Problem formulation and actor identification

Dr. ir. Igor Nikolic

26-11-12

Lecture goals

- Recap of
  - ABM theory
  - Generative science
  - NetLogo
- Understand the first step of the method
  - Problem formulation and actor identification

Modeling in general

- All models are wrong, some are useful ! (Box 1979)

- Model a problem, not a system!

- A model is thrice removed from reality !
  - A computer formalization of the modelers understanding of stakeholdeers understanding of (a part of) reality

Three main schools of Agent thinking

- Artificial Intelligence – AI
  - Agents as autonomous identities solving problems
- Multi-Agent Systems – MAS
  - Distributed control of systems
- Agent Based Modeling (and Simulation) – ABM(S)
  - Simulating (real world) phenomena

- **We will follow the ABM(S) view !**

Agents are :

- Encapsulated
  - clearly identifiable, with well-defined boundaries and interfaces;
- Situated in a particular environment
  - receive input through sensors and act through effectors;
- Capable of flexible action
  - respond to changes and act in anticipation;
- Autonomous,
  - meaning that they have control both over their internal state and over their own behavior;
- Designed to meet objectives
  - they attempt to fulfill a purpose, solve a problem, or achieve goals.

Jennings, N. (2000). On agent-based software engineering, Artificial Intelligence 117(2): 277–296.

Agent Based Model

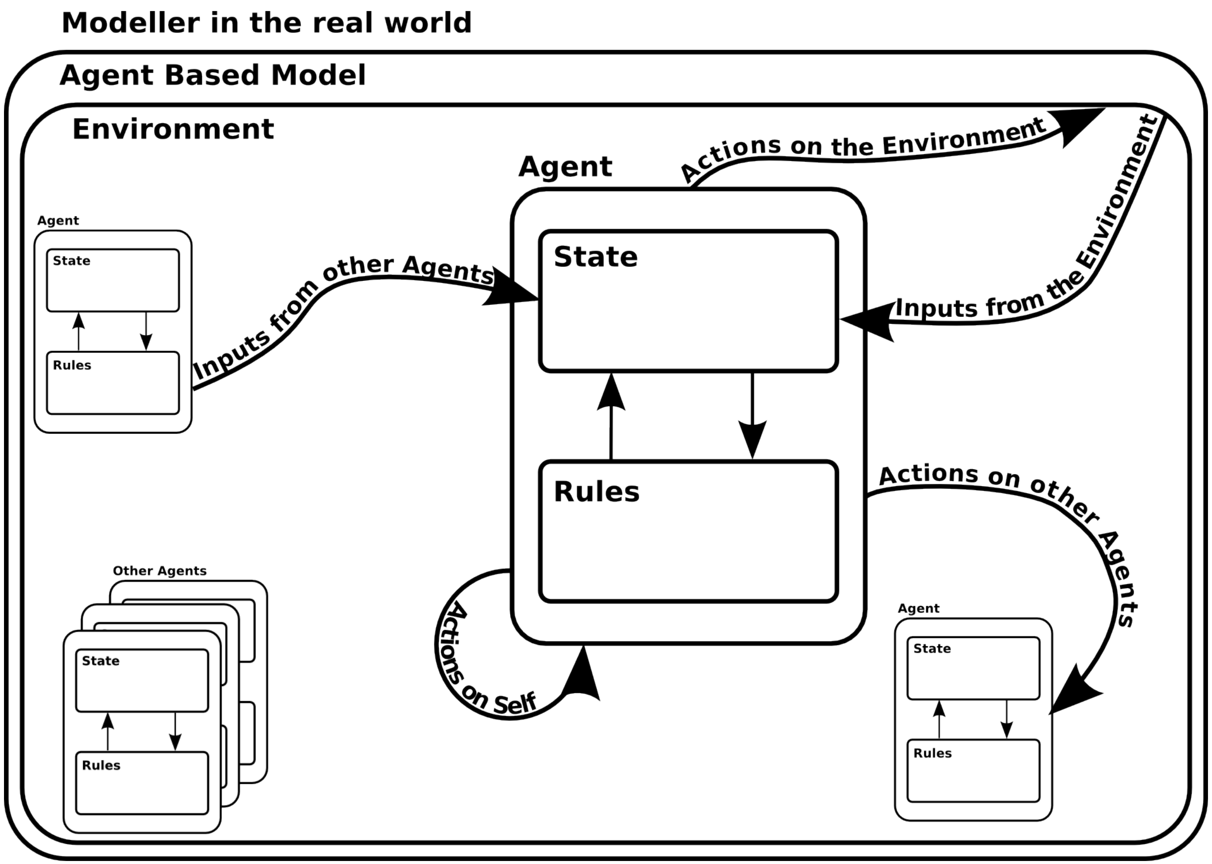
- An Agent is a persistent thing which has some state we find worth representing, and which interacts with other agents, mutually modifying each other’s states.

  The components of an agent-based model are a collection of agents and their states, the rules governing the interactions of the agents and the environment within which they live.

C.R. Shalizi. Methods and techniques of complex systems science: An overview. arXiv.org, arXiv.org:nlin/0307015, 2006. URL http://www.citebase.org/abstract?id=oai:arXiv.org:nlin/0307015.

Agent

- Agent is a thing that does things to other things

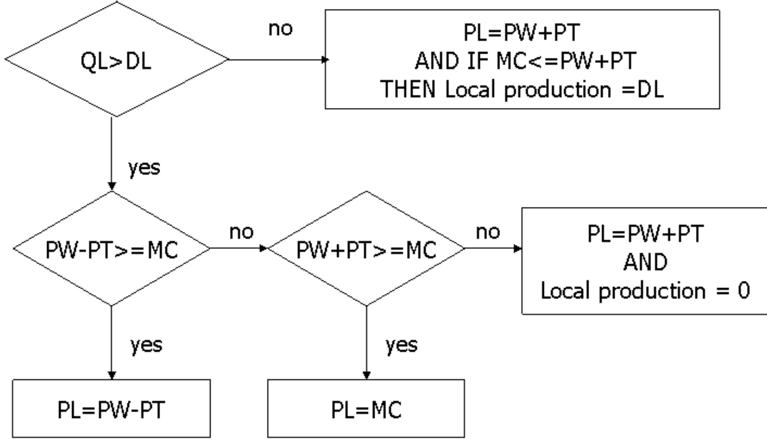


States

Agent state and behavior *and* Model state en behavior

- Stuff that Agents knows or has (including memory)
  - Can be private or public
  - Can be static or dynamic and can depend on the Rules
  - Eg:
    - Profits, Color,Location,
- State of an agent is a composite
  - of internal *and* local *and* global

Rules



- Agents *“internal models”*
- Decision and transformation rules → from inputs and states to action and behavior
- Can be static or dynamic

Types of rules

- Rule based
  - nested if-then-else structures.
- Multi Criteria Decision Making
  - Options and weights
- Inference engines
  - expert systems,facts (states) and decision heuristic
- Evolutionary Computing
  - find a optimal solution in large solution space (GA)
- Machine learning
  - Neural Networks for recognizing patterns

Actions

- Based on
  - Other Agents
  - States
  - Rules
- Agent will perform (or not perform) some action
- Action can
  - Affect other Agents
  - Own state
  - Own rule
  - Environment

- Behavior is the overall set of observable actions

Environment

- What the Agent is in.
  - Provides the agents with information and structure
- Everything that is *not* an Agent, but is relevant.
- It affects the Agent, and Agent can affect it.
- Structure :
  - Soups
  - Space (grid, GIS, etc...)
  - Networks

Time

- ABM take place in discrete time
- Time progresses in ticks
- Between two ticks, everything is assumed to happen in the same time, attempting to simulate the parallelism in real world
- As computers are serial processing machines, the order of Agent iteration is very important.

Top-Down modeling

- Start with the entire system
  - Assumes that you know how the system behaves
  - Formalize (encode) your understanding
  - Try to replicate the observed regularity
- System description is static

$$\frac{\partial u}{\partial t} + t\frac{\partial u}{\partial x} = 0.$$

$$g\frac{d^2u}{dx^2} + L\sin u = 0.$$

$$P_0(\cos\Theta) = 1$$

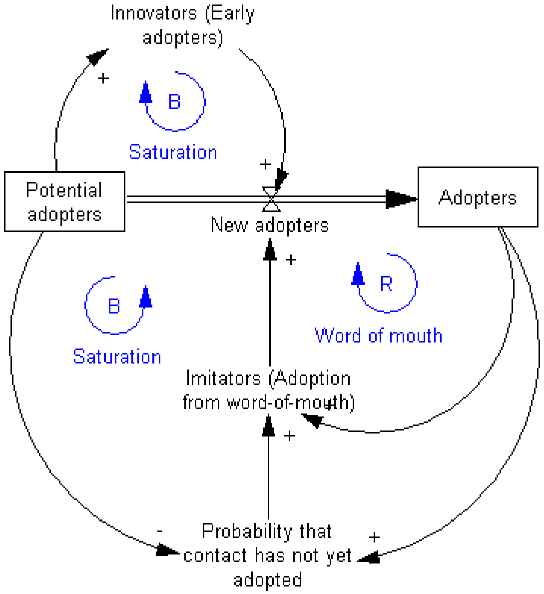
$$P_1(\cos\Theta) = \cos\Theta$$

$$P_2(\cos\Theta) = \frac{1}{2}(3\cos^2\Theta - 1)$$

$$P_3(\cos\Theta) = \frac{1}{2}(5\cos^3\Theta - 3\cos\Theta)$$

$$P_4(\cos\Theta) = \frac{1}{8}(35\cos^4\Theta - 30\cos^2\Theta + 3)$$

$$P_5(\cos\Theta) = \frac{1}{8}(63\cos^5\Theta - 70\cos^3\Theta + 15\cos\Theta)$$



Works fine as long as

- You have good understanding of the system is in its entirety
- You understand exactly how system components interact with each other.
- Works great for complicated stuff, airplanes, chemical factories, busses and glue.

- However, for complex stuff, like socio-technical systems, we need something else...

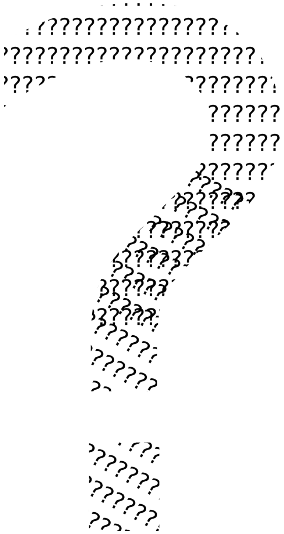
Generative Science

- *"If you did not grow it, you did not explain it!"* (Epstein 1999)
  - build understanding from the bottom up !
- Central principle :
  - phenomena can be described in terms of interconnected networks of (relatively) simple units. Deterministic and finite rules and parameters of natural phenomena interact with each other to generate complex behavior

J.M. Epstein. Agent-based computational models and generative social science. Complexity, 4 (5):41–60, 1999.

Generativist Question

- How could the decentralized local interactions of heterogeneous autonomous agents generate the given regularity?



Generativist Experiment

- Situate an initial population of autonomous heterogeneous agents in a relevant spatial environment; allow them to interact according to simple local rules, and thereby generate - or ’grow’ - the macroscopic regularity from the bottom up.

- Or, given a well understood, well described population of agents, what kinds of behavior are they capable of under different conditions

Break

Problem formulation and Actor identification

- ***Don't model a system, model a problem!***

What is the problem?

- By far the most important and difficult question.
- Stakeholder might not realize what it is.
- Subquestions :
  - What is the exact lack of insight that we are addressing?
  - What is the observed emergent pattern of interest to us?
  - Is there is a desired emergent pattern, and if so, how is it different from the observed emergent pattern?
  - What is the initial hypothesis on how the emergent patterns emerge, or, whydo the observed and desired emergent patterns differ?

What is the exact lack of insight that we are addressing?

- What it is that we want to know but do now know now?
  - Some fact?
  - Emergent system behavior?
  - Agent behavior / mechanism?
  - Effect of some intervention?
- This implicitly specifies the model

Is there is a desired emergent pattern, and if so, how is it different from the observed emergent pattern?

- Normative and *VERY* stakeholder dependent.
- Will strongly guide how/which model you will build.
- Implicitly holds the hypothesis about how the system works.

What is the initial hypothesis on how the emergent patterns emerge, or, why do the observed and desired emergent patterns differ?

- Stakeholders statement of the hypothesis is a mini-model.
- A very valuable insight into how the stakeholder thinks about the system / problem.
- You will not use this in the actual model creation, but it very insightful to compare to the final model, and see which initial assumptions still hold.

Whose problem are we addressing?

- Make the problem owner explicit.

- Standard TPM question, rarely asked outside our community.

- Makes the eventual biases explicit.
  - Your model of socio-technical systems **will be** biased.

Which other actors are involved?

- Make the social network of actors (not agents!) explicit.
- Might be very important in highly contested problem.
  - Make sure you talk to all relevant actors to get a socially acceptable model
  - Get an early warning on the problems you might get with model use / outcome interpretation.

What is our role?

- Are we an actor in the system?
  - Might be if you are doing this for a company/govt/etc?
- If not, are we hired researchers / consultants / etc?
- What is our potential bias?
  - Our background?
  - Our experience?
  - Our knowledge?

Group progress