

Multi-Method Modeling with AnyLogic

- System Dynamics
- Agent Based
- Discrete Event

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Workshop agenda

- About AnyLogic
- Modeling methods – quick intro
- Building a multi-method model
- Q & A

The AnyLogic Company

- We are:
 - Simulation software vendor (80%)
 - Consulting company (20%)
- Users
 - ~700 commercial and ~1000 educational organizations
 - Several 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/...)

Our locations

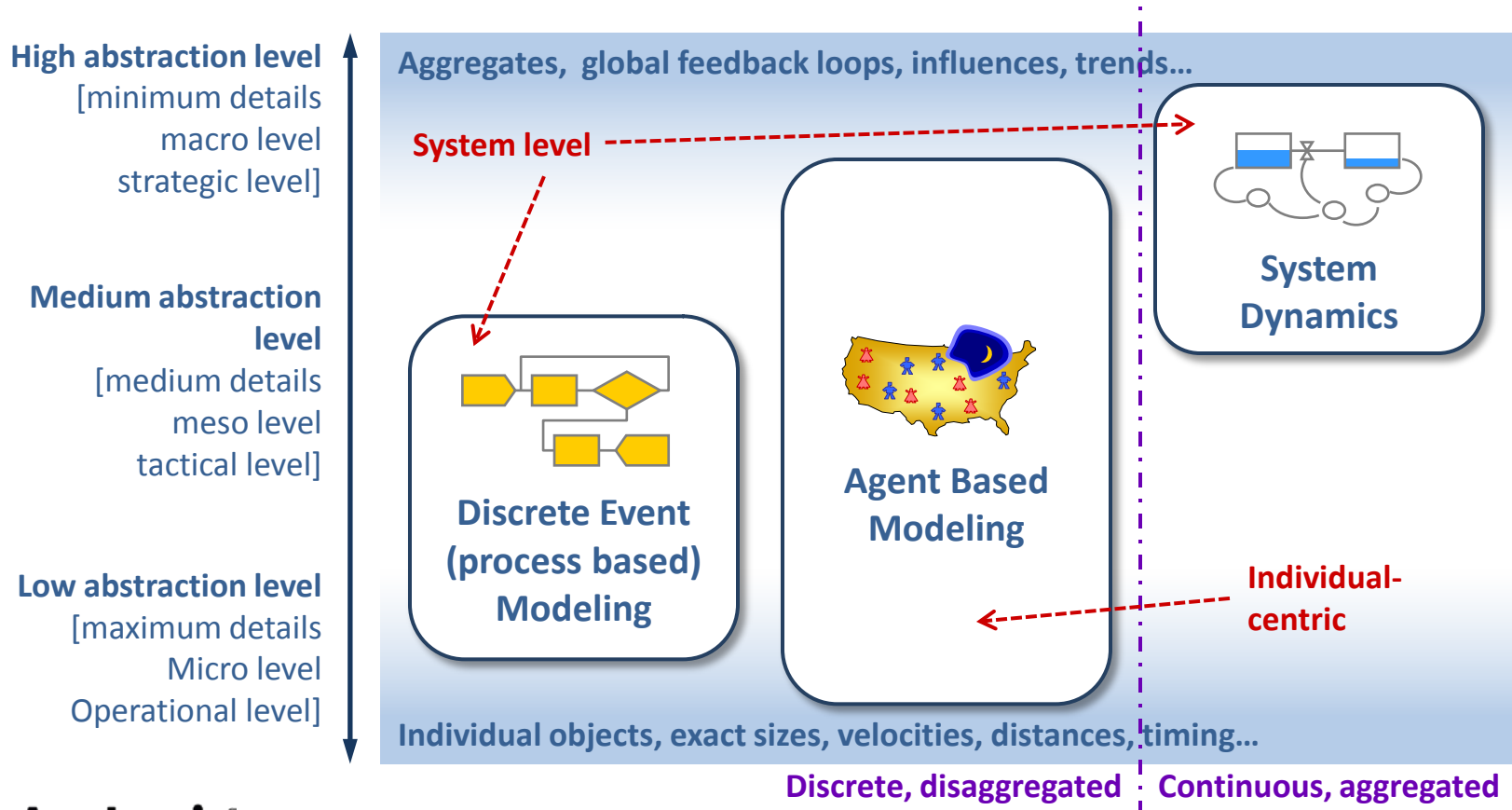


Selected commercial clients



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

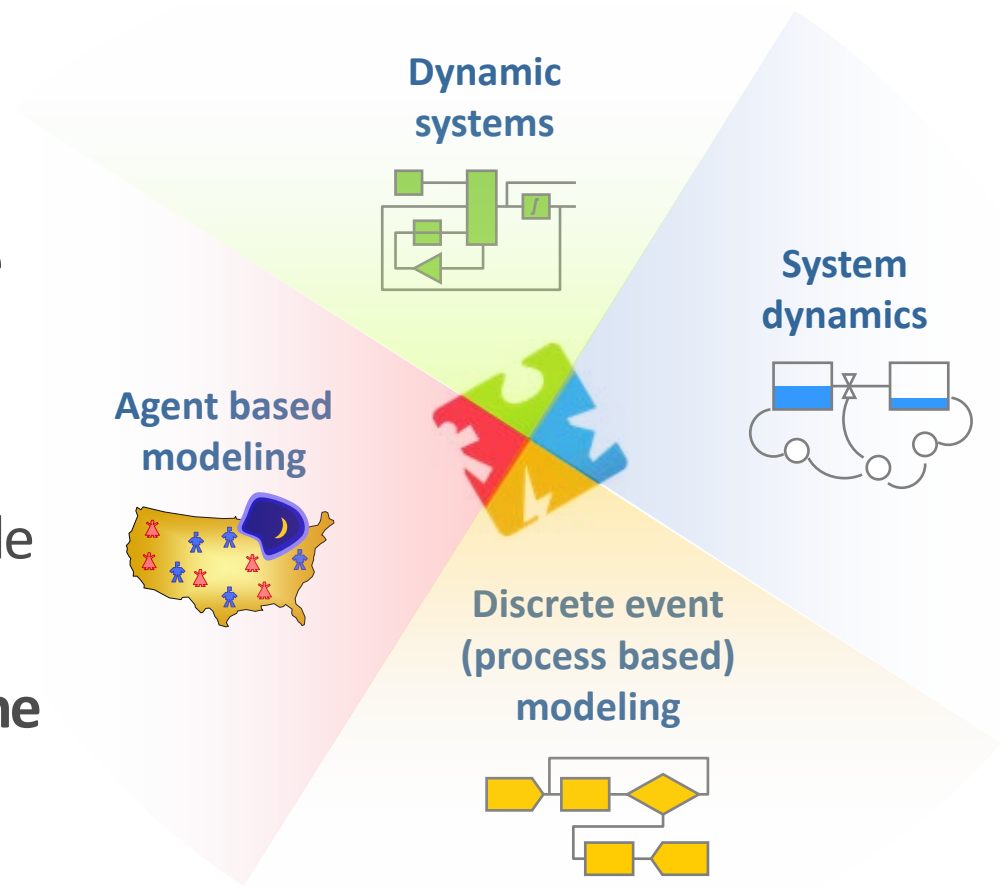


Why multi-method modeling?

- 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 and cumbersome 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

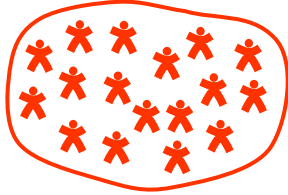
AnyLogic

- **Support all three** modeling methods on a single modern object-oriented platform
- **The modeler can choose** from a wide range of abstraction levels/methods and can efficiently vary them while working on the model
- **The modeler can combine** different methods in one model

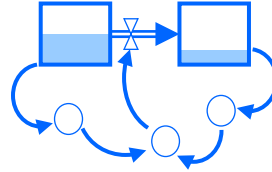


Model architectures

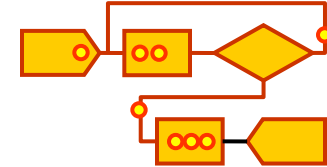
Agents



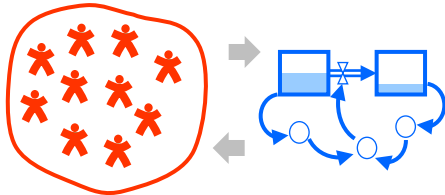
SD



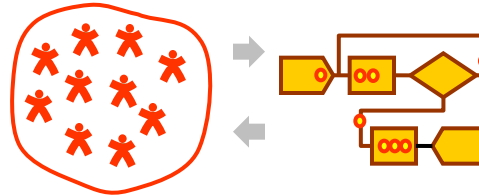
DE (Process model)



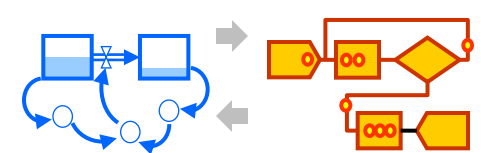
Agents + SD environment
(e.g., population + city infrastructure)



Agents + process model
(e.g., clients + service)



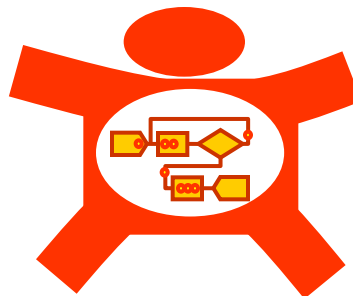
SD + process model
(e.g., demand + production)



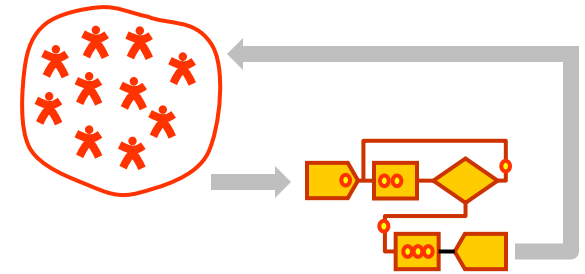
SD inside agent
(e.g. consumer's individual decision making)



Process model inside agent
(e.g. business process in a company in a bigger supply chain model)

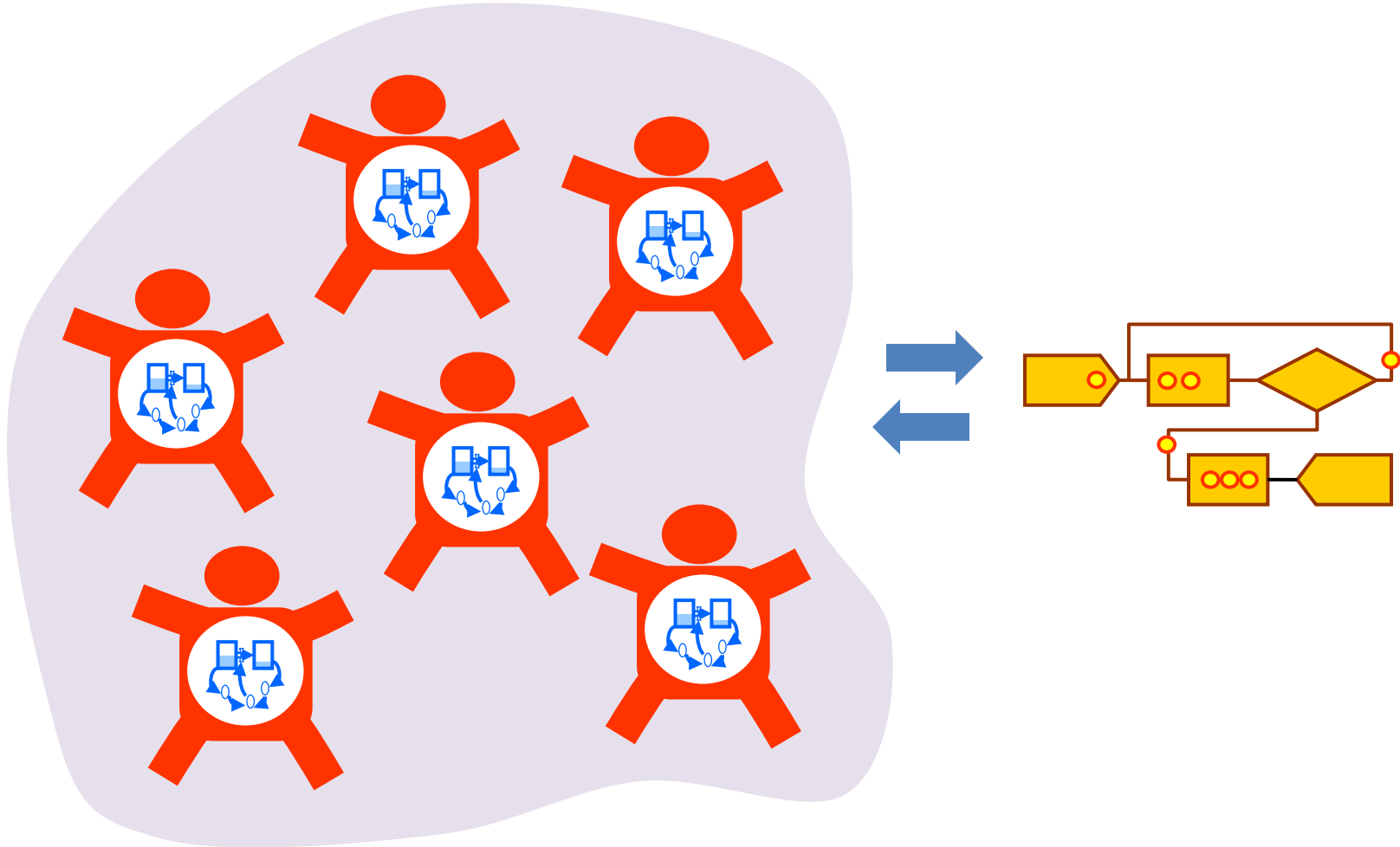


Agents become entities
(e.g., patients with chronic diseases return to hospital)



and so on in any combination...

Now we will build a multi-method model in AnyLogic



Customer Satisfaction

- Modeling customer satisfaction – slippery and elusive
 - However, it is crucial to many business—particularly service—applications.
- Models do exist in a variety of methods—SD and AB primarily.
 - Assumptions of the methods and models

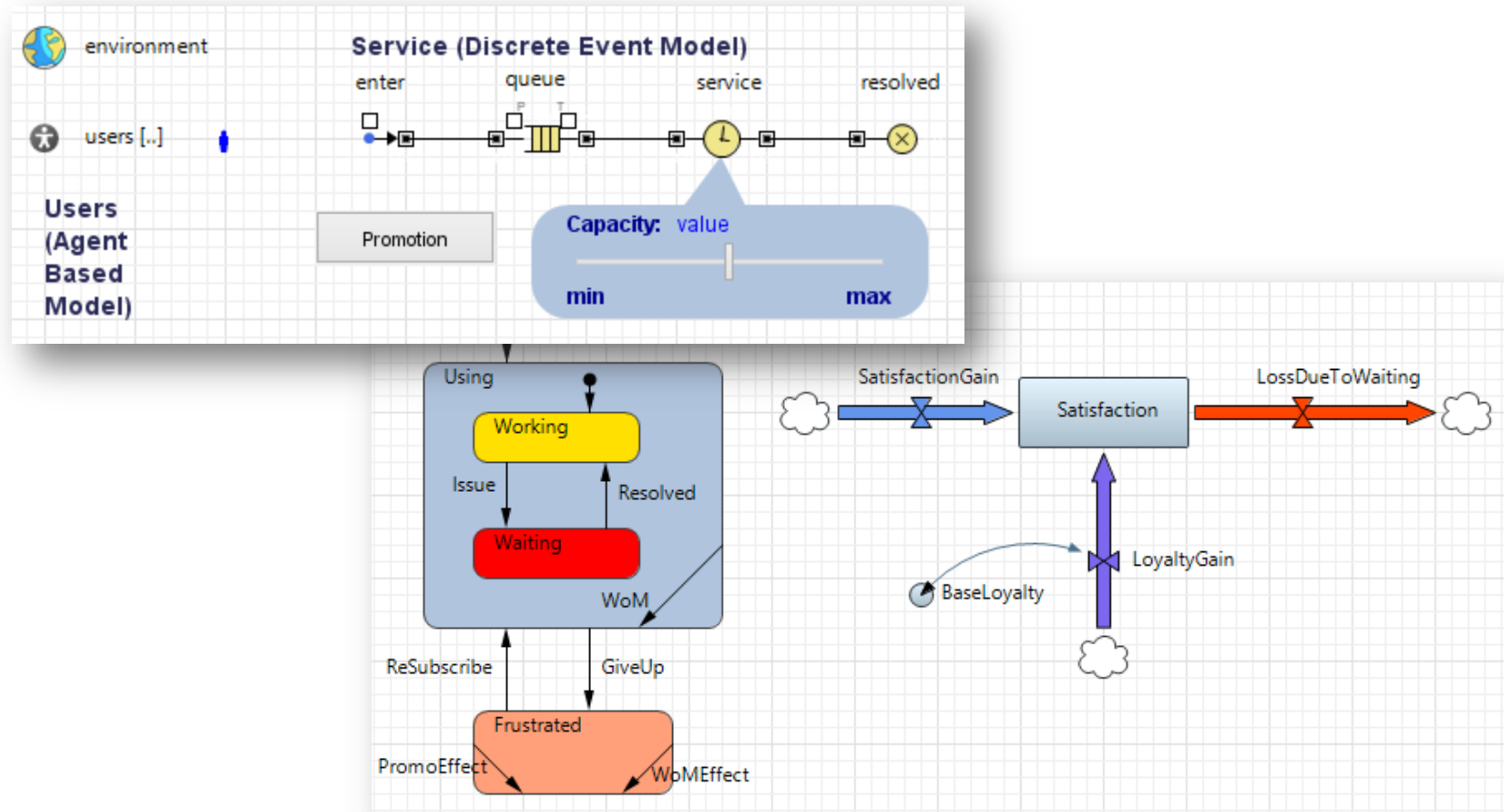
Specific Scenario

- This model is based on an actual model built for a client.
- This client offered a service that was subject to interruption, downtime, and similar issues. (E.g., an Internet provider)
- When the service is interrupted, the users of this service submit requests for the service to be restored. These requests are processed and the service restored on an individual level.
- The users have a varying level of Satisfaction for the service based on the service's performance.

Model Specifics

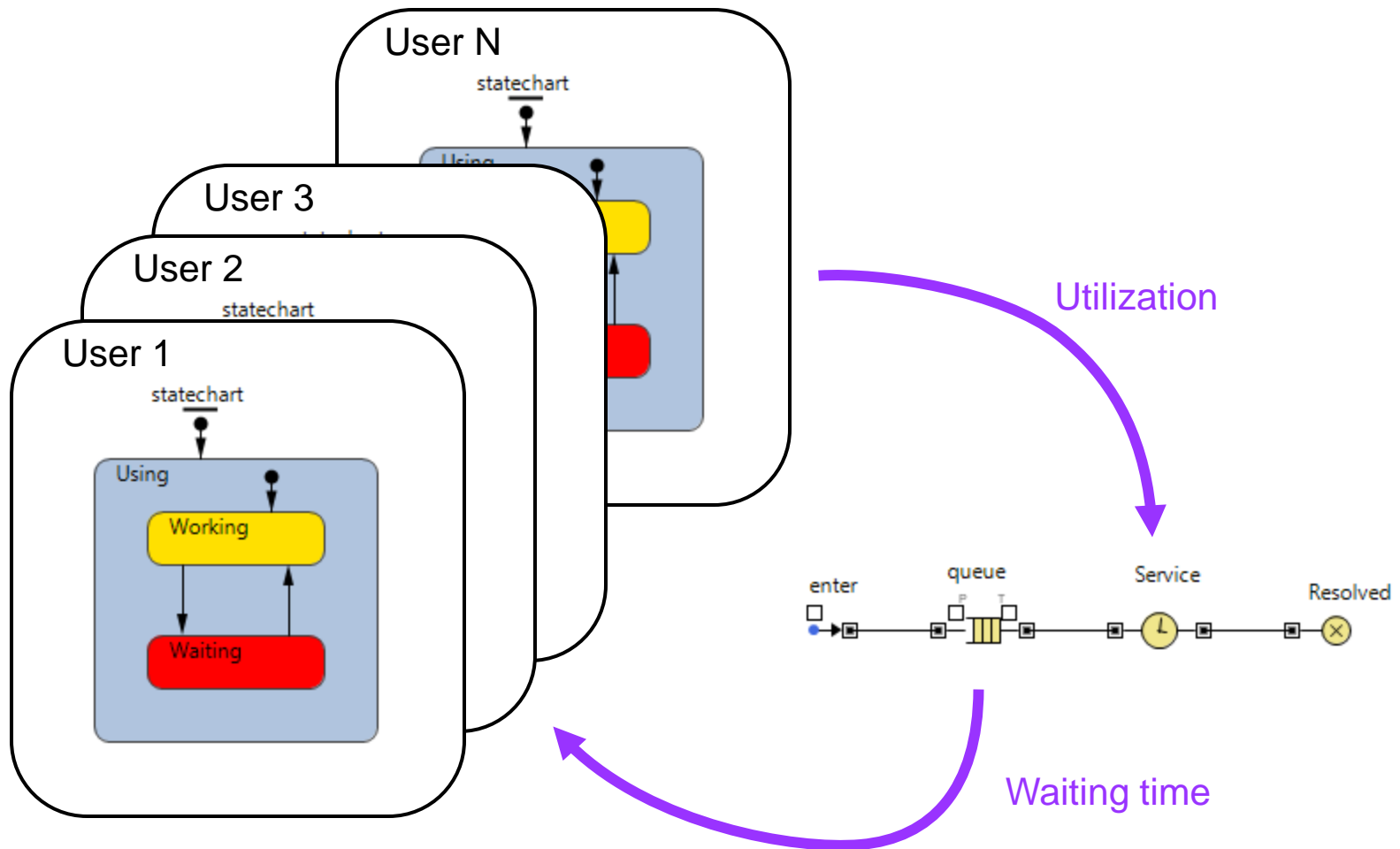
- This model will:
 - Create User agents that interact.
 - Create their behavior and attitudes towards the service.
 - Create the process to handle service restoration requests
 - Model each user's Satisfaction towards the Service.
 - Show the impacts of various level of request processors on the overall user market.

To AnyLogic!

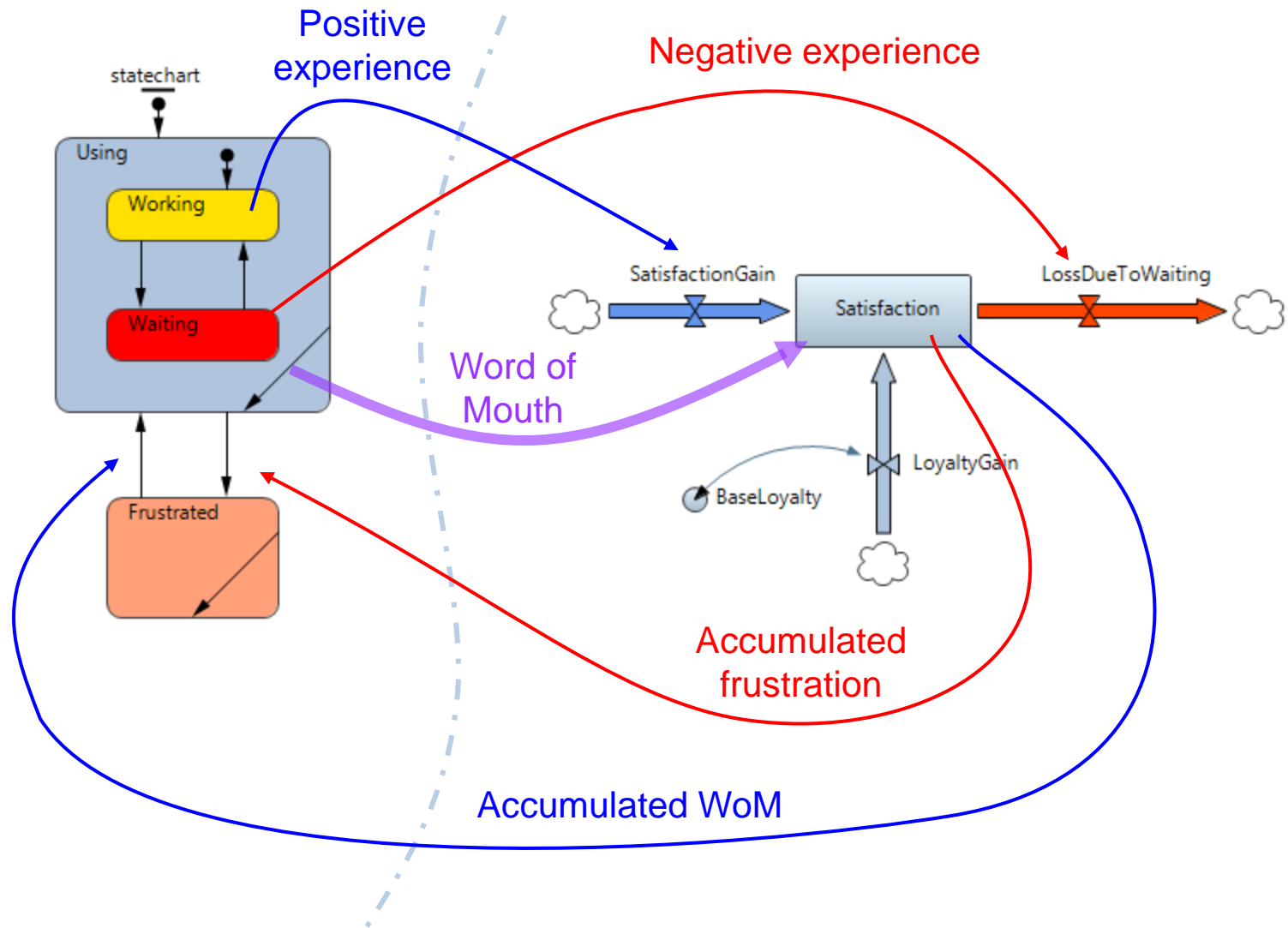


- The model source file ([User Satisfaction.alp](#)) is available in the supporting materials section

Feedbacks in the model

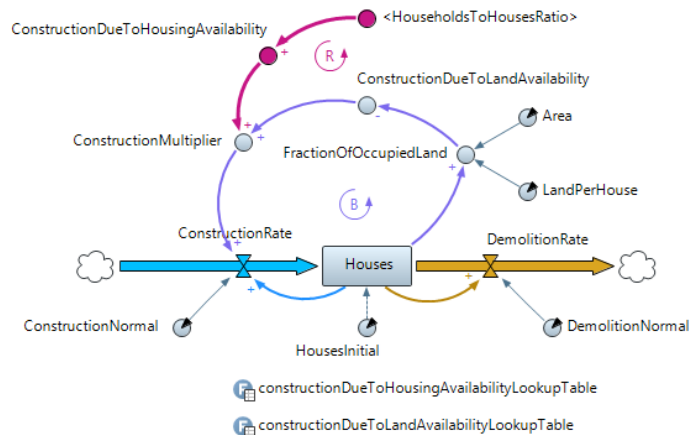


Feedbacks inside an agent

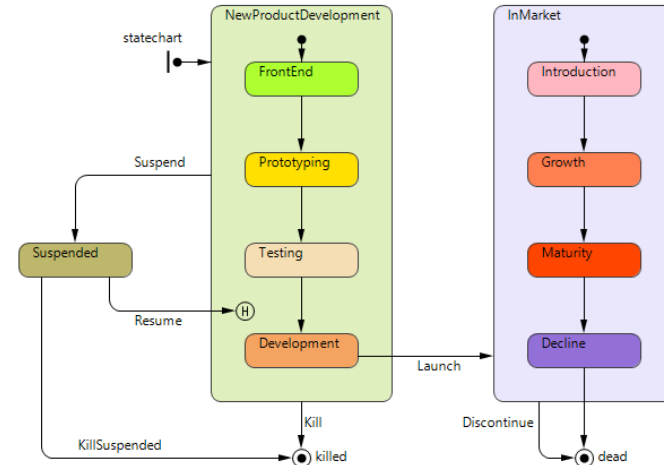


Visual languages of AnyLogic

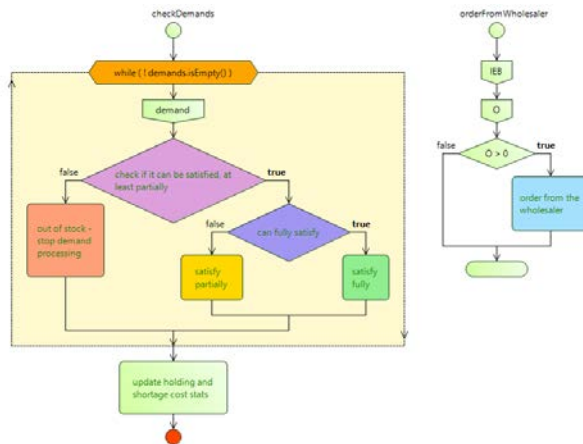
Stock & Flow Diagrams



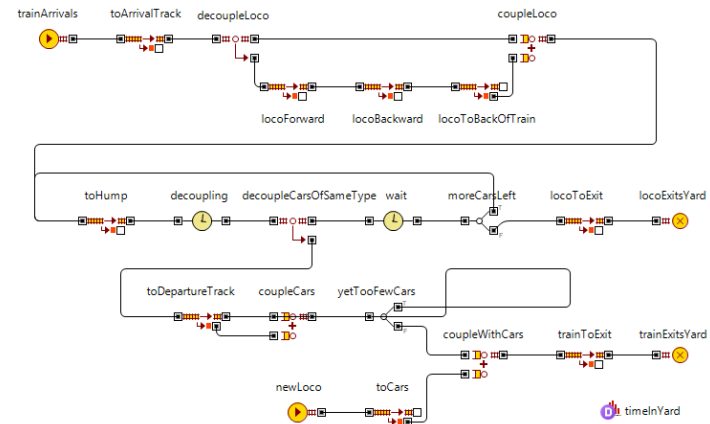
Statecharts



Action charts

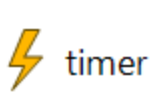


Process flowcharts



Open tool: Java “extension points”

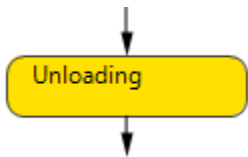
- All objects have places to insert Java code
 - to be executed when the corresponding events occur



timer

Action:

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



Unloading

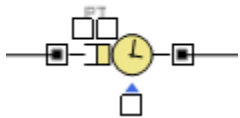
Entry action:

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

Exit action:

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

verifyAndFixBills



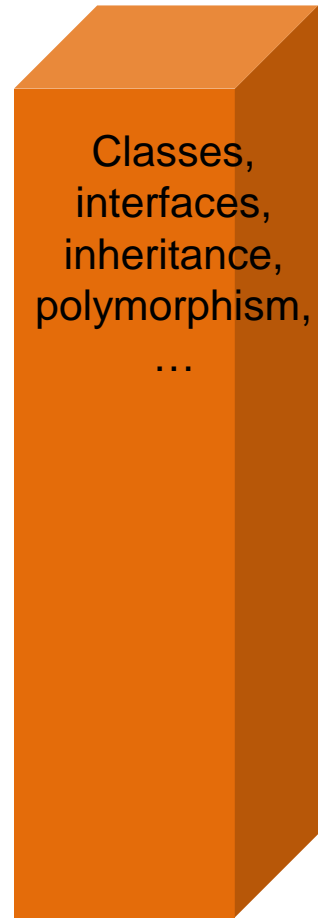
On enter^D

On enter delay^D

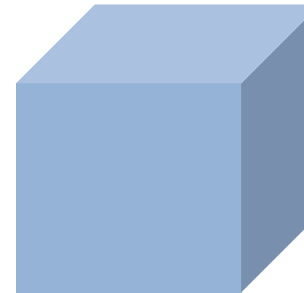
On exit^D

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

Do I need to have programming skills?



More:
expressions,
function calls,
statements



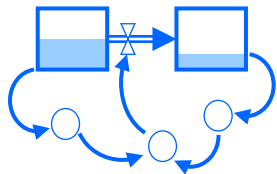
Some:
expressions,
function calls



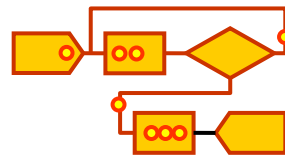
Almost none



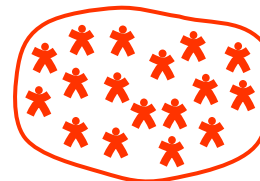
**Software
development**



SD

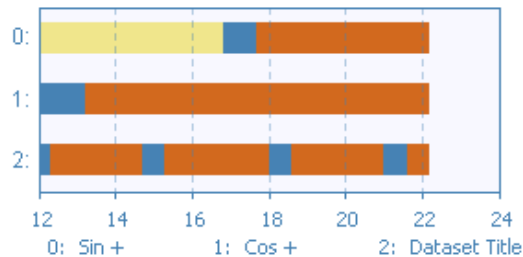
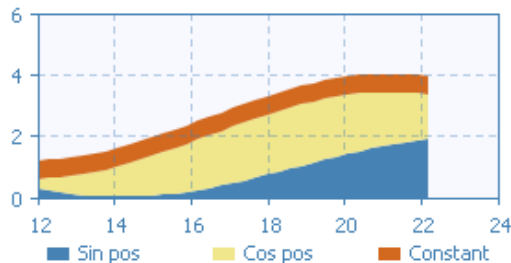
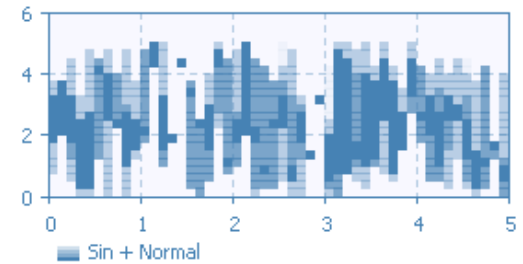
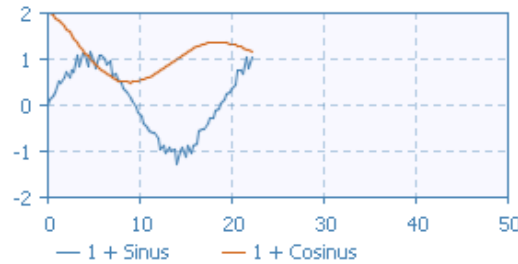
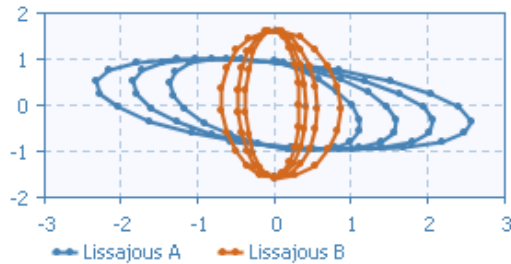
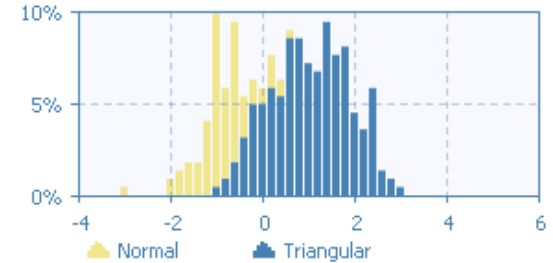
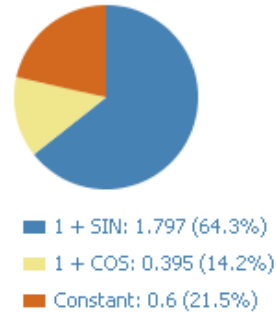
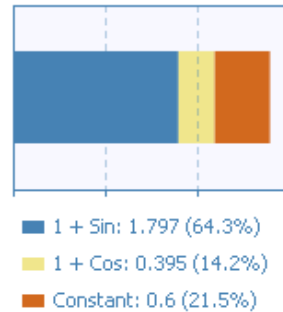
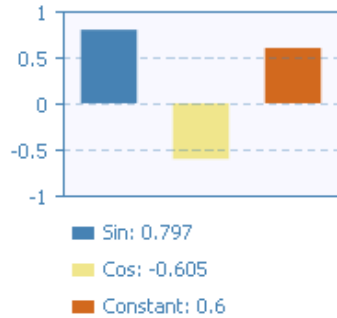


DE



AB

Input and output data visualization

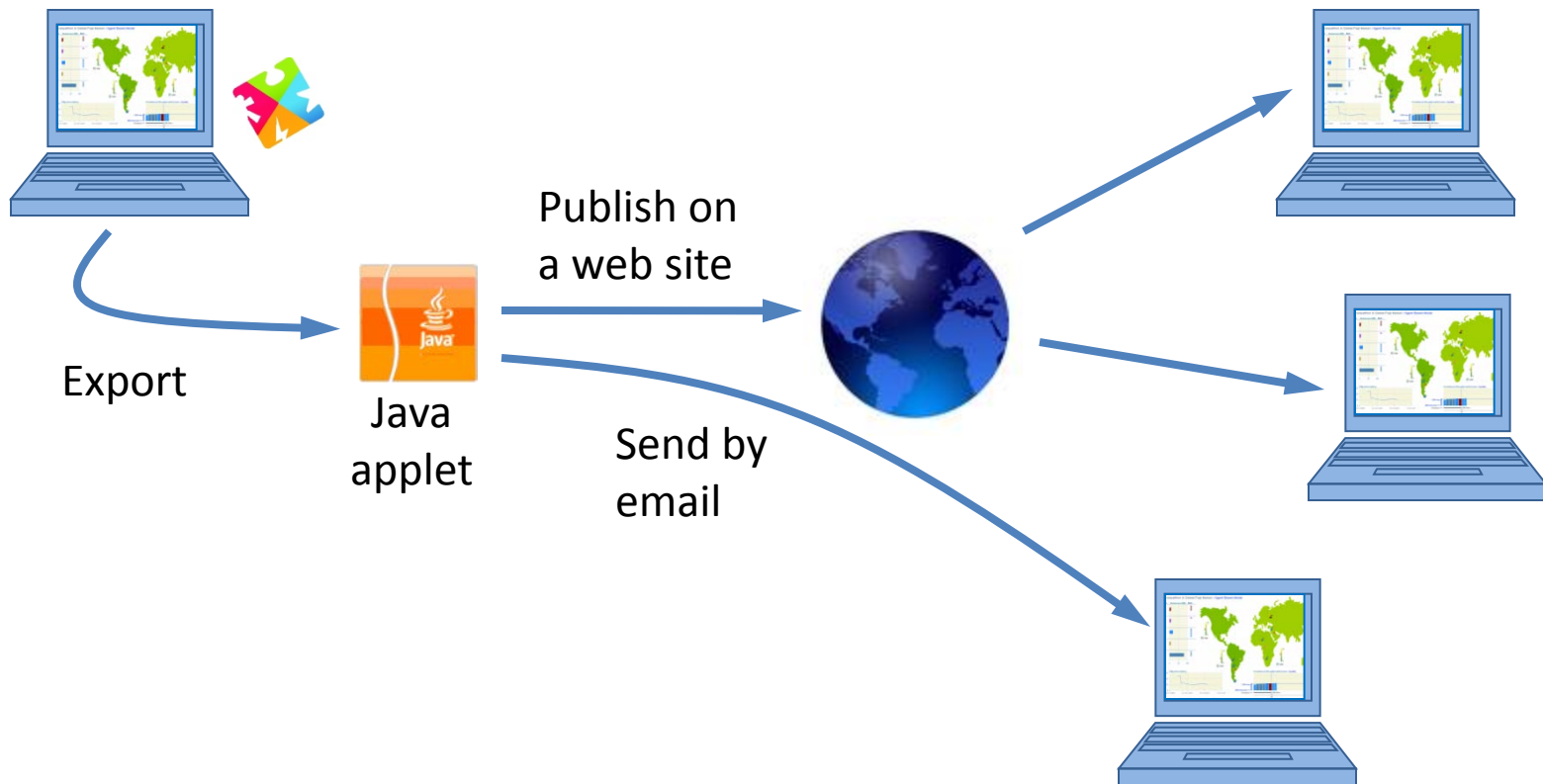


- Bar, stack, pie charts
- XY and time plots
- Time stack & color charts
- Histograms
- 2D Histograms

Exporting models from AnyLogic – applets

AnyLogic Model
Development Environment

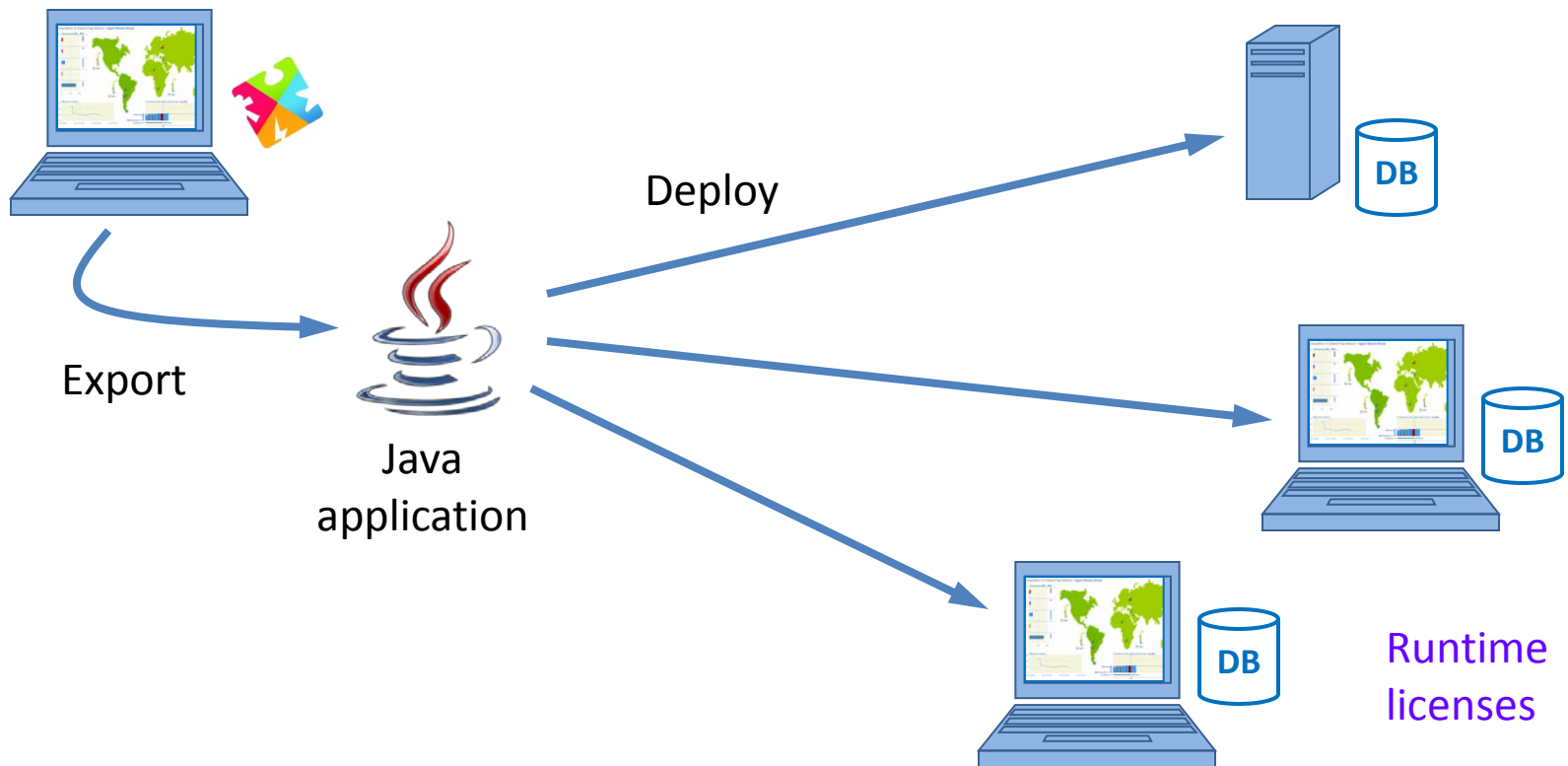
Remote users run models in web browsers
No need to install any software!



Exporting models from AnyLogic – apps

AnyLogic Professional Model Development Environment

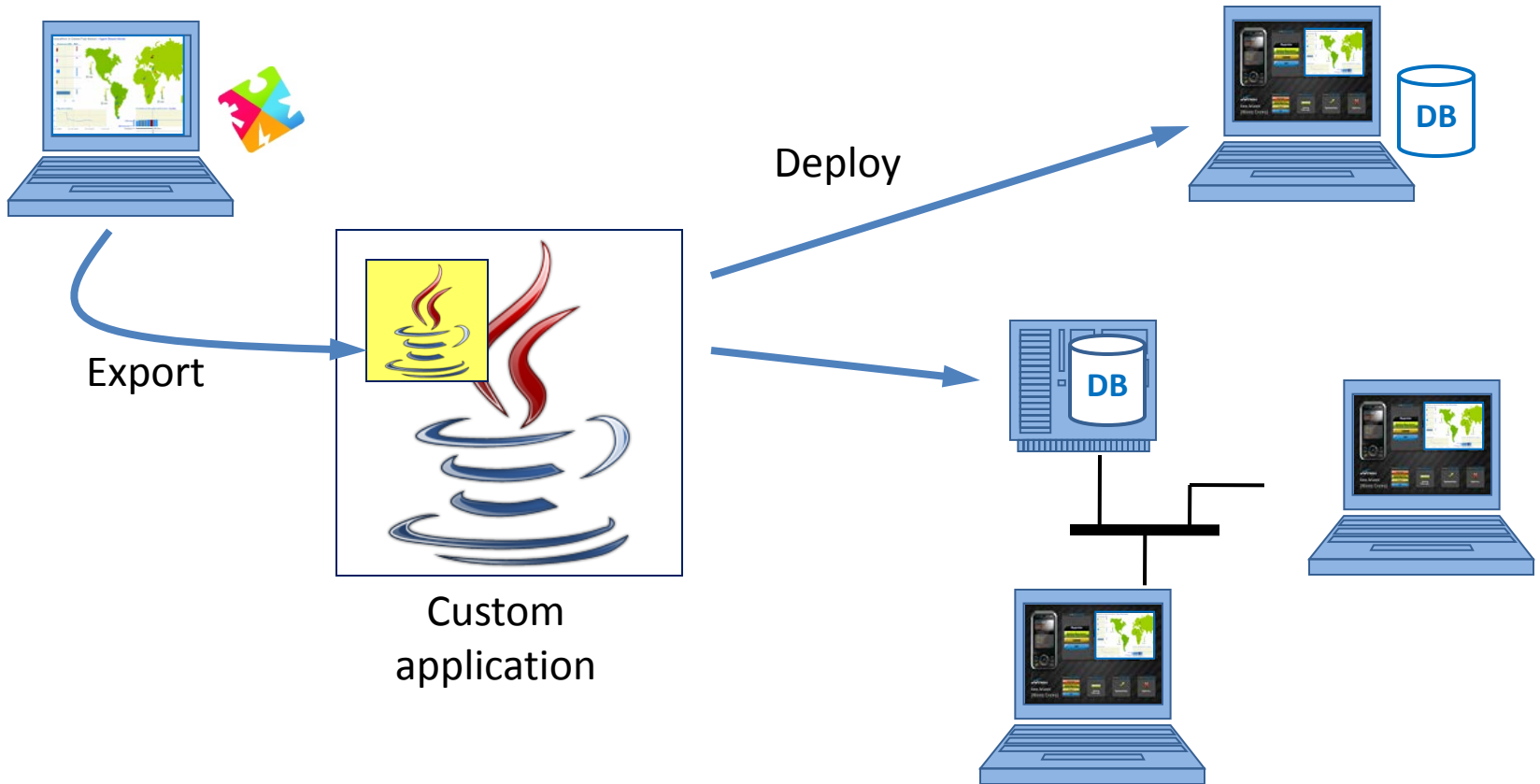
AnyLogic model runs on target machines
No need to install AnyLogic Model DE



Embedding AnyLogic models into other apps

AnyLogic Professional Model Development Environment

Custom application is deployed on target workstations or servers



Thank you!

- Questions?
- Links:
 - AnyLogic website: www.anylogic.com
 - AnyLogic models online: www.runthemodel.com