Construction Operation Simulation

Lecture #7

Introduction to DES Software

Amin Alvanchi

Construction Engineering and Management

LinkedIn Instagram WebPage

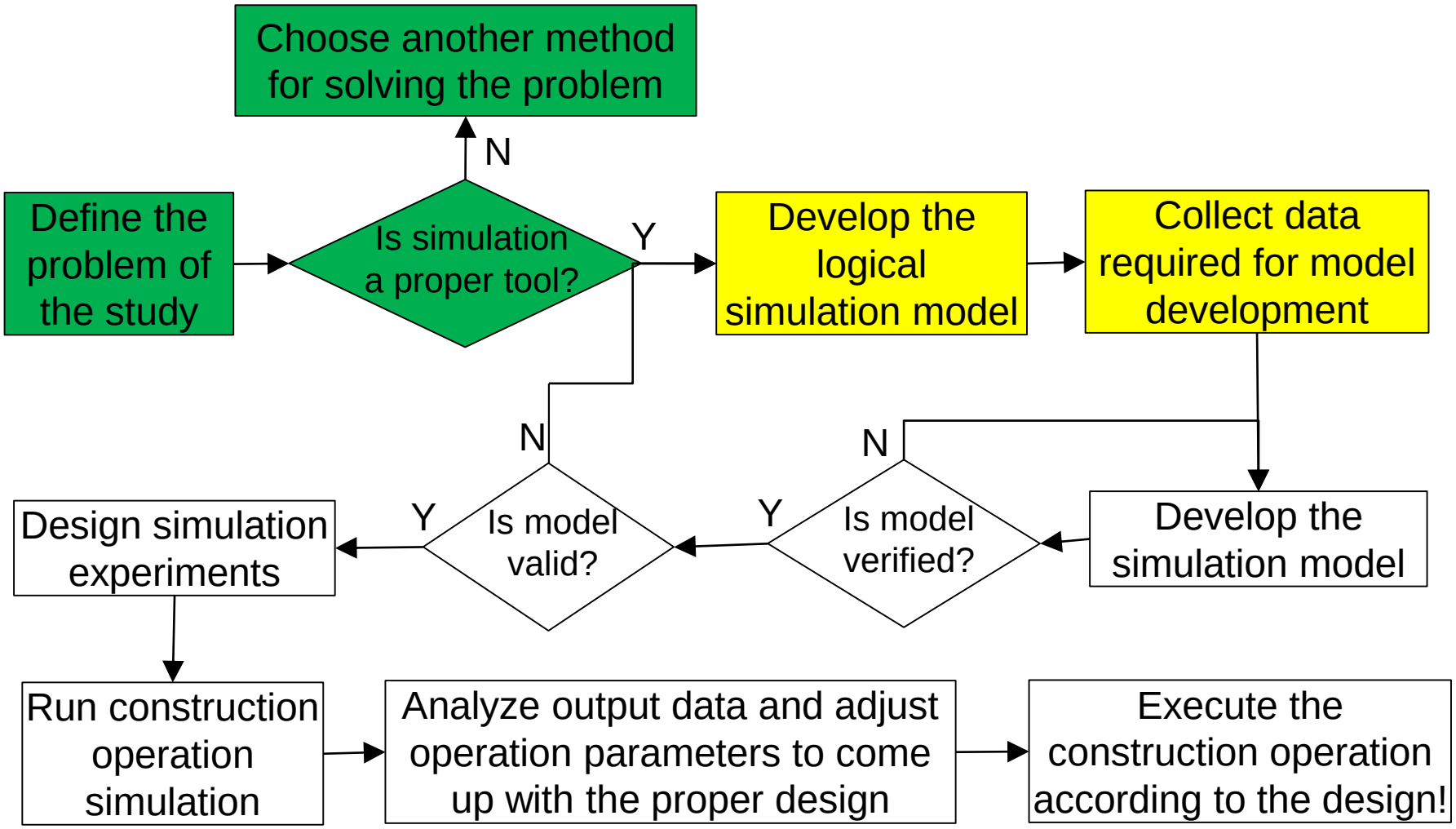
Department of Civil Engineering, Sharif University of Technology

Outline

- Introduction
- AnyLogic Modeling Environment
- Basic DES Elements in AnyLogic
- First Models in AnyLogic

Introduction

Main steps in simulation studies

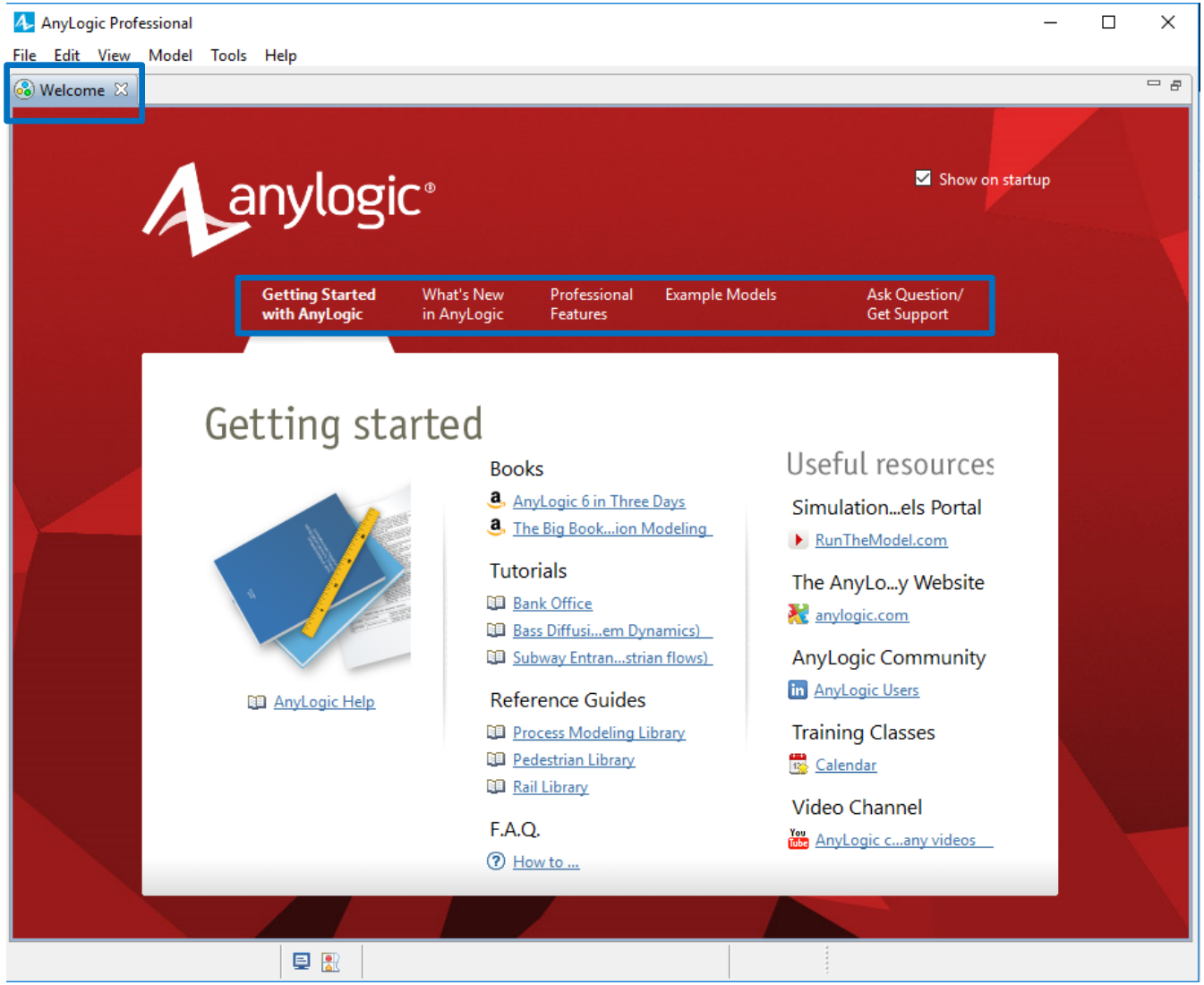


Major DES Simulation Packages

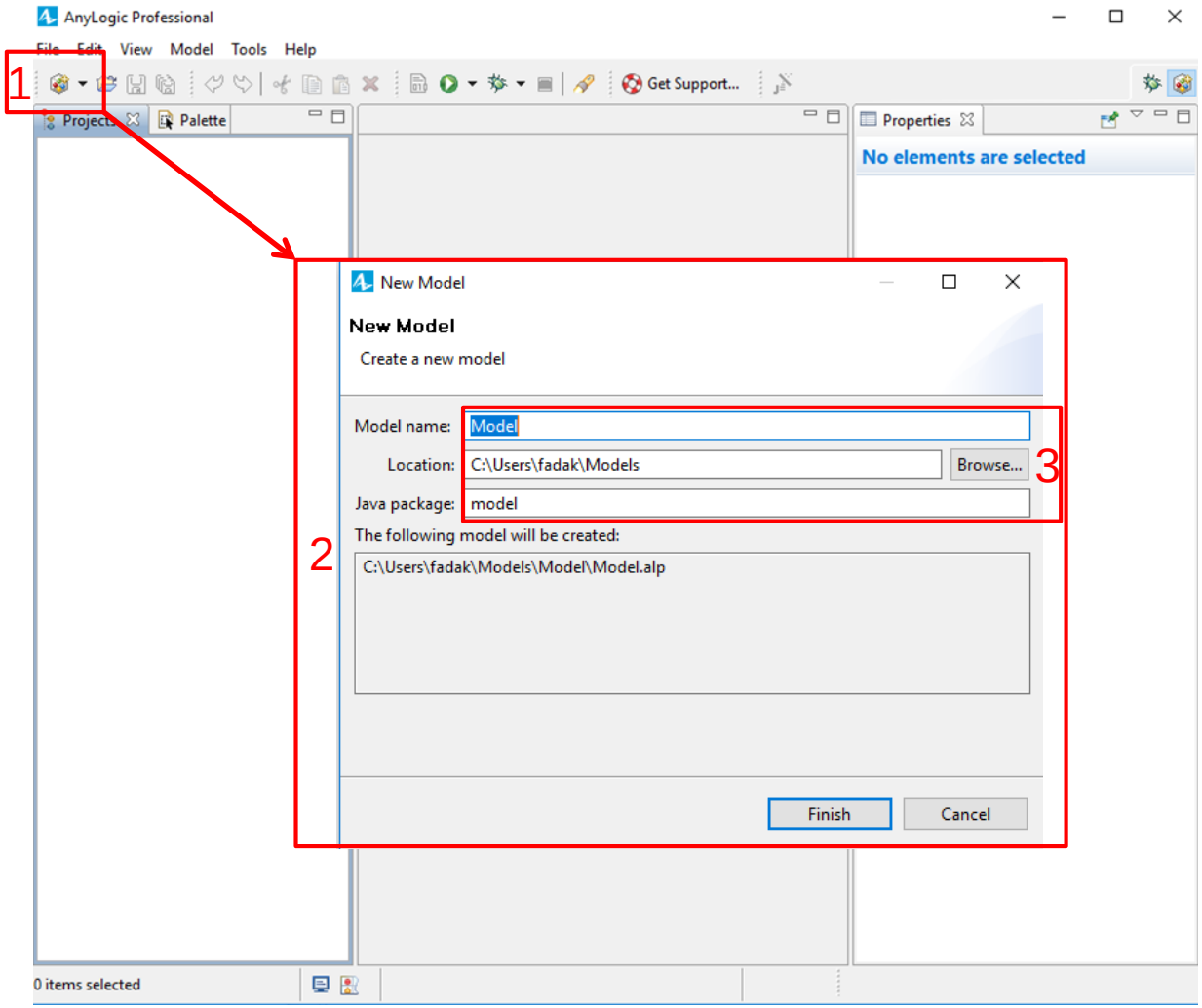
- Some famous DES software can be listed as in below (listed based on Alexa traffic-rank for websites in April 2017):
  - AnyLogic (www.AnyLogic.com)
  - Arena (www.arenasimulation.com)
  - FlexSim (www.flexsim.com)
  - Promodel (www.promodel.com)
  - Simul8 (www.simul8.com)
  - Lanner(www.lanner.com)
  - ExtendSim (www.extendsim.com)
- A more comprehensive list of commercial and open source simulation software is presented at: en.wikipedia.org/wiki/List_of_discrete_event_simulation_software
- In this course we are going to introduce AnyLogic which is one of the most famous commercial DES software developed in World.
- You can use following website for comparing different software capabilities: http://www.capterra.com/simulation-software/

AnyLogic Modeling Environment

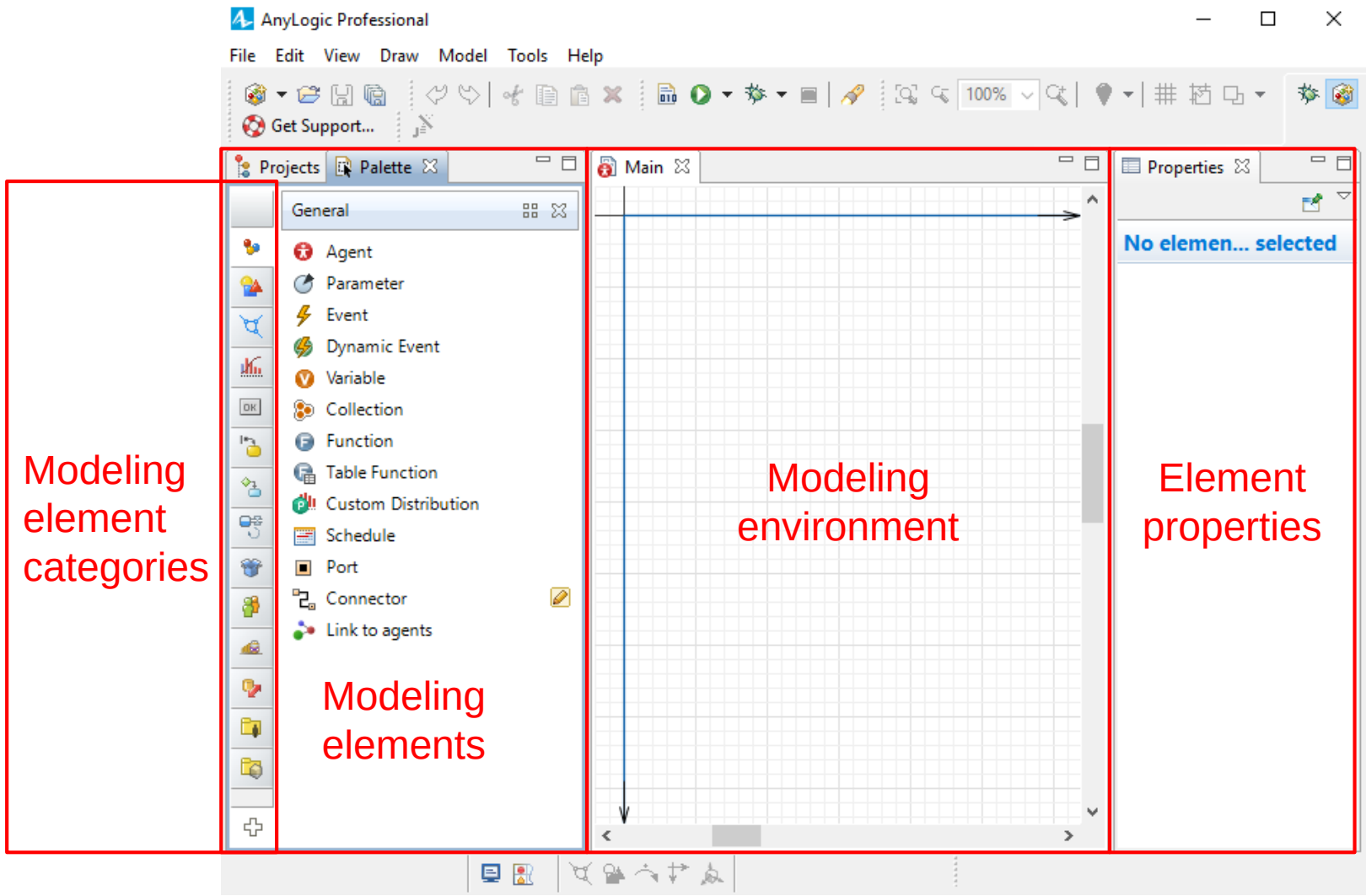
Start Working with AnyLogic



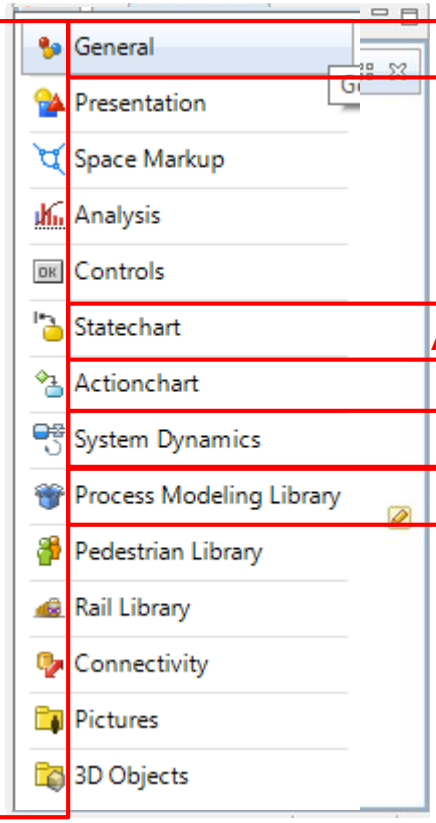
Start Working with AnyLogic



Working Environment



Working Environment



Modeling element categories

General Elements

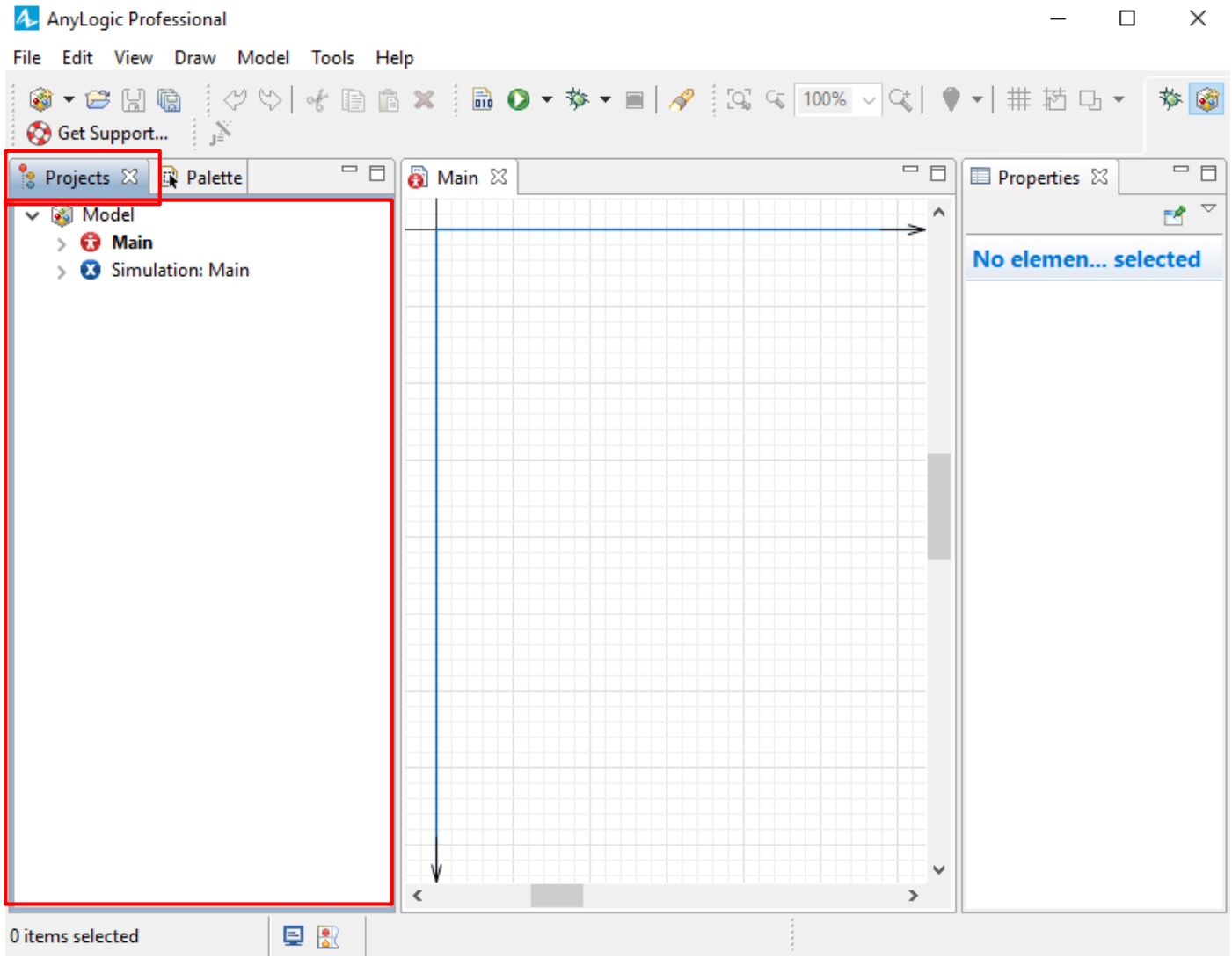
Agent Based Sim. Elements

SD Elements

DES Elements

Working Environment

Explore project models and sub-models



Basic DES Elements in AnyLogic

DES Elements

- With DES software you can quickly develop simulation models much quicker than directly coding the model by using prepared modeling elements.

What kind of simulation model elements can we expect from DES software?

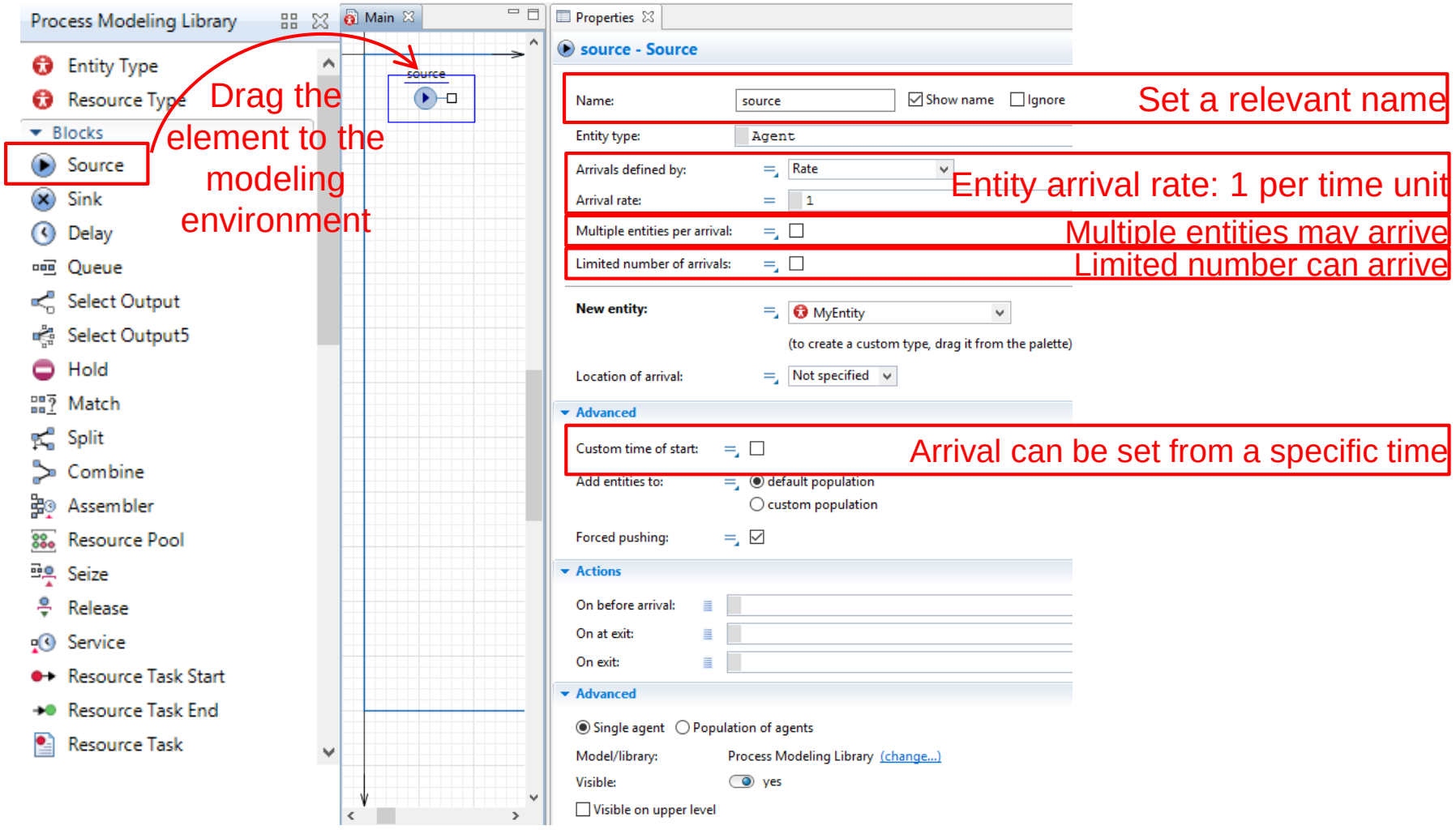
DES Elements

- We can expect following modeling elements in any DES software:
  - Entity generator
  - Resource element
  - Activity or task element
  - Entity destroy (for the entities exit the system; this element is technically important for removing non-usable entities from the computer memory)
  - Conditional branch (when entities are directed to different routes according to different conditions, e.g. for inspection stations)
  - Merge or consolidate entities element (when several entities, usually representing different system components originated from different sources are joined and form a new entity, e.g., after loading a truck with asphalt in asphalt plant or after hocking a crane to a steel element in steel construction)
  - Split or divide entity element (when an entity is split in several components and each component continues its route in a different way, e.g., after dumping asphalt from a truck in paving operation or after un-hocking a steel element from a crane in steel construction)

By learning one DES software other DES software can be more quickly learned!

Source Element

- Source element introduces (generates) entities to the model!



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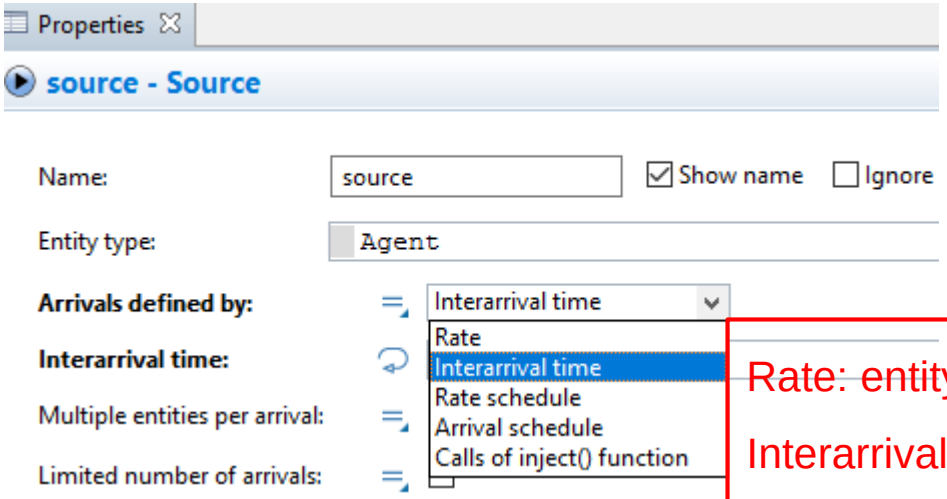


Rate: entity arrival per time unit

Interarrival: time between two entity arrival

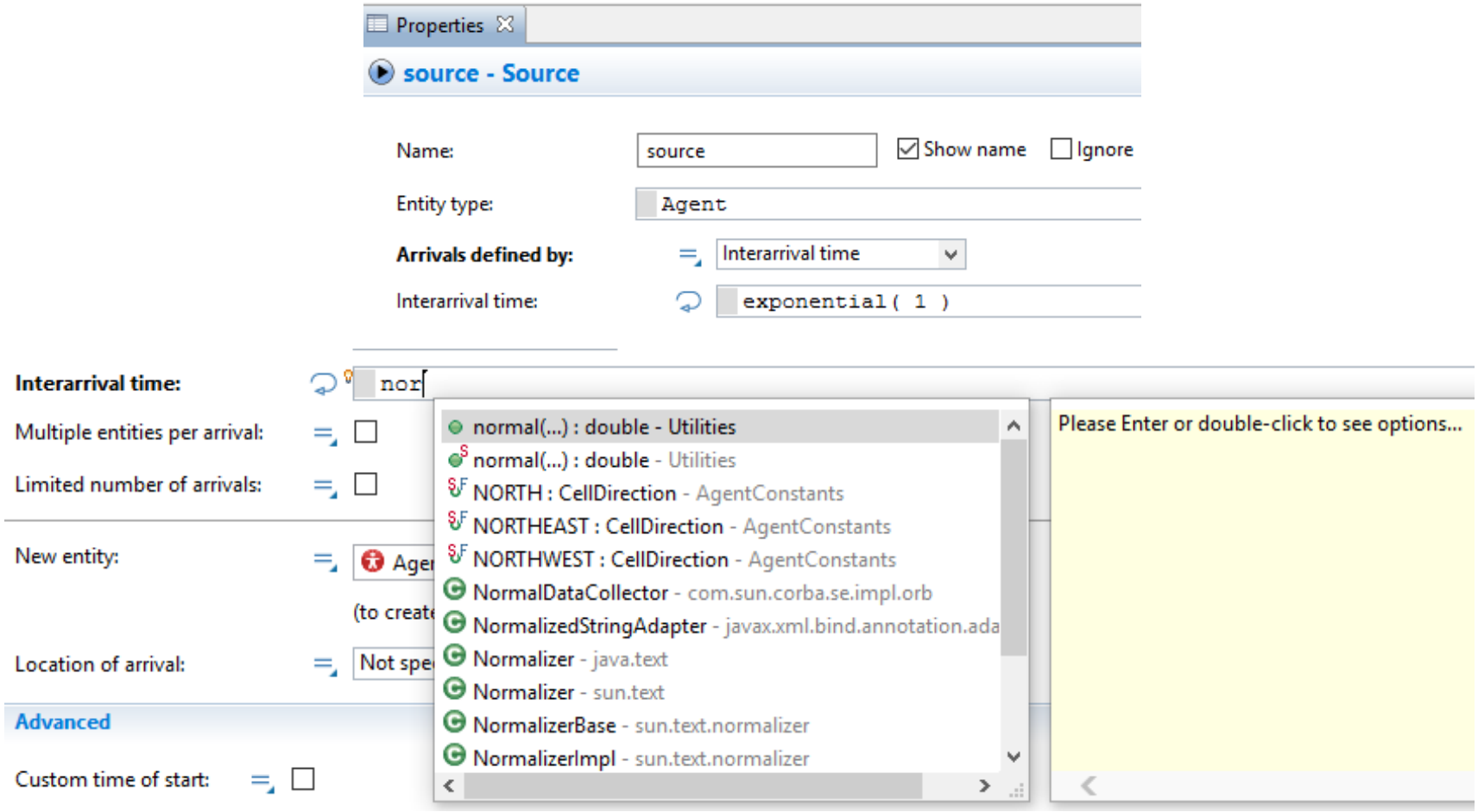
Rate schedule: reads the rate from a scheduled table

Arrival schedule: reads interarrival from a table

Calls of inject function: entity arrives based on conditions set in the model using inject function

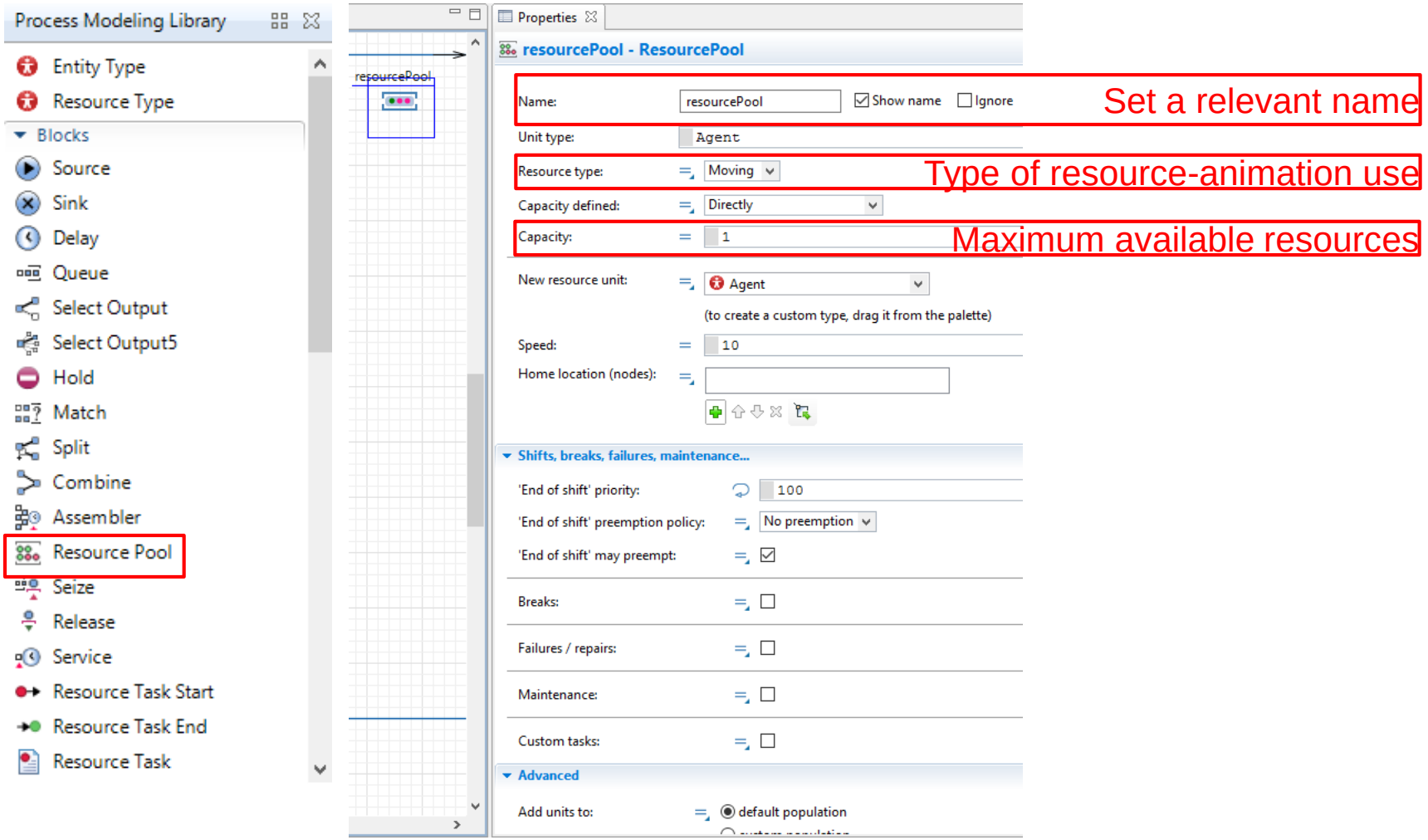
Source Element

- Set of predefined probability distribution functions are available in AnyLogic.
- By typing first letters of the function and pushing Ctrl+Space you can get access to them!



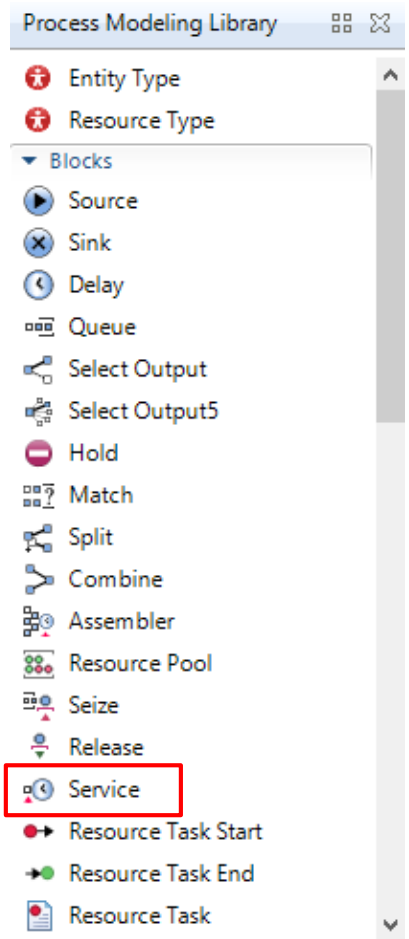
Resource Element

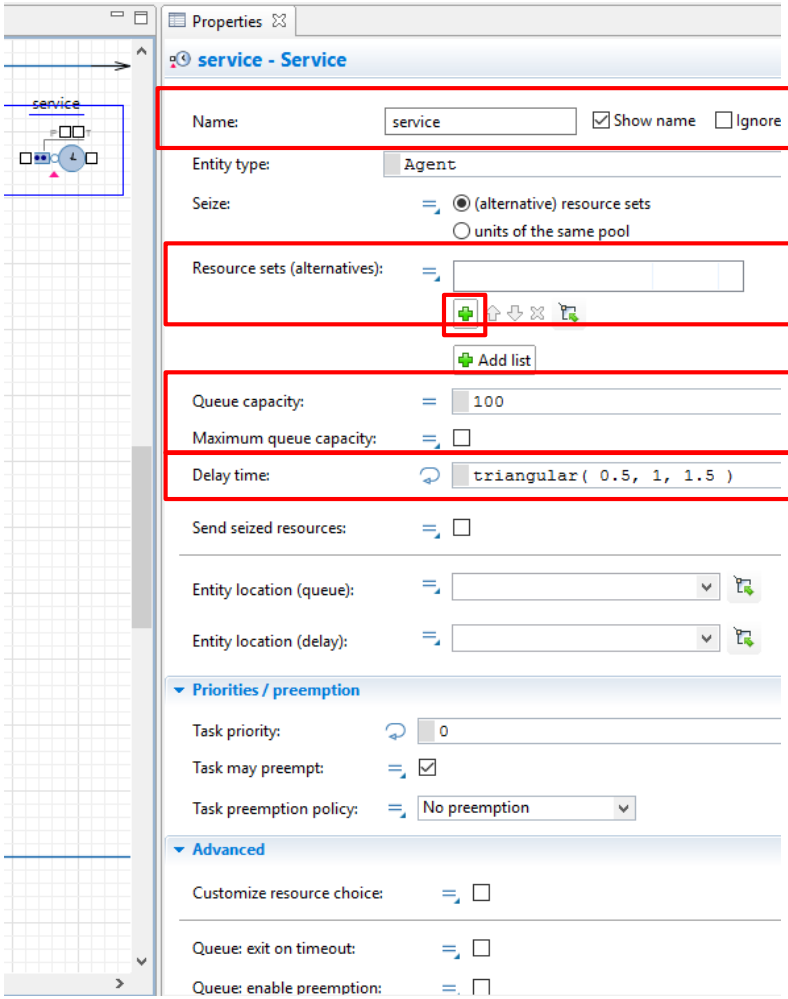
- Service element represents Activities in a construction operation



Service Element

- Service element represents Activities in a construction operation





Set a relevant name

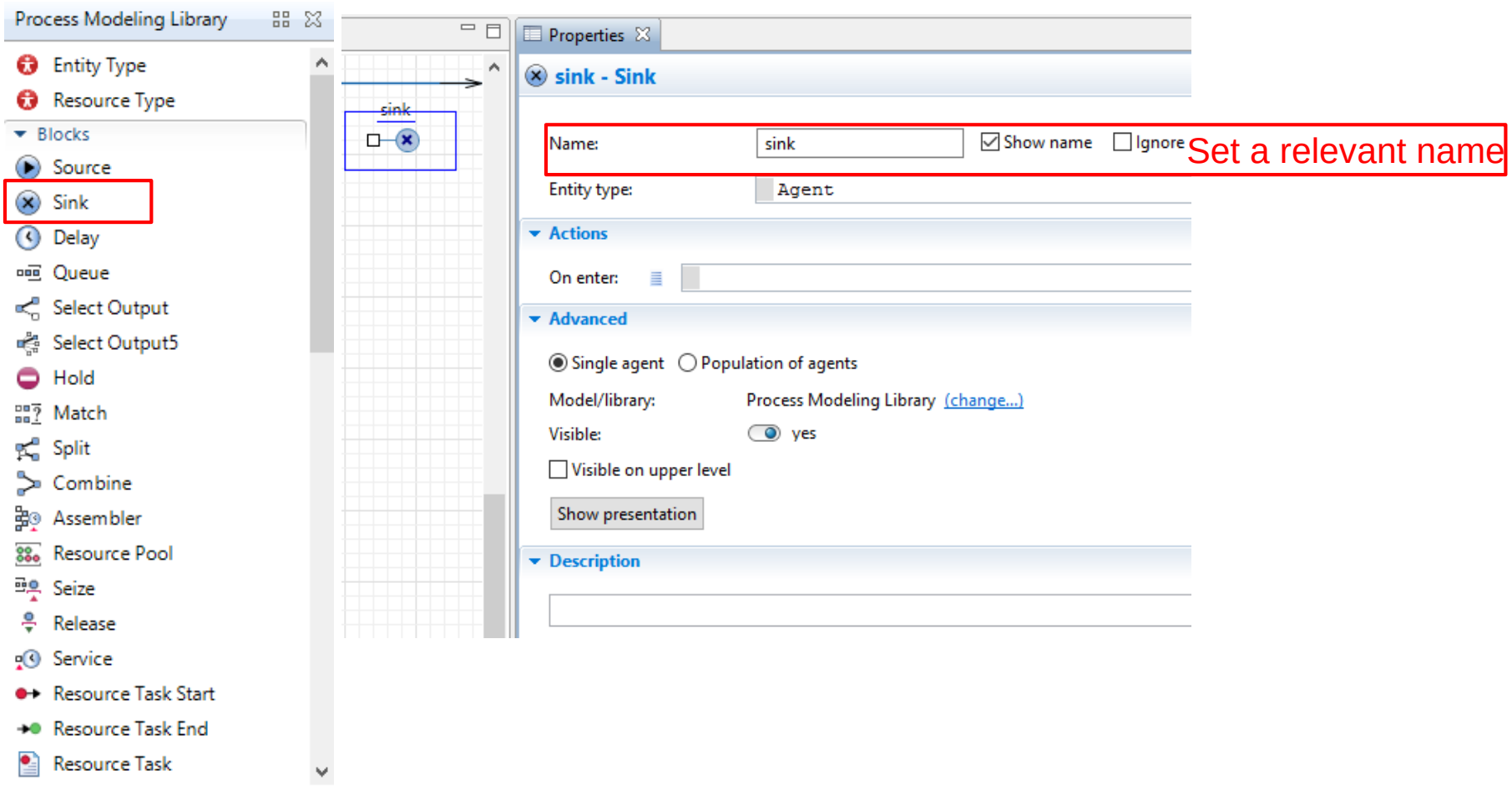
Add resources used

Maximum size of Q

Duration

Sink Element

- Sink element is used for open loop systems; it destroys entities when they leave the system.



First Models in AnyLogic

Modeling steps

- Steps required for developing a simulation models using DES software:

    1) Recognize model elements (Entity, resource, activity)
    2) Determine initial condition
    3) Setup the simulation environment
    4) Start developing the model logic within the software
    5) Run the model

Single Queue - Example 1

- **Example 1:** *Single queue example*: Suppose an asphalt plant with a single asphalt loading station. Asphalt hauling trucks from different paving project arrive to the asphalt plant randomly during the day (from 7am to 5pm). Time between truck arrival time has an exponential distribution with the average of 15 minutes. If loading station is idle, truck directly goes to the loading station and asphalt loading gets started. Loading duration has a normal distribution with the average of 10 minutes and standard deviation of 2 minutes. If loading station is busy, truck stays in the line and waits until its turn. We are going to use AnyLogic to develop the simulation model of this operation.

Single Queue - Example 1

1- Recognize model elements (Entity, resource, activity):

Entity: Truck

Resource: Asphalt plant

Activity:

- Time between truck arrival: exp(λ=4 per hour or 1/15 per minute)
- Loading: N(,10 minutes, 2 minutes)

Event:

- No need for separately identifying events, events are automatically determined start and finish of activities!

System state:

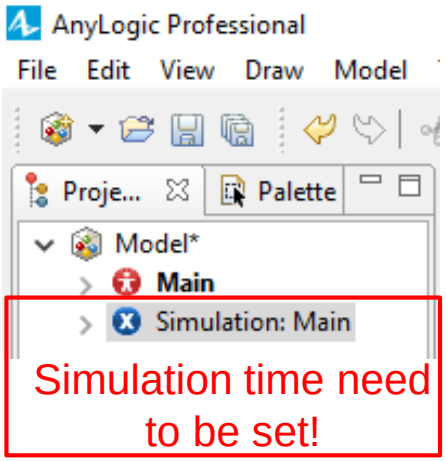
No need for separately identifying system state, since system state is a part of other elements (e.g., queue part of resource and activity and resource state part of resource element)

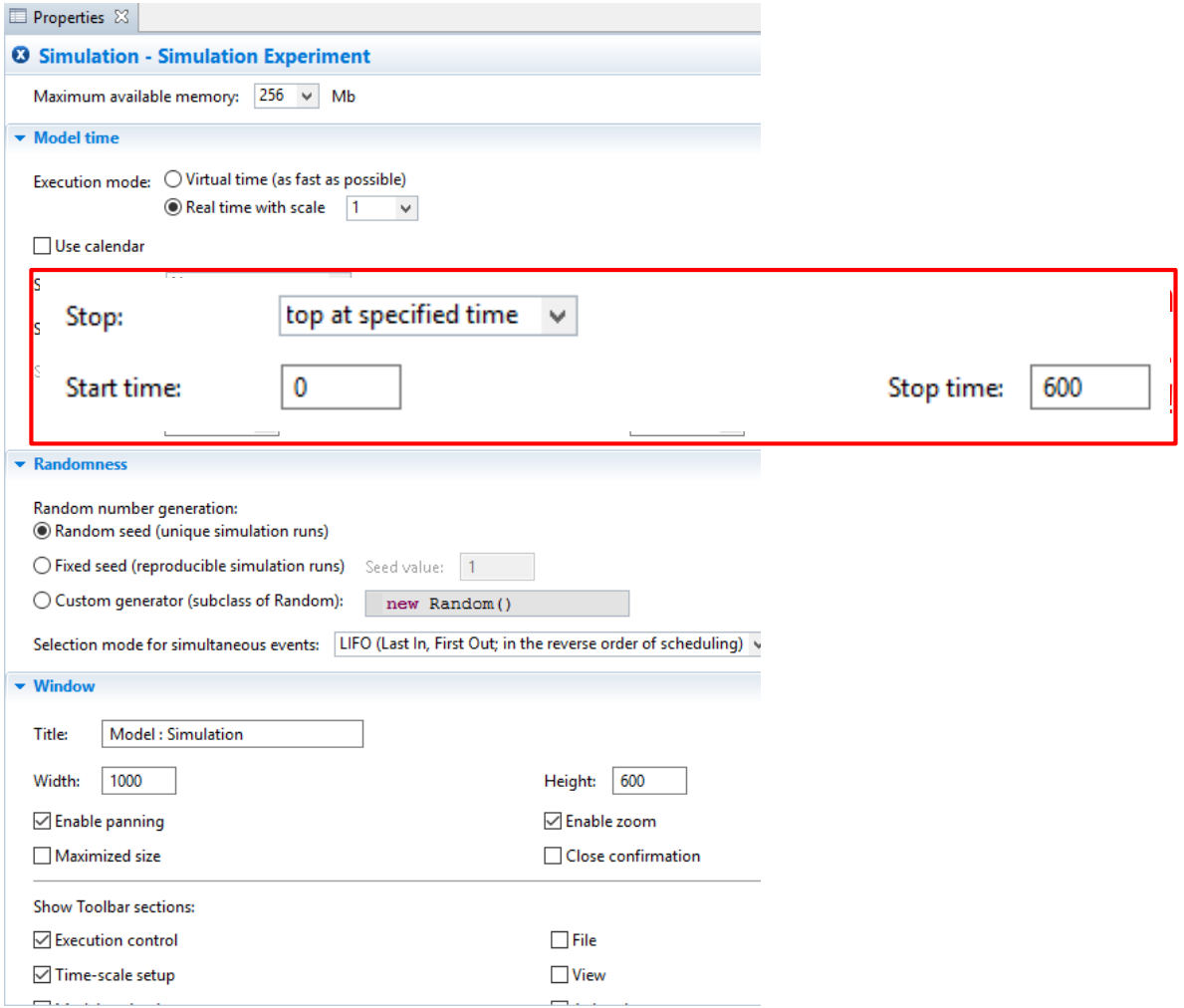
2- Determine initial condition:

No entity in the system. First entity will arrive with a random-exponential distribution after 7 am.

Single Queue - Example 1

3- Setup the simulation environment:

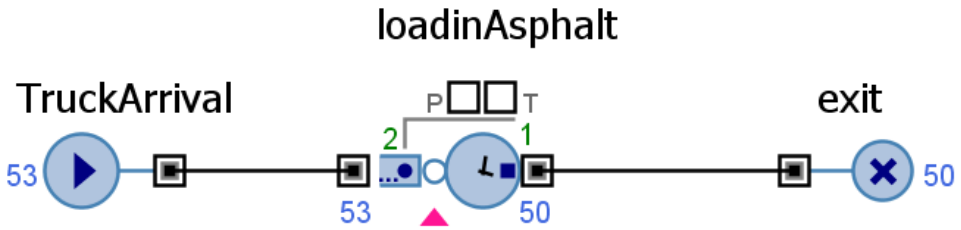




Single Queue - Example 1

4,5- Start developing and running the model logic in AnyLogic:

Hands on AnyLogic



Earthmoving - Example 2

- **Example 2:** Suppose our earthmoving example with 3 trucks and 1 loader in the system with working hours from 7 am to 7 pm. There is no limitation in number of dumping sites. Different operation activities have following durations:
  - Loading: N(10 minutes, 2 minutes)
  - Trip to dumping site: N(5 minutes, 1 minute)
  - Dumping 2 minutes
  - Trip from dumping: Uniform (3 minutes, 6 minutes)

  Time of each truck arrival at the morning has a uniform distribution between 6:50 am to 7:15 am.

  1- Model elements: Entity: truck; Resource: loader; Activities: Loading, Trip to dumping site; Dumping; Trip from dumping site.

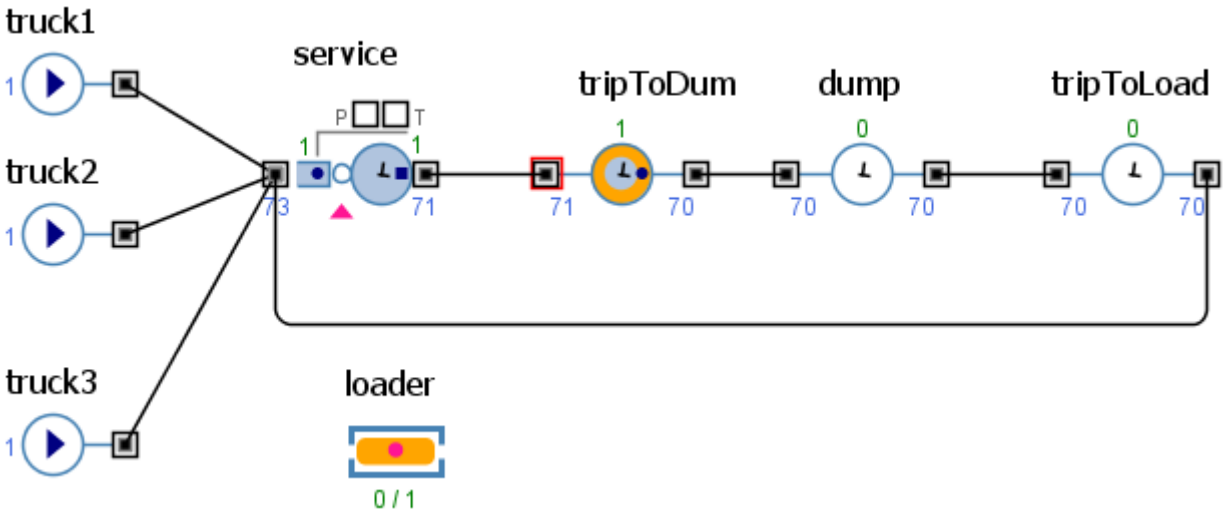
  2- Initial condition: No entity in the system; Schedule truck arrival uniformly distributed from 6:50 to 7:15.

  3- Setup the simulation environment: Setup stop time at 730 (why? ).

Earthmoving - Example 2

3- Start developing the model logic in AnyLogic:

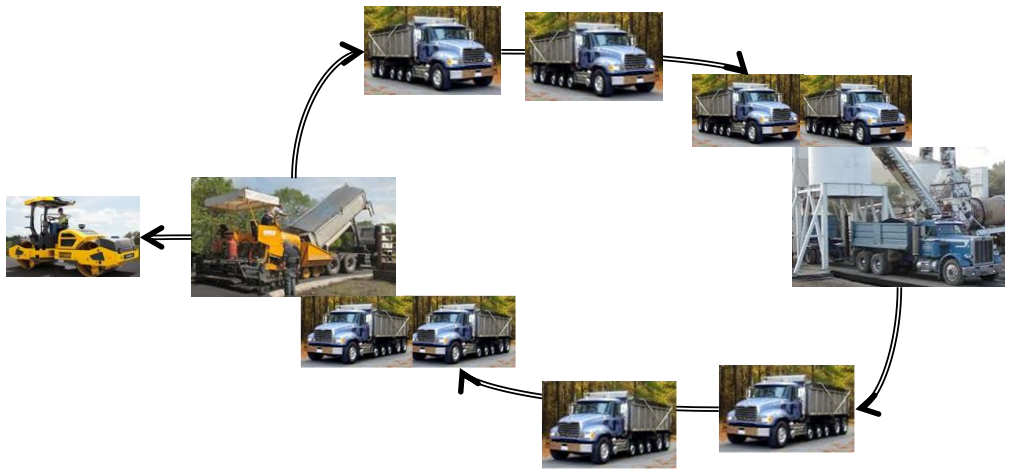
Hands on AnyLogic



Home assignment 8

In our paving example suppose trucks trip to asphalt plant is normally distributed with the mean of 9 minutes and SD of 1 minutes. There are two asphalt loading stations with a constant loading duration of 6 minutes. The return trip to the paving site has a normal distribution of 12 minutes and SD of 2 minutes. Spreading has a uniform duration between 2 to 3 minutes. Compacting of each batch of asphalt has a triangular distribution with minimum of 1, maximum of 5 and mod of 2 minutes. There are total 6 trucks working in the operation. Time of each truck arrival at the morning has a uniform distribution between 6:55 am to 7:10 am. Operation stops at 6 pm in the evening. Develop the simulation model of the operation using AnyLogic.

- **(Due in one week)**



Reference

- http://www.AnyLogic.com/learn-simulation

Thank you!