
Computer Simulations

A practical approach to simulation

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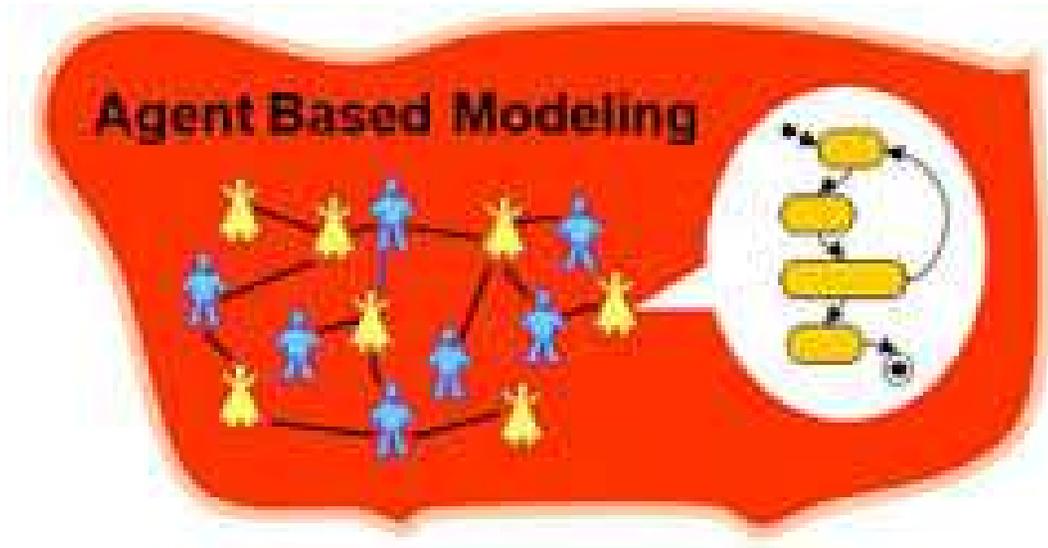
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Building agent based models.

Agent Based Models: **Connections and rules**



Building agent based models.

Agent Based Models: The Need for Agent-based Modeling

We live in an increasingly complex world.

- Systems More Complex
 - Systems that need to be analyzed are becoming more complex
 - Decentralization of Decision-Making: “Deregulated” electric power industry
 - Systems Approaching Design Limits: Transportation networks
 - Increasing Physical and Economic Interdependencies: infrastructures (electricity, natural gas, telecommunications)

Building agent based models.

Agent Based Models: The Need for Agent-based Modeling

We live in an increasingly complex world.

- New Tools, Toolkits, Modeling Approaches
 - Some systems have always been complex, but tools did not exist to analyze them
 - Economic markets and the diversity among economic agents
 - Social systems, social networks

Building agent based models.

Agent Based Models: The Need for Agent-based Modeling

We live in an increasingly complex world.

- Data
 - Data now organized into databases at finer levels of granularity(micro-data)
 - can now support micro-simulations
- Computational Power
 - Computational power advancing
 - can now support micro-simulations

Building agent based models.

Agent Based Models:

- **What is an agent?**
 - A discrete entity with its own goals and behaviors
 - Autonomous, with a capability to adapt and modify its behaviors
- **Assumptions**
 - Some key aspect of behaviors can be described.
 - Mechanisms by which agents interact can be described.
 - Complex social processes and a system can be built “from the bottom up.”

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Agent Based Models: Examples

- People, groups, organizations
- Social insects, swarms
- Robots, systems of collaborating robots

Agents are diverse and heterogeneous

Building Agent Based Models

Building Agent Based Models

- Agent based modeling is the easiest modeling method.
- You identify which objects in the real system are important for solving the problem, and create those same objects in the model.
- consider the behavior of those objects relevant to the problem, and program that same behavior in the model

Building Agent Based Models

Building Agent Based Models

What Is Agent-Based Modeling and Simulation?

- An agent-based model consists of:
 - A set of agents (part of the user-defined model)
 - A set of agent relationships (part of the user-defined model)
 - A framework for simulating agent behaviors and interactions (provided by an ABMS toolkit or other implementation)
- Unlike other modeling approaches, agent-based modeling begins and ends with the agent's perspective

Building Agent Based Models

The Process of Building Agent Based Models

Answer the following questions:

- Which objects in the real system are important? These will be the agents.
- Are there any persistent (or partially persistent) relationships between the real objects? Establish the corresponding links between the agents.
- Is space important? If yes, choose the space model (2D, 3D, discrete) and place the agents in the space. If the agents are mobile, set velocities, paths, etc.
- Identify the important events in the agents' life. These events may be triggered from outside, or they may be internal events caused by the agent's own dynamics.

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The Process of Building Agent Based Models-cont.

- Define the agents' behavior:
 - Does the agent just react to the external events? Use message handing and function calls.
 - Does the agent have a notion of state? Use a statechart.
 - Does the agent have internal timing? Use events or timeout transitions.
 - Is there any process inside the agent? Draw a process flowchart.
 - Are there any continuous-time dynamics? Create a stock and flow diagram inside the agent.

Building Agent Based Models

The Process of Building Agent Based Models-cont.

- Do agents communicate? Use message sequence diagrams to design communication/timing patterns.
- What information does the agent keep? This will be the memory, or state information, of the agent. Use variables and statechart states.
- Is there any information, and/or dynamics, external to all agents and shared by all agents? If yes, there will be a global part of the model (the term "environment" is sometimes used instead).
- What output are you looking for? Define the statistics collection at both the individual and aggregate levels.

Building Agent Based Models

Examples of Agent Based Models in Social Sciences

- Schelling's segregation model
- Traffic simulation
- AIDS
- Sugerscape
- LabourMarket Simulation

Building Agent Based Models

Examples of Agent Based Models

Example : Schelling's Neighborhood Segregation Model

- Nobel Prize Winer Thomas C. Schelling.



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Examples of Agent Based Models

Example : Schelling's Neighborhood Segregation Model

- The Schelling Segregation Model (SSM), also referred to as the "Schelling Tipping Model,"
- The model was first developed by Thomas C. Schelling (Micromotives and Macrobehavior, W. W. Norton and Co., 1978, pp. 147-155) to explain ethnic segregation structure of New York City.
- Later found many applications
- **One can find many visual applications such as “The Schelling Segregation Demo Home Page”**

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Examples of Agent Based Models in Social Sciences

Neighborhood segregation: Connections and rules:

- Consider 2-dimensional square lattice.
- Each lattice site represent an individual (agent)
- The neighbourhood of an agent is all 8 sites surrounding the original site.

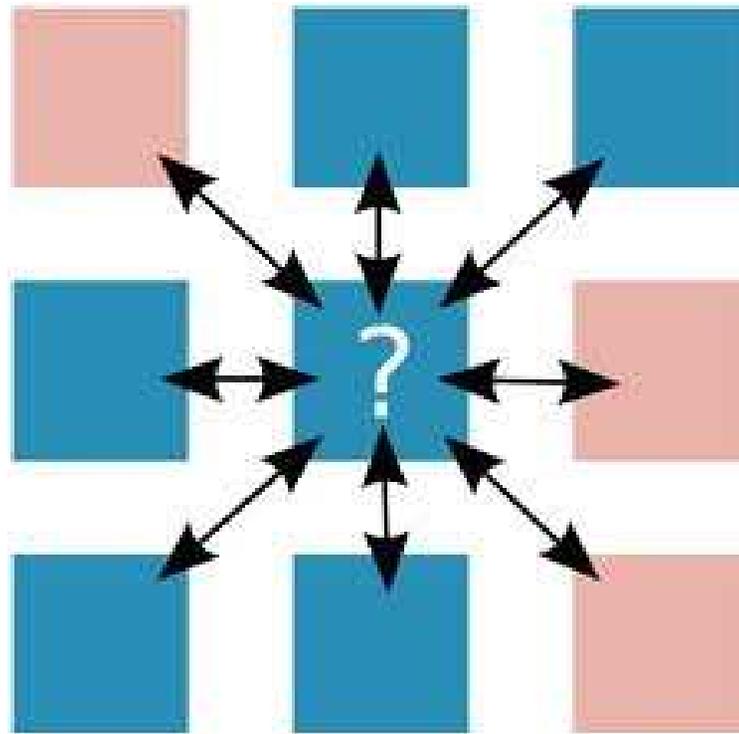
Rules:

- Determined whether a particular agent was happy in its current location.
- Stay if at least a third of neighbors are “kin”
- If it was unhappy, it would try to move to another location on the board, or possibly just exit the board entirely.

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Examples of Agent Based Models in Social Sciences

Neighborhood segregation: Connections and rules:



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Examples of Agent Based Models in Social Sciences

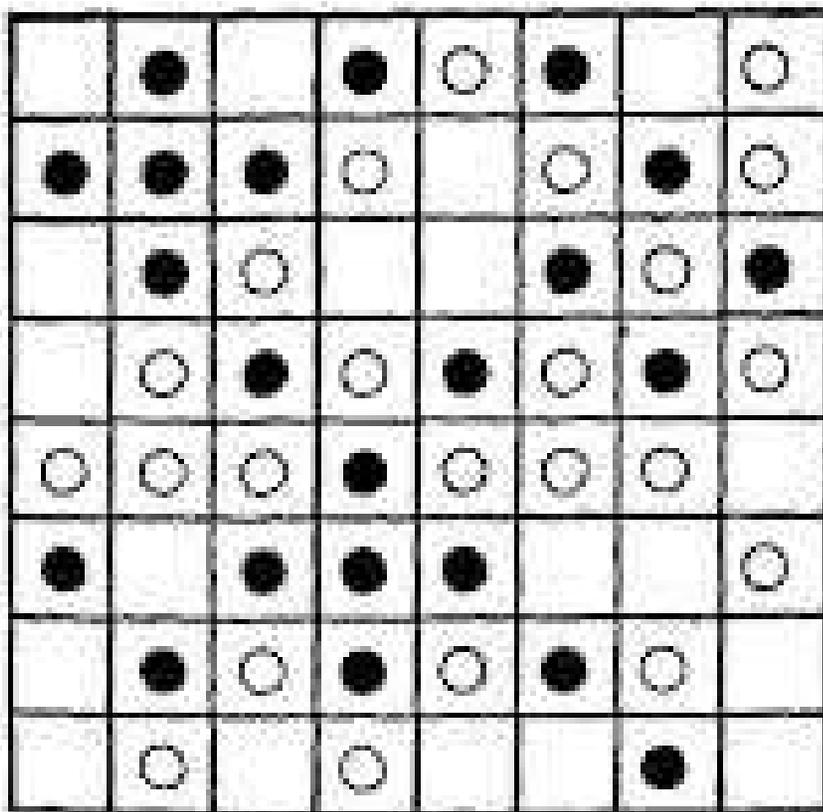
Neighborhood segregation: Connections and rules:

- Schelling found that the board quickly evolved into a strongly segregated location pattern if the agents' "happiness rules" were specified so that segregation was heavily favored.
- Surprisingly, however, he also found that initially integrated boards tipped into full segregation even if the agents' happiness rules expressed only a mild preference for having neighbors of their own type.

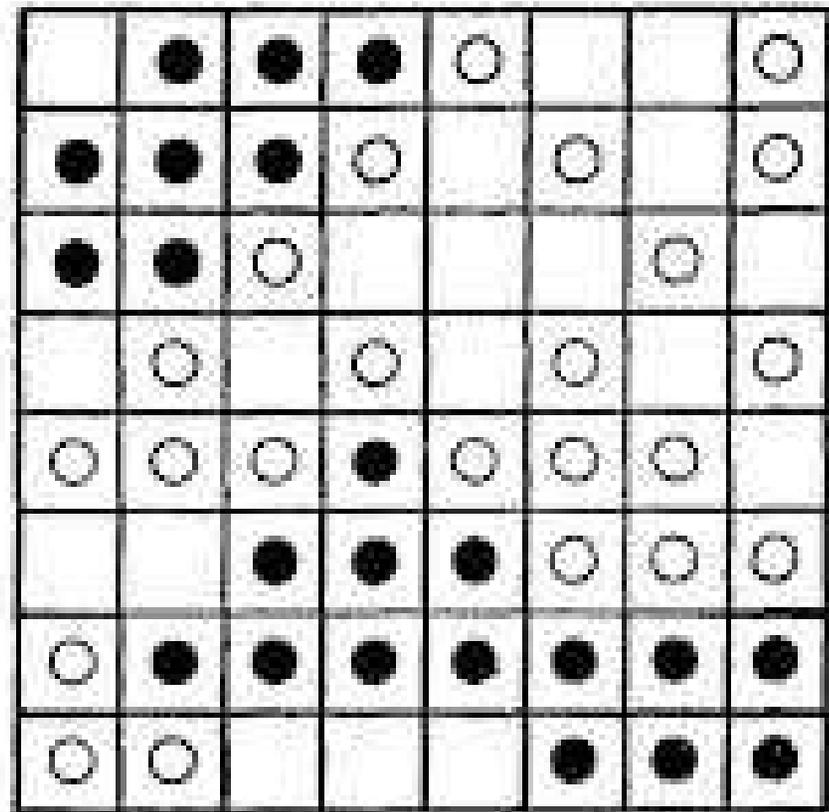
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Examples of Agent Based Models in Social Sciences

Neighborhood segregation: Connections and rules:



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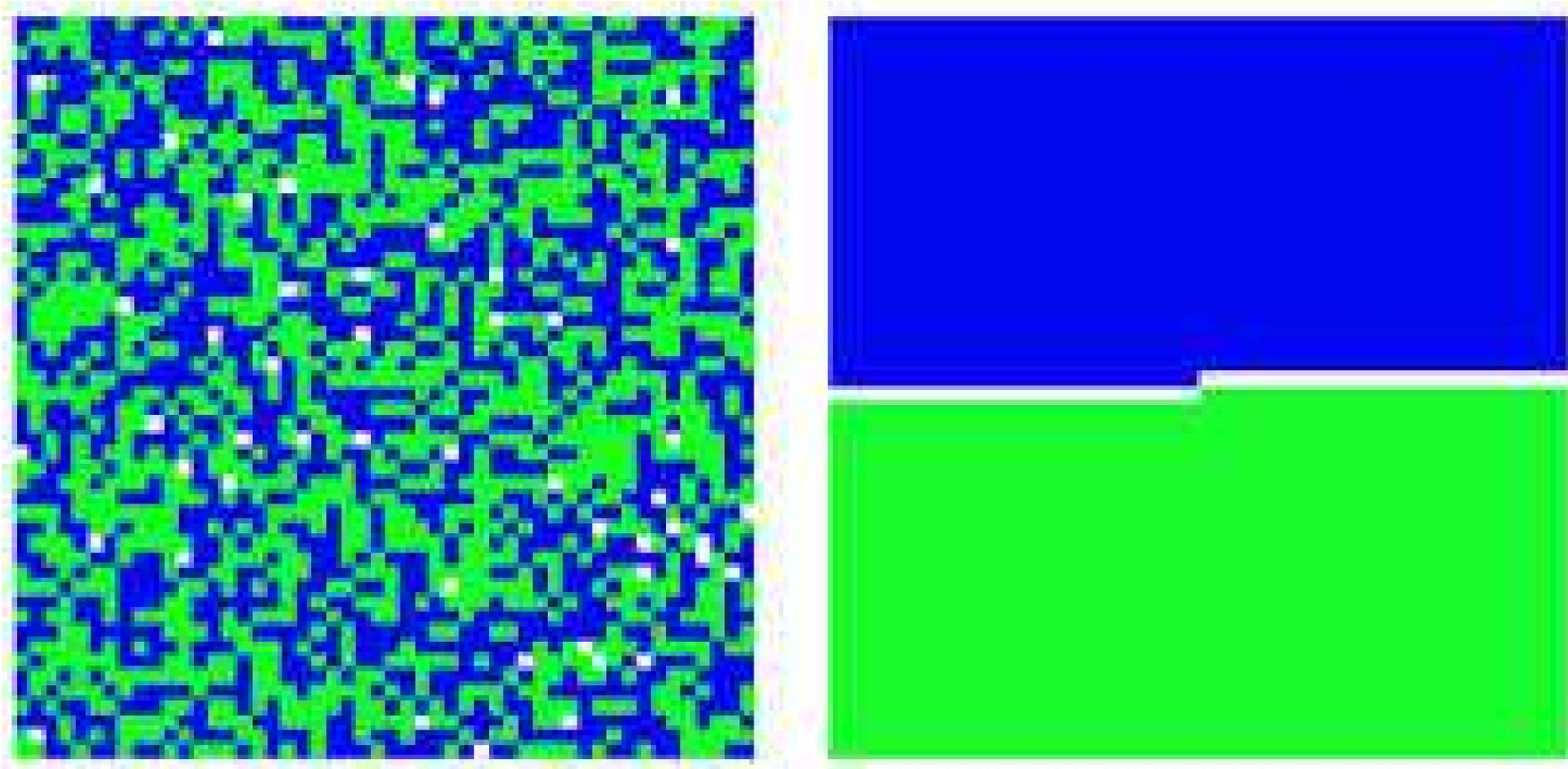


(b)

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Examples of Agent Based Models in Social Sciences

Neighborhood segregation: Connections and rules:



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Examples of Agent Based Models in Social Sciences

Example 2: Model of the movement of cars on a highway



Building Agent Based Models

Examples of Agent Based Models in Social Sciences

Example 2: Model of the movement of cars on a highway

- Configuration:
 - One dimensional continuous space.
- Rules:
 - if there's car close ahead, it slows down
 - if there's no car ahead, it speeds up
- The project demonstrates how traffic jams form spontaneously without obstacles

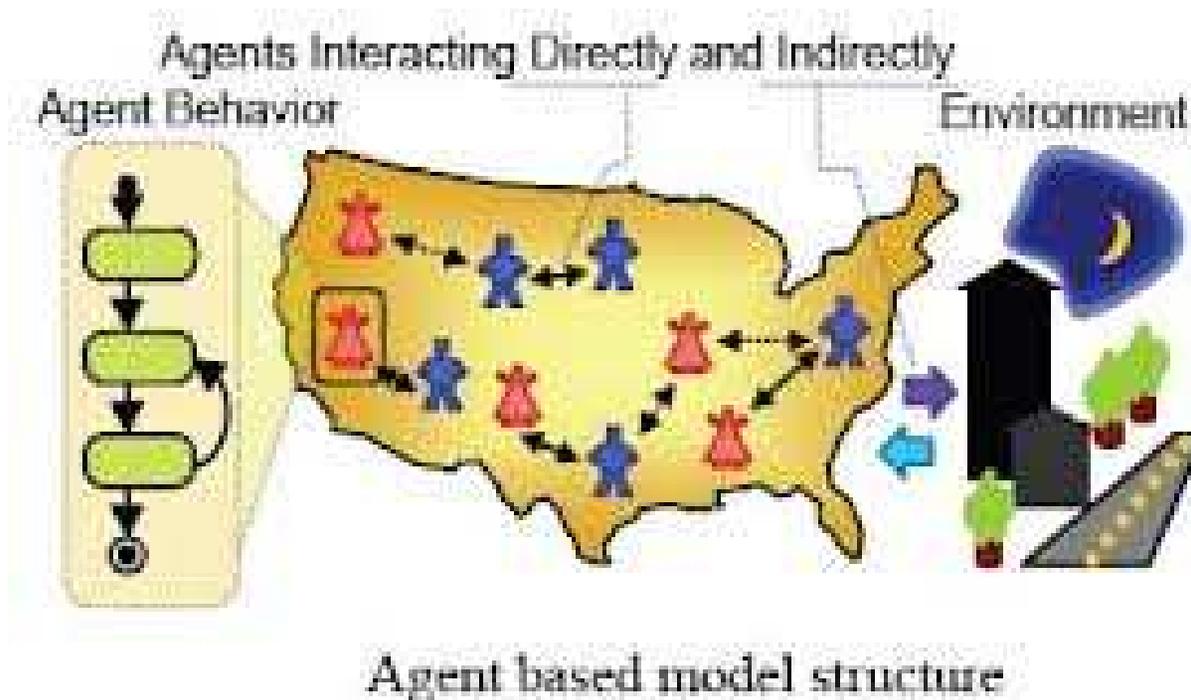
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Examples of Agent Based Models- Sugarscape

- Series of models introduced by Epstein and Axtell
1996 Growing Artificial Societies MIT Press.
- Emergent features:
 - wealth distributions
 - social networks
 - migration
 - population dynamics
 - conflict patterns
 - price formation
 - credit networks

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Examples of Agent Based Models- **Labour Market**



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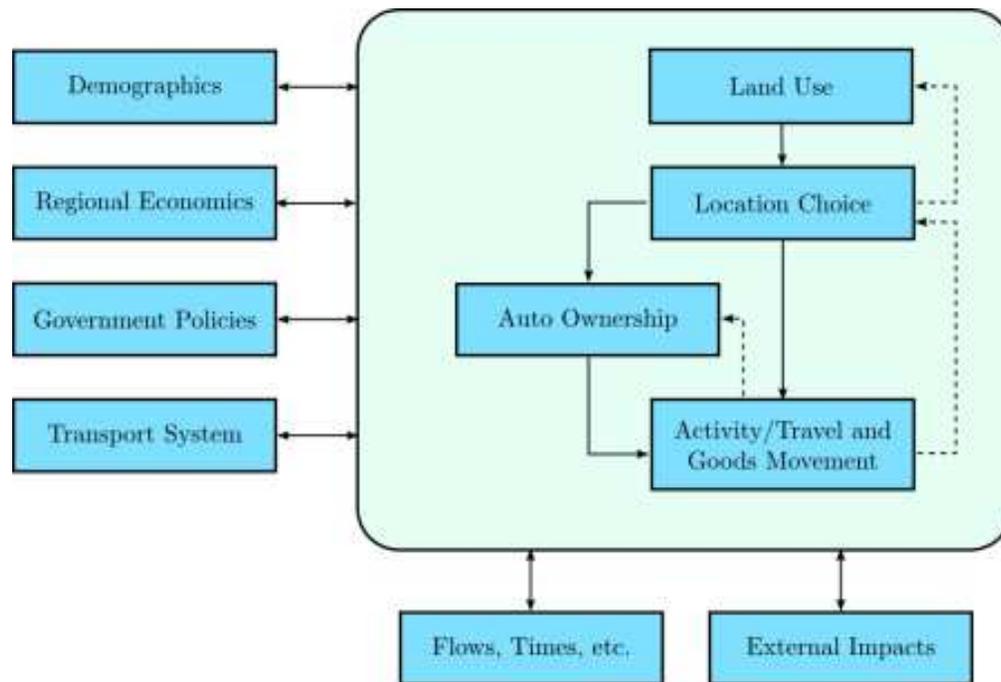
Examples of Agent Based Models- Labour Market

- Agents represent workers in an international labourmarket
- Agents' main goal is to have a job and friends
- Jobs are available according to a country's economic situation
- If the agent has been unhappy for a certain time period, it moves to another country

Building Agent Based Models

Examples of Agent Based Models - ILLUTE

Integrated Land Use Transportation Modeling from Toronto



<http://www.civ.utoronto.ca/sect/traeng/ilute/>

Building Agent Based Models

Examples of Agent Based Models - UrbanSim

- UrbanSim is a simulation model for integrated planning and analysis
- Developed at the Univ. of Washington, Seattle
 - Features decision-making by households, businesses, developers and governments
 - <http://www.urbansim.org/>

Building Agent Based Models

ABMS Platforms

- Agent-based Modeling and Simulation Toolkits
 - Repast (Java) –similar to Swarm (Objective C, Java)
 - NetLogo, StarLogo
 - MASON
 - AnyLogic(commercial)
- General Tools
 - Spreadsheets, with macro programming
 - Computational Mathematics Systems
 - MATLAB
 - Mathematica
- General Programming Languages (Object-oriented)
 - Java
 - C++

Building Agent Based Models

Examples of Agent Based Models

- Santa Fe Institute: <http://www.santafe.edu/>
- Center for the Study of Complex Systems at the University of Michigan: <http://www.pscs.umich.edu/>
- European web sites on Computer simulation of societies <http://www.soc.surrey.ac.uk/research/simsoc/> and “European Social Simulation Association” <http://essa.eu.org/>
- For the US counterpart, see <http://www.dis.anl.gov/naacos>
- Leigh Tesfatsion's site on computational economics: <http://www.econ.iastate.edu/tesfatsi/ace.htm>
- See also the Journal of Artificial Societies and Social Simulation: