



Projecting Maps into the Future: Spatially Explicit Agent-Based Simulation

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Simulation and Geographic Information – a win-win situation

Realistic information for scenario building and initialization

Mapping dynamic aspects; making usage of maps in a decision making context

Simulation and Geographic Information

- Simulation systems offer interfaces for importing geographic data in different formats
 - supported by libraries for handling spatial information (e.g. GeoTools)
 - traffic simulation (vehicles, pedestrian, shipping, ...)
- GIS systems offer interfaces for program code implementing simulations
 - next step beyond spatial analytics
- Modularization of elements → build integrated systems using a simulator, spatial analytics from GIS, VR visualization...

Simulation Approaches

Many different forms have been used together with GIS

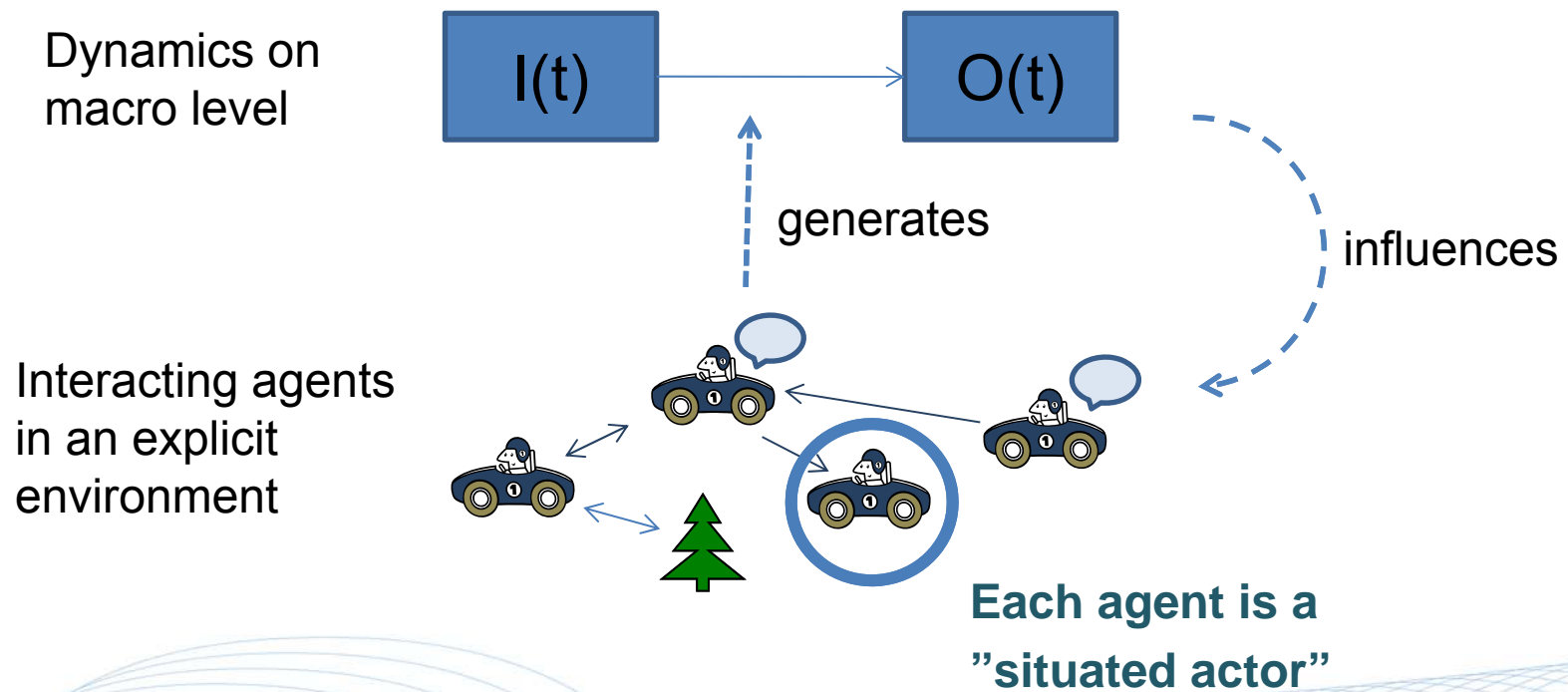
- **System dynamics**
- **Micro simulation** (economy, sociology, demography, traffic...)
- **Individual-based models** (biology, ecology)
- **Object-oriented simulation** (computer science, engineering)

→ Agent-based Modelling and Simulation

Outline

- Agent-Based Simulation
- Role and Properties of Environmental Model
- Two Examples
- SeSAM as a tool for Agent-Based Simulation
- Conclusion

Agent-Based Simulation



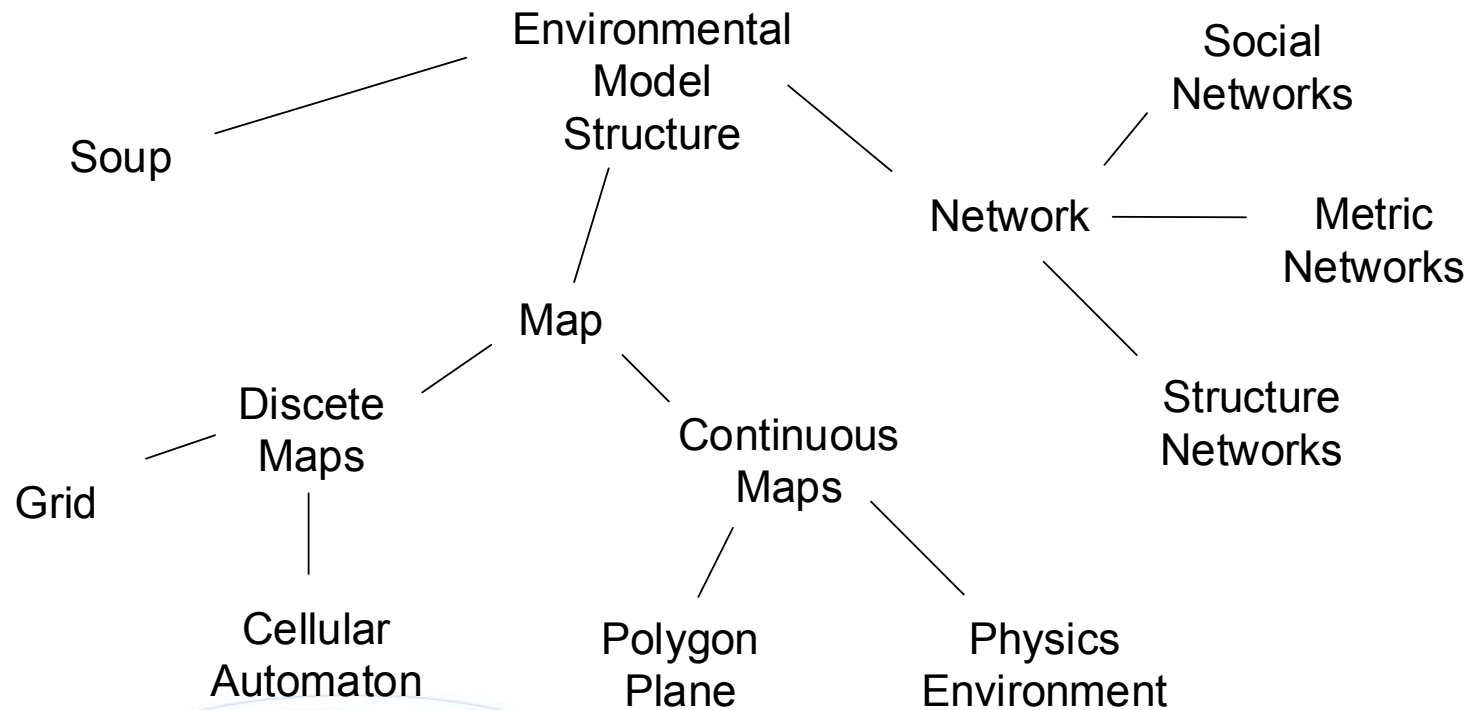
Environmental Model

- Part of the Model \leftrightarrow Infrastructure for Simulation
 - Resembles the real world/original system environment in **sufficient detail**
-
- Substrate for locality of entities
 - Ground for stigmergic interaction
 - External memory
 - In the same way as in the original system
 - Abstraction for reasoning within the agents

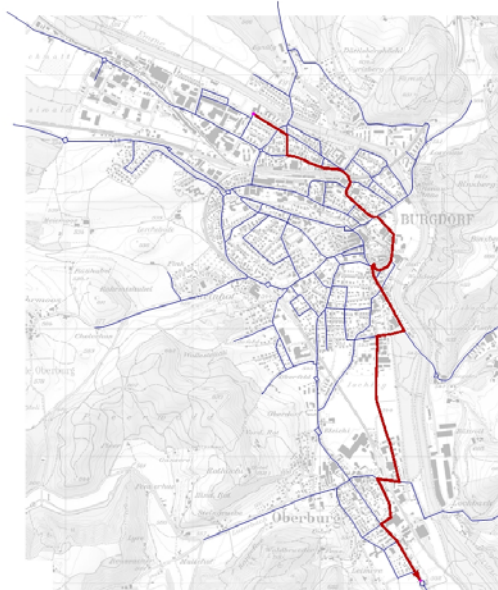
Agents interact with their environment

- Movement of entities
 - Modifying shapes
 - Generation of entities
 - Deletion of entities
 - Modifying properties
-
- Simulate effect of (many) (local) decision makers on space
 - Range of decision makers from authorities to consumers, from road operators to travelers
 - Different perspectives, indirect and direct effect

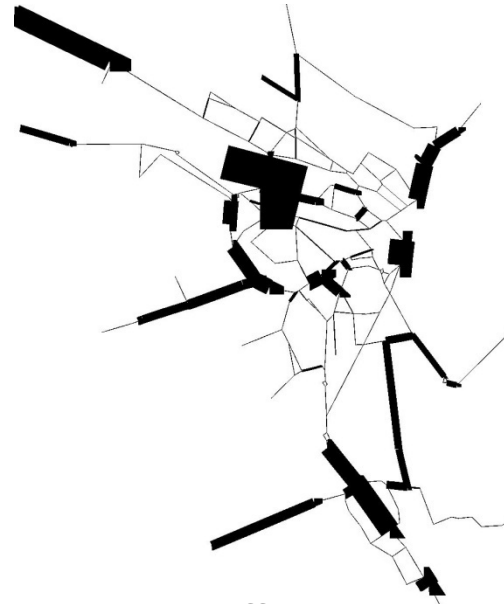
Spatial Representations for Environmental Models



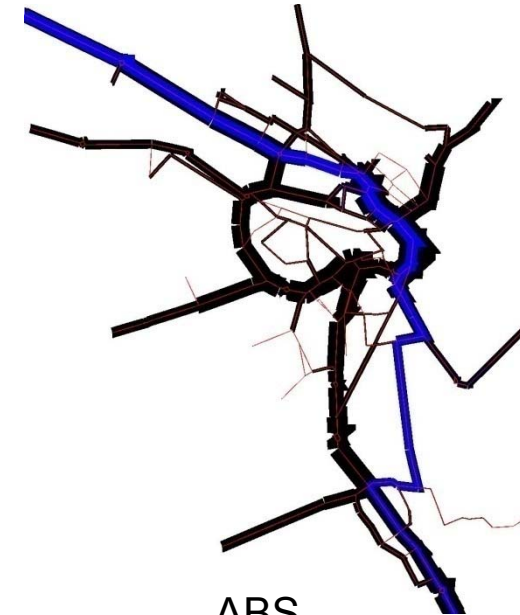
Example in Traffic



Burgdorf (2009,
Emch&Berger, Bern, CH)



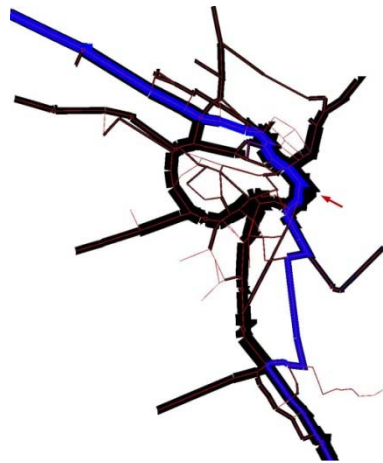
Traffic Survey Data



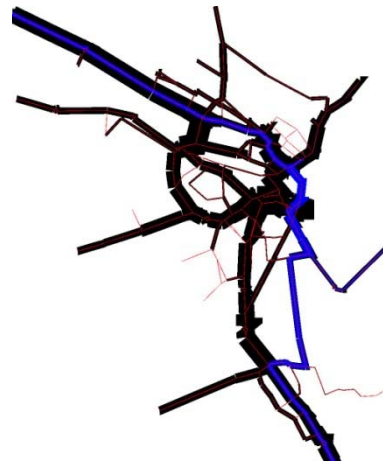
ABS,
User Optimum

With ABS we can answer...

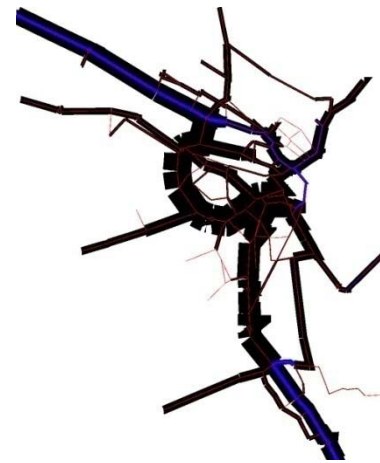
What if, a link is broken and travelers are informed in different distances?



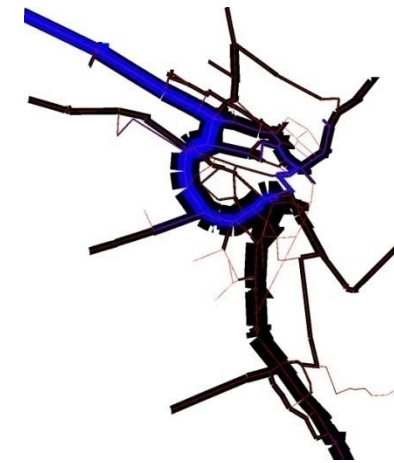
Without
Break



3 hops
away



10 hops
away



known
before
start

Another Example

What happens directly after an earthquake in a populated area?

→ what if all bridges and over/underpasses in Örebro are destroyed in a large-scale emergency situation



A kind of showcase for combination of advanced map information and complex agent-based simulation

Agents

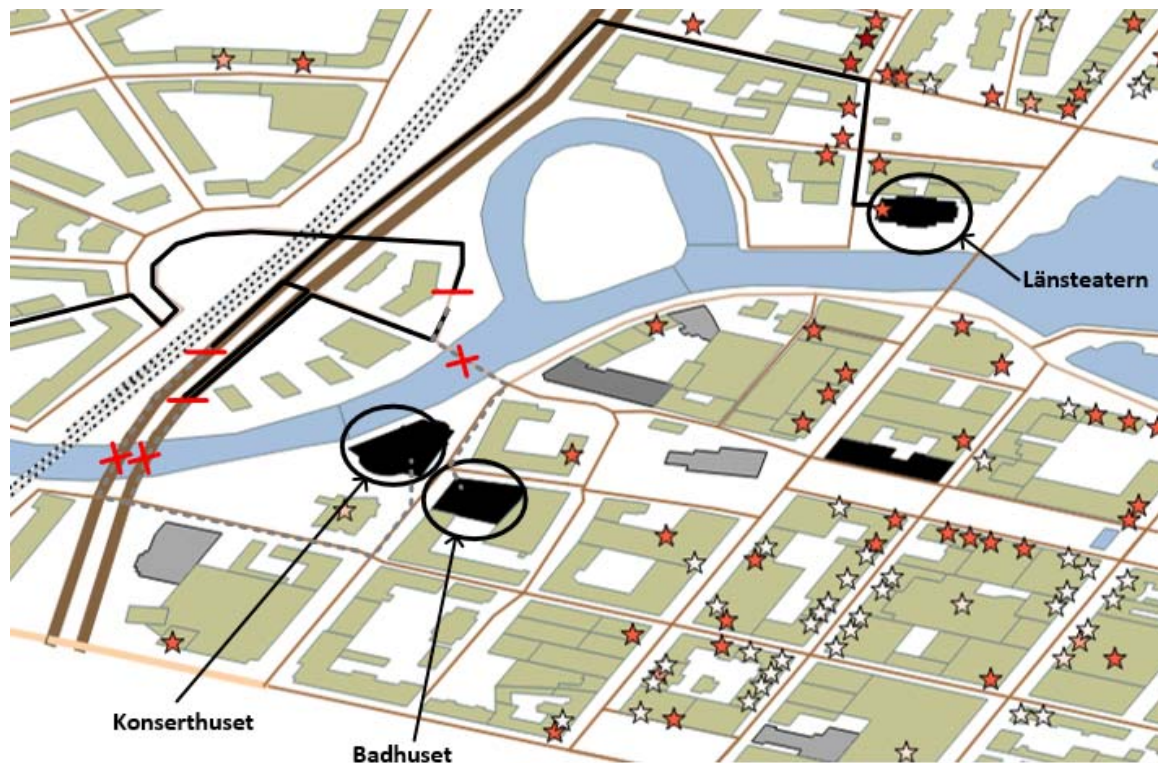
- ... have **needs** to satisfy (hunger, medical help, safety, information)
- ... want to find **places** where these needs can be fulfilled

- ... in stead of just using the object class, we add an additional **information layer with affordances**:
- ... agents **plan route** to selected object using their mental map
- ... update map if it discovers inconsistencies or if another person informs about changes
- ... if new information → feasibility of path is checked and updated

Environmental Model



Trajectory produced by agents' reasoning



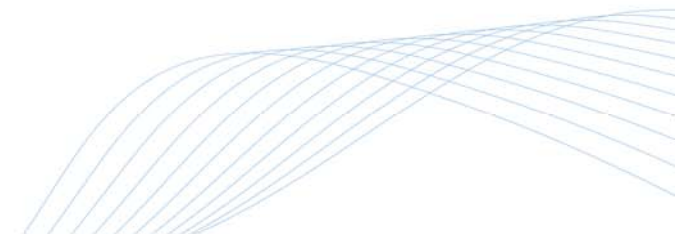
SeSAm

- **Shell for Simulated MultiAgent Systems**
- Vision: Providing a tool so that multiagent simulation is accessible to people without training in formal programming languages
- Idea: Combine the a **high-level declarative language** for describing the simulation model with **powerful visual programming**
- **Import/Export Shape-Files and OSM-Files**

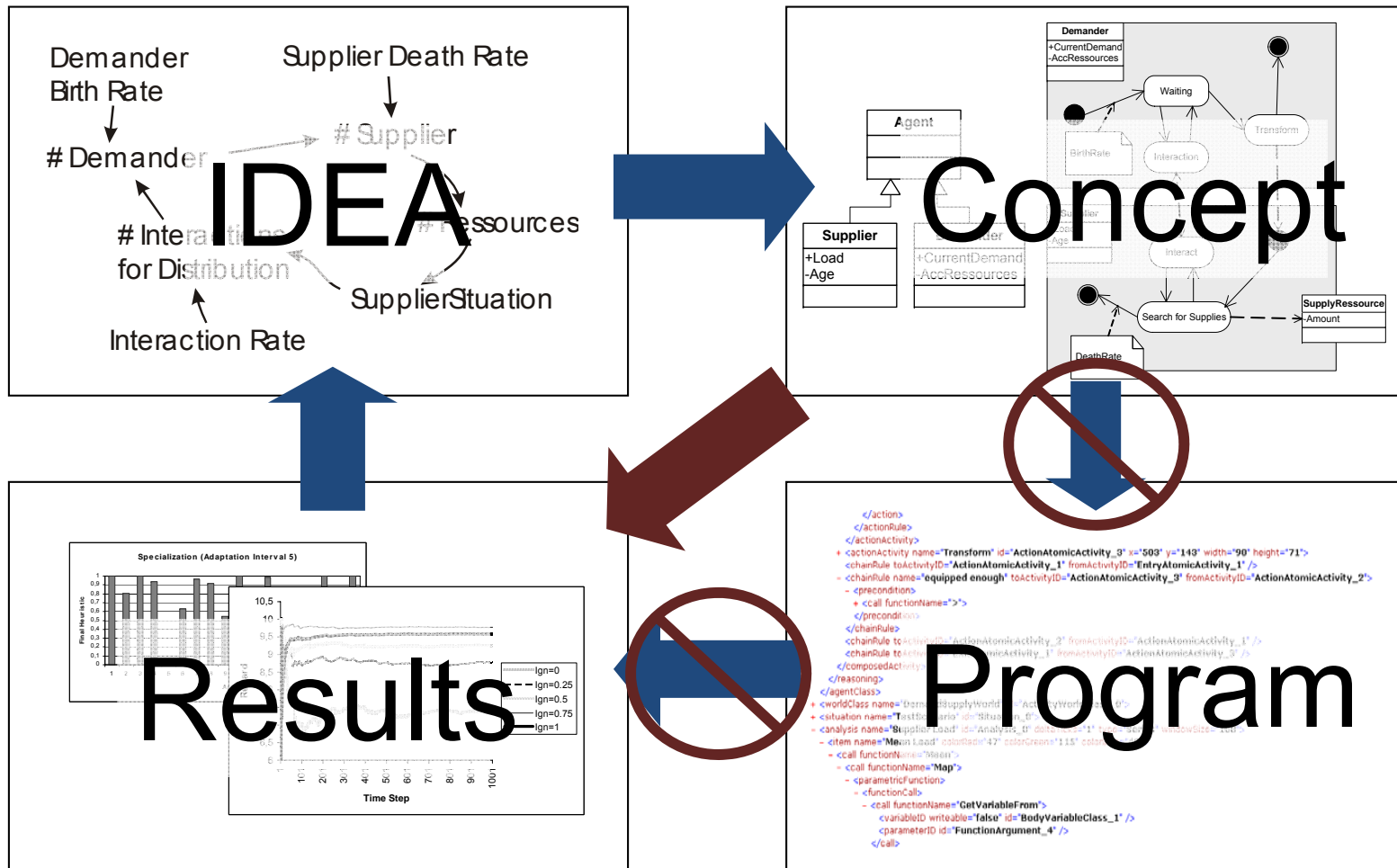
→ Rapid Prototyping for Experts

→ Easy Development for Novices

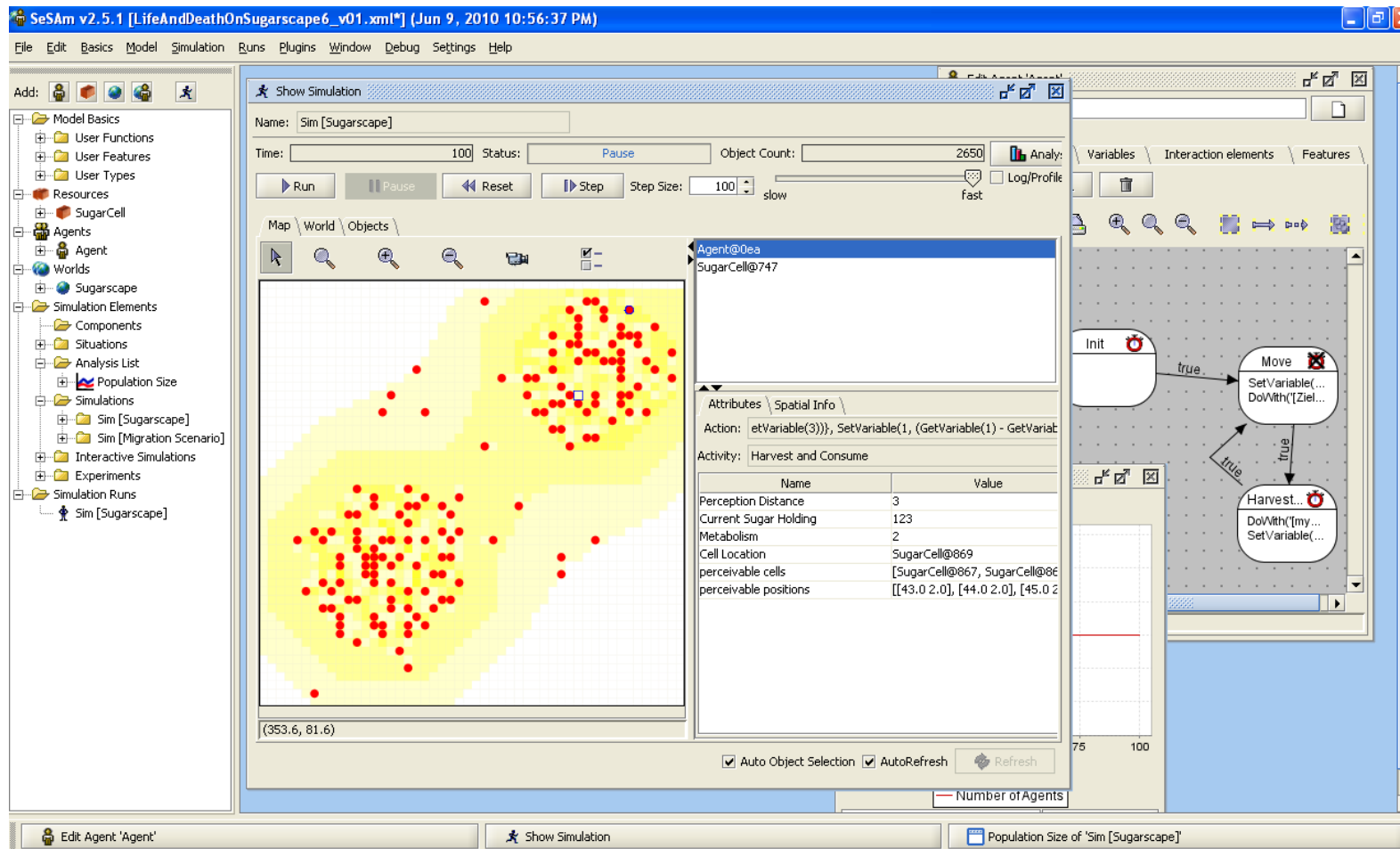
www.simsesam.org



SeSAM in the Process



How it looks like...



The screenshot displays the SeSAM v2.5.1 software interface. The main window is titled "Show Simulation" and shows a simulation named "Sim [Sugarscape]". The simulation is currently paused at time 100, with 2650 objects present. The simulation area shows a grid of yellow cells representing a landscape, with red dots representing agents. A detailed view of an agent, "Agent@Oea SugarCell@747", is shown in the center, displaying its attributes and actions. The agent's activity is "Harvest and Consume". The attributes table shows the following values:

Name	Value
Perception Distance	3
Current Sugar Holding	123
Metabolism	2
Cell Location	SugarCell@869
perceivable cells	[SugarCell@867, SugarCell@868, SugarCell@869, SugarCell@870]
perceivable positions	[[43.0 2.0], [44.0 2.0], [45.0 2.0], [46.0 2.0]]

The interface also includes a left-hand navigation pane with a tree view of the model structure, a top menu bar, and a bottom status bar showing the current agent and simulation details.

Summing Up

- Agent-based Simulation with environmental models using geographic information
- It is feasible, useful and has great potential
- Variety of tools are available for users with different expertise

Future?

- More applications with more elaborate map data
- Virtual Reality for Interaction with Users
- Integration of sensors