

Multi-Method Modeling with AnyLogic 7

Dr. Vladimir Koltchanov
ANYLOGIC EUROPE Company Director
Multi-Method Modeling Workshop
July 24, 2014
System Dynamics Conference, Delft



ANYLOGIC EUROPE Company | europe.anylogic.com

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/...)

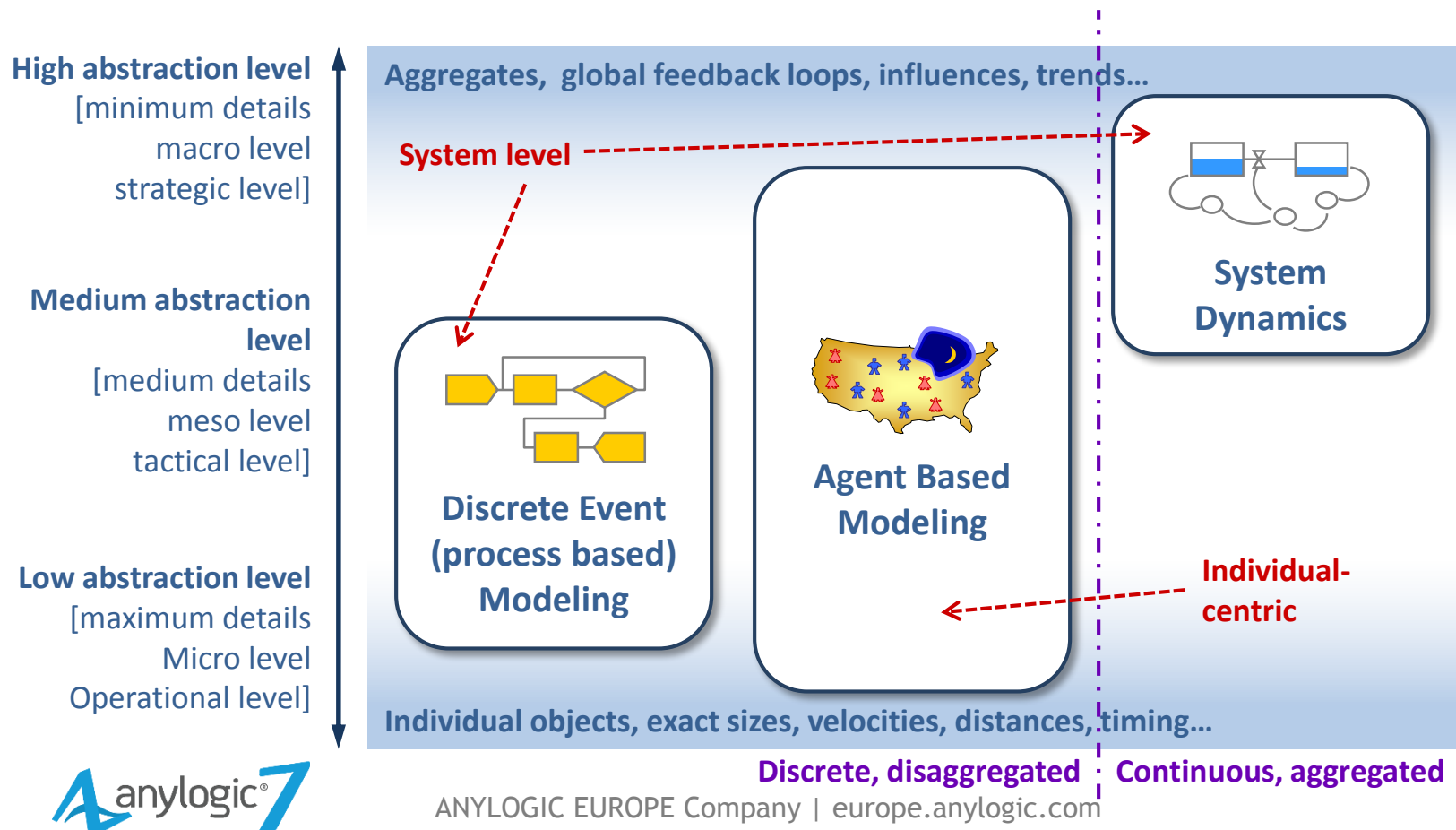
Today's agenda:

- 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



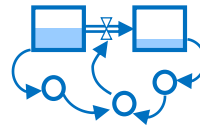
Why multi-method modeling?

- 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

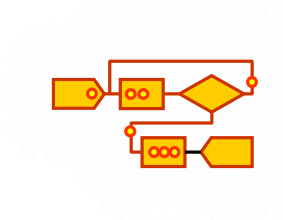
The driving philosophy of AnyLogic



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

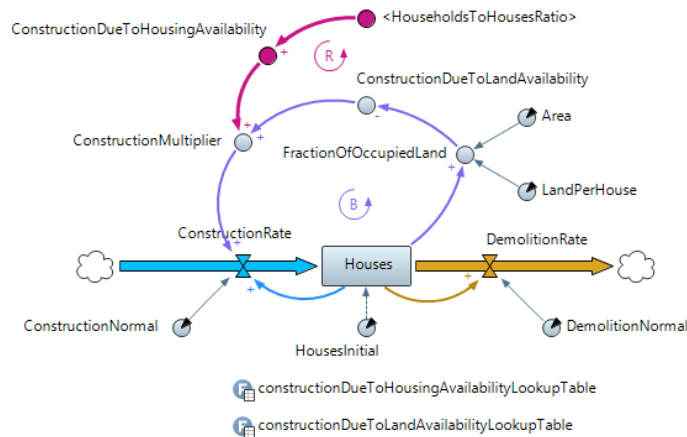


HIGHLY SCALABLE: GROWS WITH YOU AS YOUR NEEDS FOR SIMULATION GROW

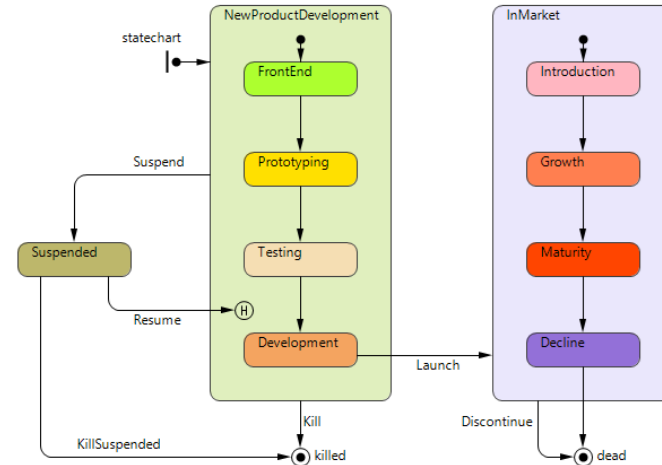


The choice of methods. Visual languages of AnyLogic

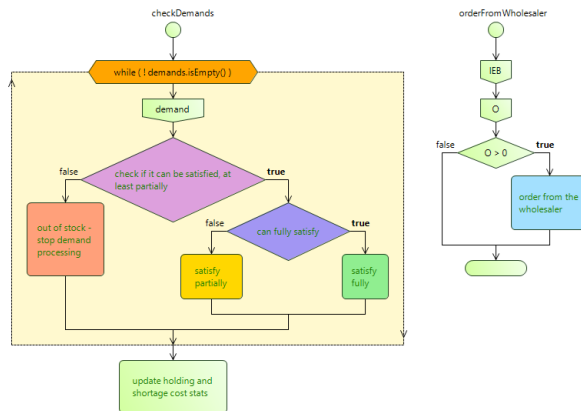
Stock & Flow Diagrams



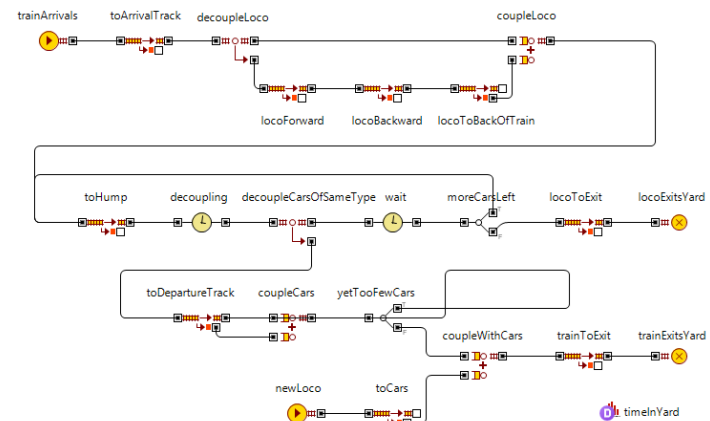
Statecharts



Action charts

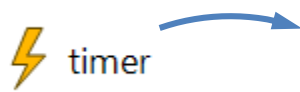


Process flowcharts



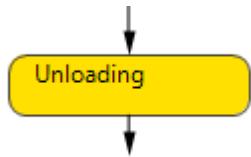
Open tool: Java “extension points”

- 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();  
}
```



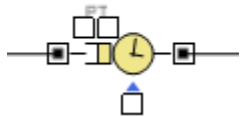
Entry action:

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

Exit action:

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

verifyAndFixBills



On enter^D

On enter delay^D

On exit^D

```
entity.setShape( groupBill10K );
```

A simple Epidemic & Clinic model

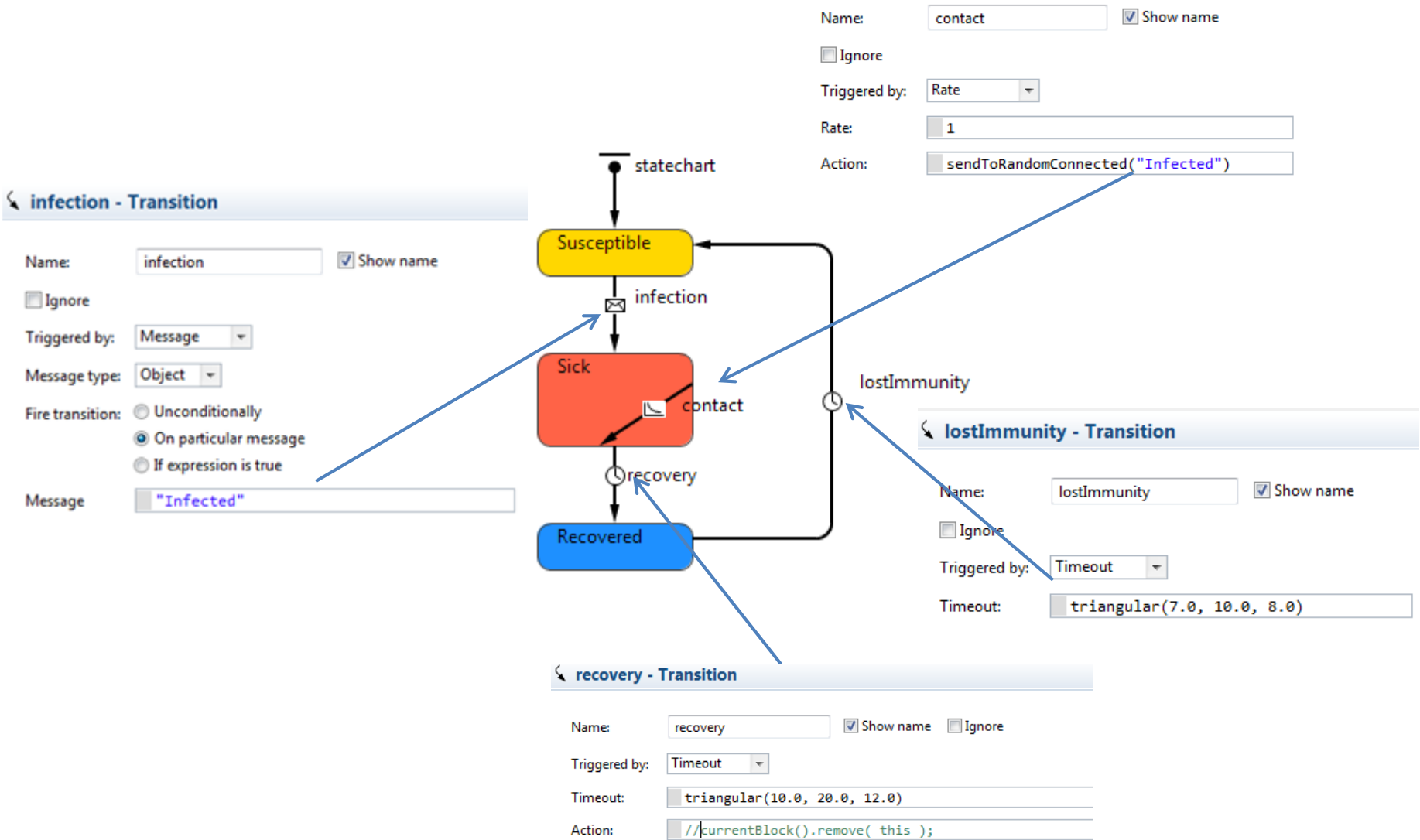
- We are to model epidemic in a region
 - Initially all people are susceptible to the disease, and a few are infected
 - People contact each other randomly at a certain rate
 - Having been infected, the person requests treatment in a clinic or do nothing and continues to live normally not reducing his 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

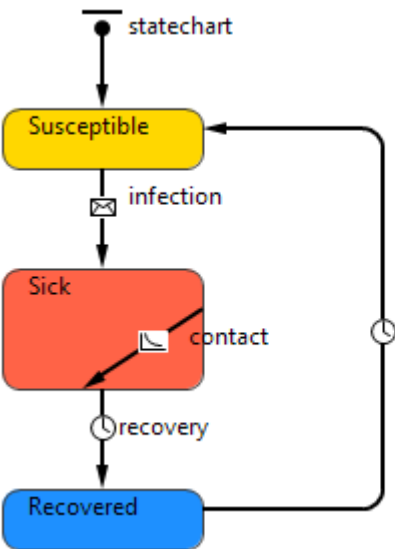
- Number of Agents (persons): 200
- Initially infected: 5
- Contact rate: 1/day/person
- Number of available beds in clinic: 1 - 25
- Immunity duration: 8 days
- Disease duration: triangular (10, 20, 12)
- Treatment duration: triangular (1, 3, 2)

Let's build this model!



Let's build this model!

Each person has individual parameters and behavior



The screenshot displays the AnyLogic Professional interface for the 'EpidemicMultiMethodModel'. The main window shows a network of agents (represented by small human figures) connected by lines, illustrating the spread of infection. A blue circle highlights a specific agent. Below the network is a 3D visualization of the same network. At the bottom of the main window is a line graph showing the population dynamics over time (0 to 100 days). The graph has three series: Susceptibles (yellow), Sick (red), and Recovereds (blue). The 'Susceptibles' count starts at approximately 200 and decreases over time. The 'Sick' count peaks at around 150. The 'Recovereds' count increases to about 100. The status bar at the bottom indicates the simulation is running, with a time of 111.15 and a date of Nov 3, 2014 8:10:44 PM. The right-hand side shows the 'Main - Agent Type' properties panel, including agent actions and movement parameters.

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

The image displays the Anylogic software interface for configuring a statechart. At the top, a statechart diagram shows states: admission, waitFortreatment, InTreatment, and exit. A transition labeled 'infection' connects 'Susceptible' to 'Sick', and 'recovery' connects 'Sick' to 'Recovered'. A 'lostImmunity' transition connects 'Recovered' back to 'Susceptible'. A 'contact' transition connects 'Sick' to 'Sick'. A 'Treated' transition connects 'Sick' to 'Recovered'. A 'recovery - Transition' configuration panel is shown at the bottom right, with the action `currentBlock().remove(this);`.

infection - Transition Configuration:

- Name: infection
- Triggered by: Message
- Message type: Object
- Message: "Infected"
- Action: `main.admission.take(this);`
- Guard: `randomTrue(0.5)`

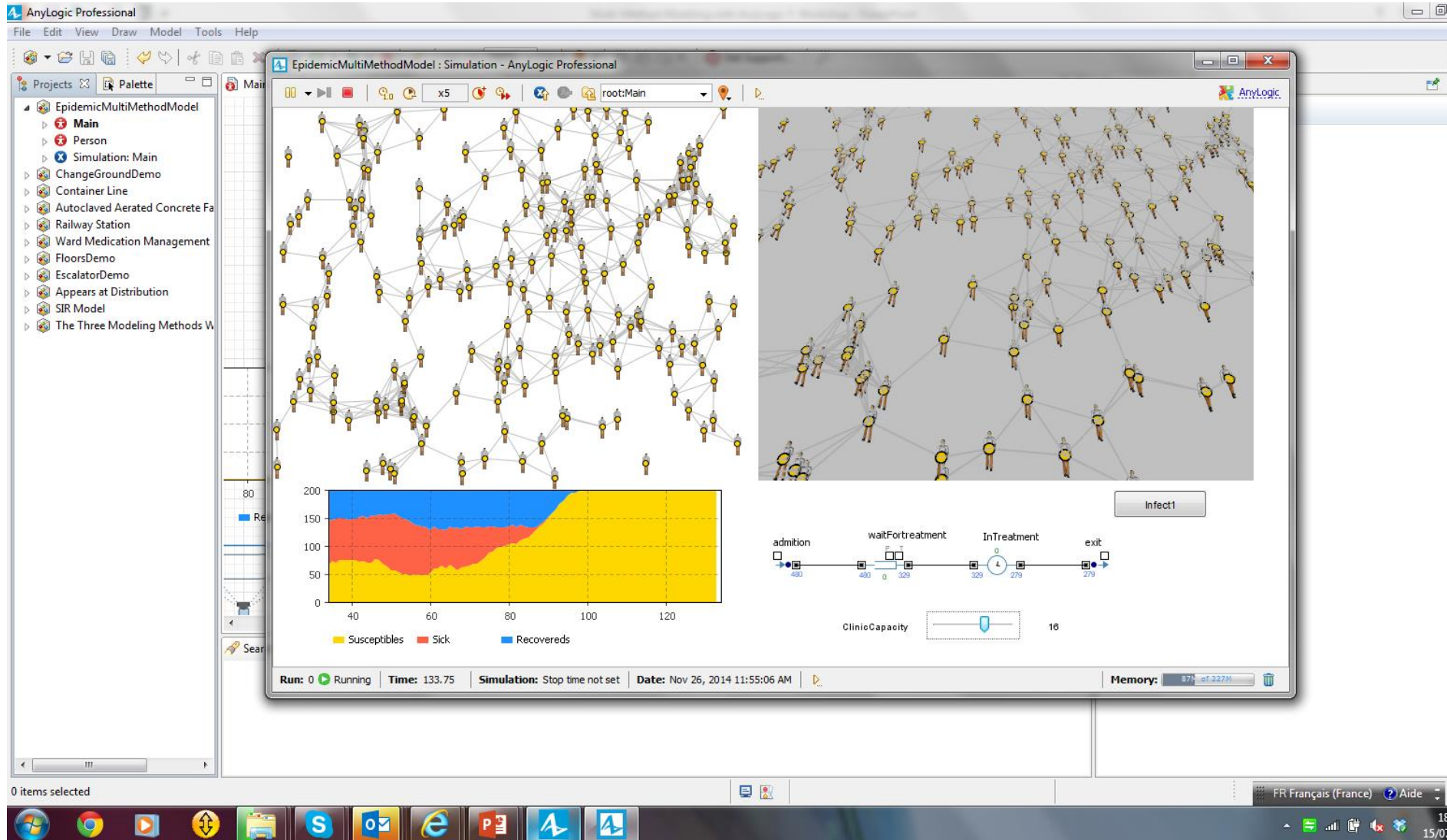
recovery - Transition Configuration:

- Name: recovery
- Triggered by: Timeout
- Timeout: `triangular(10.0, 20.0, 12.0)`
- Action: `currentBlock().remove(this);`

Annotations:

- A blue arrow labeled "Inject entity" points from the "infection" transition configuration to the "infection" transition in the statechart.
- A red arrow labeled "Notify the agent" points from the "recovery" transition configuration to the "recovery" transition in the statechart.

Population (AB) & Clinic (DE) model



Statistic collection and plotting

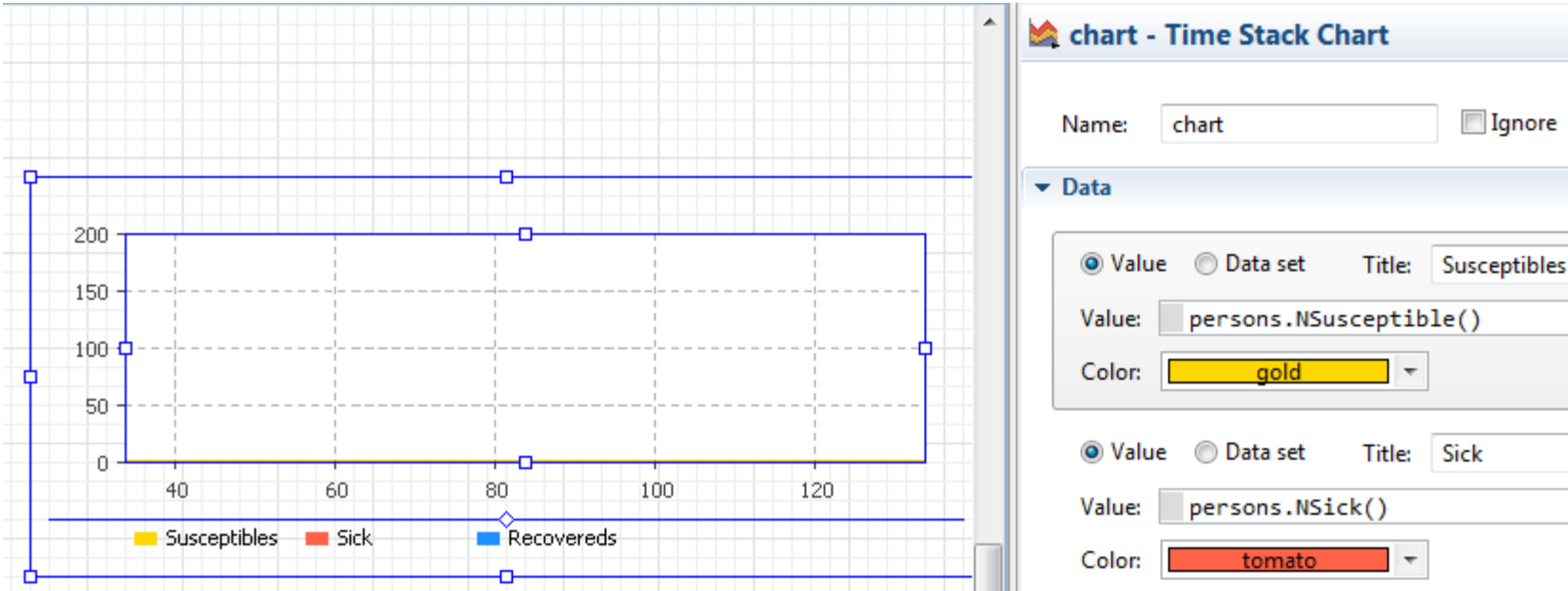
Statistics

Name:

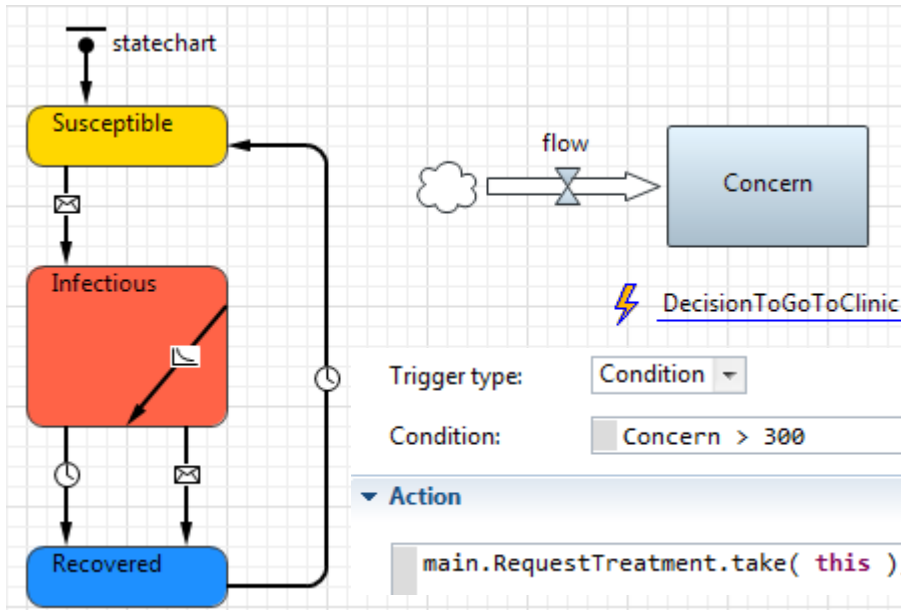
Type: Count Sum Average Min Max

Expression:

Condition:



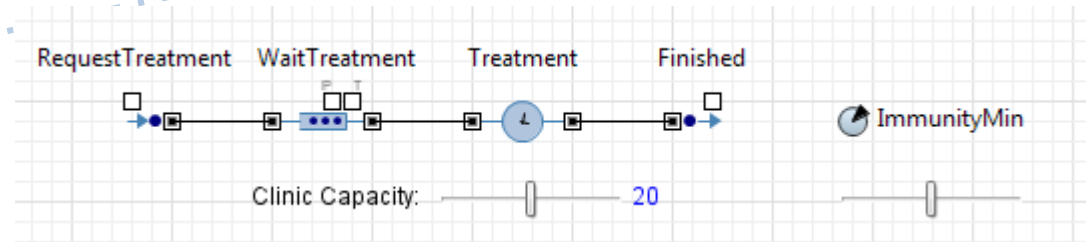
Link between AB & DE &SD in the Epidemic & Clinic model



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

"Jump" out of the process

```
On exit: entity.receive( "Treated" );
```

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

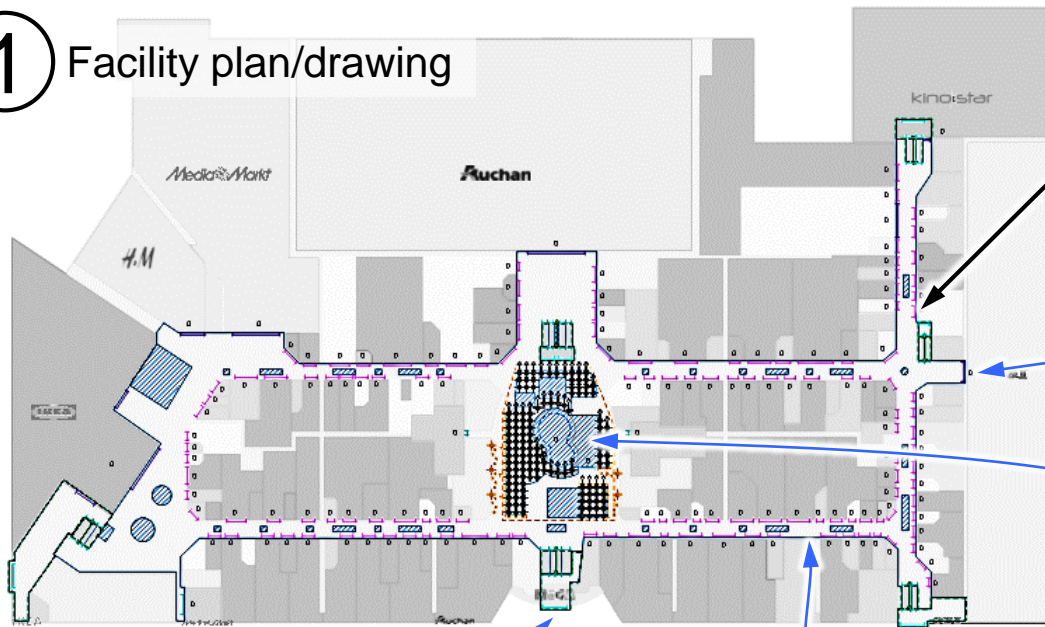
- Stadiums
- Concert halls
- Worship facilities
- Street events (festivals, rallies, demonstrations)
- As well as production, warehouse and even movements of personnel in a kitchen...

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?

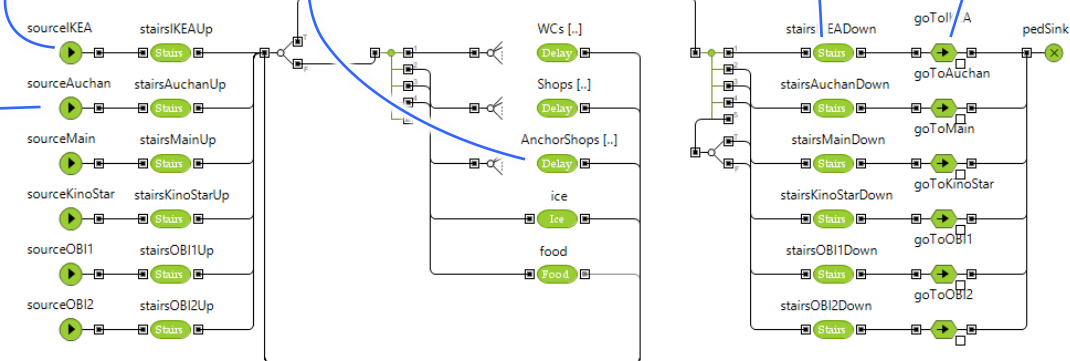
1 Facility plan/drawing

2 Space markup



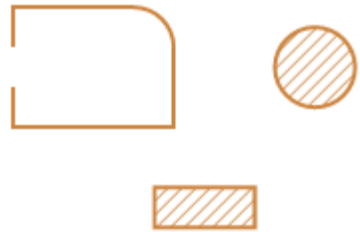
References to markup elements

3 Process description



Space Markup elements

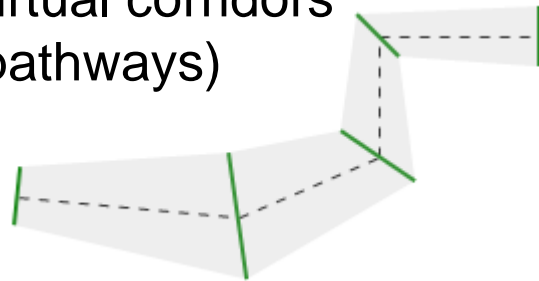
Walls



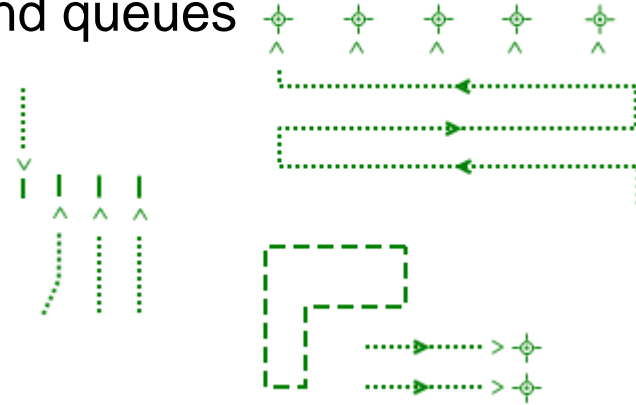
Target lines / pedestrian appearance lines



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



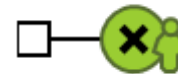
Sets waiting parameters (where to wait, in relation to time, until an event)

PedSelectOutput



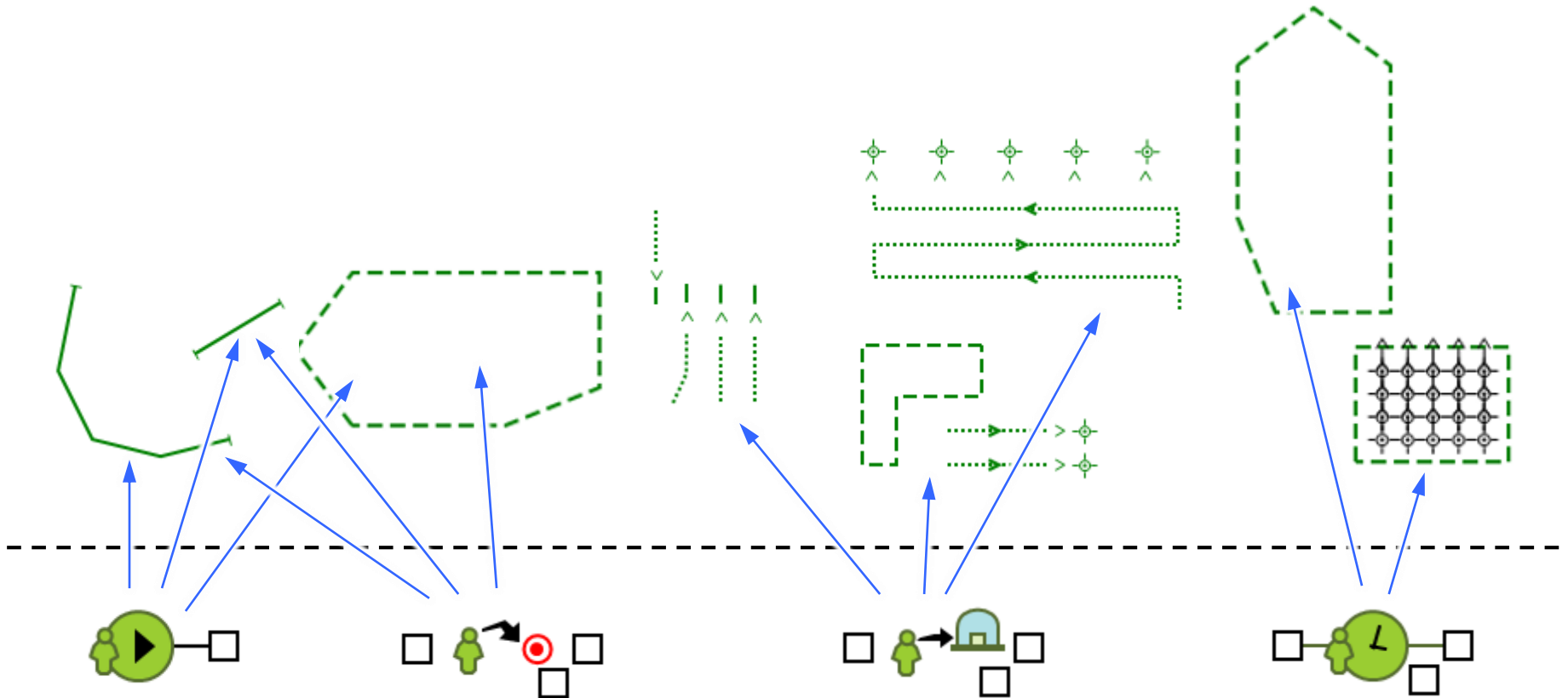
Divides a passenger flow

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

XrayService - PedService

Name: Show name Ignore

Pedestrian Type:

Services:

Queue choice policy:

Delay time:

event - Event

Name: Show name Ignore

Visible: yes

Trigger type:

Mode:

Use model time Use calendar dates

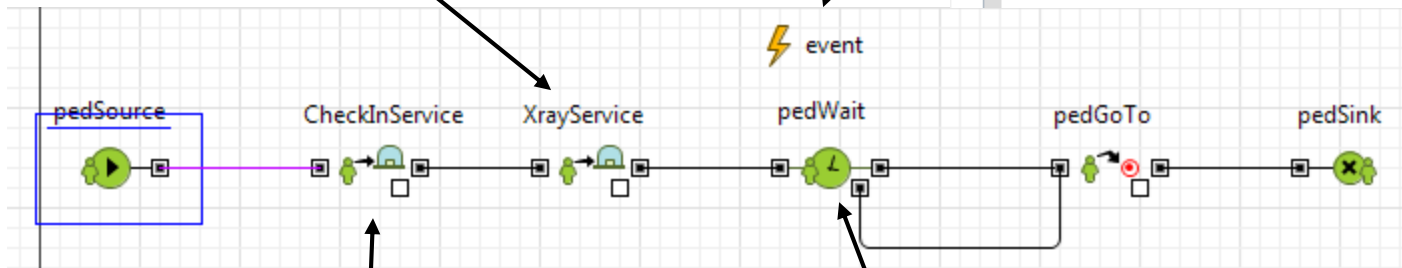
First occurrence time (absolute):

Occurrence date:

Recurrence time:

Action

```
pedWait.freeAll();
```



CheckInService - PedService

Name: Show name Ignore

Pedestrian Type:

Services:

Queue choice policy:

Delay time:

Area:

Attractor choice:

Delay ends: On delay time expiry On free() function call

Passenger behavior

oval - Oval

Name: Ignore Visible on upp
 Icon Lock
 Visible:

Appearance

Fill color:

connections

connections - Link to agents

Name:
 Visible: yes
 This is a standard agent connections link
 Agent type:
 Collection of links
 Single link
 This standard link is always bidirectional

Communication

These actions are executed for messages from all applicable connections
 Message type:
 On message received:

infection - Transition

Name:
 Triggered by:
 Condition:

Infection - Variable

Name: Sh
 Visible: yes
 Type:
 Initial value:

Infection

statechart

Susceptible

infection

Infectious

contact

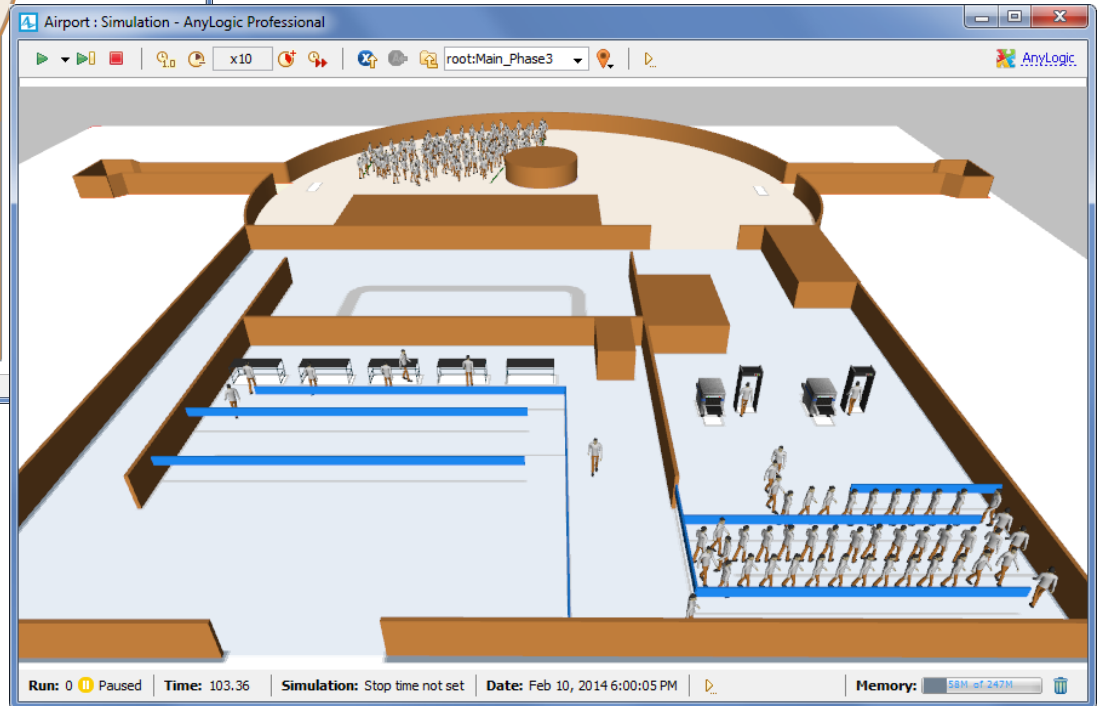
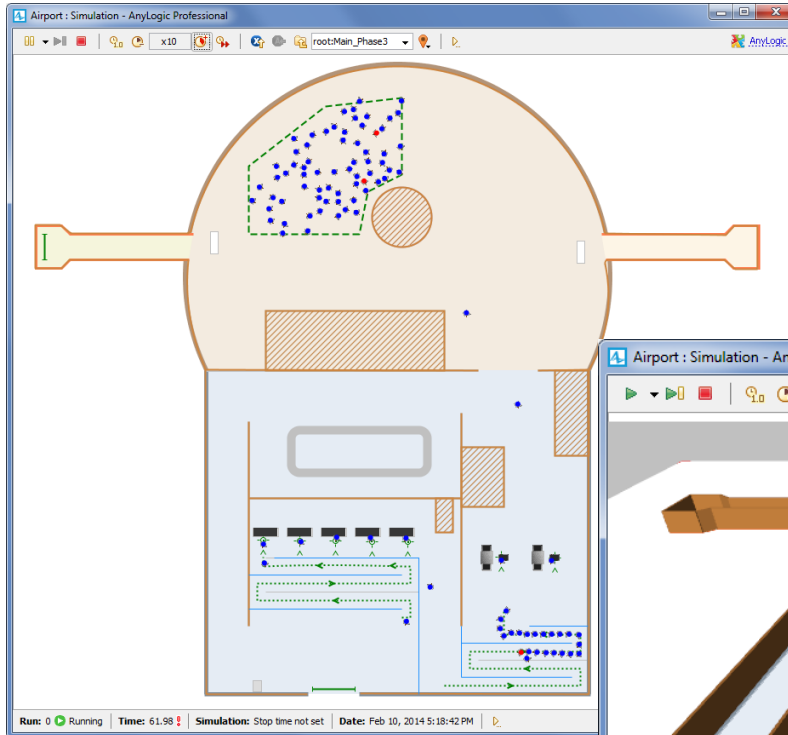
contact - Transition

Name: Show name Ign
 Triggered by:
 Timeout:
 Action:

```
for (Passenger p : agentsInRange(30))
  send("Infection", p);
```



Example: very simple Terminal model

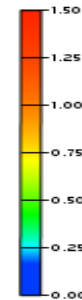


Measurements and Statistics in Pedestrian Models

- 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?