Multi-Method Modeling with AnyLogic 7

Dr. Vladimir Koltchanov
ANYLOGIC EUROPE Company Director
Multi-Method Modeling Workshop
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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/…)

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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
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

High abstraction level
[minimum details macro level strategic level]

Medium abstraction level
[medium details meso level tactical level]

Low abstraction level
[maximum details Micro level Operational level]

Aggregates, global feedback loops, influences, trends...

System level

System Dynamics

Discrete Event (process based) Modeling

Agent Based Modeling

Individual objects, exact sizes, velocities, distances, timing...

Individual-centric

Discrete, disaggregated

Continuous, aggregated
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

- **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

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

```
Entry action:
stock.set_OutFlow( UnloadingRate );
```

```
Exit action:
stock.set_OutFlow( 0 );
```

```
On enter
On enter delay
On exit
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!

**Statechart Diagram**

- **Susceptible**
  - Transition: **infection**
    - Triggered by: Message
    - Message type: Object
    - Message: "Infected"
    - Rate: 1
    - Action: sendToRandomConnected("Infected")

- **Sick**
  - Transition: **contact**

- **Recovered**
  - Transition: **recovery**
    - Triggered by: Timeout
    - Timeout: triangular(7.0, 10.0, 8.0)

- **LostImmunity**
  - Transition: **contact**
    - Triggered by: Timeout
    - Timeout: triangular(7.0, 10.0, 8.0)
  - Action: this.remove();
Let’s build this model!

Each person has individual parameters and behavior.
Let’s add a clinic and build interface between AB & DE

Inject entity

Notify the agent
Population (AB) & Clinic (DE) model
Statistic collection and plotting

![Diagram showing statistical collection and plotting in AnyLogic][1]

[1]: anylogic.com
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.

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.
Thank you!

• Questions?
Part 2
Which facilities are modeled?

- Railway stations
- Metro stations
- Airports
- Car parks
- Pedestrian passageways
- Shopping malls
- Museums
- Amusement parks
- 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
3. Process description

References to markup elements
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.

**PedGoTo**
- Sets up an objective or a route

**PedSelectOutput**
- Divides a passenger flow

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

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

**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: XrayService
Pedestrian Type: Agent
Services: servicesXray
Queue choice policy: Shortest queue
Delay time: uniform(0.75, 1.5) * minute()

CheckInService - PedService

Name: CheckInService
Pedestrian Type: Agent
Services: CheckIn
Queue choice policy: Shortest queue
Delay time: uniform(2, 3) * minute()
Passenger behavior

- **Infection**
  - Name: Infection
  - Visible: yes
  - Type: double
  - Initial value: randomTrue(0.05) ? 1 : 0

- **Connections**
  - Name: connections
  - Visible: yes
  - Description: This is a standard agent connections link
  - Agent type: Agent
  - Collection of links: true
  - Single link: false
  - This standard link is always bidirectional

- **Infection - Transition**
  - Name: infection
  - Triggered by: Condition
  - Condition: Infection > 0.5

- **Contact - Transition**
  - Name: contact
  - Triggered by: Timeout
  - Timeout: 0.5*minute()
  - Action:
    ```java
    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?