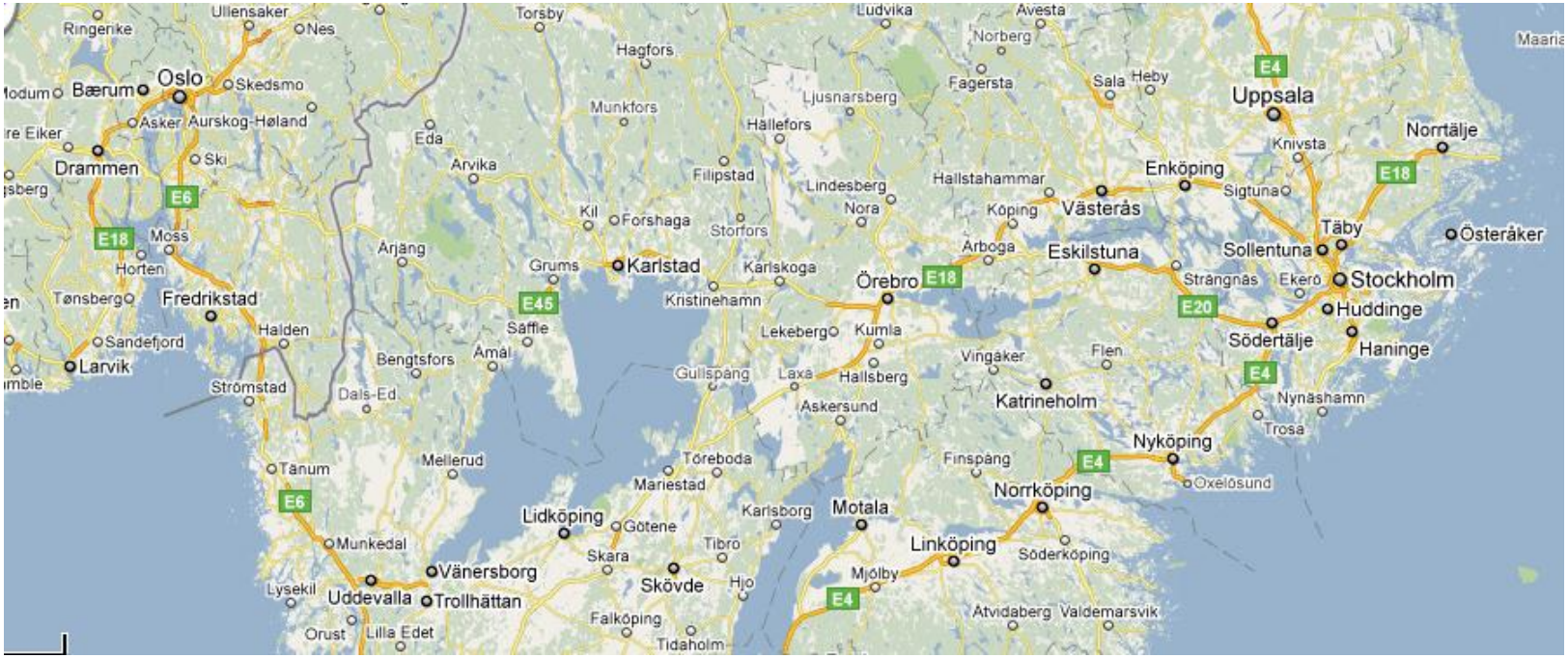
Use of Multiagent Systems in Simulation

Örebro University, Sweden

Franziska Klügl

Örebro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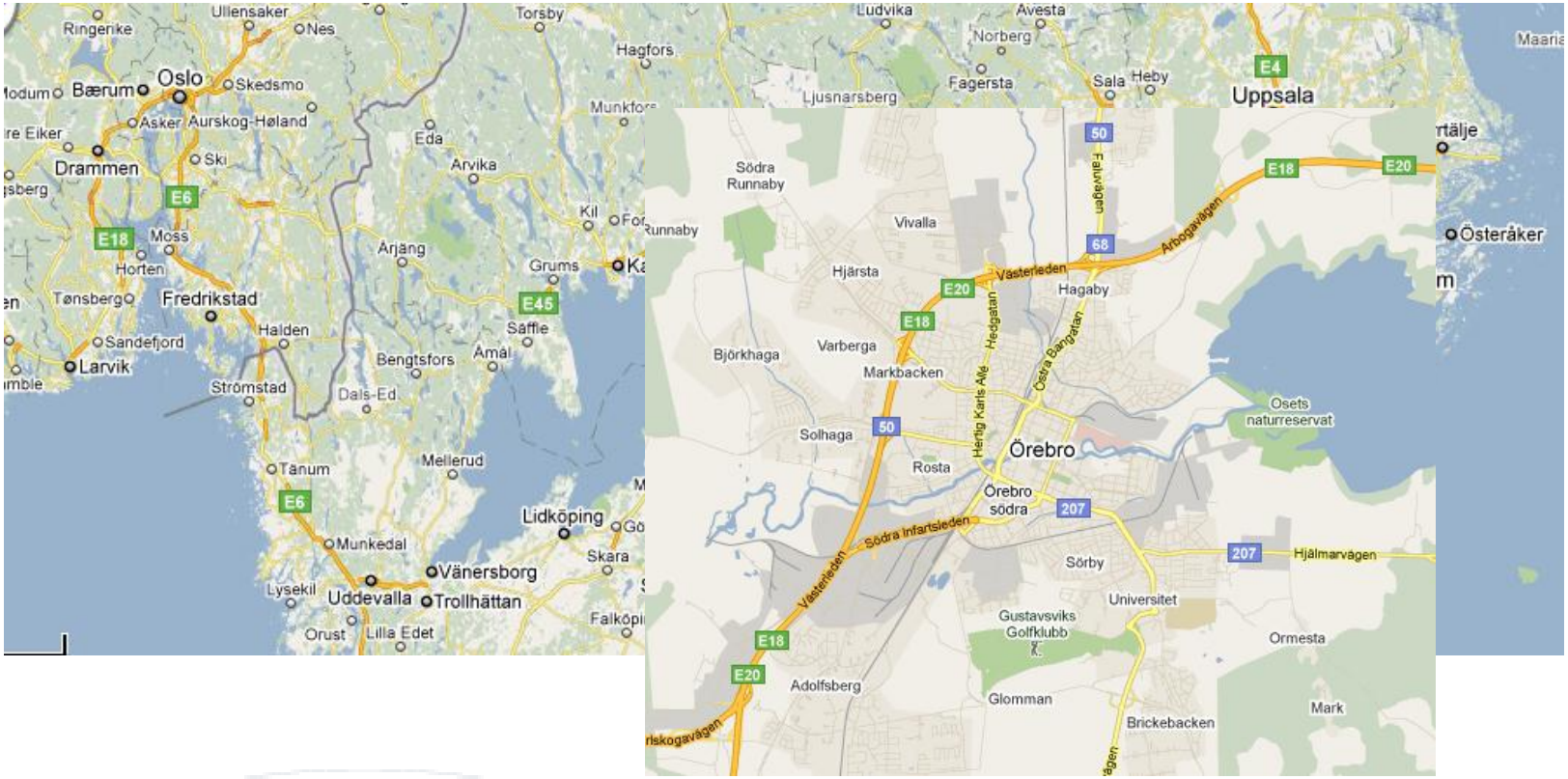
Örebro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Österåker

Örebro Universitet

16’000 Students
90 Programms
>100 Professors
500 PhD Students

Agenda for the next hour …

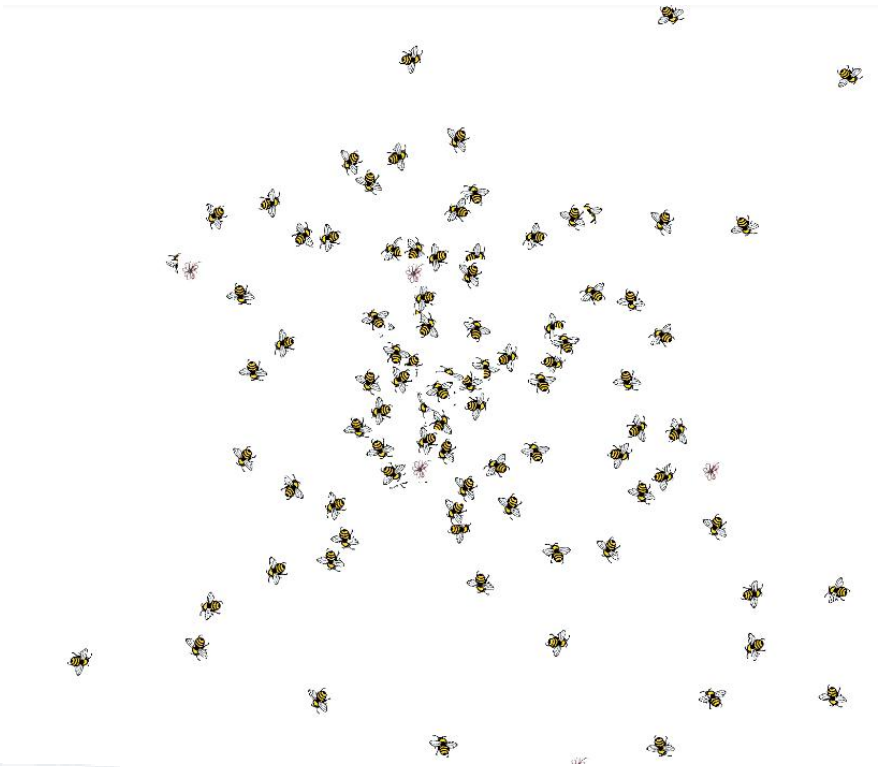
What is Multi-Agent Simulation?
  Multiagent Systems + Simulation

Properties and Elements of a model

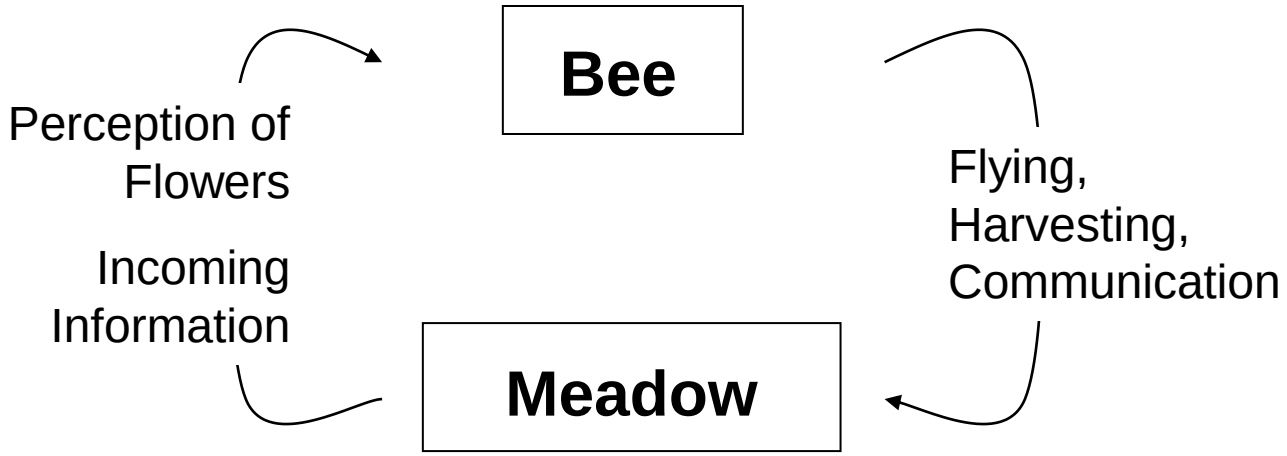
Application Example

Research Trends

Lets start with an example ...



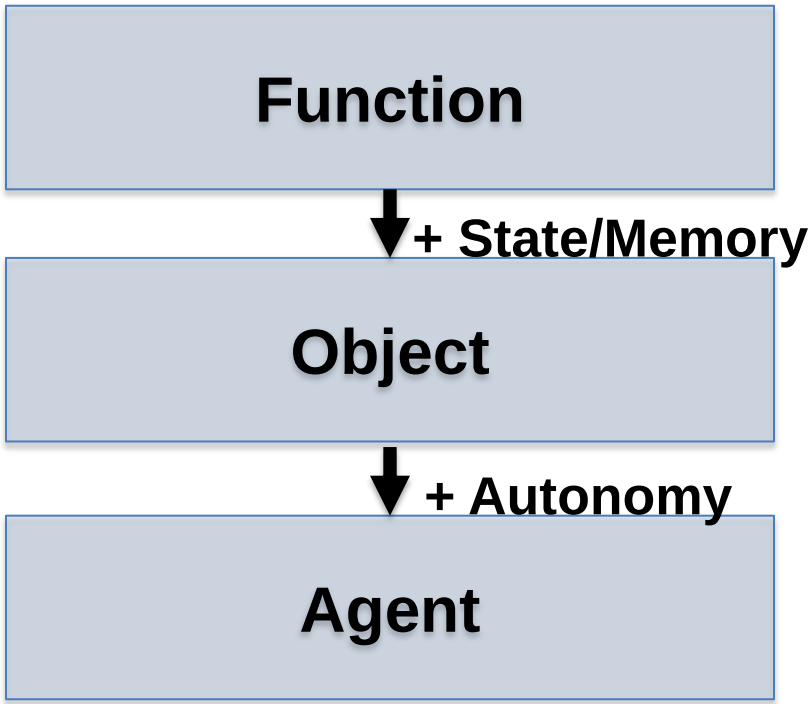
Bees


Bee
Perception of Flowers
Incoming Information
Meadow
Flying, Harvesting, Communication

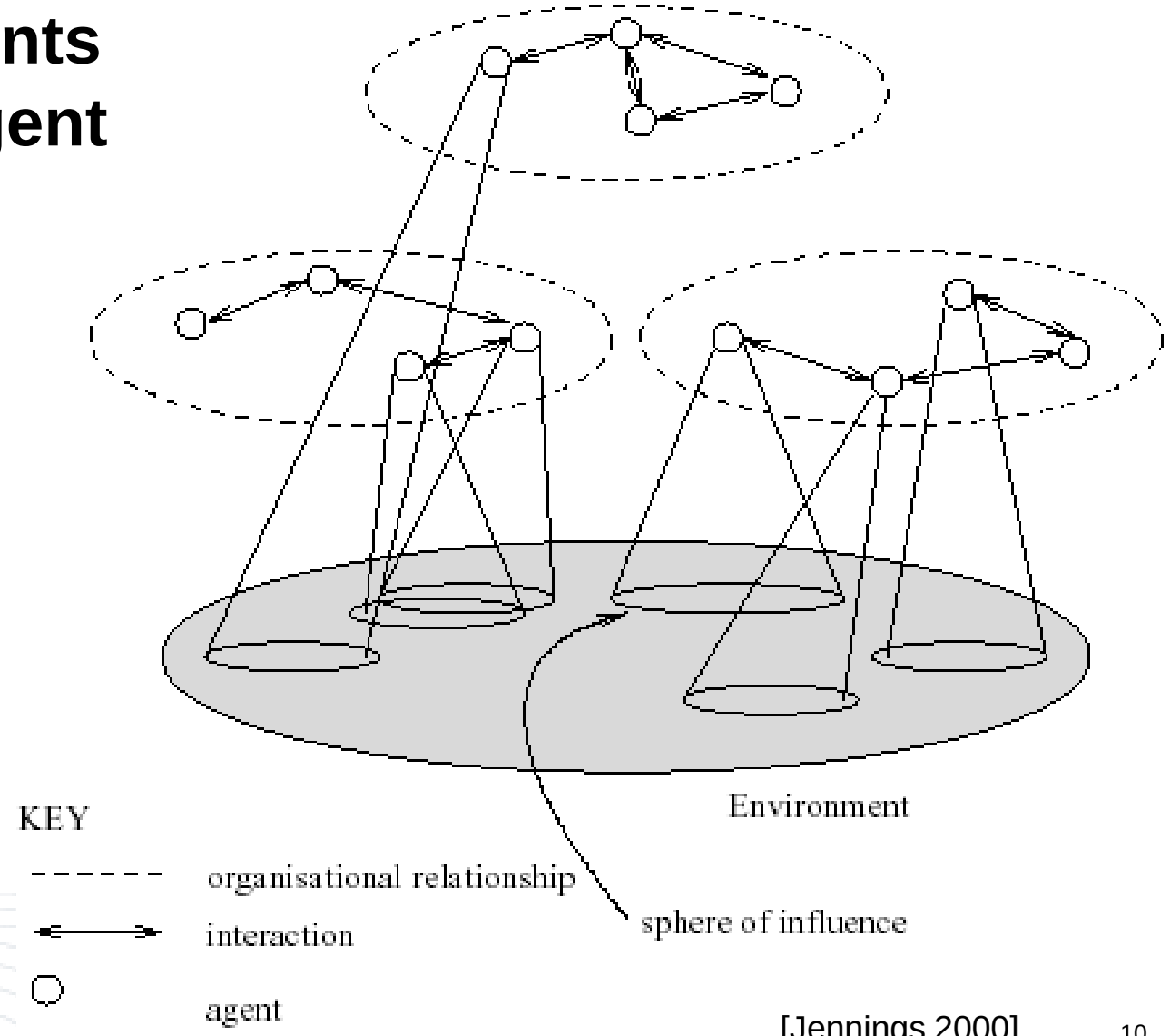
Agent as Situated Actor

Discrete entity with its own goals and behaviors, autonomous, capable to adapt its behaviors in interaction with its environment

Agent Metaphor in Computer Science



From Agents to Multiagent Systems



[Jennings 2000]

Characteristics of Multiagent Systems

- Every agent only possesses incomplete knowledge and restricted capabilities and potentially individual, in-compatible goals
- Overall system control is distributed
- Data storage is distributed
- Computations are a-synchronous

→ Heterogeneity of entities
→ Interaction, communication, cooperation
→ High-level, intuitive system and entity description
→ Inherent Modularity, Open Systems

Central Issues in Multiagent System

Who is interacting when how with whom to reach the intended overall goal?

- **Bottom-up**: What abilities/behaviors does a single agent have to possess for producing the right outcome on the macro level?
- **Top-down**: What rules on the macro level form the appropriate constraints for the interactions of the individual agents?

→ Two problem areas: **Agent Design** and **Society Design**

Central Issues in Multiagent System

Who is interacting wh intended overall goal?

- **Bottom-up**: Wha agent have to possess f n the macro level?
- **Top-down**: What e appropriate const ndividual agents?

Agent Architectures
Techniques from Artificial Intelligence
(Single-) Agent Learning

→ Two problem areas: **Agent Design** and **Society Design**

Central Issues in Multiagent System

Who is interacting wh intended overall goal?

- **Bottom-up**: Wha agent have to possess f the macro level?
- **Top-down**: What appropriate const dividual agents?

Distributed Decision Making
System Architectures,
Organizations, Coordination
Interaction Protocols,
AOSE

→ Two problem areas: **Agent Design** and **Society Design**

What is “Multi-Agent Simulation”?

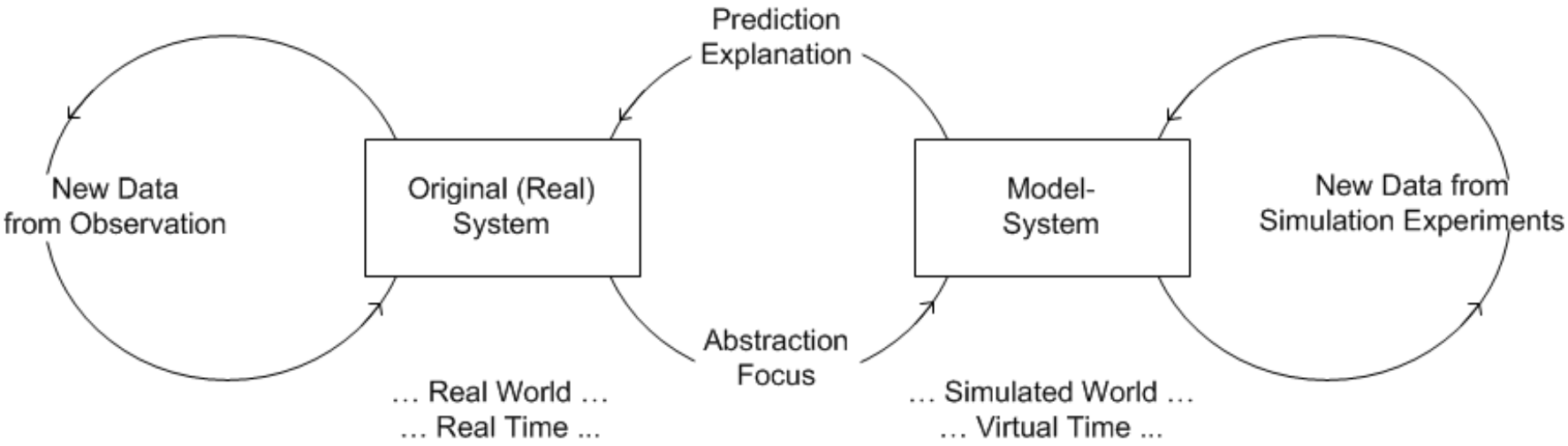
Multi-Agent Simulation is a (computational) modeling and simulation paradigm that uses the concept of a **multiagent system as the basic metaphor** of the simulation model.

Related Terms

- Agent-based Simulation (ABS)
- Multiagent Based Simulation (MABS)
- Agent-oriented Simulation
- ...

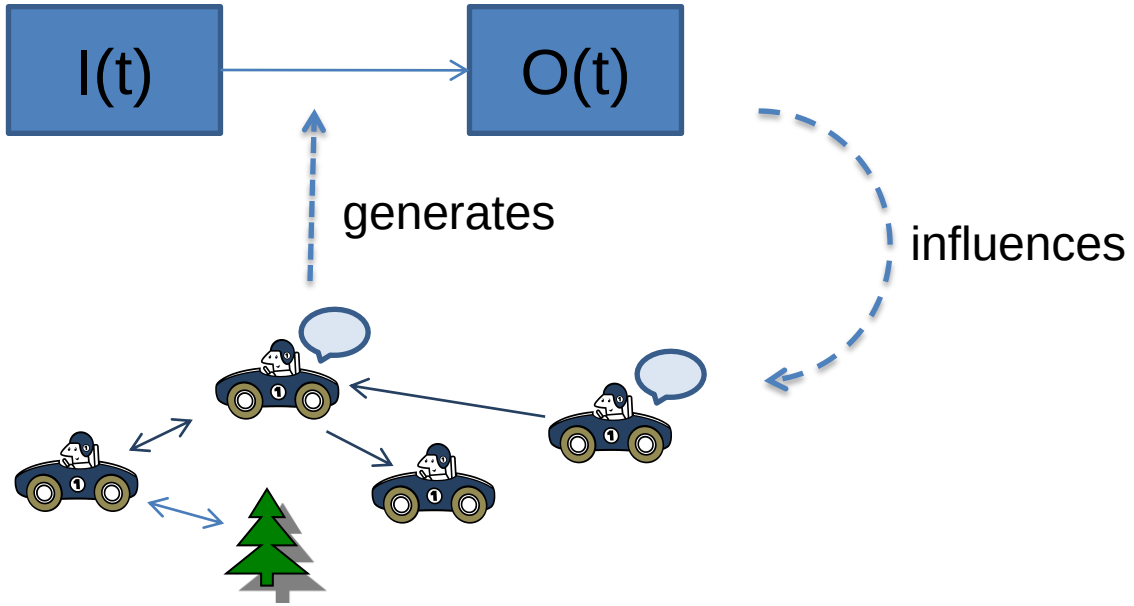
Modell? Simulation?

Model = ”any image which can be considered as a *system* and is used by a *subject* to obtain information about another system”



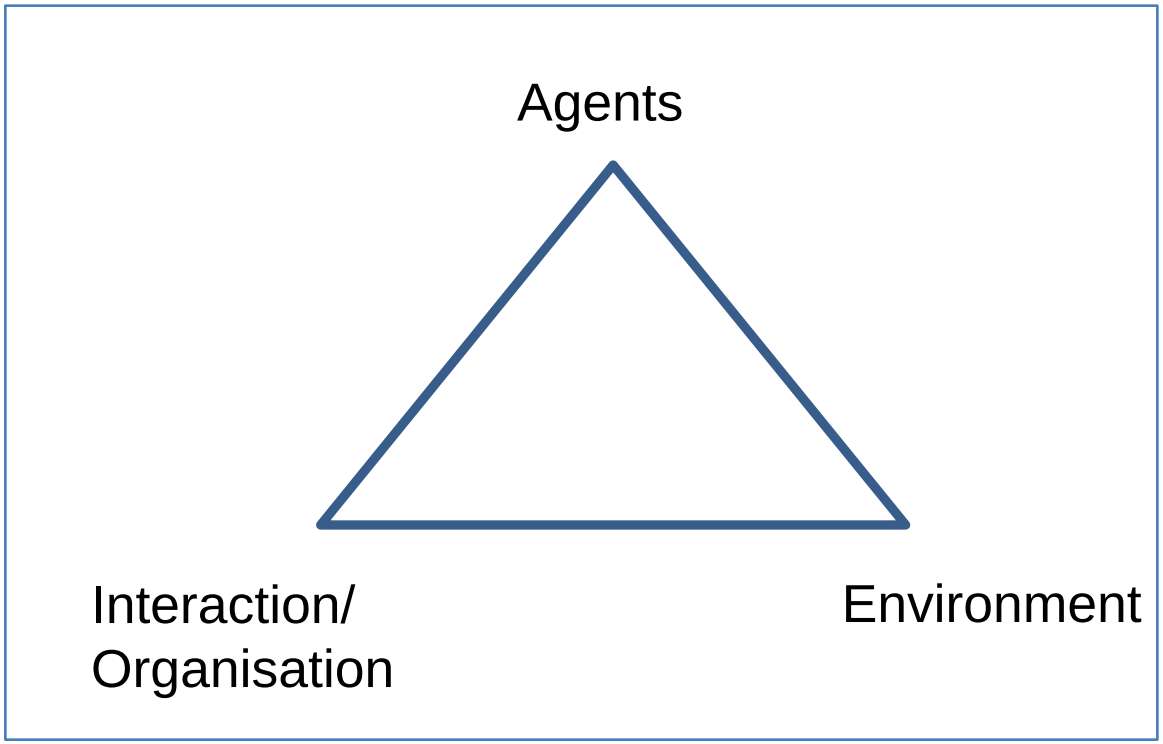
Basic Idea: Generative Simulation

Dynamics on macro level

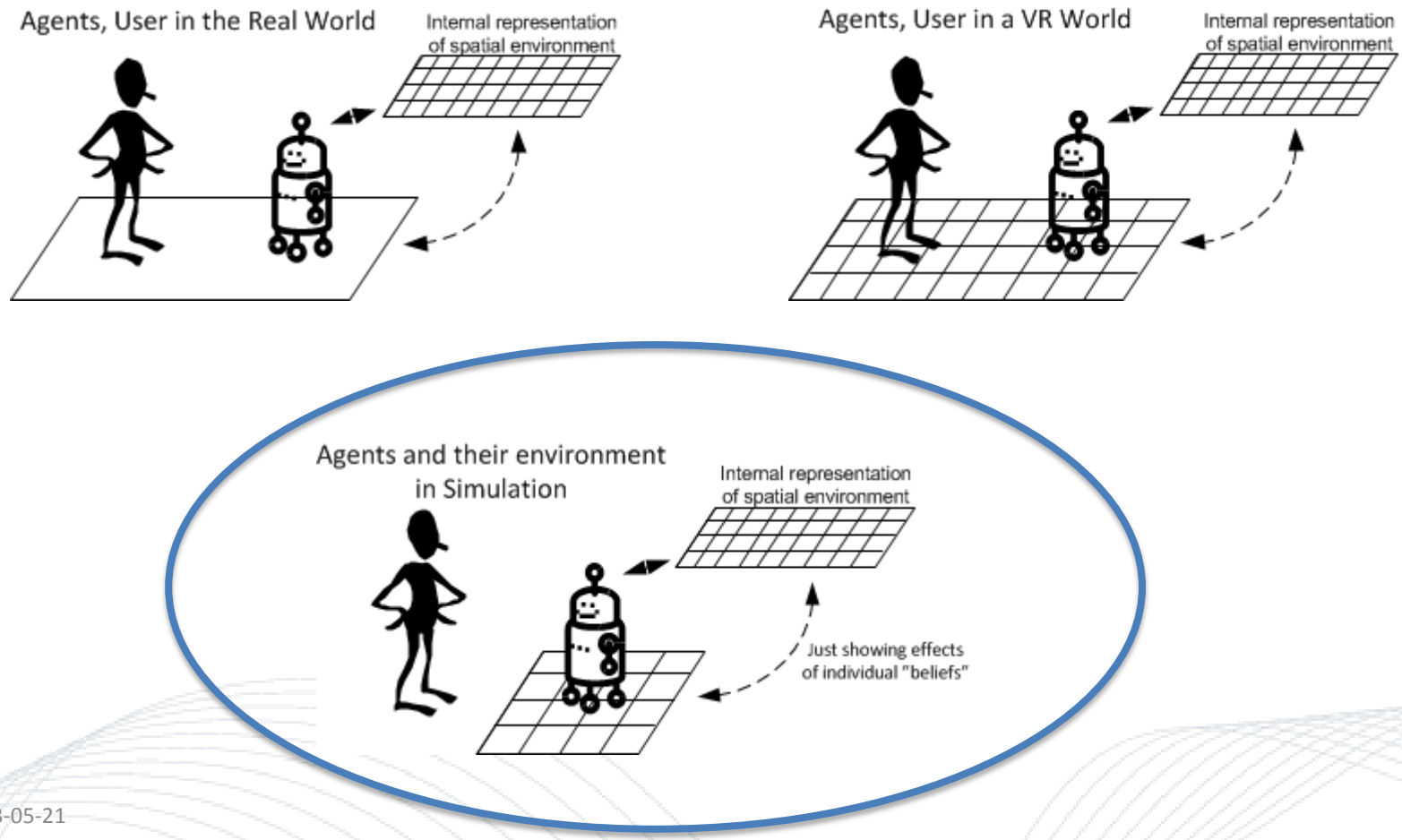


Interacting agents in an explicit environment

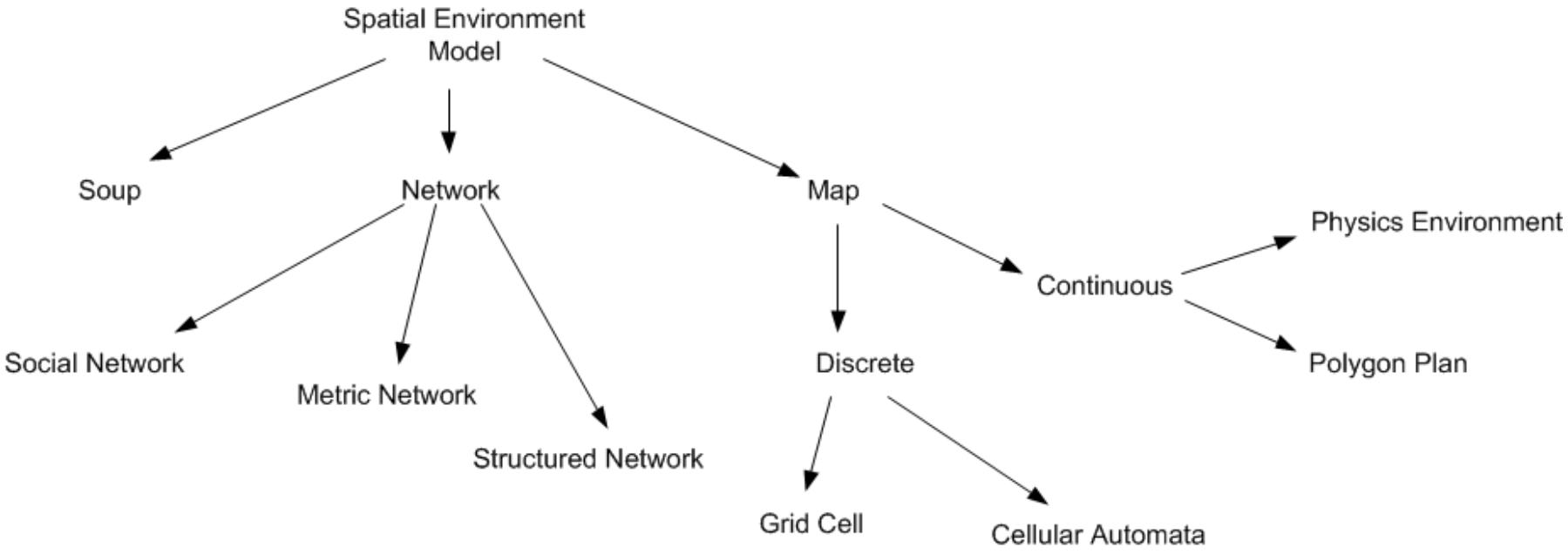
Elements of a Multiagent Simulation Model



Role of simulated environment

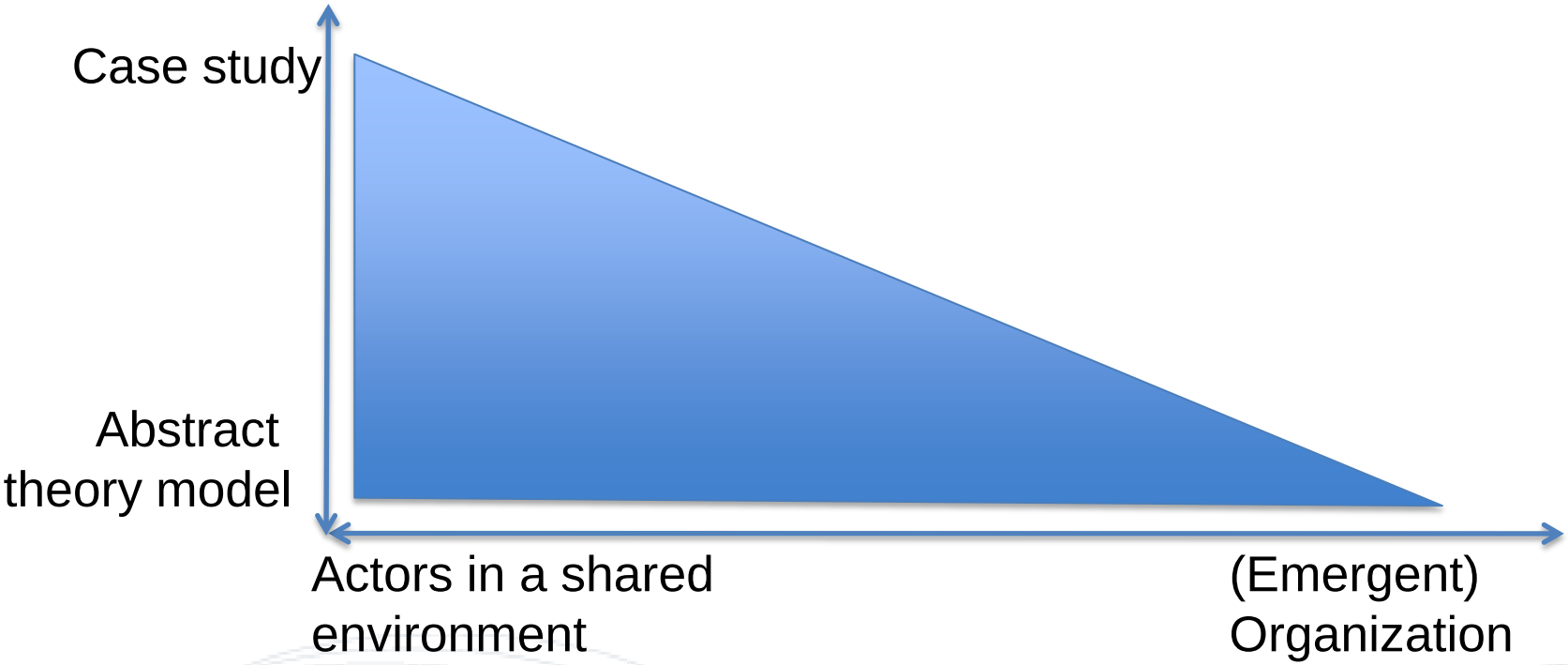


Spatial Representations



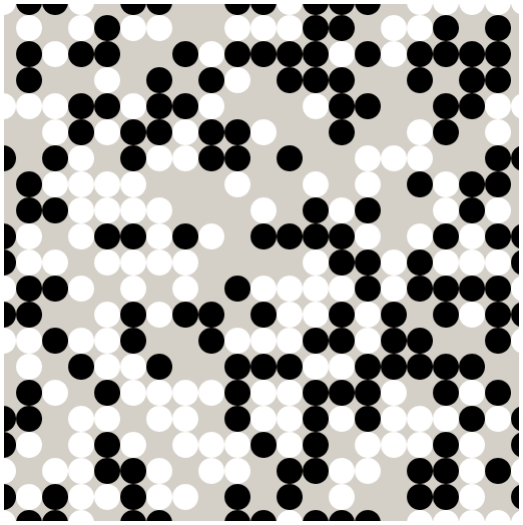
→ Dimension, Location Set, Orientation Set, Distance Function, Agent Extension, Dynamics

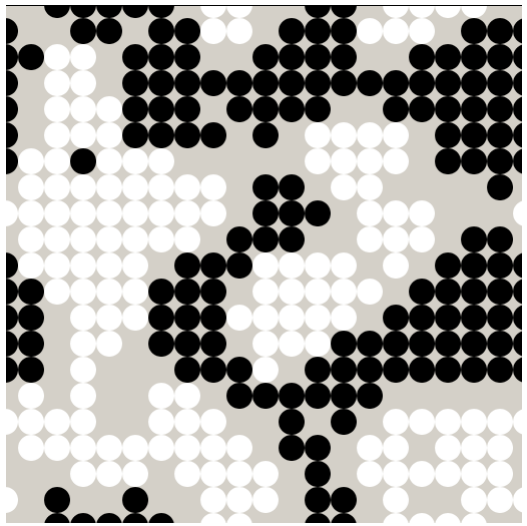
Core Types of Models



First Multi-Agent Simulation

”Checkers” Model of Urban Segregation





Movie

Glance on Application Areas

Social Science and Economic Simulation:
From Artificial Societies for testing scientific hypothesis to Market Design

Biological/Ecological Systems:
active, heterogeneous entities (e.g animals) exert influences on their local environment reacting on local stimuli → Land Use Simulations

Epidemiology and other areas of medicine

Traffic Simulation:
Microscopic models are more and more enhanced by intelligent abilities of the (single) simulated traffic participants

Military Simulations

Technical Simulation (Production, In-House Logistics…)
with relevant non-technical parts, like humans, etc.

Testbeds for Multi-Agent Systems

Benefits

- Allows modeling a system on **arbitrary level of detail**
  - Complex, also **non-rational** agents
  - Heterogeneities
  - **Flexible** interactions
  - Variable structures
- Natural integration of **geo-spatial context** and effects
- Complex **self-organizing** phenomena based on low-level adaptation/evolution
- Allows to formulate models in an **intuitive** and understandable way

Why now?

- Systems to be analysed more complex
  - Decentralization of decision making (deregulation of energy markets, local decision making ...)
  - Systems approaching limits (transportation networks)
  - Increasing dependencies, physcial, economic,...
- Availability of data on finer granularity
- Availability of computing power supporting complex micro simulation
- Tools are now available to potentially handle complexity

Why now?

- Systems to be
  - Decentral
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  - Increasin
- Availability
- Availabil
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- Tools are now availa

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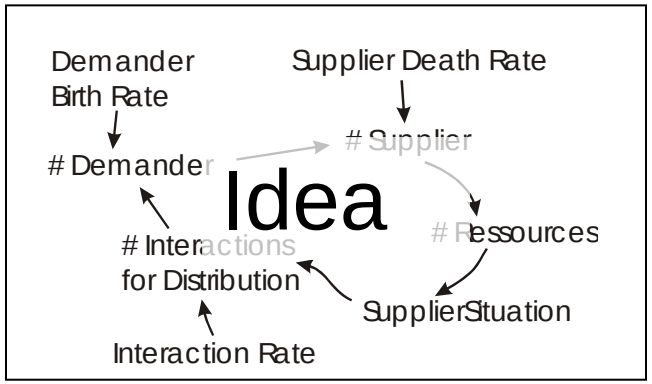
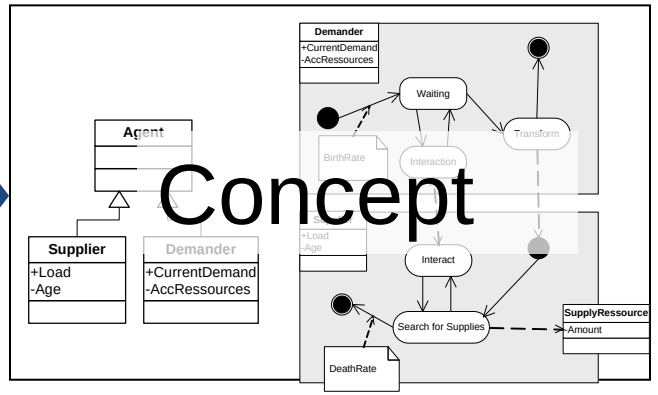
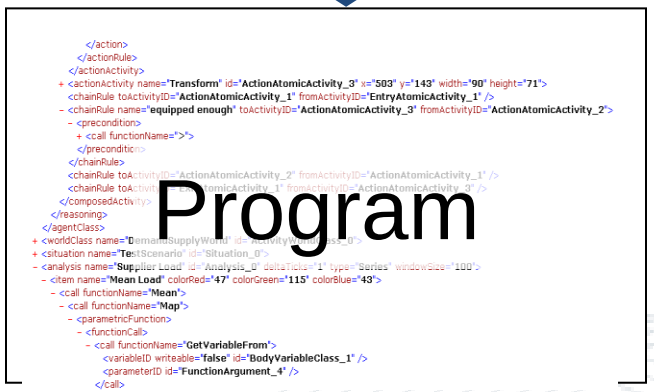
There is NO
- Accepted, shared, formal language for model representation
- Accepted, shared methodology for developing Multiagent Simulation Models
- Accepted, shared meta-model

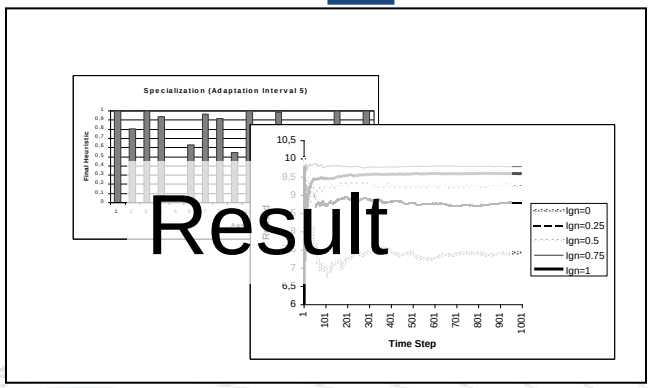
→ Computational modeling with ”best practices”

Systematic Development (???)

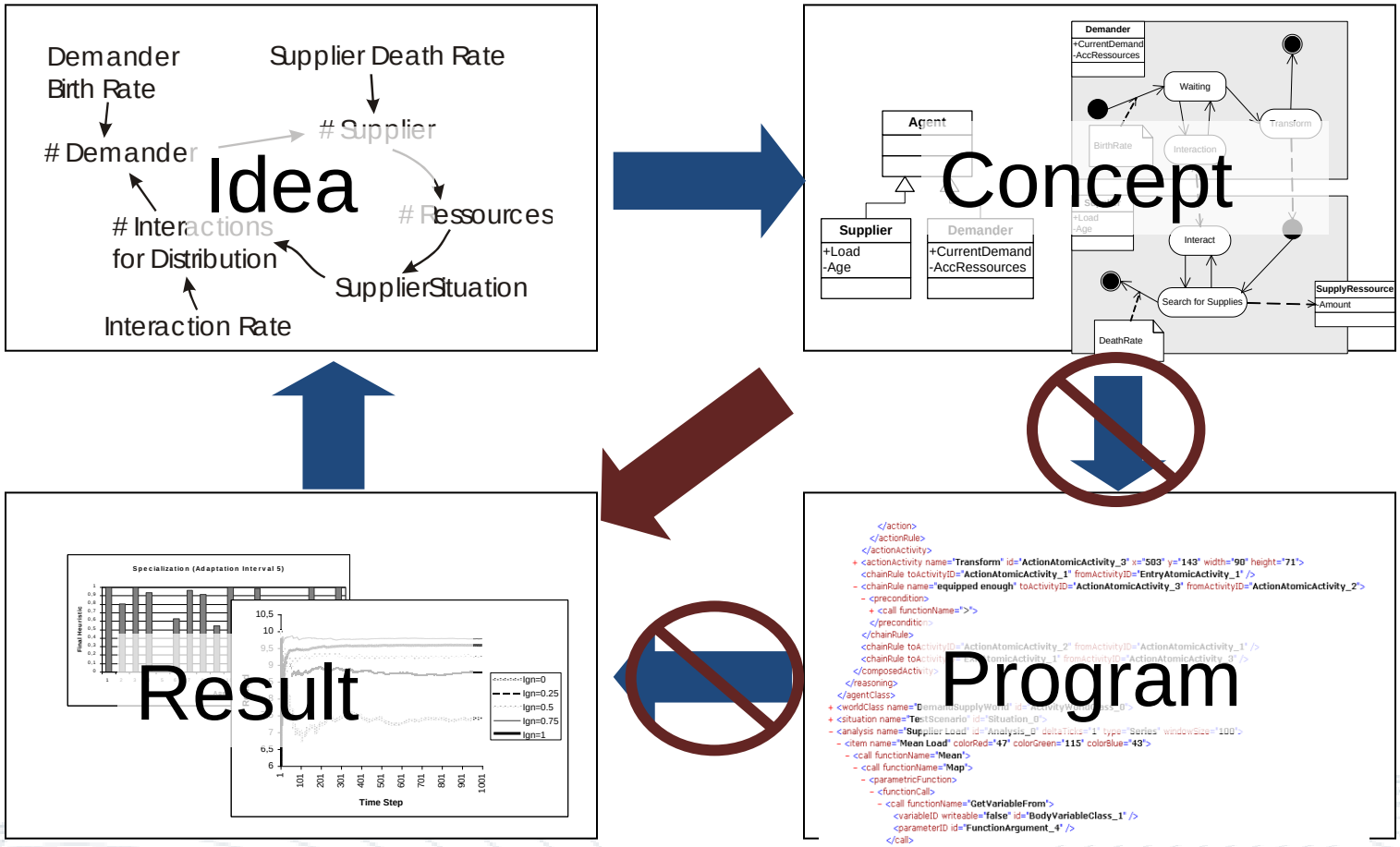






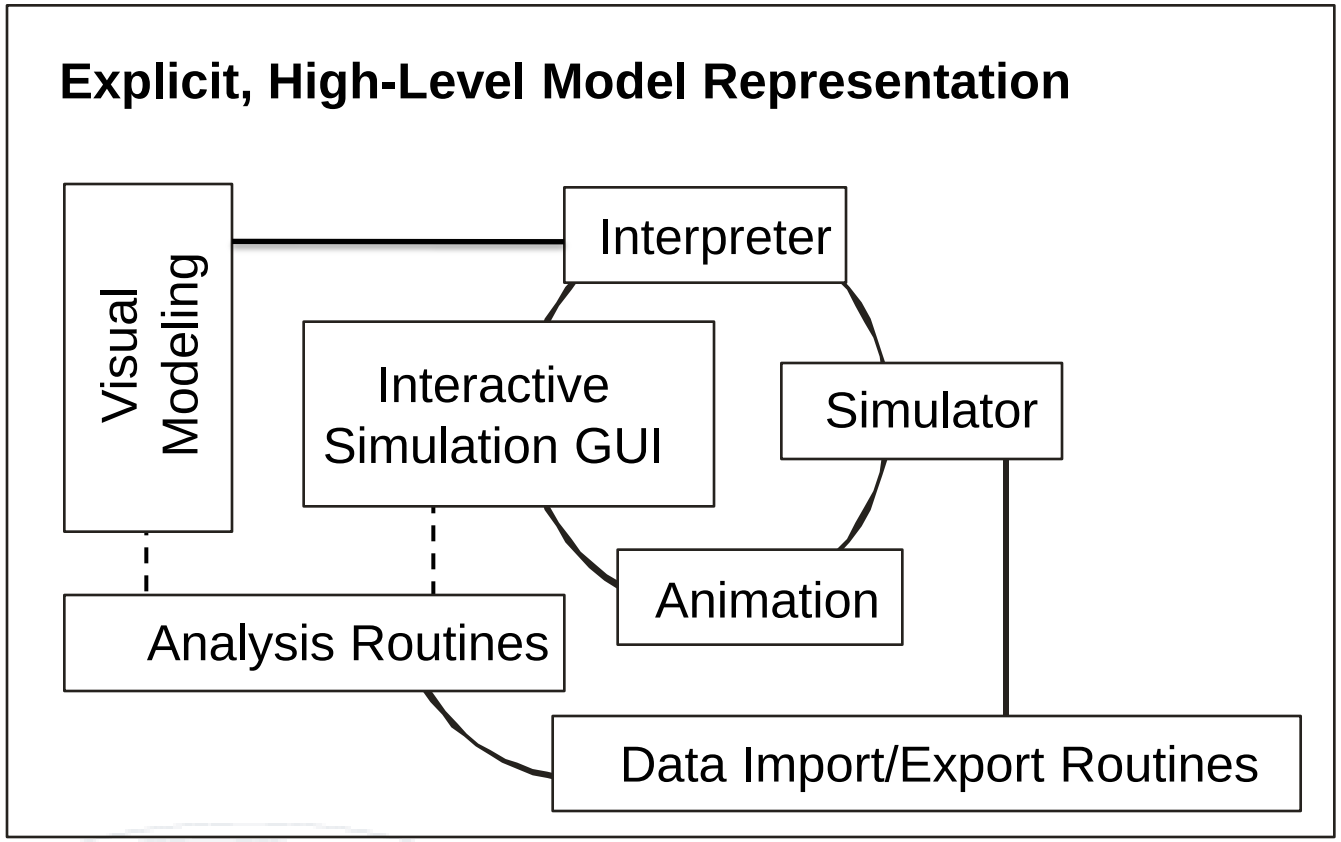


Vision for Tools

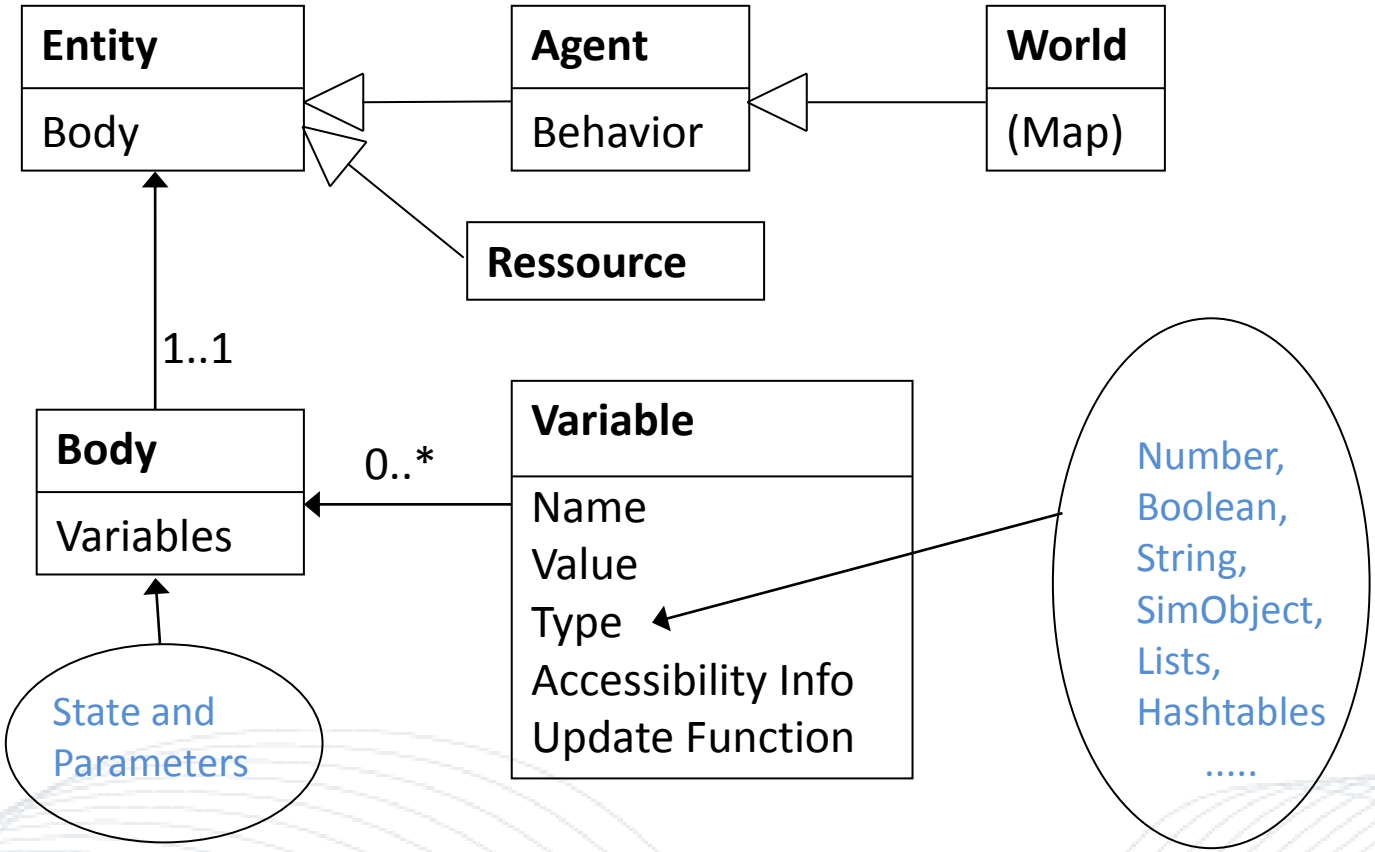


SeSAm

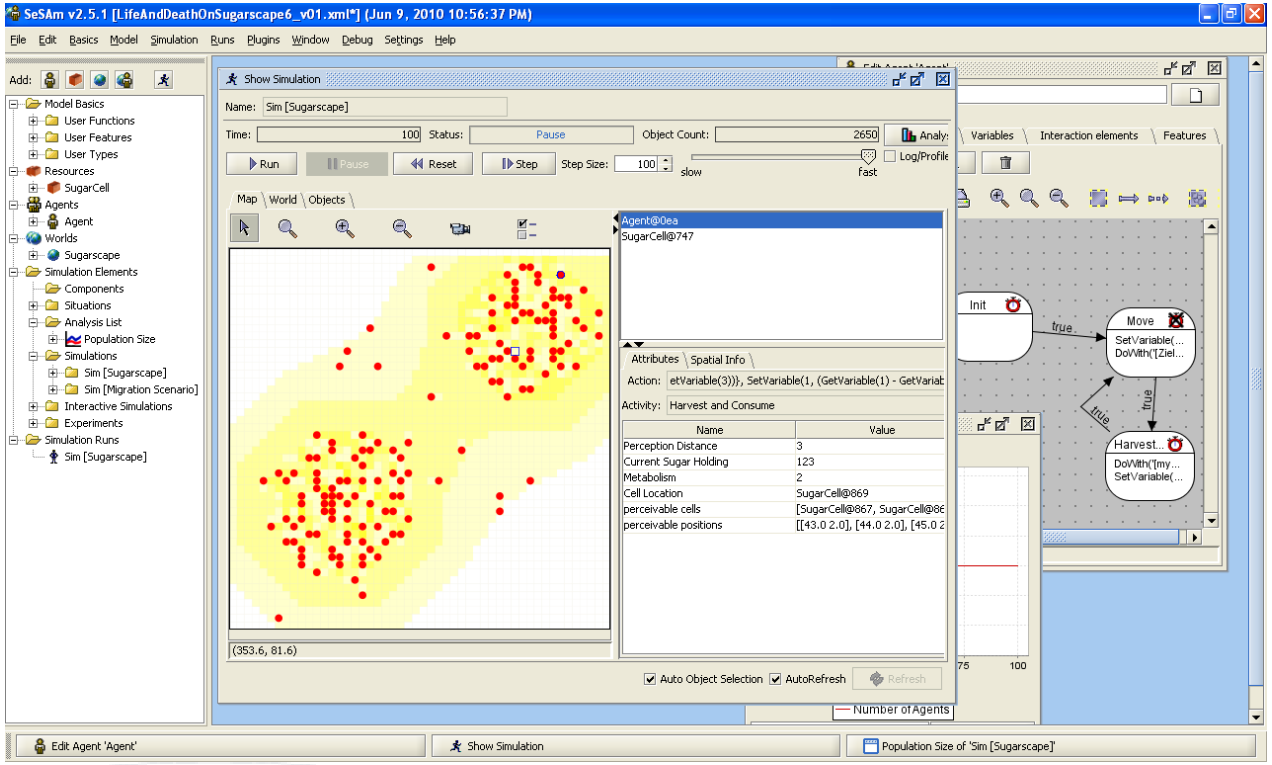
www.simsesam.org



Simplified SeSAm Meta-Model



Modeling and Simulation Platform SeSAm



More Tools

Netlogo

Repast – Family (Swarm)

Mason

Ascape

...

Projects...

- Simulation for answering diverse questions in sociobiology (1995-2006)
- Analysis of the role of information in traffic (1998-)
- Optimization in Hospital Management (1999-2006)
- Reproduction of shopping decision making (2005/2006)
- **Analysis of infrastructure layout using pedestrian simulations (2006-)**
- Testbed for complex control software for highbay warehouses (2003-2007)
- and various smaller projects

Pedestrian Simulation: OPAC Model

- Generic Model
- Separation between agent behavior and spatial representation
- Railway stations and similar environments
- Explicit spatial semantics

Environmental Model

Platforms, stairways, over- and underpass as resources

Trains as data structure for organizing gates and storing information

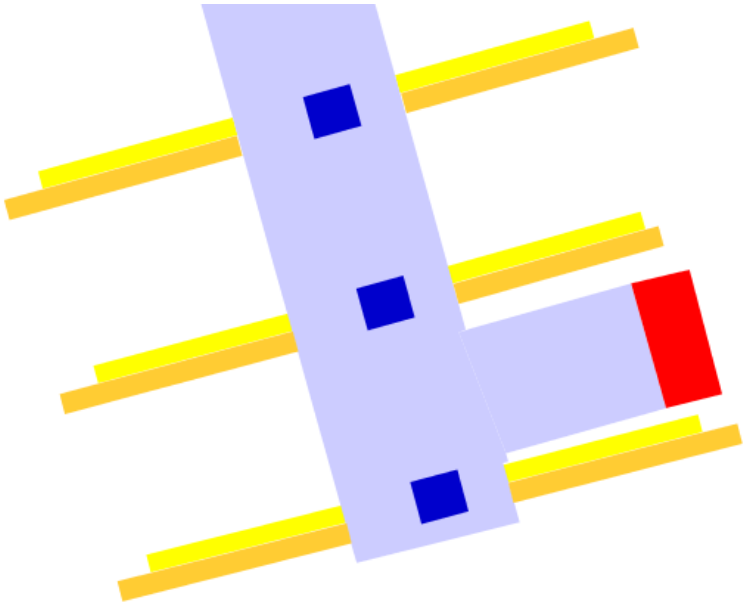
Tracks as agents that generate and close gates

Gates as agents that generate and delete passengers

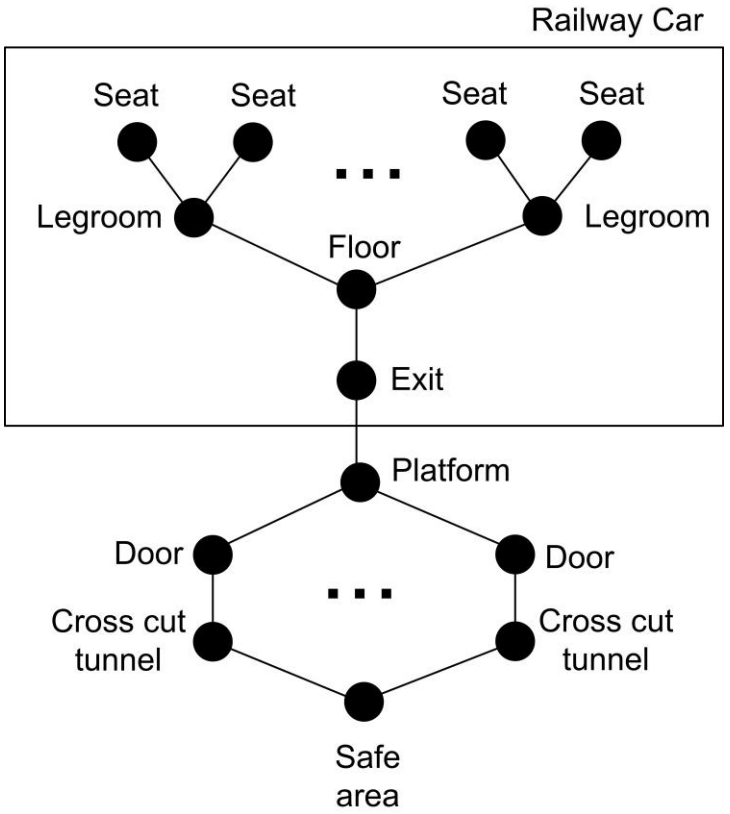
Train Arrival – modelled by occurrence of a sequence of doors distributed between given coordinates

Train Departure – delete doors and collect all information about passengers

Space Representation



Geometry from CAD Data

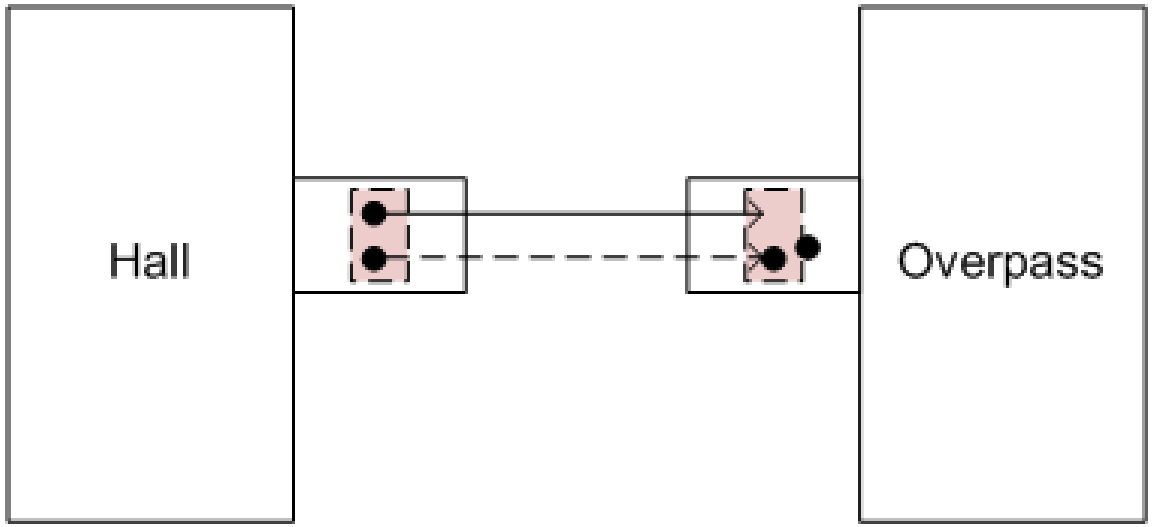


Scene space as reachability graph

Geometry

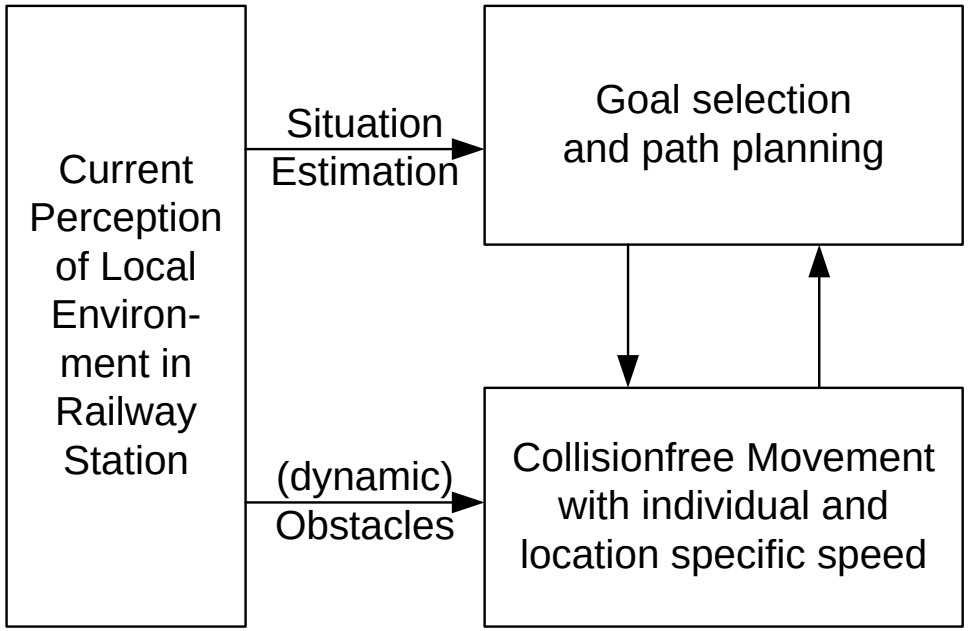
- Polygones
- Multi-Level 2D
- Rudimentary forms of topology: Obstacles aggregate to higher level obstacles
- No walls, but walkable areas
- Different types of areas

Multi-Level 2D instead of 3D



”Beaming” between dublicated stairways
for combining levels

Overview on Agent Structure



Status of Agents

- Individual desired speed (normal distribution)
- Size
- Destination (partially) fixed when entering system

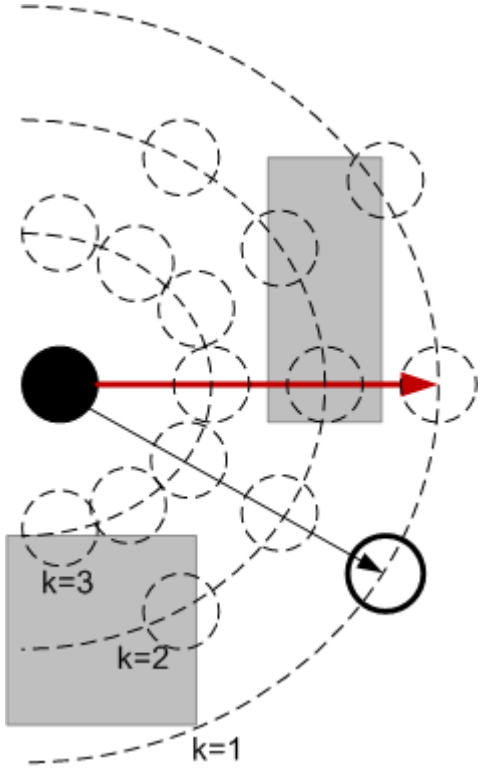
→ Agents fairly similar, local context relevant

Basic Behavior Level: Collision Avoidance

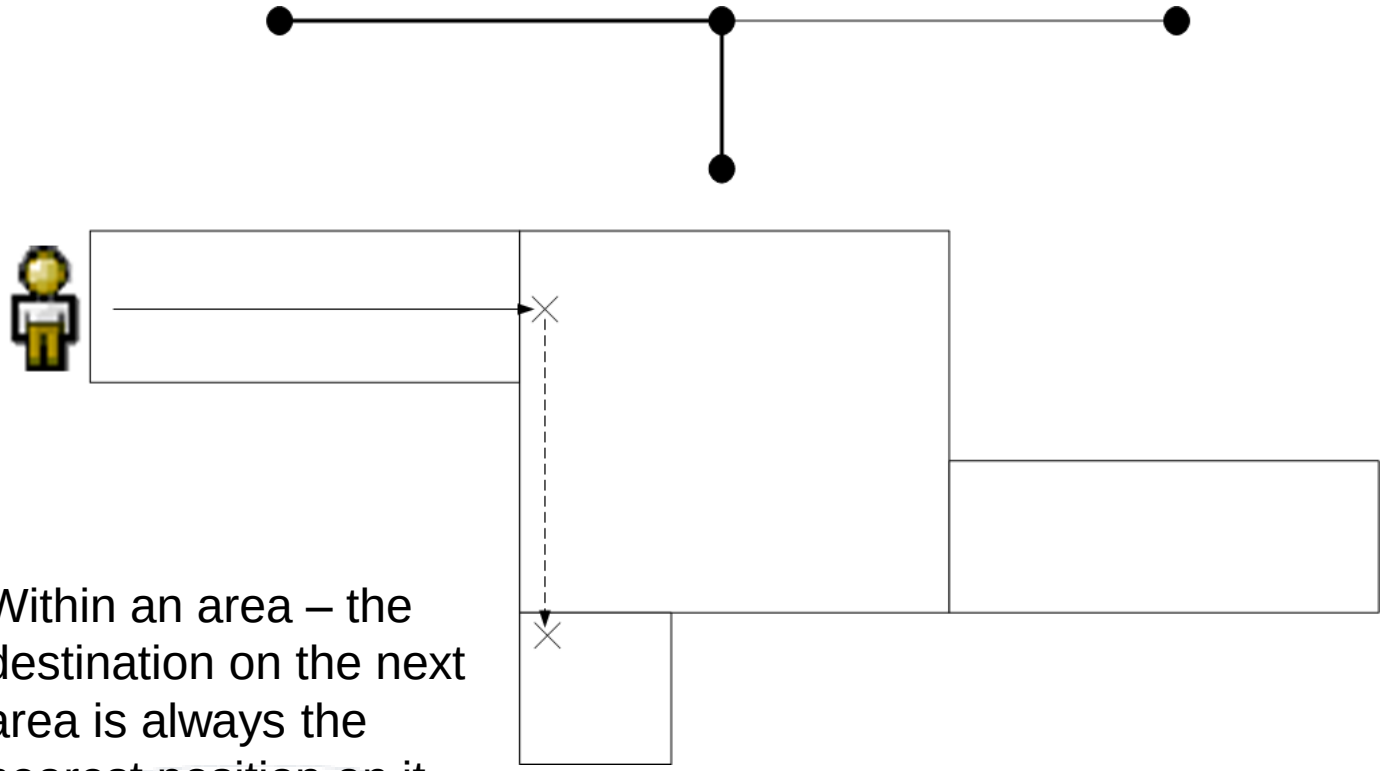
Movement in continuous space

Next step must be *feasible:*
without collision, within area

Discretized tests for possible
next positions

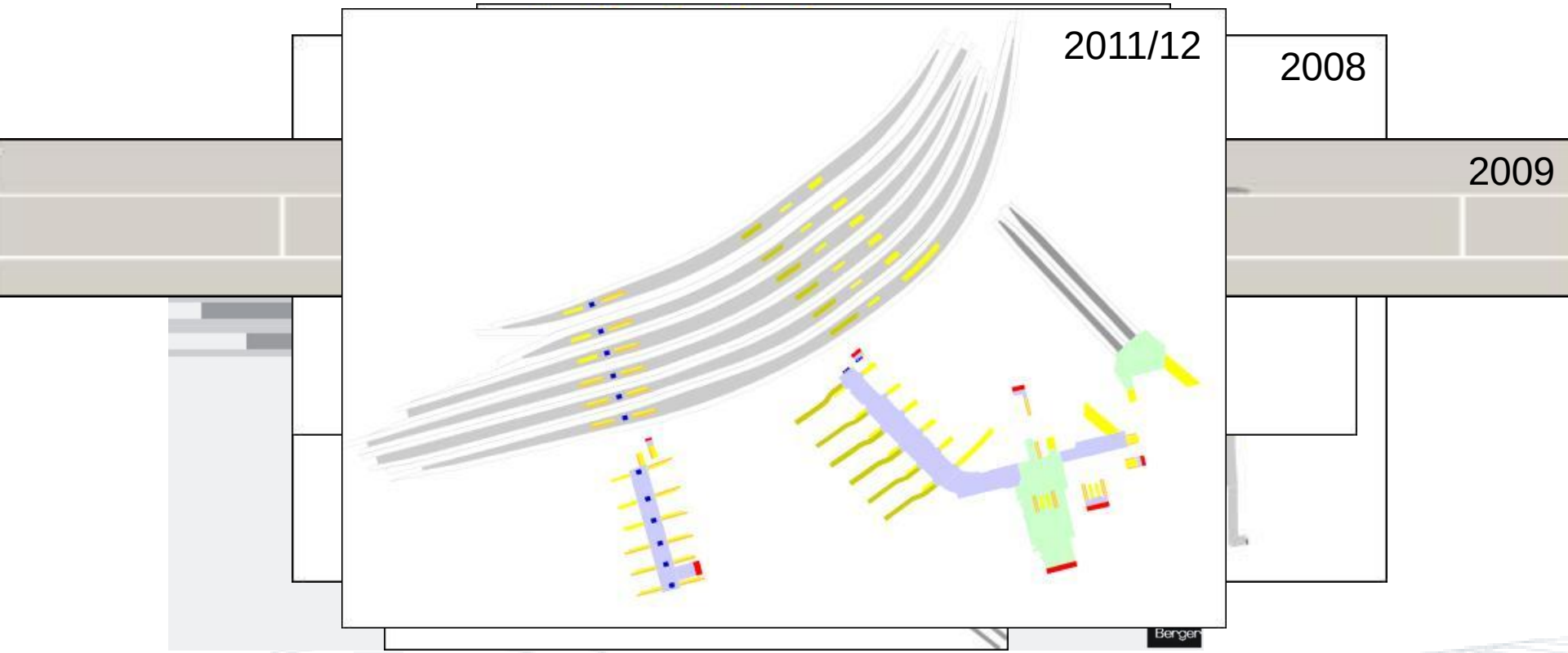


Behavior Level: Planning



Within an area – the destination on the next area is always the nearest position on it.

Our Projects



From Railway Stations to Train Tunnel Evacuation

- Basic Structure is similar (in the 2D case)
- It is not just sufficient to simulate behavior on the emergency platform, but realistic egress from trains and distribution in the shelters
- Integration of orientation and information state of agents, but pedestrian flows are mostly unidirectional
- Fatalities, injured people → dynamic obstacles

Motivation for using agents

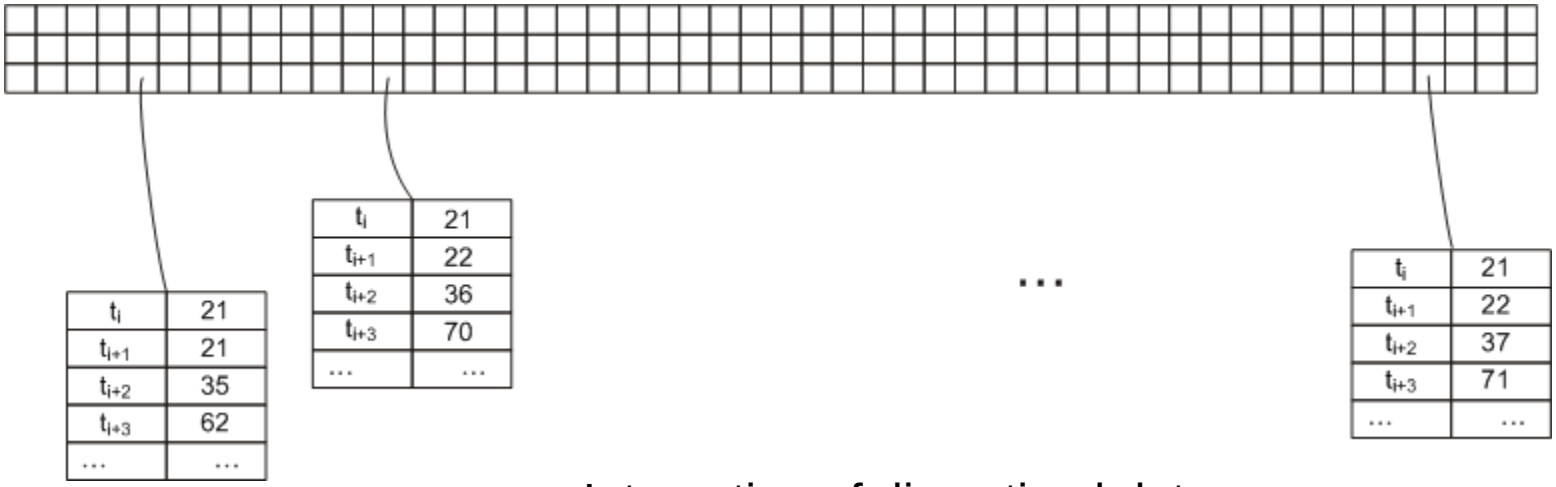
Explicit spatial model – data can be augmented/combined

Heterogenious agents,

individual, local perceptions, communication, ad-hoc decision making

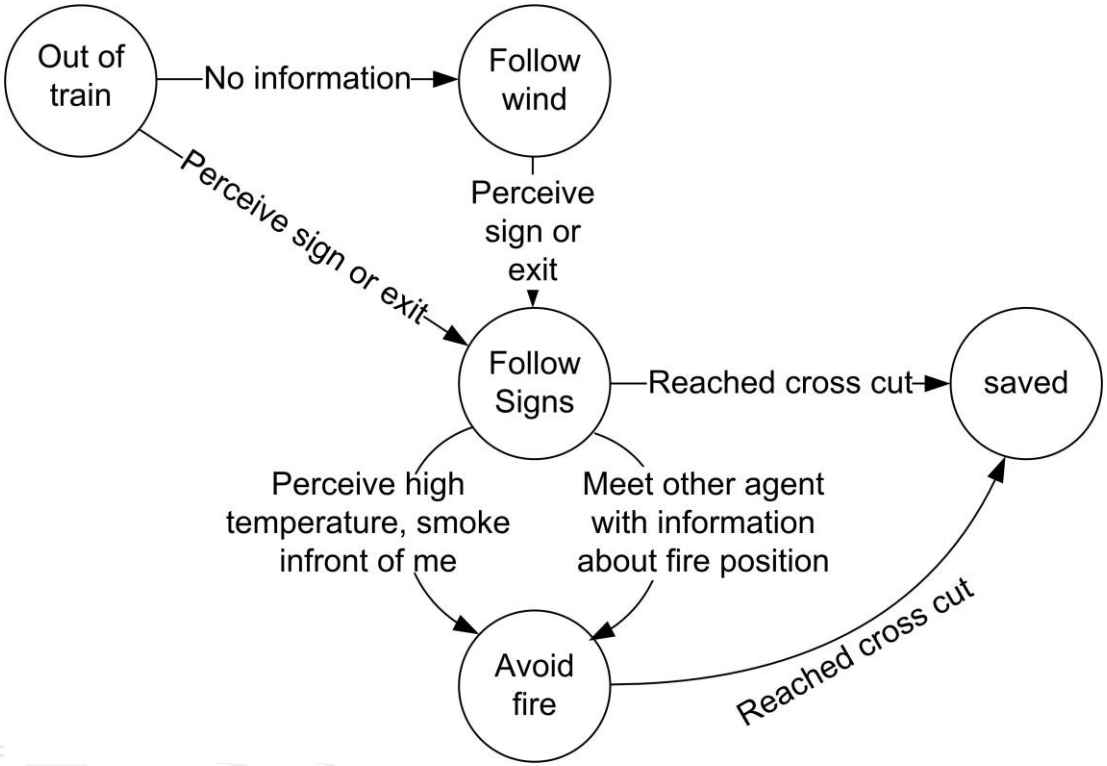
→Agents with individual informational state influencing their decision making

Integration of Environmental Dynamics

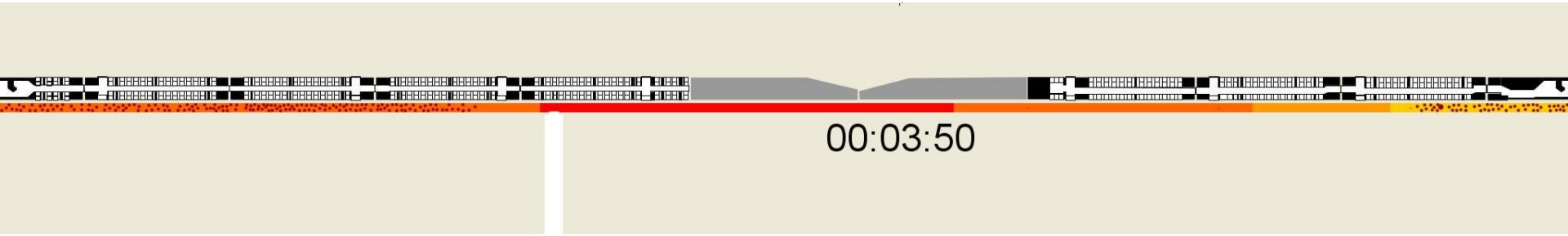


Integration of discretized data on temperature and toxic gas (CO)

Informational State



Sequence of Situations



→ Movie

Several variations:
Distance between the cross cuts
Width of the emergency platform
Size of the doors to the orthongal tunnels
Width of the orthongal tunnels
(different environmental models)

Summing up: Research Challenges

- Development of concise formal model
- Systematic development of models instead of best practices
- Robustness and reliability of simulations
- Reuse of models
- Methods for determining the appropriate level of detail
- Multilevel Models
- Scalability

Thank you for your attention!