MultiAgent-based Simulation

Repast Simphony

Recursive Porous Agent Simulation Toolkit
Argonne National Laboratory
University of Chicago
http://repast.sourceforge.net/
mirror : https://seafile.emse.fr/d/0a454872c8/

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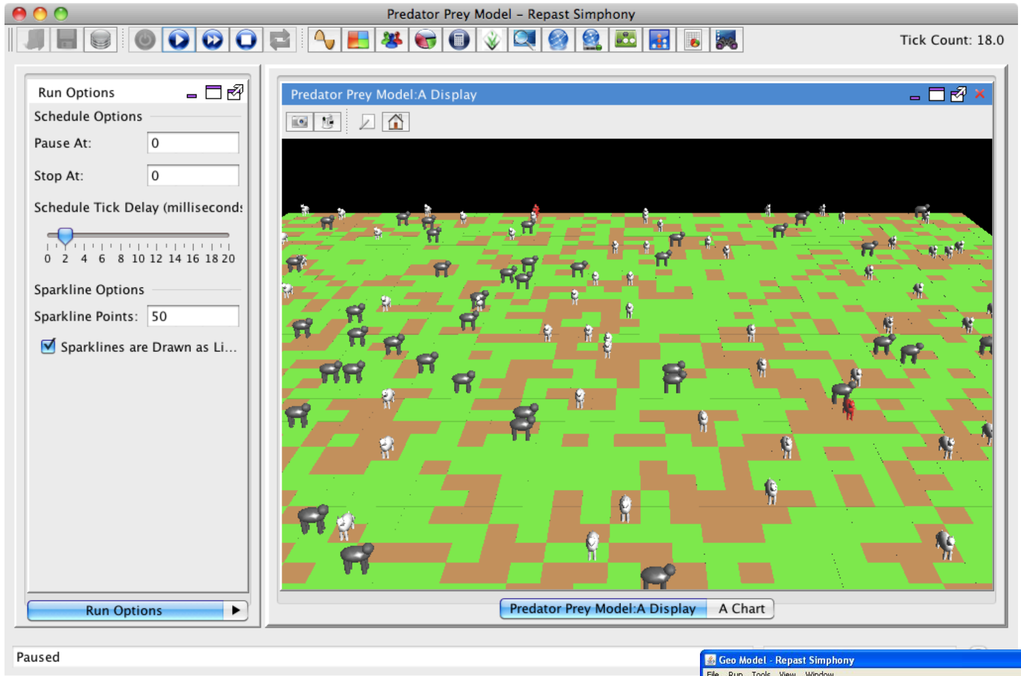
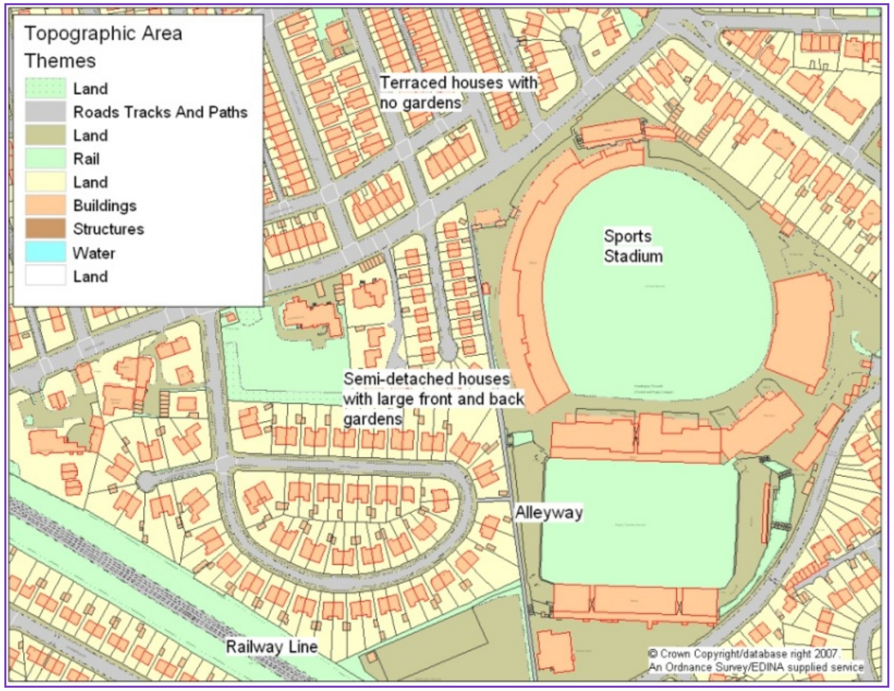
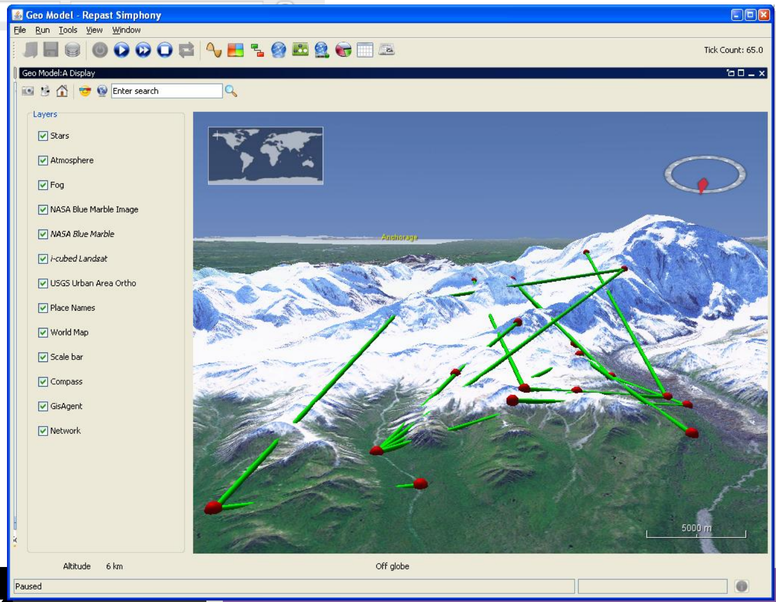
Présentation

- Repast is a multi-agent platform used to develop, test and execute multi-agent systems
- Written in Java (open-source)
- Very popular in the MAS simulation community, mainly for social and geographic simulations
- Offers an API for the design and implementation of MAS
- Offers a graphical modeling tool (specially for beginners)
  - ✓2D & 3D visualization
  - ✓ Grid management
  - ✓ Parameter management
  - ✓ Data observation
  - ✓ Data can be analyzed and exported from a format to another
- Availability of machine learning libraries (neural networks, regression)
- Import & Export of shapefile

Repast Illustration







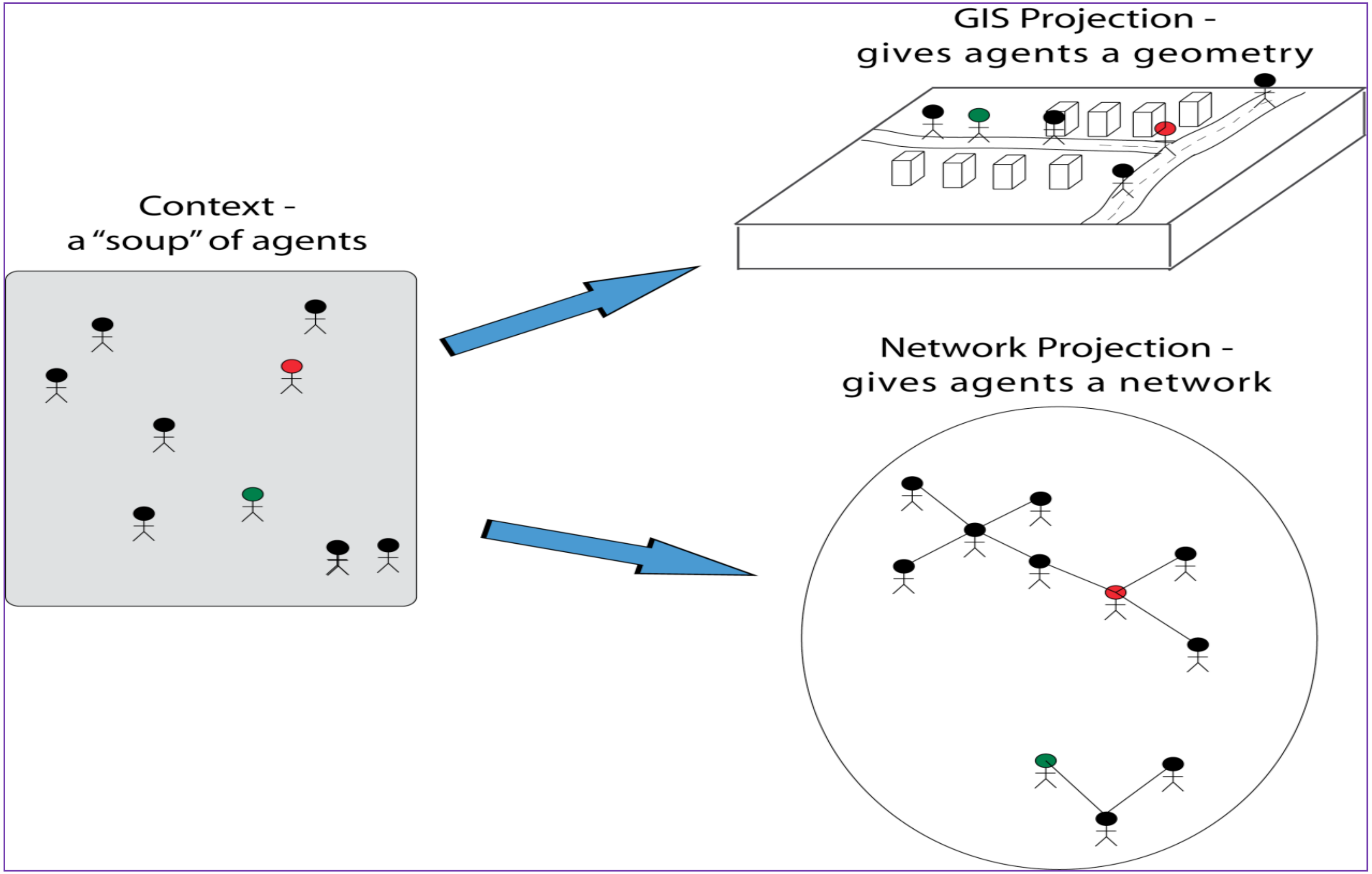
Key Notions: context

- A fundemental concept in Repast Simphony
  - ✓Offers a data structure allowing to organize agents
  - ✓Concretely, contexts are a collection of hierarchicaly nested agents each containing some of the components of the model
  - ✓These components are java objects
  - ✓Poissibility to have other contexts
  - ✓A componant can be involved in a multiple contexts at once
  - ✓A component involved in one context is also involved in all contexts having a parent relationship woth this context
  - ✓At least there is one *master context* that contains all the others

Key Notions: projection

- ➢Whereas contests create a collection allowing to organize agents, projections impose a structure on these agents
- ➢Projections allow to create a structure that define relations (can be spatial or semantic)
- ➢A projection is attached to a particular context and is applied to all the agents belonging to this context
  - ✓An object must belong to a context before being used in a projection
  - ✓Multiple projections can be appied to the same context. Thus, we can have a context that contains a grid and to « geographical » spaces (e.g. two representations of the same transport network)

Contexts and Projectons



Example:
Conway's Game of life

- Is a cellular automaton devised by the British mathematician John Horton Conway in 1970
- is a zero-player game, meaning that its evolution is determined by its initial state, requiring no further input
- You create an initial configuration and observing how it evolves
- Rules
  - an infinite two-dimensional orthogonal grid of square cells, each of which is in one of two possible states, alive or dead
  - Every cell interacts with its eight neighbours
  - Any live cell with fewer than two live neighbours dies (underpopulation)
  - Any live cell with two or three live neighbours lives on to the next generation
  - Any live cell with more than three live neighbours dies
  - Any dead cell with exactly three live neighbours becomes a live cell

Example: Conway's Game of life

- New Repast Simphony Project
- GameOfLife
- Perspective java
- In « GameOfLife.rs », « context.xml », create the projection« Grid »

```
<context id="GameOfLife" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xsi:noNamespaceSchemaLocation="http://repast.org/scenario/
context">
 <projection type="grid" id="grid"></projection>
 </context>
```

- In this configuration file, we can create all the contexts, the subcontexts and projections

Create the Class Agent

import repast.simphony.space.grid.Grid;

```
public abstract class Agent {
protected Grid<Agent> grid;
protected boolean alive;

public Agent(Grid<Agent> grid) {
        this.grid = grid;
        alive = true;
}
// modify the value of alive according to neigborhood
public abstract void compute();

// create complementary type of agent
public abstract void implement();

}
```

- **We will have different agent representation based on the agent types, for this we will create two classes extending agents**
  - DeadAgent dead cells
  - AliveAgent living cells

Create A ContextBuilder

- The principal class for Repast
- A generic class of which we specify the type of object that it contains

```
public class ContextCreator implements ContextBuilder<Agent> {

@Override
public Context<Agent> build(Context<Agent> context) {
…
}
```

Create A projection

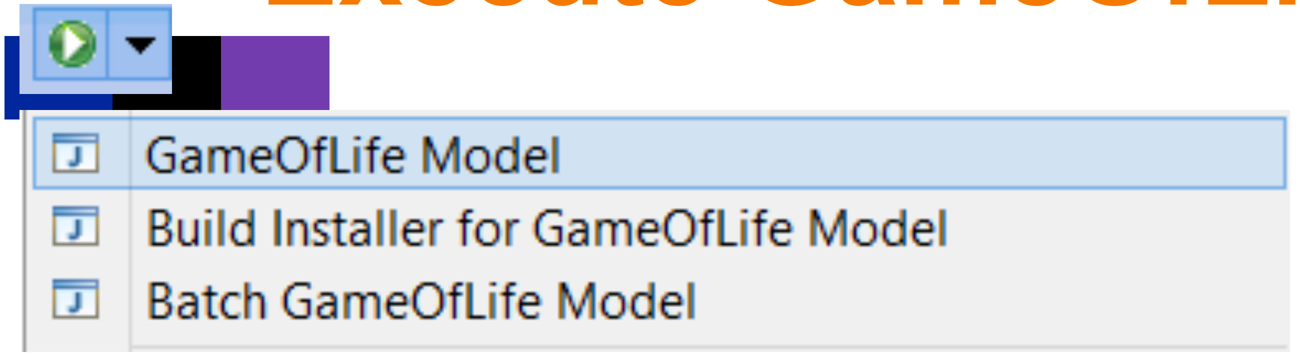
- As a general rule, *Projections* are created as follows:
  - ✓ Find their « *factory* »
  - ✓ Use the *factory* to create the *projection*

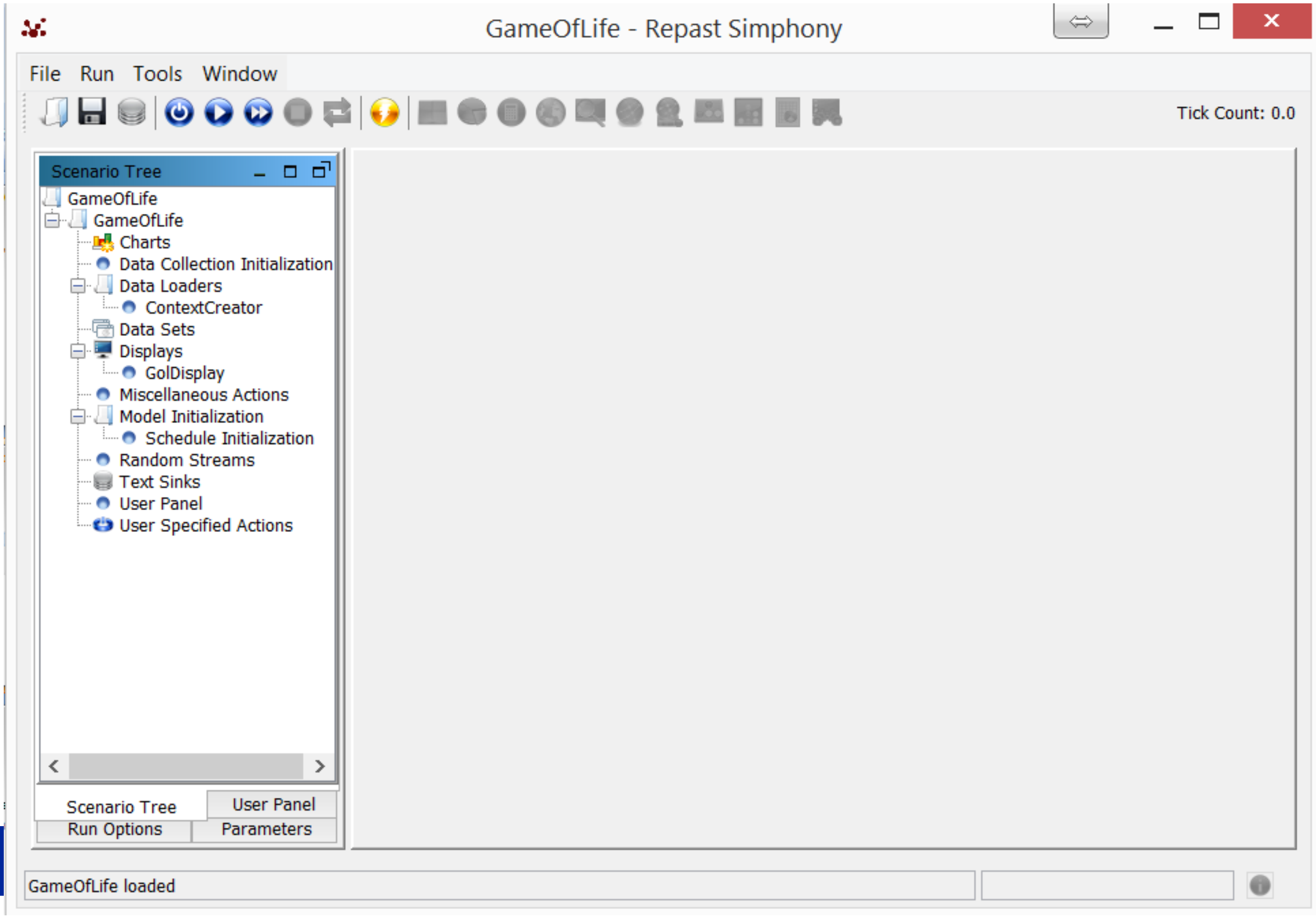
- Each *Factory* create a projection of a specific type and requires the context to which the projection is associated the name of the projection as well as some suplemmentray arguments

- Projection for GameOfLife

```
GridFactory gridFactory = GridFactoryFinder.createGridFactory(null);
Grid<Agent> grid = gridFactory.createGrid("grid", context,
new GridBuilderParameters<Agent>(new WrapAroundBorders(),
new SimpleGridAdder<Agent>(), false, 50, 50));
```

Execute GameOfLife Model

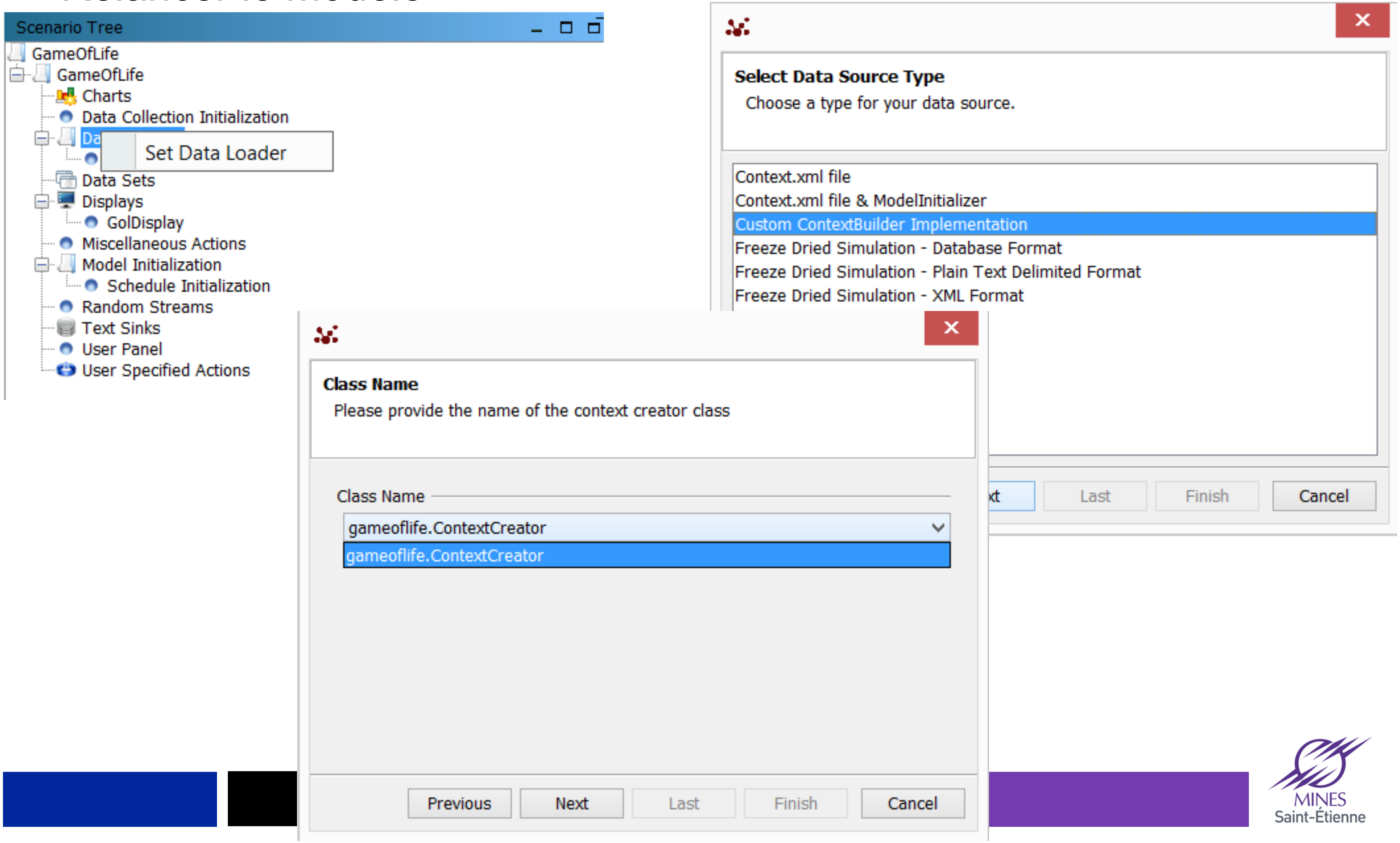




MINES Saint-Étienne

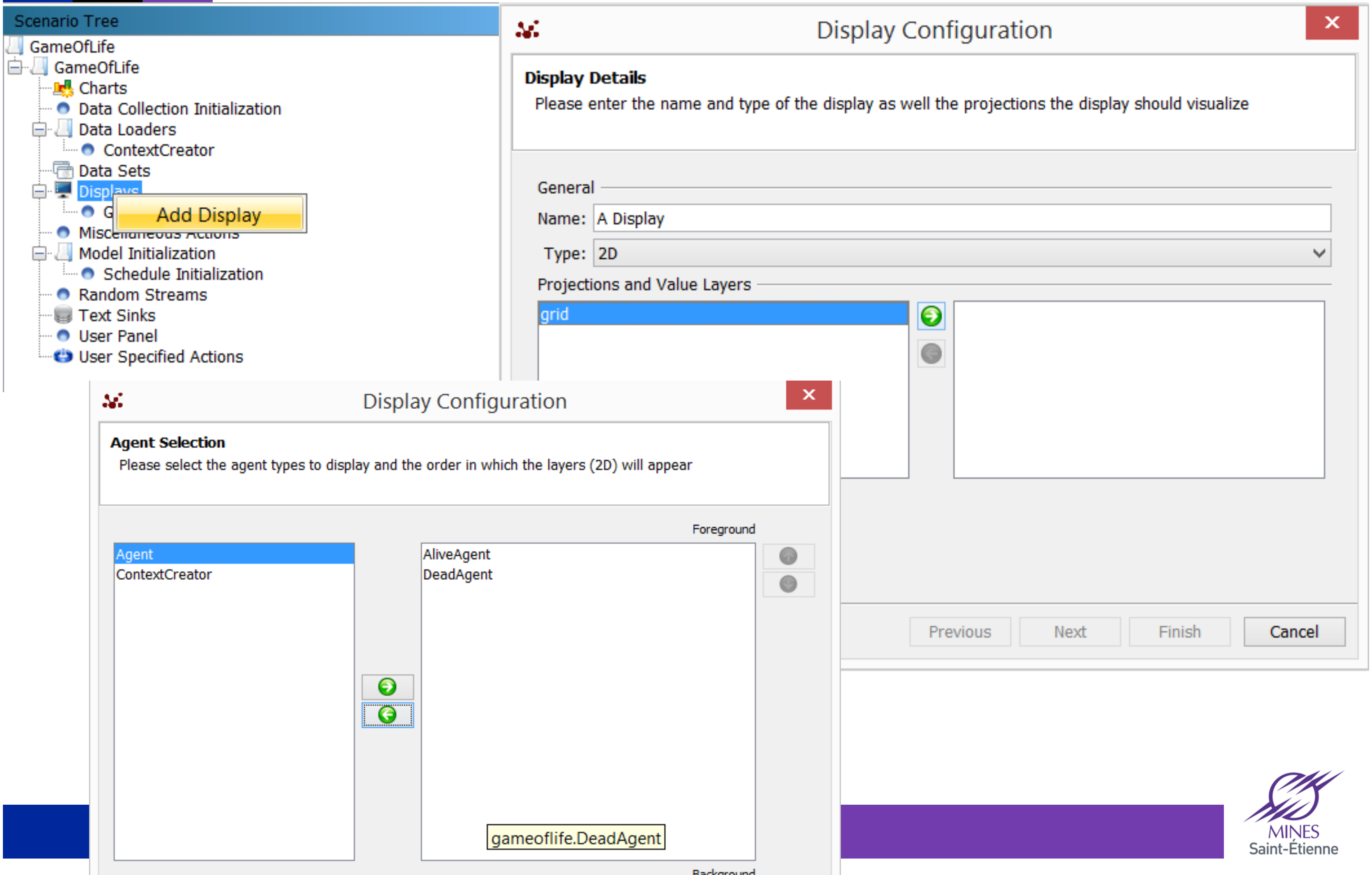
Define the principal context

- Relancer le modèle

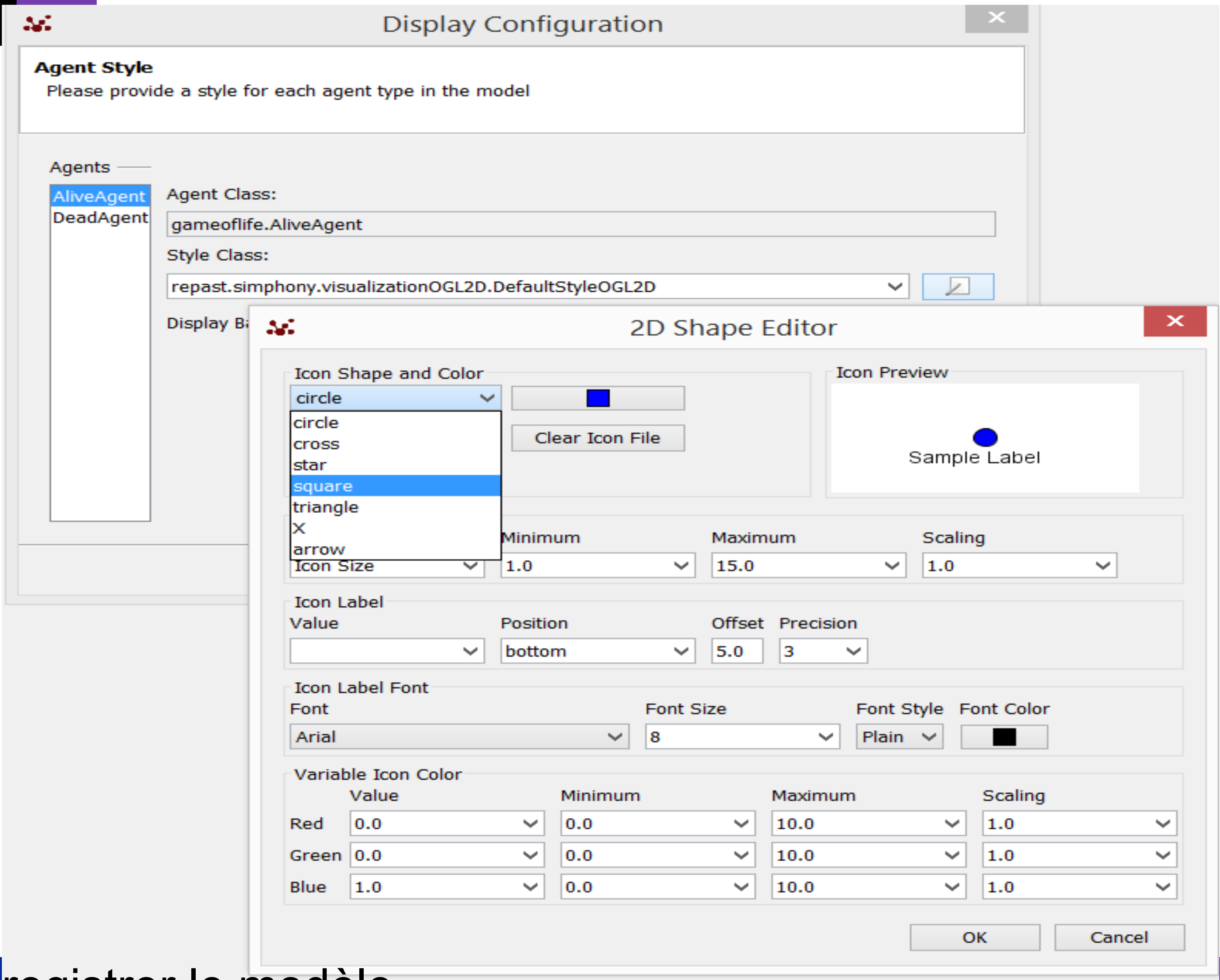


MINES Saint-Étienne

Define the visualization

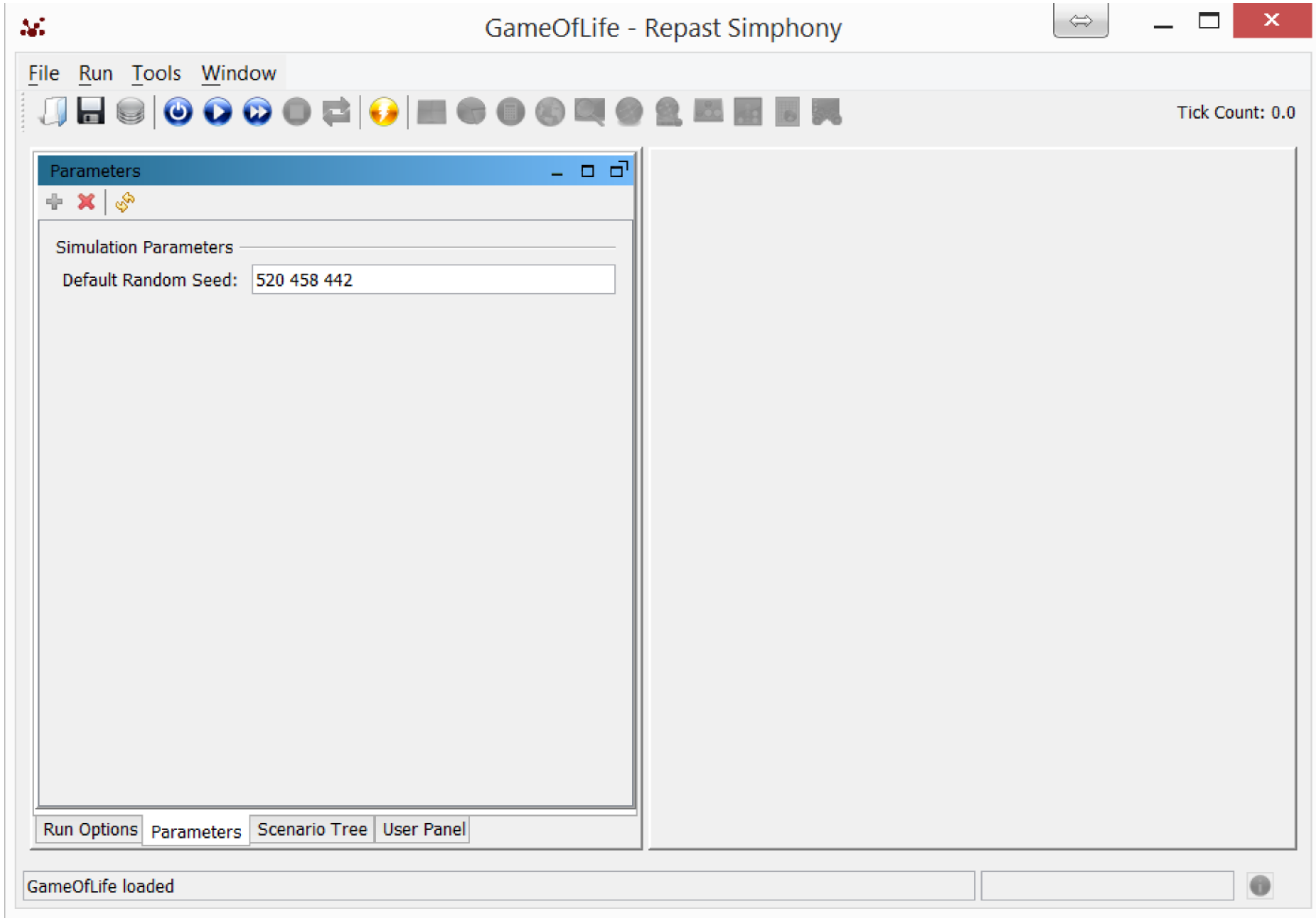


Agents' styles

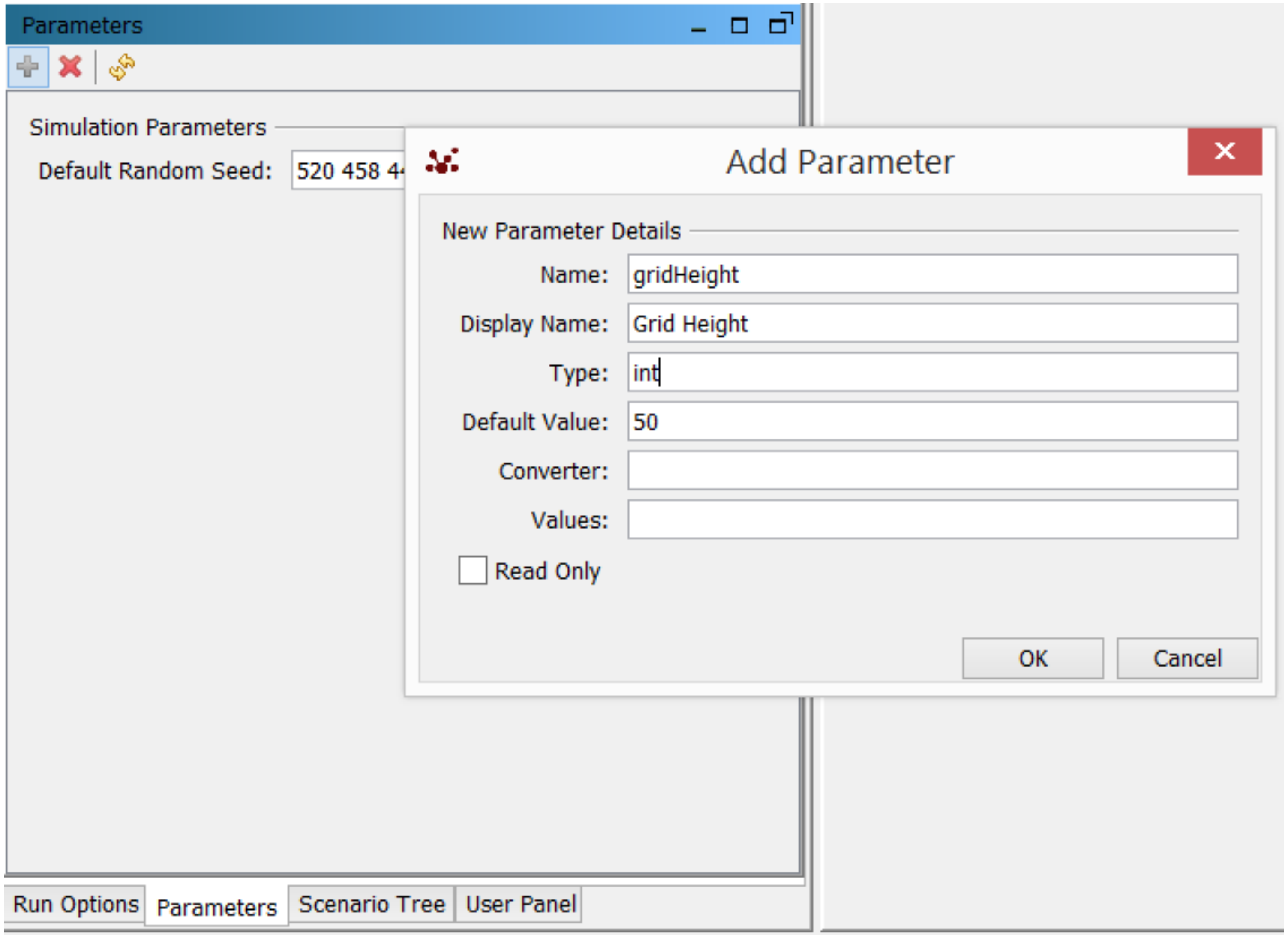


➢ Enregistrer le modèle

Parametering the Simulation



Parametering the Simulation



- Enregistrer le modèle

Using the parameters

```
public class ContextCreator implements ContextBuilder<Agent> {
@Override
public Context<Agent> build(Context<Agent> context) {
context.setId("GameOfLife");
int width = RunEnvironment.getInstance().getParameters().getInteger("gridWidth");

int height = RunEnvironment.getInstance().getParameters().getInteger("gridHeight");

GridFactory gridFactory = GridFactoryFinder.createGridFactory(null);
Grid<Agent> grid = gridFactory.createGrid("grid", context,
new GridBuilderParameters<Agent>(new WrapAroundBorders(),
new SimpleGridAdder<Agent>(), false, width, height));

for (int x = 0; x < height; x++) {
        for (int y = 0; y < width; y++) {
                boolean b = Math.random()>0.5 ? true: false;
                Agent a = b? new AliveAgent(grid): new DeadAgent(grid);
                context.add(a);
                grid.moveTo(a, x, y);
                }
        }
return context;
}
```

Scheduling in Repast (1/3)

There exists three ways to work with Repast Scheduler

- Schedule an action directly:

```
// Récupérer une réference vers l'ordonnanceur
ISchedule schedule = RunEnvironment.getInstance().getCurrentSchedule();

//Spécifier que l'action devrait commencer au tick 1 et s'exécuter à chaque tick
ScheduleParameters params = ScheduleParameters.createRepeating(1, 2);

//L'agent exécute la méthode move avec les paramètres d'ordonnancement définis
//plus haut
schedule.schedule(params, myAgent, "move");
```

- As you can see, ScheduleParameters can be created using one of its class methods:

```
//Spécifier que l'action devrait commencer au tick 1 et s'exécuter à chaque tick
ScheduleParameters params = ScheduleParameters.createRepeating(1, 2);
//L'agent exécute la méthode move avec les paramètres d'ordonnancement définis
schedule.schedule(params, myAgent, "move", "Forward", 4);
```

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Scheduling in Repast (2/3)

- Scheduling with annotations

```
@ScheduledMethod(start=1 , interval=2)
public void deliverPaper()
```

- Most of the time, objects with annotations are automatically added to the scheduler. However, if we create an object will the simulation is running, it may be not the case
- For this reason, we can user the « schedule » object to add them

```
//Ajouter les méthodes annotées de l'agent au schedule.
schedule.schedule(myAgent);
```

Comportement des agents

```java
public abstract class Agent {
protected Grid<Agent> grid;
protected boolean alive;

public Agent(Grid<Agent> grid2) {
this.grid = grid2;
alive = true;
}

@ScheduledMethod(start = 1, interval = 1, priority = 2)
public abstract void compute();

@ScheduledMethod(start = 1, interval = 1, priority = 1)
public abstract void implement();

}
```

Scheduling in Repast (3/3)

- Scheduling with the « Wathcers »

- Watchers are desinged to be used to schedule in a dynamic manner
- A watcher allows an agent to be notified about a change of status of another agent and thus to plan a an event that will take place subsequently
- (e.g. the agent « A » decides that if agent « B » does an action it will make a reaction)

- The watcher is used via an annotation:
  - ✓A request defining the agents to observe
  - ✓A request defining the condition that should be met in order to trigger and execute the action.

```java
@Watch(watcheeClassName = "repast.demo.simple.SimpleHappyAgent",
        watcheeFieldNames = "happiness", query = "linked_from",
        whenToTrigger = WatcherTriggerSchedule.LATER,
        scheduleTriggerDelta = 1, scheduleTriggerPriority = 0)

public void friendChanged(SimpleHappyAgent friend) {
    if (Math.random() > .25) {
        this.setHappiness(friend.getHappiness());
    } else {
        this.setHappiness(Math.random());
    }
    System.out.println("Happiness Changed");
}
```

- watcheeClassName defines the type of agents that this object is going to watch.
- watcheeFieldName defines the attribute to be watched. When this attribute changes, this object will be notified
- query: determines (or filter) the instances of Simple happy agents to be watched
    - ✓ Here, we watch agents that are linked to us.
- whenToTrigger specifies if the action should be executedimmediatly (before other actions scheduled at this instant are executed) or wait for the next tick
- scheduleTriggerDelta defines how many ticks to wait before scheduling the actions
- scheduleTriggerPriority defines the priority of the action

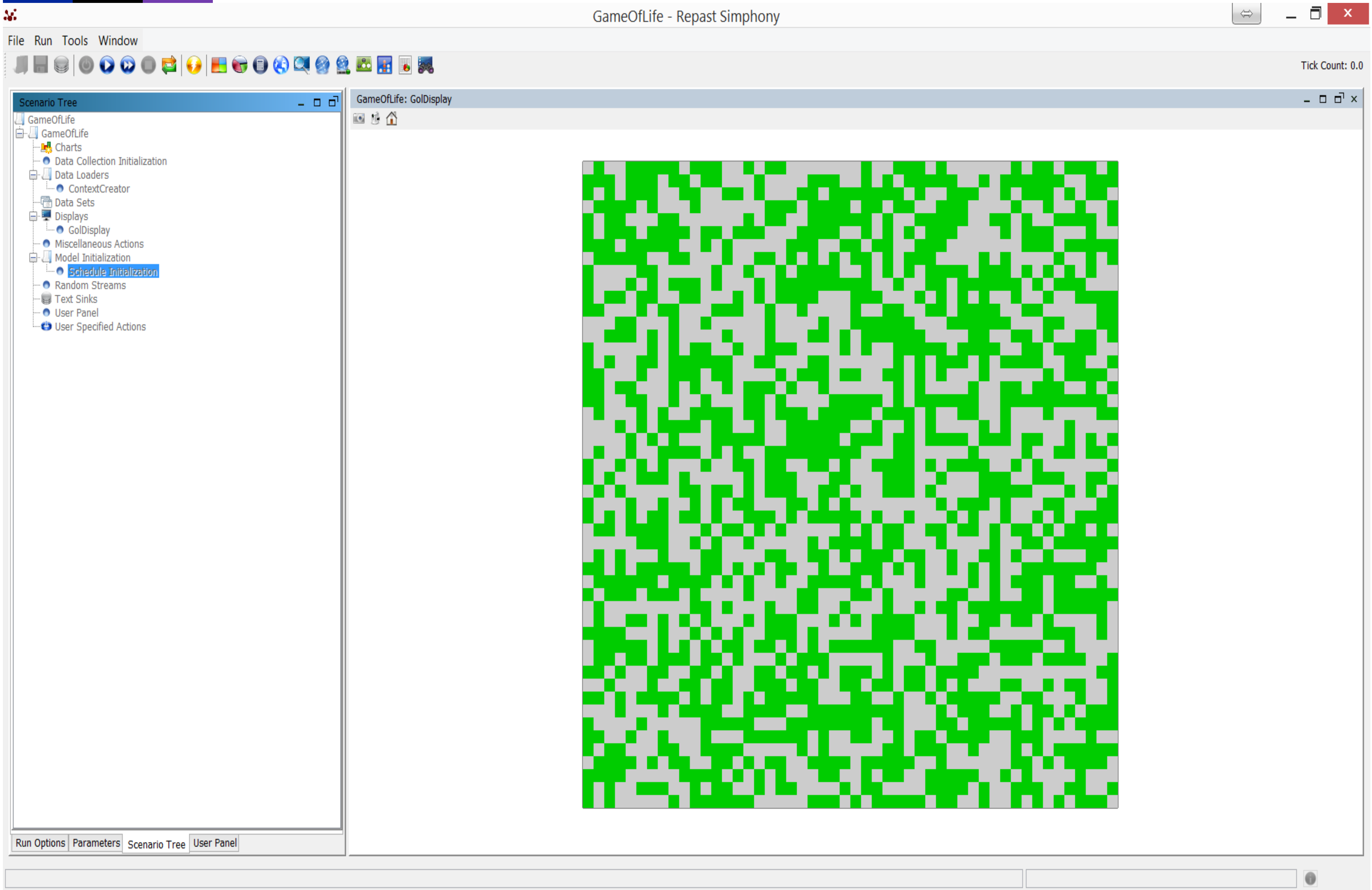
Agents Behavior

```
public class AliveAgent extends Agent{
public AliveAgent(Grid<Agent> grid) {
super(grid);
alive = true;}

public void compute() {
MooreQuery<Agent> query = new MooreQuery<Agent>(grid, this);
int neighbours = 0;
for (Agent o : query.query())
        if (o instanceof AliveAgent)
                neighbours++;
if (neighbours != 2 && neighbours != 3)
        alive = false;
}

public void implement() {
if (!alive) {
GridPoint gpt = grid.getLocation(this);
Context<Object> context = ContextUtils.getContext(this);
context.remove(this);
DeadAgent a = new DeadAgent(grid);
context.add(a);
grid.moveTo(a, gpt.getX(), gpt.getY());
}
}
```

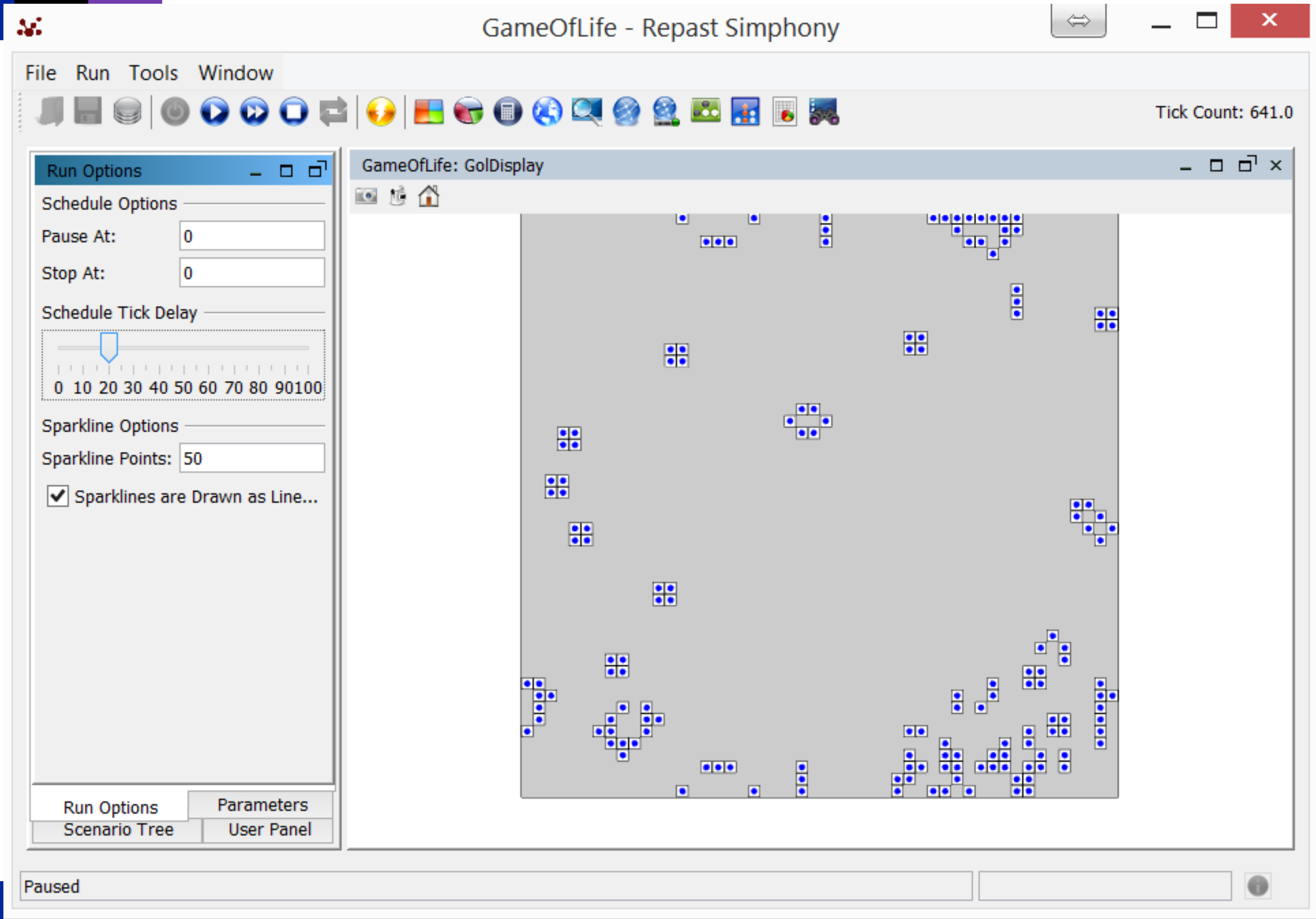
Agents Behavior

```
public class DeadAgent extends Agent{
public DeadAgent(Grid<Agent> grid) {
         super(grid);
         alive = false;
}

public void compute() {
MooreQuery<Agent> query = new MooreQuery<Agent>(grid, this);
int neighbours = 0;
for (Agent o : query.query())
         if (o instanceof AliveAgent)
                  neighbours++;
if (neighbours == 3)
         alive = true;
}

public void implement() {
if (alive) {
GridPoint gpt = grid.getLocation(this);
Context<Agent> context = ContextUtils.getContext(this);
context.remove(this);
AliveAgent a = new AliveAgent(grid);
context.add(a);
grid.moveTo(a, gpt.getX(), gpt.getY());
         }
     }
}
```

Executing the model



Run options



Saint-Etienne

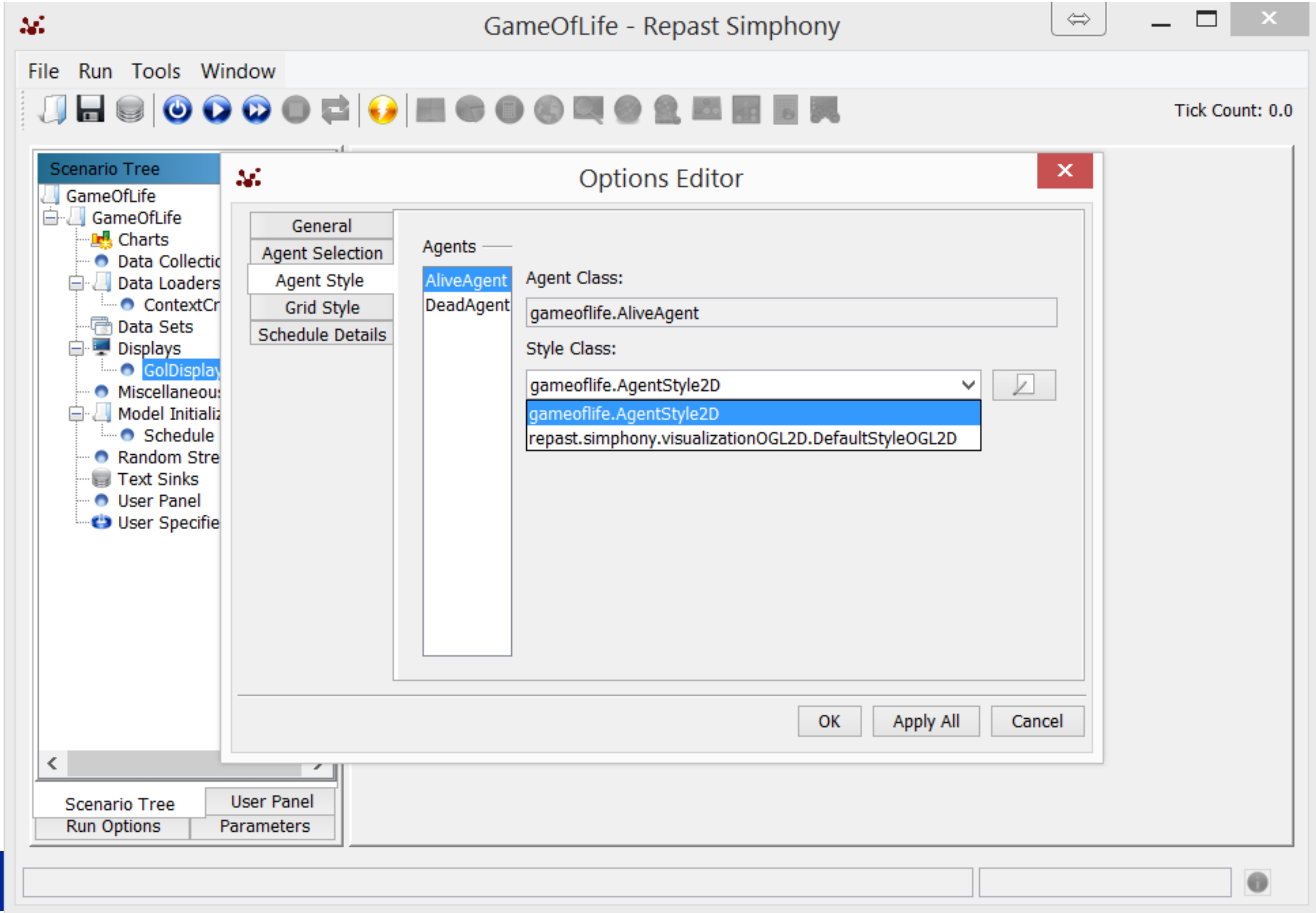
Dynamic Agent Styles

```
public class AgentStyle2D extends DefaultStyleOGL2D {

@Override
public Color getColor(Object o) {
if(RunEnvironment.getInstance().getCurrentSchedule().getTickCount()%2==0)
        return Color.RED;
        else
        return Color.BLUE;
        }
}
```

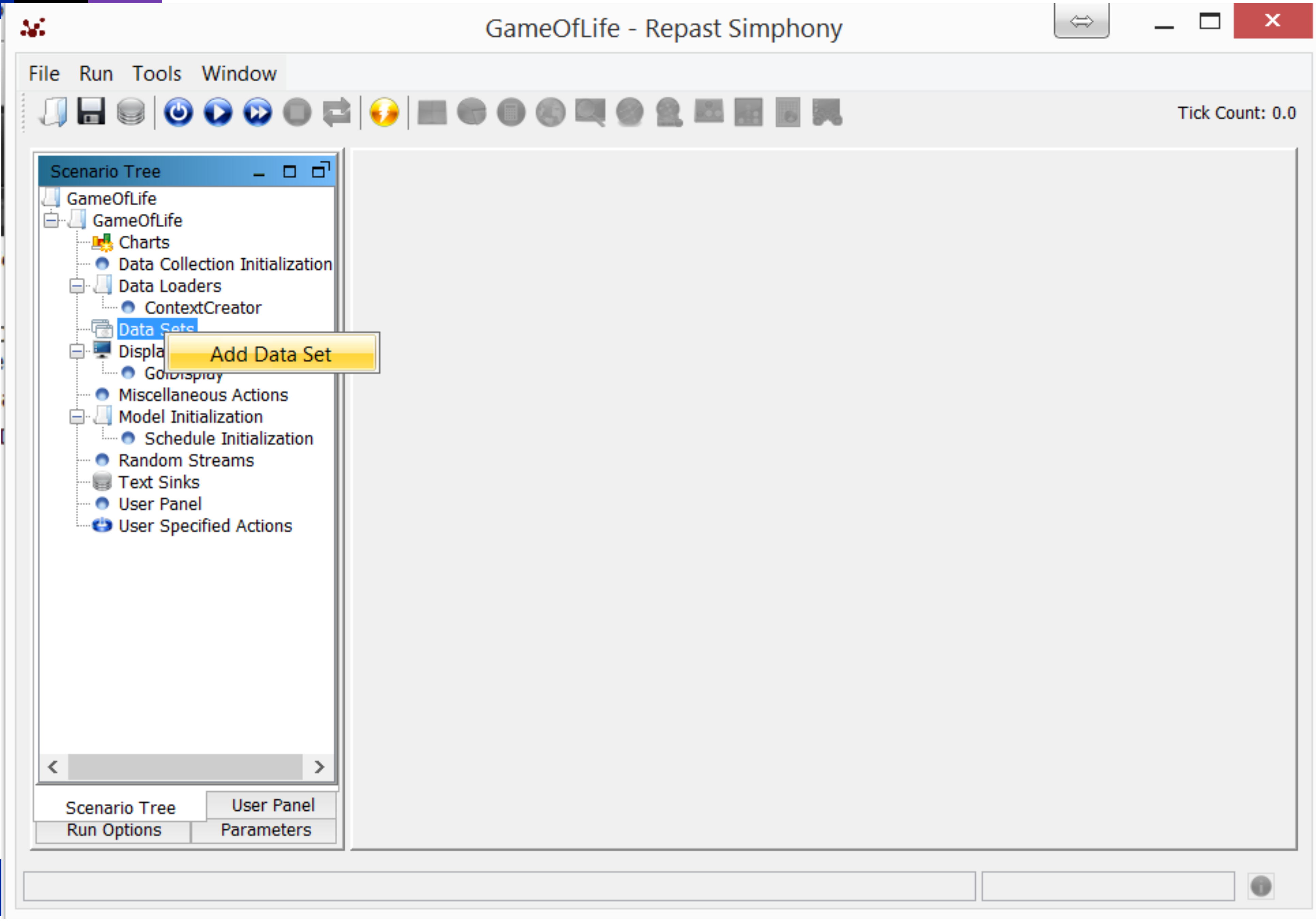
Dynamic Agent Styles

```
public class AgentStyle2D extends DefaultStyleOGL2D {

@Override
public Color getColor(Object o) {

if (o instanceof AliveAgent)
       if((AliveAgent) o).getAge()>=100)
              return Color.BLACK;

if(RunEnvironment.getInstance().getCurrentSchedule().getTickCount()%2==0)
       return Color.RED;
       else
       return Color.BLUE;
}
}
```

Dynamic Agent Styles

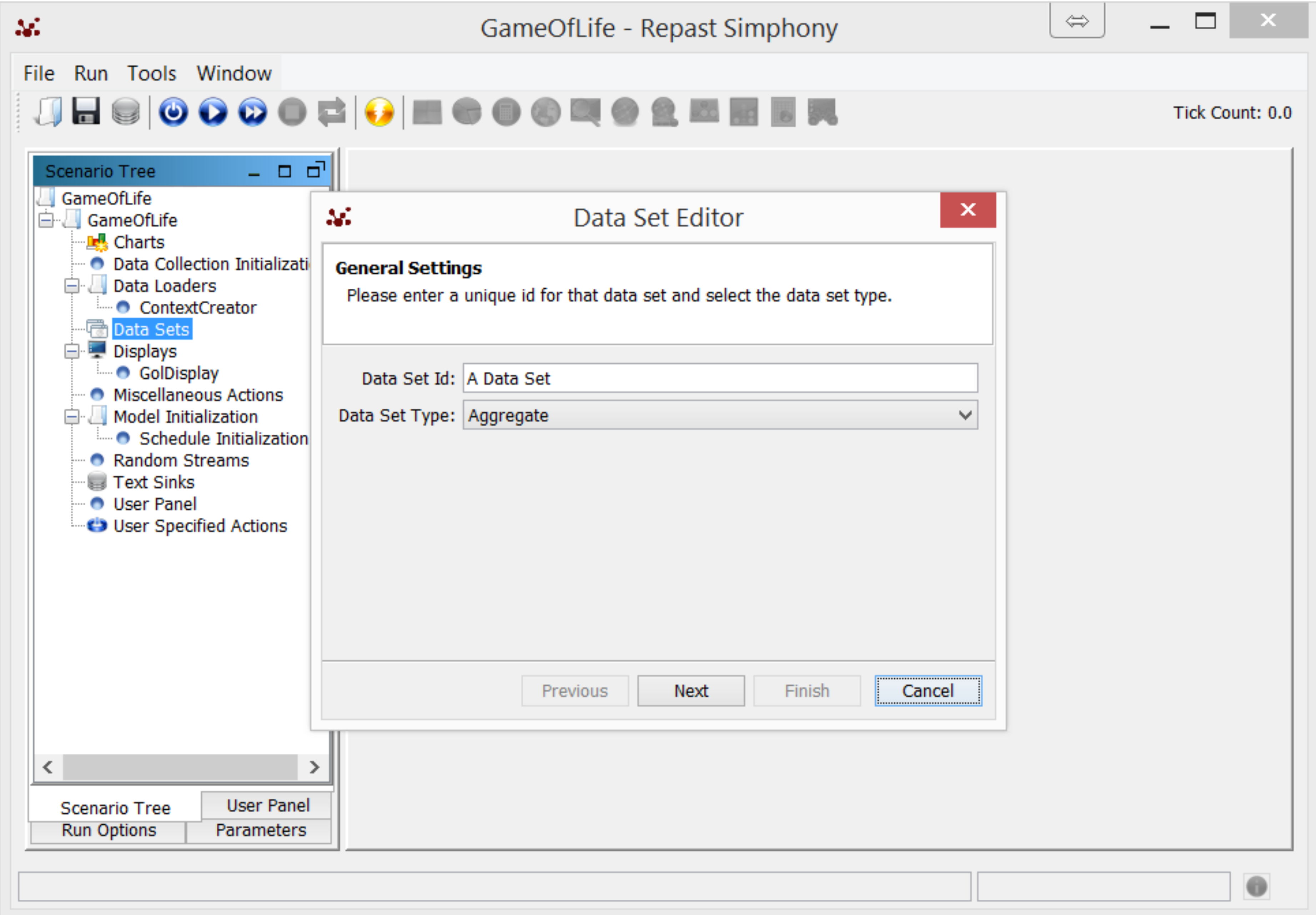


Data Sets



GameOfLife - Repast Simphony
File
Run
Tools
Window
Tick Count: 0.0
Scenario Tree
GameOfLife
GameOfLife
Charts
Data Collection Initialization
Data Loaders
ContextCreator
Data Sets
Add Data Set
Miscellaneous Actions
Model Initialization
Schedule Initialization
Random Streams
Text Sinks
User Panel
User Specified Actions
Scenario Tree
User Panel
Run Options
Parameters

Data Obesrvation and Export



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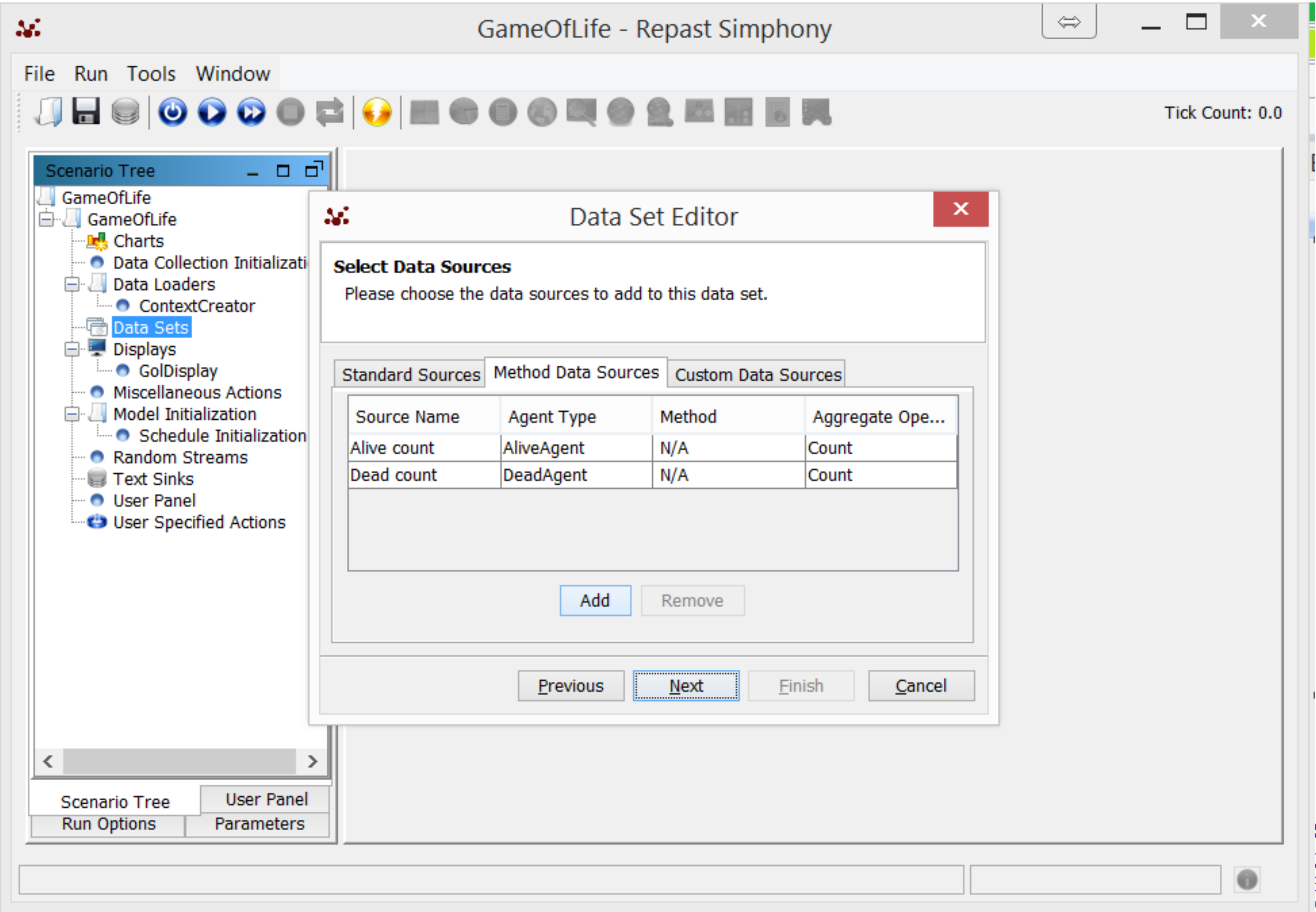

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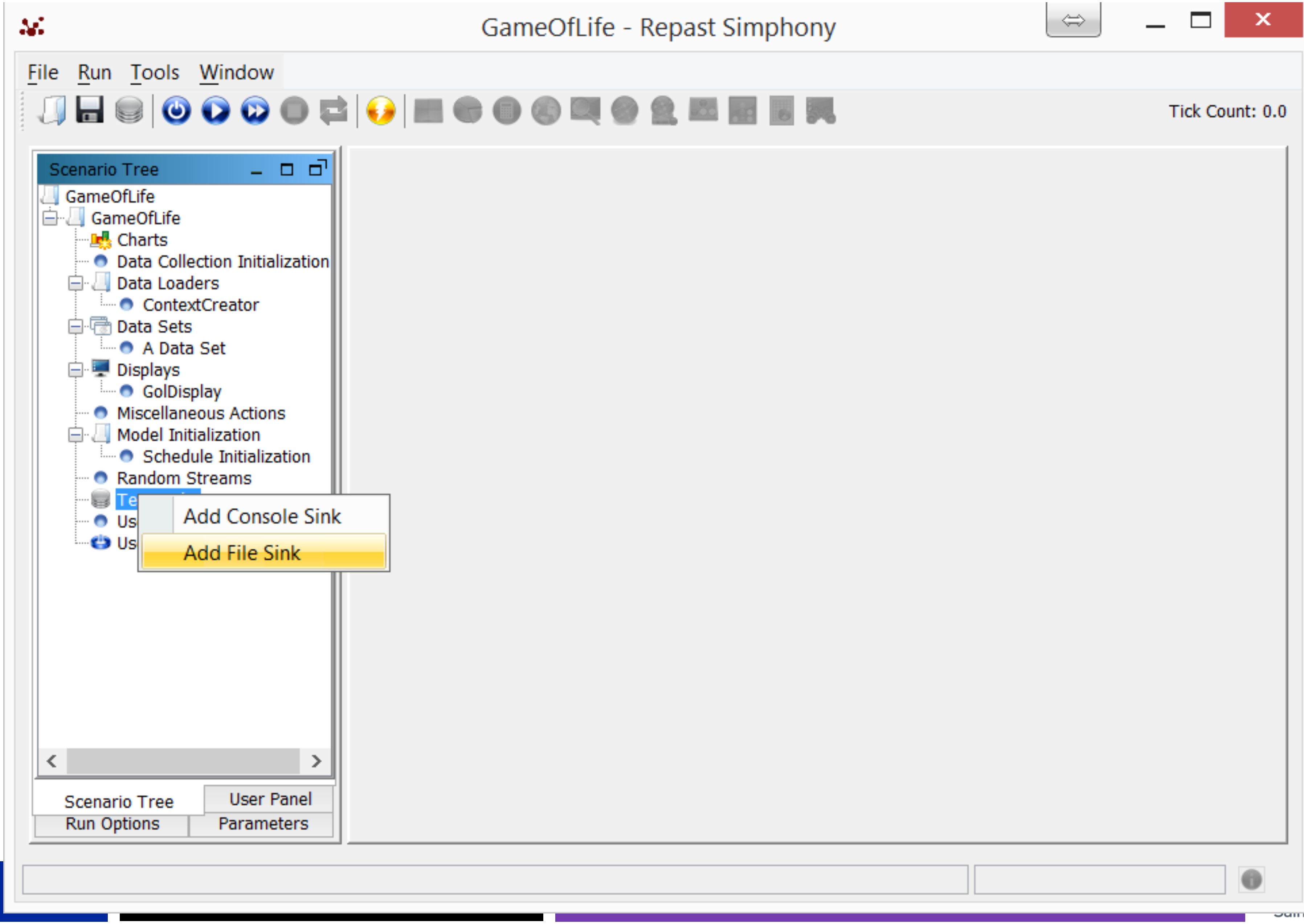

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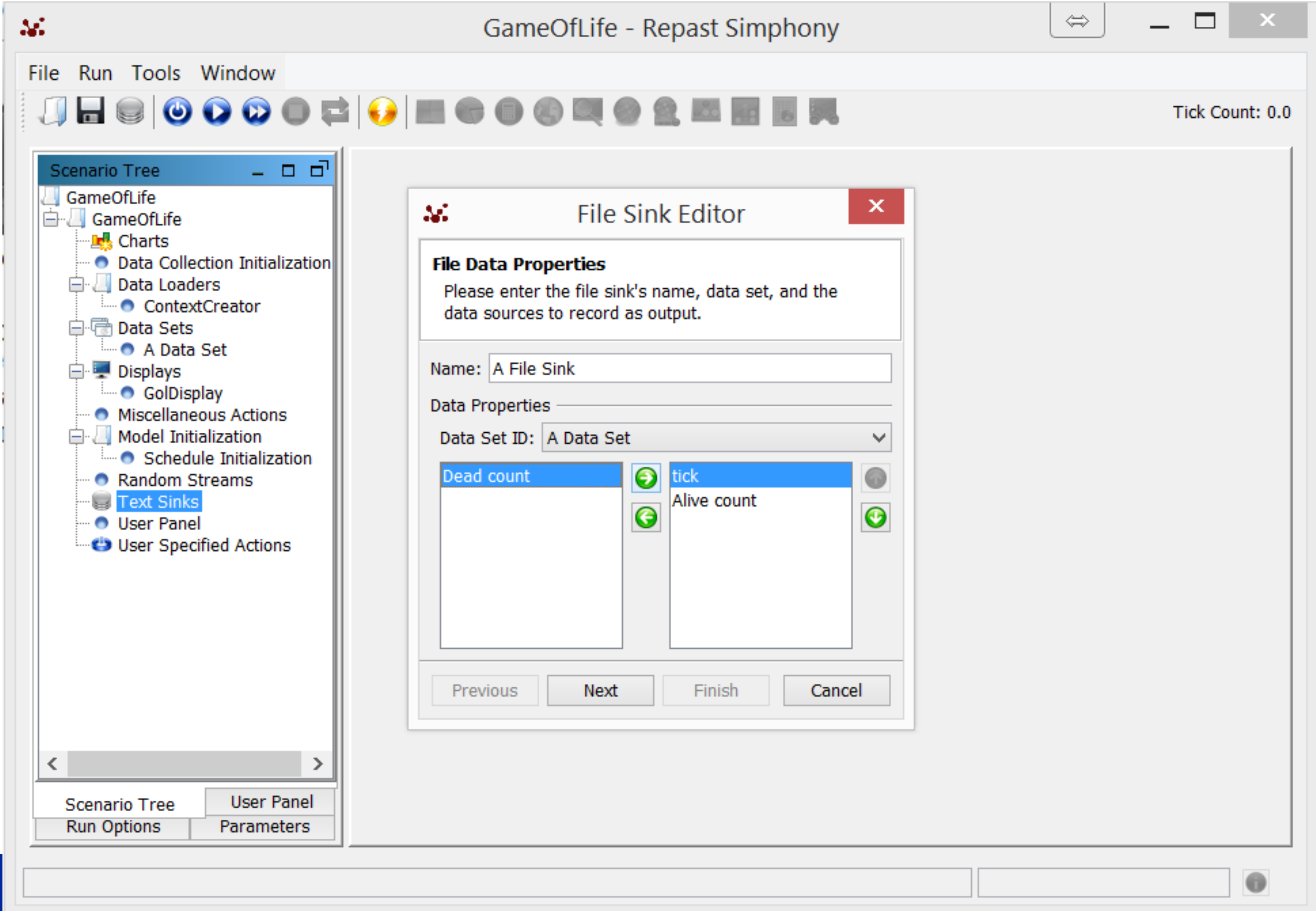

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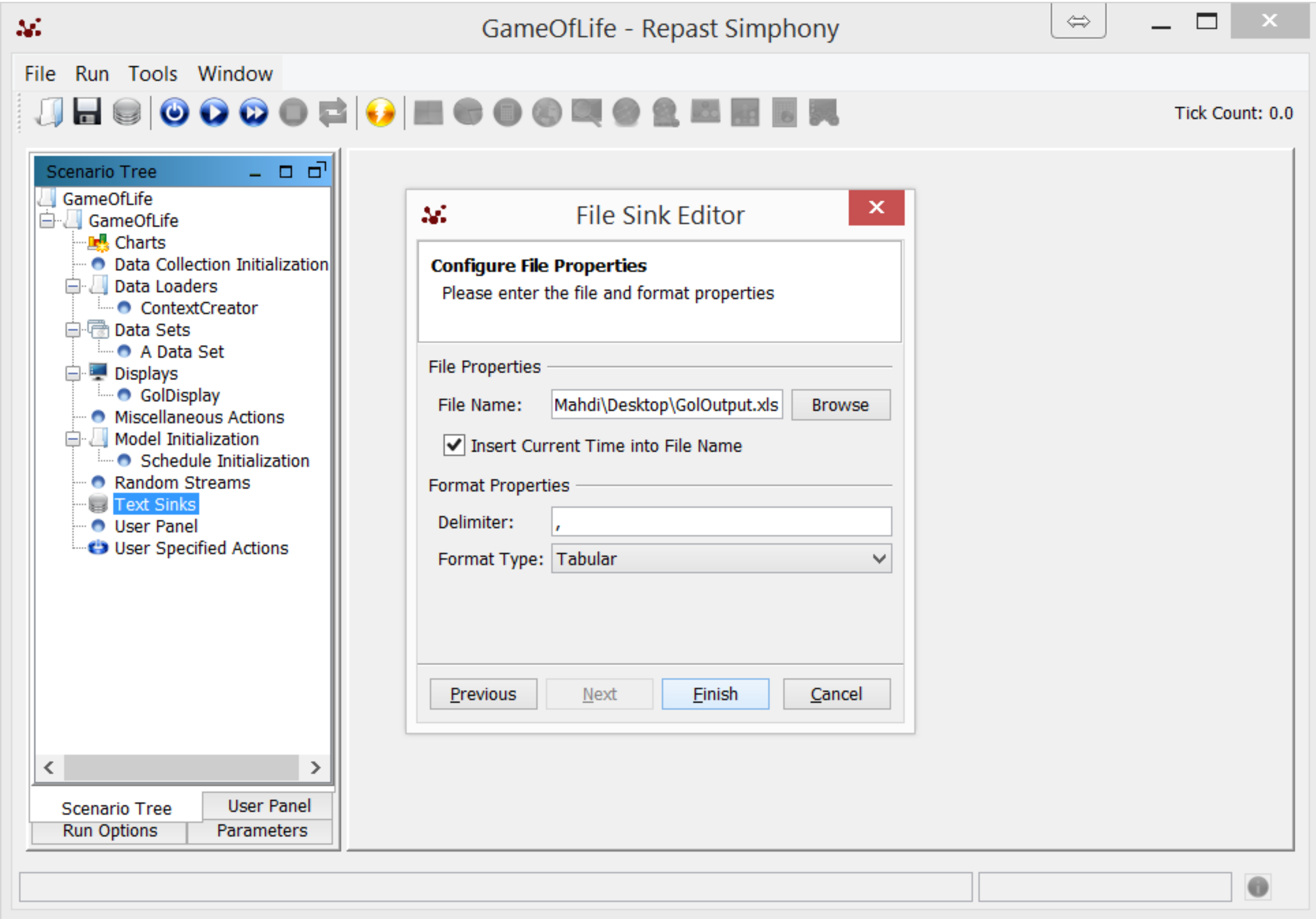

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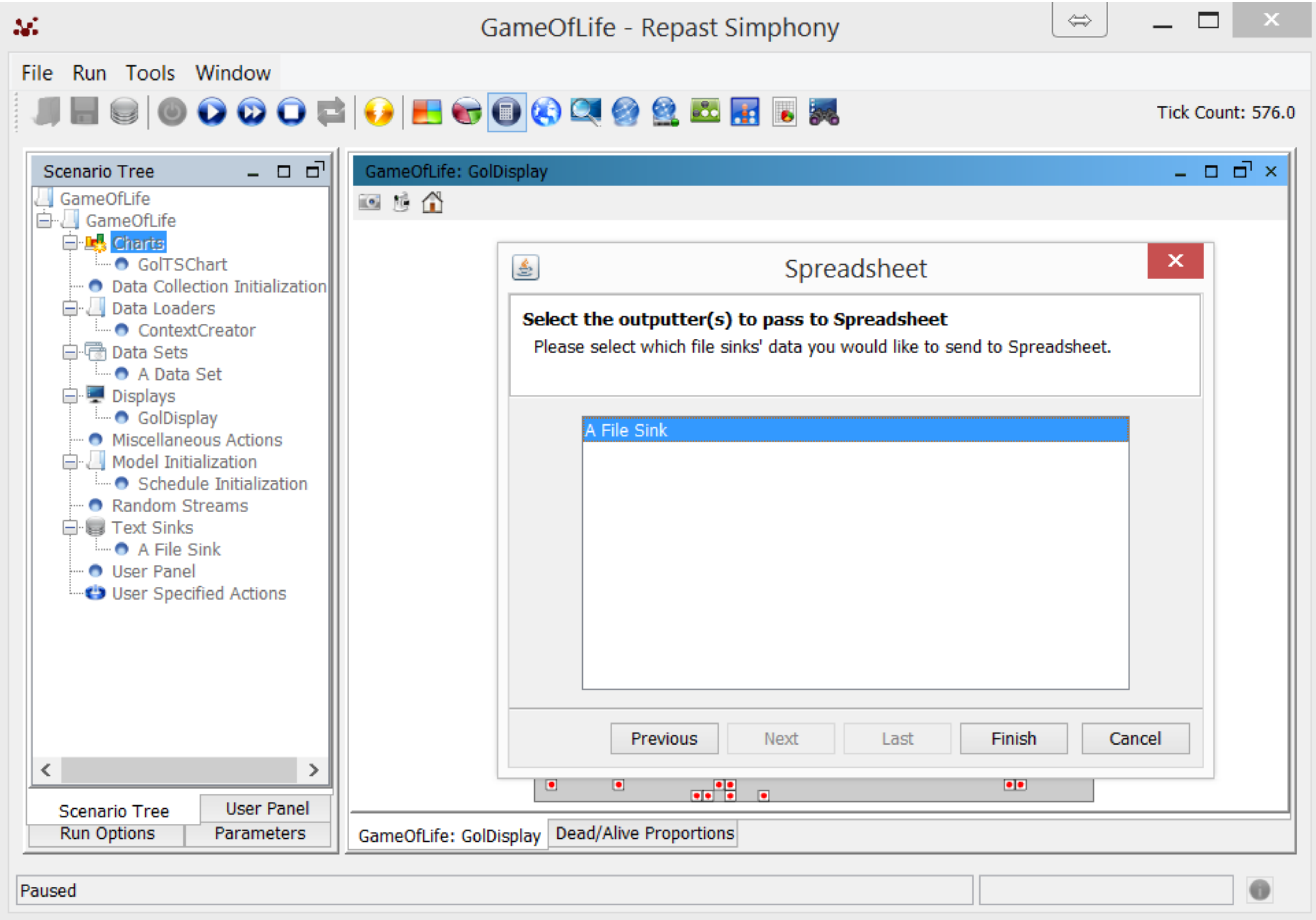

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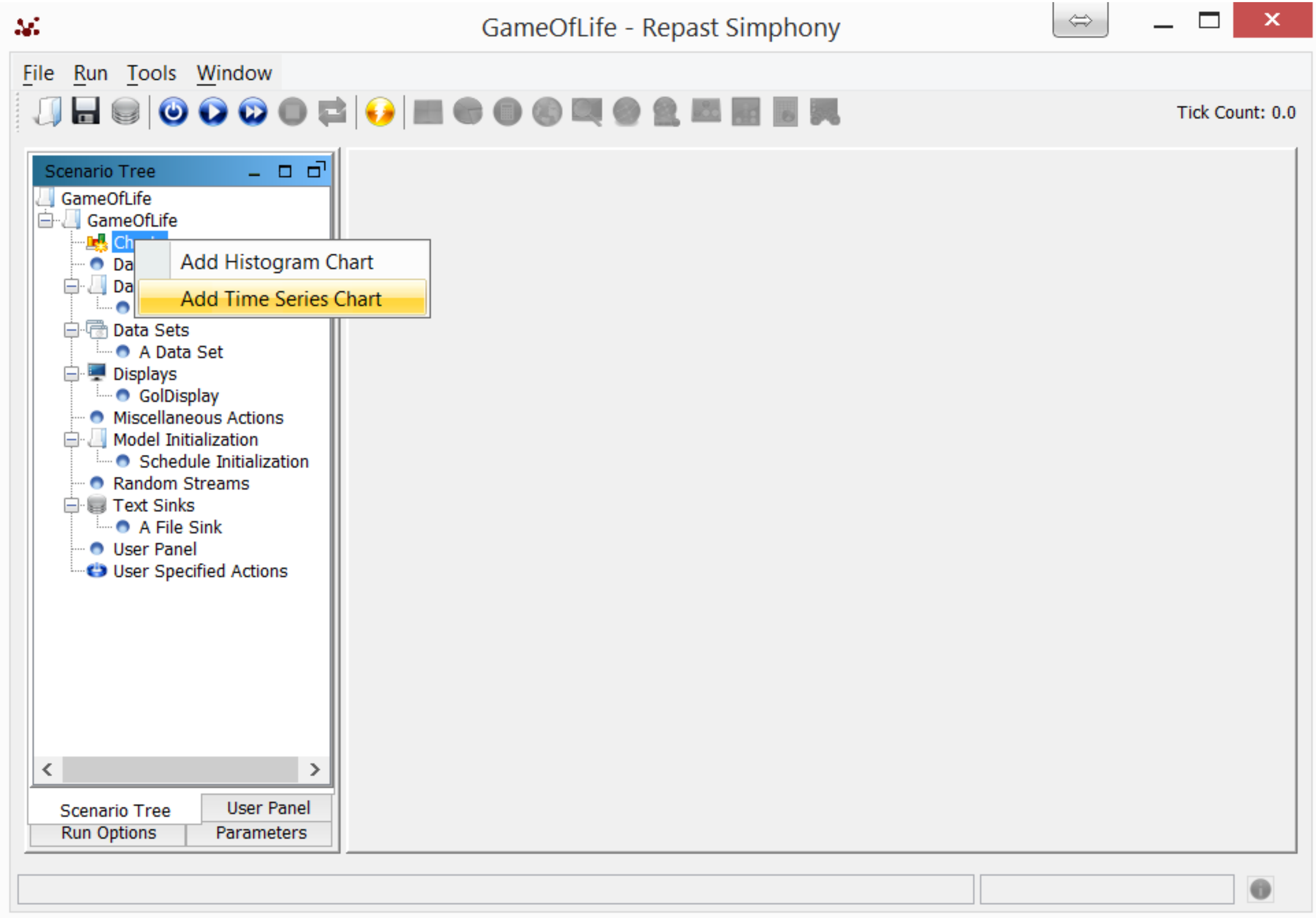

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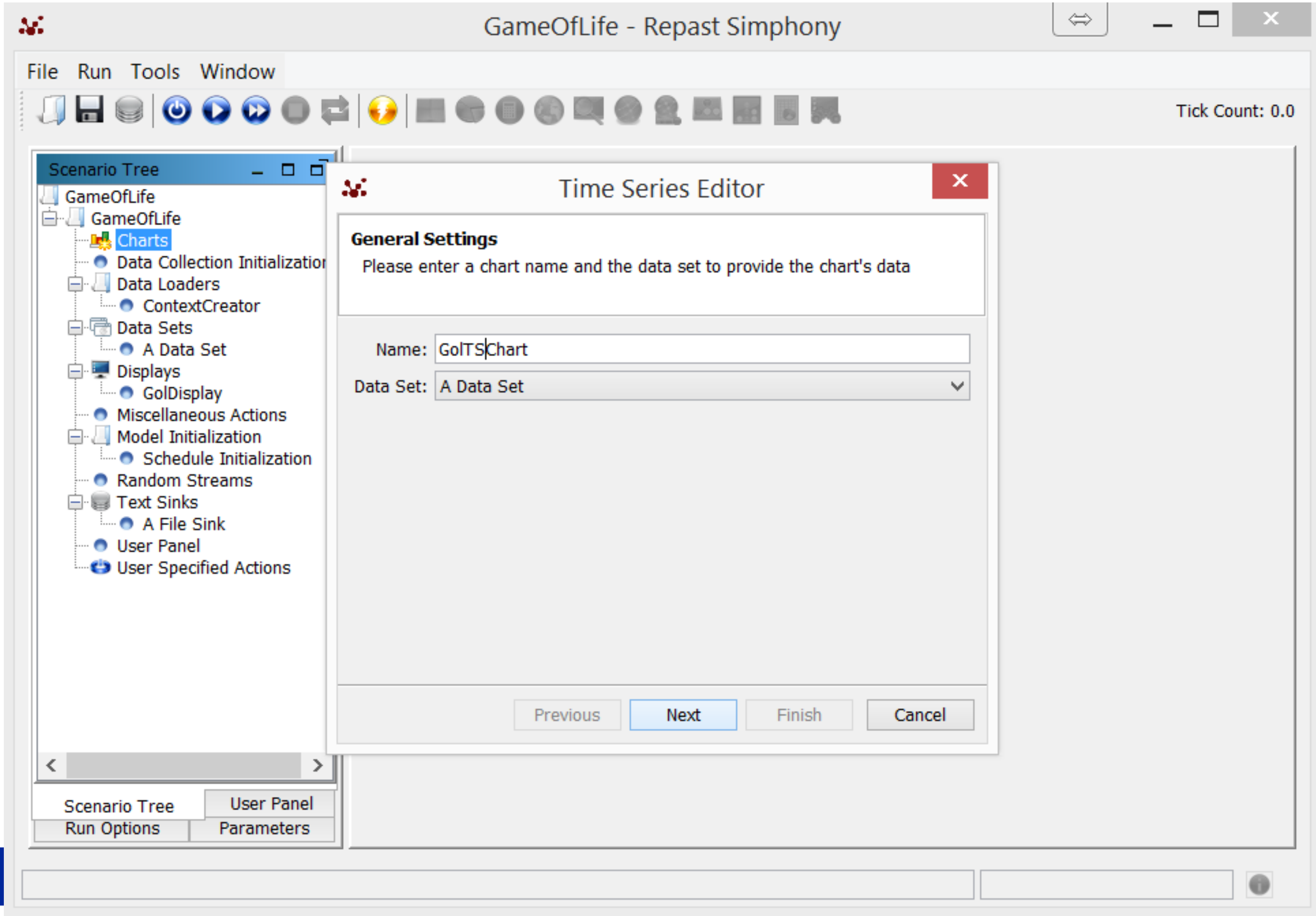

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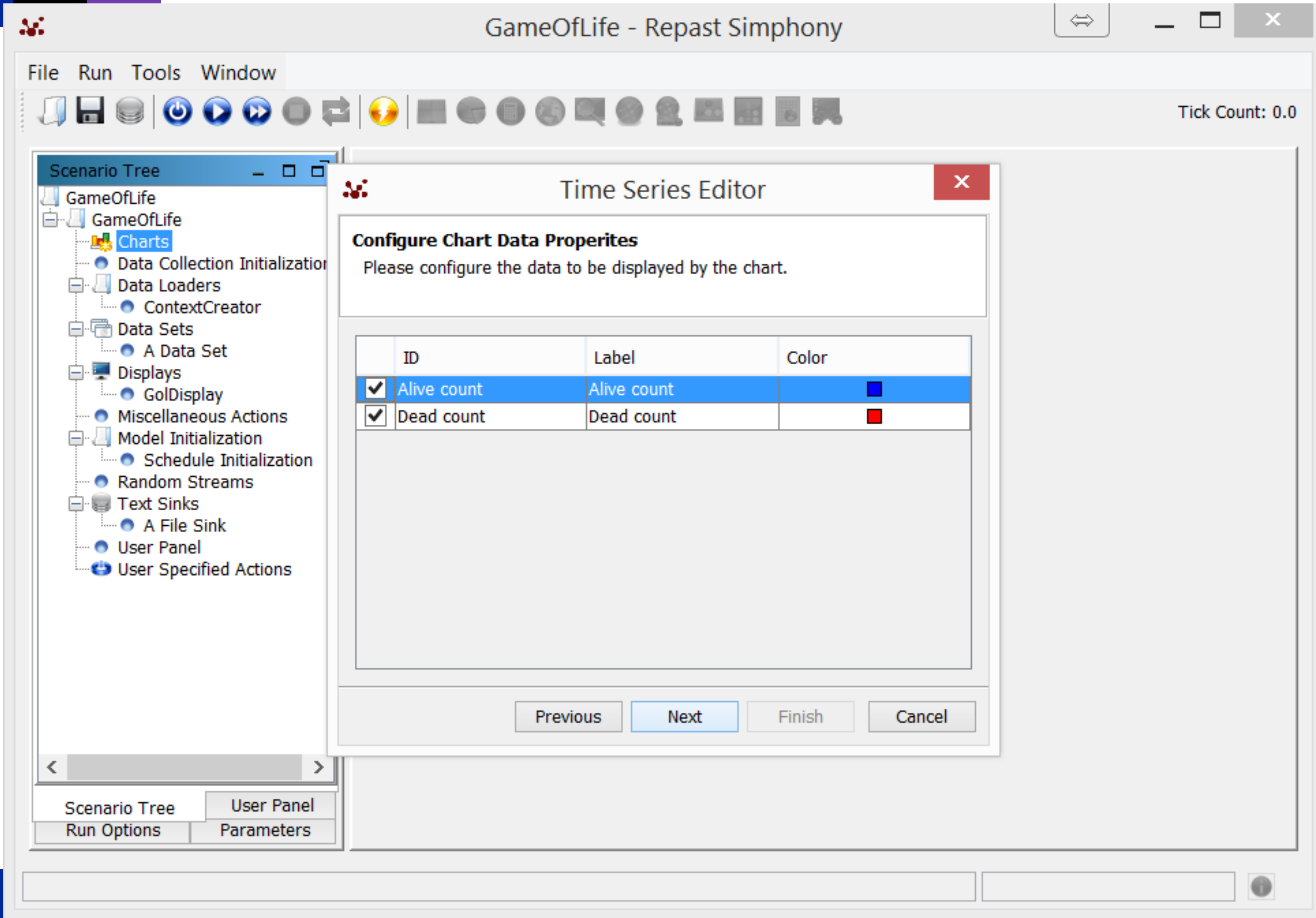

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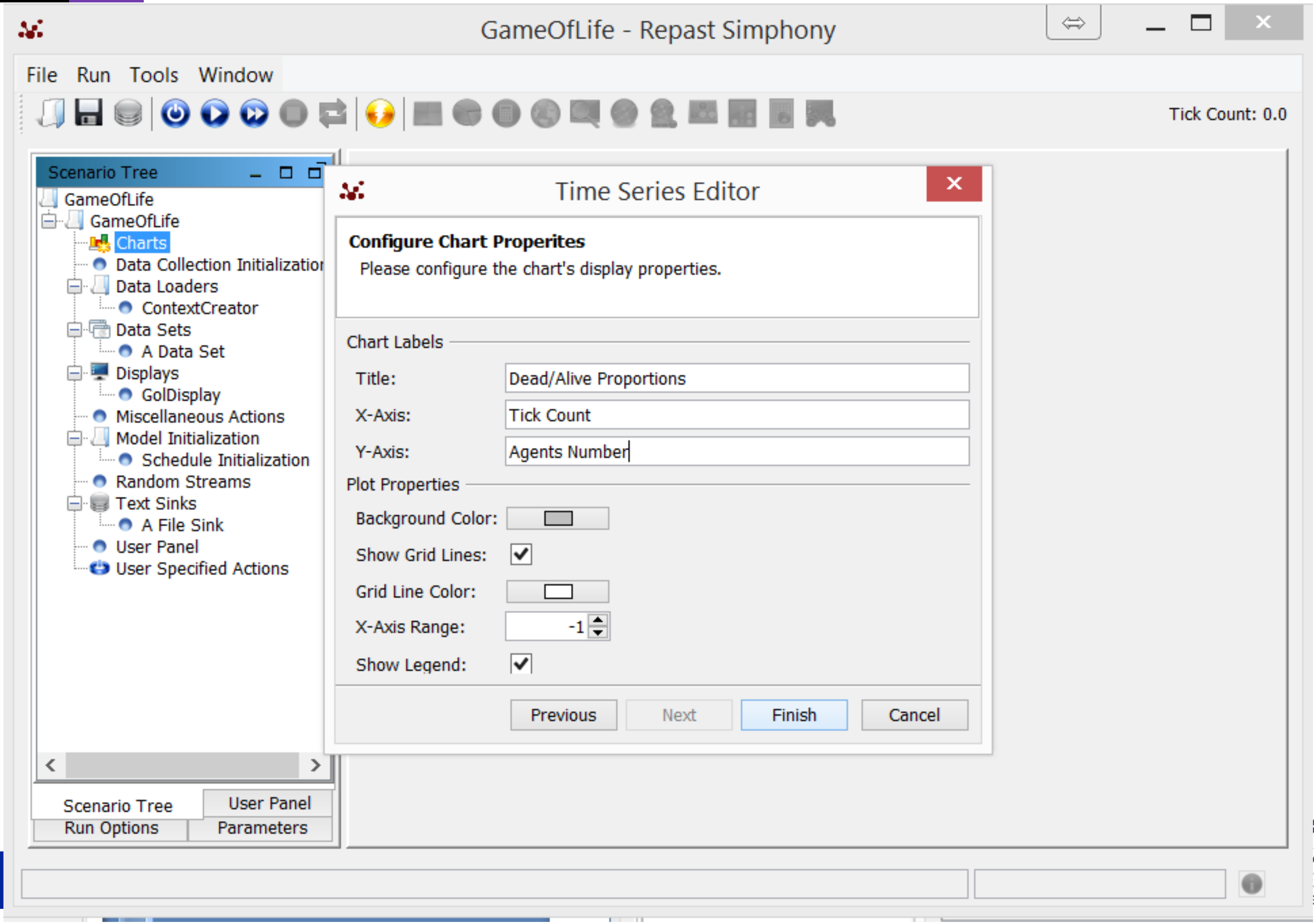

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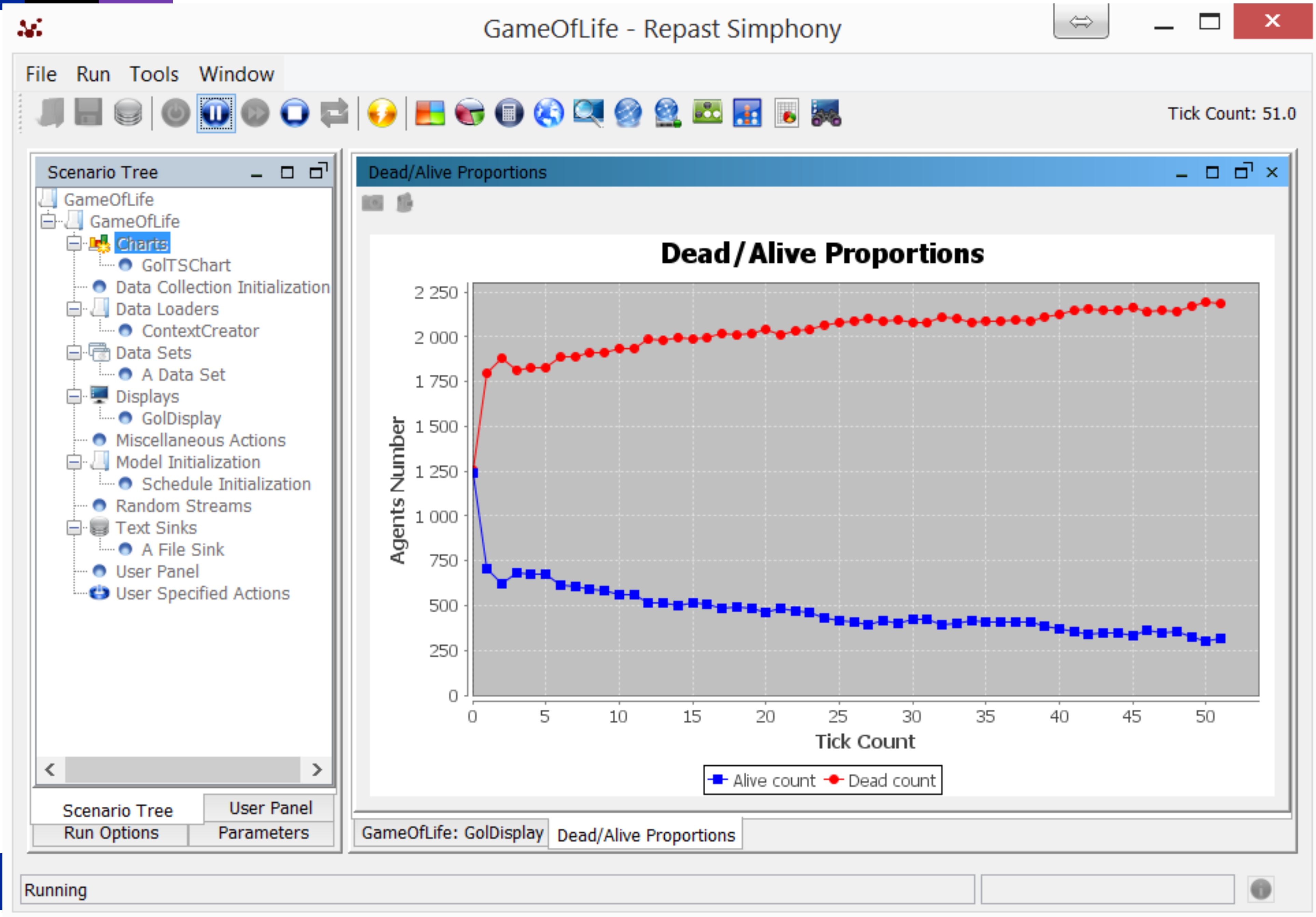

Exercice

- **Create a new project where vehicules move in a continuous space and change their color when they have more than 3 vehicles around them**
- **Continuous Space:**

```
ContinuousSpaceFactory spaceFactory =
ContinuousSpaceFactoryFinder.createContinuousSpaceFactory(null);
ContinuousSpace<Voiture> space = spaceFactory.createContinuousSpace("space", context,
        new RandomCartesianAdder<Voiture>(), new
repast.simphony.space.continuous.WrapAroundBorders(), 50, 50);
```

- **Getting the location**
  - NdPoint myPoint = space.getLocation(this);
- **Move Action**
  - Space:
    - NdPoint otherPoint = new NdPoint(50*Math.random(), 50 *Math.random());
    - double angle = SpatialMath.calcAngleFor2DMovement(space, myPoint, otherPoint);
    - space.moveByVector(this, 1, angle, 0);
  - Grid
    - myPoint = space.getLocation(this);
    - grid.moveTo(this, (int) myPoint.getX(), (int) myPoint.getY());