Econofisica / Econophysics, Prof. Terna

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UNIVERSITÀ
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DI TORINO

Introduction - GAMA

- Gis & Agent-based Modeling Architecture
- Agent-based, spatially explicit, modeling and simulation platform
- Free and Open Source tool
- GAMA webpage

Introduction - JADE

- JAVA Agent DEvelopment Framework
- Multi-agent systems through a middle-ware that complies with the Fipa specifications
- Free and Open Source tool
- JADE webpage

Introduction - WADE

- Workflows and Agents Development Environment
- Built on top of JADE
- Java Based + Graphical Workflow design
- Free and Open Source tool
- WADE webpage

Features

Features

- Initially developed as an Eclipse plug-in, now is an independent tool.

- GAML (Gis & Agent-based Modeling Language) agent-oriented language, close to Java.

- Instantiation of agents from any kind of dataset, including Gis data (e.g.: road traffic model).

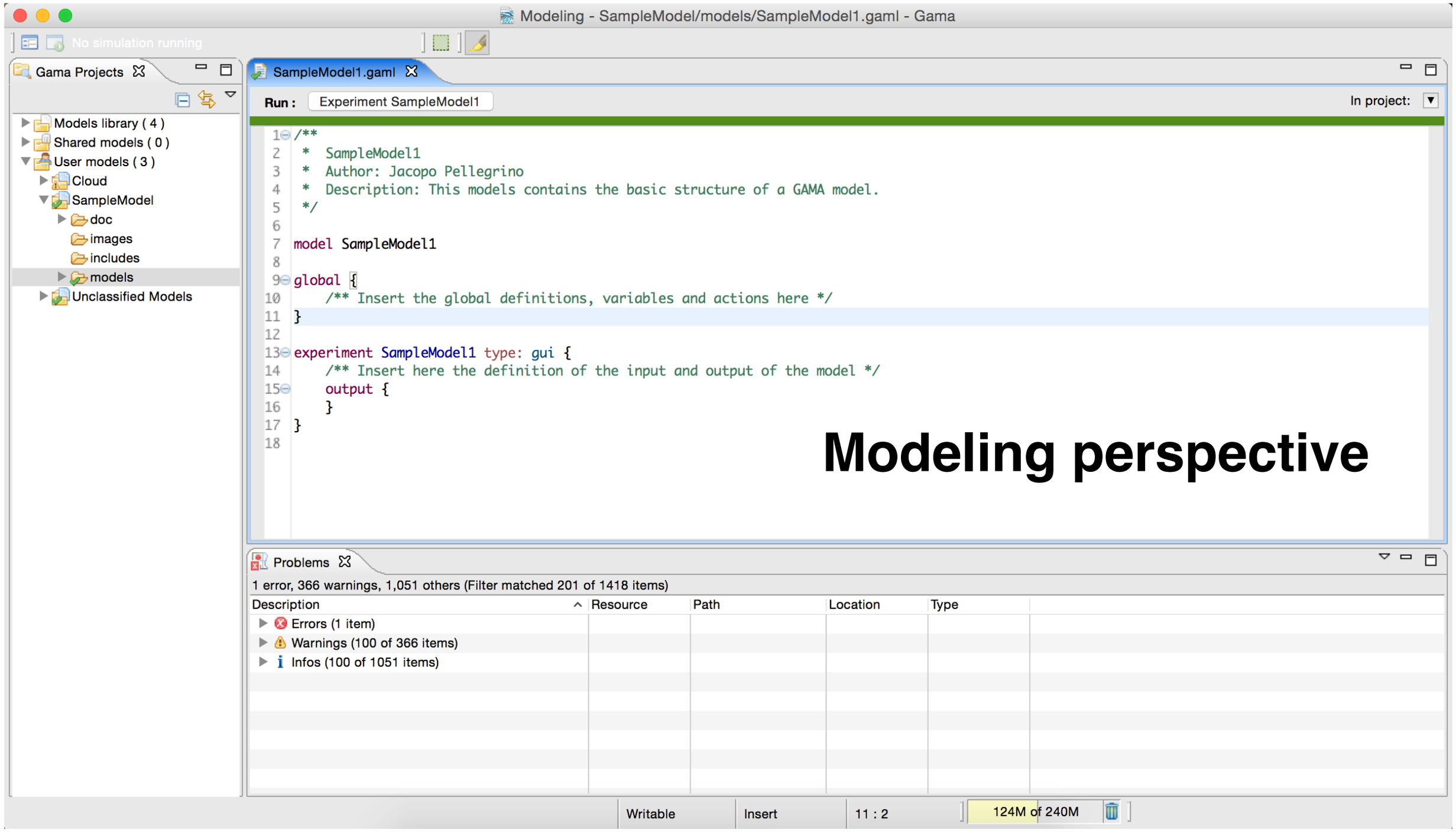
Features

- Discrete or continuous topological layers.
- Multiple levels of agency: micro and macro species, inheritance.
- Multiple paradigms such as mathematical equations, control architectures, finite state machines.

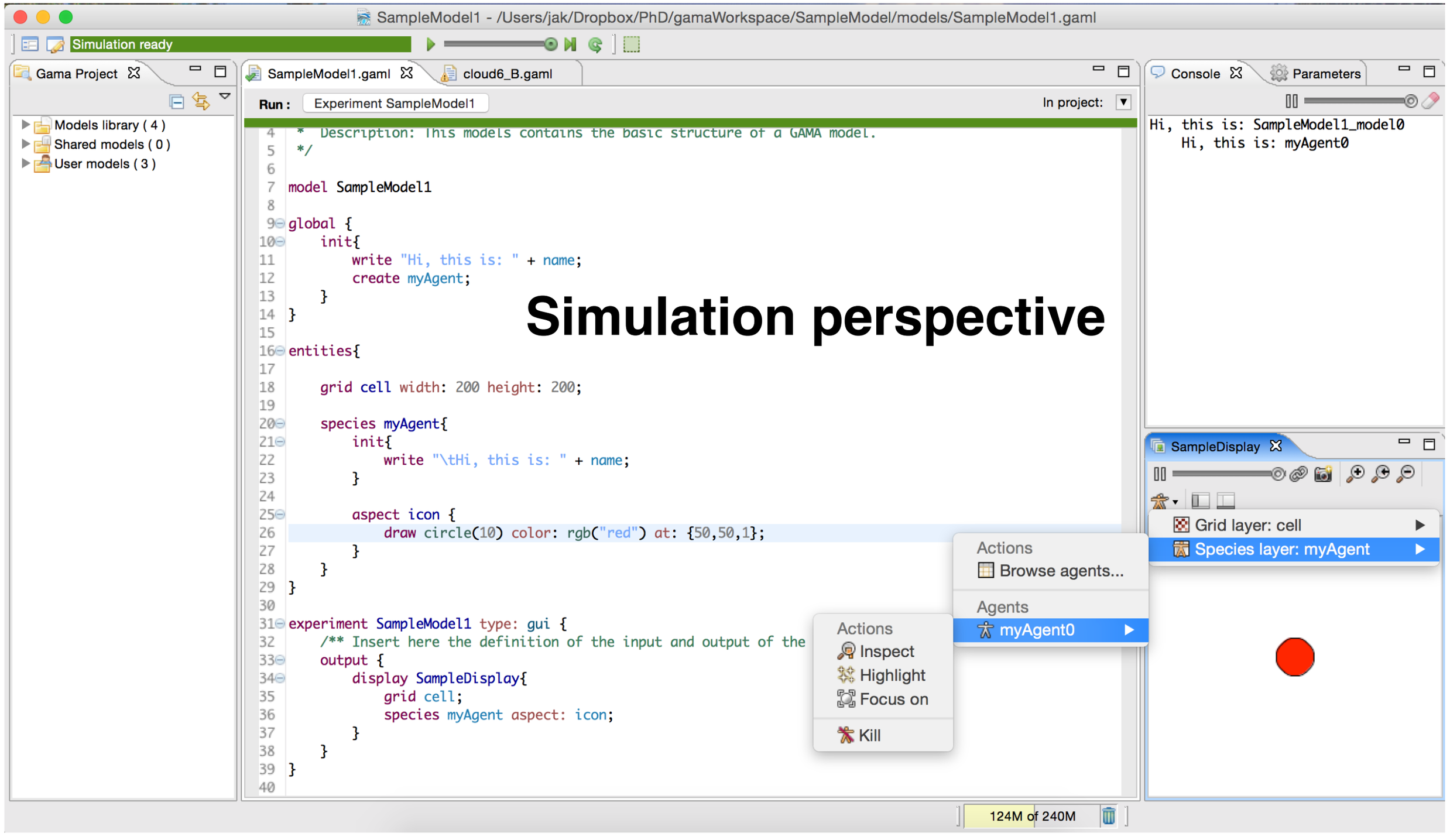
Features

- Possibility to define several experiments.
- Development environment with different perspectives.
- User-friendly interface for both development and model simulation.

Features


Modeling - SampleModel/models/SampleModel1.gaml - Gama
No simulation running
Gama Projects
Models library (4)
Shared models (0)
User models (3)
Cloud
SampleModel
doc
images
includes
models
Unclassified Models
SampleModel1.gaml
Run :
Experiment SampleModel1
In project:
/**
* SampleModel1
* Author: Jacopo Pellegrino
* Description: This models contains the basic structure of a GAMA model.
*/
model SampleModel1
global {
/** Insert the global definitions, variables and actions here */
}
experiment SampleModel1 type: gui {
/** Insert here the definition of the input and output of the model */
output {
}
}
Problems
1 error, 366 warnings, 1,051 others (Filter matched 201 of 1418 items)
Description
Resource
Path
Location
Type
Errors (1 item)
Warnings (100 of 366 items)
Infos (100 of 1051 items)
Writable
Insert
11 : 2
124M of 240M
Modeling perspective

Features



Simulation perspective

Modeling

Modeling Introduction

Model file made up of three main parts:

- global
- (entities)
- experiment

```
7  model SampleModel1
8
9  global {
10
11 }
12
13 entities{
14
15 }
16
17 experiment SampleModel1 type: gui {
18     output {}
19 }
20
```

Species Relationship

Species can be related to each other:

- **Nesting**: a species can be defined within another one. The enclosing one is referred as *macro species*, the enclosed on as *micro species*.

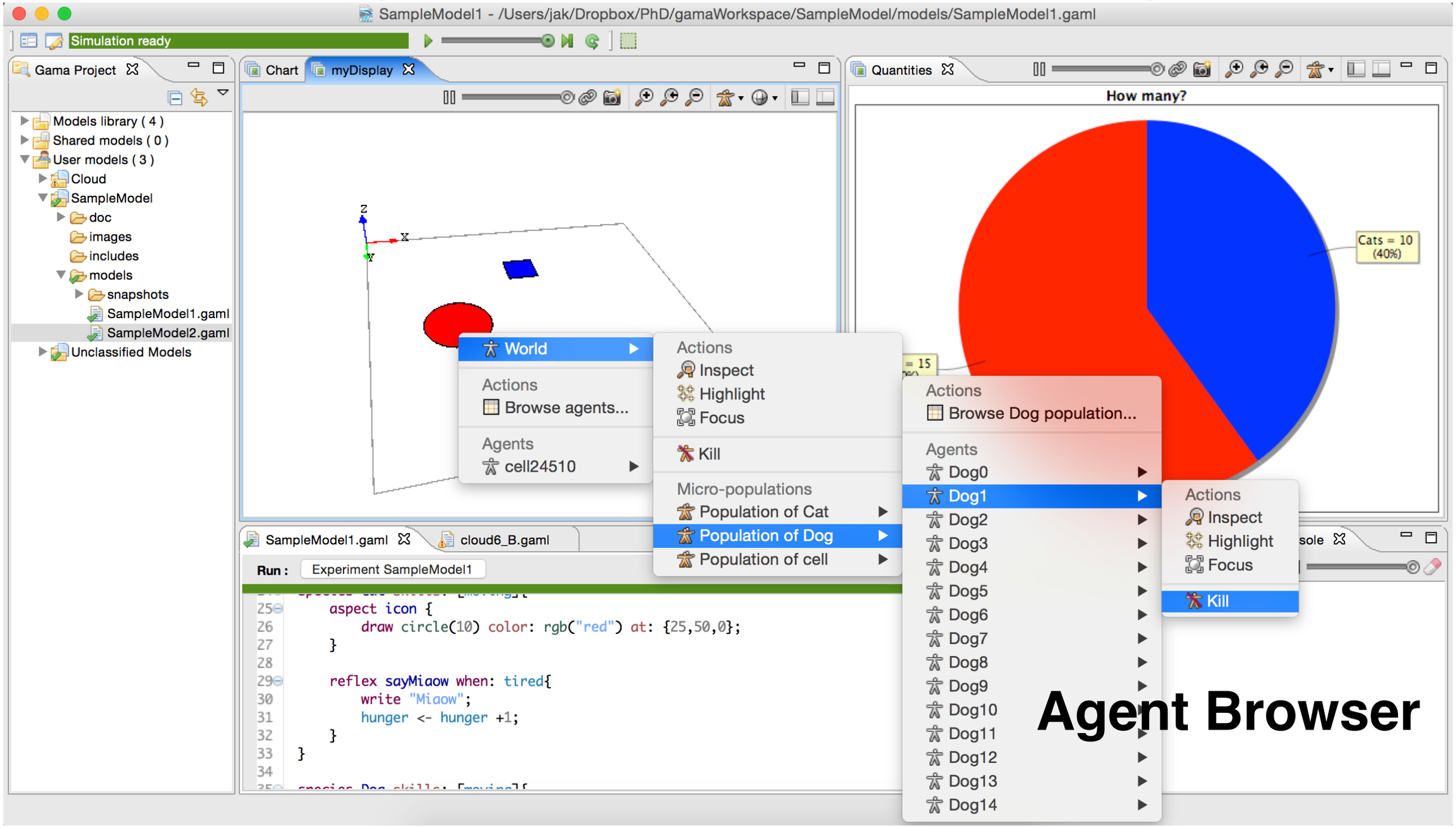
- **Inheritance**: a *child* species extends behavior from the *parent*, close to what happens in Java.

Agent Monitoring

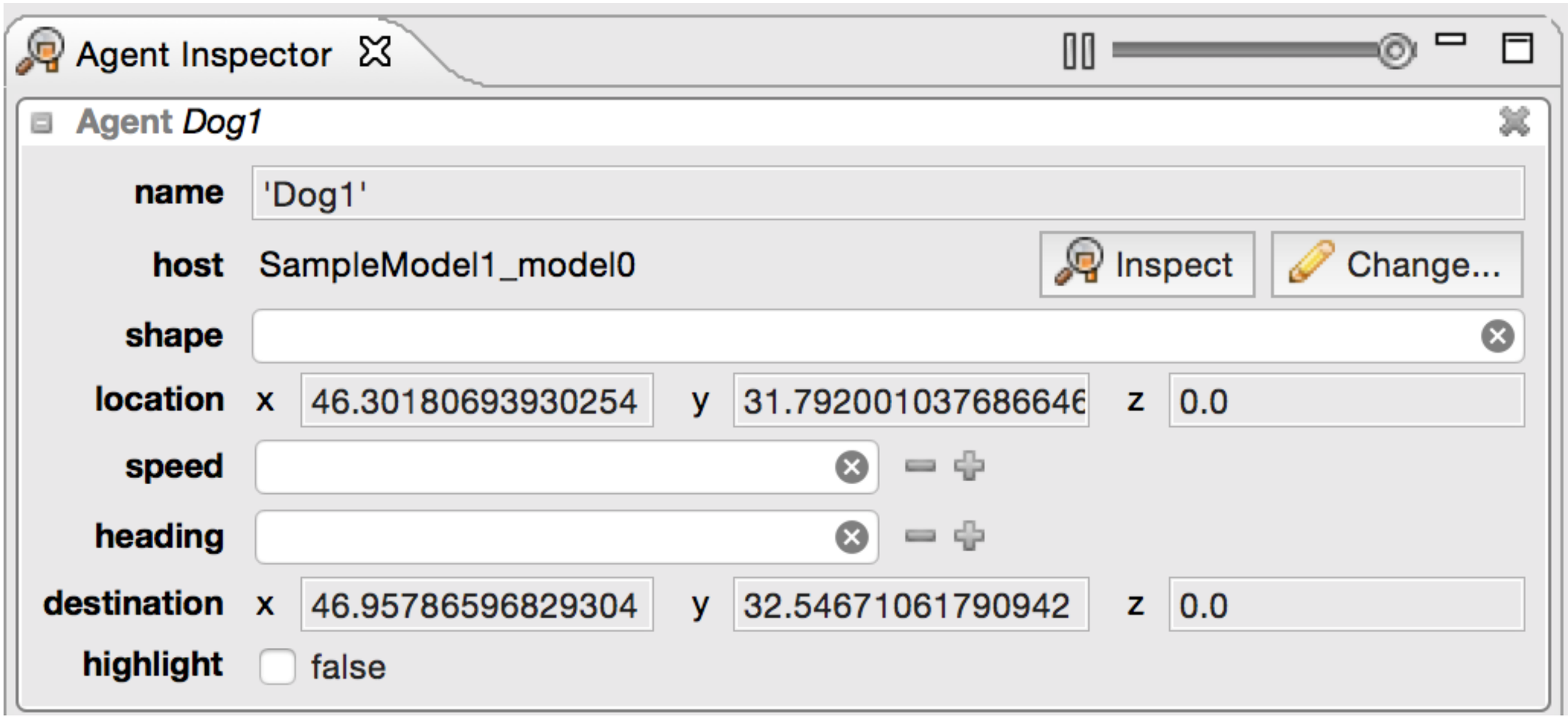
It is possible to monitor agents:

- Agent Browser: browse population of agent species, highlight one, monitor a species.
- Agent Inspector: retrieve information related to one or more specific agent(s), e.g. position, speed, internal variables and the like.

Agent Monitoring



Agent Monitoring



Agent Inspector

Data input and output

Data I/O:

- Data can be imported and exported in and from the model.

- The project folder allows to gather data to be imported to be accessible to the code.

- Several common formats can be read in: .txt, .csv, .png, etc.

Errors Detection

Warnings and Errors:

- As most of the common development tools, GAMA notifies the user about bad code or mistakes with warnings and errors (at compile time), e.g.: bad syntax.

- In case of run time errors the simulation stops and a description of the problem is provided, e.g.: null reference, out-of-bound.

Variables, Actions, Reflexes

Modeling

In the following we will take a closer look to the implementation of a MAS in GAMA focusing on:

- The GAML language (structures, operators, etc.)
- The display of agents and data
- The FIPA communication protocol

Further information can be found in the documentation.

GAML - Variables

Variables Access:

- **global**: can be directly accessed by any agent in every part of the model.
- **species variables**: can be directly accessed by the agent of the corresponding species in every part of the model. They can be accessed remotely, by other agents, with the syntax:

```
type varName <- remote_Agent.remoteVariable;
int dogAge <- one_of(Dog).age;
```

- **temporary variables**: can only be accessed directly and within the statement block. They stop existing when the statement is completed.

GAML - Actions

Actions Definition:

- An action embodies a **capability of an agent**, it can take from 0 to many arguments and return 0 or one variable. It is declared as follows:

```
action noArgNoReturn{
}
action noArgReturn{
  return returnVar;
}
action argNoReturn(type1 arg1, type2 arg2){
}
```

- It is possible to assign a return variable directly to a variables as follows:

```
int myVar <- argReturn(arg1::val1, arg2::"val2");
```

GAML - Reflexes

Reflexes Definition:

- A reflex can be considered as an action that the **agent automatically performs** at any time step or when a given condition occurs. In reflexes action can be called. A reflex is defined as follows:

```
reflex everyTime{
  //is executed at every time step
}

reflex someTimes when: booleanExpression{
  //is executed only when the boolean expression is true
}
```

- The `init` is a special kind of reflex that is executed when the agent is created.

GAML - Control Structures

- Actions and Reflexes have been defined. Now how to tell agents what to do?

- GAMA provides the most common control structures to **control the flow of execution** of the code. The most used are:

- Loop Statements

- Conditional Statements

Graphical Environment

GAML - Graphics

- A graphical representation can be useful in several modeling scenarios.

- GAMA allows the display of agents within an environment referred as the grid.

- Layers of agents can be displayed separately.

- The output of the experiments can be displayed too.

GAML - Aspects

Aspects Definition:

- The aspect defines the way agents will be displayed. Each species can have more than one aspects, in the experiment the user indicates which one will be used for the display. Aspects are defined as follows:

```
aspect aspectName {
  draw shape color: rgb("aRGBColor") at: {position};
}
aspect default {
  draw circle(5) color: rgb("red") at: {25,50,0};
}
```

- As indicated, it is possible to add facets like the color, the position and the like. It is also possible to use .jpg, .gif, or .png image as icon for the agent.

GAML - Grid

Grid Definition:

- The grid can be considered a particular set of agents that share a topology. This agents are automatically created and are mainly used for the implementation of the environment where the other species reside.

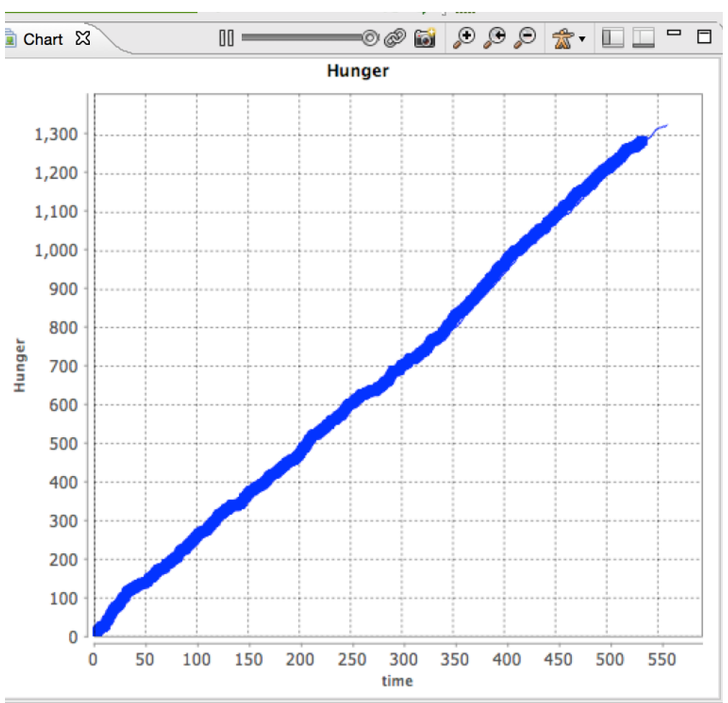
```
grid cell width: xSize height: ySize neighbors: neighNb;
```

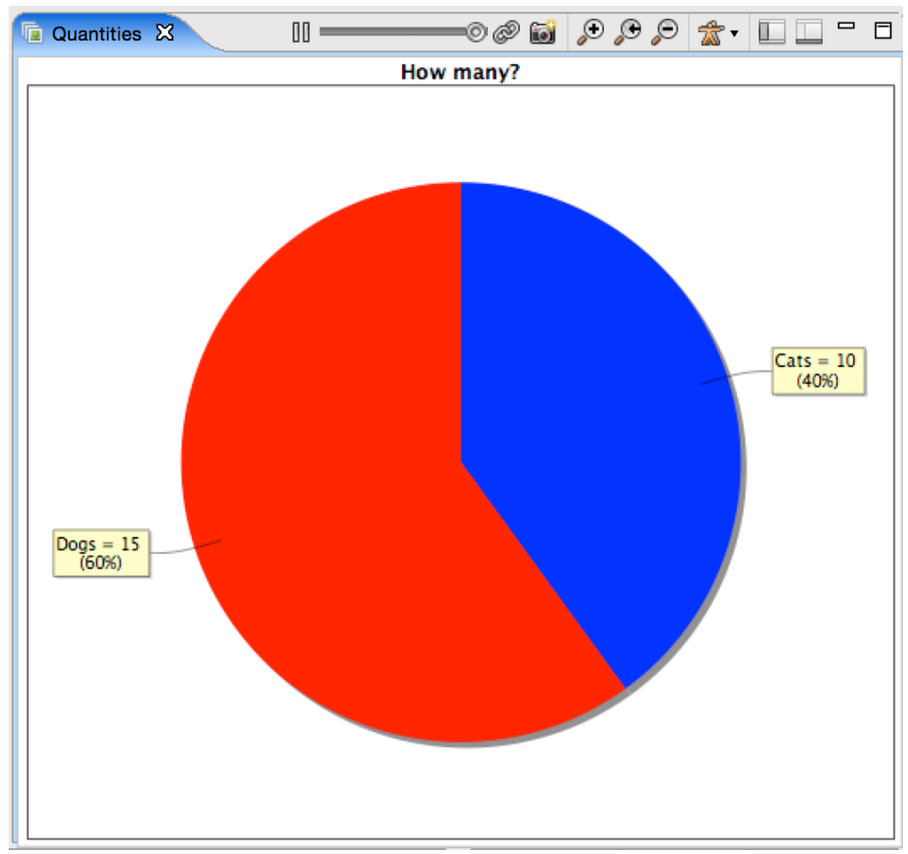
- It is also possible to create the grid from a given file such as a GIS file, see the Road Traffic example.

GAML - Experiments

Display Examples:

```
display Chart{
     chart "Hunger" type: series position: {0.0, 0.0} background: rgb("white") size: {1.0, 1.0}{
          data "Hunger" value: hunger color: rgb('blue');
     }
}

display Quantities{
          chart "How many?" type: pie position: {0.0, 0.0} background: rgb("white") size: {1.0, 1.0}{
               data "Cats" value: length(Cat) color: rgb('blue');
               data "Dogs" value: length(Dog) color: rgb('red');
          }
     }
```

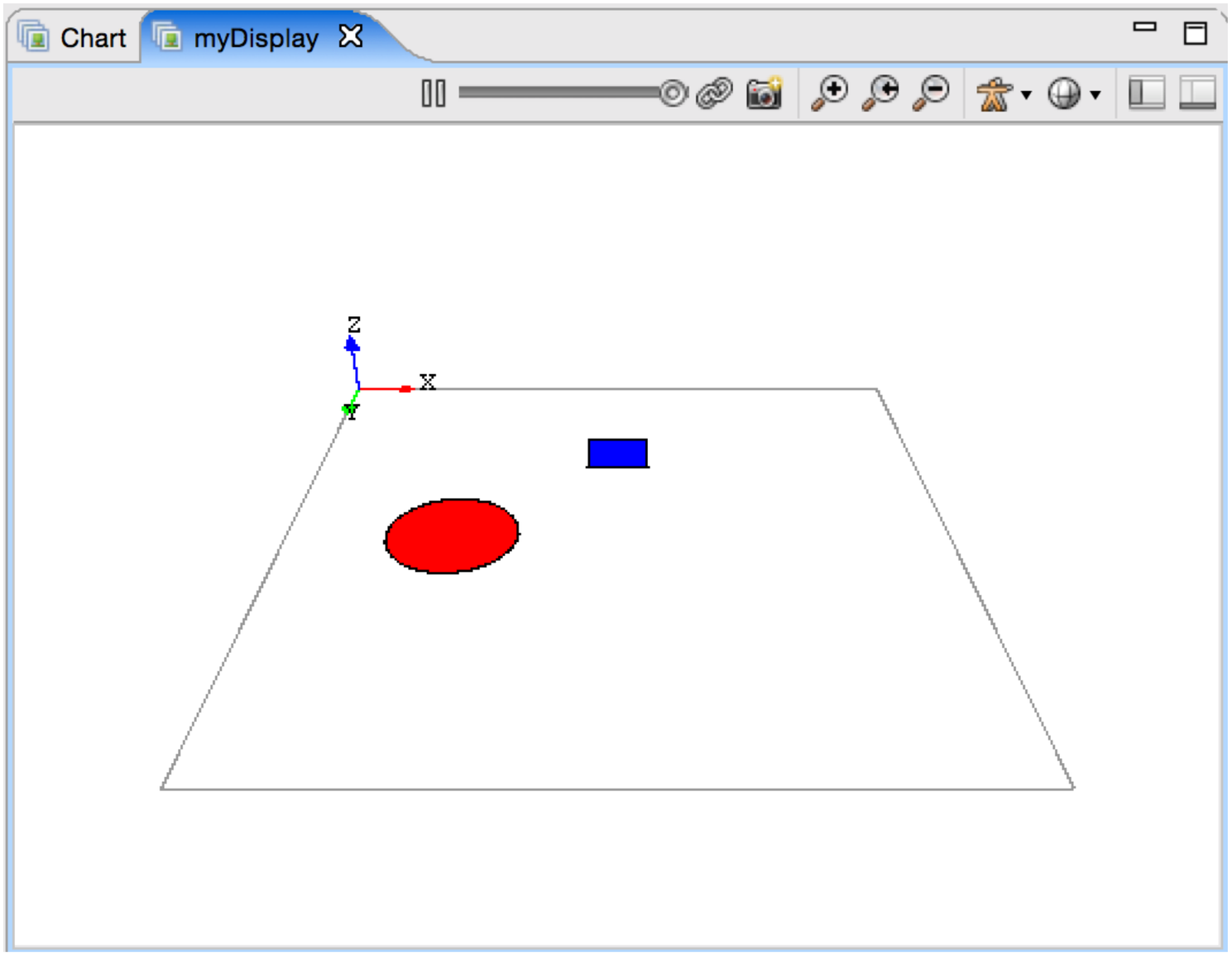




GAML - Experiments

Display Examples:

```
display myDisplay type:opengl {
    grid cell;
    species Cat aspect: icon;
    species Dog aspect: icon;
}
```



Communication

Communication

- The communication has to be guaranteed by **standards**.

- Agents involved have to be compliant to the standard.

- Definition of **ACL** (Agent Communication Languages) with an explicit, general and well-defined semantics.

- Ability of software systems of **exchanging information** and of **automatically interpreting** its meaning.

GAML - Communication

- In GAMA the communication is based upon the FIPA Agent Communication Language.

- FIPA messages are labeled with a **performative** that specifies the type of message in terms of purpose.

- Thanks to the performatives it is possible to build **interaction protocols** (patterns of behavior).

GAML - Communication

List of FIPA performatives:

performative	passing info	requesting info	negotiation	performing actions	error handling
accept-proposal			x		
agree				x	
cancel		x		x	
cfp			x		
confirm	x				
disconfirm	x				
failure					x
inform	x				
inform-if	x				
inform-ref	x				
not-understood					x
propose			x		
query-if		x			
query-ref		x			
refuse				x	
reject-proposal			x		
request				x	
request-when				x	
request-whenever				x	
subscribe		x			

Introduction to GAMA

QUESTIONS?

Prey / Predator Model

- The prey / predator model is provided in GAMA as tutorial.

- There are several models with increasing complexity to let the beginner understand the features of GAMA and the GAML syntax.

- In the following the model will be explained and analyzed in detail.

Prey / Predator Model

The aim of this model is to simulate a natural environment in which two species of animals coexist.

- The environment is made up of a grid of cells representing the soil with grass.
- Preys look around for grass to eat.
- Predators look around for preys to eat.

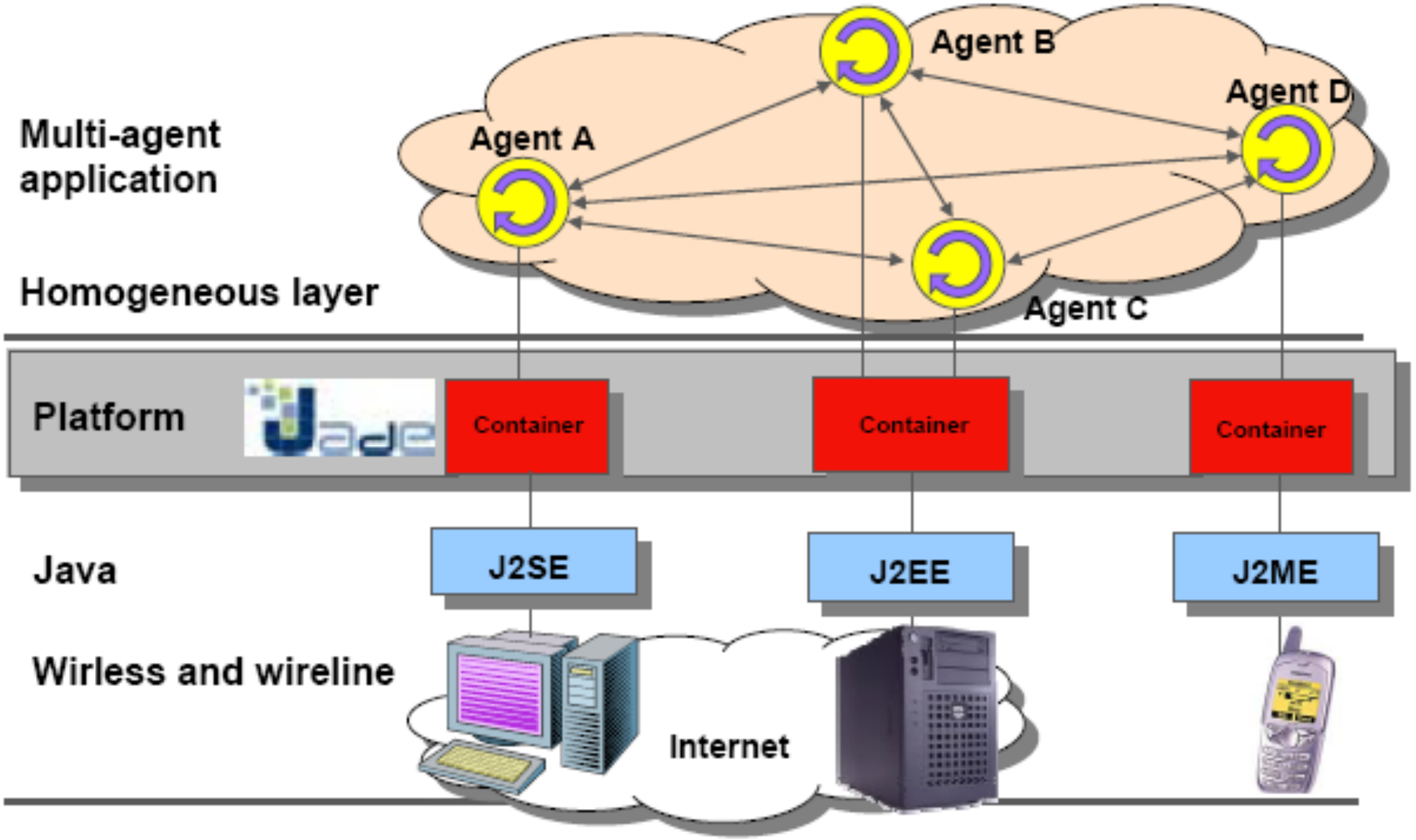
Features

Features

- Flexible and efficient messaging.
- Java Language.
- Agents are implemented as one thread per agent.
- Graphical User Interface (GUI).
- Can be distributed across machines.

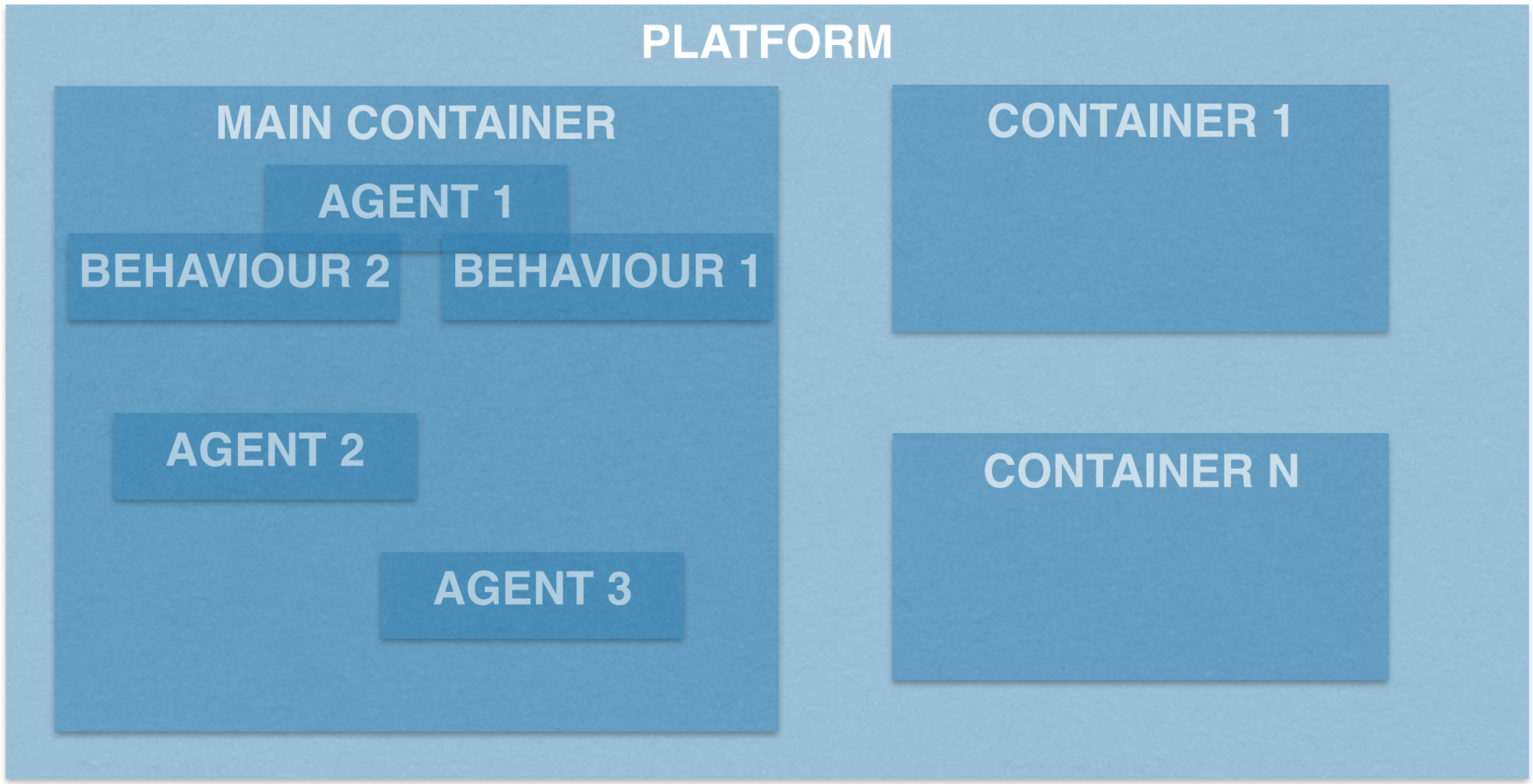
Features

- Can be distributed across machines.



Structure of JADE

The platform is made up of:



Structure of JADE

The platform is made up of:

- a **main container**.
- other (remote) containers.
- each agent is a **peer** living in its container.

Structure of JADE

The **main container** contains two “special agents”:

- The **AMS** (Agent Management System):
  - provides the naming service (unique names).
  - represents the authority in the platform (create / delete).

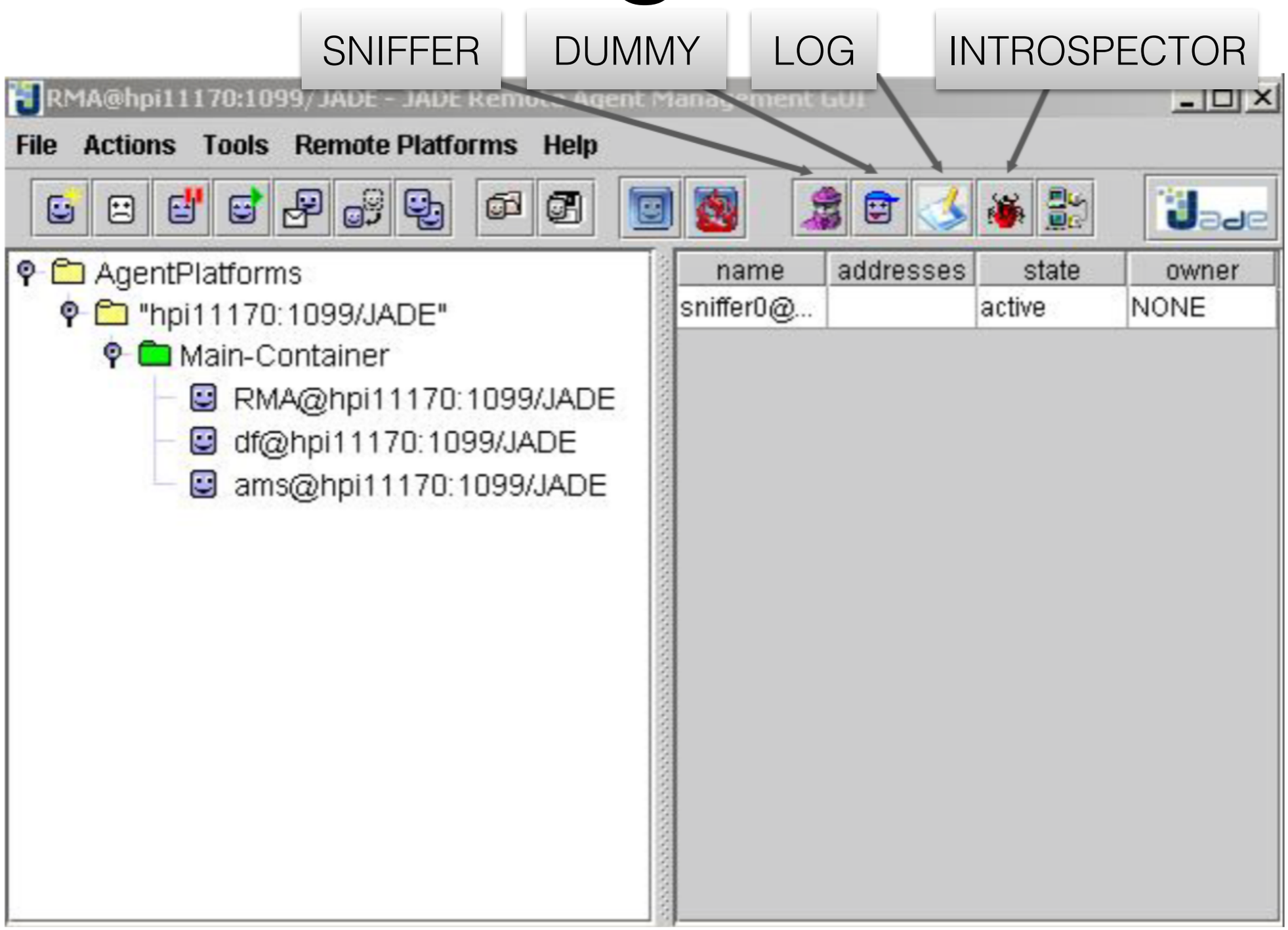
- The **DF** (Directory Facilitator)
  - provides a Yellow Pages service (agent/service).

Structure of JADE

Other “special” agents are provided by default:

- RMA (Remote Monitoring Agent).
- Dummy Agent.
- Sniffer Agent.
- Introspector Agent.
- Log Manager Agent.
- DF (Directory Facilitator) GUI.

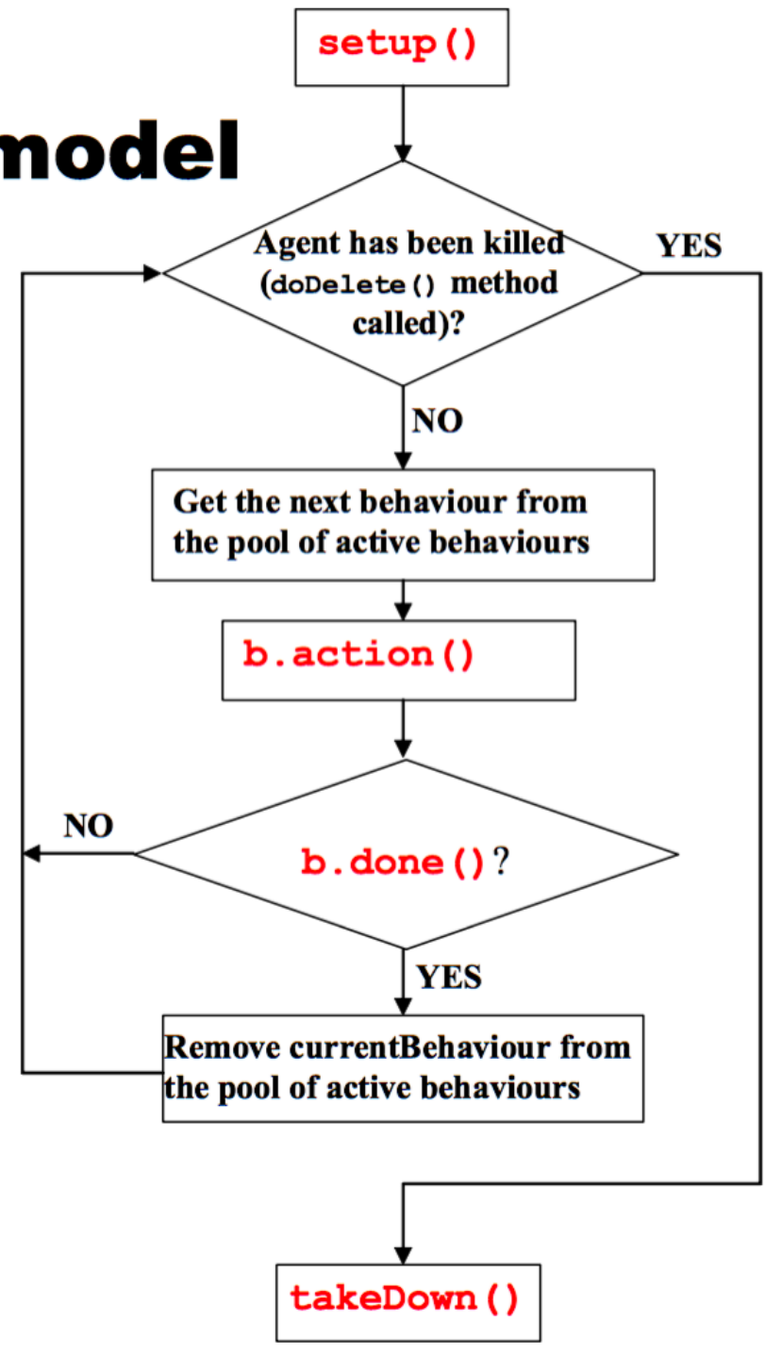
Starting JADE



Modeling

Modeling Introduction

The agent execution model



Highlighted in red the methods that programmers have to/can implement

Slide from JADE Tutorial for beginners

Species Relationship

Species can be related to each other:

- **Inheritance**: a *child* species extends behavior from the *parent*, as happens in Java.
    - All agents inherit from jade.core.Agent.
- NO **nesting**: all agents live inside the container at the same level.
    - Each agent can create other agents.

Data input and output

Data I/O:

- Common Java I/O libraries.

- It is possible to make agents write to a **database**.

- It is a good idea to initialize the model using a **configuration file** (csv, xml, …).

Errors Detection

Warnings and Errors:

- Running JADE from the shell errors/exceptions will be prompted and agents may die.
- A good practice is to use an IDE (Eclipse, NetBeans) which helps a lot.

JAVA - Control Structures

- Behaviours have been defined. Now how to tell agents what to do?

- JAVA provides the most common control structures to **control the flow of execution** of the code. The most used are:

  - Loop Statements.

  - Conditional Statements.

- Keep code in methods.

Graphics and Communication

JADE - Graphics

- JADE does not provide a graphical environment like GAMA does.

- Users may create their own with external tools.

- JADE is focused on the communication rather than graphics.

JADE - Communication

- In JADE, as in GAMA the communication is based upon the FIPA Agent Communication Language.

- FIPA messages are labeled with a **performative** that specifies the type of message in terms of purpose.

- Thanks to the performatives it is possible to build **interaction protocols** (patterns of behavior).

JADE - Communication

- **Asynchronous message passing**

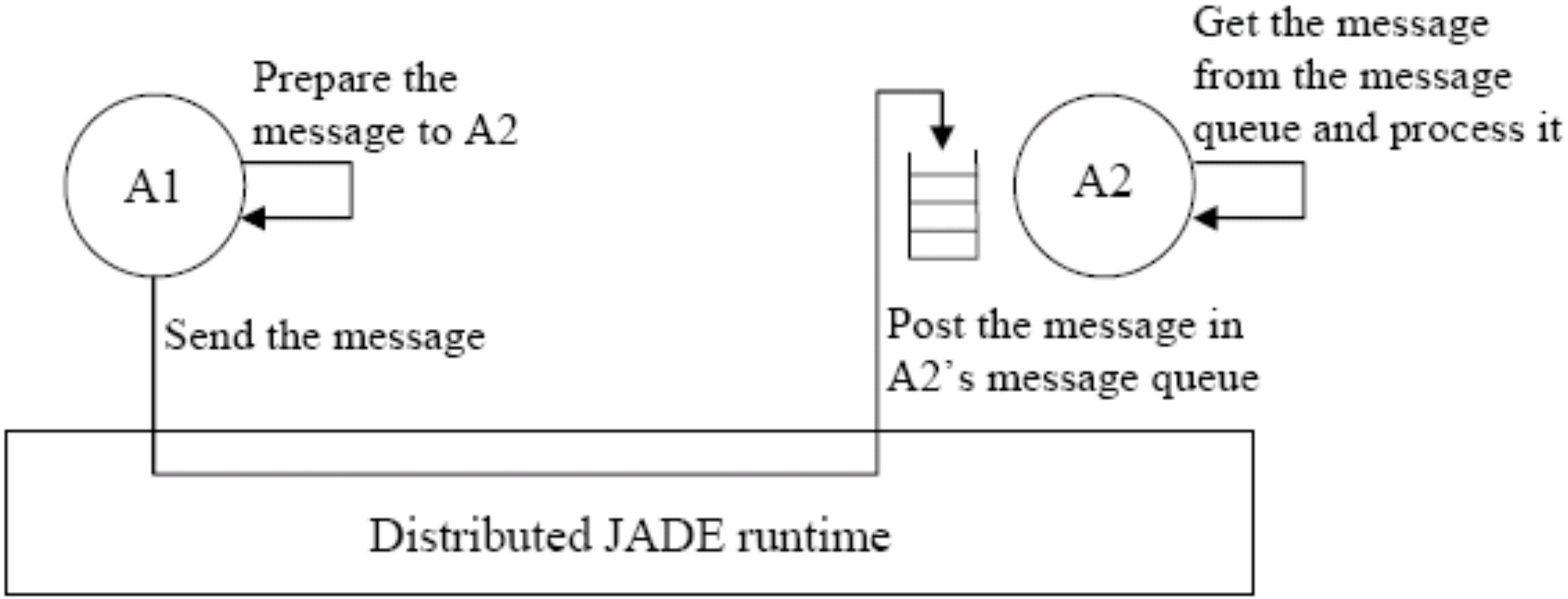
- When a message is sent the platform takes care of putting it in the **queue** of the receiver agent.

- There are method to easily reply.

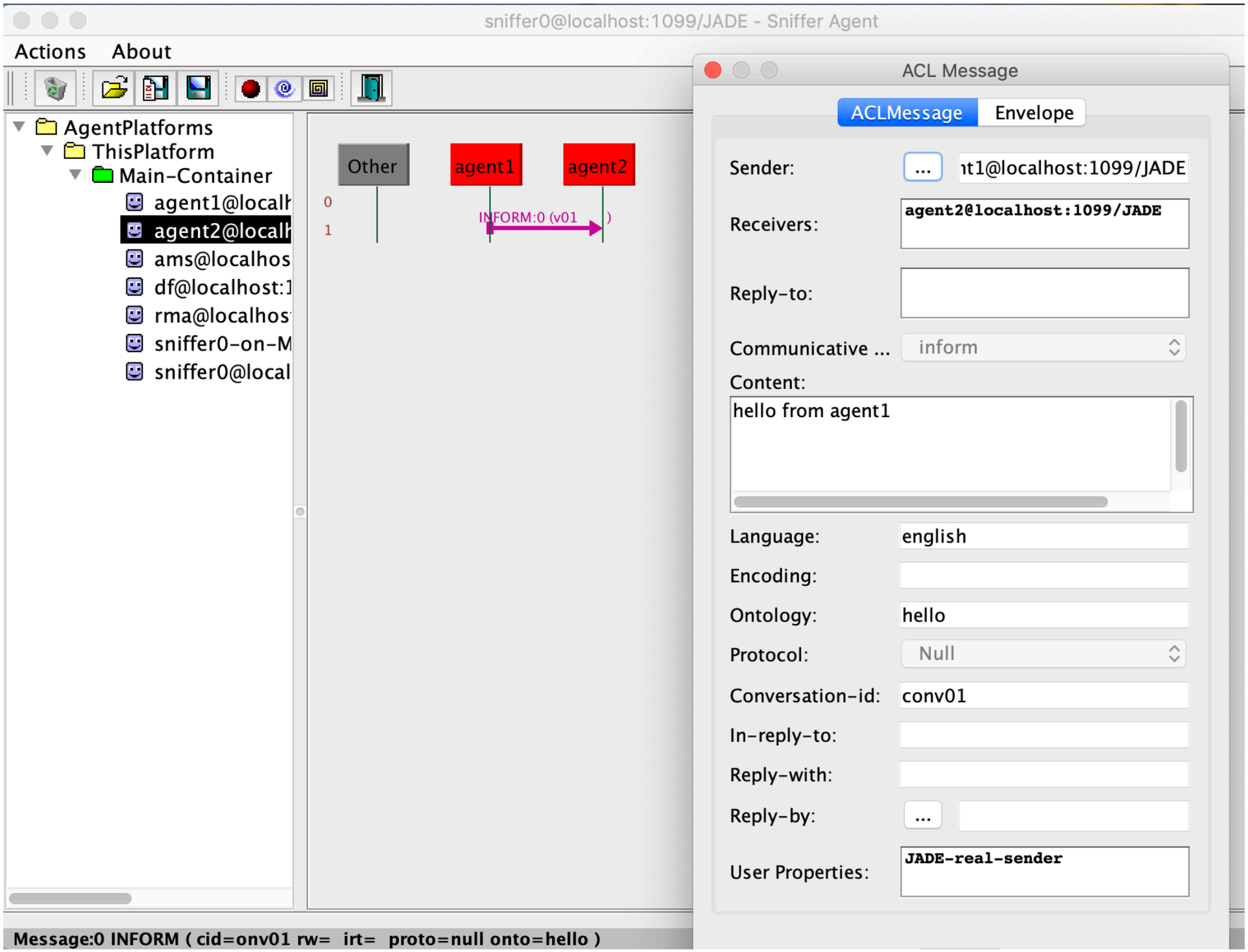
- Pay attention to blocking/non-blocking receive.

JADE - Communication

What happens behind the scenes:



JADE - SnifferAgent



Features

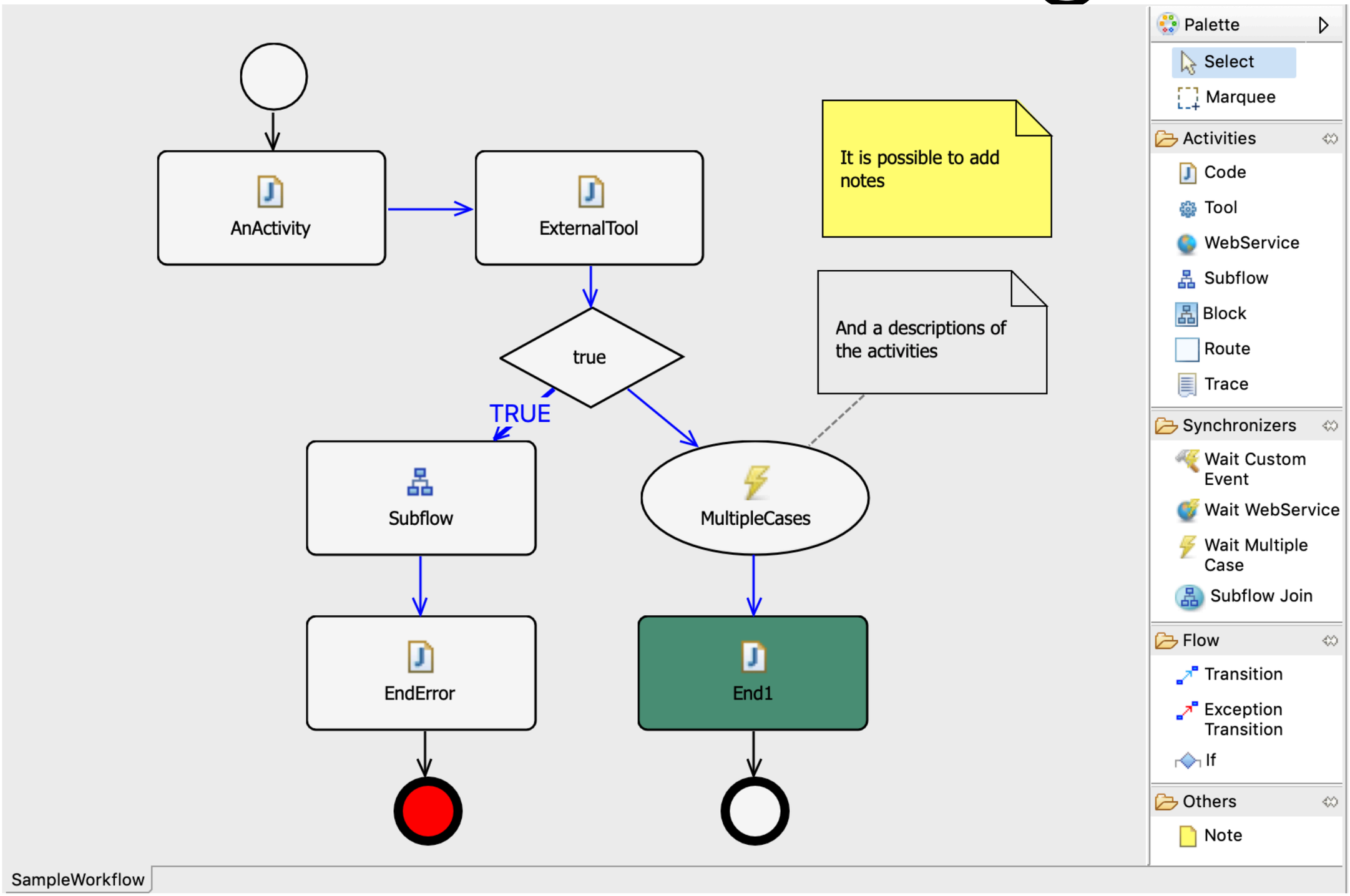
Features

- All the features provided by JADE
- Agents capable of executing workflows and handle events
- Workflows designed as set of ordered activities
- Graphical User Interface (GUI) to design workflows
- Has a web interface

Features

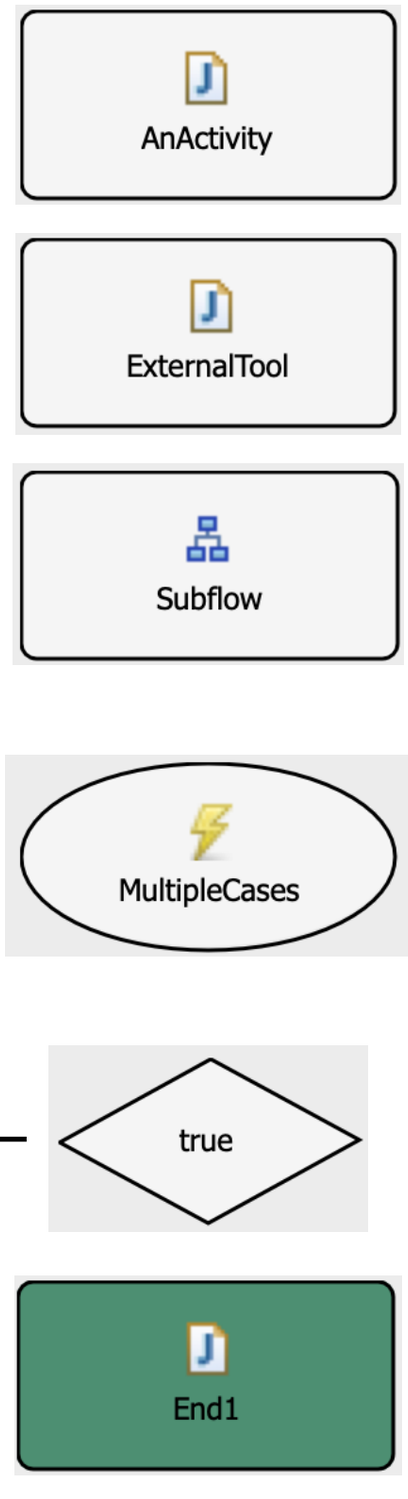
- It is possible agents and events in a XML configuration file: agents will be then deployed in the specified container
- The WOLF Eclipse plugin allows for the design of workflows
- The skeleton is automatically generated

Workflows Design



Workflows Design

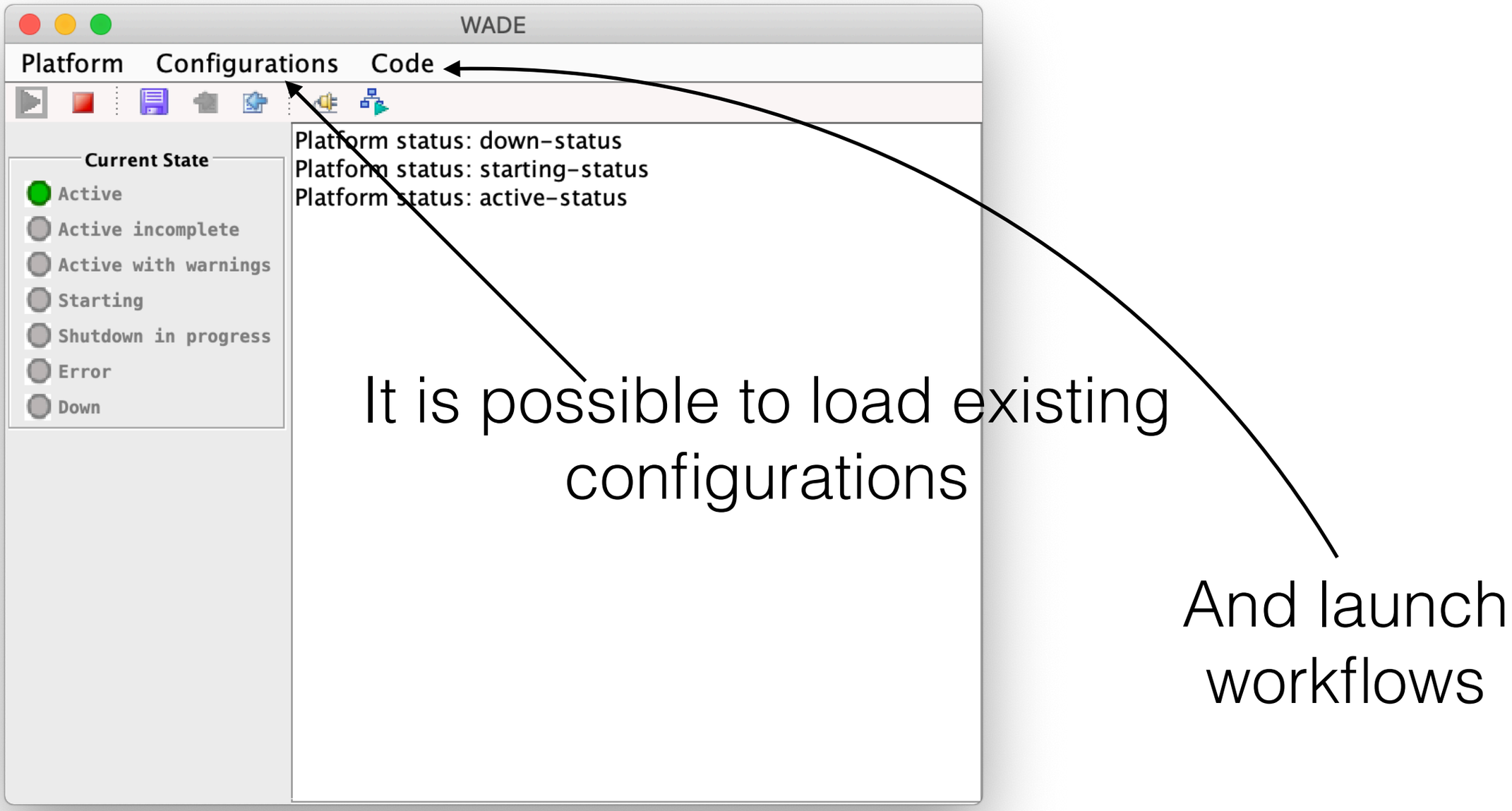
```
}

/**
 */
protected void executeAnActivity() throws Exception {
}

/**
 */
protected void executeExternalTool() throws Exception {
}

/**
 */
protected void executeSubflow(Subflow s) throws Exception {
}

/**
 * And a descriptions of the activities<br>
 * @layout visible=true;position=(353,115);size=(100,54)
 */
protected void beforeMultipleCases(Map ets) throws Exception {
}

protected void afterMultipleCases(String caseId, GenericEvent ge) throws Exception {
}

/**
 */
protected boolean checkTestCondition() throws Exception {
    return true;
}

/**
 */
protected void executeEnd1() throws Exception {
}
```



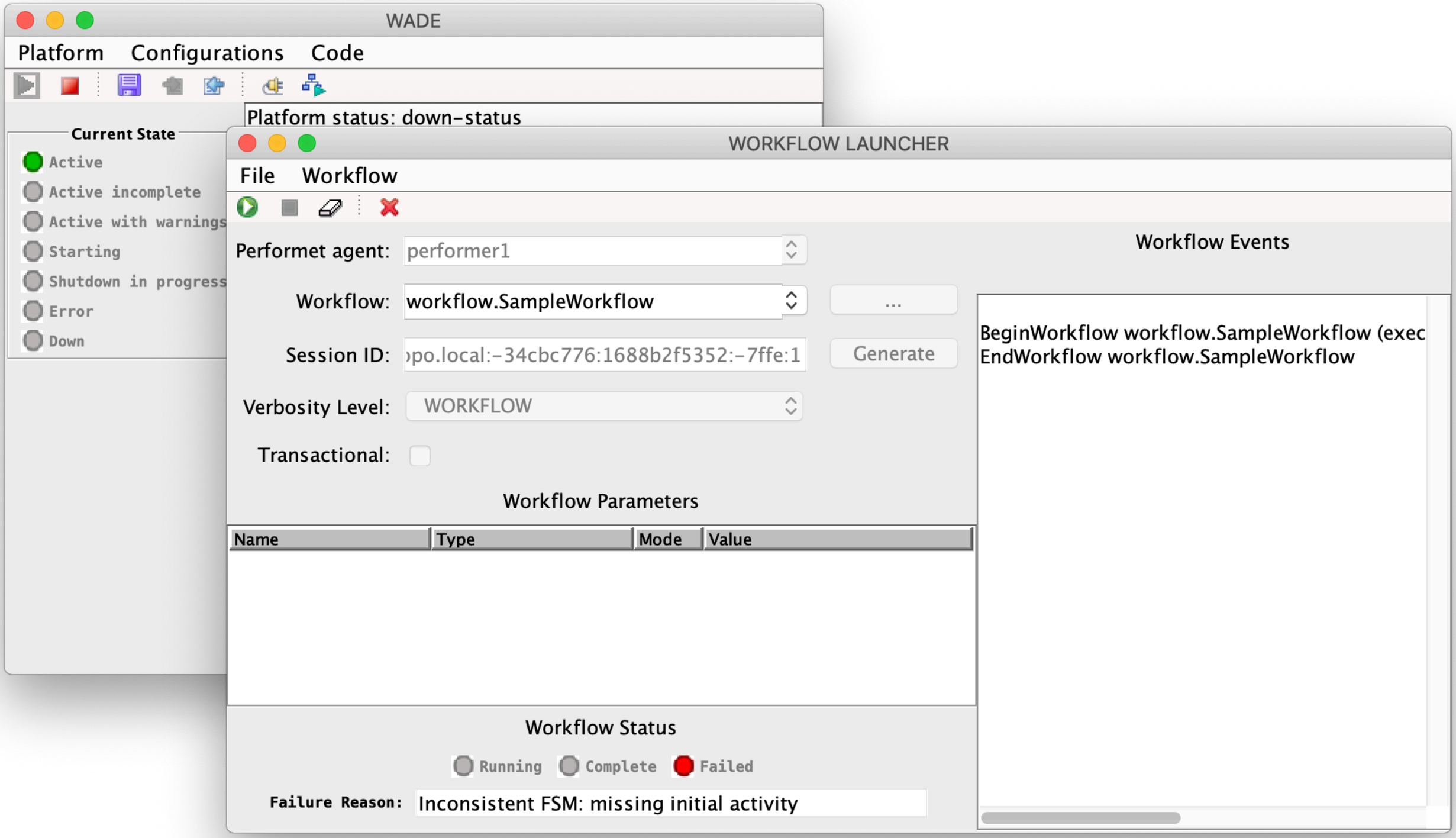
Features

- Thanks to the WADE GUI it is possible to:
  - manage the various configurations
  - launch existing workflows and see the result
- A web GUI exists as well for the platform management but it is not very up to date

WADE GUI


WADE
Platform
Configurations
Code
Current State
Active
Active incomplete
Active with warnings
Starting
Shutdown in progress
Error
Down
Platform status: down-status
Platform status: starting-status
Platform status: active-status
It is possible to load existing configurations
And launch workflows

WADE GUI


WADE
Platform
Configurations
Code
Platform status: down-status
Current State
Active
Active incomplete
Active with warnings
Starting
Shutdown in progress
Error
Down
WORKFLOW LAUNCHER
File
Workflow
Performet agent:
performer1
Workflow:
workflow.SampleWorkflow
...
Session ID:
po.local:-34cbc776:1688b2f5352:-7ffe:1
Generate
Verbosity Level:
WORKFLOW
Transactional:
Workflow Parameters
Name
Type
Mode
Value
Workflow Events
BeginWorkflow workflow.SampleWorkflow (exec
EndWorkflow workflow.SampleWorkflow
Workflow Status
Running
Complete
Failed
Failure Reason:
Inconsistent FSM: missing initial activity

Thanks for your attention

Dr. Jacopo Pellegrino - http://personalpages.to.infn.it/~japelleg/

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