Multi-Method Modeling with AnyLogic 7

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Multi-Method Modeling Workshop
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System Dynamics Conference, Delft

The AnyLogic Company

- We are:
  - Simulation software editor and vendor
  - Consulting company
- Offices
  - World-wide: St. Petersburg, Russia (development, sales, consulting)
  - European: Paris, France (sales & consulting)
  - North America: Chicago, USA (sales & consulting)
- Users
  - ~700 commercial and ~1000 educational organizations
  - Thousands of users
- Applications
  - Logistics/Transportation/Supply chains
  - Healthcare (from hospital capacity planning to policies & epidemiology)
  - Manufacturing
  - Service industry
  - Military/Defense
  - Strategic planning (Market/HR/Project management/Urban/…)

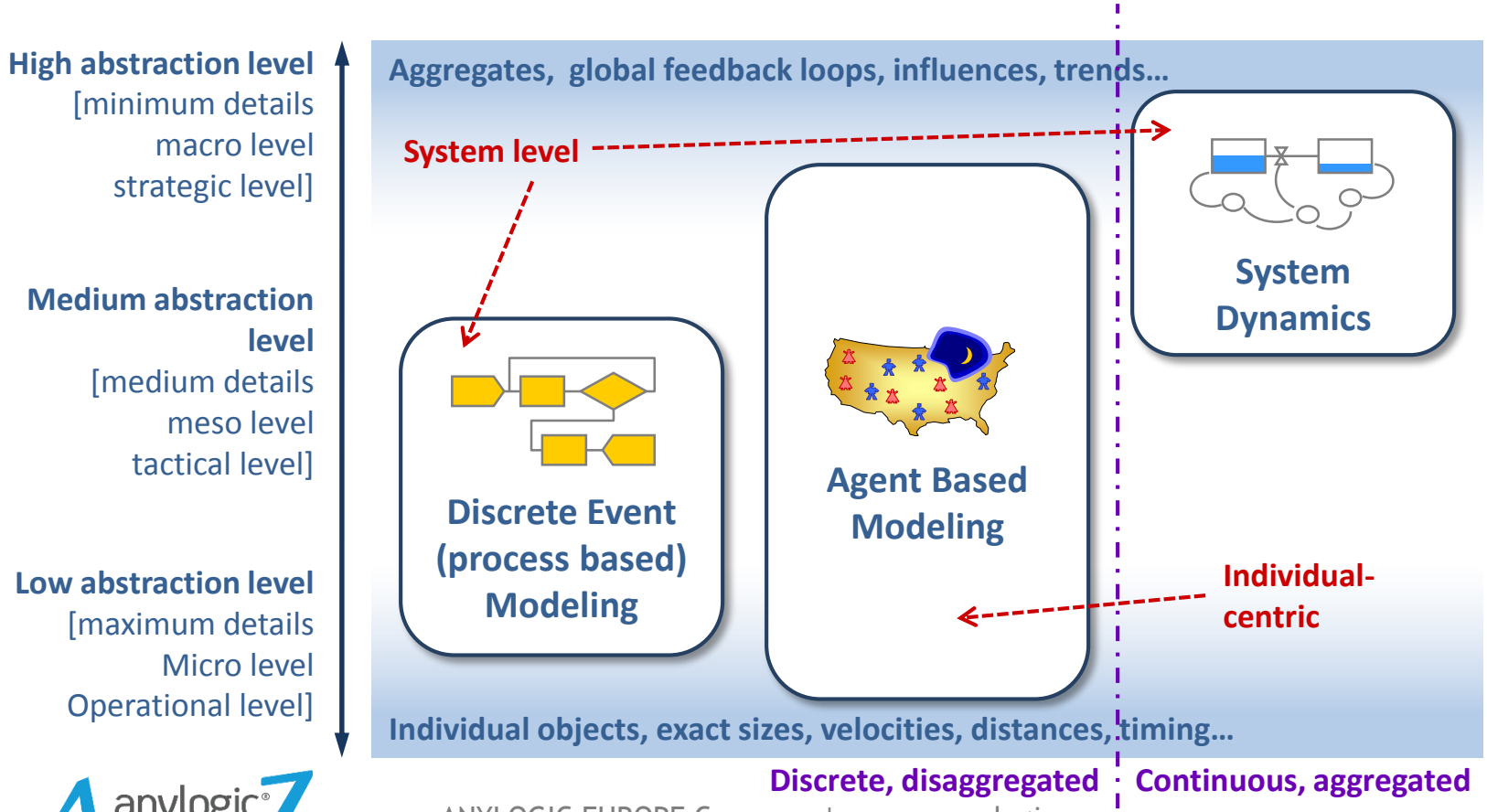
Today's agenda:

- Part I. Multi-method modeling
  - Modeling and simulation modeling
  - The three methods
  - Why multi-method modeling?
  - Languages supported by AnyLogic
  - Epidemic model development
  - Examples
- Part II. Multi-method modeling
  - Special libraries: Pedestrian Library
  - Aeroport model development
  - Examples
  - Publishing AnyLogic models on the Web, RunTheModel.com
  - Q & A

Part 1

The three methods in simulation modeling

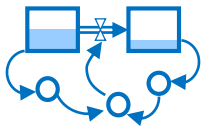
- The three modeling methods are the three different viewpoints
  - …the modeler can take when mapping the real world system to its image in the world of models



Why multi-method modeling?

- Sometimes, at the beginning of the project it is not clear which abstraction level and which method should be used
  - The modeler may start with, say, a highly abstract system dynamics model and switch later on to a more detailed discrete event model
- Frequently, the problem cannot completely conform to one modeling paradigm
  - Different components may be best described by using different methods.
- Using a traditional single-method tool, the modeler inevitably
  - Either starts using **workarounds** (unnatural language constructs), or
  - Just leaves part of the problem outside the scope of the model (treats it as **exogenous**).
- If we want to capture business, economic, and social systems in their natural complexity and interaction, "thinking single-method" becomes a serious limitation

The driving philosophy of AnyLogic



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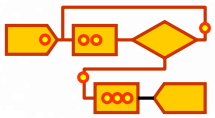
Multi-Method simulation software

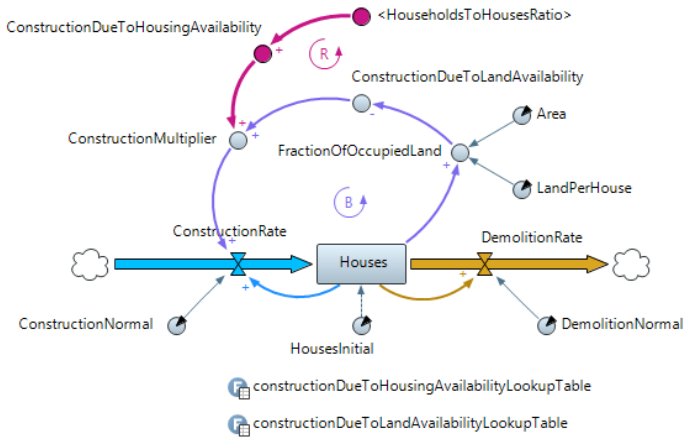


- Supports:
  - System dynamics
  - Discrete event
  - Agent based modeling
  - … and allows for combining different methods
- Used on multiple levels:
  - Operational (execution support)
  - Tactical (periodic decisions)
  - Strategic planning
- Allows you to better leverage your (growing) data
  - Using agent based modeling

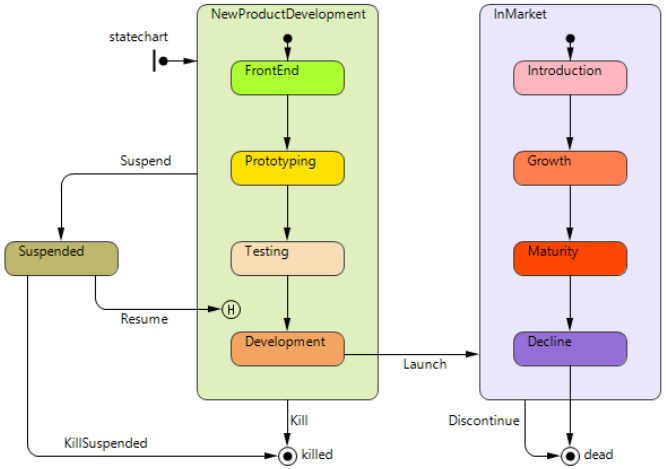
HIGHLY SCALABLE: GROWS WITH YOU AS YOUR NEEDS FOR SIMULATION GROW

The choice of methods. Visual languages of AnyLogic

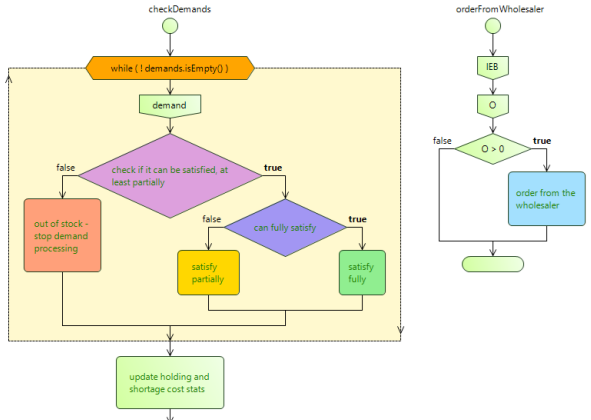
Stock & Flow Diagrams



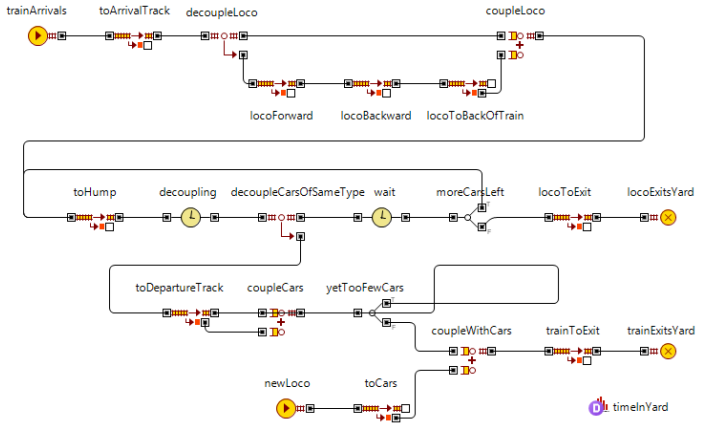
Statecharts



Action charts

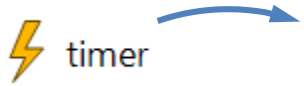


Process flowcharts



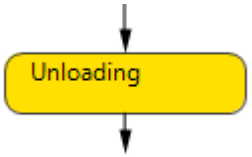
Open tool: Java “extension points”

- All objects have places to insert Java code
  - to be executed when the corresponding events occur



Action:

```
if( InFlow > OutFlow ) {
    V = Capacity;
    onFull();
} else {
    V = 0;
    onEmpty();
}
```

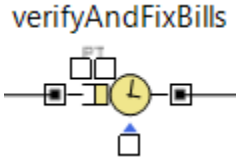


Entry action:

```
stock.set_OutFlow( UnloadingRate );
```

Exit action:

```
stock.set_OutFlow( 0 );
```



On enter[D]

On enter delay[D]

On exit[D]

```
entity.setShape( groupBillOK );
```

A simple Epidemic & Clinic model

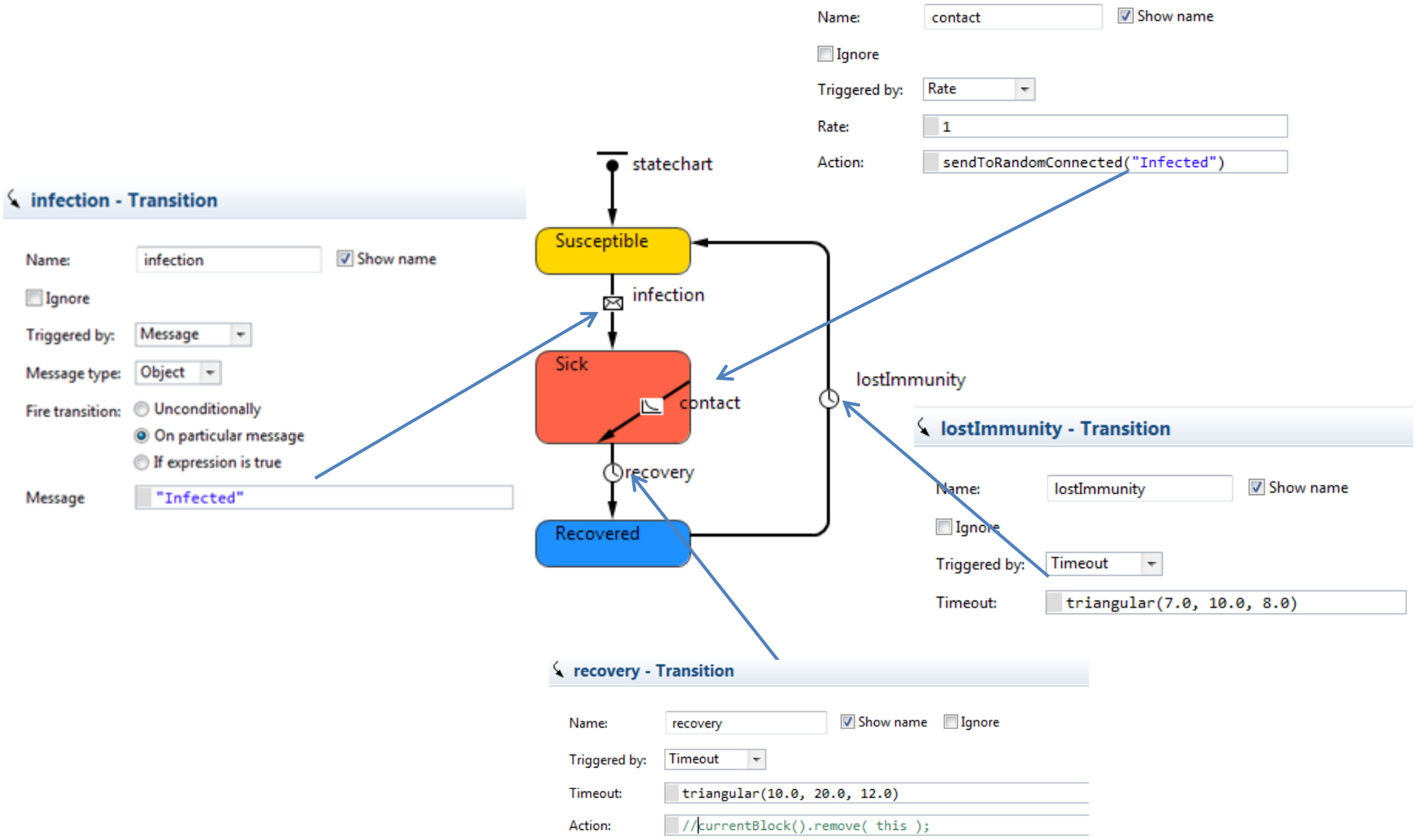
- We are to model epidemic in a region
  - Initially all people are susceptible to the disease, and a few are infected
  - People contact each other randomly at a certain rate
  - Having been infected, the person requests treatment in a clinic or do nothing and continues to live normally not reducing his contacts
  - After disease duration sick person recovers and becomes temporary immune to this disease
  - The sick person treated in clinic, recovers in short time and becomes also temporary immune to this disease
- The clinic
  - Has a finite capacity (number of beds)
  - Treatment takes several days

A simple Epidemic & Clinic model parameters

EXEMPLE

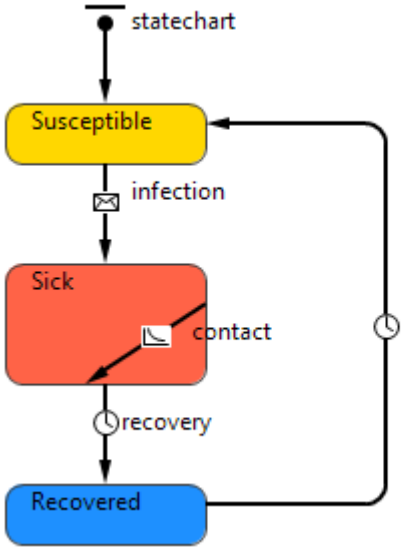
- Number of Agents (persons): 200
- Initially infected: 5
- Contact rate: 1/day/person
- Number of available beds in clinic: 1 - 25
- Immunity duration: 8 days
- Disease duration: triangular (10, 20, 12)
- Treatment duration: triangular (1, 3, 2)

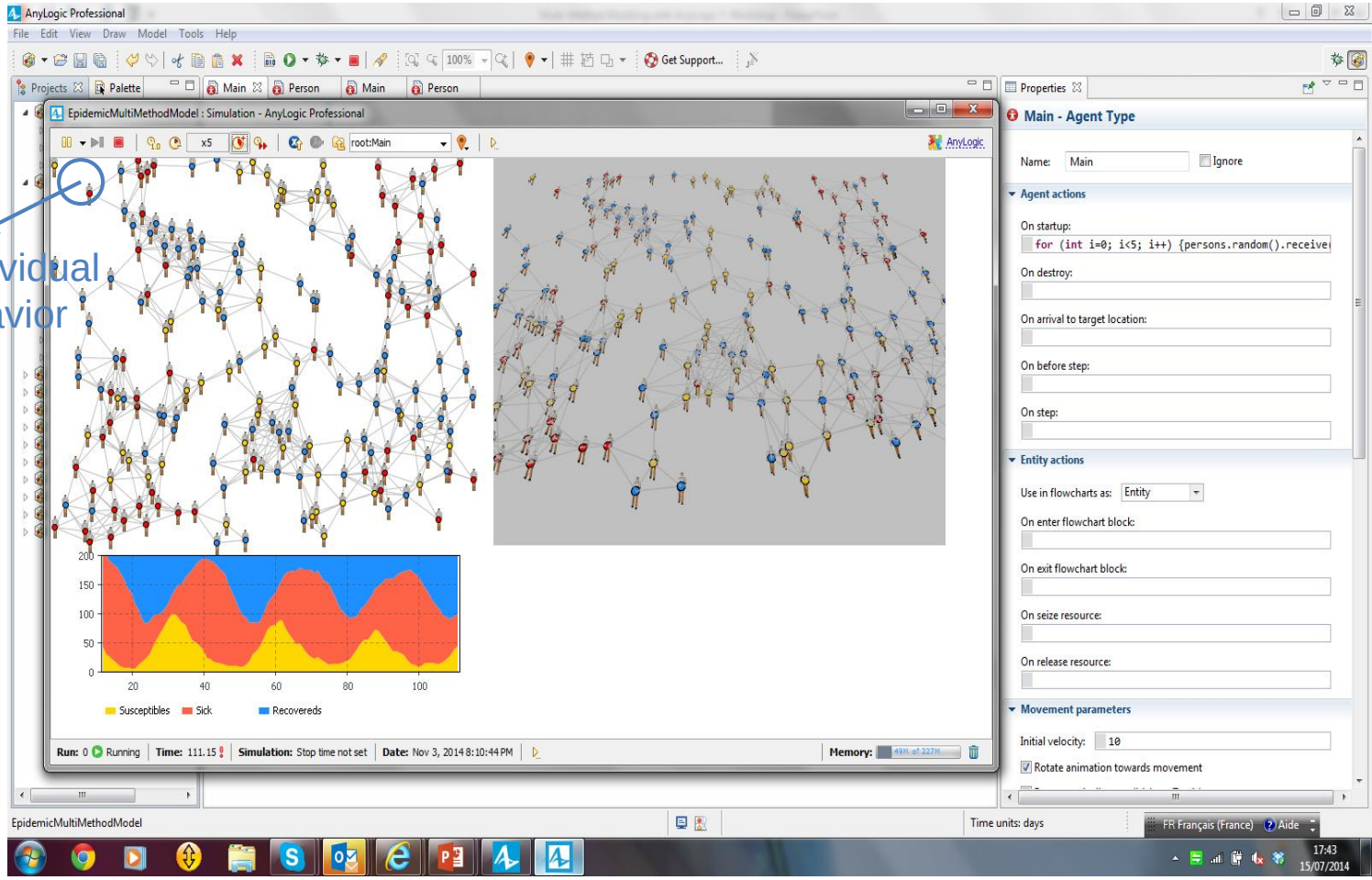
Let's build this model!



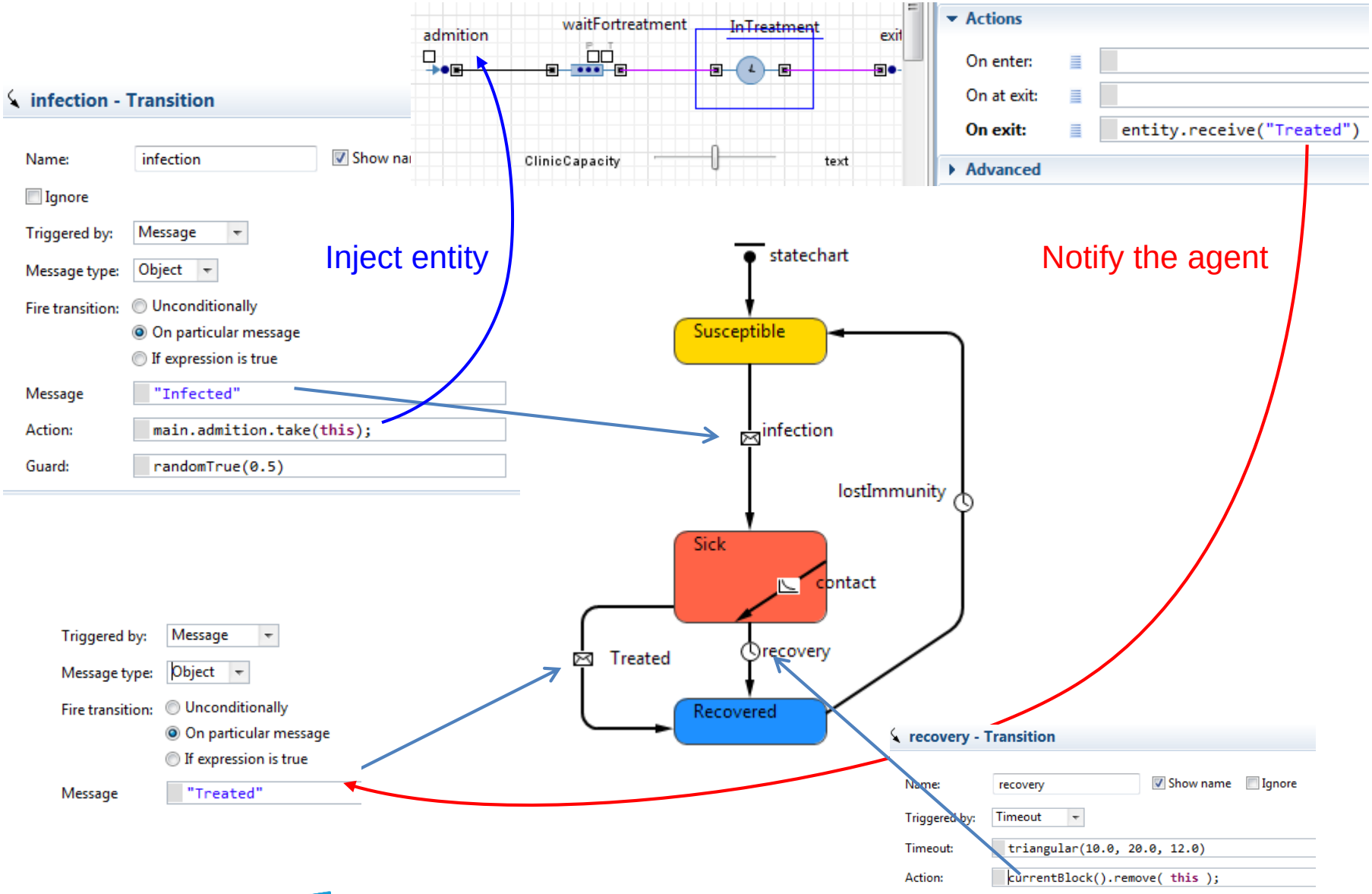
Let's build this model!

Each person has individual parameters and behavior

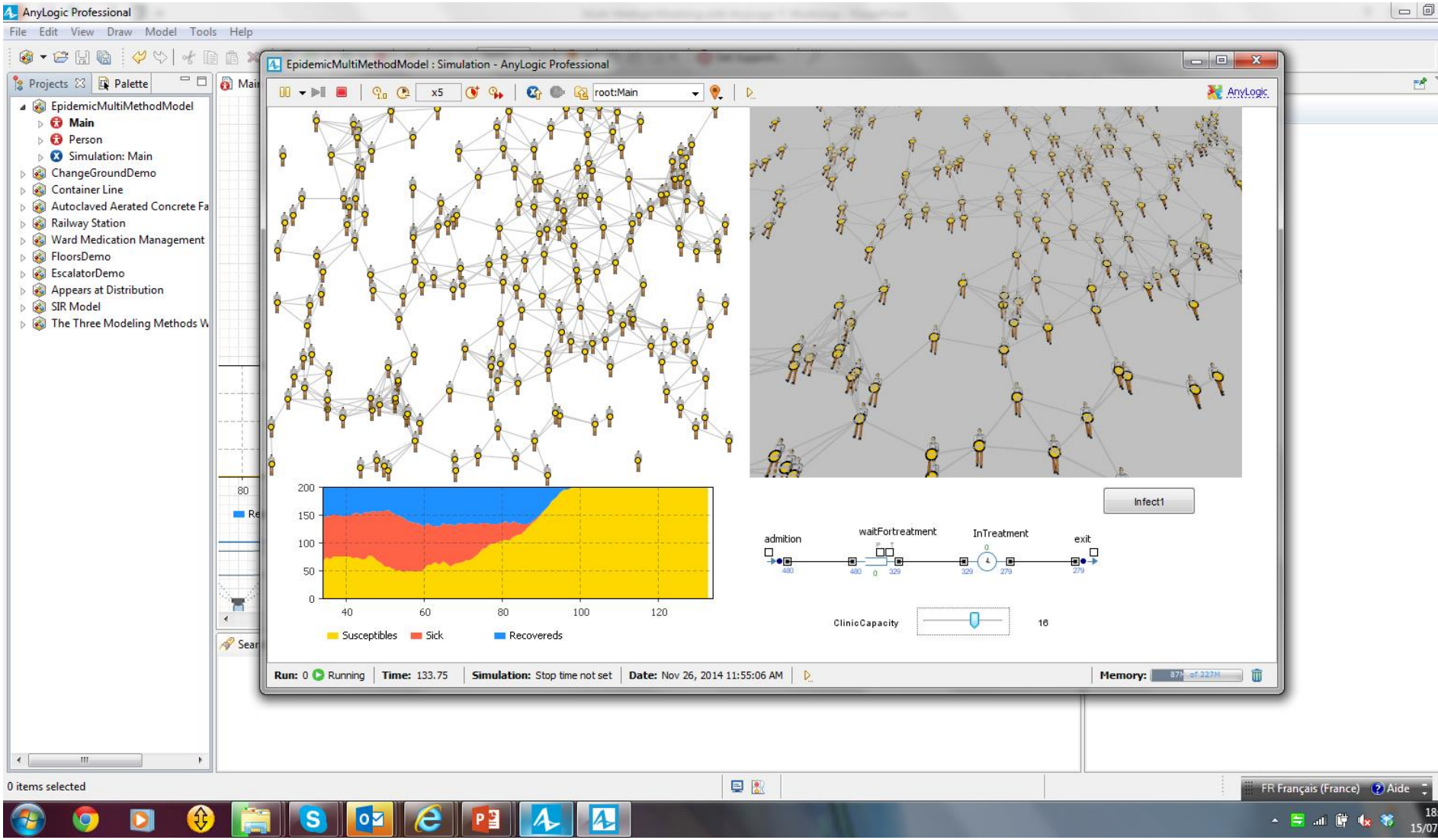




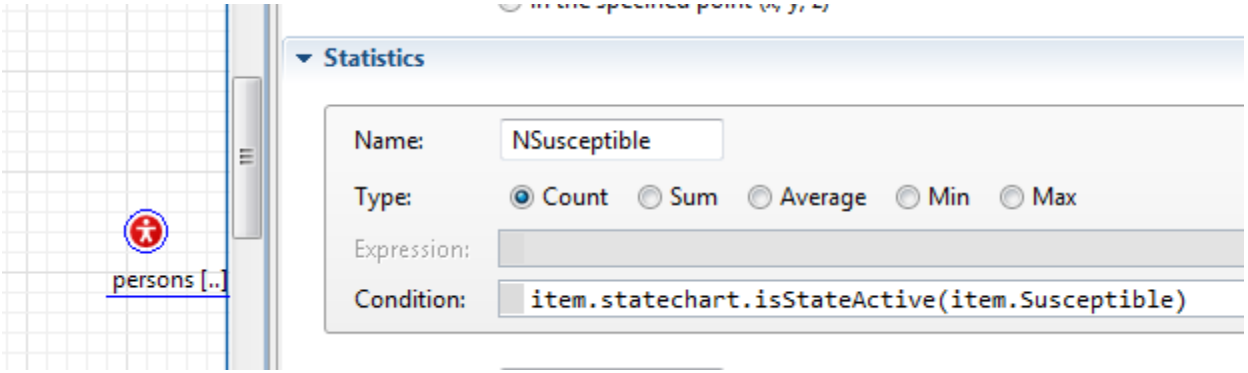
Let's add a clinic and build interface between AB & DE

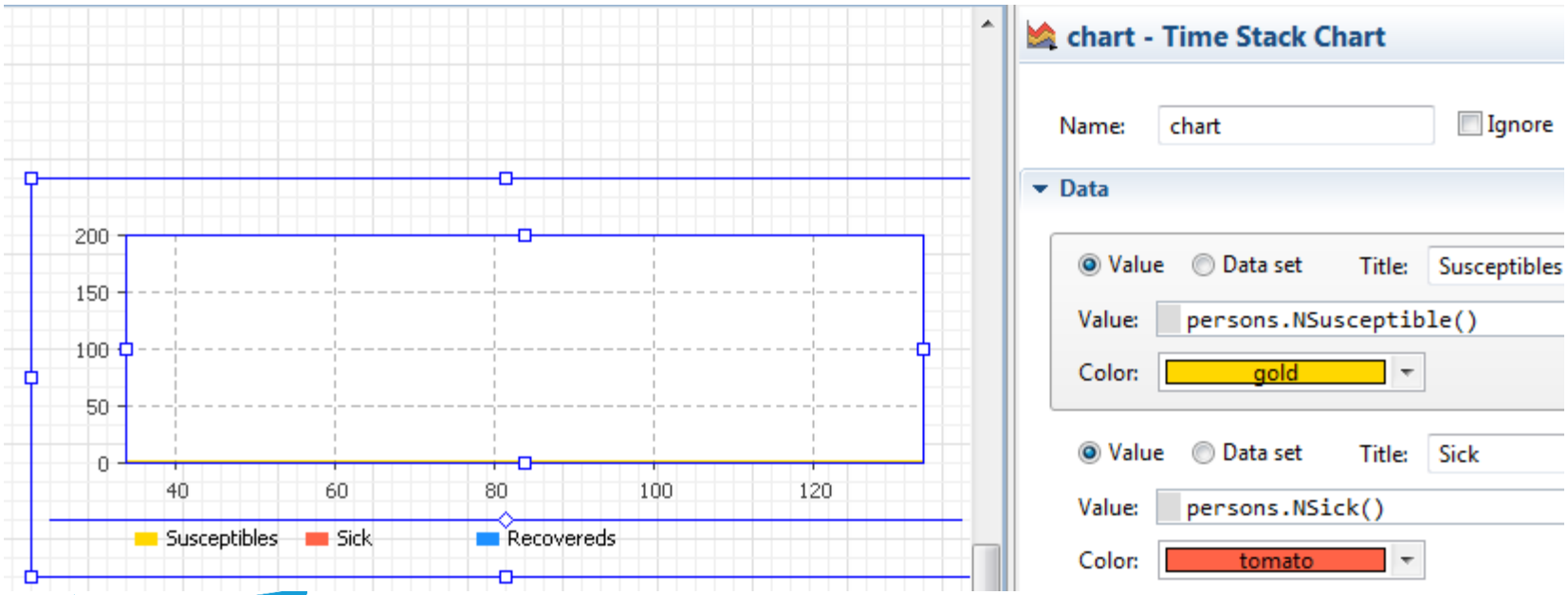


Population (AB) & Clinic (DE) model

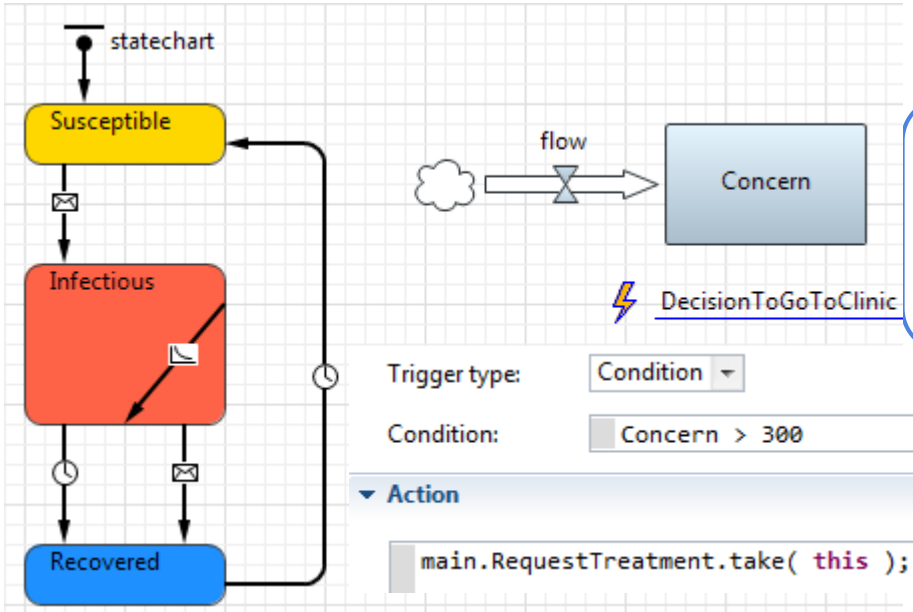


Statistic collection and plotting





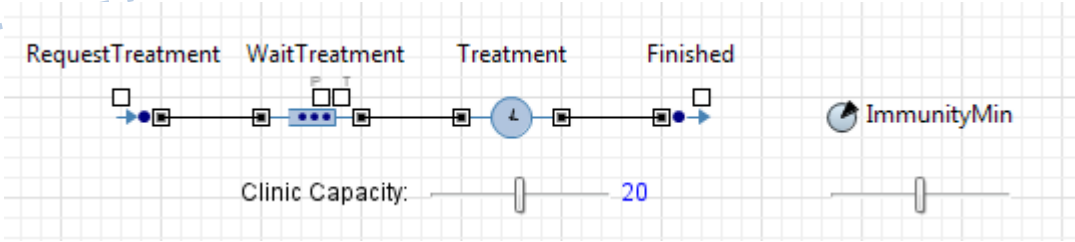
Link between AB & DE &SD in the Epidemic & Clinic model



1. When the agent (person) take the decision to go to the clinic, we put this agent (person) in the flowchart
   "Dive" into the process

Clinic (environment)

Person (agent)



2. When finished the process defined by the flowchart, we send the message to the agent that triggers the transition **On exit:** `entity.receive( "Treated" );`

"Jump" out of the process

Thank you!

- Questions?

Part 2

Which facilities are modeled?

transport
- Railway stations
- Metro stations
- Airports
- Car parks
- Pedestrian passageways

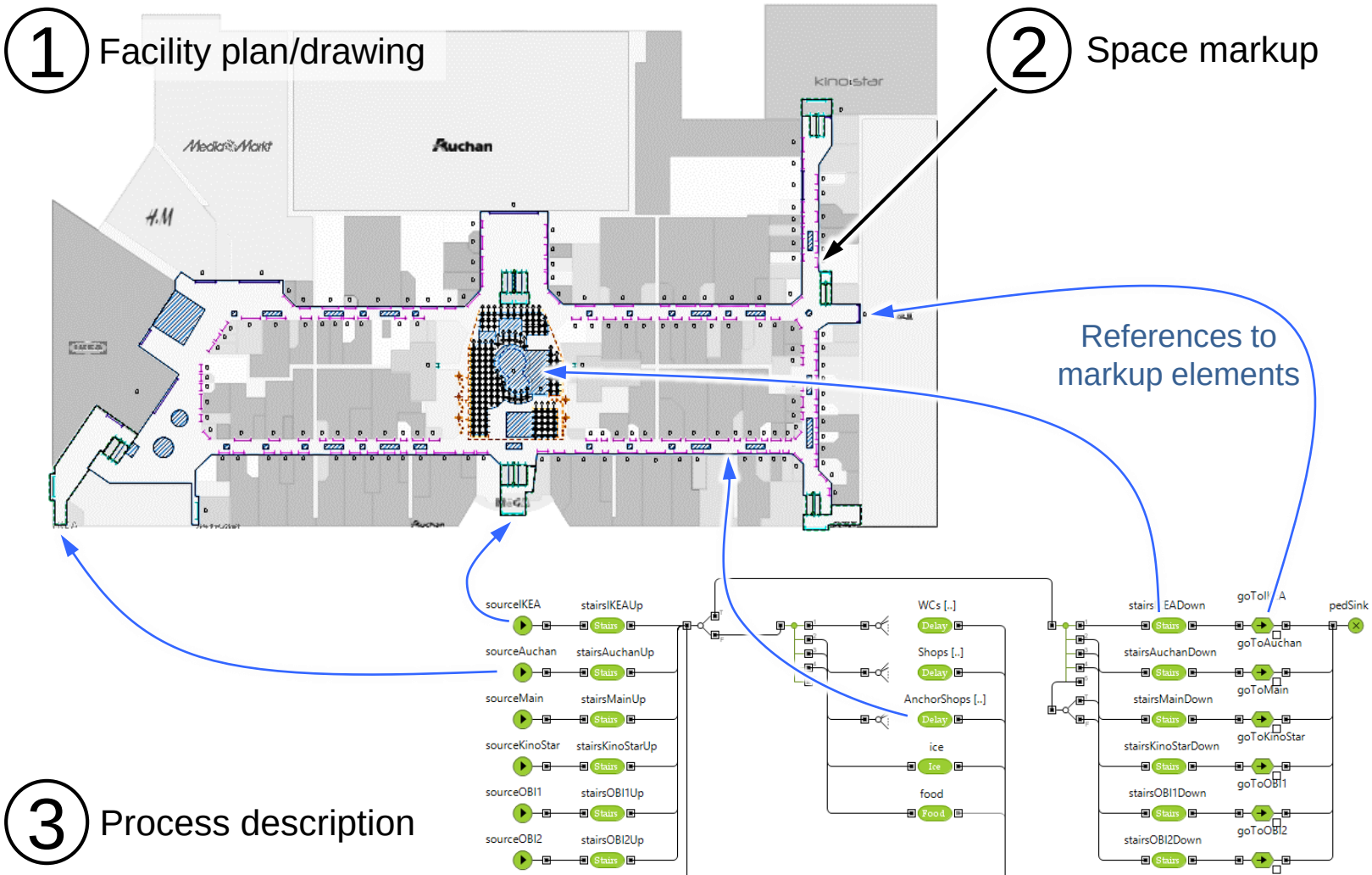
"attractions"
- Shopping malls
- Museums
- Amusement parks

events
- Stadiums
- Concert halls
- Worship facilities
- Street events (festivals, rallies, demonstrations)

- As well as production, warehouse and even movements of personnel in a kitchen…

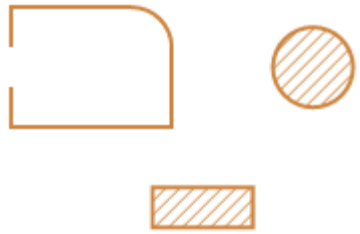
In general all the facilities where the arrangement of physical space for pedestrians affects throughput capacity, quality of service, and safety

How are pedestrian models built with AnyLogic?



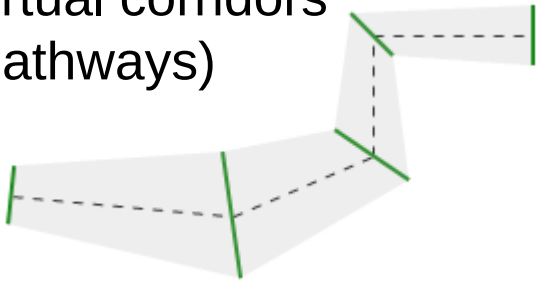
Space Markup elements

Walls

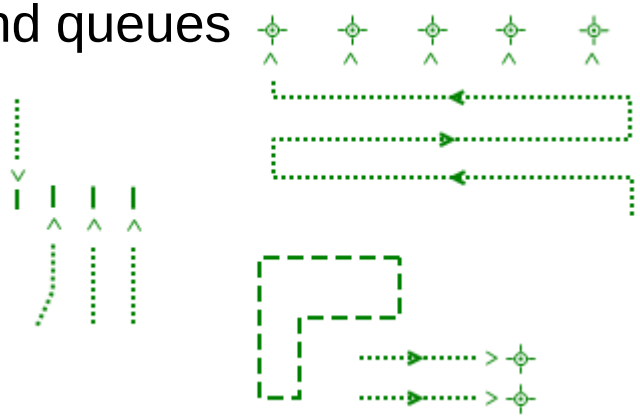


Target lines / pedestrian appearance lines

Virtual corridors (pathways)



Services (service points) and queues



Waiting areas / target areas

Acceleration / deceleration areas

Process Description Basic Blocks

PedSource

Creates pedestrians on a line, at a point or in an area with a given rate, according to a time schedule, etc.

PedService

Sets servicing parameters (where is a delay, the selection of a queue, etc.)

PedGoTo

Sets up an objective or a route

PedWait

Sets waiting parameters (where to wait, in relation to time, until an event)

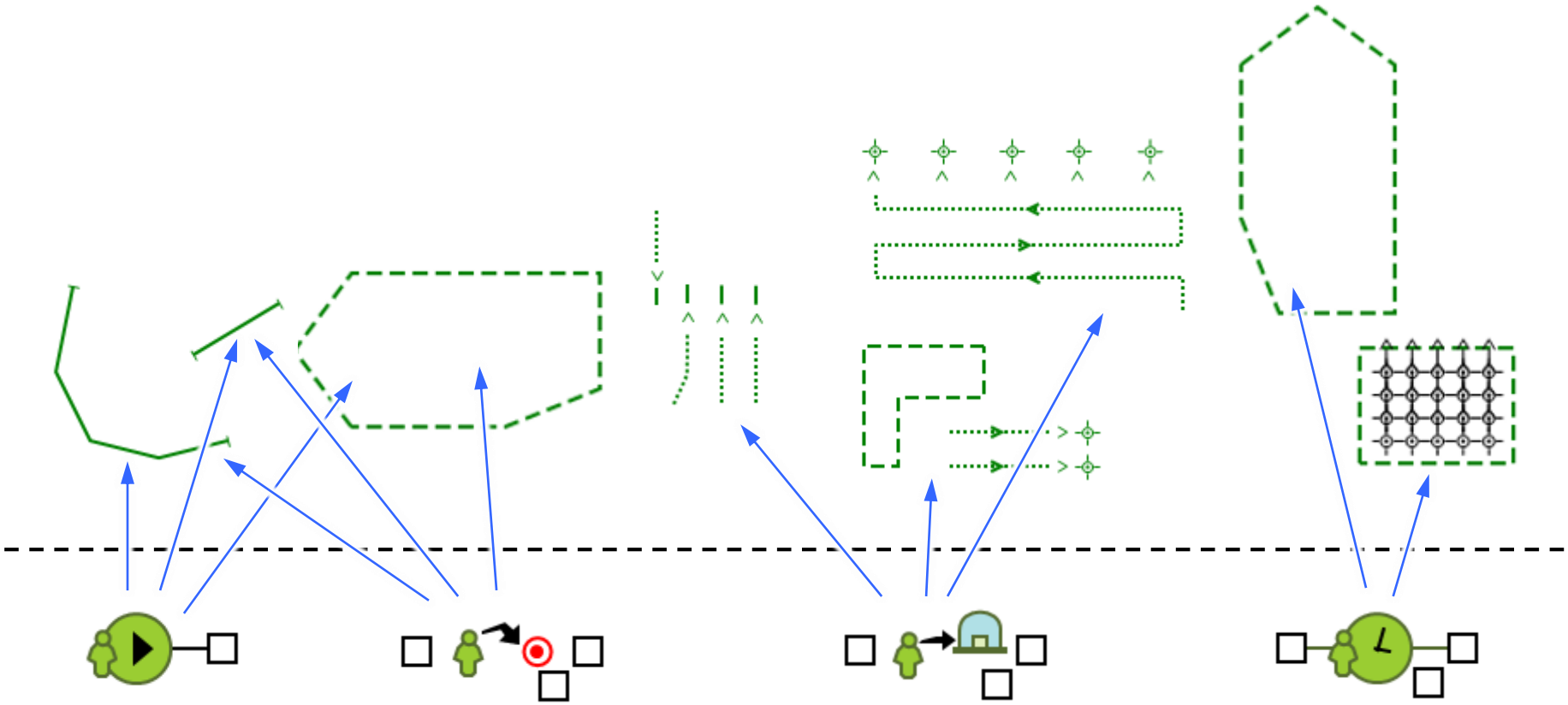
PedSelectOutput

Divides a passenger flow

PedSink

Deletes passengers from the model

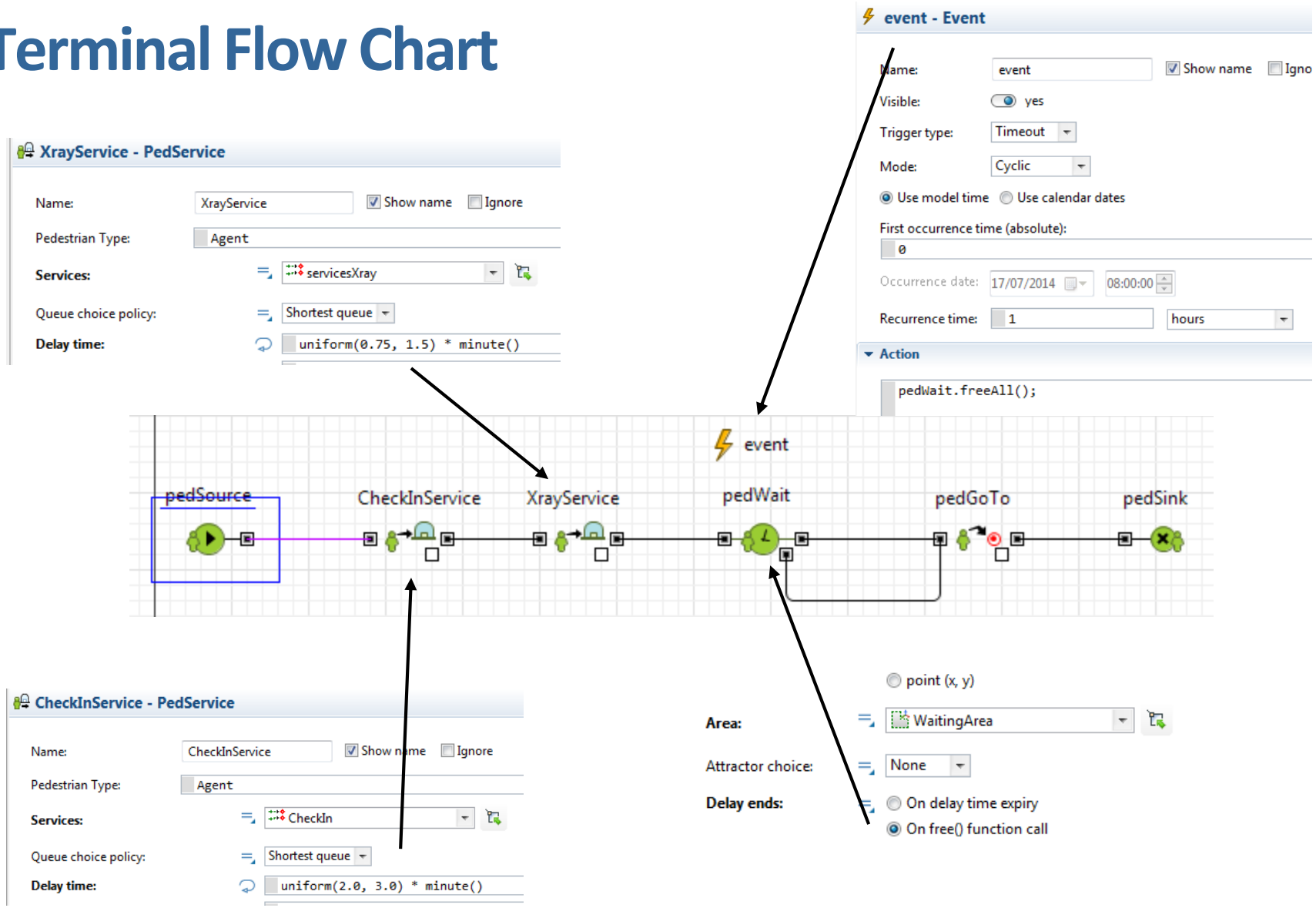
Process and Markup Connection



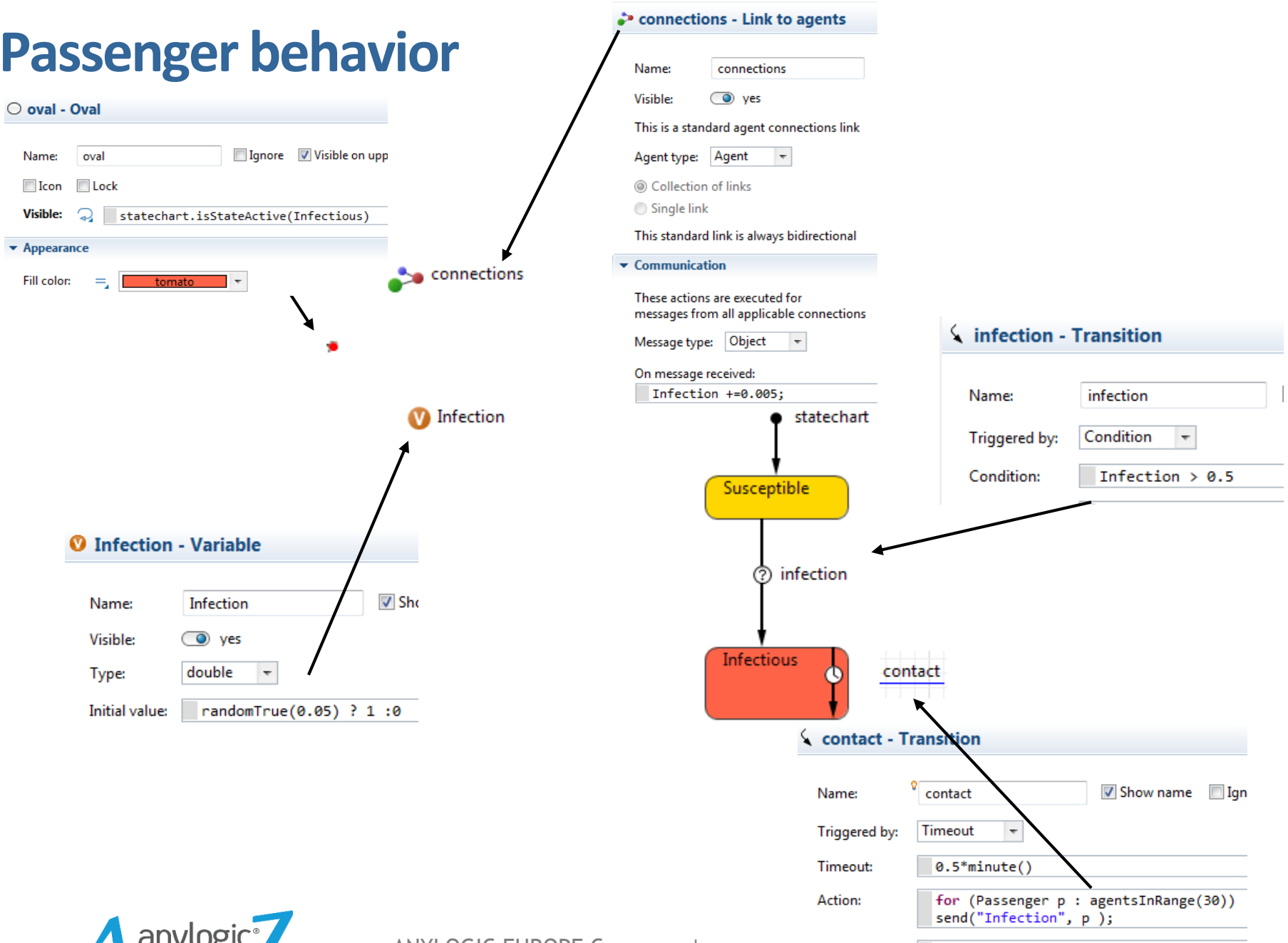
Example: very simple of Terminal model

- Passengers enter in terminal, follow Checking and Security controls, wait in Waiting zone for embarkation
- An infection can spreading in the terminal
- From time to time infected person will enter the terminal, and in case of long queues they will infect the passengers that will be standing near them for a reasonable time.
- Number of Agents (passengers): 100/hour
- CheckIn time: uniform (2.0,3.0) minutes
- Security Control time : uniform (0.75,1.5) minutes
- Initially infected: 5%

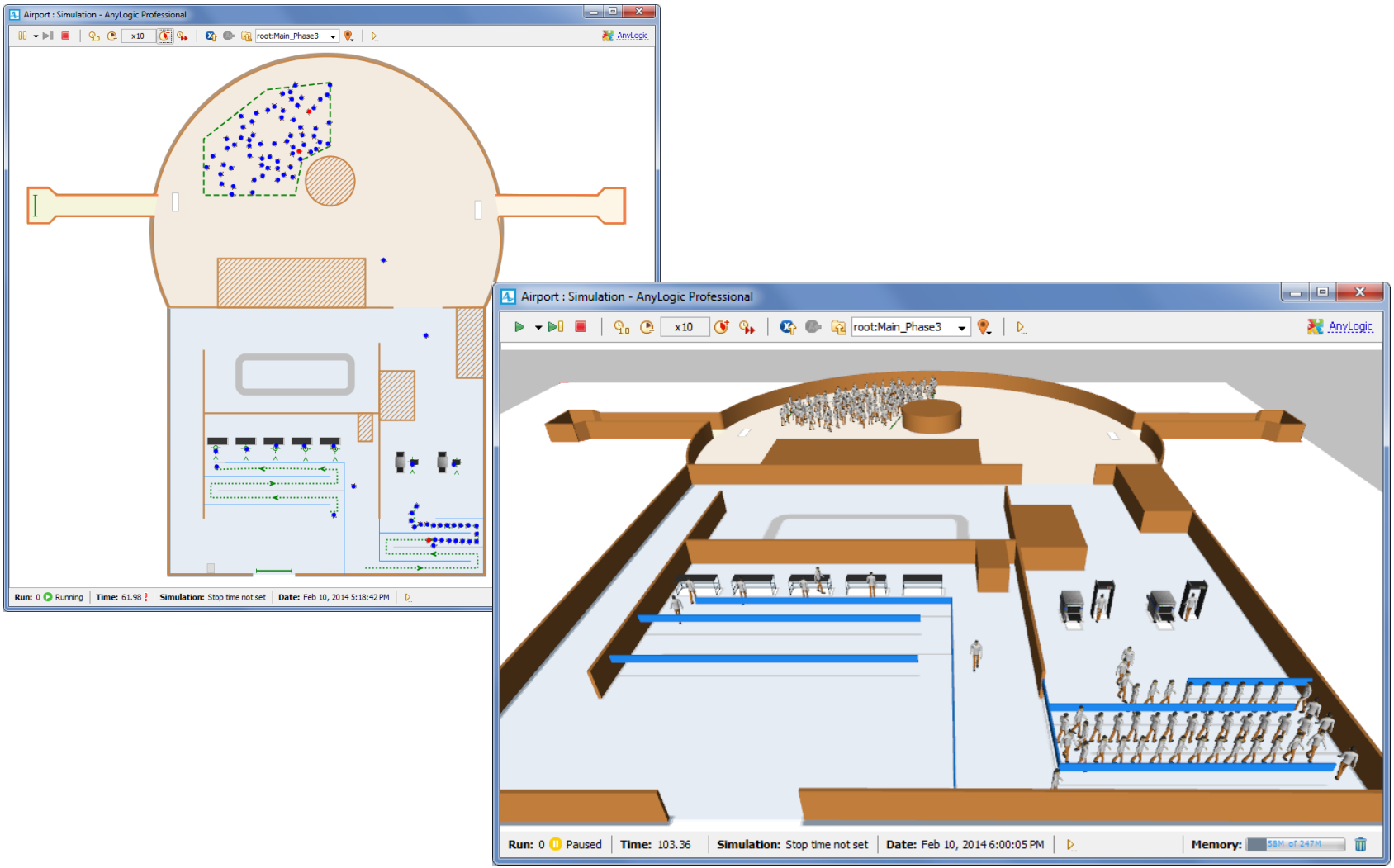
Terminal Flow Chart



Passenger behavior



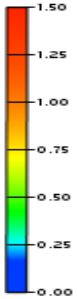
Example: very simple Terminal model



Measurements and Statistics in Pedestrian Models

- Metrics typical for discrete event models
  - Queue lengths
  - Waiting time
  - Time in a system
  - Utilization of service points (services)
- Metrics specific for pedestrian models
  - Flow characteristics: the total number of passenger having passed through a section per a unit of time, the same quantity per a unit of length
  - Density in a certain area: the number of passengers per square meter (average per a unit of time); density charts

PedFlowStatistics



PedestrianDensityMap

Thank you!

- All additional information on our site: www.anylogic.com
- Contact: Vladimir Koltchanov europe@anylogic.com
- Questions?