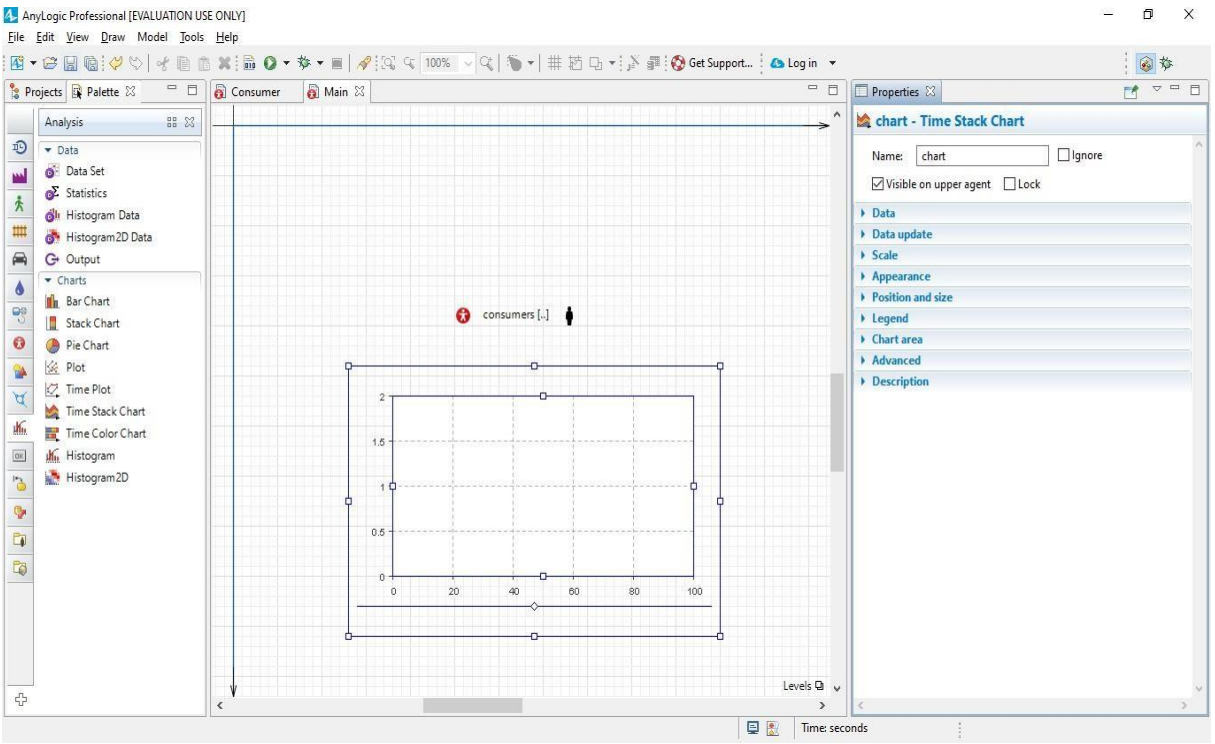
Increase the time stack chart as shown in the figure below:



Add two data items for the chart to display. Here we'll call our statistics functions NUser and NPotential we have defined for consumers population on the previous step. Click Add data item to add the statistics you want to draw on the chart.

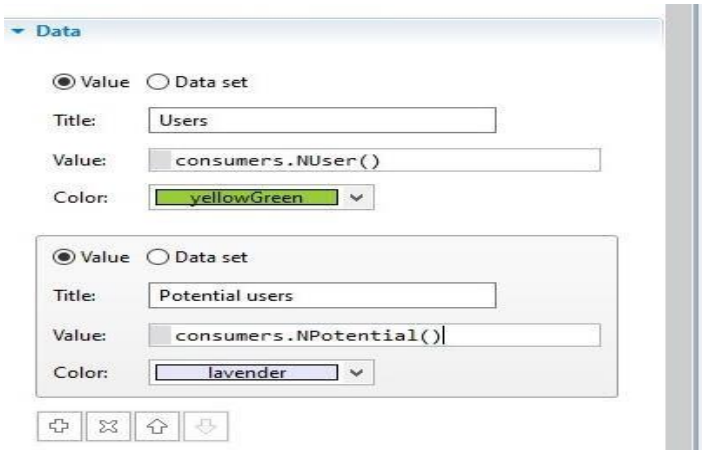
Modify the data item's properties:

- Title: Users – the data item's title.
- Color: yellowGreen
- Value: consumers.NUser()

Add one more data item:

- Title: Potential users
- Color: lavender
- Value: consumers.NPotential()

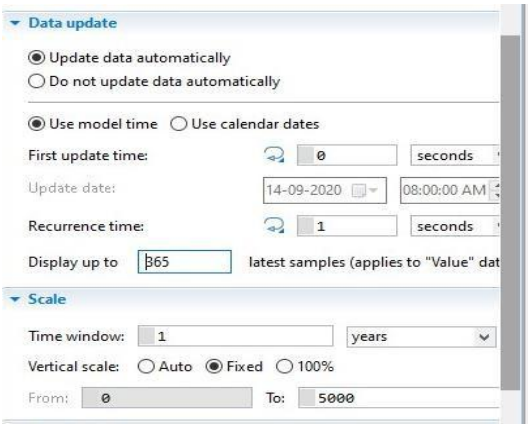
Our agent population name is consumers, and NUser() is the statistics function that we defined for this population.



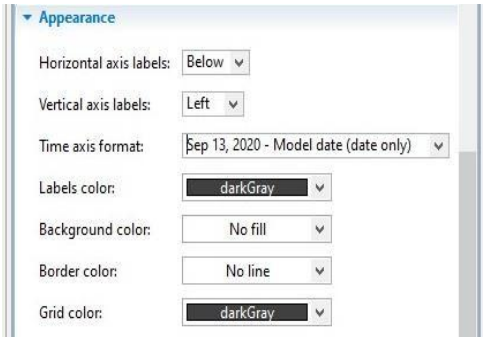
Go to the Scale section and set Time window equal to 1 year.

Since our chart will show statistics for consumers population and our model has 5,000 consumers, set the chart's Vertical scale to Fixed, and enter 5000 in the to: box.

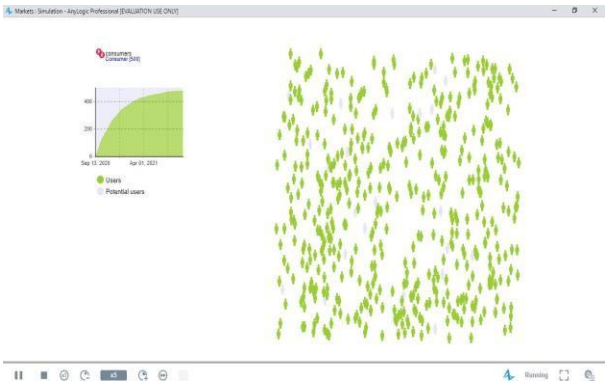
Now that we've set the time window, change the maximum number of data samples that the chart displays by navigating to the section Data update and setting Display up to 365 latest samples. Since we'll add one data sample each day, 365 data sample is an ideal amount for a one year range.



Go to the time stack chart's Appearance properties and set it to display Model date (date only) near the time axis.



Run the model and use the time stack chart to review the process



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PRACTICAL NO: 02

Aim: Design and develop agent based model by

- Creating the agent population
- Defining the agent behavior
- Add a chart to visualize the model output.
- Adding word of mouth effect
- Considering product discards
- Considering delivery time

[Use a case scenario like restaurant].

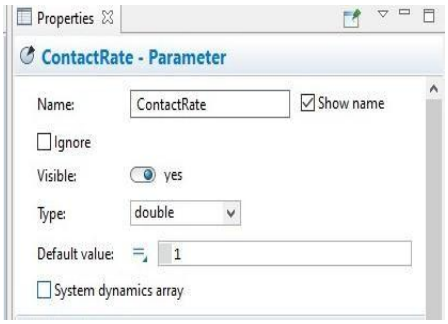
Code:

Adding word of mouth effect

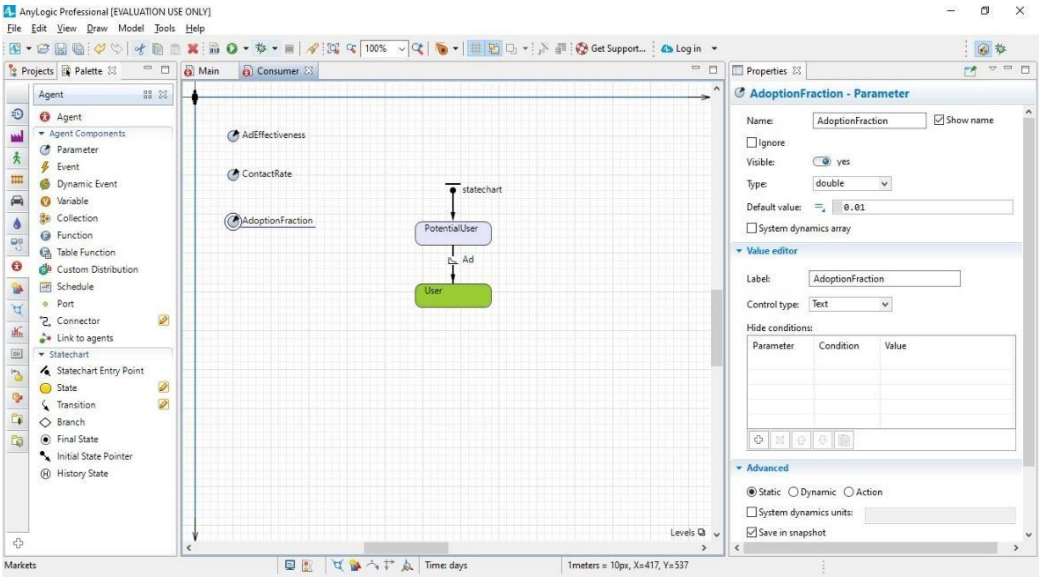
In the Projects tree, open Consumer diagram by double-clicking on Consumer.

Add a parameter to define a consumer's average daily contacts. Drag the Parameter from the Agent palette on to the diagram.

The rate is 1 contact per day, so type 1 as the parameter's diagram. Name the parameter ContactRate default value.



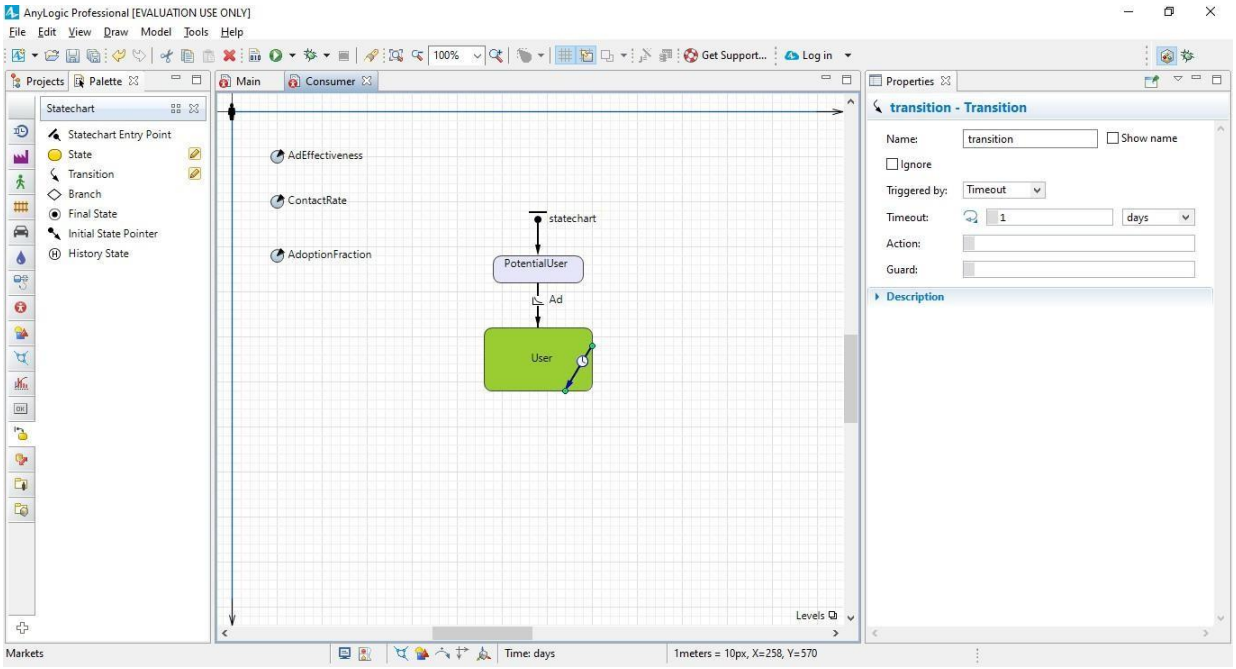
Add another parameter - AdoptionFraction - to define a person's influence on others, a number that we'll express as the percentage of people who will use the product after they come into contact with the consumer. Leave the default parameter's Type: double and set the Default value: 0.01.The Consumer diagram should look like this:



Open the Consumer diagram and increase the User state to fit the internal transition we'll draw inside the state on the next step

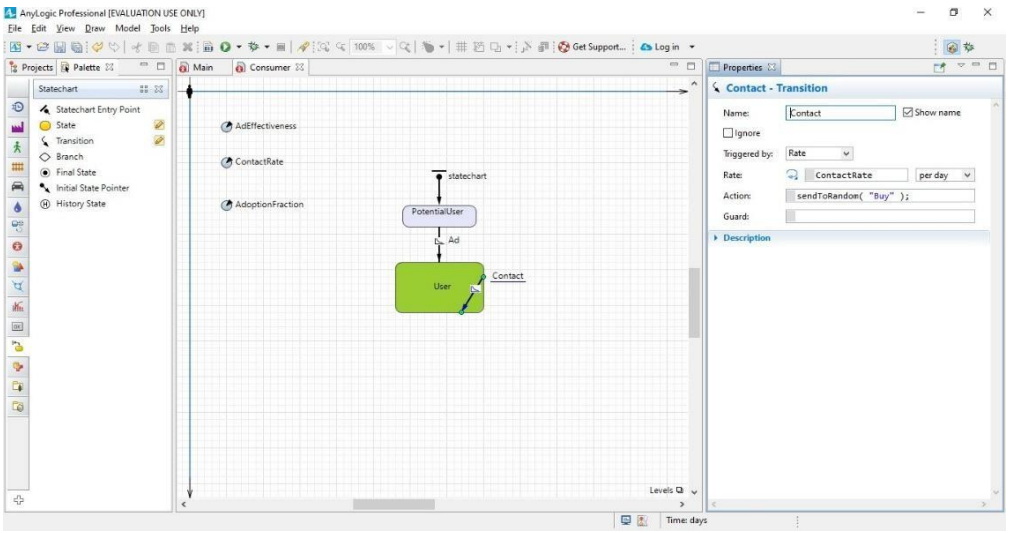
Draw an internal transition inside the User state. To draw a transition like the one shown below, drag the Transition from the Statechart palette inside the state so the transition's start point lies on the state border.

Afterward, you can move the transition end point to another point on the state border. To add a salient point, double-click the transition.



Modify the transition properties. This transition will occur with the specified Rate ContactRate (use code completion rather than typing the parameter's full name). Name the transition Contact and set it to show its name.

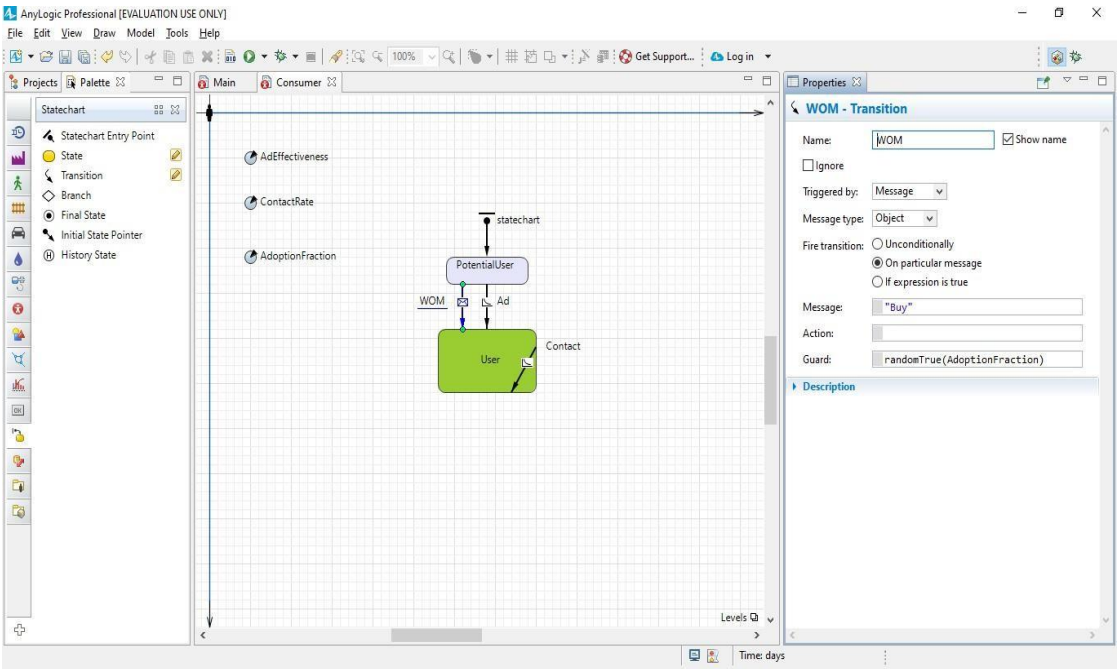
Specify the Action that will be executed on triggering this transition (use the code completion to write the code):sendToRandom("Buy");



Draw another transition from PotentialUser to User state, and name it WOM (Word of Mouth). This transition will model purchases caused by word of mouth.

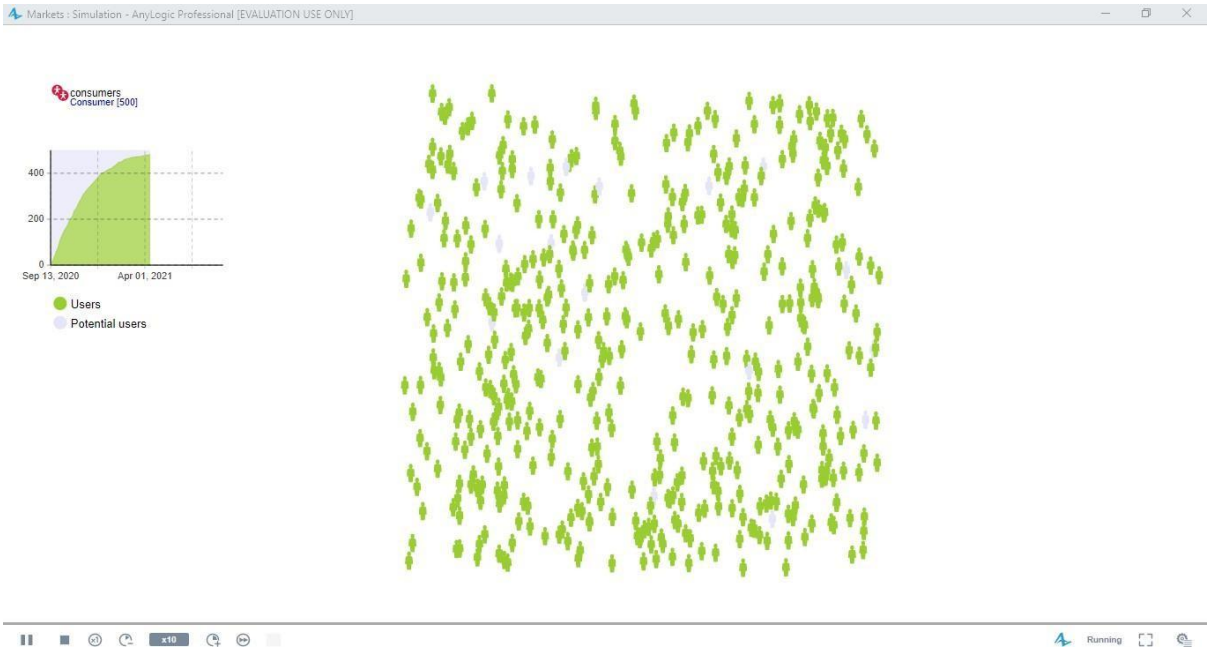
Modify the transition properties:

- In the Triggered by list, click Message.
- In the Fire transition area, select on particular message.
- In the Message field, type "Buy"
- Since we know not every contact is successful – in other words, a contact may not convince the potential user to buy our product – we'll use AdoptionFraction to make successful contacts less common. Specify the transition's Guard: randomTrue(AdoptionFraction)



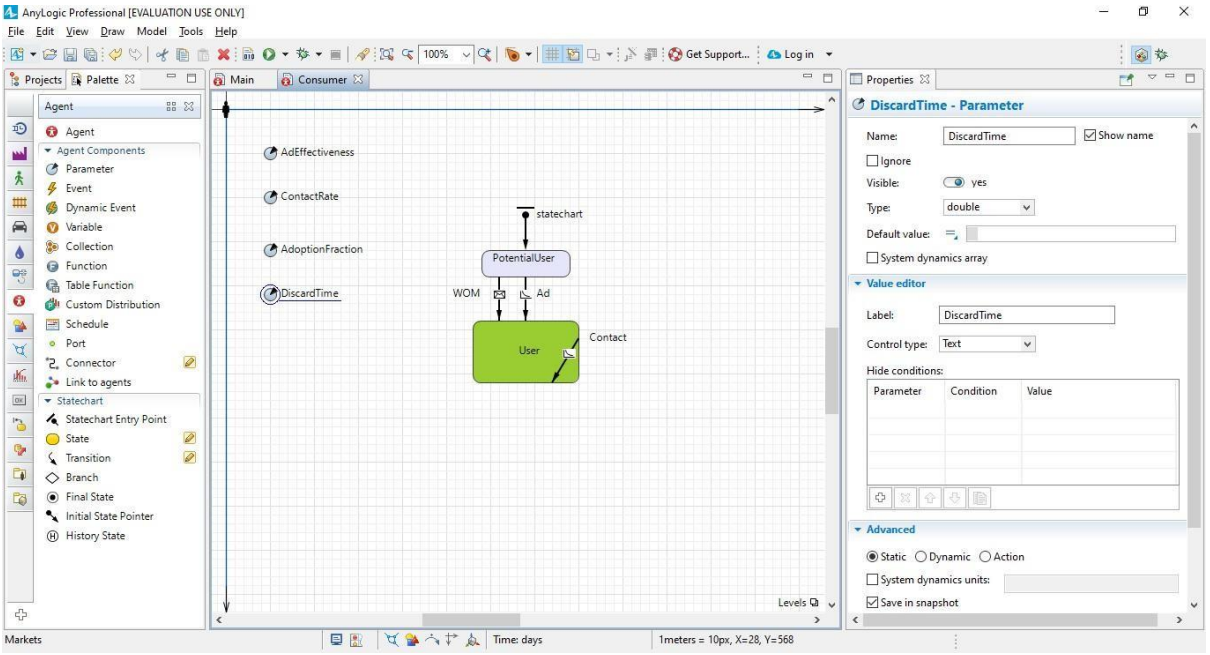
In the Projects view, you may see an asterisk near the model item that shows your model has unsaved changes. On the toolbar, click Save to save your model.

Run the model.



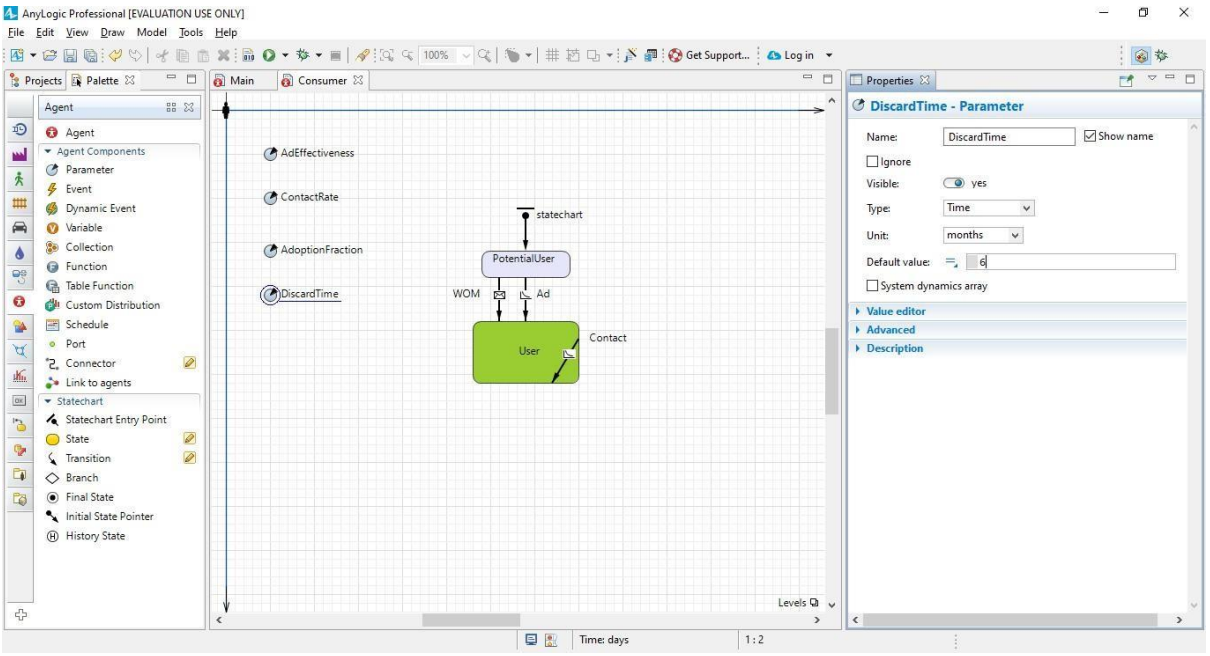
Considering Product Discards

Open the Consumer diagram and add a DiscardTime parameter



This parameter will define our product's lifespan.

Choose Time as the parameter's Type, click months in the Unit list, and type 6 as the Default value.



Draw a transition from User to PotentialUser state to model product discards.

To draw a transition with salient points like those shown in the figure, double-click the Transition element in the Statechart palette (this should change the element's icon in the palette to), click the transition's source state User, click at the salient point places, and click the target state PotentialUser.

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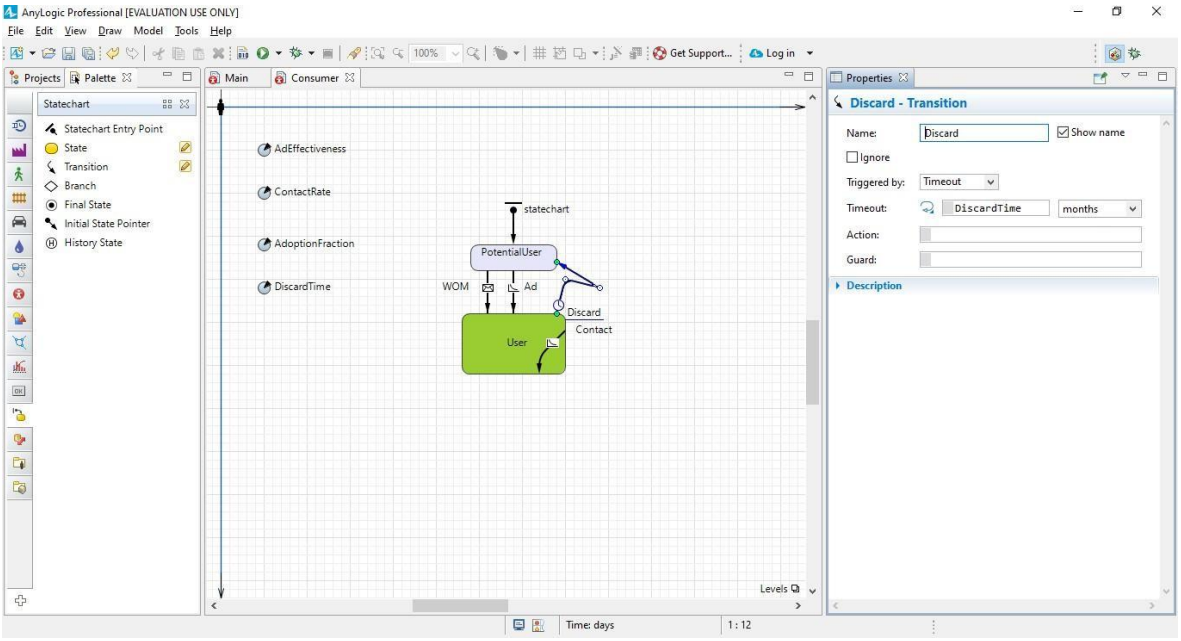
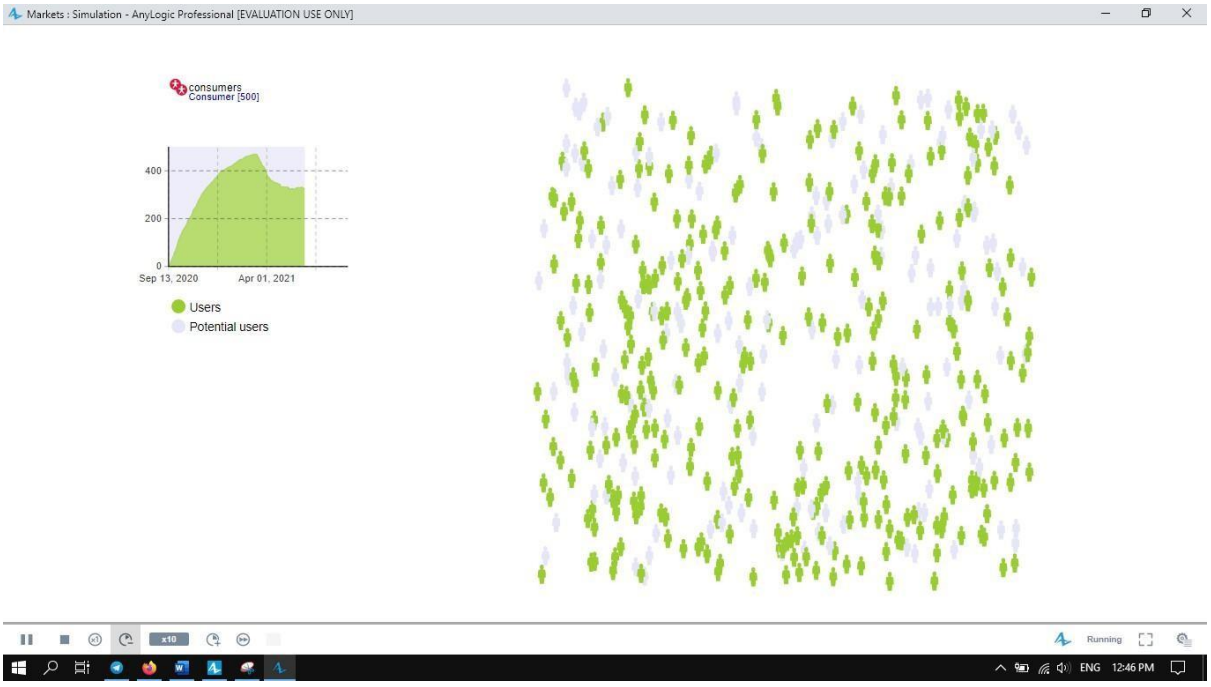
Name the transition Discard and set it to be triggered by a constant timeout DiscardTime. In the list to the right, click months.



Run the model.



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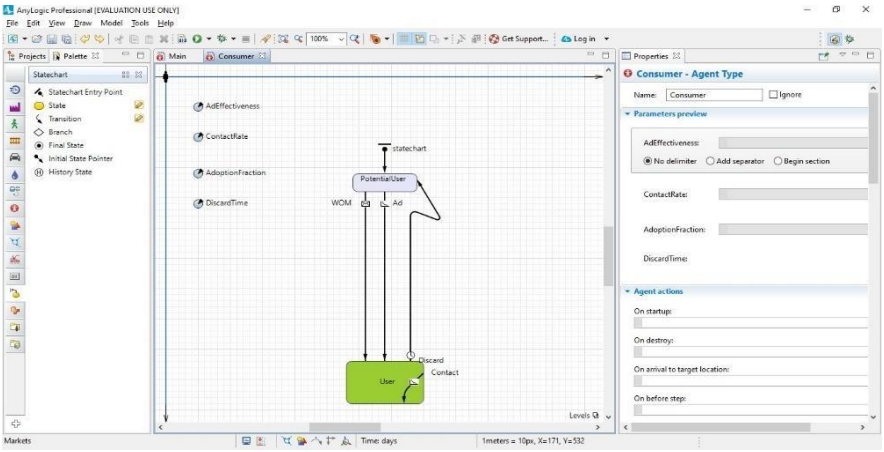
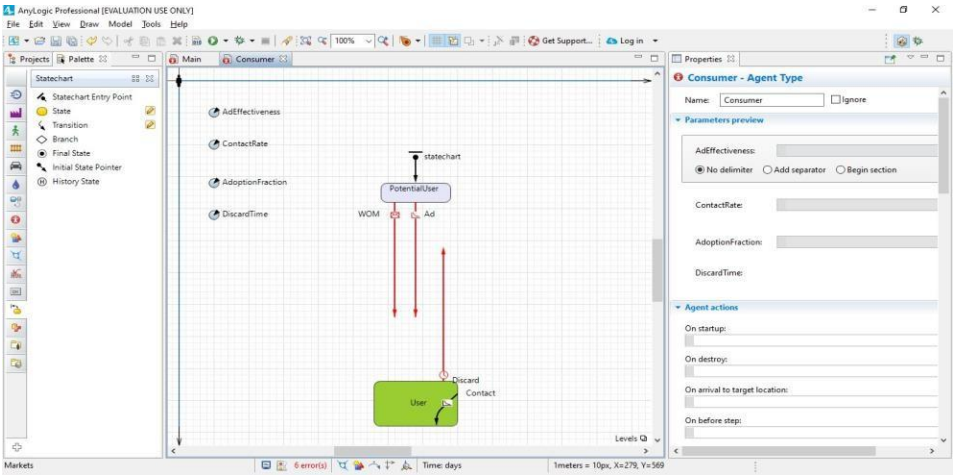
Considering Delivery Time

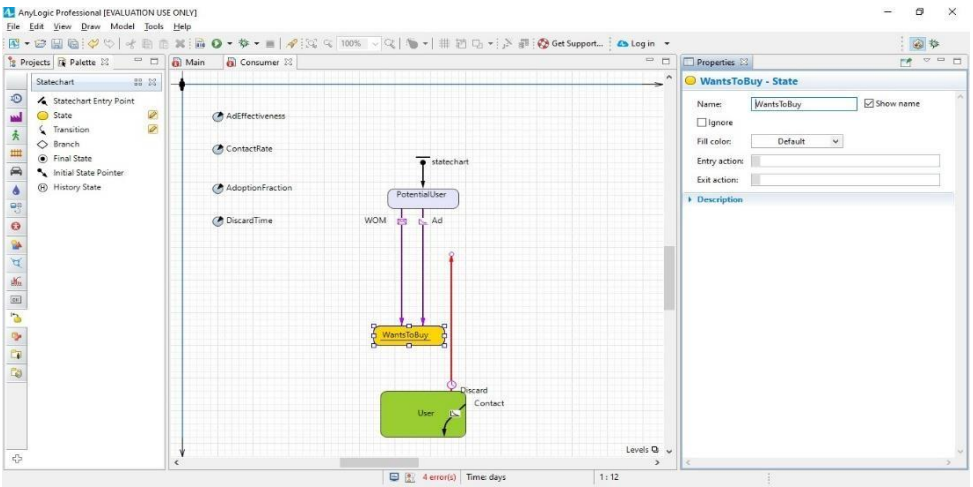
Prepare a place for another state between PotentialUser and User by moving the User state toward the bottom of the screen.



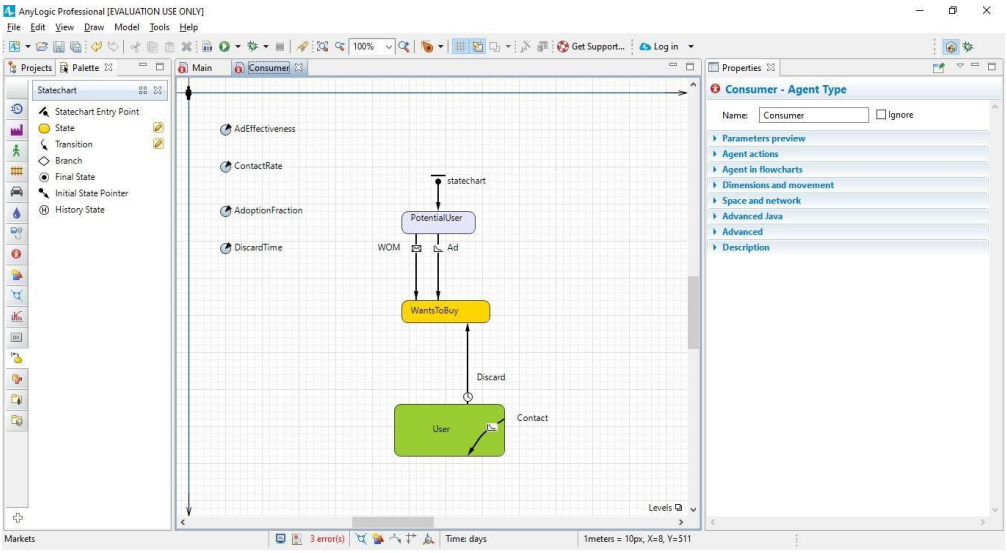
Disconnect the User state from the transitions. Select the WOM and Ad transitions, move their end points toward the top of the screen, and disconnect the discard transition from PotentialUser. Afterward, you'll notice the disconnected transitions are drawn in red.



Add another State from the Statechart palette to the middle of the consumer's statechart and name it WantsToBuy. Consumers in this state have decided to purchase the product, but they have not done so.



Reconnect transitions to the middle state: the WOM, Ad, and Discard transitions should now end in the WantsToBuy state.



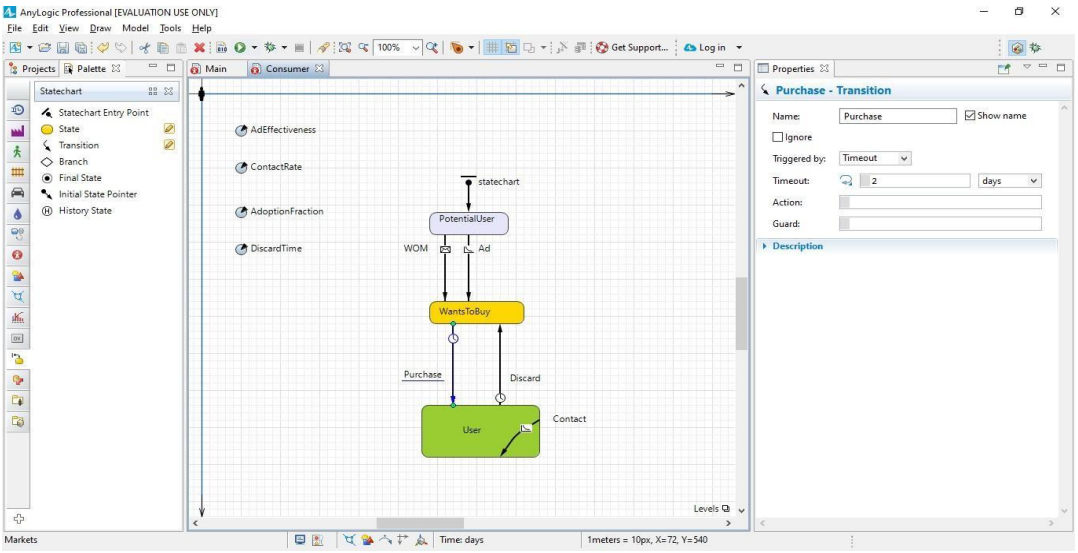
Modify WantsToBuy similar to other states:

Fill color: gold

Entry action: shapeBody.setFillColor(gold);

Add a transition from WantsToBuy to User state to model the product shipment and name it Purchase.

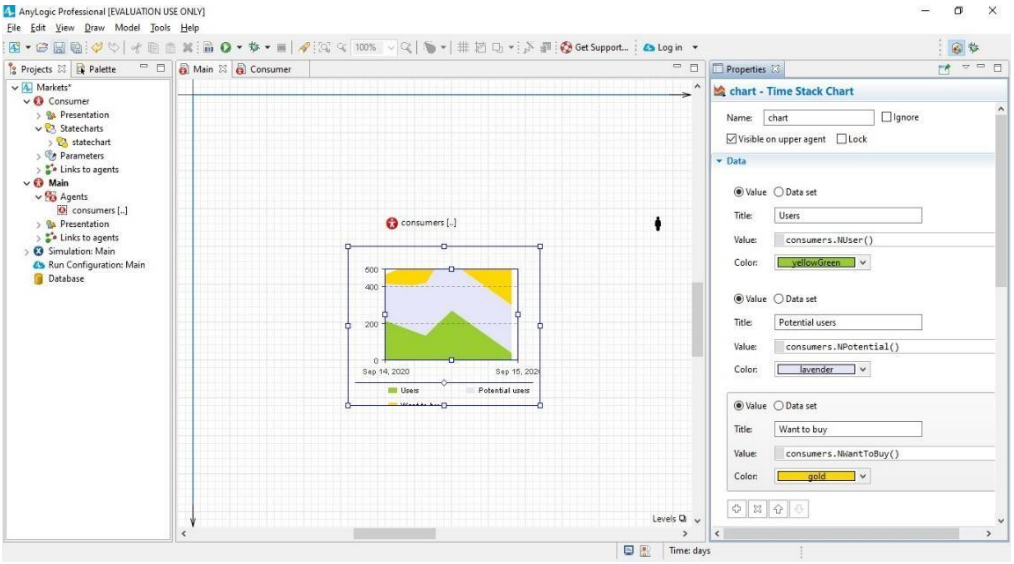
Let's assume it typically takes a user two days to get the product. This means once the consumer's statechart enters the state WantsToBuy, it will proceed to the state User with a two- day delay. With this in mind, set 2 days timeout for the Purchase transition:



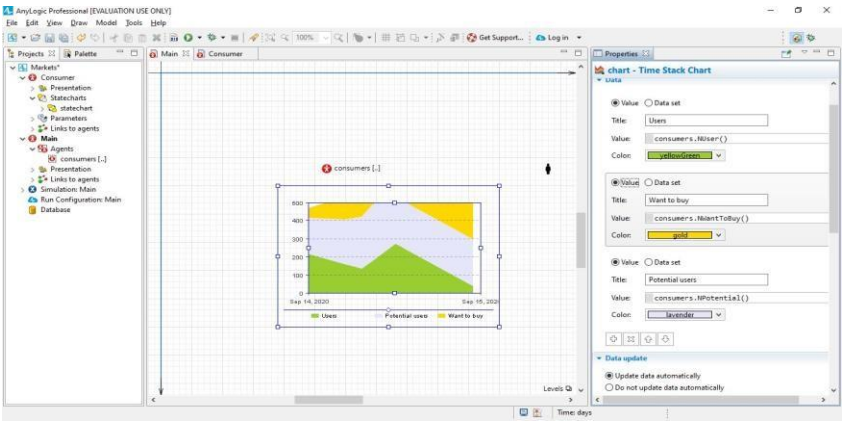
Define one more statistics function to count the product's market-driven demand.

In the editor of Main, click the consumers, go to the Statistics properties section, and add a statistics item: NWantToBuy with condition item.inState(Consumer.WantsToBuy)

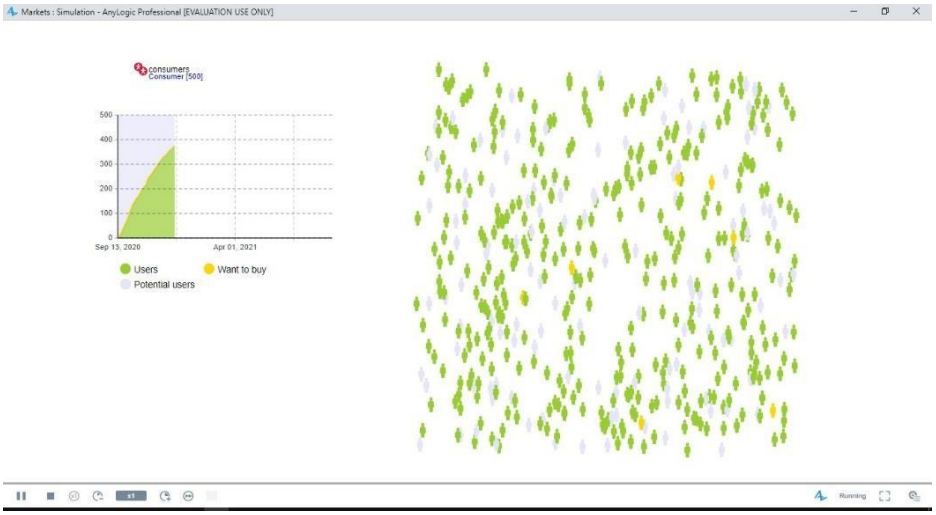
On Main, select the time stack chart, and add another data item to be displayed with the chart: consumers.NWantToBuy() in value with the title Want to buy and color gold.



Make the newly-defined data item second in the list by selecting the item's section and clicking the "up" button.



Run the model, and you'll notice AnyLogic displays the number of consumers who are waiting for the product in yellow.



Roll No: 25166009

PRACTICAL NO: 03

Aim: Design and develop agent based model by

- Creating the agent population
- Defining the agent behavior
- Adding a chart to visualize the model output.
- Adding word of mouth effect
- Considering product discards
- Considering delivery time
- Simulating agent impatience
- Comparing model runs with different parameter values

[Use a case scenario like market model].

Code:

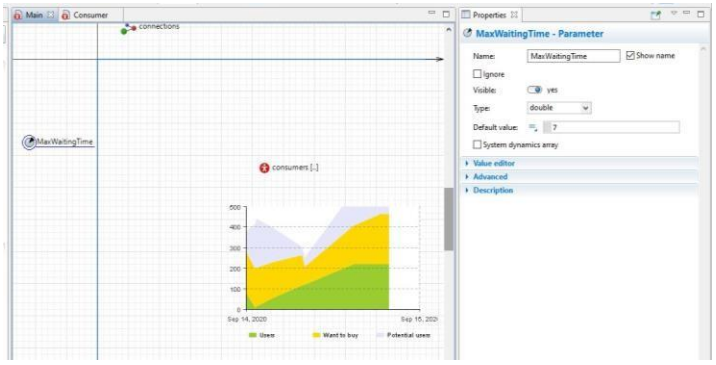
Open the Main agent type diagram.

Since we don't want the model window to display the model's parameters at runtime, we can place them outside the model window's default display area.

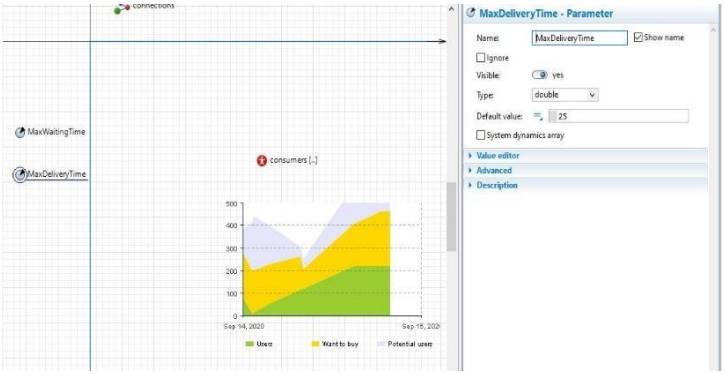
On Main, the model window is depicted with a blue rectangular frame. Elements inside the frame will be visible at the model runtime, but you can hide them by moving the graphical diagram's canvas slightly to the right and placing two parameters as shown in the figure below.

To move the graphical diagram's canvas, hold down the right mouse button as you move the mouse.

Configure the parameters. MaxWaitingTime defines the maximum time a consumer will wait for the product (in this case, seven days).



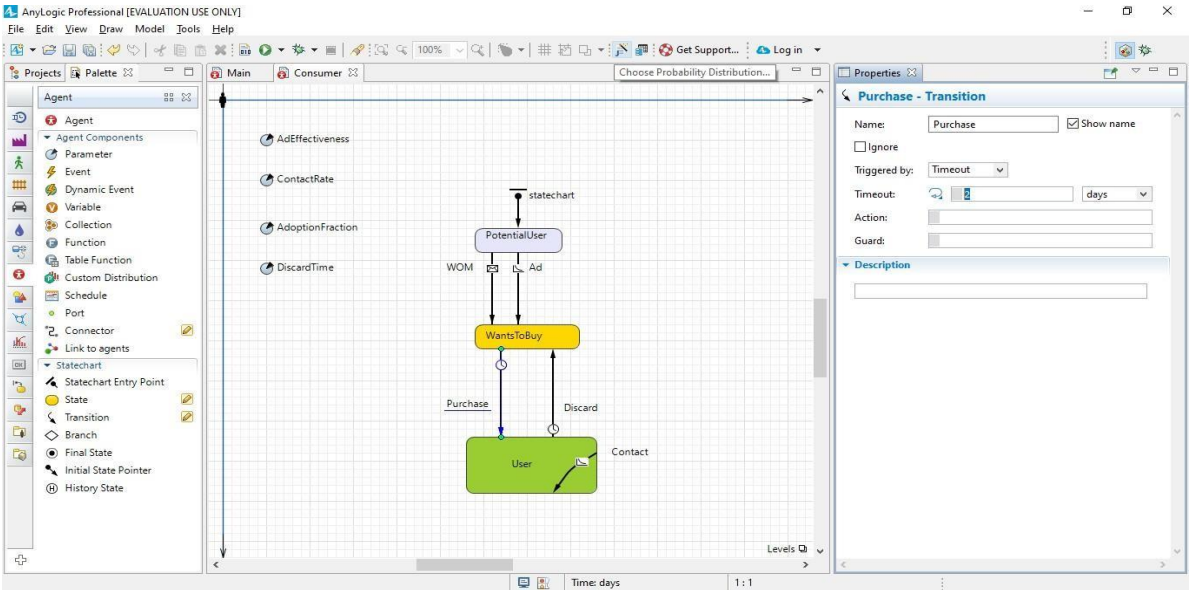
Set the other parameter, MaxDeliveryTime to 25 days to reflect our assumption it may take up to 25 days to deliver a product.



We assume it takes between one and 25 days – with an average of two days – to deliver the product. With that in mind, let's change the delivery time from a fixed two day delivery period to the stochastic expression that describes this pattern.

Open the Consumer diagram and select the Purchase transition. We want to change the transition's timeout expression, and we'll do that by using a wizard to choose the distribution function and insert the function's name in the property. To substitute the existing value, use your mouse to select the existing Timeout expression.

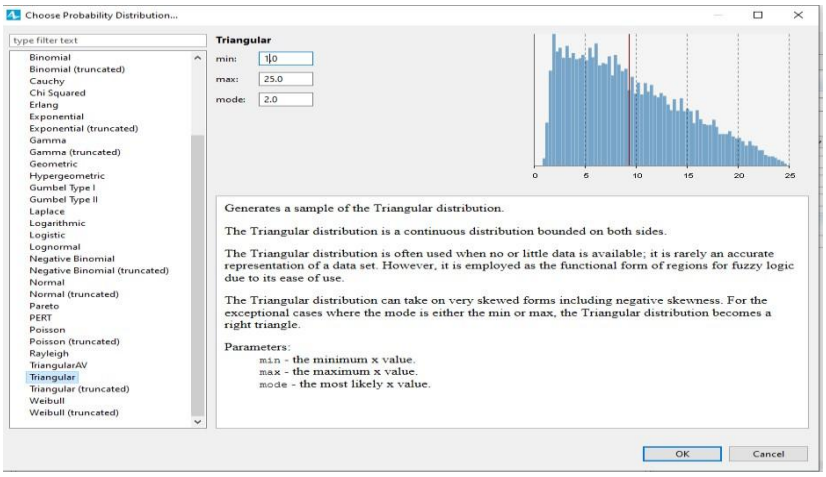
Click the Choose Probability Distribution... button.



You'll see the Choose Probability Distribution... dialog box.

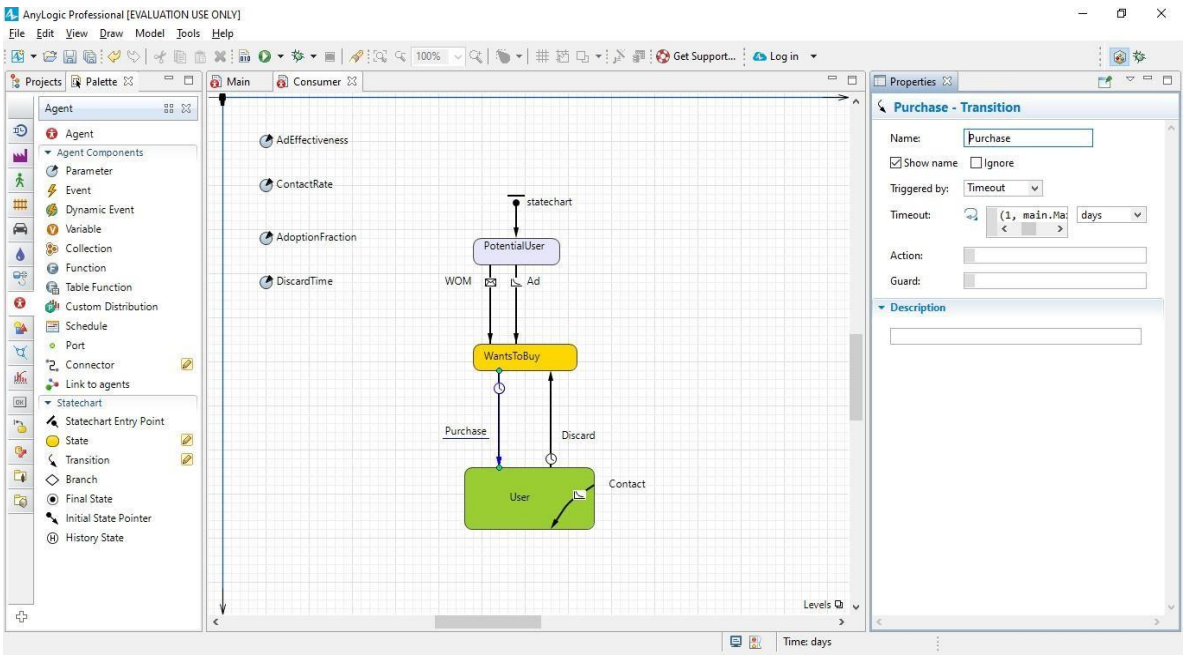
The Choose Probability Description screen allows you to view the list of supported distributions, and you can click any name in the list to view the distribution's description.

Choose triangular in the list. Set min, max and mode parameters equal to 1, 25, 2 respectively. In the upper right, you'll see PDF instantly built for the distribution with the specified parameters. Click OK when finished.

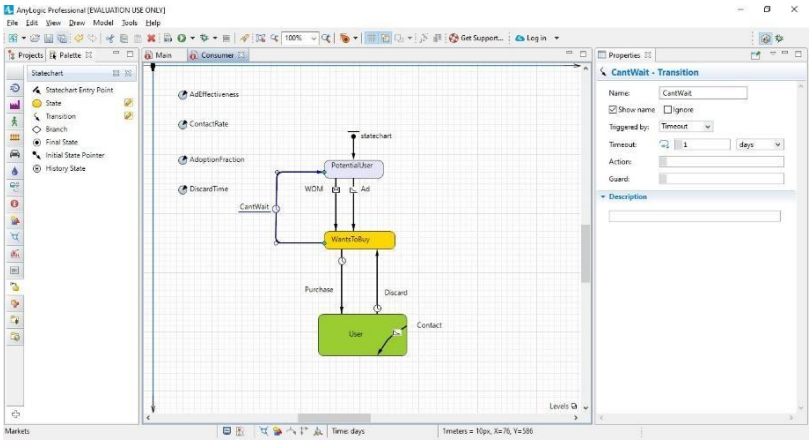


You'll see the expression triangular(1, 25, 2) automatically inserted as the timeout value. Let's modify the line to triangular(1, main.MaxDeliveryTime, 2)

Here main is how we access the Main agent from the consumer agent.

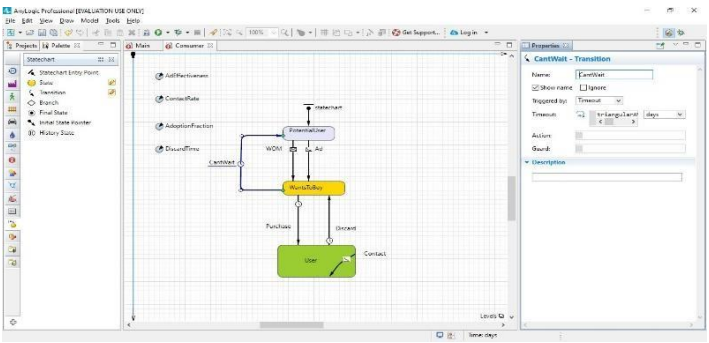


Draw the last transition CantWait that goes from WantsToBuy to PotentialUser state. This transition will model how a consumer's impatience causes them to change their purchase decision, and the Consumer diagram will look like this:



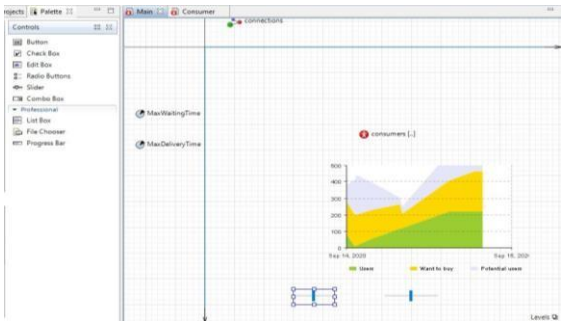
Modify the transition properties so it is triggered by Timeout which equals

triangularAV(main.MaxWaitingTime, 0.15) days



Rather than setting the maximum waiting time equal to constant MaxWaitingTime, we assume it follows a triangular distribution with an average of one week and a possible variation to up to 15 percent.

Go back to Main diagram. Open the Controls palette and drag two Sliders on to the diagram below the chart. We'll eventually link the sliders to our two parameters.

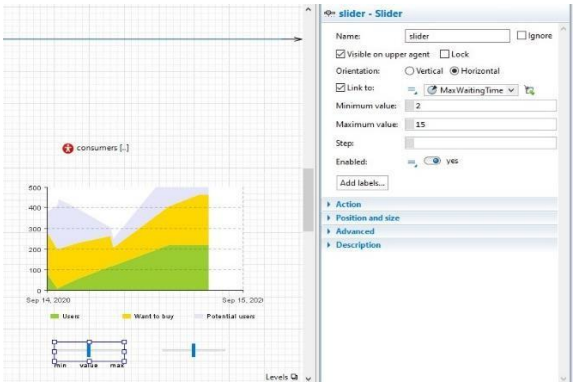


Modify the slider's properties:

Select the checkbox Link to and select the parameter MaxWaitingTime to the right.

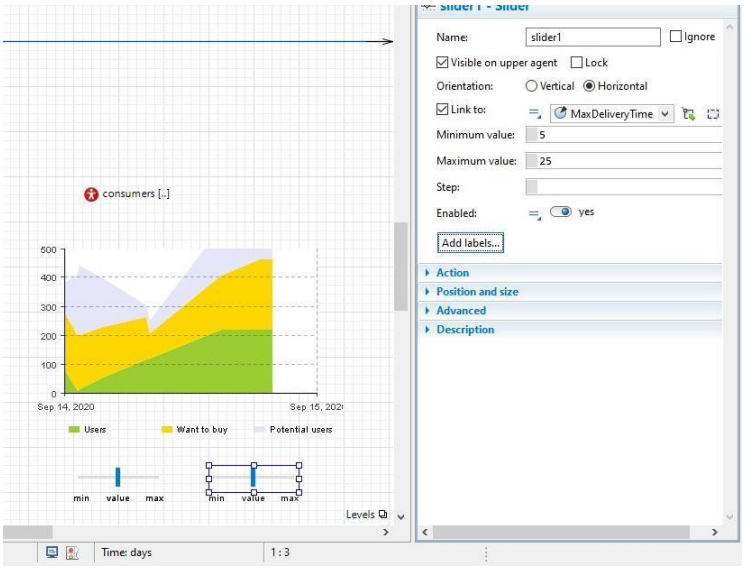
Set the slider's Minimum and Maximum values. The parameter value can vary within the range you define here, and we'll set 2 as Minimum and 15 as Maximum value.

Finally, click the Add labels... button to display the slider's minimum, maximum, and current values at runtime (the min, value, and max text shapes will appear beneath the slider).



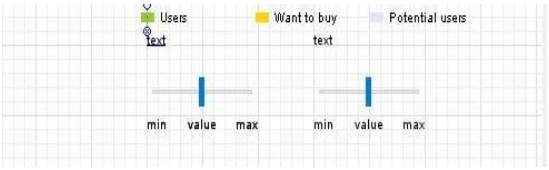
On other slider Select the checkbox Link to and select the parameter MaxDeliveryTime to the right.

Set Minimum value as 5 and Maximum value as 25. Then click on Add label.



Roll No: 25166009

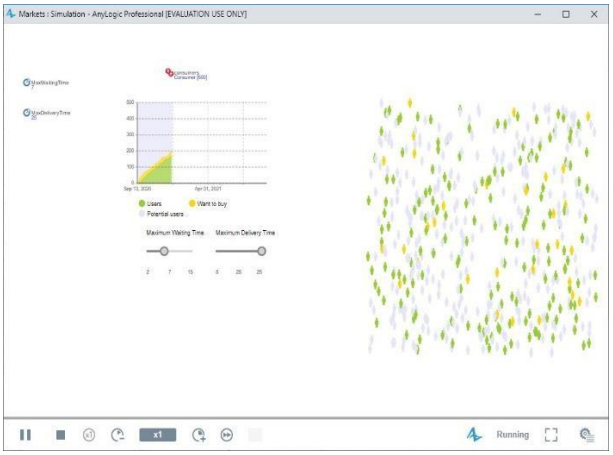
Open the Presentation palette, drag two Text shapes on to the diagram, and place them above the sliders. Let's configure the titles of these controls.

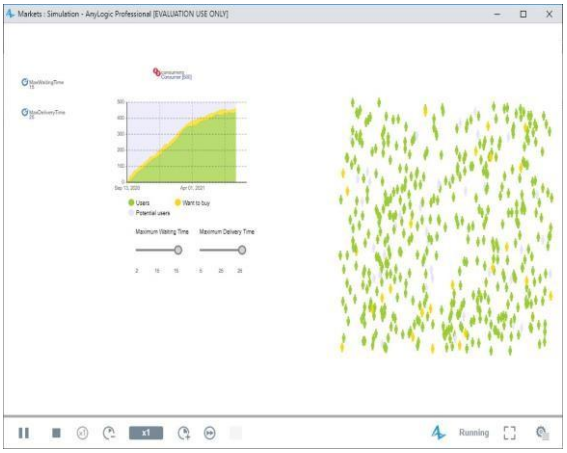


In the properties view, in the Text section, enter the text that the model will display. Using text shapes, name one slider Maximum waiting time and the other slider Maximum delivery time.

In the properties section, under Appearance, you can customize the text's color, alignment, font, and point size.

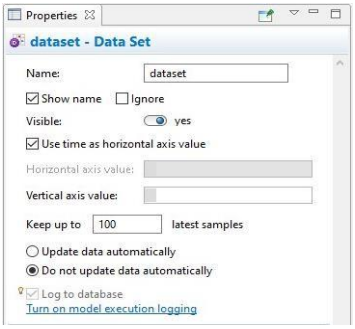
Run the model and observe the behavior. As you use the sliders to change the maximum waiting time or delivery time, you'll see your changes reflected in consumer behaviors and whole adoption dynamics.





Comparing model runs with different parameter values

Open the Main diagram and add a Data Set from the Analysis palette. Name it userDS.

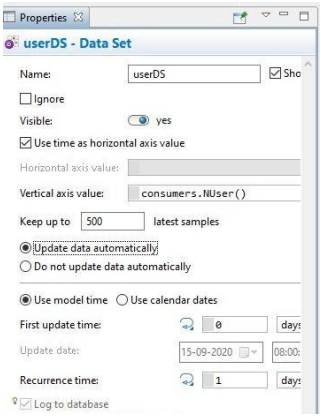


Data Set is capable of storing 2D (X,Y) data of type double. We want this data set to store the history of product sales dynamics. We'll store data samples, each with a timestamp and the current number of the product users.

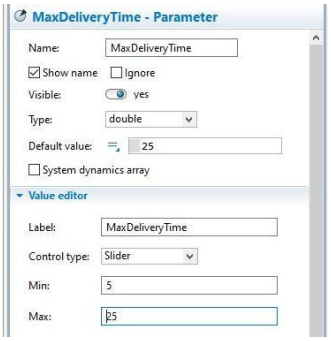
To store the timestamps, leave the dataset's option Use time as horizontal axis value selected.

Set the value that the dataset will store. In the Vertical axis value property, type: consumers.NUser().

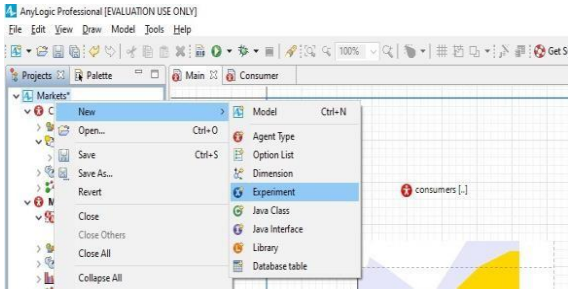
The dataset keeps a limited number of recent latest data items, and we'll limit our sample size to 500. Set the dataset to Keep up to 500 latest samples. Set it to Update data automatically with the default Recurrence time: 1. We'll add one data sample for one day of the model's lifetime.

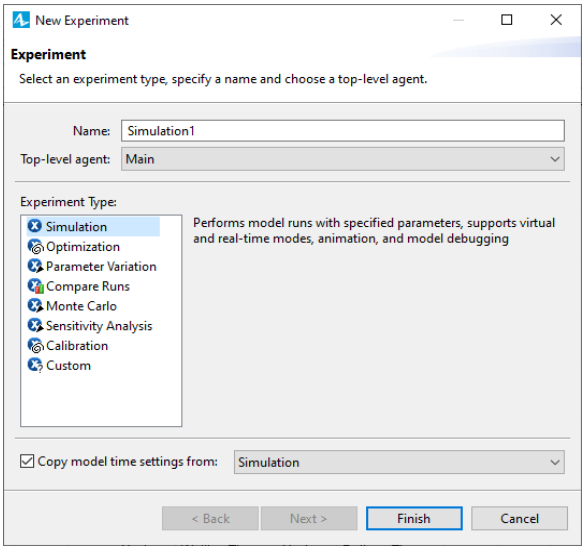


Next, make changes in the Value editor section for both parameters on Main diagram (MaxWaitingTime and MaxDeliveryTime). Choose Slider as Control type, set Min and Max values the same as we have in the sliders on Main, and if you want, change the default label (say, Maximum waiting time).

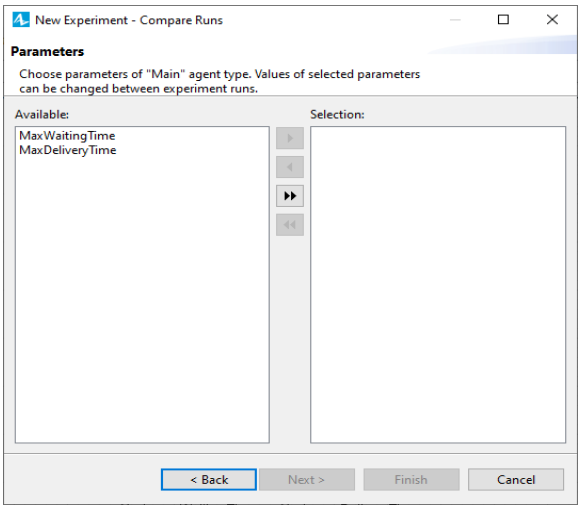


Open the Projects view, right-click the model item, and select New > Experiment from the context menu. The New experiment wizard will pop up.

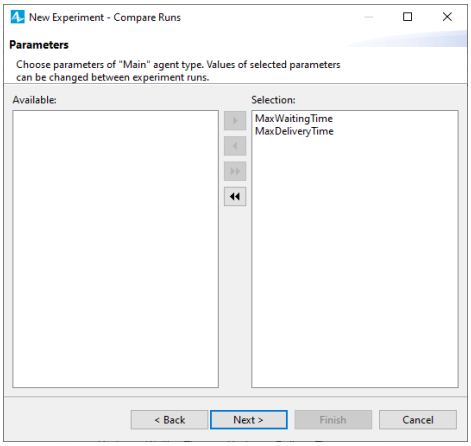




Select Compare Runs experiment from the list of experiment types and click Next.

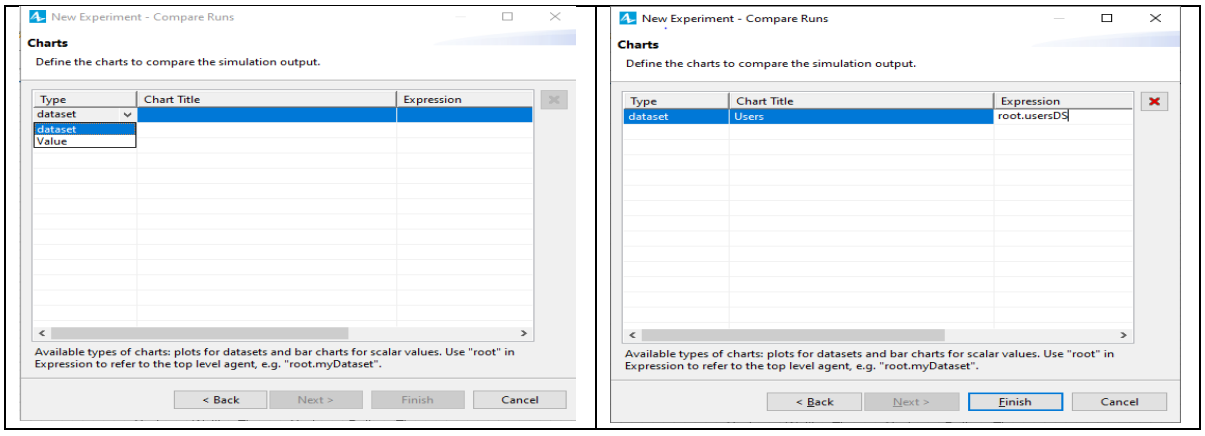


On the Parameters page, add both parameters to the Selection column. To add a parameter, select it in the Available list on the left and click the arrow. You can also click the button to add all the parameters. Click Next after both parameters are in Selection.



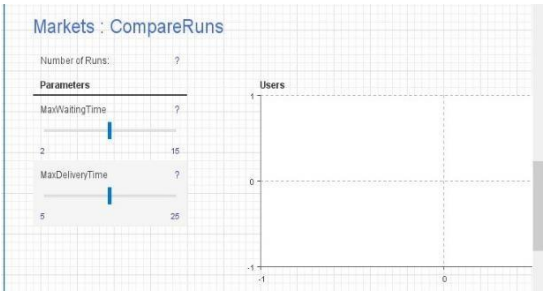
On the wizard's following page, configure the output charts for this experiment. The chart will display the data collected by the dataset usersDS. In the Charts table, do all of the following :

- In the Type column, select dataset.
- In the Chart Title column, type Users.
- In the Expression column, refer to the dataset you defined in Main as root.usersDS where root is the model's top-level agent (Main)

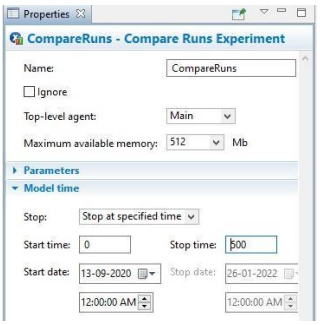


The chart will display the data collected by the dataset usersDS. Click Finish.

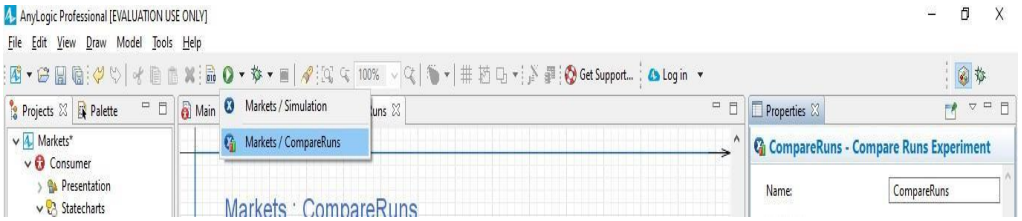
The CompareRuns experiment diagram should open automatically, and you'll see the default user interface we created with the wizard.



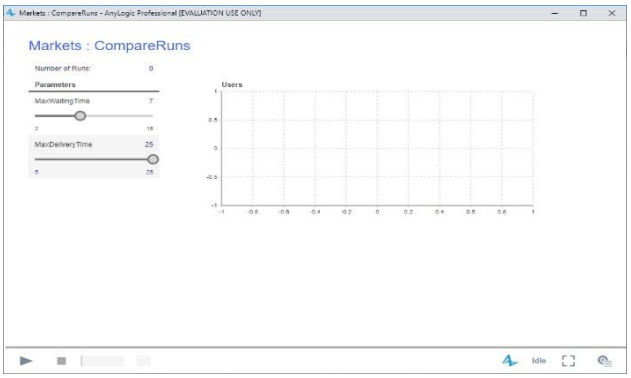
We want our experiment to simulate the model for just 500 days. To do this, select CompareRuns experiment in the Projects tree. In the experiment properties, open the Model time properties section, and type 500 in the Stop time field.



Run the experiment. Select the newly-created experiment from the Run list: Market / CompareRuns, or right-click the CompareRuns experiment in theProjects tree and select Run from the context menu.



In the model window, click the Run button to see the result associated with the default parameter values. Afterward, change the parameter values and click Run again to observe the system behavior for the new settings. The chart displays all the results for your review.



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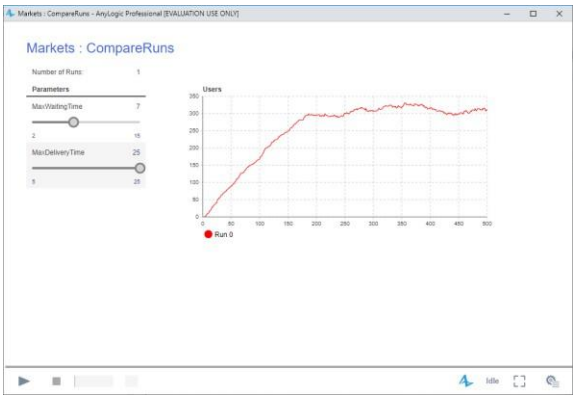
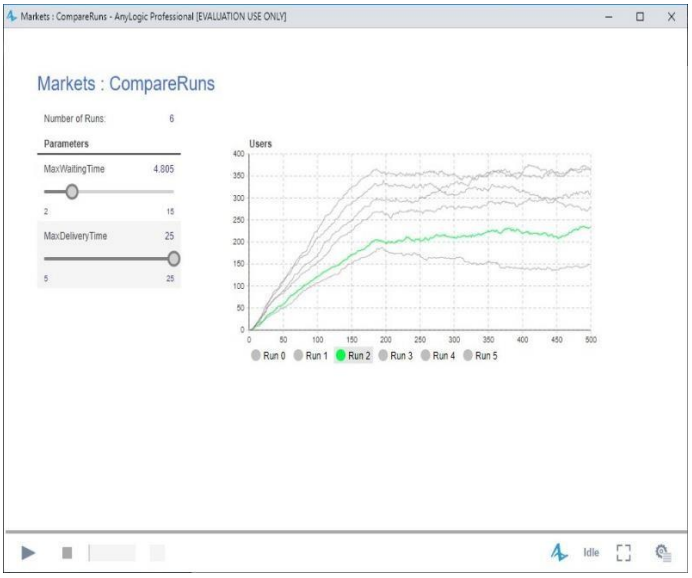


Each curve in a chart corresponds to a specific simulation run, and you can click any item in the chart's legend to highlight the curves that correspond to the run. The controls on the left will show the values that led to this result. To deselect a curve, click on its legend a second time.



You can copy the datasets by clicking in the legend and selecting Copy all or Copy selected from the context menu.

Roll No: 25166009

PRACTICAL NO: 04

Aim: Design and develop System Dynamic model by

- Creating a stock and flow diagram
- Adding a plot to visualize dynamics
- Parameter variation
- Calibration

[Use a case situation like spread of contagious disease for the purpose].

Code:

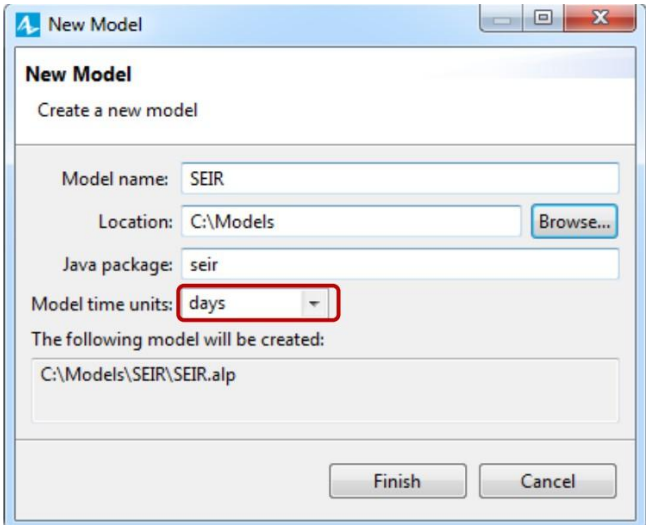
SIER Model

We're about to build a model that displays the spread of a contagious disease among a large population. Our sample model will have a population of 10,000 people – a value we call TotalPopulation – of which one person is infectious.

- During the infectious phase, a person comes into contact with an average of ContactRateInfectious = 1.25 people each day. If an infectious person comes into contact with a susceptible person, the susceptible person's probability of infection is Infectivity = 0.6.
- After a susceptible person is infected, the infection latent phase lasts for AverageIncubationTime= 10 days. We'll use the word exposed to describe people who are in the latent phase.
- After the latent phase, infectious phase starts. This phase lasts for AverageIllnessDuration = 15 days.
- Persons who have recovered from the disease are immune to a second infection.

Phase 1. Creating a stock and flow diagram

Create a new model by selecting File > New > Model from the menu, and then name it SEIR. Select days as Model time units.



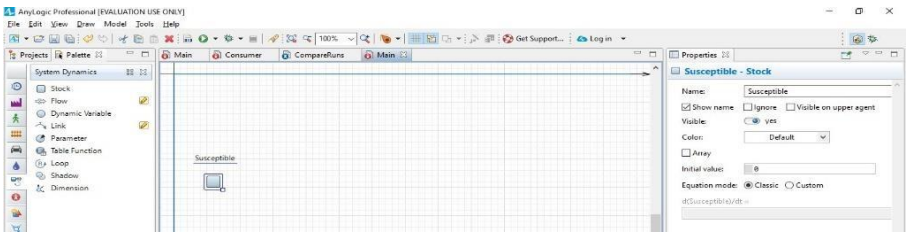
In this example, we'll consider four important characteristics:

- Susceptible - people who are not infected by the virus.
- Exposed - people who are infected but who can't infect others.
- Infectious - people who are infected and who can infect others.
- Recovered – people who have recovered from the virus

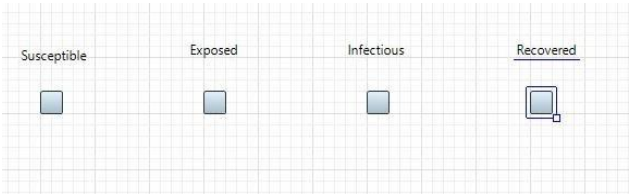
SEIR is an acronym that represents the four stages: Susceptible-Exposed-Infectious- Recovered. The terminology and the overall structure of the problem is taken from the ("Compartmental models in epidemiology". n.d.) --namely, from the SEIR (Susceptible Exposed Infectious Recovered) model.

There are four stocks in our model -one for each stage.

Open the System Dynamics palette. Drag the Stock from the System Dynamics palette on to the diagram. Name it Susceptible.



Add three more stocks. Place them as shown in the figure and name them Exposed, Infectious, and Recovered.

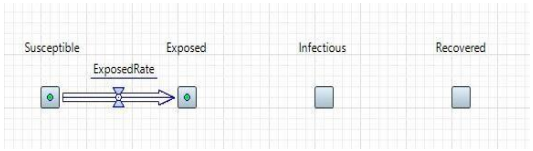


The flow's arrow shows its direction.

In our model, susceptible people are exposed to the virus, become infectious, and then recover. It's a progression that requires our model to use three flows to drive people from one stock to the next.

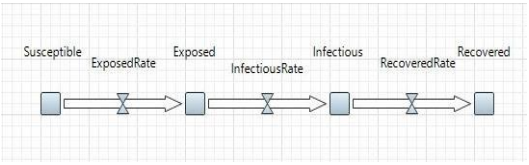
Add the first flow that flows from the stock Susceptible to Exposed. Double-click the stock where the flow flows out (Susceptible), and then click the stock where it flows in (Exposed).

Name the flow ExposedRate.

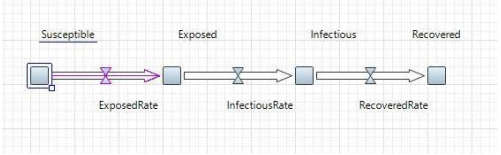


Add a flow from Exposed to Infectious, and then name it InfectiousRate.

Add a flow from Infectious to Recovered, and then name it RecoveredRate.

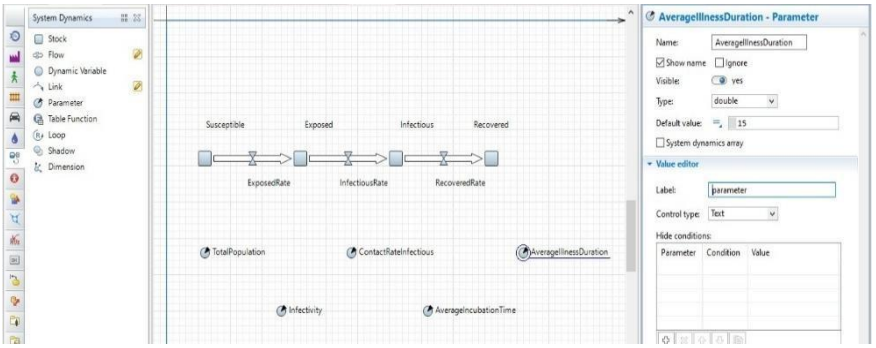


Rearrange the flow names as shown in the figure below. To do this, select a flow and then drag its name.

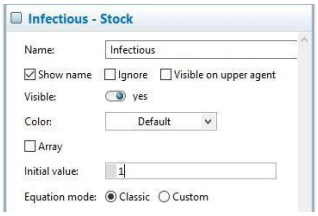


Add five Parameters, name them, and then define their default values according to the information below:

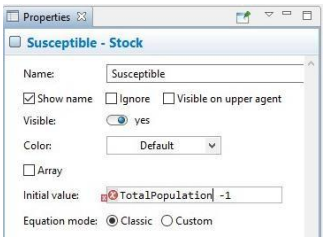
- TotalPopulation = 10000
- Infectivity = 0.6
- ContactRateInfectious = 1.25
- AverageIncubationTime = 10
- AverageIllnessDuration = 15



Define the number of infected people by specifying 1 as the Initial Value of the stock Infectious.

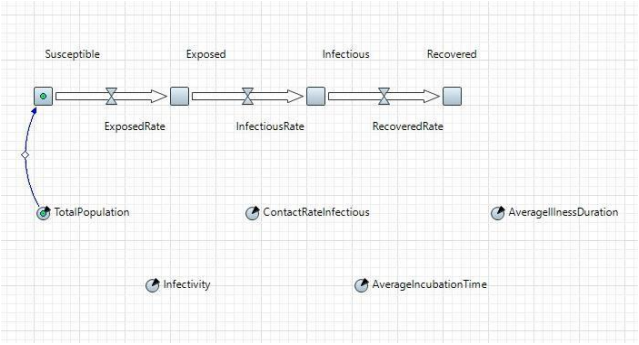


Define the Initial Value for the stock Susceptible: TotalPopulation-1.



Draw a dependency link from TotalPopulation to Susceptible.

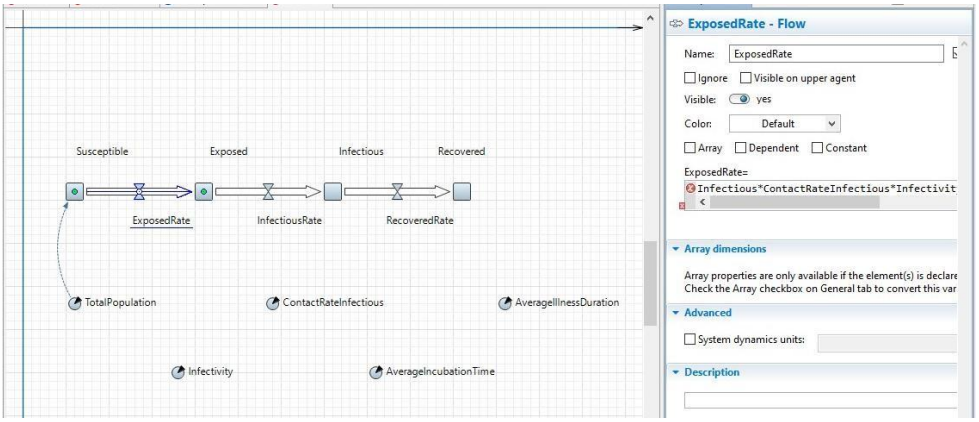
In the System Dynamics palette, double-click the Link element, click TotalPopulation, and then click the stock Susceptible. You should see the link with small circles drawn on its end points:



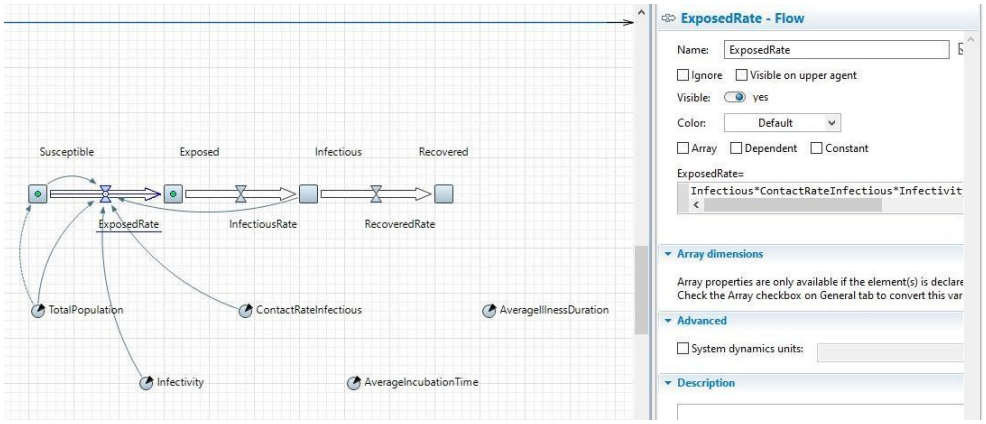
Let's define the formula for the flow ExposedRate.

Click the flow and define the following formula using the Code Completion assistant:

Infectious*ContactRateInfectious*Infectivity/TotalPopulation+Susceptible



Right-click ExposedRate flow in the graphical diagram and choose Fix Variable Links > Create Missing Links from the context menu. Afterward, you should see the links in the stock and flow diagram:



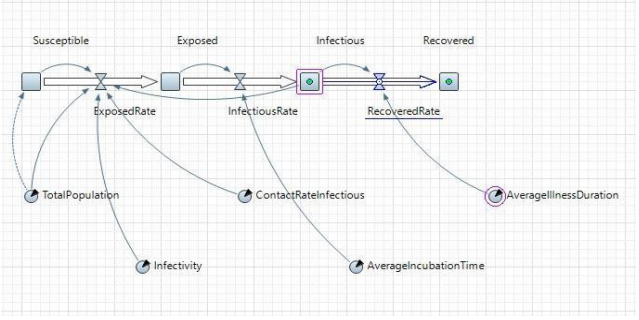
Define the following formula for InfectiousRate:

Exposed/AverageIncubationTime

Define the following formula for RecoveredRate:

Infectious/AverageIllnessDuration

Draw the missing dependency links, and your stock and flow diagram should resemble the following image:



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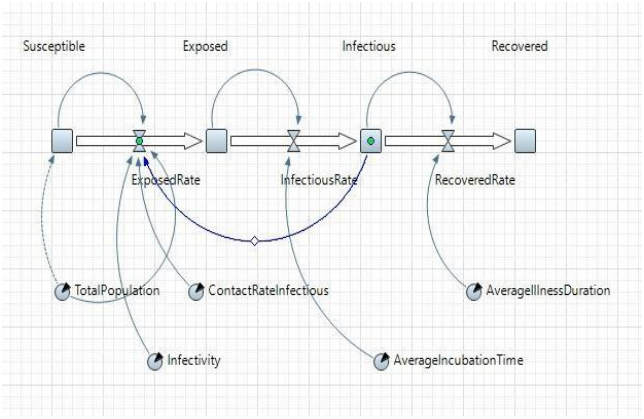
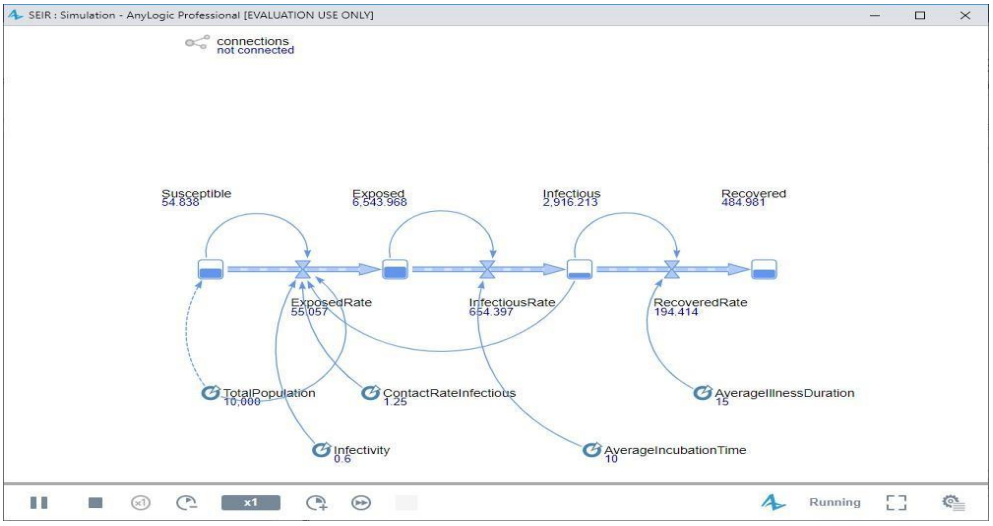
Adjust the appearance of dependency links. Modify the link's bend angles to make the diagram match the figure below. To adjust the link's bend angle, select it, and then drag the handle in the middle of the link.



Run the model and inspect the dynamics using the variable's inspect windows. To open a variable's, inspect window, click the variable to select it. To resize the window, drag its lower right corner.

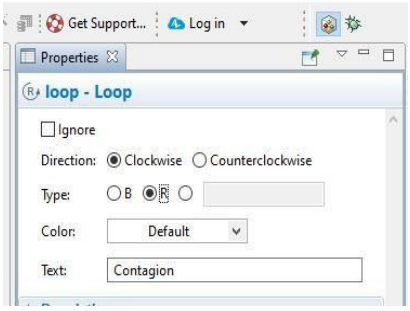


Adding a plot to visualize dynamics

We'll add a loop identifier for one loop to show you.

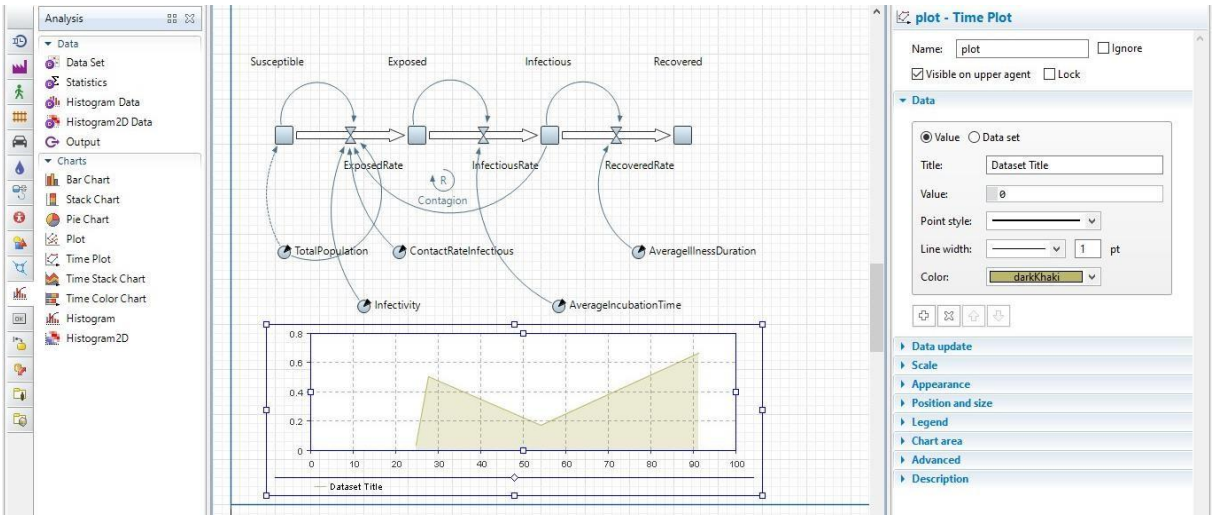
Drag the Loop element from the System Dynamics palette on to the diagram, and then place it as shown in the figure.

Go to the loop's Properties, change its Type to R(stands for Reinforcing), leave the default Clockwise Direction, and specify the text AnyLogic will display near the loop icon: Contagion.



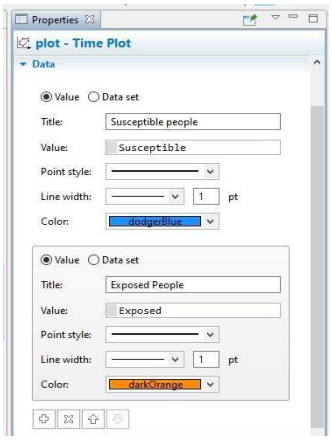
Let’s add a time chart to plot Susceptible, Exposed, Infectious, and Recovered people.

Drag the Time Plot from the Analysis palette on to the diagram, and extend the time plot as shown in the figure below:

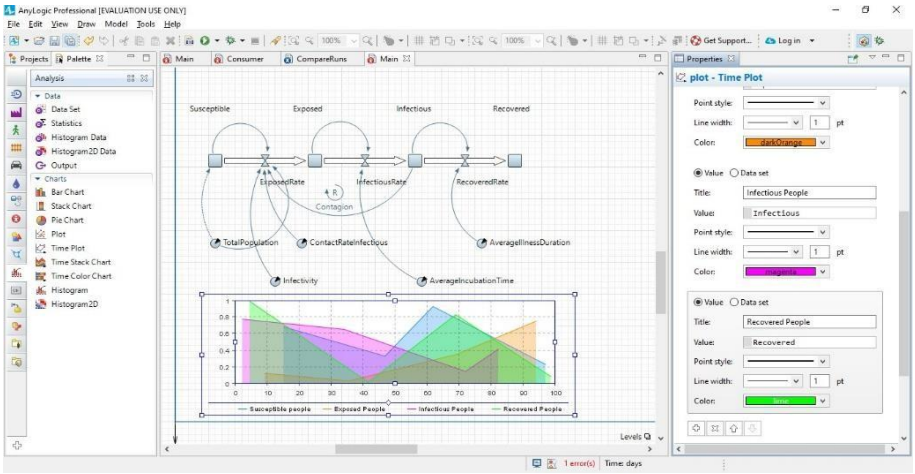


In the Properties view, go the section Data and click the Plus button to add a new data item. Modify the data item's properties:

Title : Susceptible people – title of the data item. Value : Susceptible (use Code Completion Master).



Add three data items to display the values of stocks Exposed, Infectious, and Recovered in the same way -and don't forget to define the corresponding Titles.



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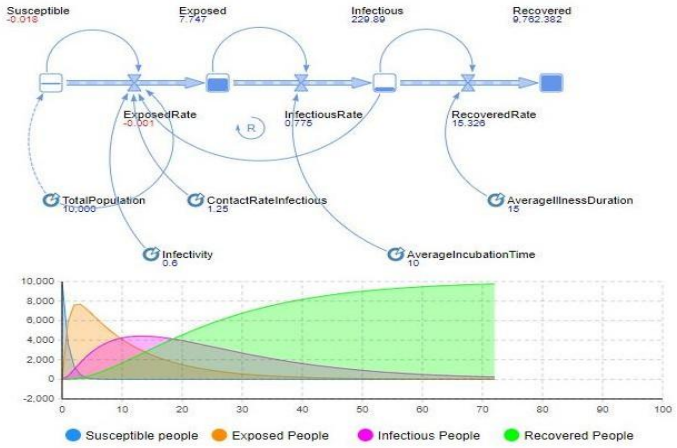
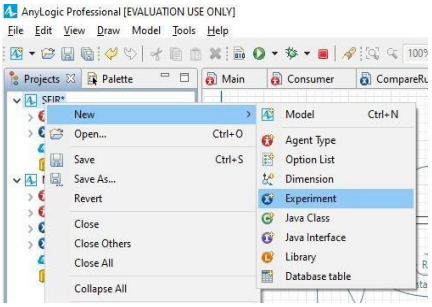
We've finished our last model. Now, run the model and use the chart you added to view its dynamics.



Parameter Variation

The parameter variation experiment allows us to create a complex model simulation that performs a series of single model runs that vary by one or many parameters. After the experiment is complete, AnyLogic can display each run's results on a single diagram to help us better understand how the varying parameters affected our model's results.

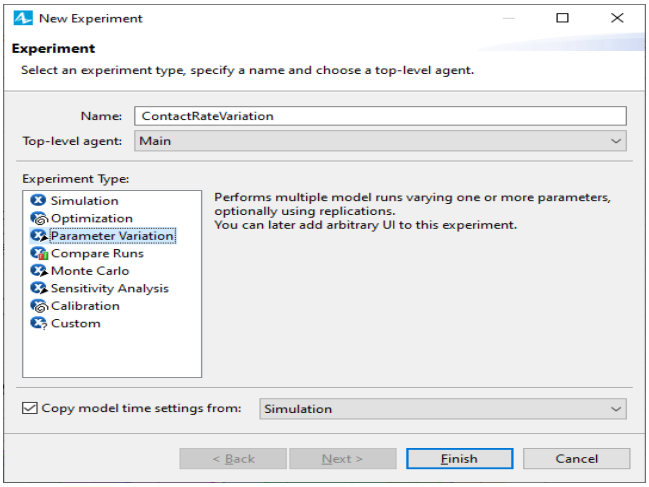
To add an experiment to the model, right-click the model item (SEIR) in the Projects tree, point to New, and then click Experiment.



In the New Experiment wizard's Namefield, type ContactRateVariation.

AnyLogic will automatically select the Main agent type as the Top-level agent.

In the Experiment Type area, click Parameter Variation, and click Finish.



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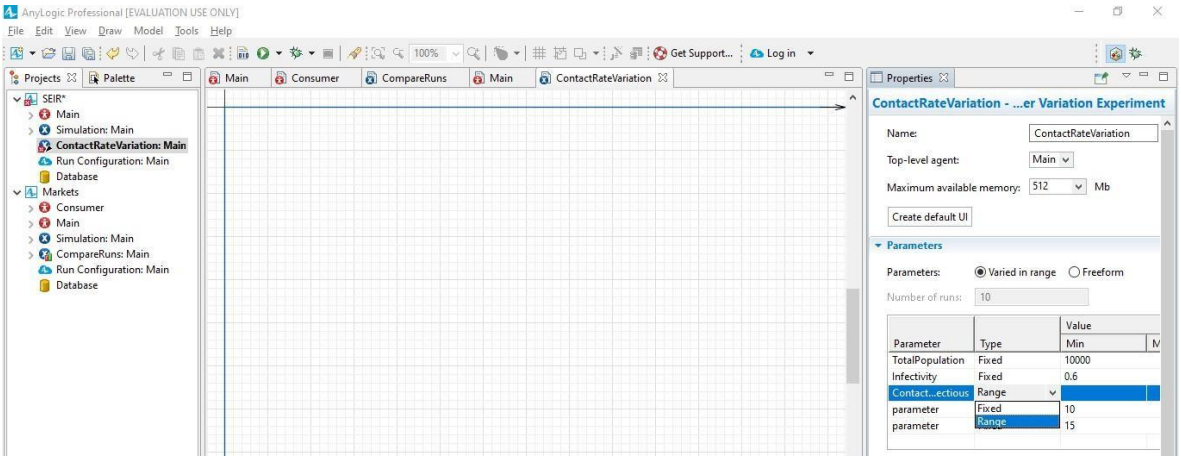
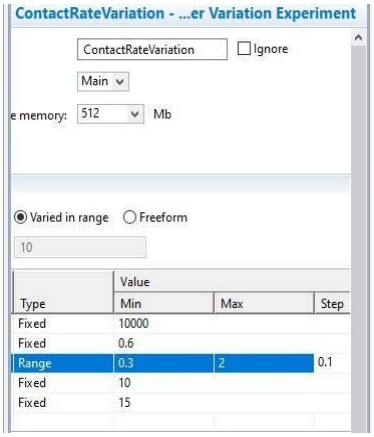
In the experiment's properties, open the Parameters section. The parameters of the experiment's top-level agent (in our case, Main) display.

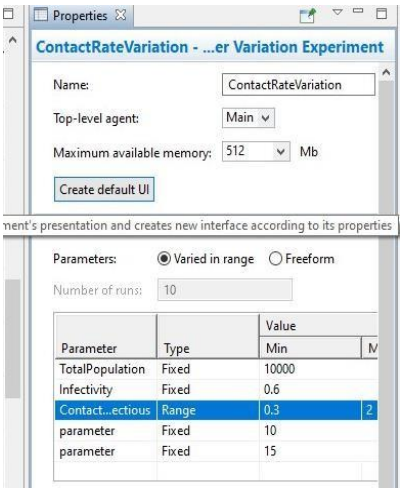
To ensure our experiment varies the contact rate, locate the table's ContactRateInfectious parameter and change its Type to Range



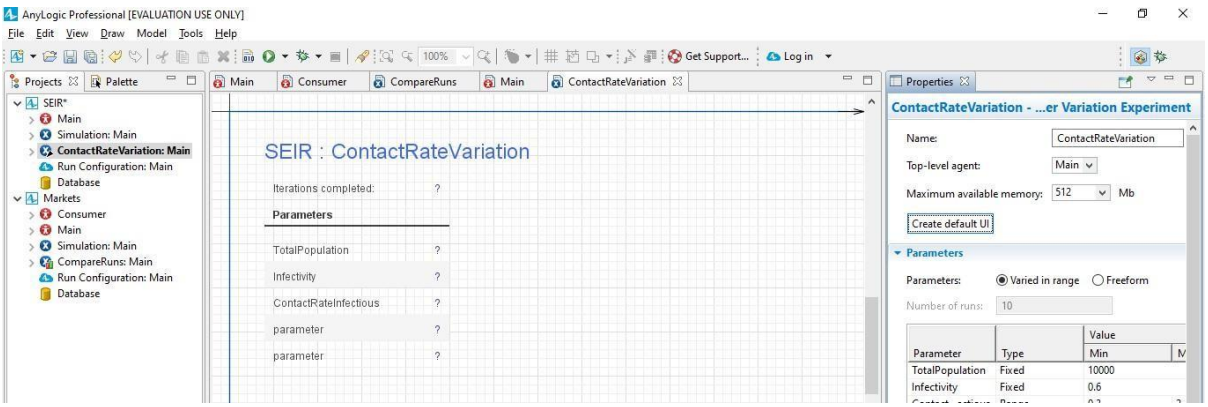
Set the parameter's minimum and maximum values by setting Min: 0.3 and Max: 2 with a Step of 0.1.



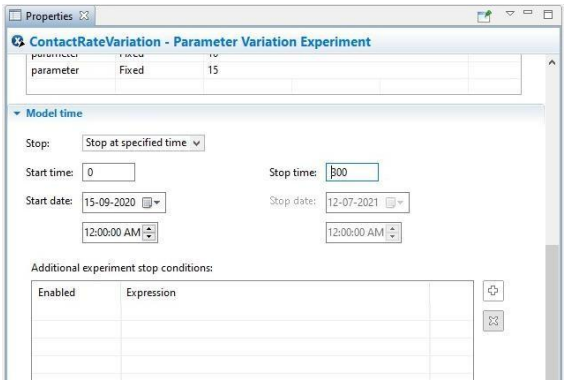
In the Properties area, click Create default UI.



The experiment diagram will display the simple user interface

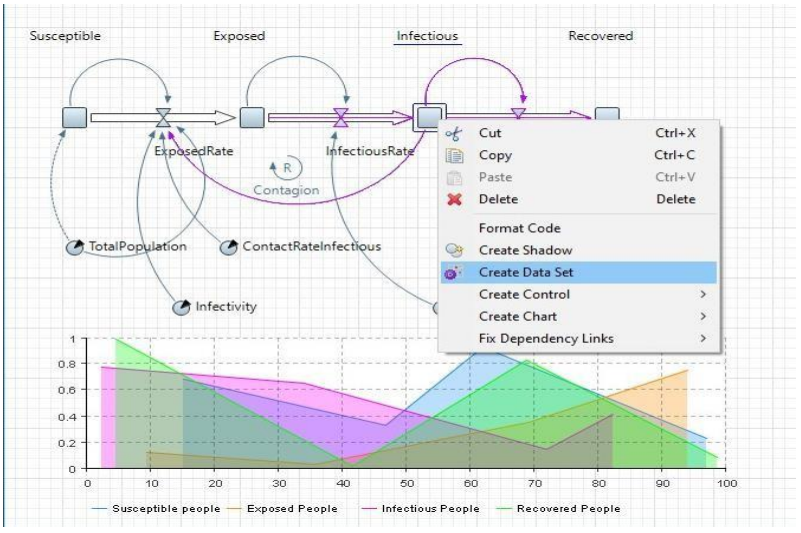


To ensure each run simulates exactly 300 days, we need to limit the model's lifetime to 300 days. Click ContactRateVariation in the Projects tree to open its properties. In the Properties view, open the Model time section, select Stop at specified time from the Stop list, and type 300in the Stop timebox



Now, we'll add a time plot to display our experiment's results. Our first step is to gather data about the number of infectious persons.

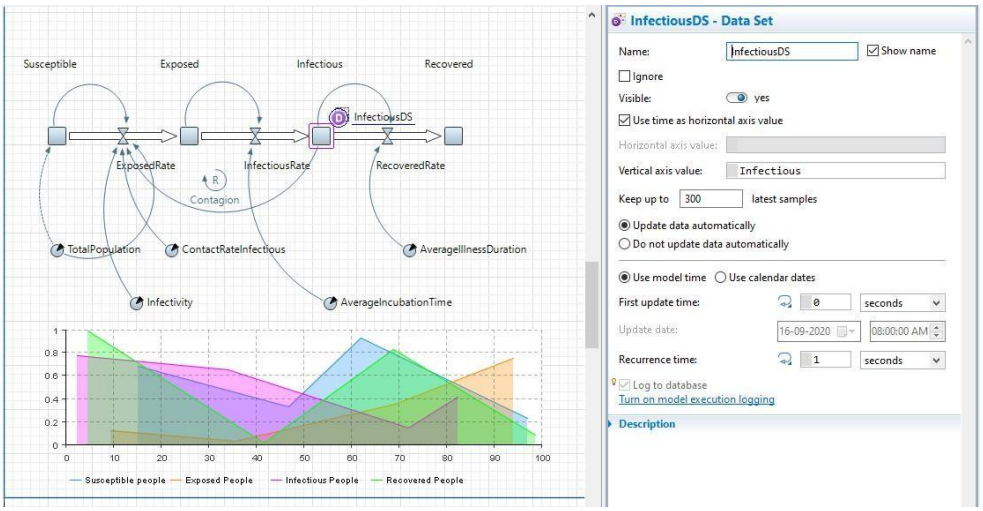
Open the Main diagram, right-click the Infectious stock and then click Create Data Set.



After the InfectiousDS data set displays, navigate to its properties. Since we want to view the infectious disease's dynamics, leave the Use time as horizontal axis value checkbox selected.

Select Update data automatically and leave Recurrence time: 1 to add one data sample to our dataset for each model life day.

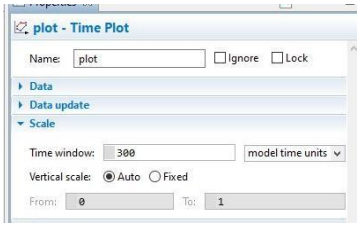
To obtain data samples for the whole model run, set the dataset to Keep up to 300 latest samples.



We're ready to add a chart to the ContactRateVariation experiment diagram that will display our results.

Open ContactRateVariation diagram, and drag the Time Plot from the Analysis palette.

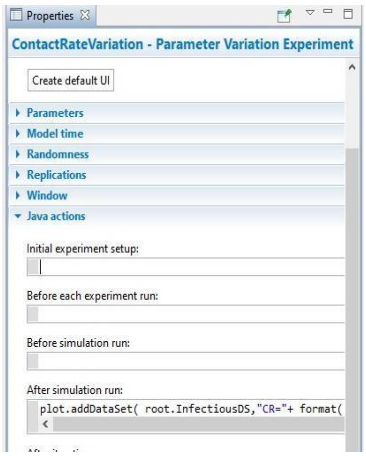
Open the time plot's properties. In the Scale section, ensure the time plot displays data for 300 model time units by setting the Time window to 300 model time units. Enlarge the area available for the plot's legend by dragging the diamond handle toward the top of the screen.



The plot's curves will each display the results from one model run: the history of disease spread for a contact rate collected by the InfectiousDS dataset.

Click ContactRateVariation in the Projects tree to open its properties, and then add data to the plot by navigating to the Java actions section and typing the following code in the After simulation run field:

```
plot.addDataSet( root.InfectiousDS,"CR="+ format( root.ContactRateInfectious ) );
```



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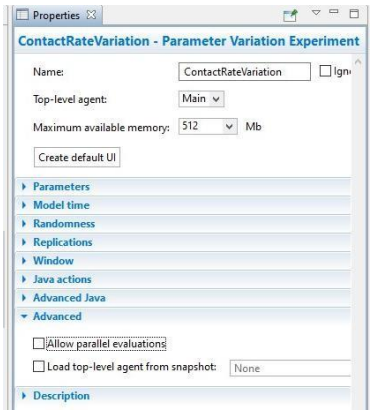
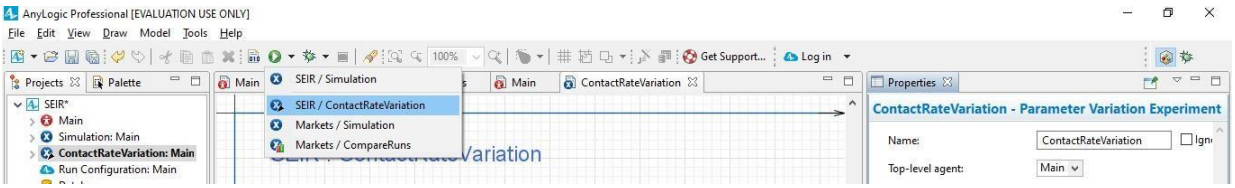
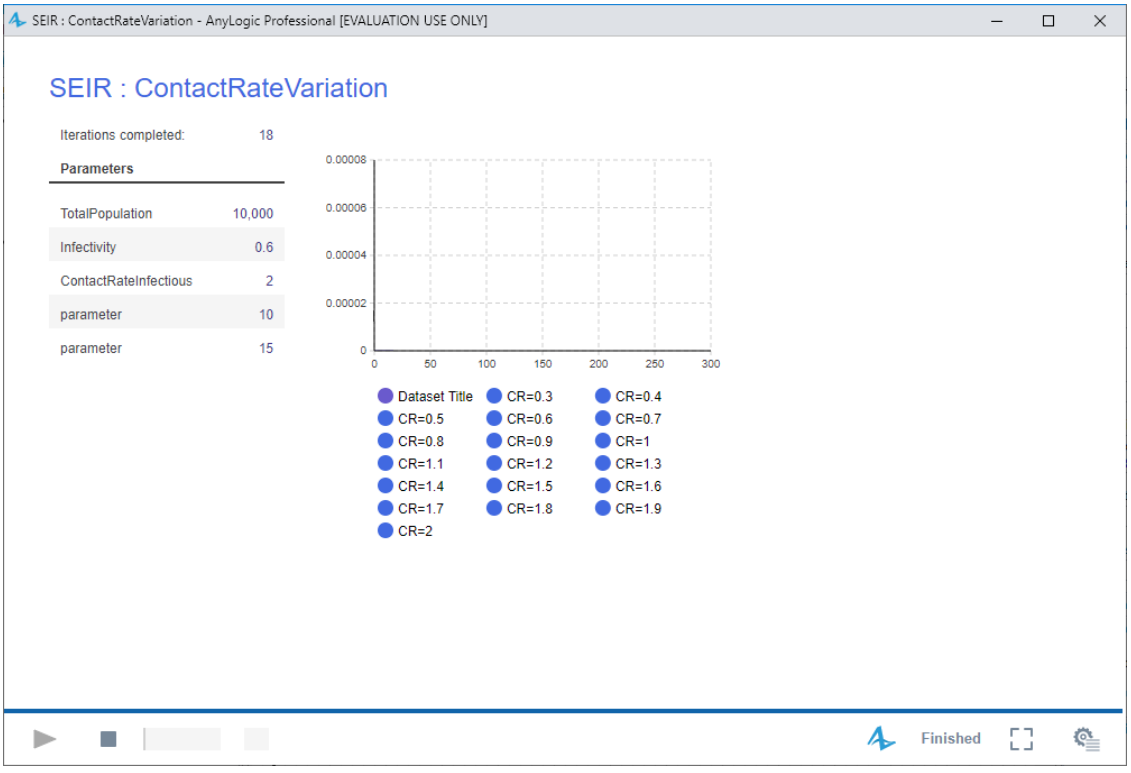
Open the ContactRateVariation experiment properties Advanced section and then clear the Allow parallel evaluations checkbox.



We're ready to run the experiment and use our chart to observe the data we've gathered from multiple simulation runs. In the toolbar, on the Runlist, select SEIR / ContactRateVariation.



In the presentation window, click Run.



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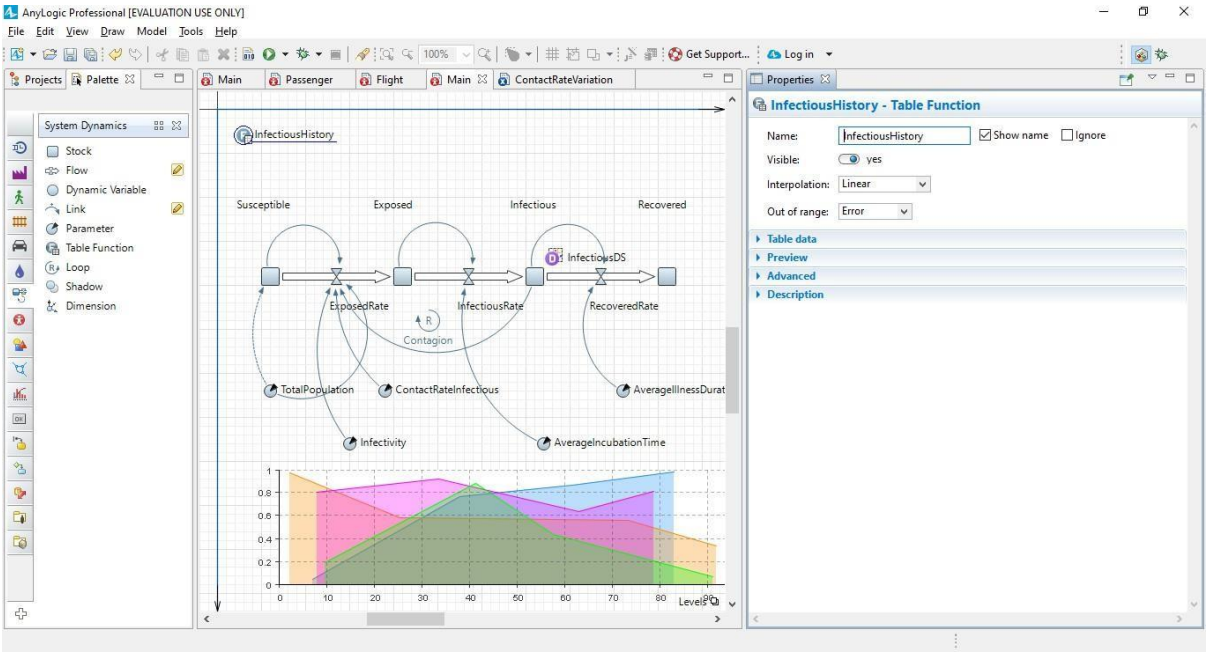
Calibration experiment

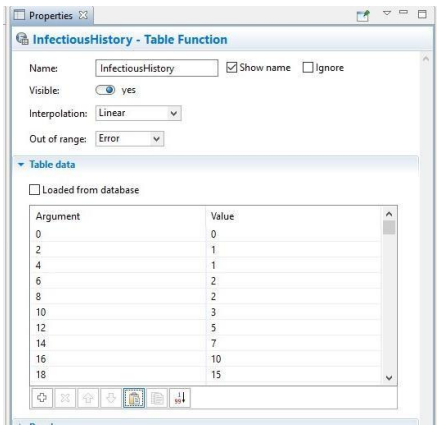
- Calibration experiment uses the built-in OptQuest optimizer to locate the model parameter values that correspond to the simulation output that best fits the given data.
- Calibration experiment iteratively runs the model, compares the model's output to the historical pattern, and then changes the parameter values. After a series of runs, the experiment will determine which parameter values produce the results that best match the historical pattern.

Open the Main diagram and add a Table function from the System Dynamics palette. Name it InfectiousHistory.

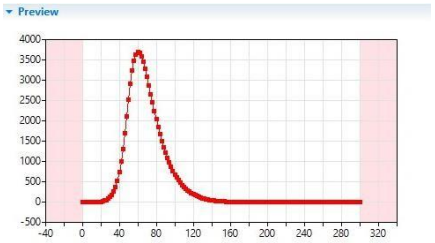


Open the HistoricData.txt file from AnyLogic folder/resources/AnyLogic in 3 days/SEIR. The AnyLogic folder is the location on your computer where you installed AnyLogic, such as Program Files/AnyLogic 7 Professional.

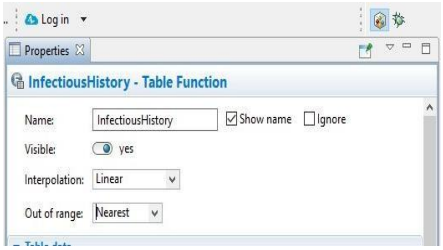
Copy the text file's contents to the Clipboard, go to the table function properties Table Data section, and then click the Paste from clipboard button. The Argument and Value columns will automatically update.



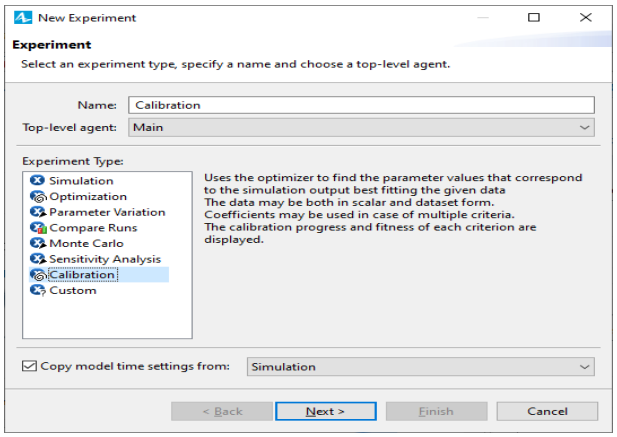
You can preview the curve built for the table function in the table function's properties' Preview section.



Set the Out of range option to Nearest to ensure the function correctly addresses cases where the function's argument exceeds the value of 300 that we defined in the Table data.



Right-click the model item (SEIR) in the Projects tree, point to New, and then click Experiment. In the New Experiment wizard, choose Calibration as the Experiment type and then click Next. This time, we'll use the wizard to set the parameters.

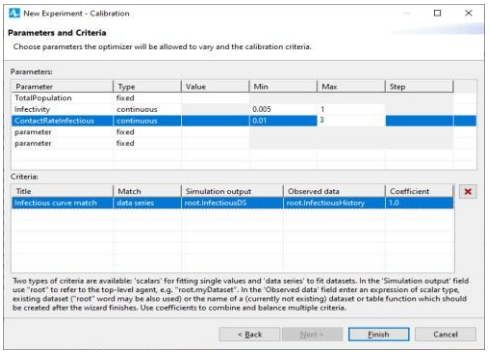


Change the parameter types we want to calibrate (Infectivity and ContactRateInfectious) from fixed to continuous, and then set the range's Min and Max values as shown in the figure below.

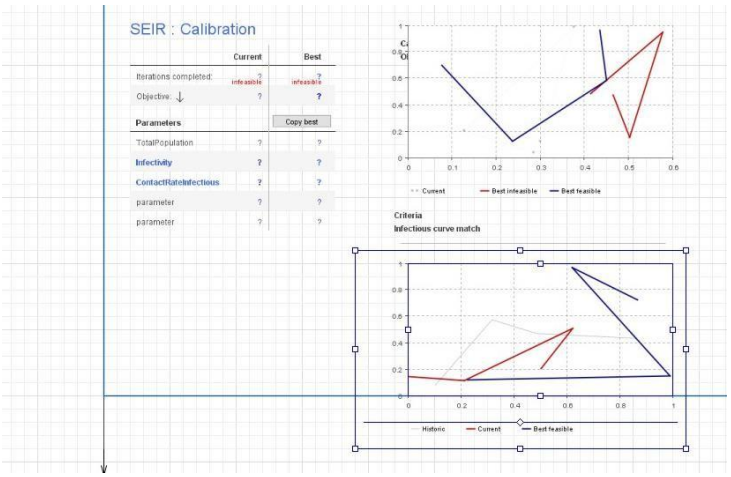
In the Criteria table shown below, enter the following information. Title: Infectious curve match

Match: data series

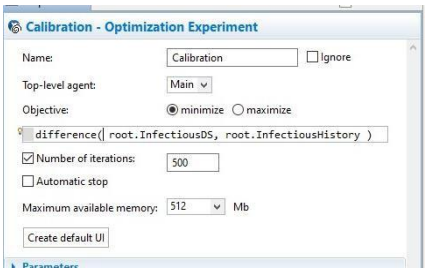
Simulation output: root.InfectiousDS
Observed data: root.InfectiousHistory
Coefficient: 1.0



Click Finish. The Calibration experiment diagram will display the configured user interface (UI).

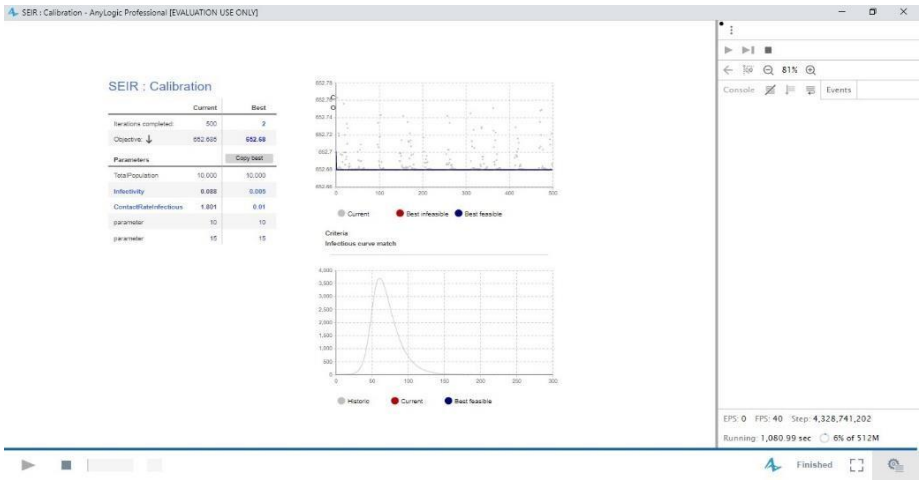


The image below shows the experiment's properties. Its objective is to minimize the difference between the model output and historical data.



Open the calibration experiment properties' Advanced section and then clear the Allow parallel evaluations checkbox.

Run the calibration experiment by either right-clicking Calibration in the Projects view and then clicking Run, or by selecting SEIR / Calibration from the list of experiments in the Run toolbar menu



After the calibration is complete, you can copy the best fitting parameter values by clicking the experiment window's copy button and then paste them into the simulation experiment by clicking the Paste from clipboard button that you'll find on the Simulation experiment's properties page.

After you've pasted the parameter values into the experiment, you can then run the Simulation with the newly - calibrated parameter values.

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PRACTICAL NO: 05

Aim: Design and develop a discrete-event model that will simulate process by

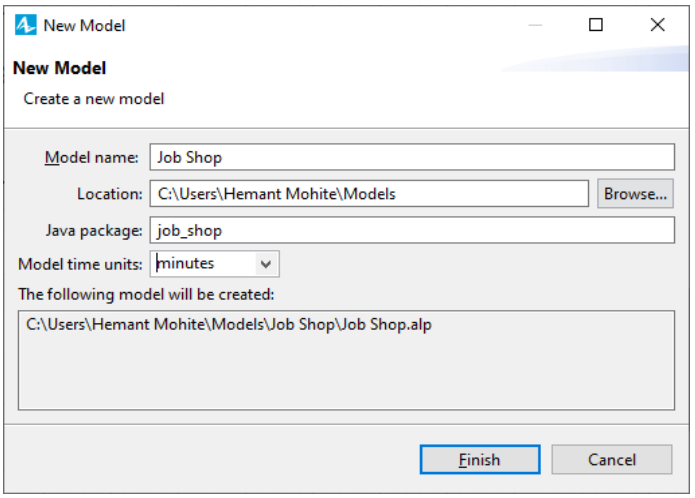
- Creating a simple model
- Adding resources

[Use a case situation like a company's manufacturing and shipping].

Code:

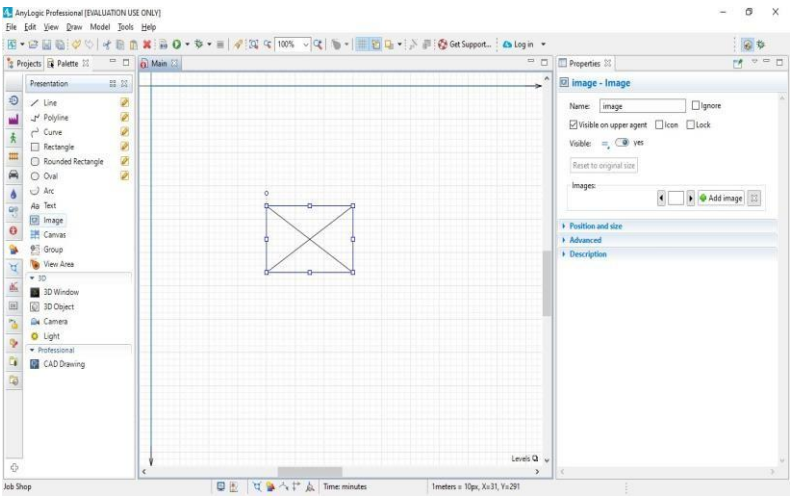
Creating Simple Model

Create a new model. In the New Model wizard, set the Model name: Job Shop, and Model time units: minutes.



Open the Presentation palette. The palette has several shapes that you can use to draw model animation, including a rectangle, a line, an oval, a polyline and a curve.

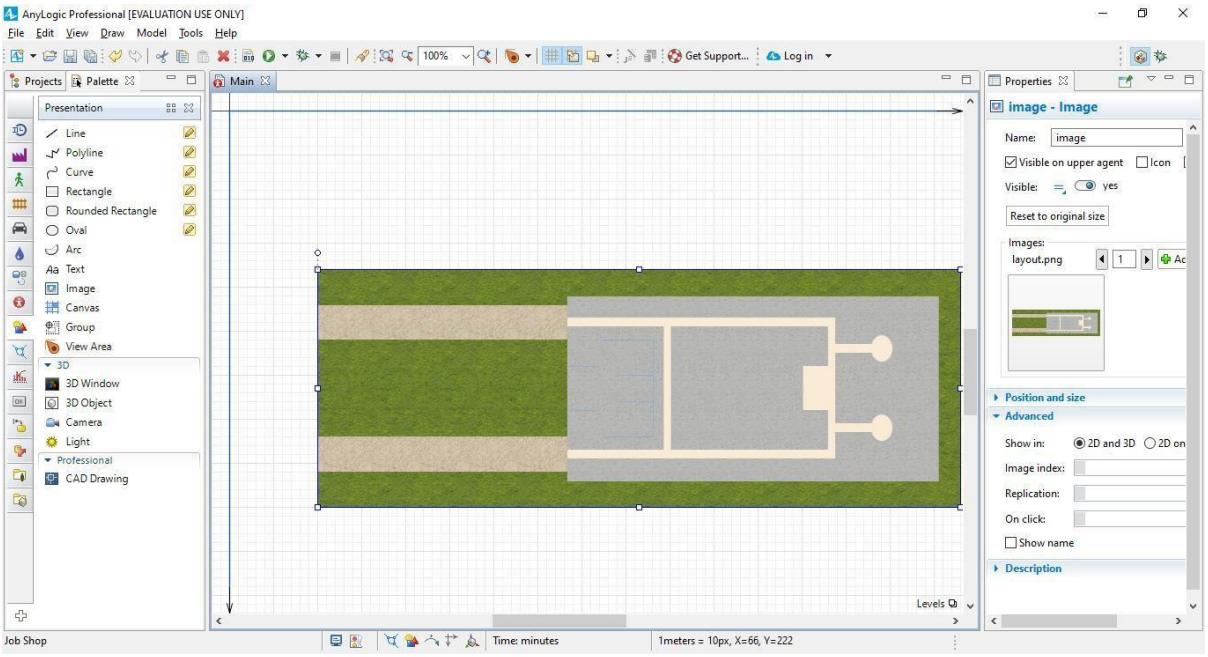
On the Presentation palette, select the Image shape and then drag it onto the Main diagram. You can use the Image shape to add images in several graphic formats -- including PNG, JPEG, GIF, and BMP – to your presentation.



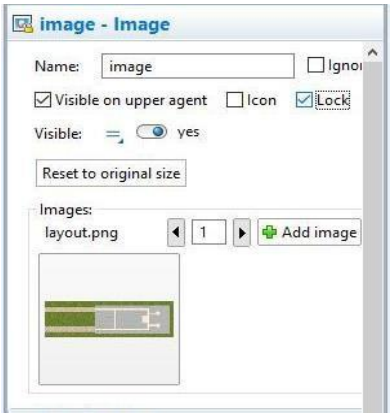
You'll see the dialog box that prompts you to choose the image file the shape will display. Browse to the following location and then select the layout.png image:

AnyLogic folder/resources/AnyLogic in 3 days/Job Shop

After you select the layout.png image, our diagram of the Main agent type should look like the following image:

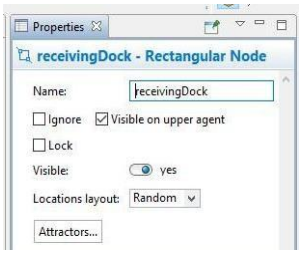


Select the image in the graphical editor. In the Properties view, select the Lock checkbox to lock the image.

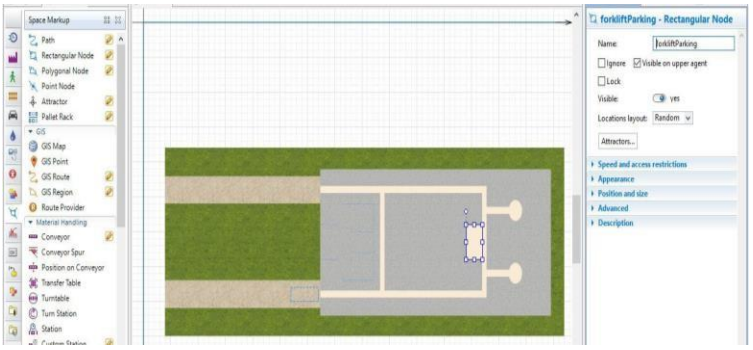


Open the Space Markup palette and drag the Rectangular Node element on to the Main diagram. Resize the node. The node should look as in the figure below.

Name the created node receivingDock.



Draw a node to define the location where the model's agents will park forklift trucks once the trucks are idle or the agents no longer need them to complete a task. Use another Rectangular node to draw the parking area as shown in the figure below and then name this node forkliftParking.

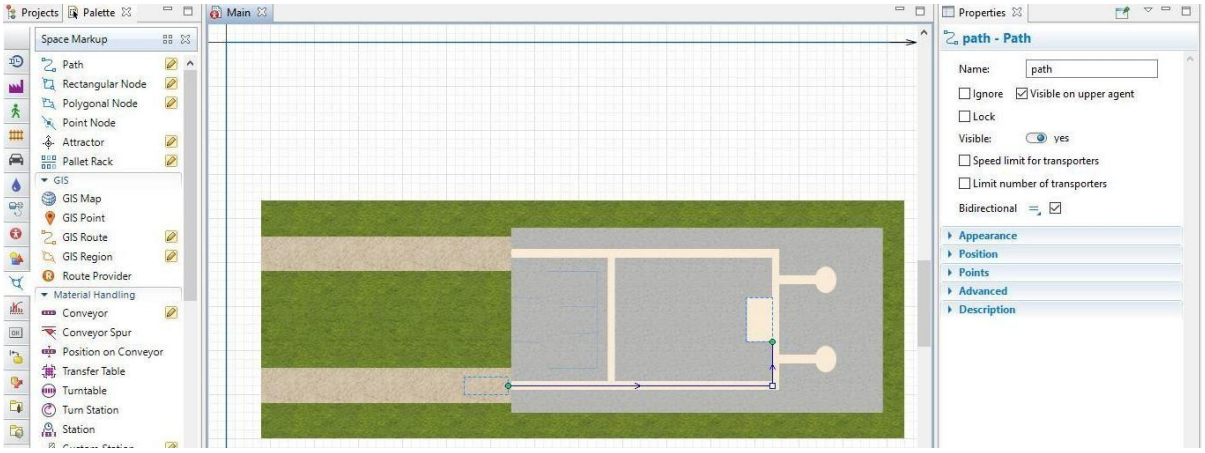


Let's draw a movement path to guide our model's forklift trucks.

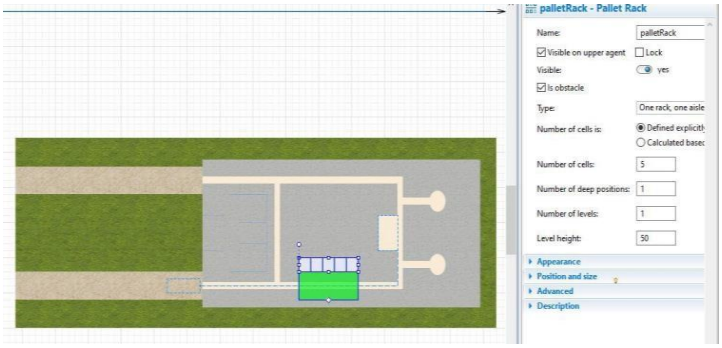
Do the following to draw a movement path that will guide our model's forklift trucks:

a. In the Space Markup palette, double-click the Path element to activate its drawing mode.
b. Draw the path as shown in the figure below by clicking the receivingDock border, clicking in the diagram to add the path's turning point, and then clicking the forkliftParking node's border.

If you've successfully connected the nodes, the path's connection points will display cyan highlights each time you select the path.



Define your model's warehouse storage by dragging the Pallet Rack element from the Space Markup palette on to the layout and placing its aisle on the path. A correctly - placed pallet rack will display a green highlight that shows it is connected to the network.



In the pallet rack's Properties area, do the following:

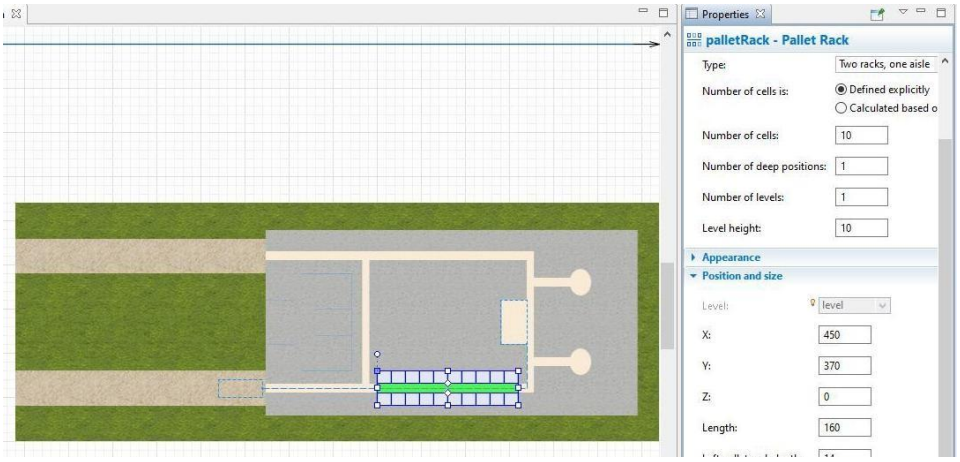
a. Set Type to: two racks, one aisle
b. Number of cells:10
c. Level height: 10

In the Position and size section:

d. Length: 160
e. Left pallet rack depth: 14
f. Right pallet rack depth: 14
g. Aisle width: 1113.

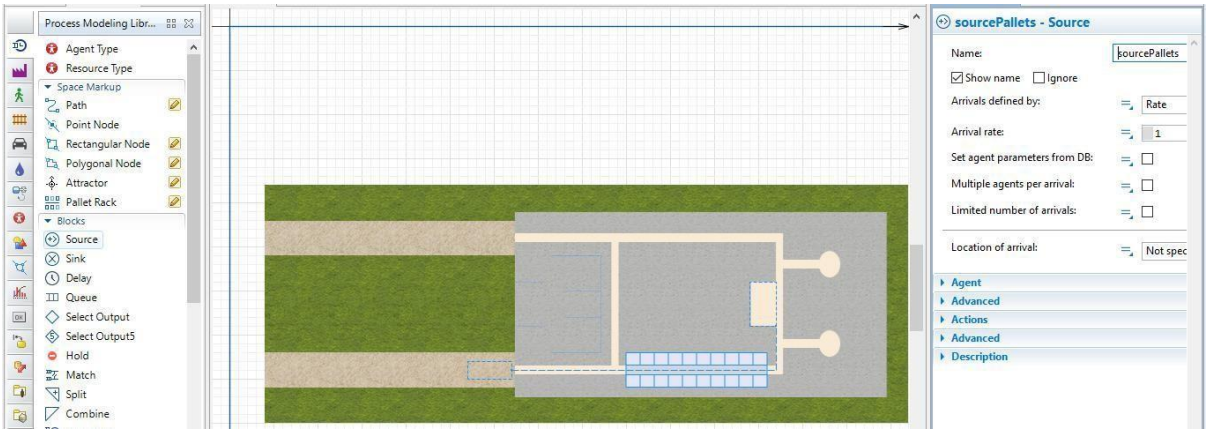
After you've completed these changes, the pallet rack should resemble the pallet rack shown in the figure below. If necessary, move the pallet rack so that its center aisle lies on the path.

Make sure the pallet rack is connected to the network by clicking it twice to select it. Your first click will select the entire network, and the second will select the pallet rack. The pallet rack should display a green highlight that shows it is connected to the network.



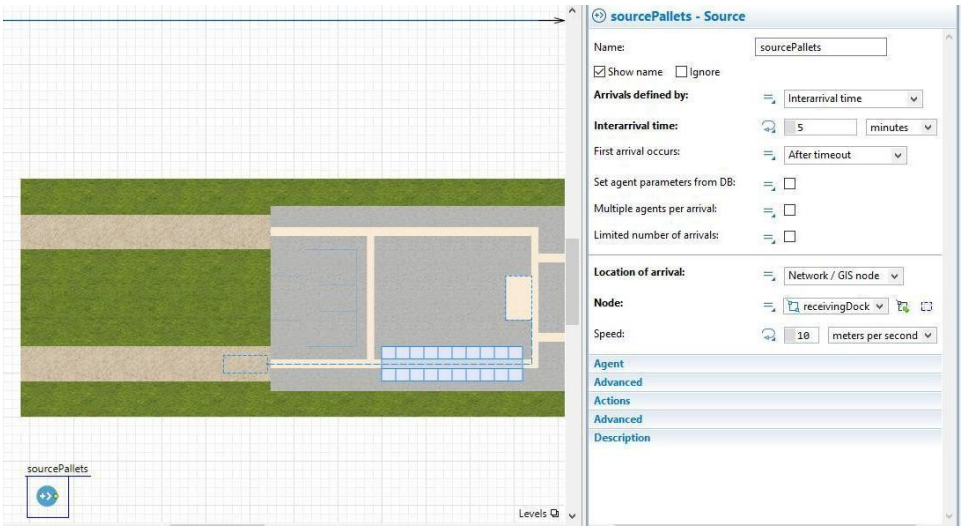
Drag the Source element from the Process Modeling Library palette on to the graphical diagram and name the block sourcePallets.

While the Source block usually acts as a process starting point, our model will use it to generate pallets.



In the sourcePallets block's Properties area, do the following to ensure the model's pallets arrive every five minutes and appear in the receivingDock node.

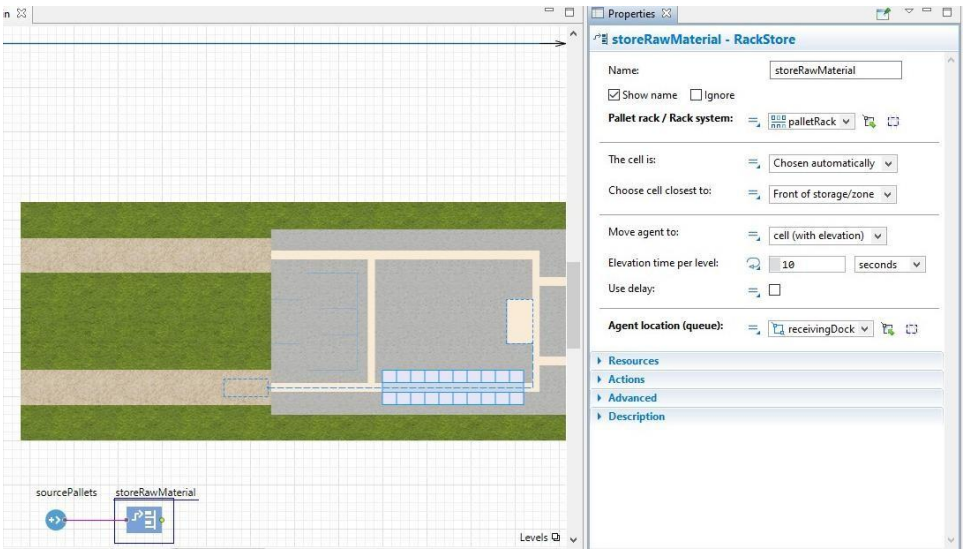
a. In the Arrivals defined by area, click Interarrival time.
b. In the Interarrival time box, type 5, and select minutes from the list on the right to have pallets arrive every five minutes.
c. In the Location of arrival area, click Network / GIS node in the list.
d. In the Node area, click receivingDock in the list.



Drag the RackStore block from the Process Modeling Library palette on to the diagram and place it near the sourcePallets block so they are automatically connected as shown in the diagram below.

The RackStore block places pallets into a given pallet rack's cells. In the rackStore block's Properties area, do the following:

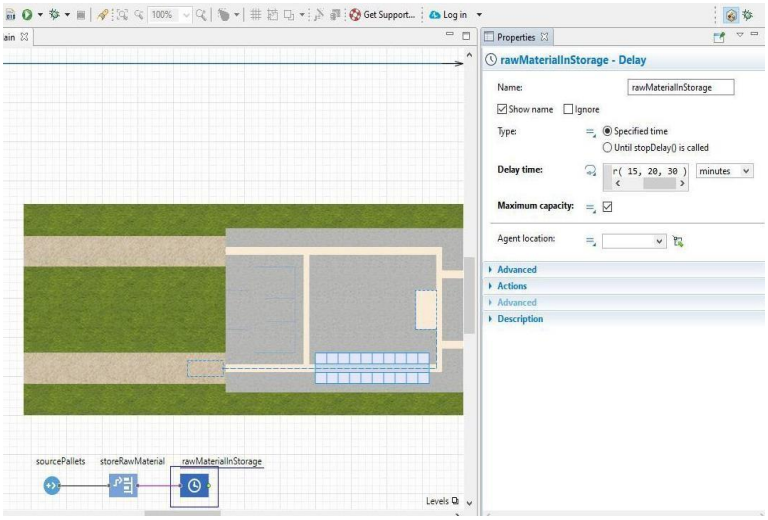
a. In the Name box, type storeRawMaterial.
b. In the Pallet rack / Rack system list, click palletRack.
c. In the Agent location (queue)list, click receivingDock to specify the location where agents wait to be stored.



Add a Delay block to simulate how pallets wait in the rack and then name the block rawMaterialInStorage.

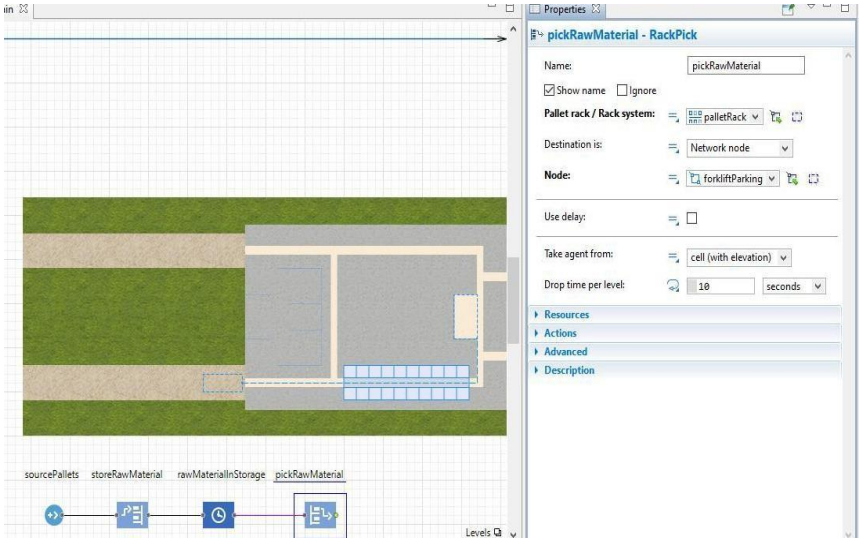
In the rawMaterialInStorageblock's Properties area, do the following:

a. In the Delay timebox, type triangular(15, 20, 30) and select minutes from the list.
b. Select the Maximum capacity checkbox to ensure agents will not get stuck as they wait to be picked up from storage.

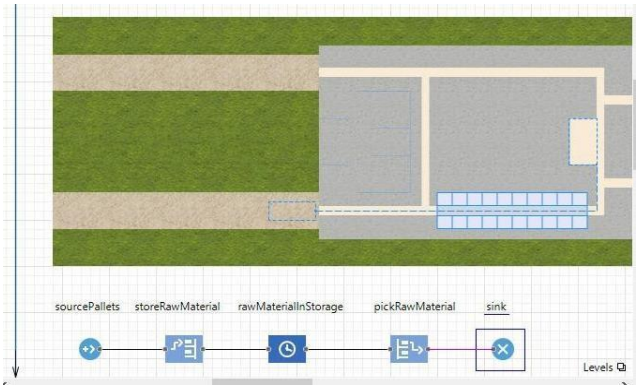


Add a RackPick block, connect it to the flowchart, and then name it pickRawMaterial. In the pickRawMaterial block's Properties area, do the following:

a. In the Pallet rack / Rack system list, click palletRack to select the pallet rack that will provide pallets to agents.
b. In the Node list, click forkliftParking to specify where the agents should park forklift trucks.



Add a Sink block. The Sink block disposes agents and is usually a flowchart's end point.



We've finished building this simple model, and you can now run it and observe its behavior. Run the model (Job Shop / Simulation experiment).

Roll No: 25166009

Adding Resources

Resources

Resources are objects that agents use to perform a given action. An agent must obtain the resource, perform the action, and then release the resource.

Some examples of resources include:

- A hospital model's doctors, nurses, equipment, and wheelchairs
- A supply chain model's vehicles and containers
- A warehouse model's forklift trucks and workers

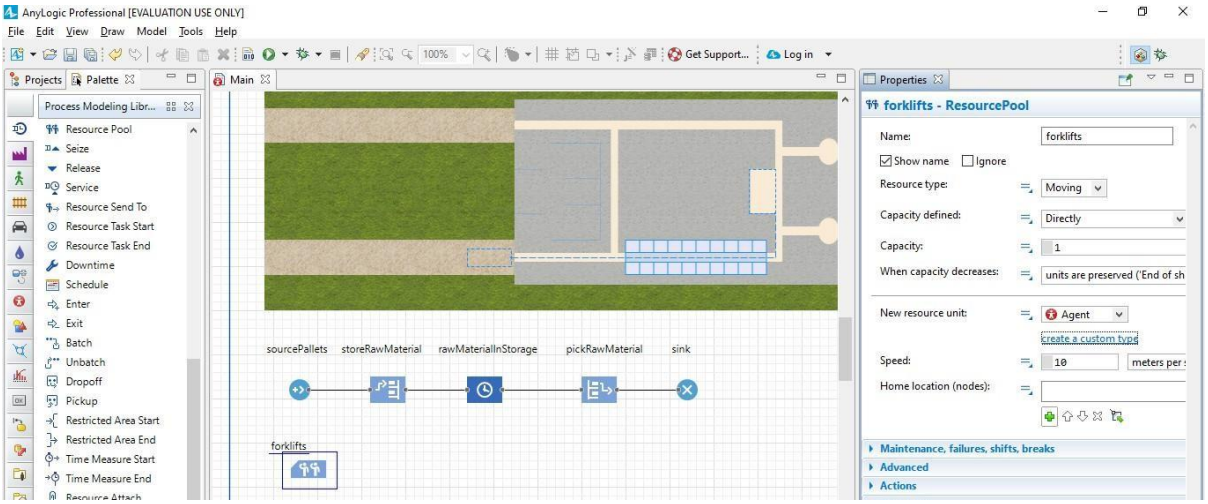
There are three types of resources: static, moving, and portable.

- Static resources are bound to a specific location, and they cannot move or be moved.
- Moving resources can move independently.
- Portable resources can be moved by agents or by moving resources.

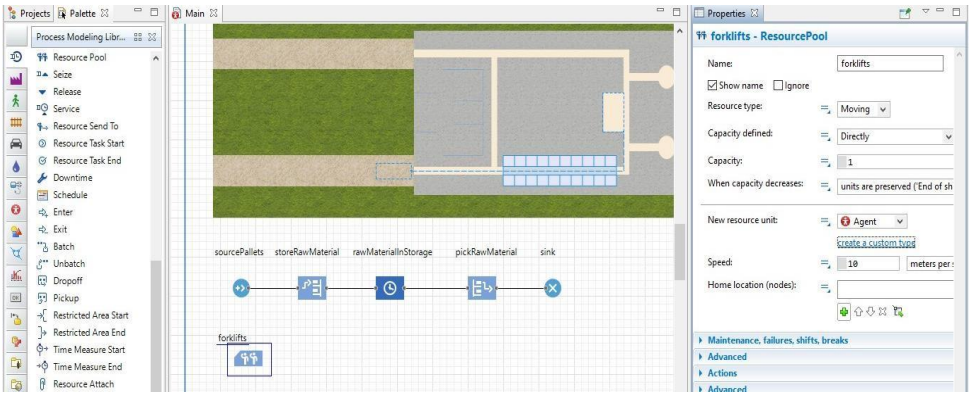
Our model's resources are the forklift trucks that move pallets from the unloading zone to a pallet rack and then deliver pallets from the rack to the production zone.

On the Process Modeling Library palette, drag the ResourcePool block on to the Main diagram. You do not have to connect the block to the flowchart.

Name the block forklifts.



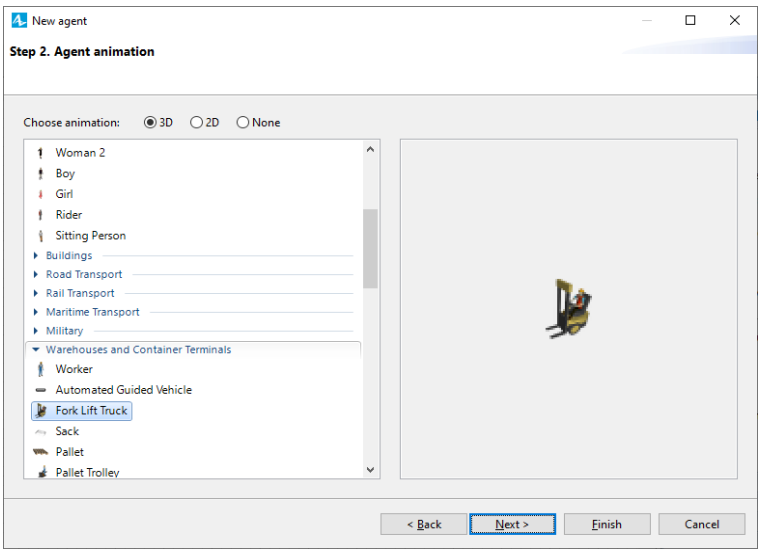
In the forklifts block's Properties area, click the button create a custom type. This way we create a new type of a resource.



In the New agent wizard:

a. In The name of new type box, type ForkliftTruck.
b. In the list in the left part of the wizard, expand the Warehouses and Container Terminals area, and then click the 3D animation figure Fork Lift Truck.
c. Click Finish.

The ForkliftTruck agent type diagram will open and display the animation shape you selected in the wizard.

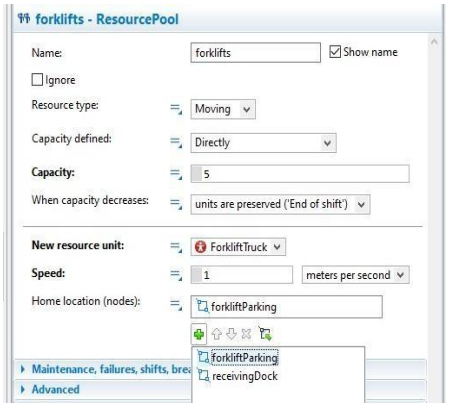


Click the Main tab to open the Main diagram.

You'll see the ForkliftTruck resource type has been selected in the ResourcePool block's New resource unit parameter.

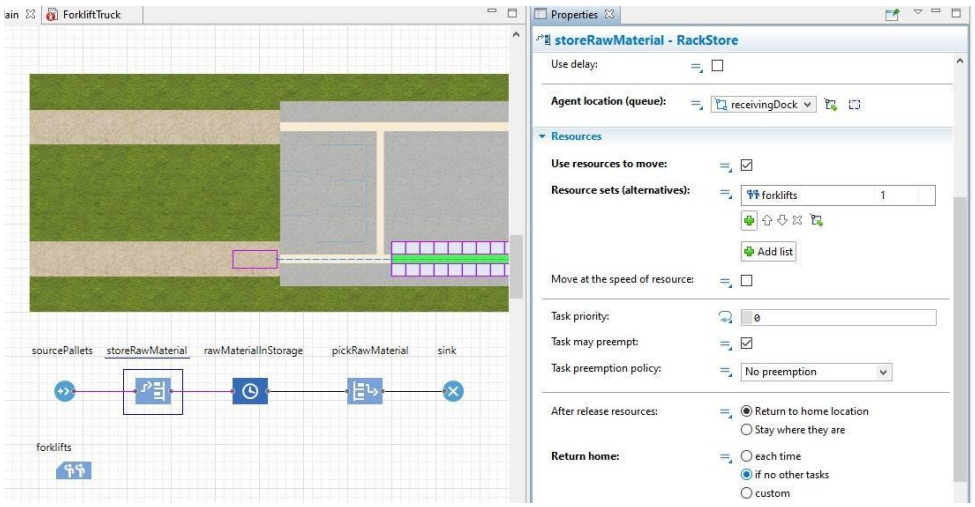
Modify the forklifts resource type's other parameters:

a. In the Capacity box, type 5 to set the number of forklift trucks in our model.
b. In the Speed box, type 1 and choose meters per second from the list on the right.
c. In the Home location (nodes) area, select the forkliftParking node. Click the plus button and then click forkliftParking in the list of the model's nodes.



In the storeRawMaterial block's Properties area, do the following:

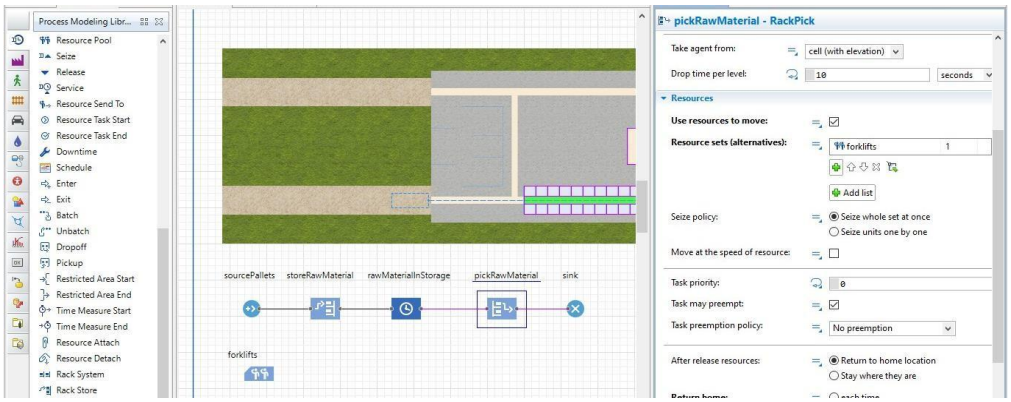
a. Click the arrow to expand the Resources area.
b. Select the Use resources to move check box.
c. In the Resource sets (alternatives)list, click forklifts to ensure the flowchart block uses the selected resources -- in our case, the forklift trucks -- to move the agents.
d. In the Return home area, select if no other tasks to ensure the forklift trucks return to their home location after they complete their tasks.



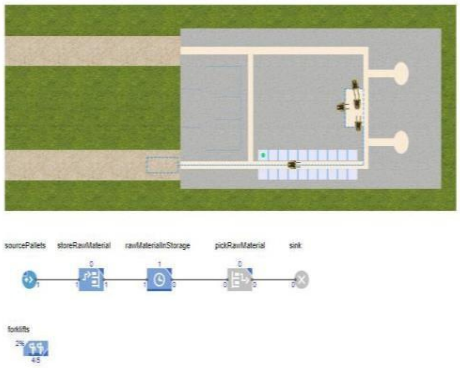
In the pickRawMaterial block's Properties area, do the following:

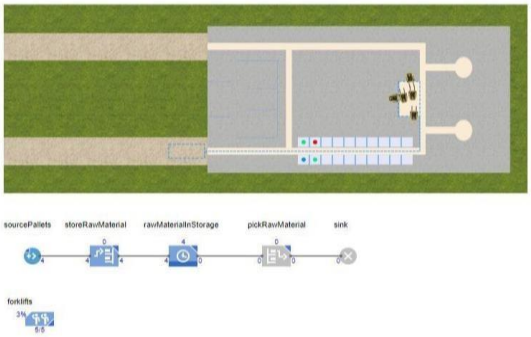
a. Click the arrow to expand the Resources area.
b. Select the Use resources to move check box.
c. In the Resource sets (alternatives) list, click forklifts to ensure the flowchart block uses the forklift trucks to move the agents.
d. In the Return home area, click if no other tasks to ensure the forklift trucks return to their home location after they complete their tasks.

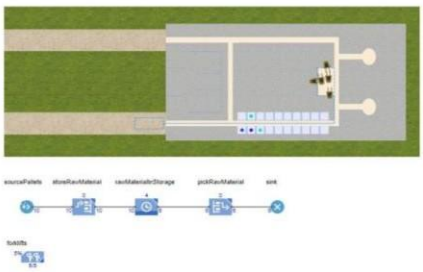
Roll No: 25166009



Run the model.







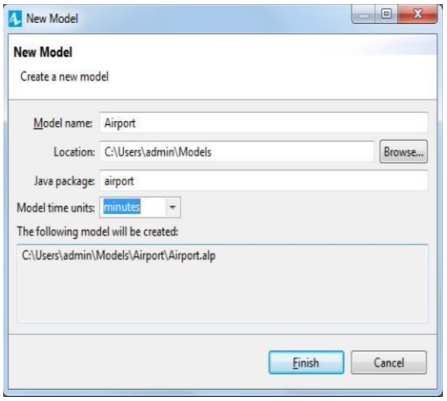
Roll No: 25166009

PRACTICAL NO: 06

Aim: Design and develop time-slice simulation for a scenario like airport model to design how passengers move within a small airport that hosts two airlines, each with their own gate. Passengers arrive at the airport, check in, pass the security checkpoint and then go to the waiting area. After boarding starts, each airline's representatives check their passengers' tickets before they allow them to board.

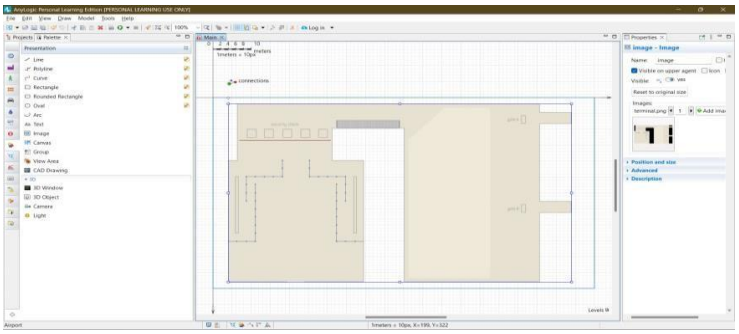
Code:

Create a new model and name it Airport. Select minutes as the model time units.



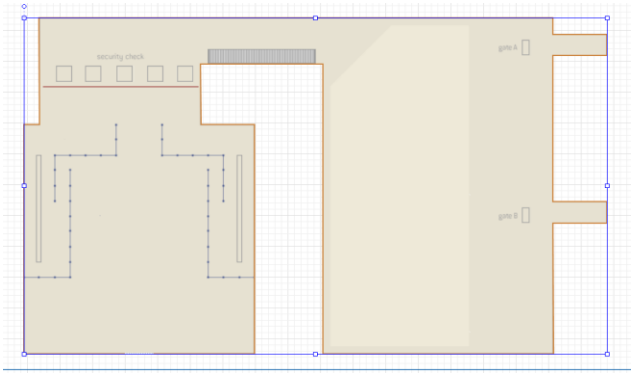
Drag an Image from the Presentation palette on to the Main diagram.Choose terminal.png image file from AnyLogic folder/resources/AnyLogic in 3 days/Airport. On the Main diagram,

place the image in the blue frame's lower left corner

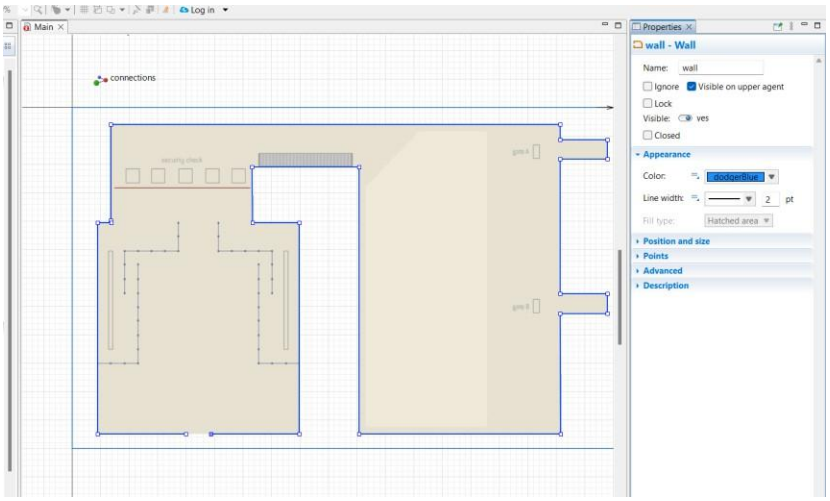


Use the Pedestrian Library palette to draw the airport's walls. Double-click the Wall element you'll find

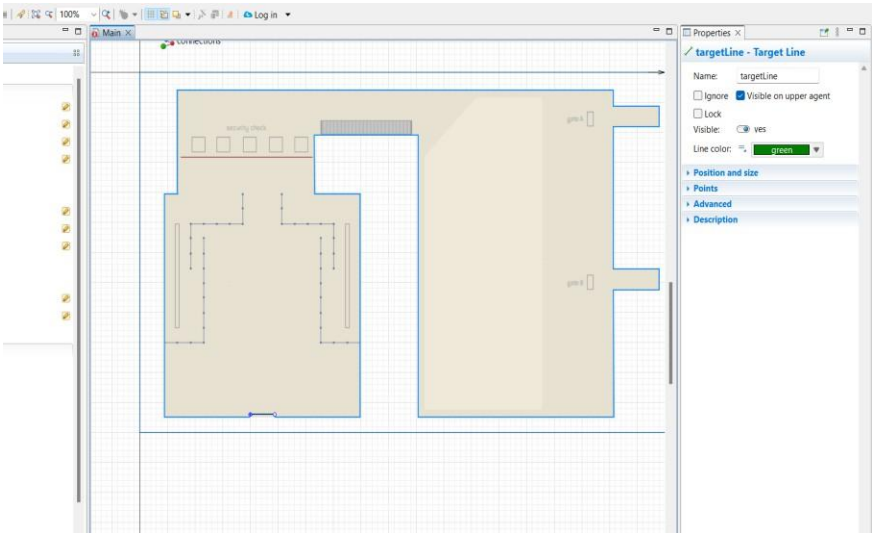
in the Pedestrian Library palette's Space markup section and then draw the wall around the airport building's border



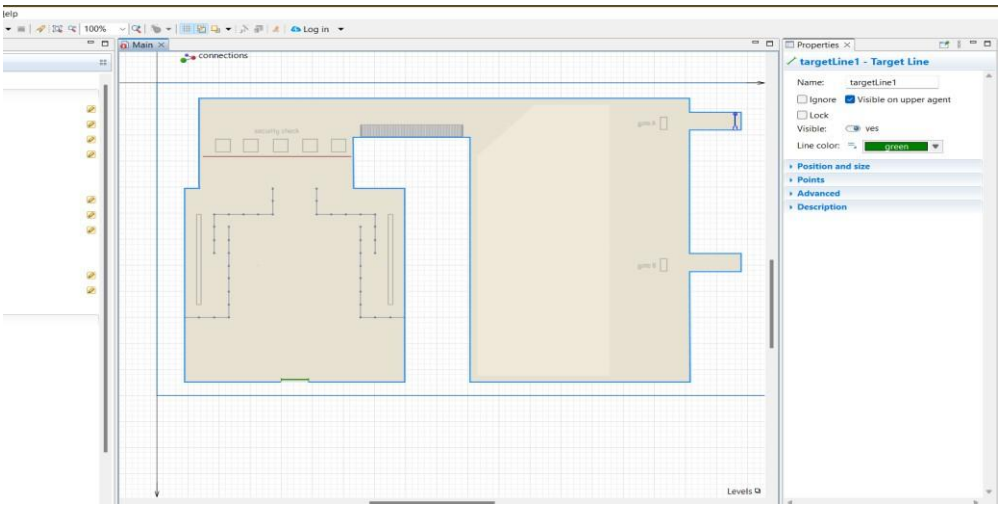
Navigate to the wall's properties and then select the Color: dodgerBlue in the Appearance section.



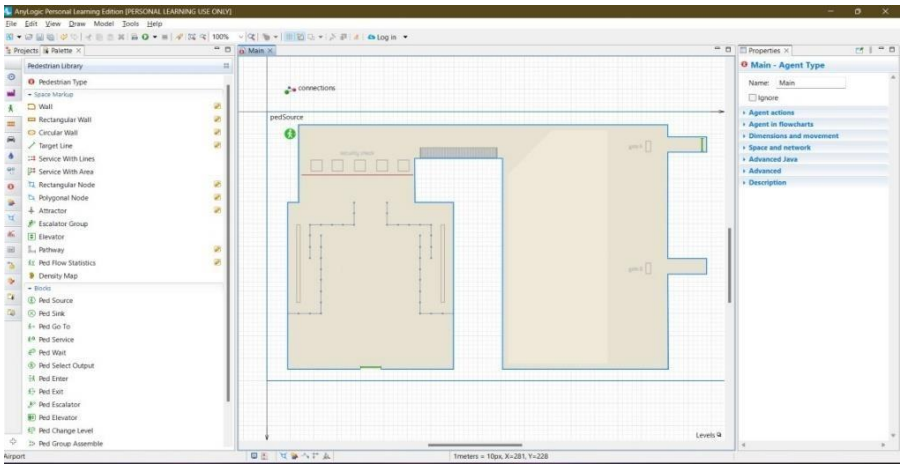
Define the location where your model's passengers appear by dragging the Target Line element from the Pedestrian Library palette on to the graphical diagram, as shown in the figure below.



Define a second target line that passengers will move toward after they enter the airport, place it in the gate area as shown in the figure below, and then name it gateLine1.



Start by dragging the PedSource block from the Pedestrian Library palette on to our Main diagram.

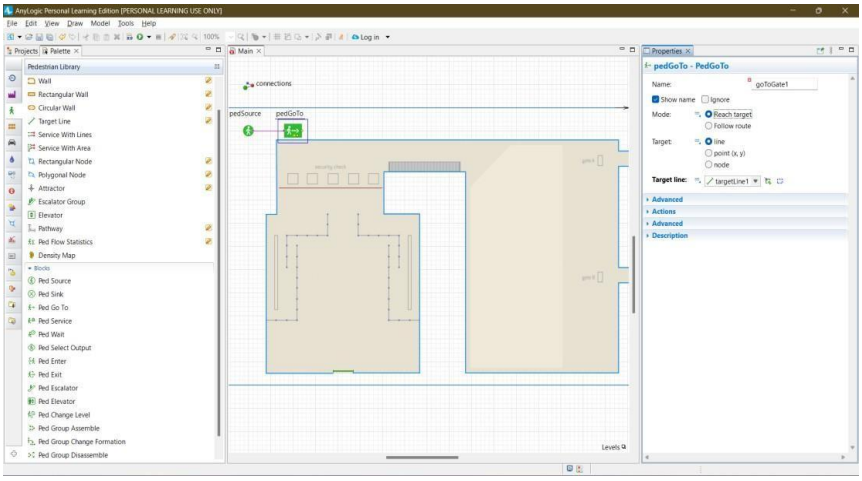


Since we want passengers to arrive randomly at an average rate of 100 passengers per hour, go to the ped Source block properties and then type 100 in the Arrival rate box.

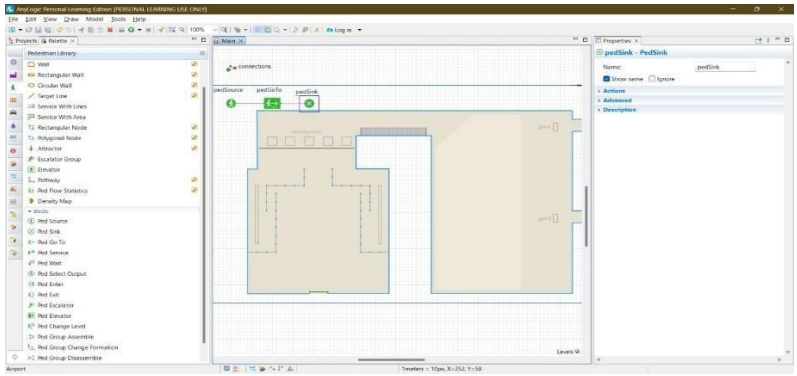
Specify the location where the passengers appear in the simulated system by clicking arrivalLine in the Target line list.

Add a PedGoTo block to simulate pedestrian movement to the specified location and then connect it to pedSource. Since we want our passengers to go to the gate, name the object goToGate1.

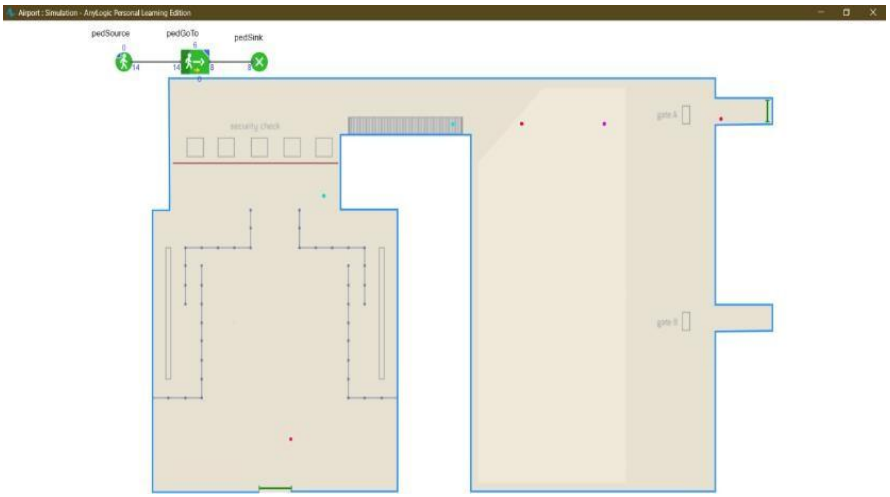
Specify the movement destination by selecting gateLine1 from the Target line combo box.



Add a PedSink block to discard incoming pedestrians. Pedestrian flowcharts typically start with a PedSource block and end with a PedSink block.



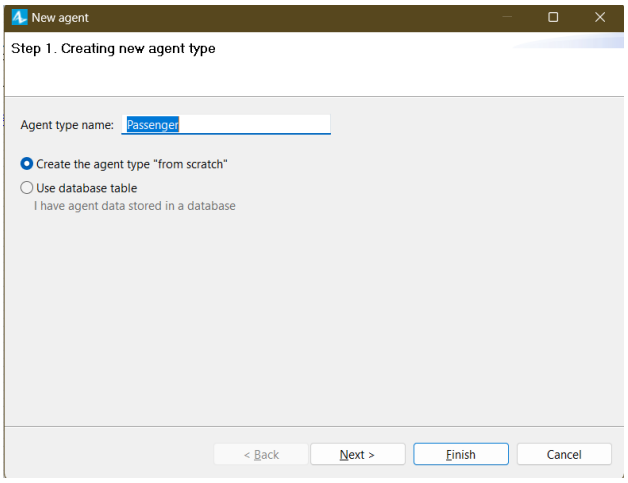
Run the model. In the 2D animation, you'll see the pedestrians move from the airport entrance to the gate.



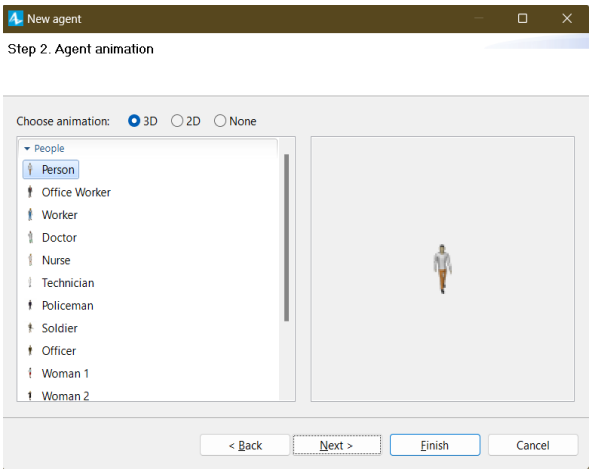
Drawing 3D animation

From the Pedestrian Library palette, drag the Pedestrian Type element on to the Main diagram.

In the New agent wizard, enter the new pedestrian type's name – Passenger – and then click Next.

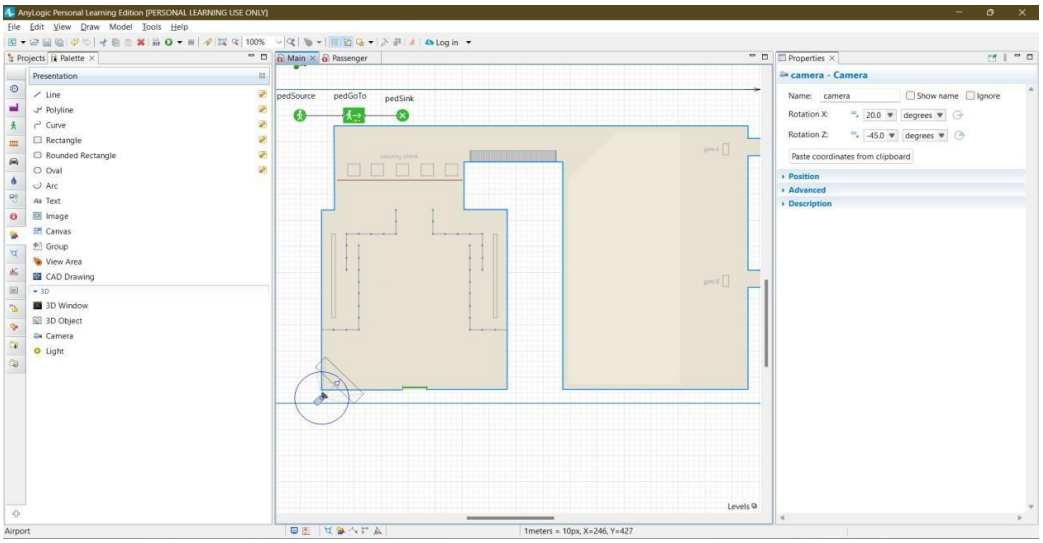


On the Agent animation page, select the General list's first item: Person, and click Finish.

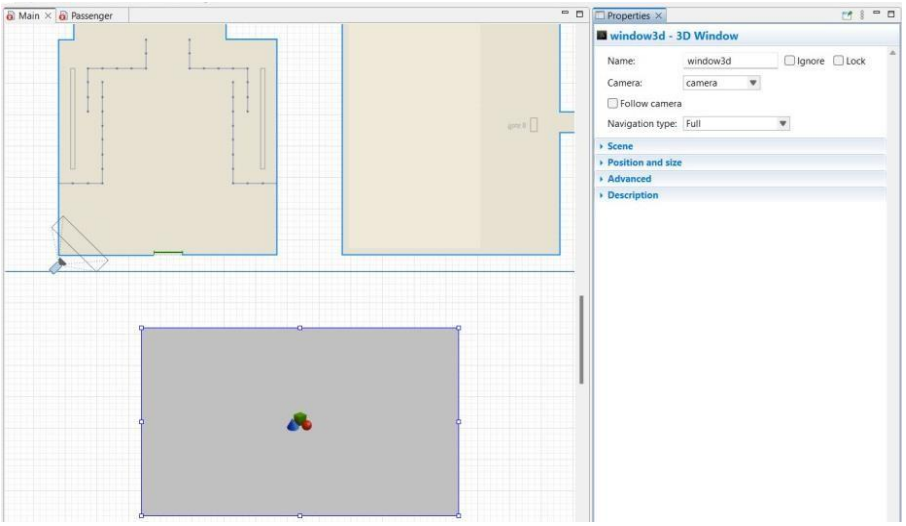


After the Passenger diagram opens, return to the Main diagram.

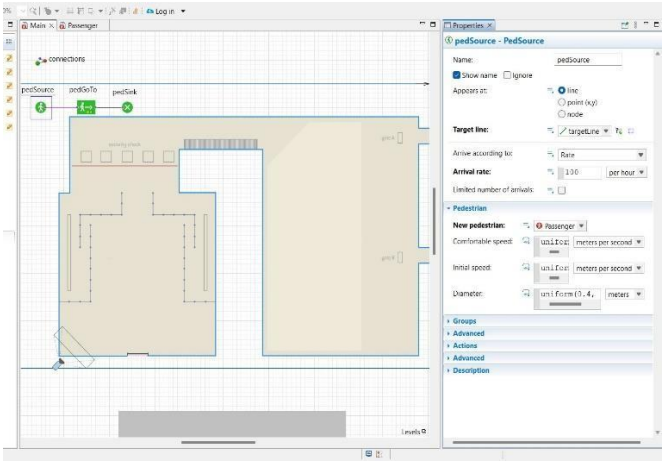
From the Presentation palette, drag the Camera on to the Main diagram and place it so it faces the terminal.



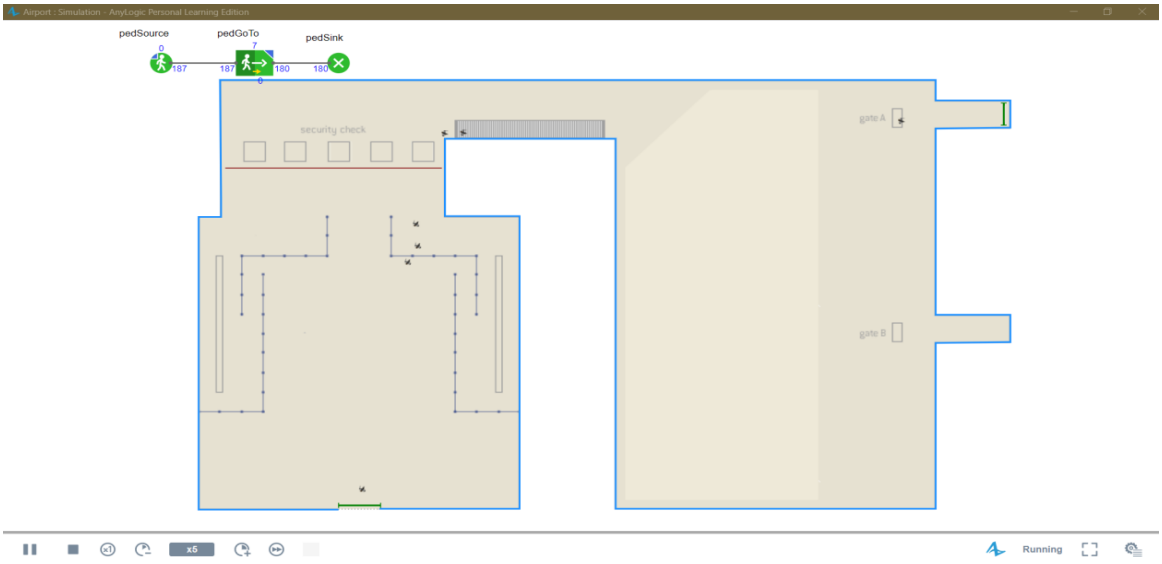
Drag the 3D Window on to the Main diagram and place it below the terminal layout image.



Open the 3D Window properties, and then select camera from the Camera list.We want our flowchart block pedSource to create pedestrians of our custom Passenger type. Open the pedSource properties, and then select Passenger from the New pedestrian box in the Pedestrian section.

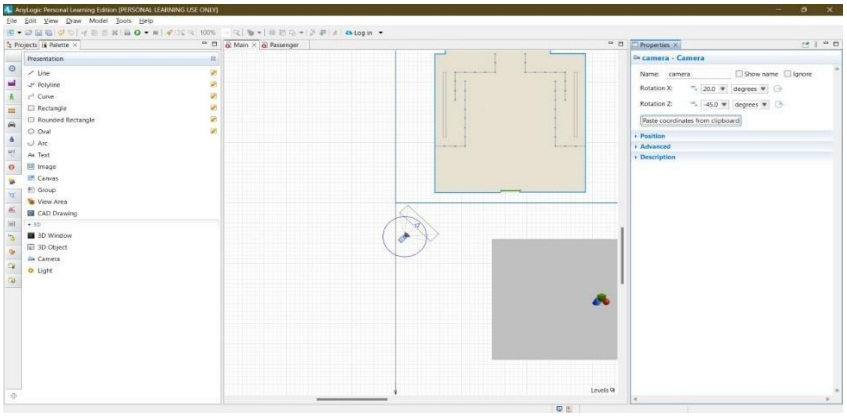


Run the model, and you'll see pedestrians move from the entry to the gate inside the building. You can switch to a 3D view by clicking the toolbar's Navigate to view area… button and then selecting [window3d] from the list.



Navigate the scene to get the best view, right-click inside the 3D scene, and then click Copy the camera's location.

Close the model's window, open the camera's properties, and then apply the optimal camera you selected during the previous step by clicking Paste coordinates from clipboard.

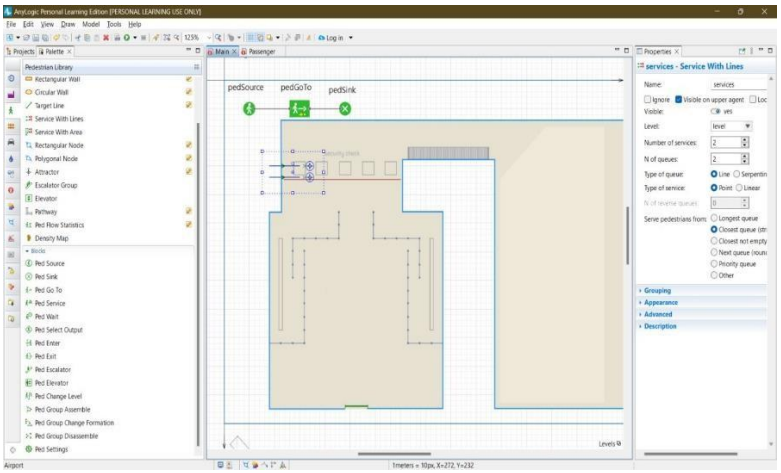


Run the model a second time and view the 3D view that the new camera position provides.

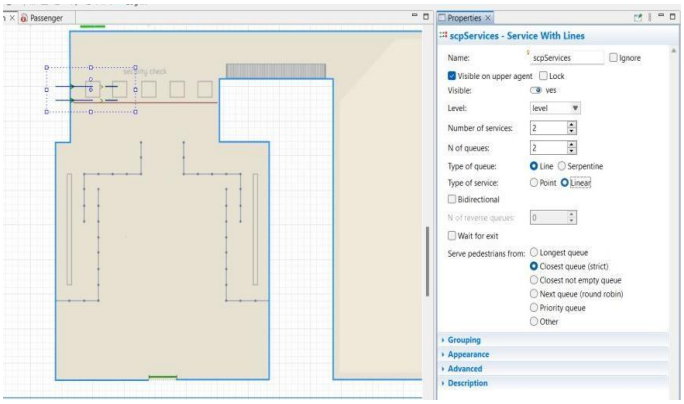
Roll No: 25166009

Adding security checkpoints

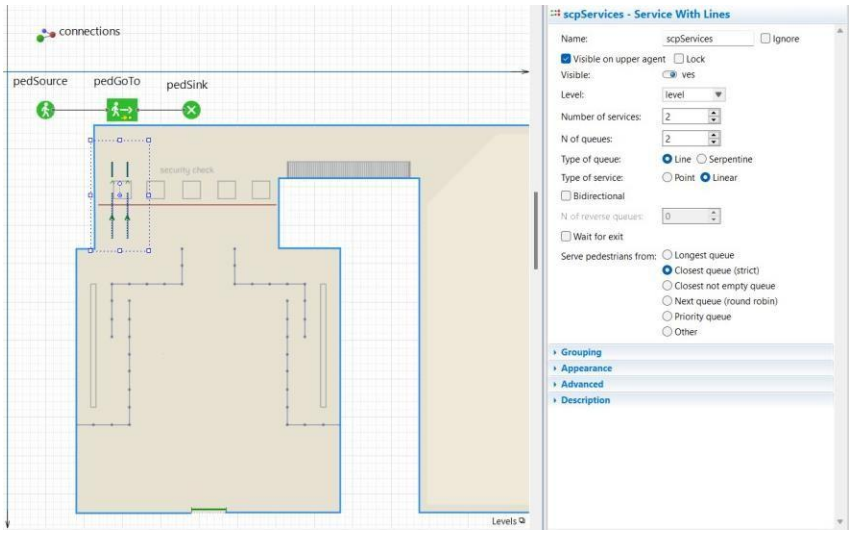
Drag the Service with Lines element from the Pedestrian Library palette on to the terminal layout. By default, a service will have two service points and two queue lines that lead to the service points.



Open the Service With Lines properties area, use the Name box to name the shape scpServices - in this case, “scp” stands for security checkpoints - and then change the Type of service to Linear.



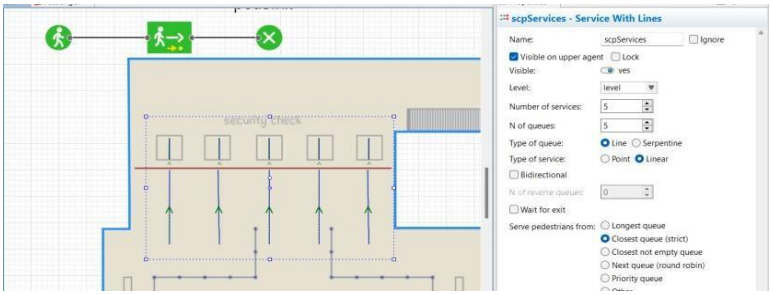
Use the round handle above the shape’s center to rotate the service. So that the arrow points upward



Move the service in a way that ensures the first linear service crosses the rectangle that represents the metal detector frame.

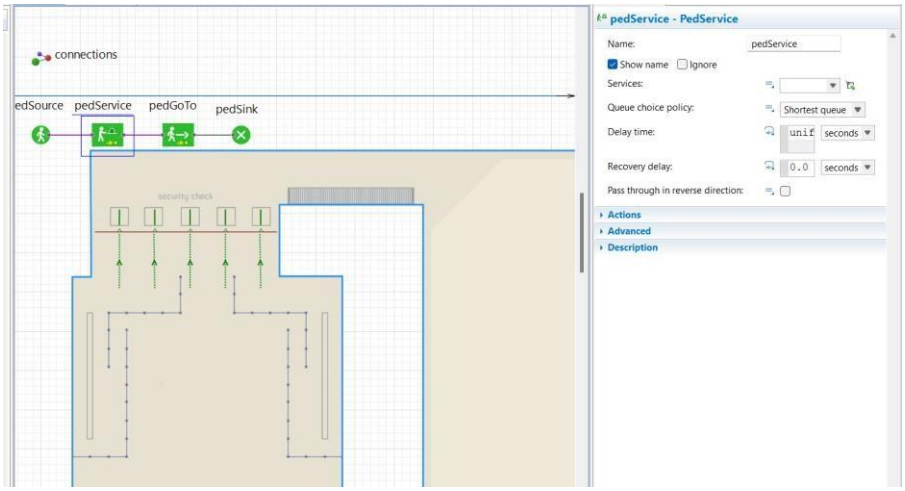
Select the next service line Accurately place the service line on top of the second security checkpoint placeholder and then adjust the queue location.

Navigate to the Service with Lines shape's properties and then change both the Number of services and Number of queue to 5 and then adjust the queue location as before. . After you've completed this step, the service shapes should look like those in the figure below.

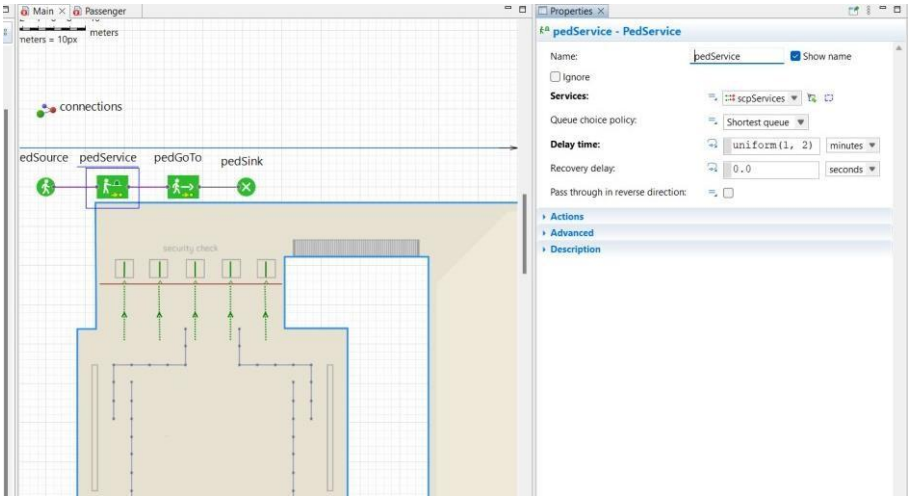


Add the PedService block on to the flowchart between the PedSource and PedGoTo blocks to make pedestrians pass through the service we defined using the referenced Service with Lines shape, and

Then name it securityCheck.



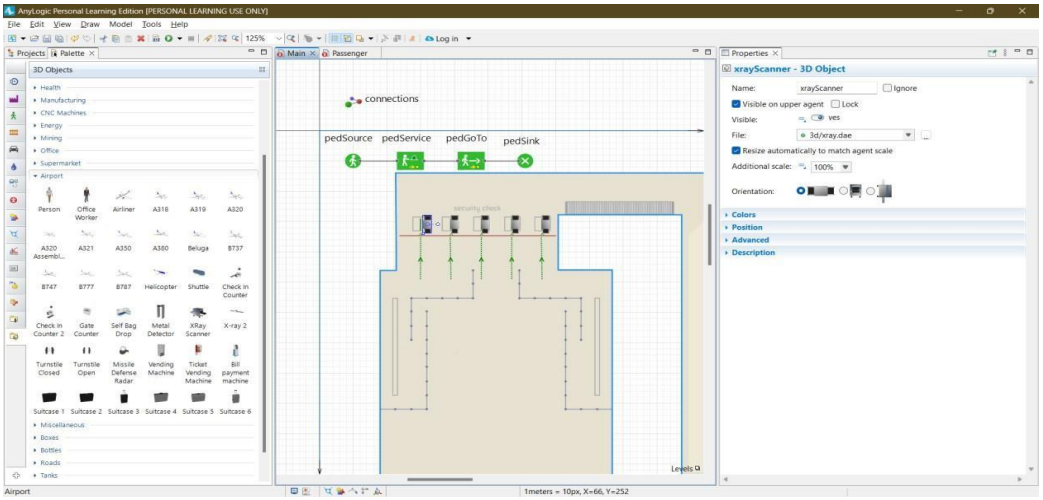
Go to the securityCheck block's properties. Select the services scpServices as Services.



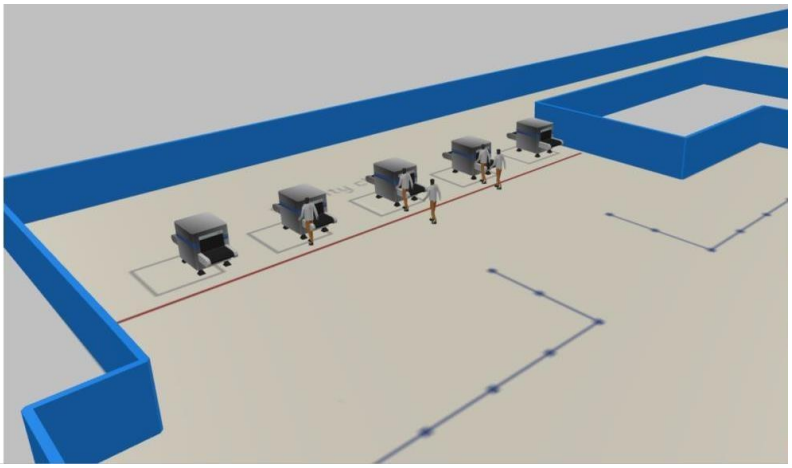
Since we assume it takes between 1 to 2 minutes to pass through the security checkpoint, type uniform (1, 2) minutes as the Delay time.

Now let's add 3D models of the security checkpoints. Using the 3D Objects palette, Airport sections Metal Detector and XRay Scanner elements, draw five security checkpoints.

You will see the message box, prompting you to change the scale of 3D object. Select the option Do not ask me again and click OK.

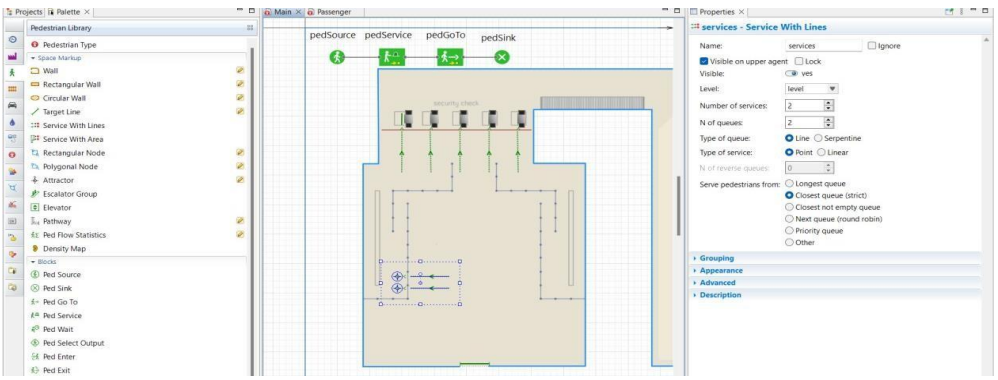


Run the model. You'll see that passengers are now scanned at the security checkpoints.



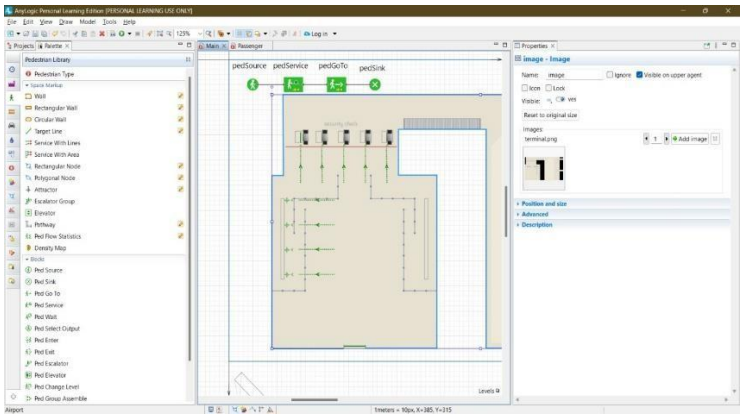
Adding check-in facilities

Draw check-in locations with another Service with Lines shape. Rotate it so that the arrow points towards left.

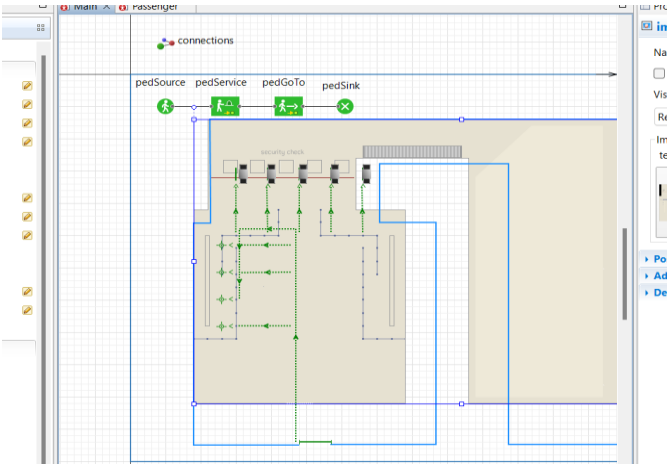


Navigate to the Service with Lines shape's properties and then change both the Number of services and Number of lines to 4.

Name the services checkInServices. Place the shape in the location shown in the figure below.

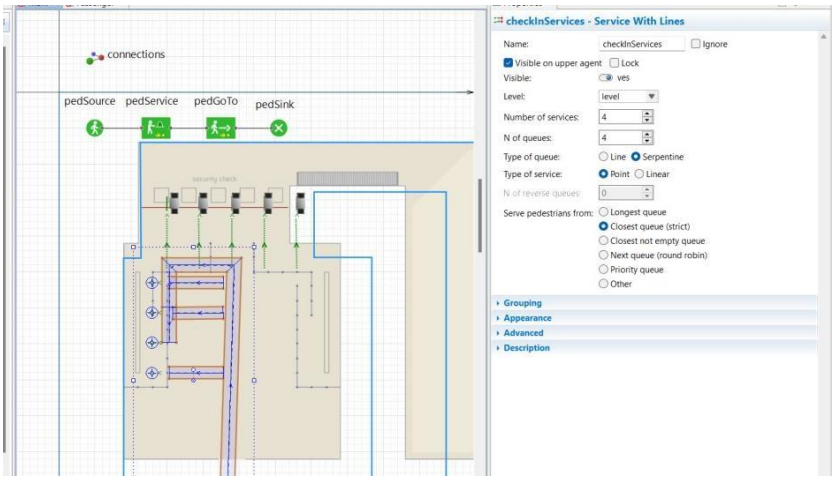


Add more salient points to the line. Right-click the queue line and choose Add points from the pop-up menu. Add more points by clicking where you want to place the line's salient points. Finish drawing the line by double-clicking. Finally you should get the queue line of the following form



In the properties of this Service with Lines shape, change the Type of queue to Serpentine. Use this option to simulate serpentine (also named "zigzag") queues.

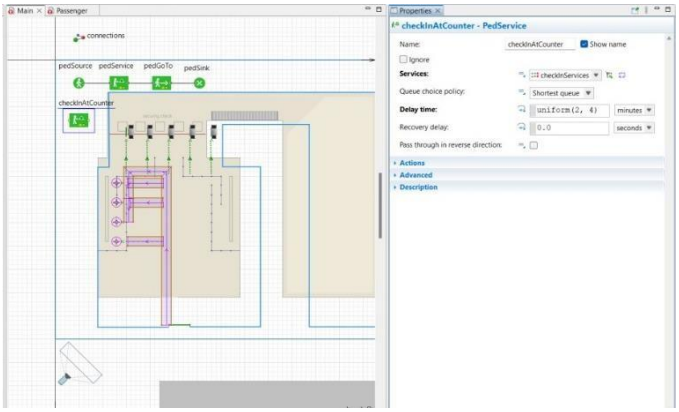
You will see that the queue has borders now. In 3D animation they will appear as belt barriers.



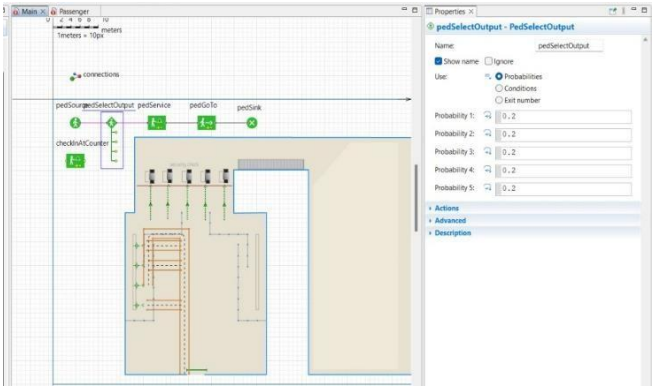
Add another PedService block and name it checkInAtCounter.

In the block's properties, select the space markup shape checkInServices as Services.

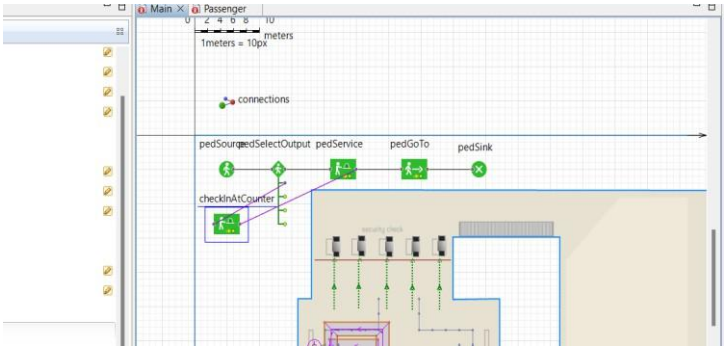
Since we assume it takes between 2 to 4 minutes to check in, type uniform(2, 4) minutes as the Delay time.



Add the PedSelectOutput block to route passengers to different flowchart branches.



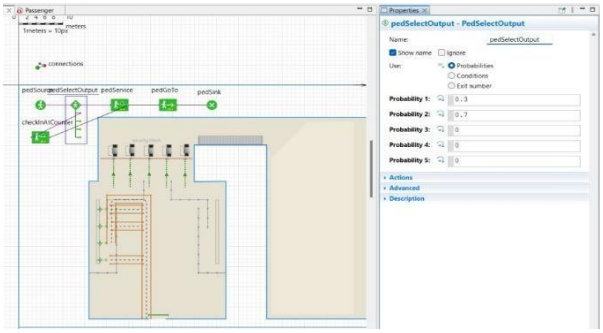
Connect the checkInAtCounter block to the existing flowchart blocks as shown in the figure below.



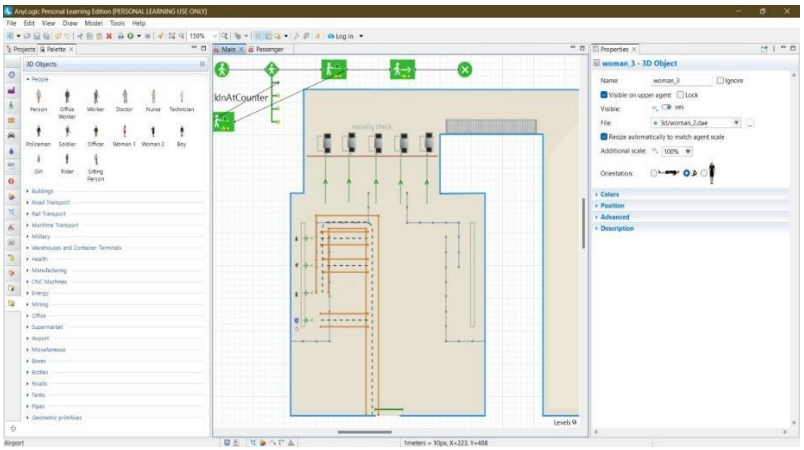
Since we're assuming 30 percent of our passengers will check in online and 70 percent will check in at

the counter, we'll model this behavior by setting pedSelectOutput's Probability 1: to 0.3 and Probability 2: to 0.7. This action will route 30 percent of the passengers to the upper flowchart branch and 70 AnyLogic 7 in Three Days 219 percent of the passengers to the lower branch. You must set Probability

3, Probability 4, and Probability 5 to 0 to prevent AnyLogic from routing passengers to the block's lower three output ports.

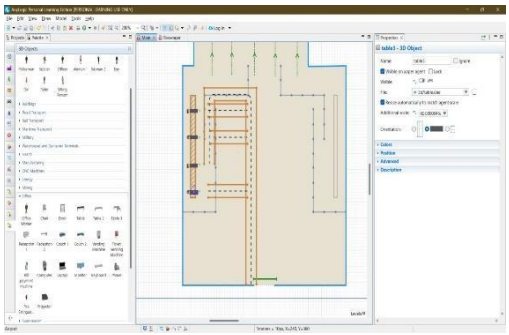


Let’s add ready-to-use 3D models to the airport’s check-in area. On the Palette's 3D Objects tab, expand the Peoplesection, and then add two copies of both Office Worker and Woman 2. to the diagram. As shown below.



Define the area that is not accessible by passengers. Add the Rectangular Wall element from the Space markup section of the Pedestrian Library palette and place it as shown in the figure below. In the wall's properties, set Visible to no to make this wall invisible at the model runtime.

On the Palette’s 3D Objects tab, select the Office section, and then drag four copies of the Table object on to the diagram.



Since the tables aren’t facing the correct direction, use their Properties section’s Position area to set Rotation, Z: 90 degrees.

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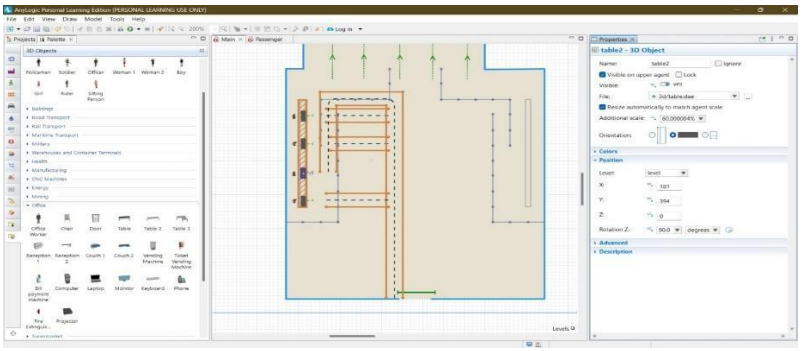
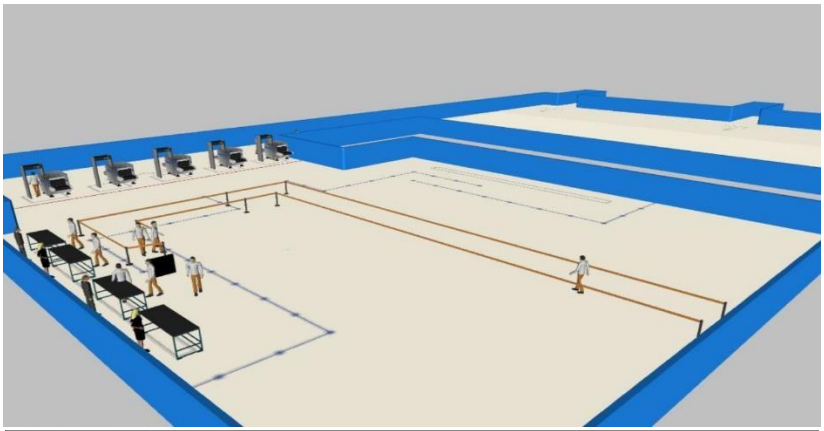
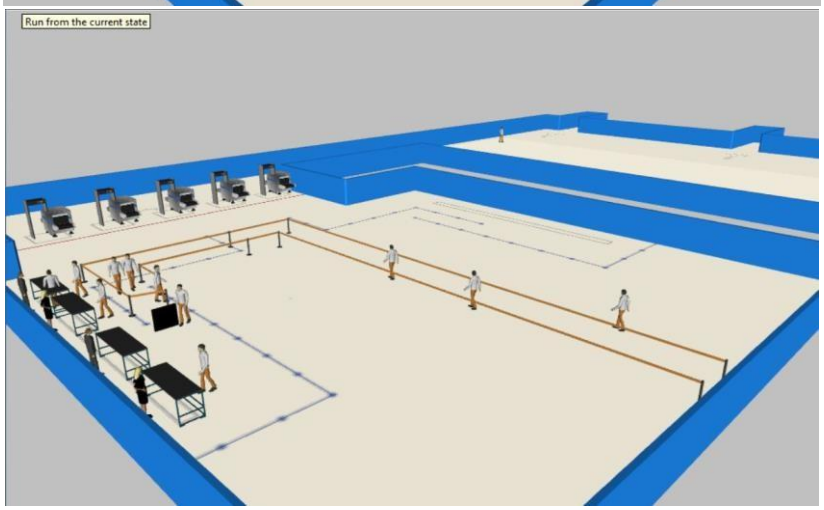


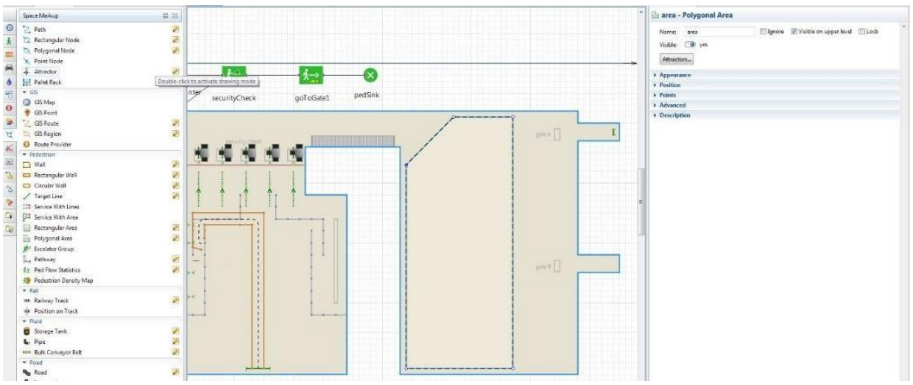
Run the model. You'll see some passengers check in and then go through the metal detector



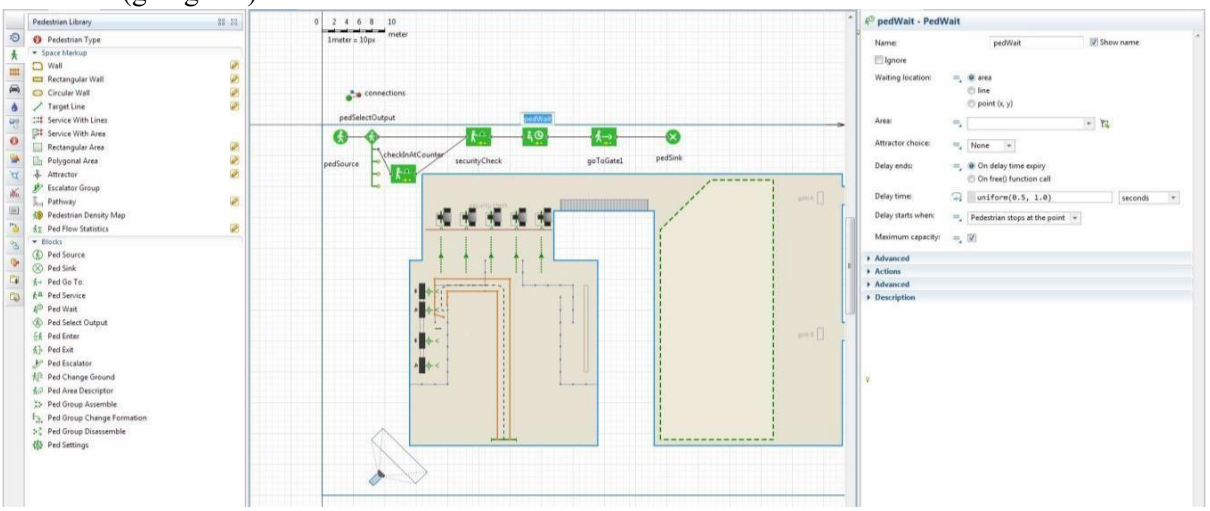


We want the passengers to wait before they go to the gate. To do this, we need to draw the waiting area where the passengers will wait and then add a flowchart block (PedWait) to simulate the waiting. Draw the waiting area before the gates using the Polygonal Area element from the Space Markup section of the Pedestrian Library palette. Switch to the drawing mode and draw the area as shown in the figure below by clicking your mouse each time you want to add a point. When you're finished, doubleclick your mouse.

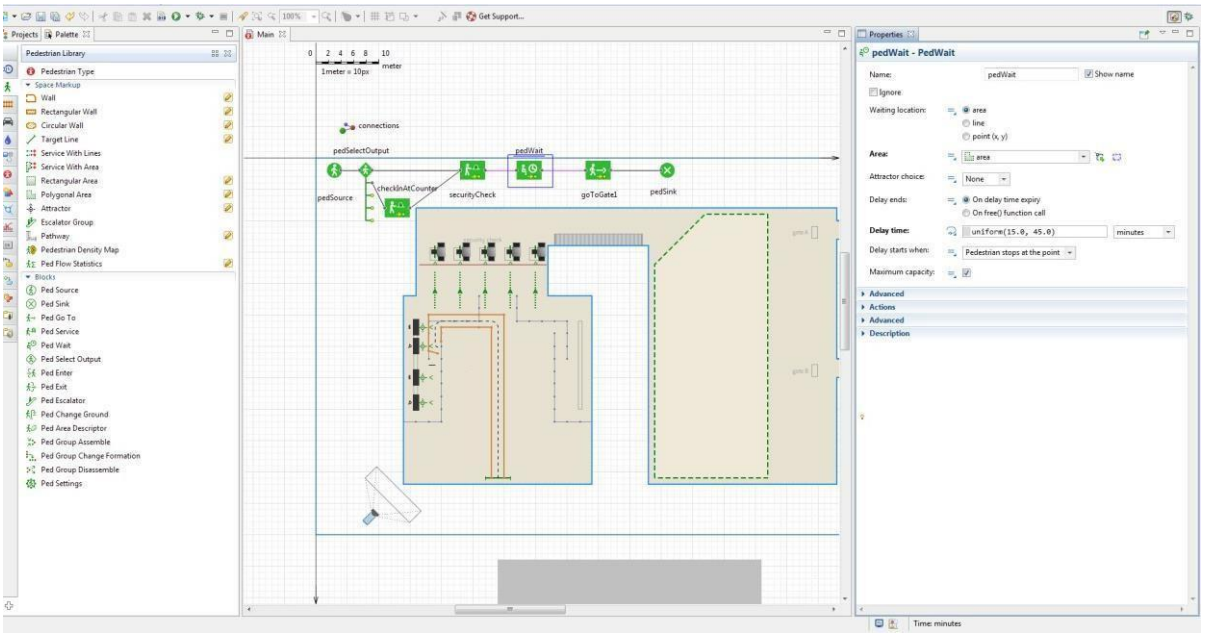
Roll No: 25166009



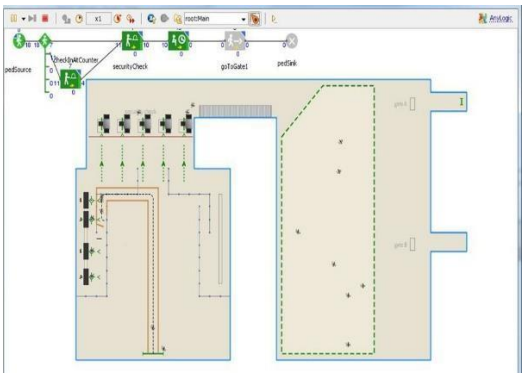
Add the PedWait block on to the flowchart between PedService (securitycheck) and PedGoTo.(gotogate1) as shown below

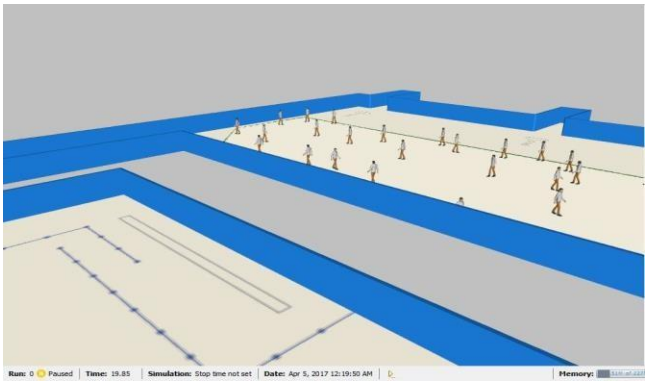


Modify the block's properties by selecting the area from the Area list, and then setting the Delay time to uniform(15, 45) minutes.



Run the model again, and you'll see the passengers now wait in the waiting area before they proceed to the gate.



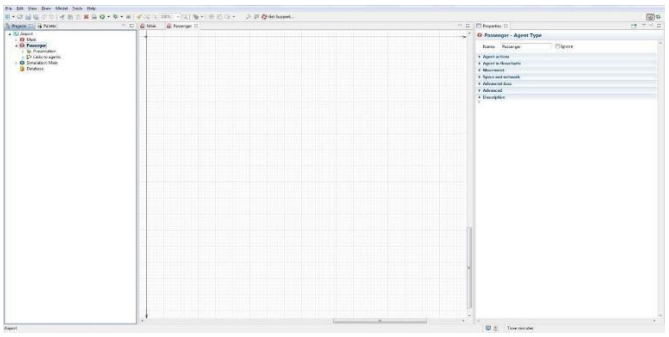


You can add more check-in facilities on the right and configure the

PedSelectOutput to separate the pedestrian flow to more branches.

Defining the boarding logic

In the Projects tree, open the Passenger agent type diagram by double-clicking the Passenger item.

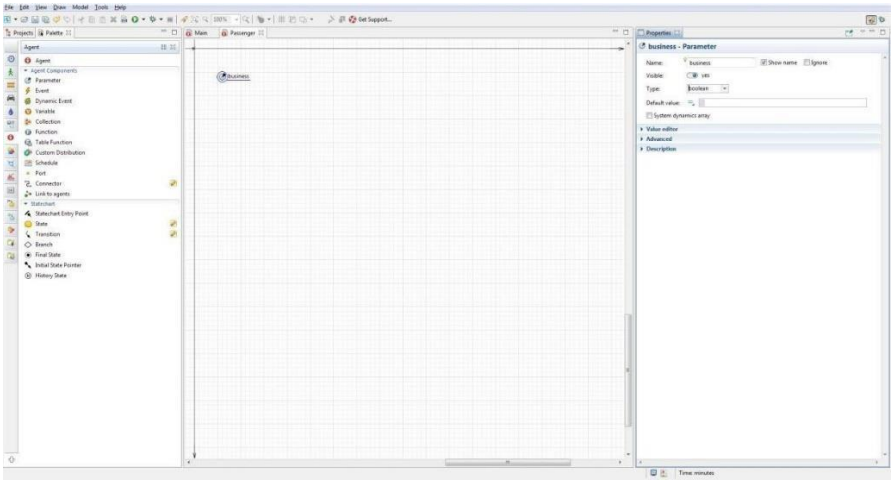


Add a Parameter from the Agent palette to define the passenger's class.

Name it business, and set Type: Boolean. If the parameter is equal to true, this is a business class passenger, otherwise (if the parameter is false), this is an economy class passenger.

We want to distinguish passengers in 3D animation, namely animate business class and economy passengers with different 3D models. To do this, we'll use the existing Person 3D object to represent economy passengers and add another 3D shape to represent business class passengers.

Add the 3D object Office worker to animate a business class passenger and then place the figure on the axis origin point (0,0), right on the Person shape.



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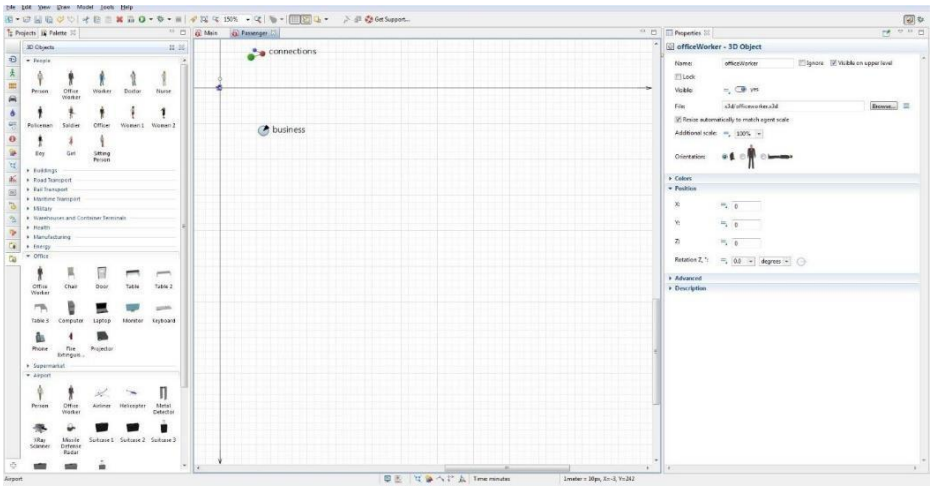
Add the 3D object Office worker to animate a business class passenger and then place the figure on the axis origin point (0,0), right on the Person shape.

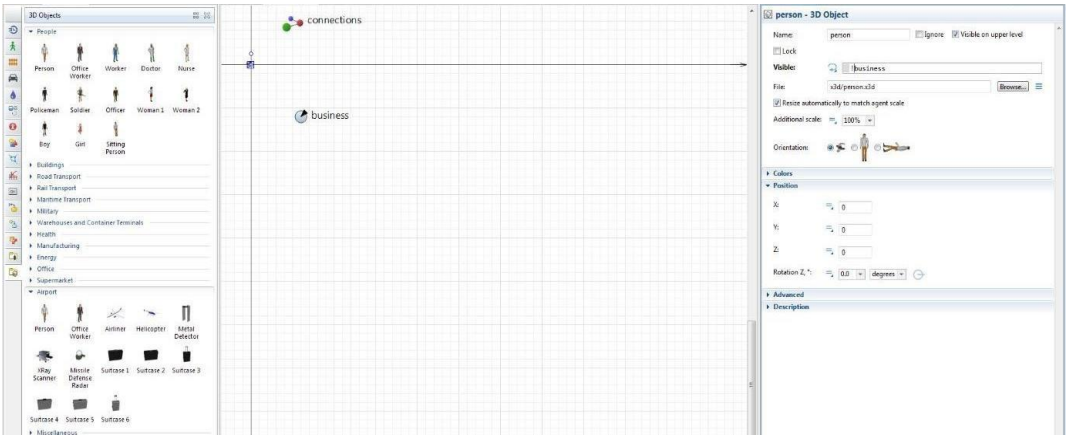


Change the visibility of these objects. First, click the Office worker shape. We want this shape to be visible only when this is a business class passenger, that is, when its business parameter is true. Switch to the Visible property's dynamic value editor by clicking the icon to the right of the Visible label,and then type business in the box. By doing this, we're making this 3D shape visible only when pedestrian's business parameter is true.

Now select the person 3D object (you can do this from Projects tree), and set Visible:

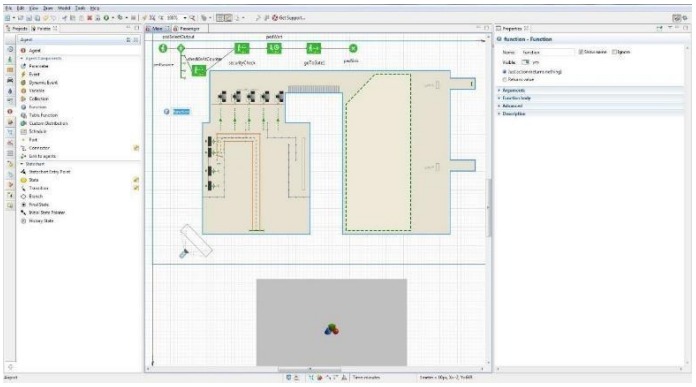
! business . This shape will be visible only if the passenger is an economy passenger.

The symbol ! is the boolean operand NOT. The expression !business returns true when the business is NOT true – when the passenger is not a business class passenger but is an economy passenger



We want to set up the passengers' class when they arrive to the airport terminal.

Return to the Main diagram and add a Function from the Agent palette. Name it setupPassenger.



Configure the function as follows:

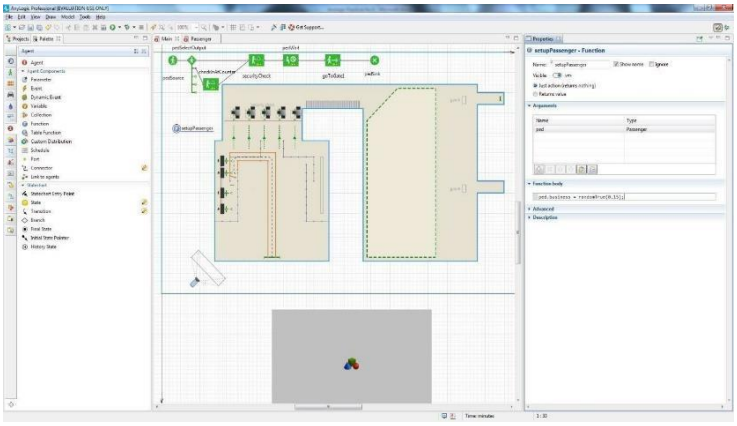
• Create one argument in the agument drop down list to pass the newly-created passenger to the function:

Name: ped

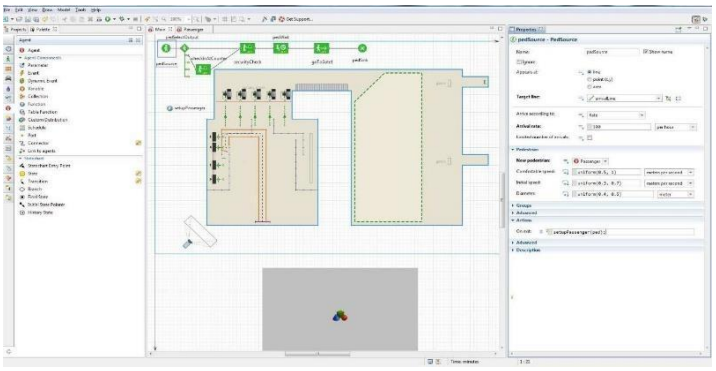
Type: Passenger

The function's code defines the frequency with which the business class passengers appear in the model:

in the function body list write this ped.business = randomTrue(0.15);



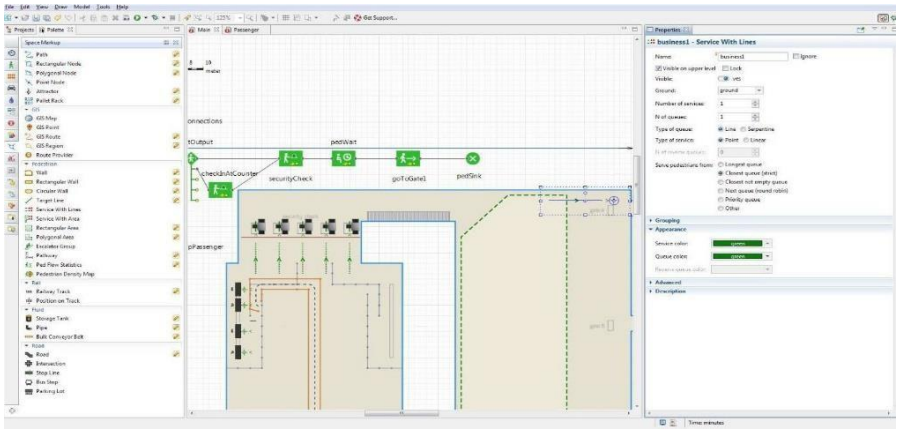
In this case, ped is the function's argument, of type Passenger. Having set up the Passenger as the argument type, we can directly access the custom pedestrian field business simply as ped.business. The function randomTrue(0.15) returns true in an average of 15 percent of cases, which means an average of 15 percent of our model's passengers will travel in business class. Call this function when a new pedestrian is created by the pedSource block. In the pedSource properties area, click the arrow to expand the Actions section, and then enter the following code in the On exit box: setupPassenger(ped);



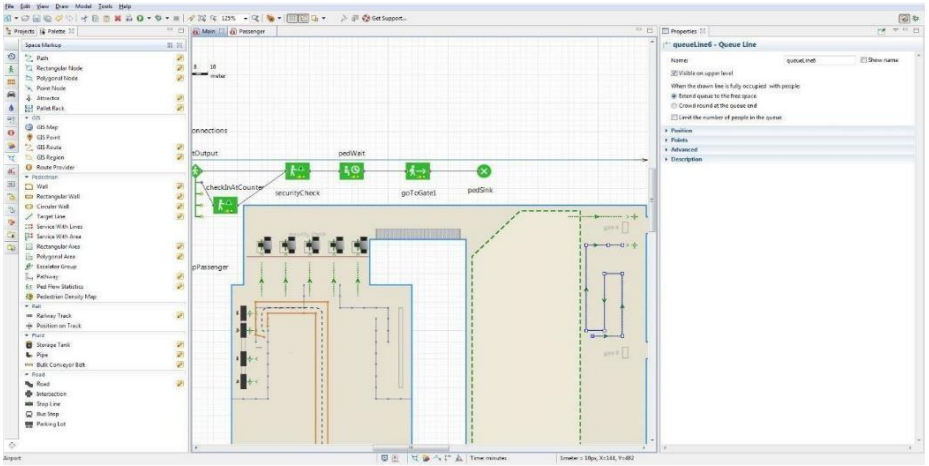
Here we call our function setupPassenger for the newly-created pedestrian. This pedestrian is passed to the function via its argument.

Draw two services with lines for the upper gate, one for business class and one for economy passengers.

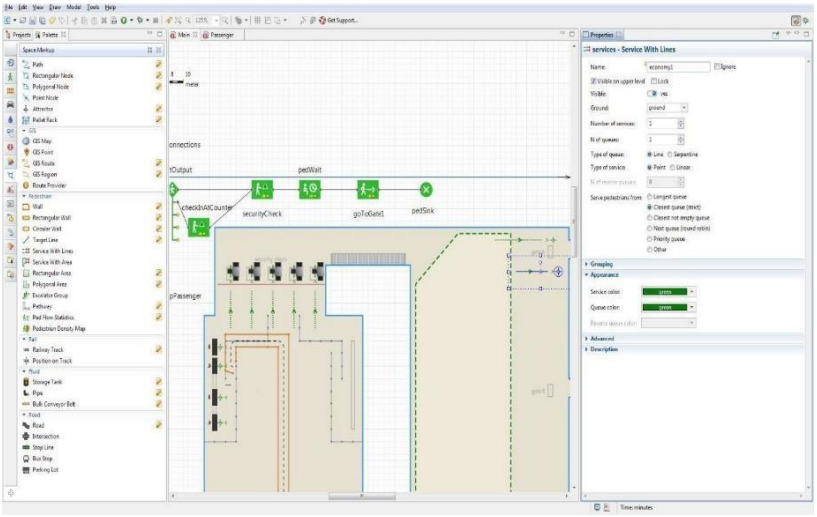
Draw a Service with Line, defining the priority line (point service, 1 service, 1 line). Name this service business1



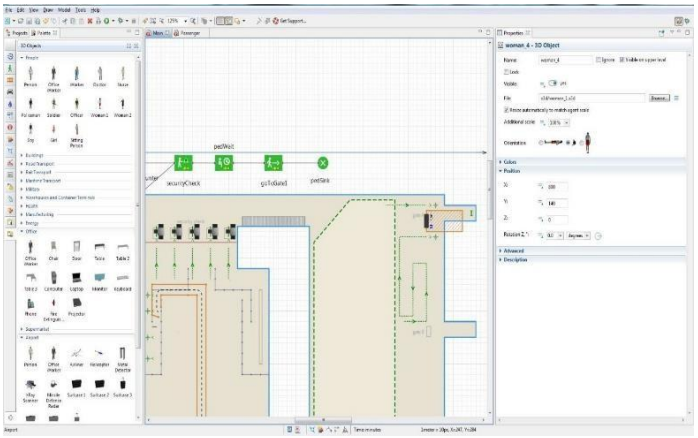
Add one more Service with Line, and name it economy1



Add more point to the queue

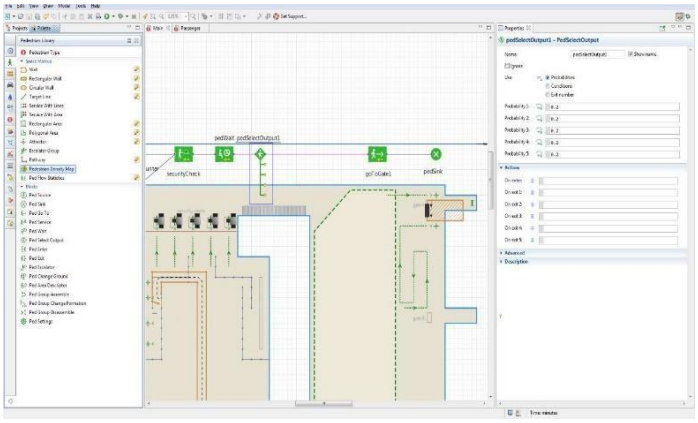


Draw an area at the gate with the Rectangular Wall element, from the apce markup and then add a table from 3d office & rotate it 90 degree as per display and add two 3D woman models at the table. properties, set Visible to no to make this wall invisible at the model runtime.

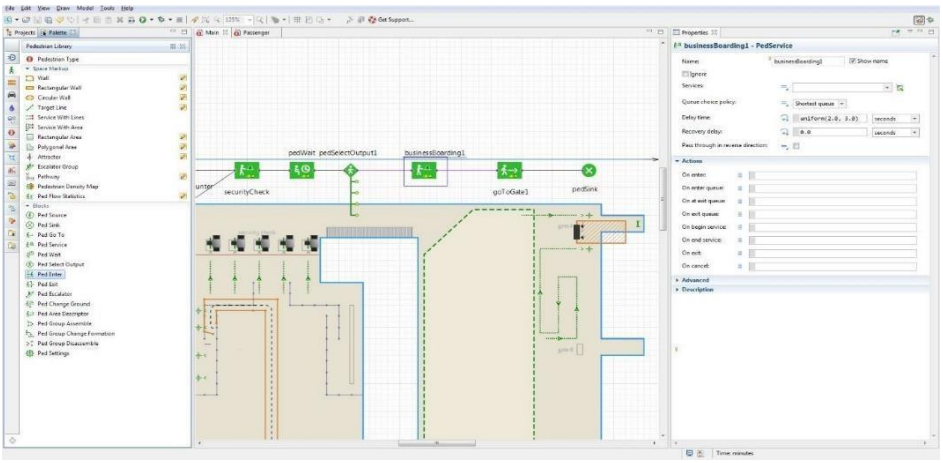


Insert the blocks into the flowchart between the pedWait and goToGate1 objects.

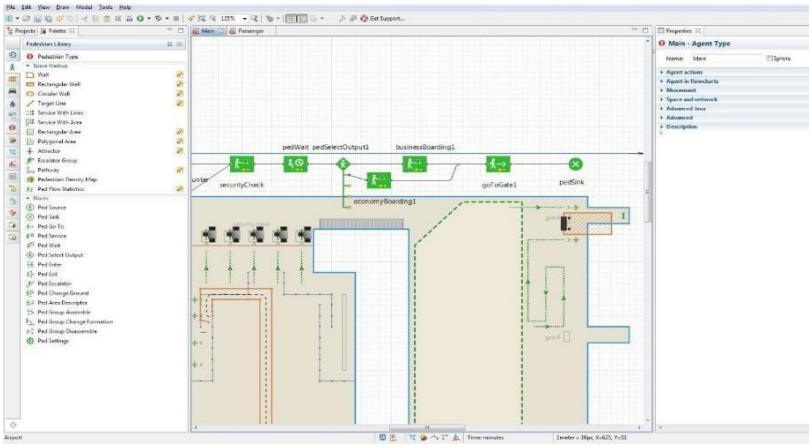
Add PedSelectOutput to route business class and economy passengers to different lines. As shown below



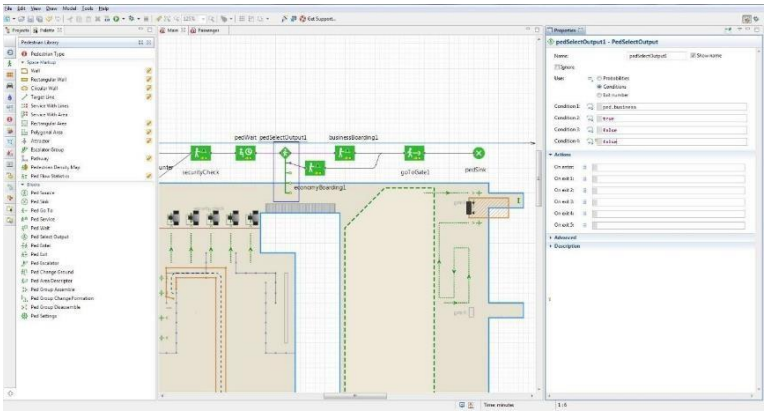
Add two PedService blocks: businessBoarding1 and economyBoarding1 to simulate the process of checking passengers' tickets at the gate.



Connect it as shown in the figure below



Since the PedSelectOutput block routes business class and economy passengers to different lines, select Use: Conditions, and then type ped.business in the Condition 1 box. This expression will return true for all business class passengers, which means they will follow the upper flowchart branch and join the priority line. After you set up the conditions for the block's next output ports (true, false, false), the model will direct all other passengers to the second output port.

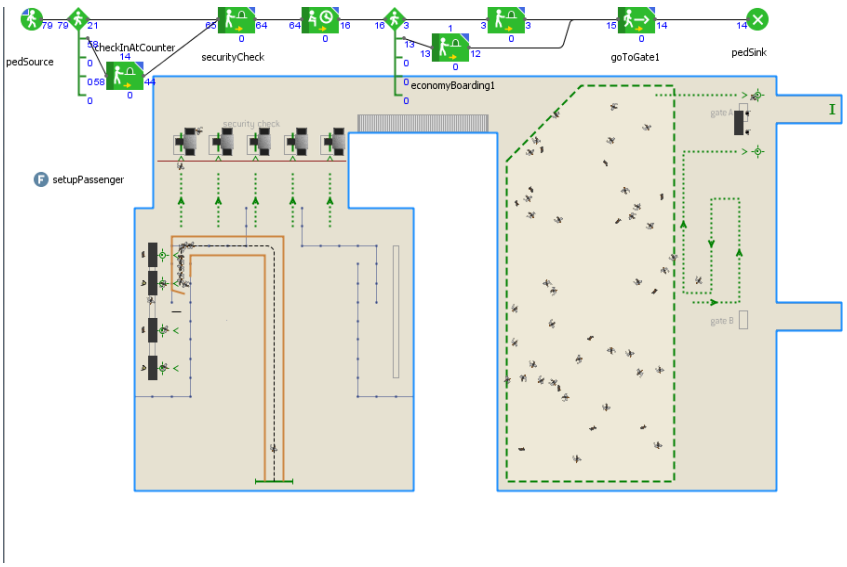


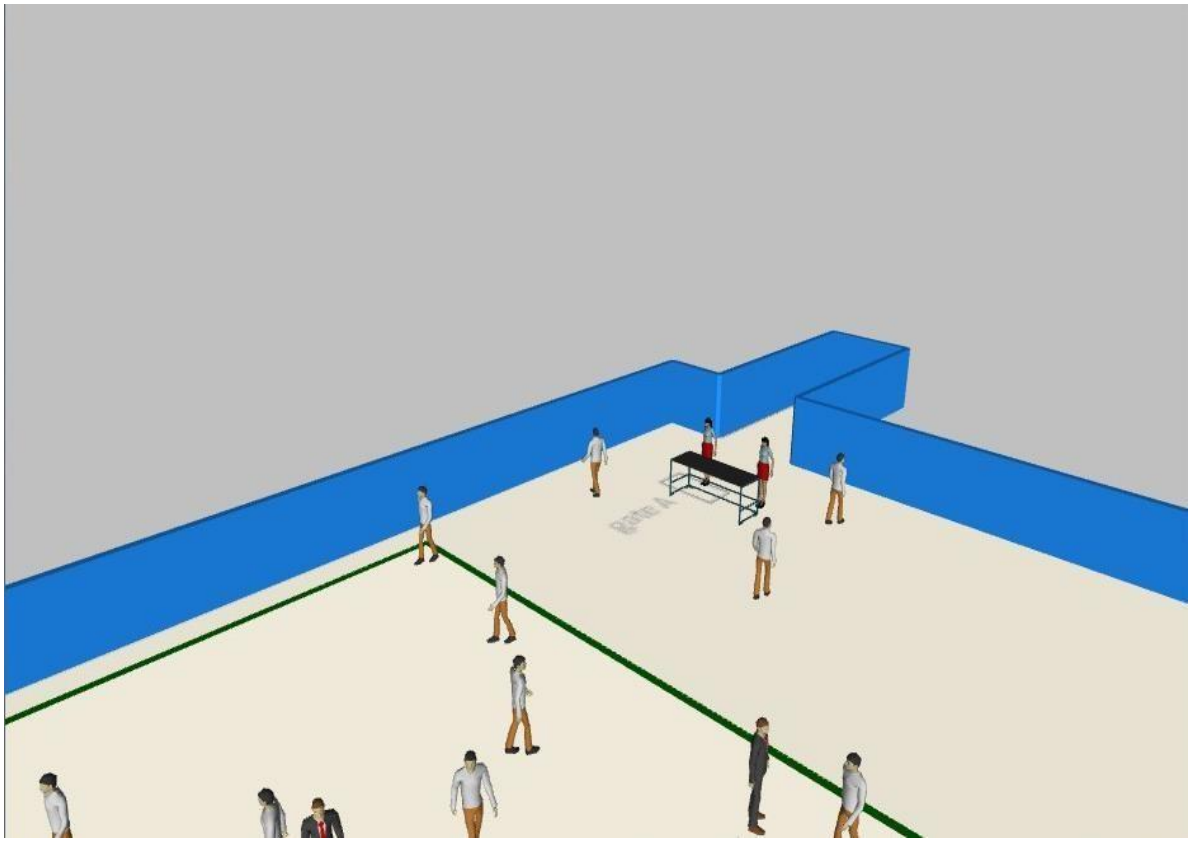
For the PedService block businessBoarding1, choose business1 as Services. Since it takes between two to five seconds to check a passenger's ticket, you can slightly change the Delay time.

For economyBoarding1, set Services: economy1, adjust the Delay time. Run the model. You'll see passengers pass the checkpoint, and a small number of them will take the priority line.

For the PedService block businessBoarding1, choose business1 as Services. Since it takes between two to five seconds to check a passenger's ticket, you can slightly change the Delay time.

For economyBoarding1, set Services: economy1, adjust the Delay time. Run the model. You'll see passengers pass the checkpoint, and a small number of them will take the priority line.





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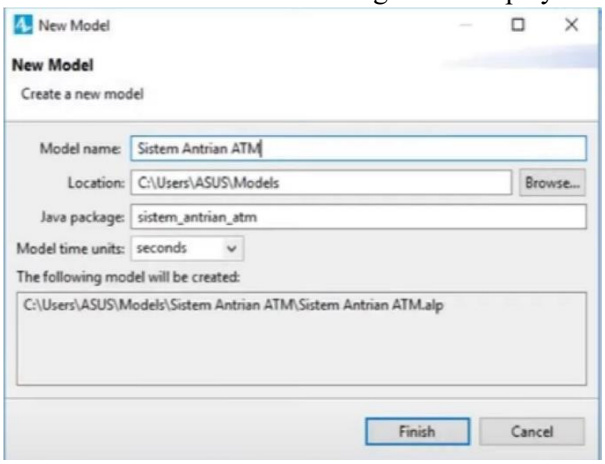
PRACTICAL NO: - 7

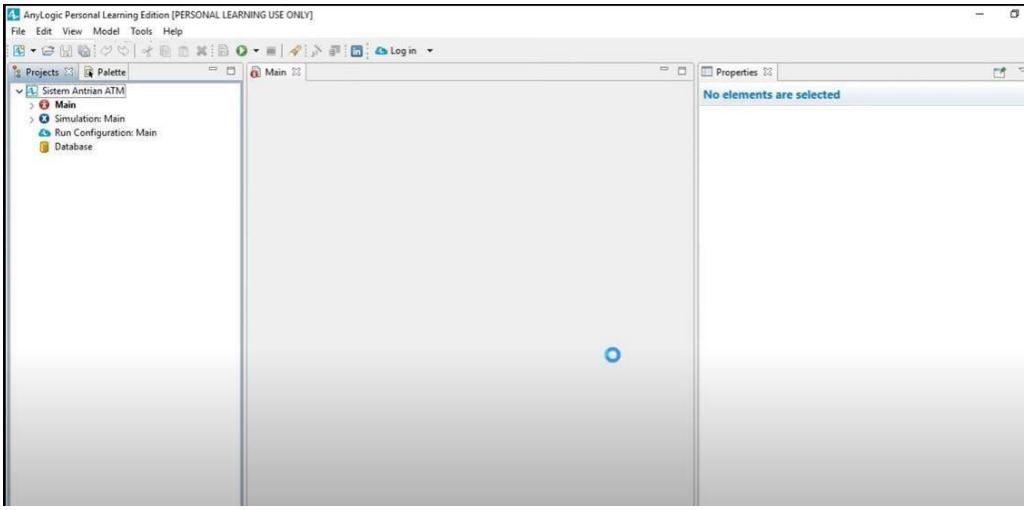
Aim: - Verify and validate a model developed like bank model or manufacturing model

Code: -

1. Create a new model
2. Click the New toolbar button. The New Model dialog box is displayed.



3. Specify the name of the model. Type Bank in the Model name edit box.
4. Specify the location where you want to store your model files. Browse for the existing folder using the Browse button, or type the name of the folder you want to create in the Location edit box.
5. Select minutes as model time units.
6. Click Finish to complete the process.



Creating a process flowchart

Now we will define the process with a flowchart composed from Process Modeling Library blocks.

Each block here defines some operation that will be performed with agents passing through this block.

In AnyLogic you create flowcharts by adding the blocks from the library palette to the graphical diagram, connecting blocks together and tuning the parameters of the blocks.

Create the model flowchart

The Palette view and display the Process Modeling Library palette:

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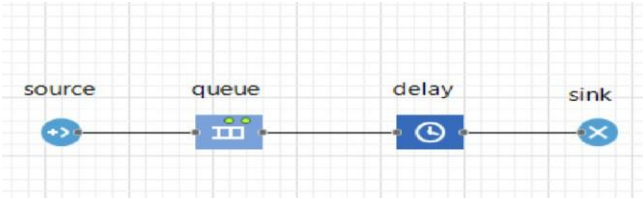
1. Add Process Modeling Library blocks on the diagram and connect them as shown in the figure below. To add a flowchart block on the diagram, drag the required element from the palette into the graphical editor.



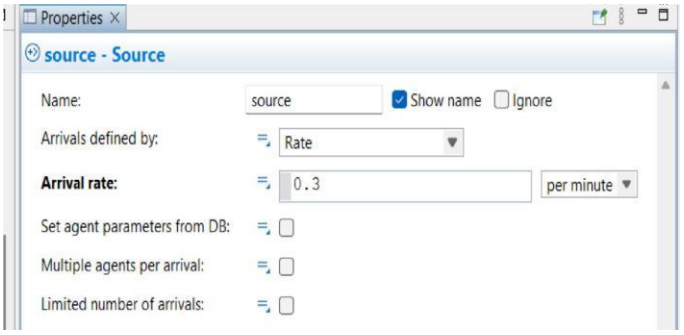
While dragging the blocks, and placing them close to each other, you may see the lines connecting the blocks appear. These connectors should connect only the ports lying on right and left borders of the block icons.

Our flowchart describes the simplest queuing system, consisting of a source of agents, a delay, a queue before this delay, and the final sink block.

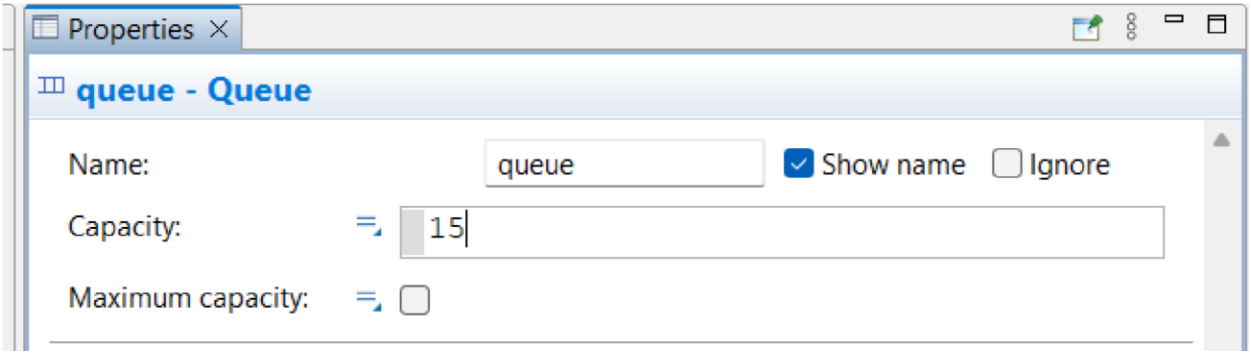
Let's say a couple of words about these flowchart blocks.

- Source block generates agents. It is usually used as a starting point of the process flow. In our example, it models customer arrival.
- Queue block models queues. In this model it simulates a queue of customers waiting for the moment they can start accessing ATM services.
- Delay here simulates the delay associated with the service at ATM.
- Sink block indicates the end of the flowchart and destroys the incoming agents.

Configure the flowchart blocks Source block.



Queue block



Rename the Delay block to ATM . Assume that processing time inside ATM is triangularly distributed with mean value of 1.5 , min of 0.8 and max value of 3.5 minutes .

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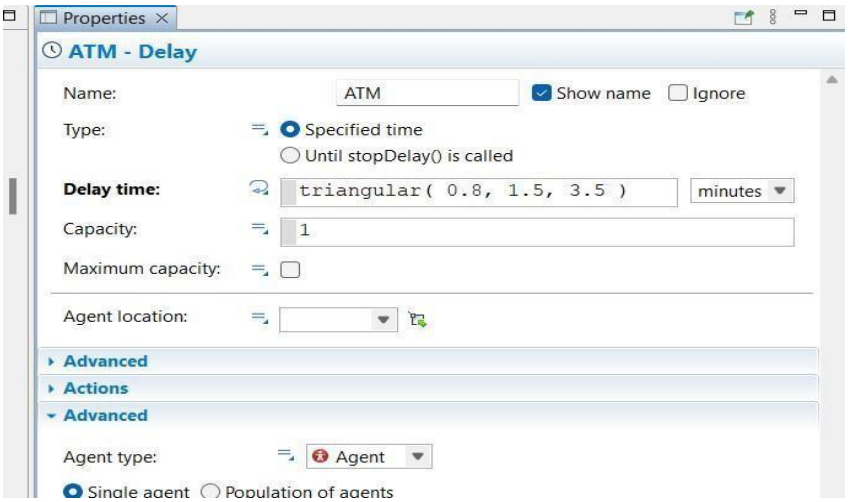
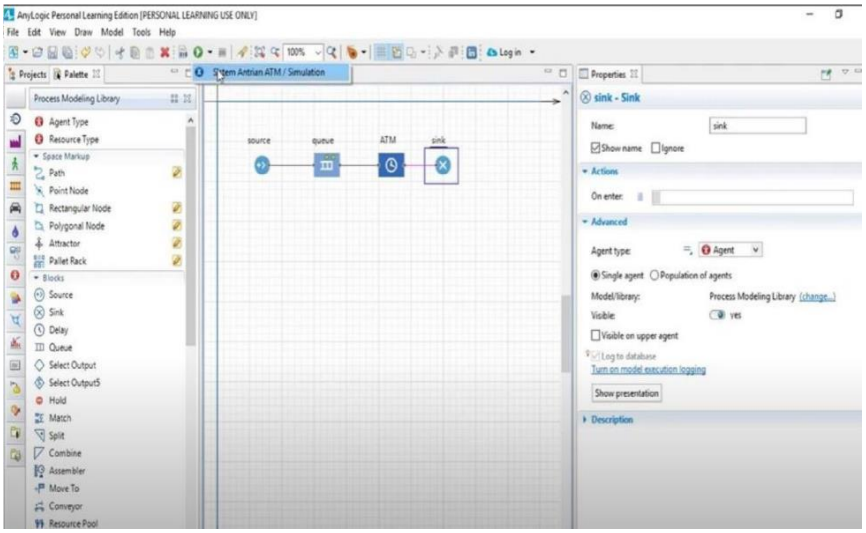
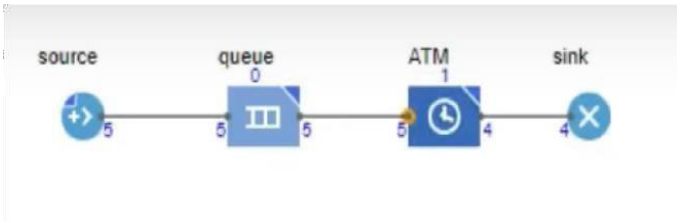


Run the model



The model will launch immediately. You will see animated flowchart. Each model created with Process Modeling Library instantly has animated flowchart where you can see detailed current block status, for example queue size, number of agents left and so on — completely visualized!



If needed, adjust the execution speed to your needs using Slow down and Speed up buttons in the control panel.

Click on the block to open it's inspect window. Inspect window shows statistics of the block,

e.g. Queue blocks inspect shows the queue capacity, the number of agents passed through either port of the block or also whether the timeout option is enabled for this queue. Contains string displays the number of agents currently being in the block along with IDs of these agents.

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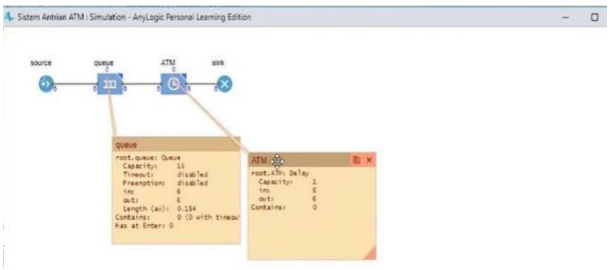
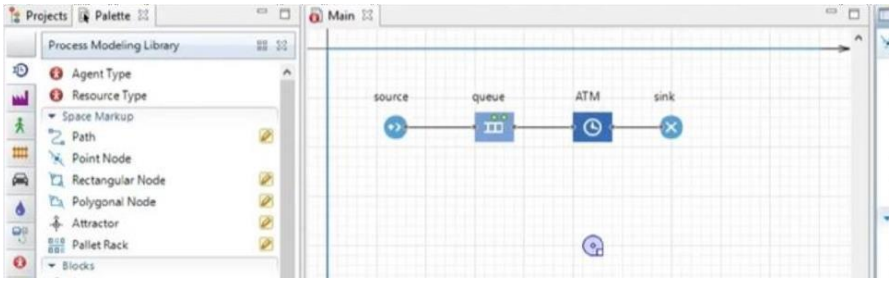


Phase 2: Creating Model Animation Adding Space Markup shapes

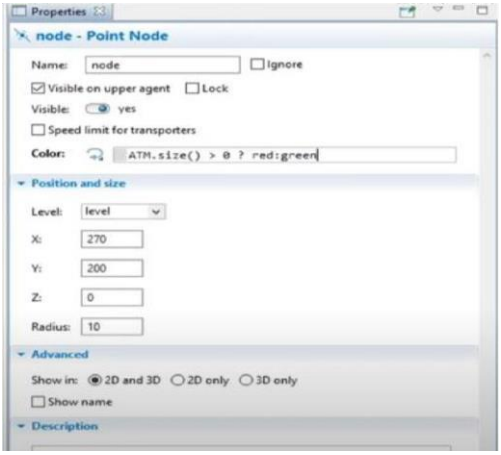
Set up space markup for ATM

1. Draw the ATM as a point node. First, open the Space Markup palette in the Palette view .

2. Drag the Point Node element from the Space Markup palette into the graphical editor and place it under the flowchart.



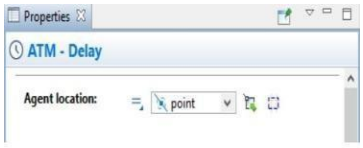
3. Select the point node in the graphical editor to open its Properties view . Enter the expression that will allow to change the color of the shape at runtime in the Color property: ATM.size() > 0 ? red : green



4. Click the ATM block in the flowchart to open its Properties view.

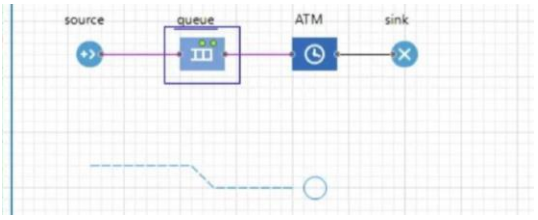
5. In the Agent location option select the point node that you have drawn previously.

You can either click the down arrow and select the point node from the list of appropriate space markup elements, or you can click the button, located on the right, to select this space markup shape from the graphical editor (the rest of the elements in the editor will be greyed out).



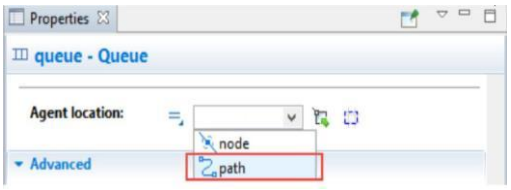
Set up space markup for the queue

1. Draw the queue as a path. First, open the Space Markup palette in the Palette view.
2. Double-click the Path element in the palette. A pencil icon will appear next to it, which means that you have switched to the drawing mode.
3. Click in the graphical editor to put the first point of the path. Do more clicks to add turning points. Finish drawing with a double -click.

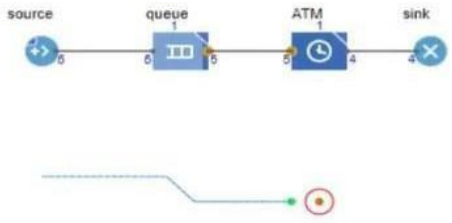


4. Click the queue block in the flowchart and go to its Properties view.

5. In the Agent location option select the path you have drawn previously. You can either click the down arrow and select the path from the list of appropriate elements, or you can click the button, located on the right, to select this space markup shape from the graphical editor (the rest of the elements in the editor will be greyed out).



Run the model and observe its behavior. If you want to speed up the simulation significantly, switch to virtual time mode by clicking the Run as fast as possible (virtual time mode) control. Switching to virtual time mode allows you to view simulation run at its maximum speed. Therefore, you can simulate a long period of time.

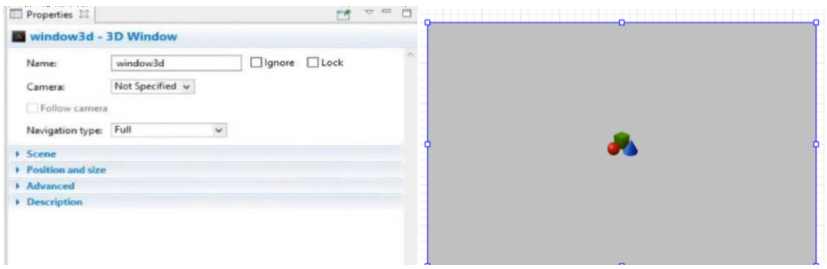


Adding 3D Animation

1. Drag the 3D Window element from the 3D section of the Presentation palette to

the graphical editor.

2. The grey area will appear on the screen. Locate it where you want your 3D presentation to be shown at the model runtime:



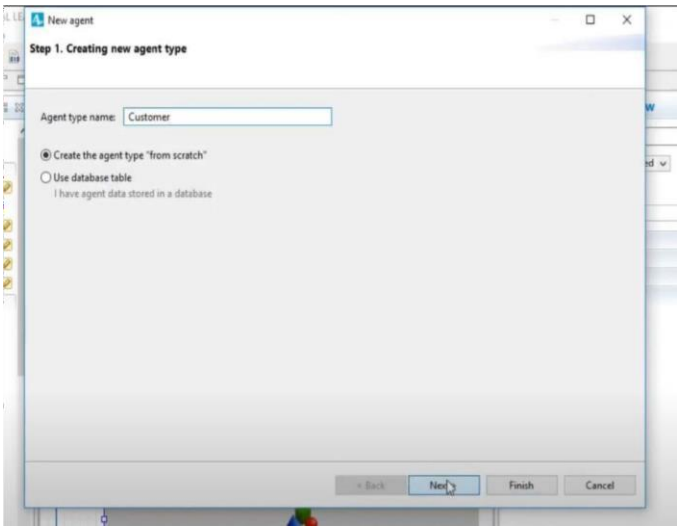
Adding 3D objects

Create a new agent type

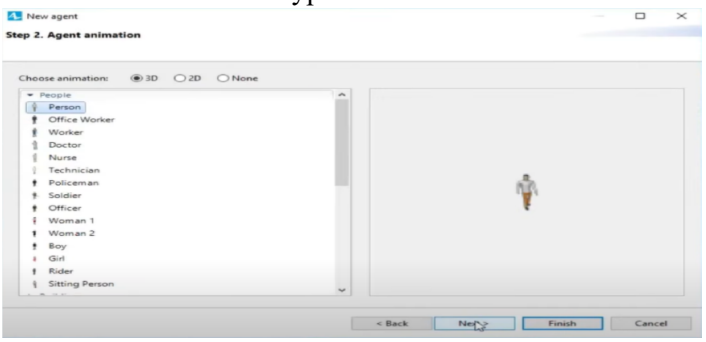
1. Open the Process Modeling Library in the Palette view.

2. Drag the Agent type element into the graphical editor.

3. The New agent wizard will open on the Creating new agent type step. Enter Customer as the Agent type name, and leave the Create the agent type "from scratch" selected. Press Next.



4. In the next step sele3cDtas the animation type and sePleecrtsonfrom the list of the 3D figures.

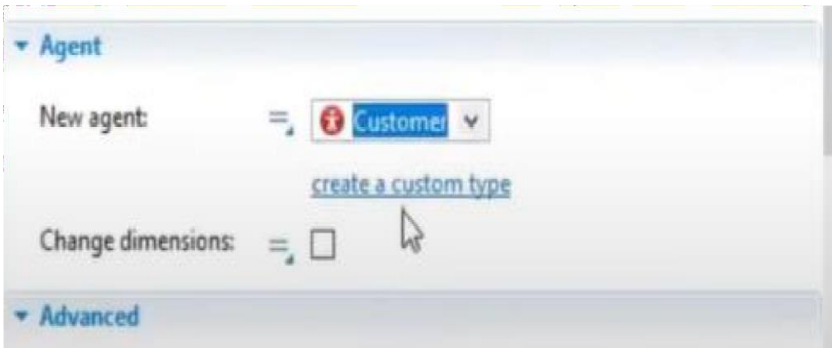


5. ClickFinis.hThe new Customedr iagram will open. You can findPtehreson3D figure in the axis origin. Switch back to tMheaindiagram.

Configure flowchart to use the new type

1. On the Main diagram, select the source block in the graphical editor.

2. Choose Customer from the New agent drop-down list.



3. Go to the Properties view of the node element and set Visible control to no. This way the markup shape will be invisible during animation on model runtime.

4. In the same manner make the path element invisible at runtime too.

5. Run the model and switch to 3D view to see our customers moving in the queue.

Add an ATM figure

1. Open the 3D Objects palette in the Palette view.

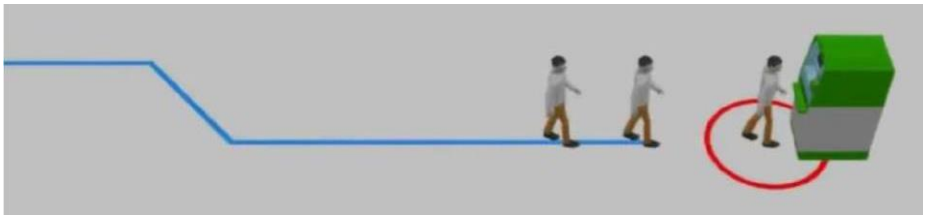
2. Drag the ATM 3D figure from the Supermarket section of this palette onto the node in the graphical editor. In the displayed Auto scale 3D object dialog box click the Yes button.

3. If you run the model now and check 3D animation in window3D mode, you will notice that our ATM does not face the customers' flow and we need to rotate it.

4. Select the atm 3D object in the graphical editor and open the section Position in its Properties view.

5. Choose 0 degrees from the drop-down list of the Rotation Z option.

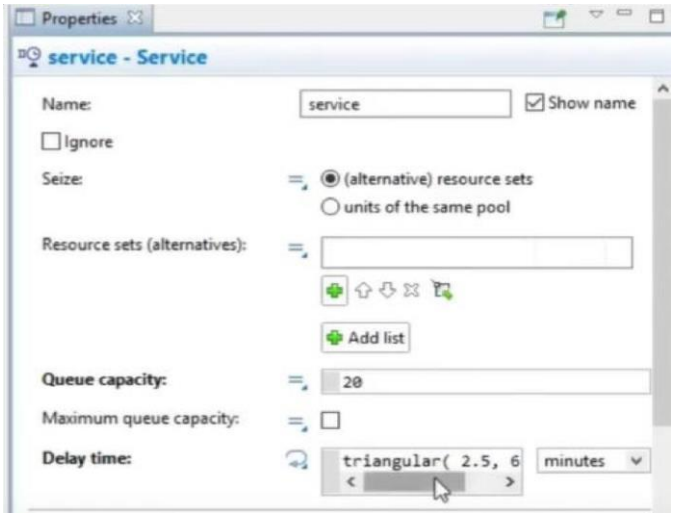
6. Run the model to double-check that the ATM is facing the customers now.



Phase 3: Adding tellers Modifying the flowchart

Create a service

1. Open the Process Modeling Library in the Palette view and drag the Service block onto out Main diagram.
2. Go to the Properties view of the service block.
3. Modify the block's properties:
    1. There is only one queue for all tellers. Set up Queue capacity to 20.
    2. We assume that service time is triangularly distributed with the min value of 2.5, average value of 6, and the max value of 11 minutes. Set Delay time to triangular (2.5, 6, 11)



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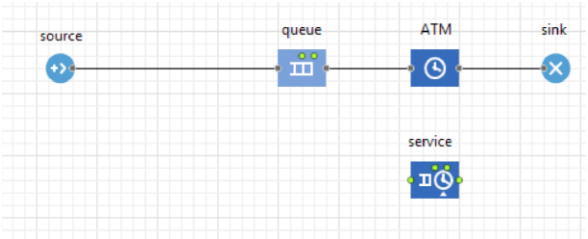
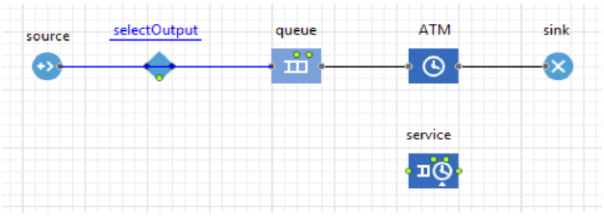
Adjust the process flowchart

1. Move the blocks queue, ATM, and sink to the right to make space for one block between the source and the queue .



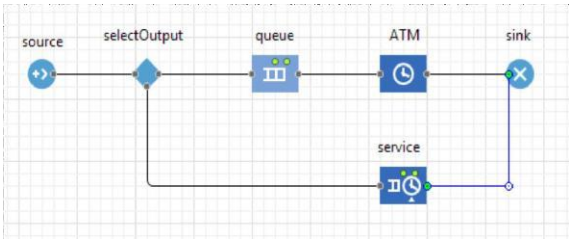
2. Open the Process Modeling Library in the Palette view and add the SelectOutput block in the resulting space. When you place the block on the connector, it will automatically get built in.



SelectOutput is a decision-making block. The agent arrived at the block is forwarded along one of two output ports depending on the user-defined condition.

2. Select selectOutput in the flowchart and go to its Properties view. Choose the option If condition is true for the Select True Output parameter. Make sure that Condition is randomTrue(0.5). This agent routing condition defines that the number of customers competing for ATM and teller service will be approximately equal.

3. Connect selectOutput and service with other blocks as shown in the figure:

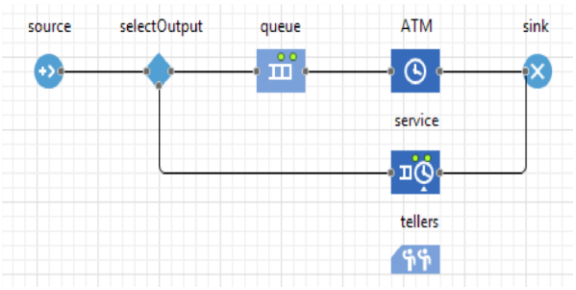


Add resources for the service

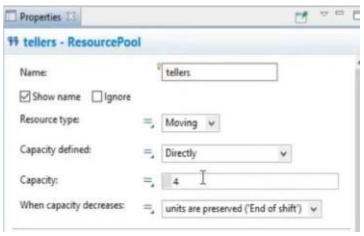
1. Open the Process Modeling Library in the Palette view and drag the ResourcePool block onto our Main diagram. ResourcePool block is a storage for resource units.

2. Place it under service and go to its Properties view.

3. Name the block tellers

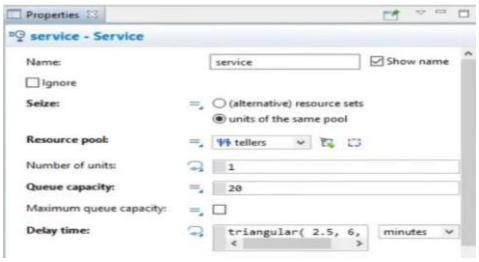


4. Specify that this resource block has only four resource units by setting its Capacity to 4.



5. ResourcePool block should be connected to resource seizing and releasing block (Service in our case). So we need to modify the properties of the service block.

6. Select service in the flowchart to open its properties. Set the Seize parameter to units of the same pool. Then specify the resource pool we have created in the option Resource pool. You can either click the down arrow to select the resource pool object from the drop-down list, or you can click the button, located on the right, to select the object in the graphical editor (all inappropriate objects will be greyed out).



Now since the model has changed, we need to alter the model animation as well.

Adding space markup shapes

Set up space markup for the queue to tellers

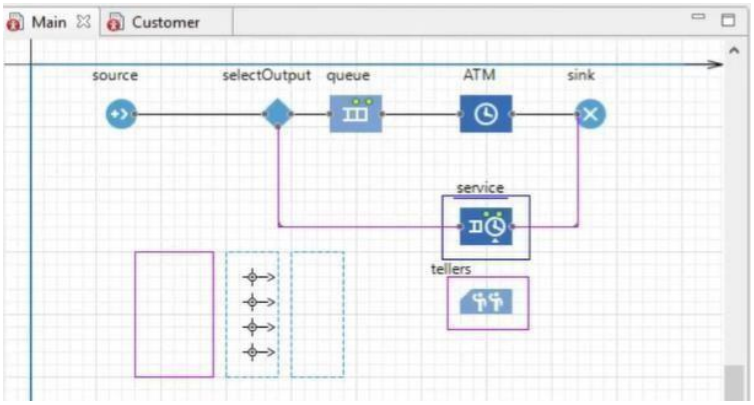
1. This time we will draw a waiting area using a rectangular node. First, open the Space Markup palette in the Palette view.

2. Double-click the Rectangular Node element to switch to the drawing mode.

3. Click in the graphical editor and drag the rectangle without releasing the mouse button. Release when you have a rectangular node of the required form. You can edit its form later as you need.

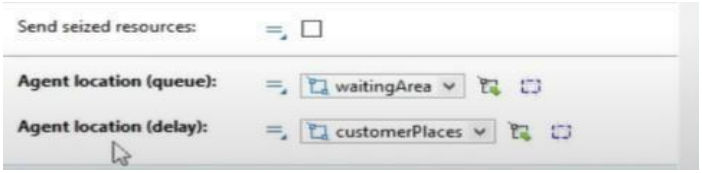
4. Name the node waitingArea

5. Switch the Visible control to no. This way the markup shape will be invisible during animation at model runtime.



6. Click the service block in the flowchart and go to its Properties view.

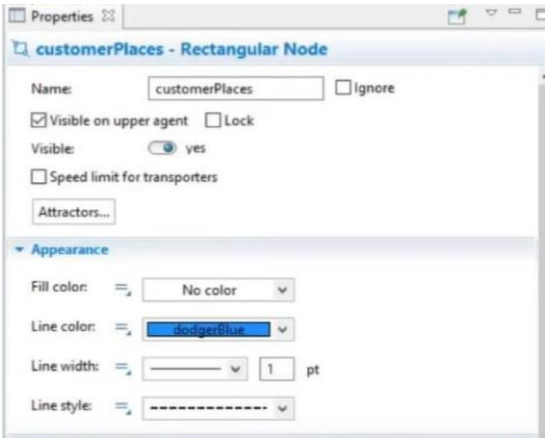
7. Select the waitingArea node in the Agent location (queue) option.



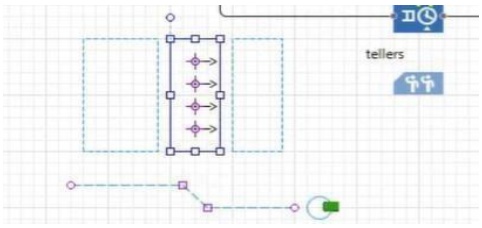
Set up space markup for the customers

The customers need a place to stand somewhere while they are getting serviced by tellers.

1. Draw another rectangular node as displayed in the image below. Name the node customerPlaces and in its properties switch the Visible control to no.

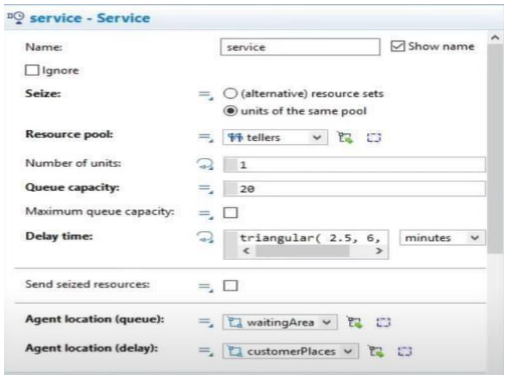


2. In the Attractors window that will pop-up, specify 4 for the creation mode Number of attractors and click OK . You will see that attractors appeared in the customerPlaces node with an even offset.



3. Now we need to refer to this area in the flowchart. Click the service block in the flowchart and go to its Properties view.

4. Select the customerPlaces node in the Agent location (delay) option.



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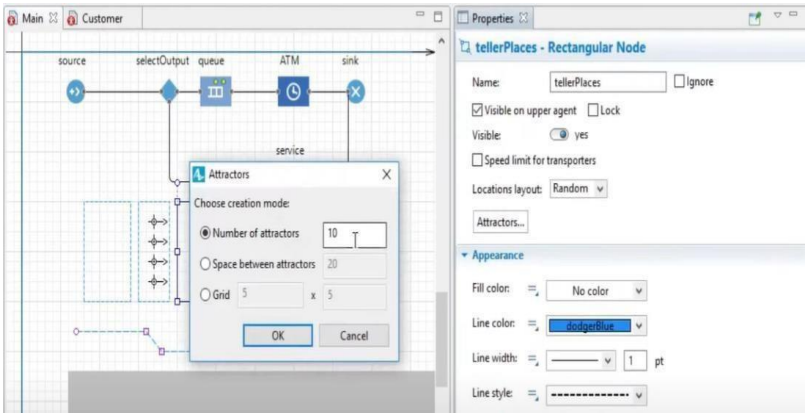
Set up space markup for the tellers

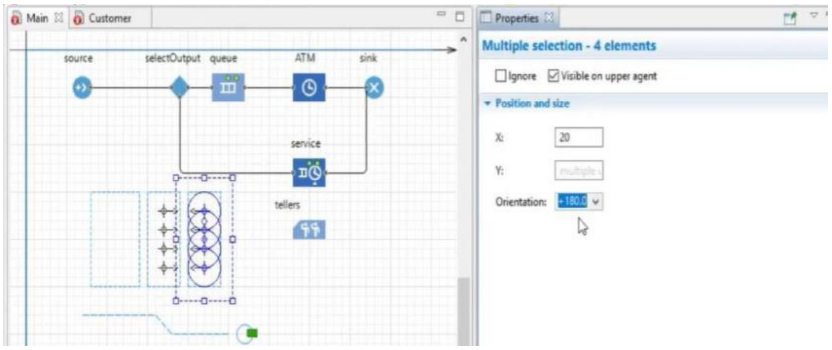
1. Since we have 4 tellers, we will use a rectangular node to draw this service area.

2. Draw another rectangular node as displayed in the image below. Name the node tellerPlaces and in its properties switch the Visible control to no.



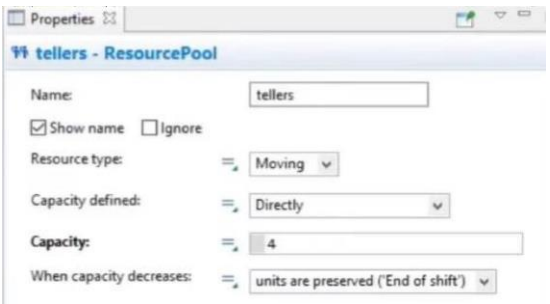
3. Create 4 attractors inside the node to specify tellers in the same manner as you have done before.

4. You will see attractors appear in the tellerPlacesnode with the even offset, but facing the wrong direction. Select all attractors by clicking each one while holding Shift key and go to the Properties view. In the section Position and size, change the Orientation parameter to 180.0 .



5. Click the tellers block in the flowchart and go to its Properties view.

6. Select the tellerPlaces in the Home location (nodes) parameter by clicking .



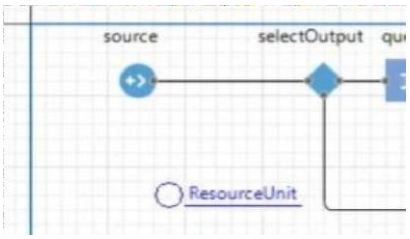
Adding 3D objects

It is time to add teller 3D objects to our model. We will create a new resource type to animate tellers.

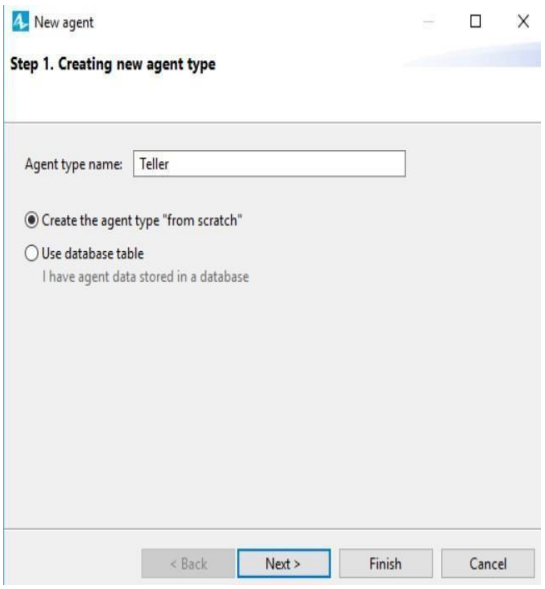
Create a new resource type

1. Open the Process Modeling Library palette.

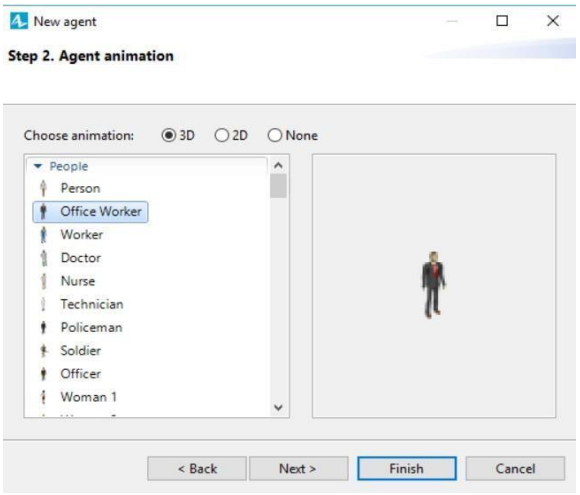
2. Drag the Resource Type element into the graphical editor.



3. The New agent wizard will open on the Creating new agent step. Enter Teller as the Agent type name and leave the Create the agent type "from scratch" selected. Press Next.



4. In the next step select 3D as the animation type and select Office worker from the list of the 3D figures.



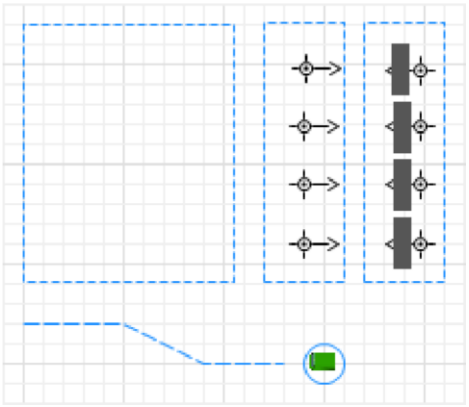
Click Finish . The new Teller diagram will open. You can find the Office worker 3 D

figure in the axis origin. Switch back to the Main diagram. Add tables for the tellers

1. Open the 3D Objects palette.

2. Drag four Table 3D figures from the Office section of this palette onto the tellerPlaces in the graphical editor. In the displayed Auto scale 3D object dialog box click the Yes button.

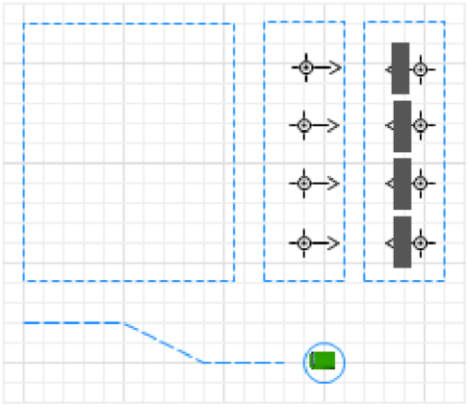
3. Place the tables over attractors since attractors are the places where the tellers stand.



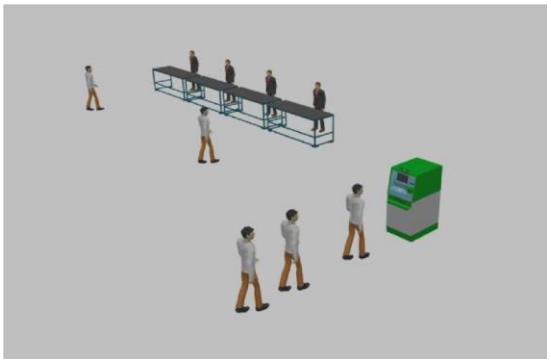
4. You can see that their orientation is wrong. Select all tables by clicking them while holding the Shift key and go to the Properties view.

5. In the section Position , change the parameter Rotation to -90.0 degrees.

6. If necessary, rearrange all eight attractors and four tables so that they are reasonably lined up.



Now you can run the model and observe in 3D how some customers go to the ATM and other get service at the teller's tables.



Phase 4. Collecting statistics Collecting utilization statistics

Add a bar chart to indicate mean ATM utilization

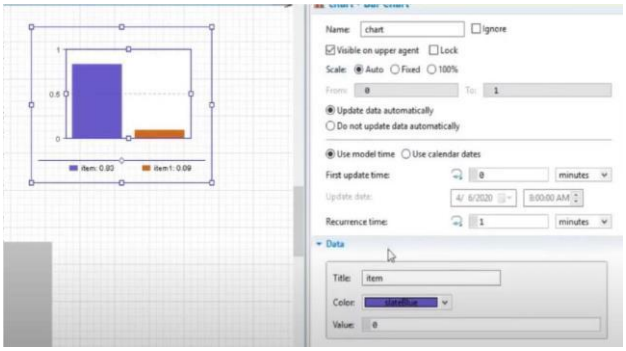
Roll No: 25166009

1. Open the Analysis palette. This palette contains charts and data objects used for collecting data and performing various statistical analysis on them. Drag the Bar Chart element from the stencil into the graphical editor.

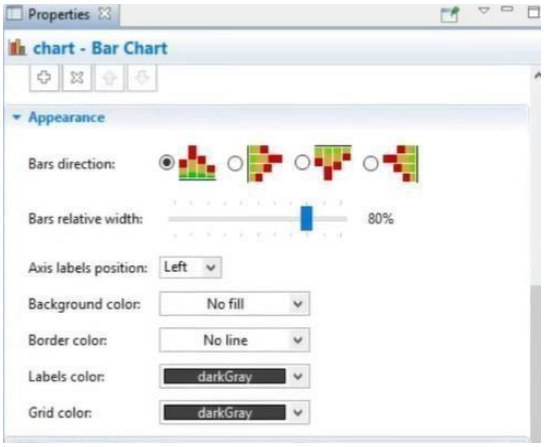
2. Go to the Data section of the chart's properties. Click the Add data item button to add data item to be displayed by this chart.

3. Set the data item's Title: ATM utilization

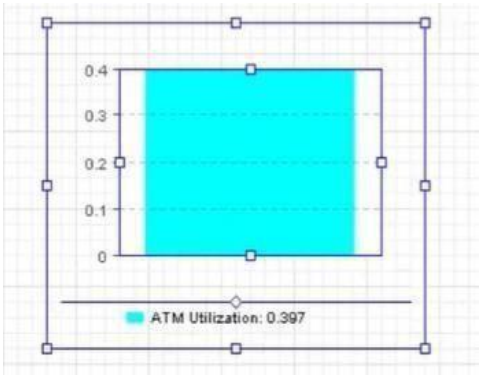
4. Type ATM.statsUtilization.mean() as the Value of the data item. ATM is the name of the Delay block we created. Each Delay block has a statsUtilization data set that collects statistics on the object utilization. The mean() is the function that returns the mean value measured. You can use other functions to get statistical values, such as min() and max().



5. Change the position of the chart's legend in the Legend properties section.



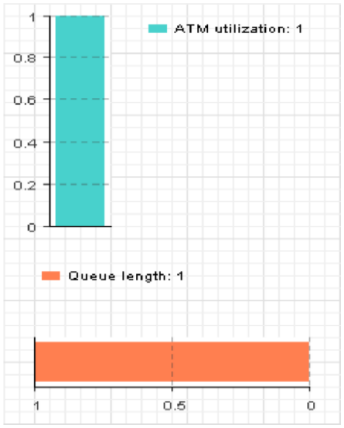
6. Now resize the chart as shown in the figure below:



Add a bar chart to indicate mean queue length

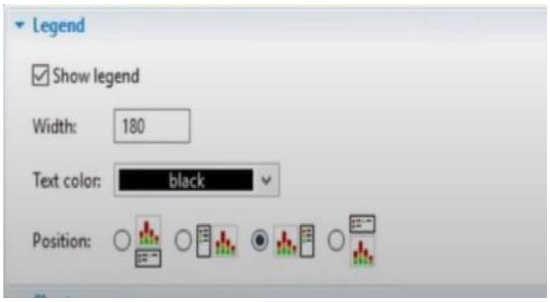
Roll No: 25166009

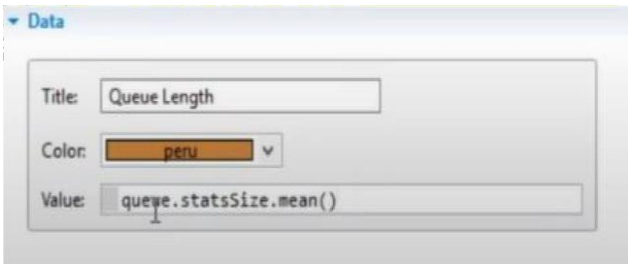
1. Add another bar chart in the same way. Resize it to look like the one in the figure below.



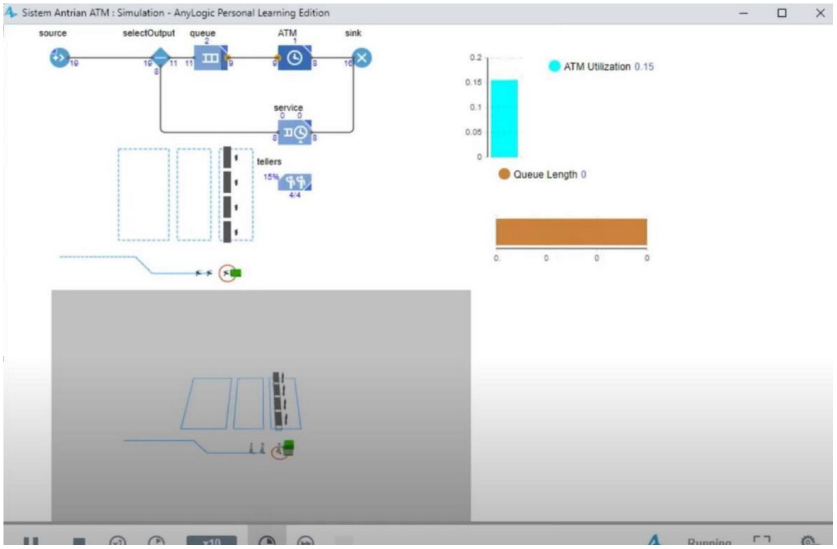
Open the Appearance section of the Properties view and choose the last option in the Bars direction property to make bars grow to the left. Change the position of the

chart's legend in the section Legend (like it is shown in the figure below).





Run the model and observe the ATM utilization and mean queue length with new created charts.

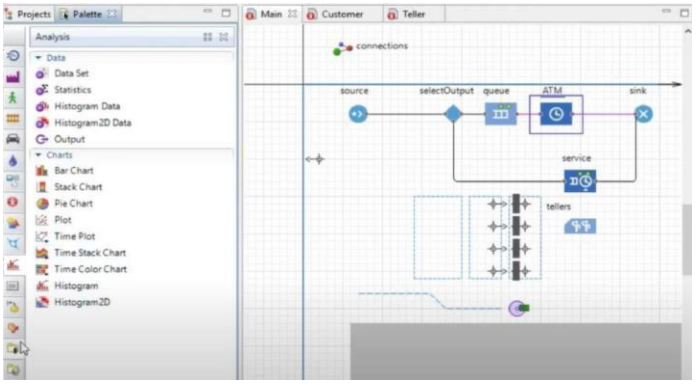


Add time measurement blocks to the flowchart.

1. Adjust the flowchart to make space for a new block between source and selectOutput.

2. Open the Process Modeling Library in the

Palette view and add the TimeMeasureStart block in the resulting space. Make sure that the ports of the block are properly connected.

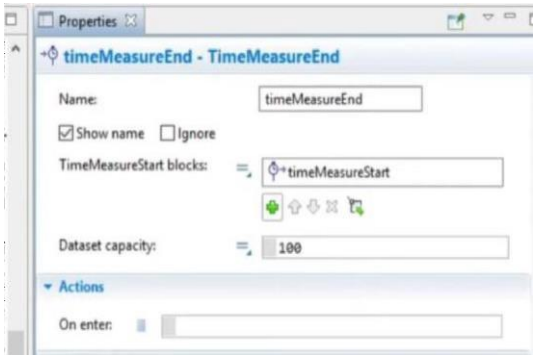


3. Move block sink to the right and rearrange the connection between service and sink to make space for a block after the connector.

4. Drag the TimeMeasureEnd block from the Process Modeling Library in the Palette view into the graphical editor and place it before the sink block. Name the block timeTotal

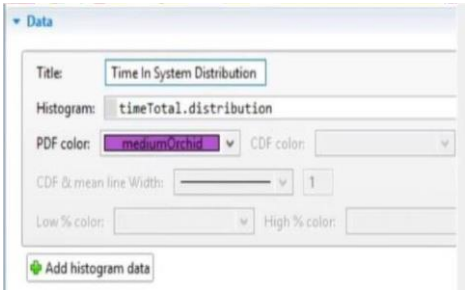
5. Make sure that the ports of the timeTotal block are properly connected both to ATM and service blocks.

6. Every TimeMeasureEnd block must have at least one TimeMeasureStart block specified in its properties to calculate the time distribution for agents. Specify our timeMeasureStart block in its TimeMeasureStart blocks parameter.



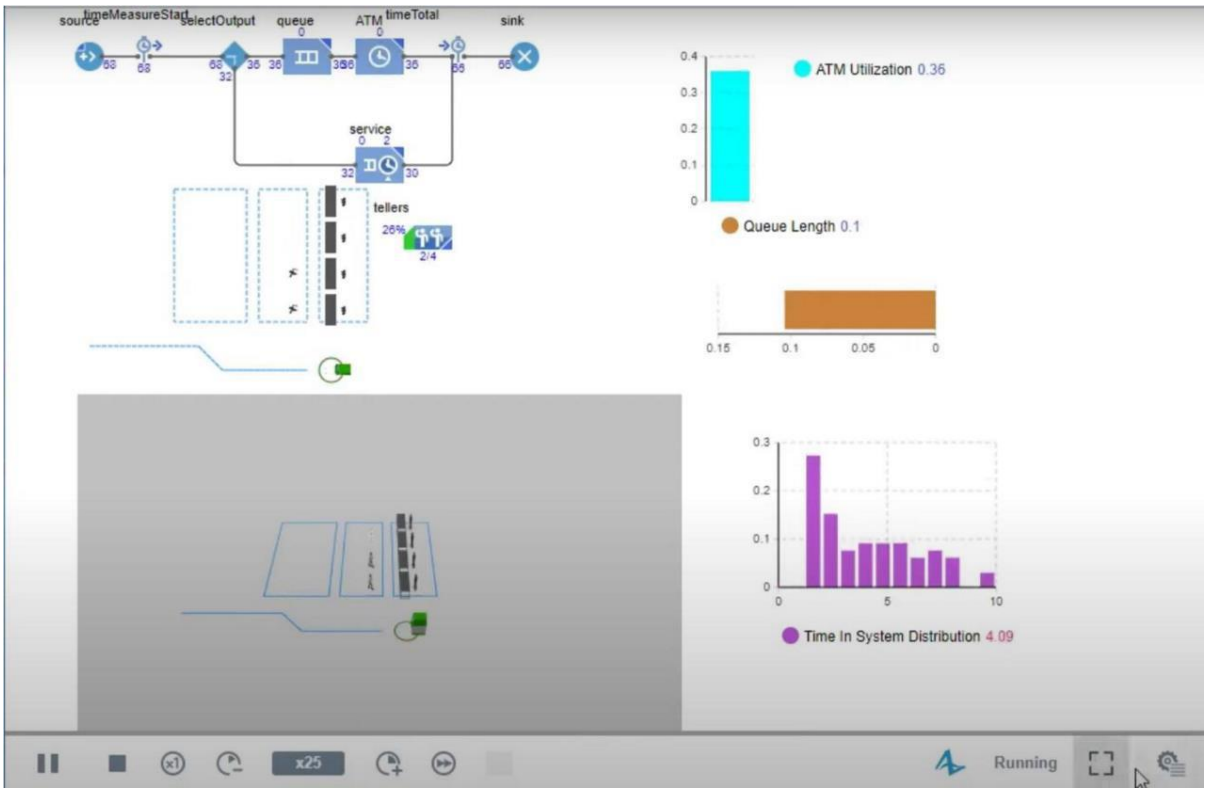
Add a histogram to indicate the collected statistics

1. Open the Analysis palette. Drag the Histogram element from the palette into the graphical editor.



Roll No: 25166009

Run the model. Set virtual time mode and observe distribution of customer's time in system.



Roll No: 25166009

PRACTICAL NO: 08

Aim: Create defence model to stimulate aircraft behaviour

Code:

In the first phase we will create a new model and populate it with buildings that will be subject to bombing.

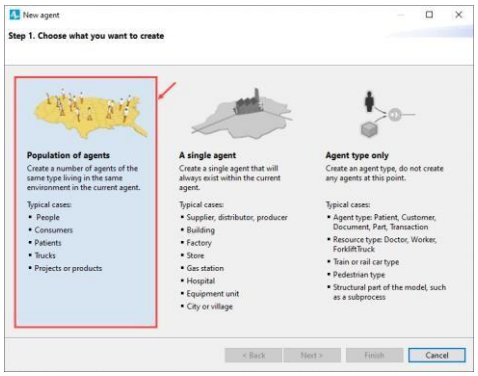
Create a new model

1. Click the New toolbar button toolbar button. The New Model dialog box will be displayed.
2. Define the parameters of the new model:
   - Specify the name of the model in the Model name field. Type Air Defense System
   - Set the new model location if necessary by clicking the Browse button and selecting the required folder.
   - Set Model time units to seconds.
3. Click Finish to create a new model.

We'll begin the design our model with creating a new population of agents that will represent 10 facilities.

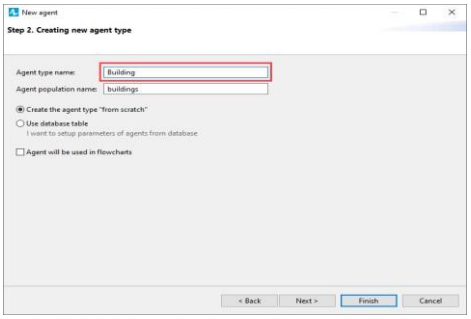
Create a new population of agents

1. Drag the Agent element from the Agent palette onto the Main diagram. The New agent dialog box will open.
2. Click Population of agents. You will be taken to the next step of the New agent wizard.

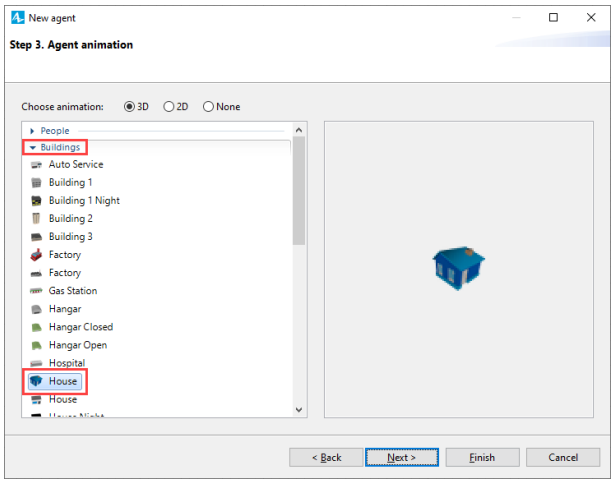


3. Type Building

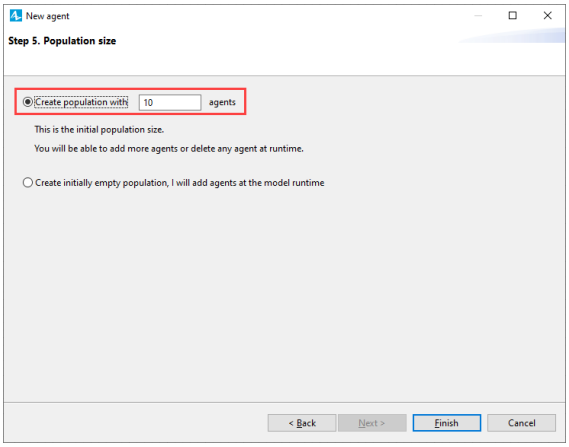
   in the Agent type name field. The Agent population name will be automatically filled. Click Next to proceed to step 3.



4. Leave the Choose animation parameter set to 3D mode and choose the House animation shape in the Buildings section. Click Next to proceed to step 4.

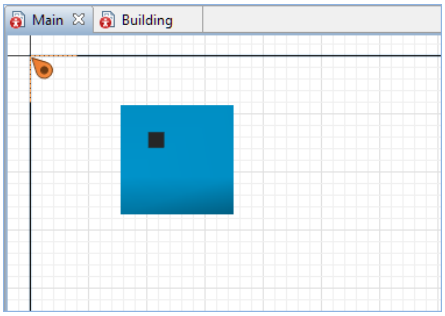


5. We will not set any agent parameters, you may click Next to proceed to step 5.
6. Set the Create population with parameter to 10.



7. Click Finish to save the changes and create the customized population.

We have created a population of agents and defined animation shape for them.



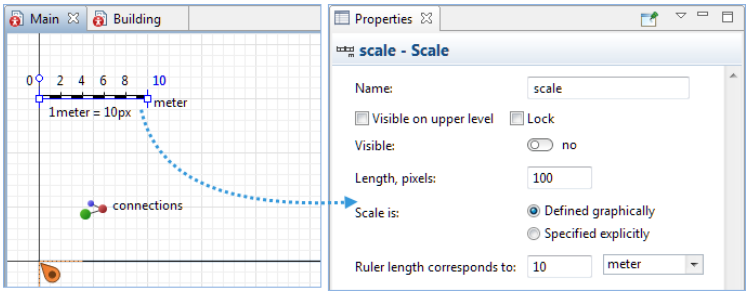
We want to place our agents to randomly selected points within the continuous space. By default the space has the size of 1000x600 pixels.

Define locations for the agents

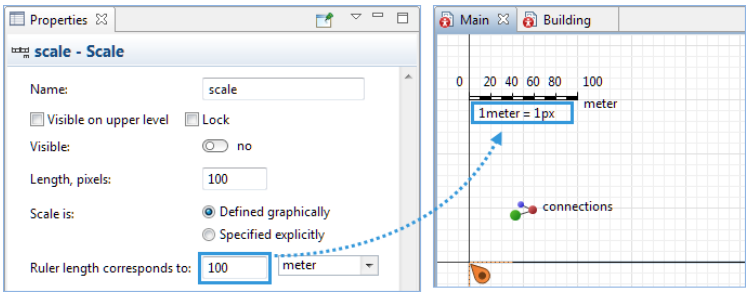
1. Click Main in the model tree to open its Properties.
2. Expand the Space and network section of the Main agent type's properties.
3. Set the Layout type to Random.

Adjust the scale of the model

1. Click the Scale element on the Main diagram to open its Properties.



2. Set the Ruler length corresponds to parameter to 100. The scale on the ruler will change.

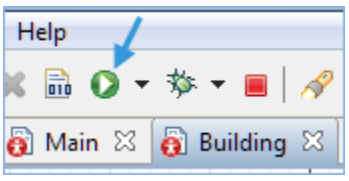


We modified the scale of the model, as a result the building shape changed its size. As you can see in the image above, if we will keep the animations of our agents resized corresponding to the model scale, these agents (such as building here) will become invisible in our model's animation scene. So we will use greater scales for the agents to make them visible during the animation.

We have completed setting up the population of agents and may now run our model for the first time to observe the model behavior.

Run the model

1. Click the Run toolbar button.

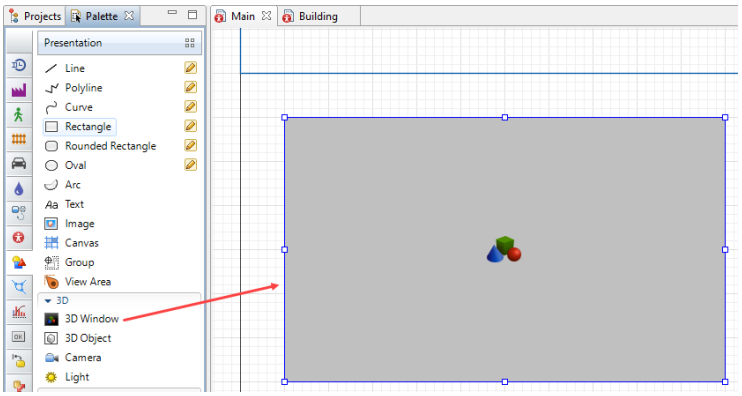


The model window will appear and the model will launch automatically. You will see the 10 building shapes randomly distributed in a 500 by 500 pixel space. This is the space size set by default. We do not need to change it as we will customize the location of the facilities.

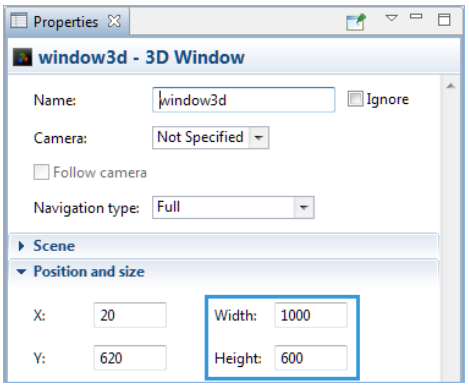
Now we will create 3D animation for our model. First of all we need to add 3D window to our Main diagram. The 3D window plays the role of a placeholder for 3D animation. It defines the area on the presentation diagram where 3D animation will be shown at runtime.

Add 3D window

1. Drag the 3D Window element from the 3D section of the Presentation palette to the graphical editor. Place the window below the model window frame.



2. Navigate to the Properties view of the 3D window and set its Width and Height parameters to 1000 and 600 respectively.

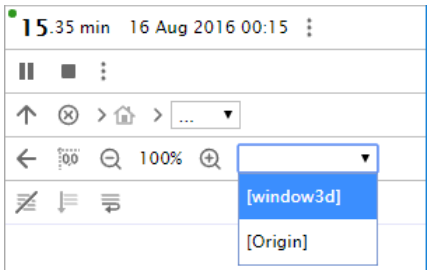


Now we will run the model and switch between the 2D and 3D views in the model window.

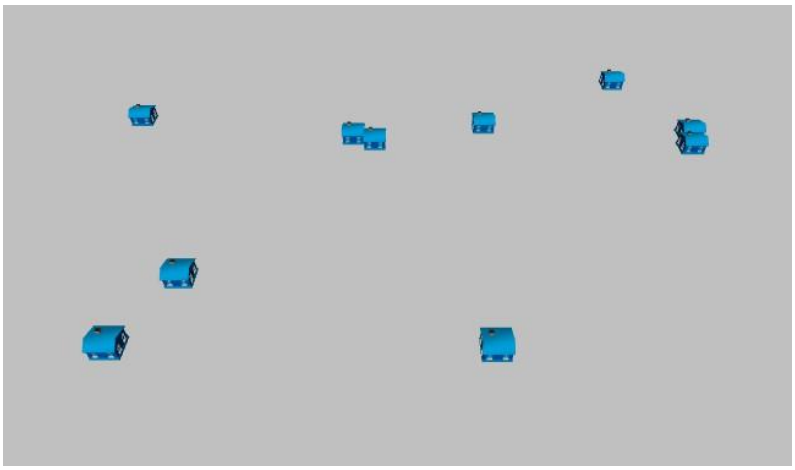
Compare 2D and 3D views

1. Click Run in the toolbar to run the model.

2. When you create a 3D window, AnyLogic adds a view area that allows you to easily navigate to the 3D view at runtime. To switch to this 3D view while the model is running, open the developer panel by clicking the Developer panel control in the right corner of the control panel. In the developer panel, expand the select view area to navigate list and select [window3d] from the list.

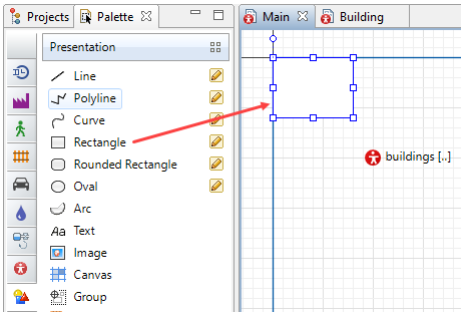


3. The view mode will change to 3D.

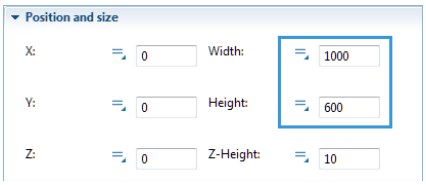


Draw the surface

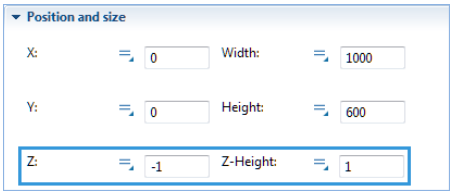
1. Drag a Rectangle shape from the Presentation palette onto the editor of Main, place its top left corner at (0,0).



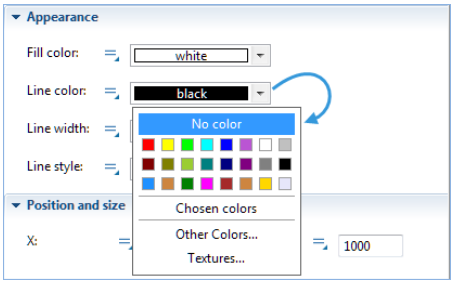
2. Navigate to the Position and size section of the rectangle's Properties and set its Width and Height parameters to 1000 and 600 respectively, hence the area size is 1000*600 meters.



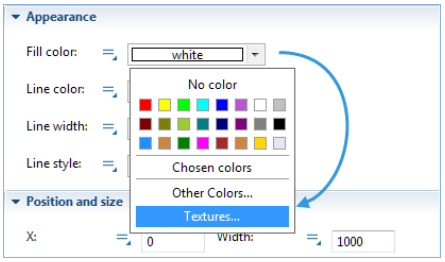
3. Now set the Z and Z-Height parameters to -1 and 1 respectively.



4. In the Appearance section of the rectangle's Properties set the Line color option to No color.



5. Now we will define the texture of the rectangle area. Click the Fill color control and select Textures to open a dialog box with available textures.



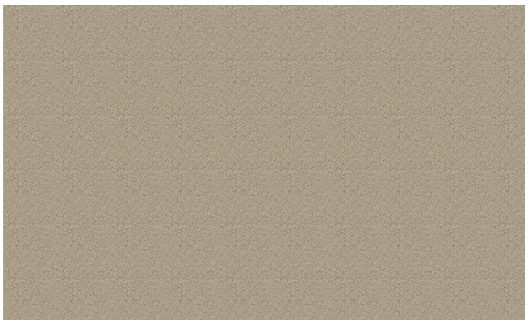
6. Click Earth texture to set it as the fill color for the rectangle shape.

7. Click OK to close the dialog box. The rectangle shape will change it appearance.

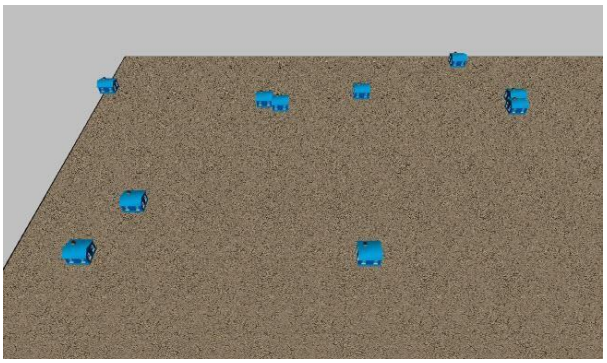
Now run the model and observe the new layout both in 2D and 3D modes.

Observe the new layout

1. Run the model. You will observe the model in the 2D view. As you can see, we have the new layout here but no buildings can be seen.



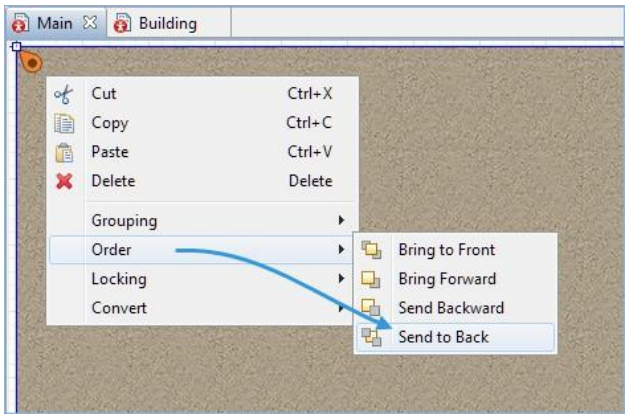
2. Switch to 3D animation scene. You can observe buildings in 3D view.



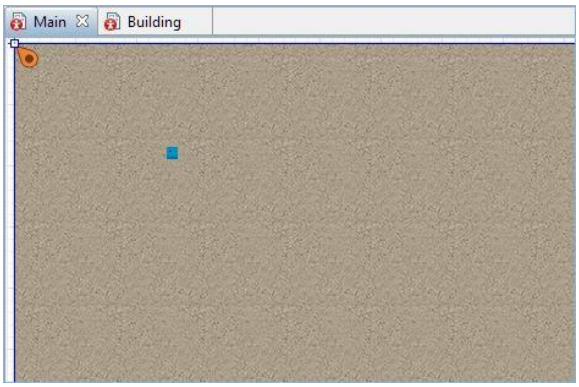
In order to make buildings visible in the 2D view we must reorder the shapes in the design.

Reorder shapes

1. Right-click the rectangle shape to open its context menu. Then click the Order menu item and select the Sent to Back sub-item from the list of available orders.



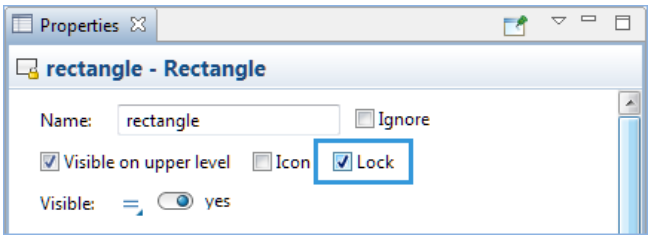
The 2D building shape will now be visible.



Now the model should have correct visualization in both 2D and 3D view. Prior to running the model to check if everything works like it should, we will lock the Rectangle shape and add camera.

Lock the rectangle shape

1. In the Properties view select the Lock option to lock the shape. This will prevent occasional selection of the rectangle while working with other elements on the diagram.



Add a camera

1. Drag the Camera element from the 3D section of the Presentation palette onto the graphical editor. You will see the camera icon in the graphical editor.
2. Direct the camera at the buildings presentation shapes (the positioning is described in details in the Camera article).

It is time to run the model and adjust the camera position to the desired one. We will save that position afterwards to have the camera always located at the set position.

Adjust the camera position

1. Run the model and switch to 3D mode.
2. Right-click the 3D model presentation to open a pop-up menu. Navigate to the Camera menu item and select camera sub-item. You will switch to the camera view.
3. Position the camera to have the best possible picture while observing the model in the runtime (for more details on navigating the 3D scene, see Moving and rotating 3D scene at runtime).
4. When done, right-click the 3D model presentation and click Copy camera's location.

You may stop the simulation now. We have set up our camera and copied its position, now we need to apply the new camera position.

Apply new camera position

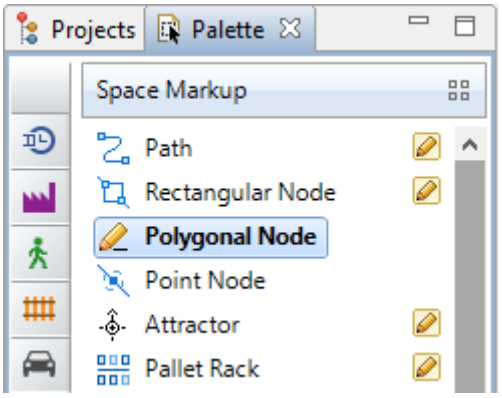
1. Click the Camera element to open its Properties view.

2. Click the Paste coordinates from clipboard button in the Properties view. The rotation parameters will change.

In the last step of this phase we will create a protected area, within which the buildings will be placed. The area will further be equipped with the air defense system, eliminating the air attacks on our facilities.

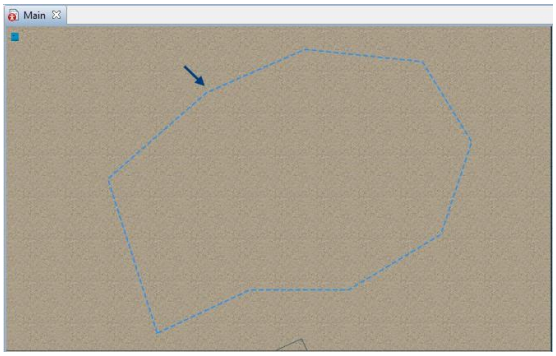
Define protected area

1. Double-click the Polygonal Node element in the Process Modeling Library palette to activate drawing mode.

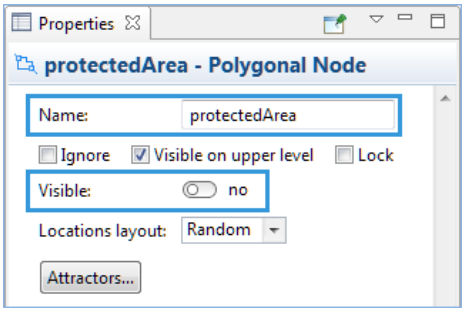


2. Click on top of the rectangle to start drawing the protected area.

3. Finish drawing with a double-click on the last node.



4. Navigate to the element's Properties, name it protectedArea and set its Visible parameter to no.

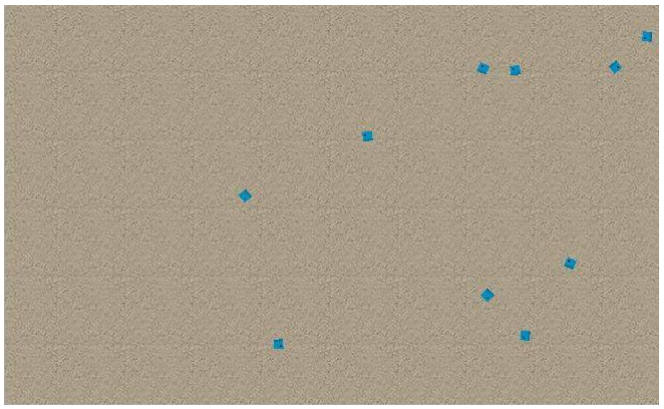


We have created a new area, now we need to locate our facilities within its boundaries.

Relocate the facilities

1. Click the buildings population on the Main diagram to open the Properties view.
2. Navigate to the Initial position section and set the Place agent(s) parameter to in the node. The Node parameter will appear below.
3. Click the set by default None value for the Node parameter and select protectedArea from the drop-down list of available nodes.
4. Now open the properties of Main and navigate to the Space and network section.
5. Set the Layout type to User-defined.

Finally, we may run the model. The buildings will be located within the area defined by the polygonal node



Phase 2. Creating bombers

In the previous phase we created a new model, populated it with facilities, defined animation shapes for the facilities, added 3D view and camera to observe the running model and finally added protected area. In this phase we will add bomber aircrafts to our model, define their behavior and mission.

Let us start with creating a new population of agents that will represent the bombers. Create a new agent type

1. Drag the Agent element from the Agent palette onto the Main diagram. Place it nearby the buildings population to the left of the model animation.

2. Click Population of agents. You will be taken to the next step.

3. Specify Bomber in the Agent type name field on the third step of the agent wizard. Click Next.

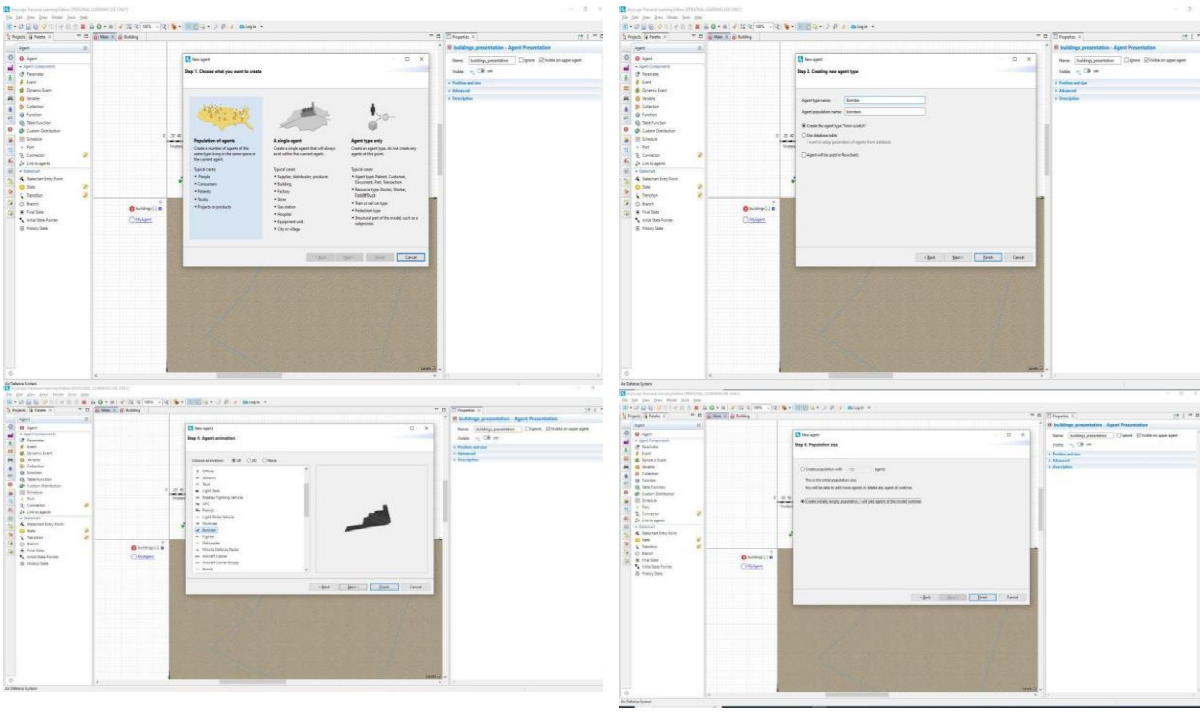
4. Choose the Bomber animation shape in the Military section. Click Next.

5. Define the population's parameter:

- Click add new... to create a parameter.
- Type target into the Parameter field.

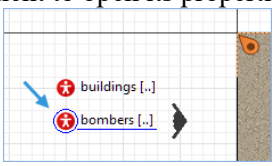
- Set Type to Other (additional drop-down list will appear next to it).
- Select Building from the additional drop-down list of the parameter's type (This will be the target building in the bomber mission).

Click Next.

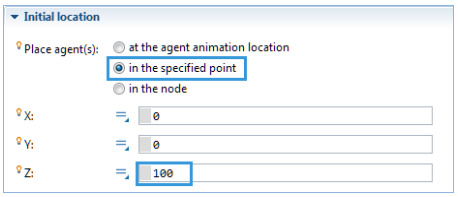


Define initial location

1. Click the bombers population element to open its properties.



2. Navigate to the Initial position section of the element's Properties, set its Place agent(s) parameter to in the specified point to manually specify the point of appearance and then type 100 into the Z coordinate's field to specify the altitude at which the bombers will be flying into the scene.



The next step is to define the velocity of the aircraft. It is done right here, in the same Properties view, just above the Initial position section.

Define the velocity of the aircraft

1. Navigate to the Dimensions and movement section and set the Initial speed parameter to 600, then click the speed units drop-down menu to the right of it and select kilometers per hour.

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Now that we have created bombers and defined their animation, initial location and target, we can move on to create the initial version of their behavior using the statechart.

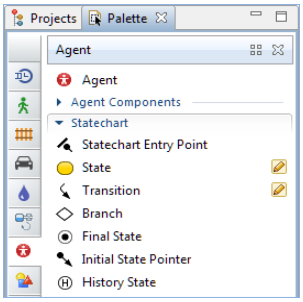
Once created, the bombers will be heading towards the buildings (it is set by

the target parameter). We will now define the further behavior, which will make the bombers gradually get to a lower altitude and then return to the initial point where they will delete themselves from the model.

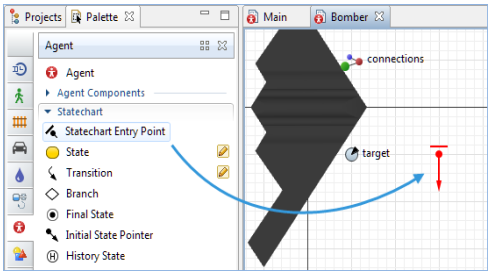
Create the behavior defining statechart

1. Double-click Bomber in the Projects view to open its diagram.

2. Switch to the Agent palette to use its statechart section.

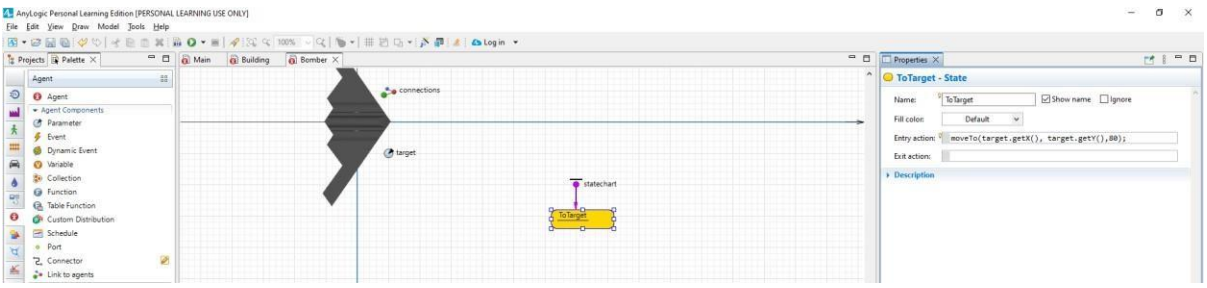


3. Drag the Statechart Entry Point element to the graphical editor of the Bomber agent.



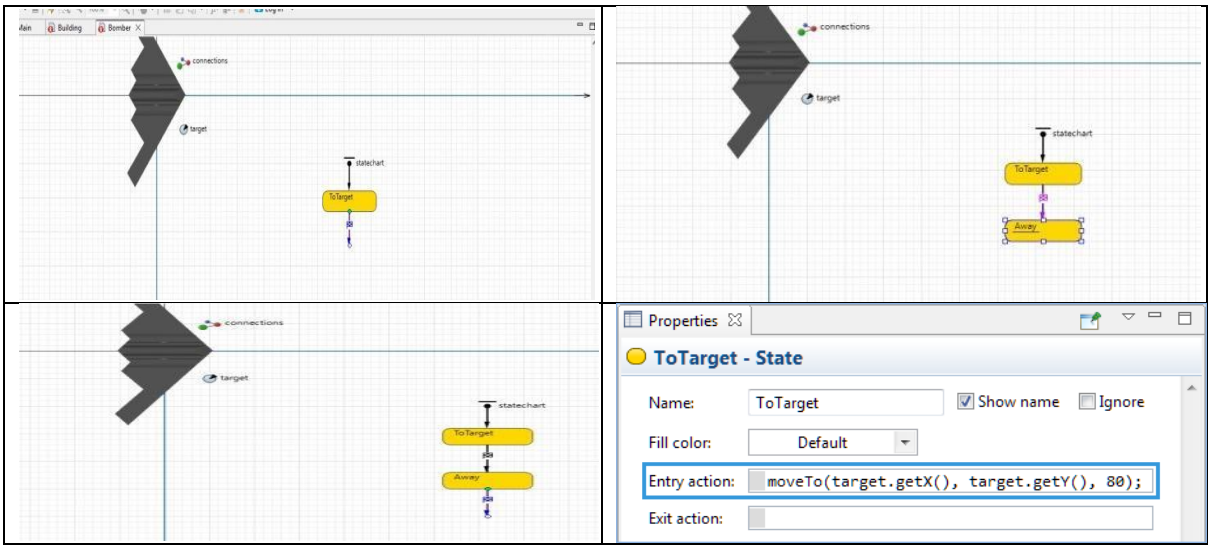
4. Double-click the State element to activate the drawing mode and draw a state rectangle below the previously drawn Statechart Entry Point.

5. Name it ToTarget and drag it up to the entry point until you see the green dot indicating that the two elements can be connected.

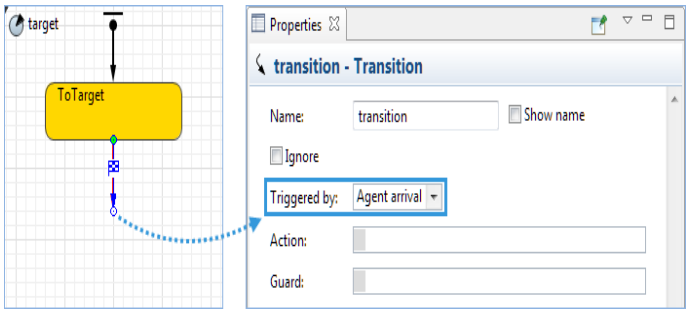


Modify the Entry action field in the Properties view of the ToTarget state. Type in the following code to define the coordinates of the bombers' location. By specifying the code we will define the

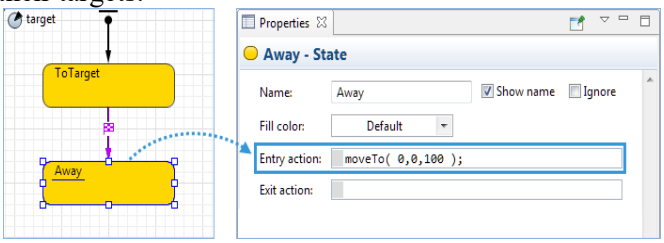
altitude different from the one specified in the Initial position section. It will make the bombers get to a lower altitude on their way to the targets, which are represented in our case by the buildings.



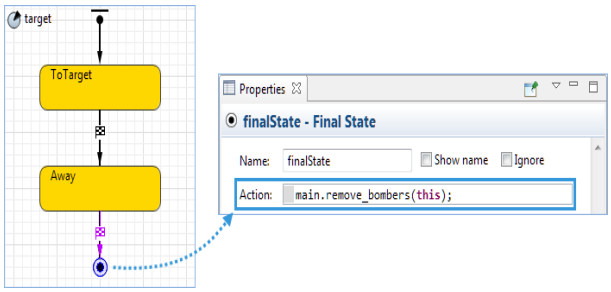
1. Drag the Transition element to the ToTarget state on the diagram and connect them. Then navigate to its properties and set the Triggered by parameter to Agent arrival.



2. Now drag another State element to the agent diagram and connect it to the Transition element. Name it Away.Then navigate to its Properties view and type the following code into the Entry action field, which will make the bombers get back to their previous altitude once they have reached their targets.



3. Drag another Transition element to the agent diagram and connect it to the Away element. Then navigate to its properties and set the Triggered by parameter to Agent arrival. The two transition elements on the statechart diagram must be identical.
4. Finally, drag the Final State element to the agent diagram and connect it to the last added Transition element. Then navigate to its Properties view and type the following code into the Entry action field, which will remove the bombers that have completed all the steps of this statechart.



We have completed the behavior defining statechart. As you can see we call the moveTo() function in the On enter field of both states to initiate movement of the agent. The transition from one state to another is triggered by the agent arrival. This pattern is very common in the agent based models.

The next step is to create the mission assignment. We will do it with the help of the Event element.

Program mission assignment

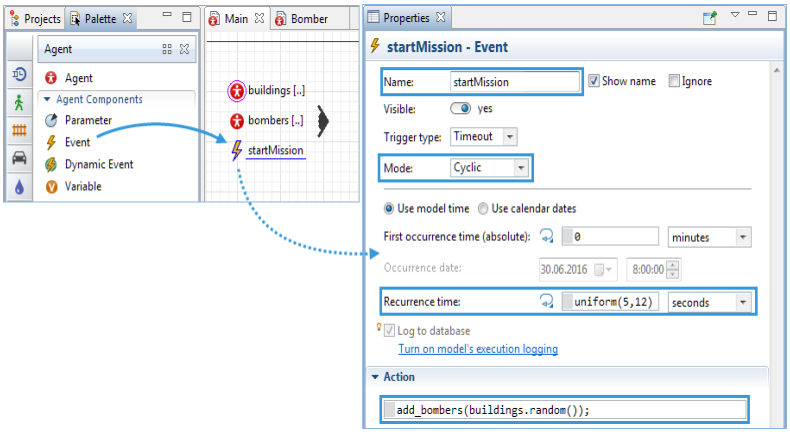
1. Switch to the Main diagram of the top level agent.

2. Drag the Event element from the Agent palette to the Main diagram and place it beside the agents populations.

3. Navigate to its Properties and perform the following changes:

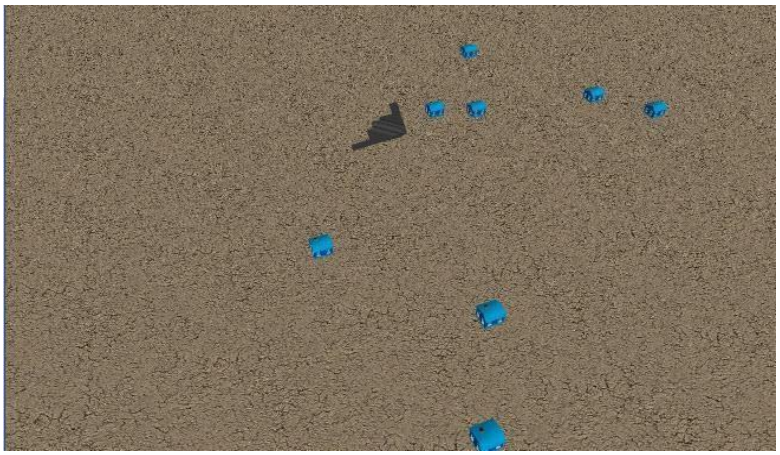
- Name it startMission
- Set the Mode parameter to Cyclic.
- Set the Recurrence time parameter's time units to seconds and type uniform(5,12) into the parameter's field.
- Type add_bombers(buildings.random()); into the field of the Action section.

4. The cyclic event periodically looks for a building without a bomber already flying to it. We use iteration across the agent population twice: in the outer loop we iterate across buildings, and in the inner loop we iterate across bombers. If such a building is found, we create a new bomber agent and assign the building to the bomber as the target (as long as the Bomber agent has one parameter target of type Building, AnyLogic generates a constructor with that parameter).



Finally, we can run the model to observe the flight of the bombers live.

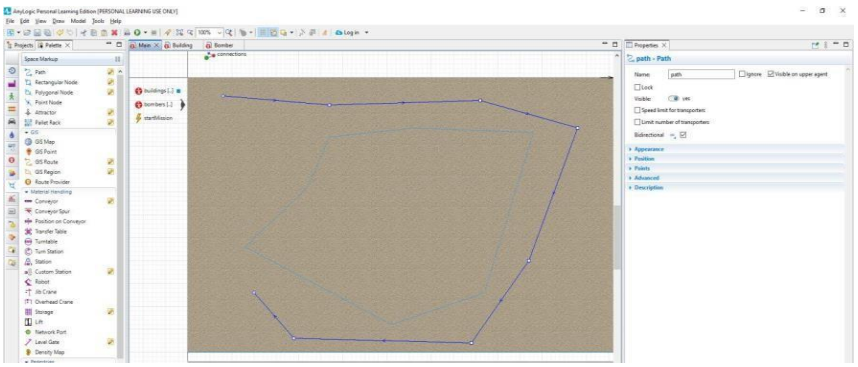
Upon creation, a bomber takes direction to the target building, makes an “instant u- turn”, and heads back to (0,0). So far, the bombers use straight line trajectories — this is assumed by the moveTo(x, y, z) function. We will further draw the 3D “escape trajectory” for the return route and set the bombers to follow that trajectory on their way back. We will use another version of the method: moveTo(main.exitNode);



Now we will create escape route that the aircrafts will be following to avoid being hit by a missile.

Draw the 3D escape route

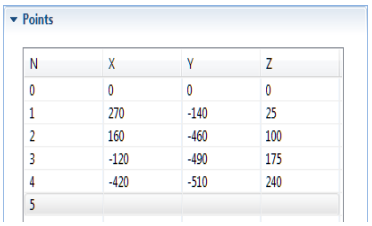
1. Open the Space Markup palette, double-click the Path element to activate the editing mode and draw a path, as shown in the figure.



1. Navigate to its properties and name the path escapeRoute

2. Set the Z parameter of the Position section to 100 (this will be the base Z- coordinate of the polyline).

3. Open the Points section of the path properties and modify the individual Z coordinates of the points approximately, as shown in the figure. The idea is to have the initial section of the path at about the same altitude as the bomber attack altitude.



Points

N	X	Y	Z
0	0	0	0
1	270	-140	25
2	160	-460	100
3	-120	-490	175
4	-420	-510	240
5			

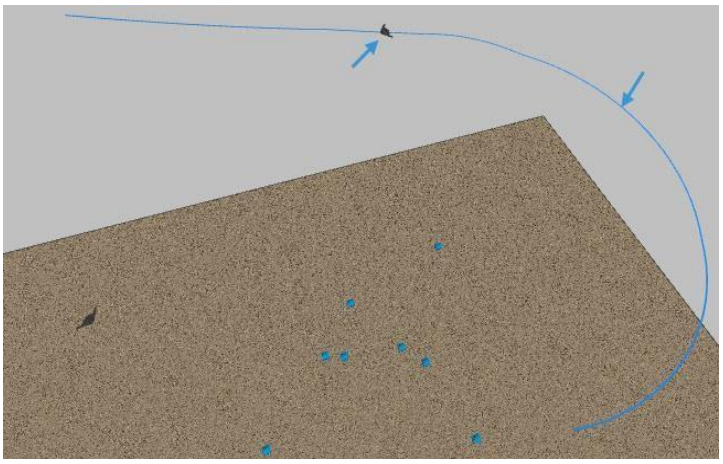
Roll No: 25166009

1. Add Point Node from the Space Markup palette to the end of the path, make sure the node connects to the path. Name it exitNode. Set its Z parameter of the Position and size section to 340.

2. Open the diagram of the Bomber agent, click the Away state to navigate to its properties and change the Entry action to: moveTo(main.exitNode);

We need to put the prefix main before the exitNode because this graphical object is located not inside the Bomber agent, but one level up, in Main. Run the model. See how the bombers return to the base using the defined by the path route.

The escapeRoute is visible at runtime. We will now set the Visible parameter of both the escapeRoute and the exitNode to no, to hide both of them. Hide escapeRoute during runtime



1. Click the escapeRoute to select it.

2. Navigate to its Properties view and click the Visible parameter's toggle button to switch the visualization state to no. The escapeRoute will not be visible during runtime now.

In the same way hide the exitNode.

Run the model. No odd elements are present in the scene now.