



# Introduction to Agent Based Modeling

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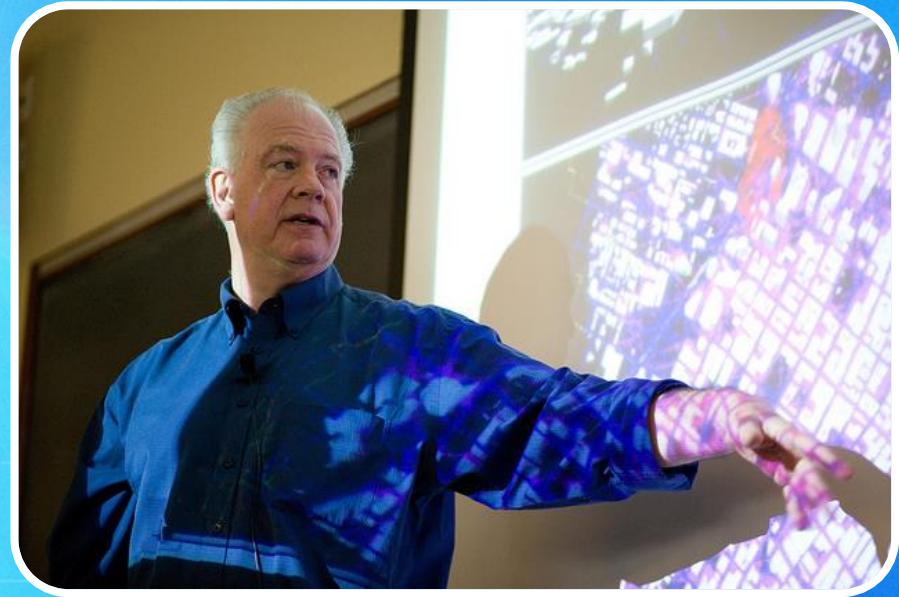


# Lecture goals

- Understand the concepts of generative science
- Understand what an Agent, and an Agent Based Model is.
- Help you start exploring ABM on your own.

# Generative Science

- *“If you did not grow it, you did not explain it!”*  
(Epstein 1999)
- Build understanding from the bottom up !



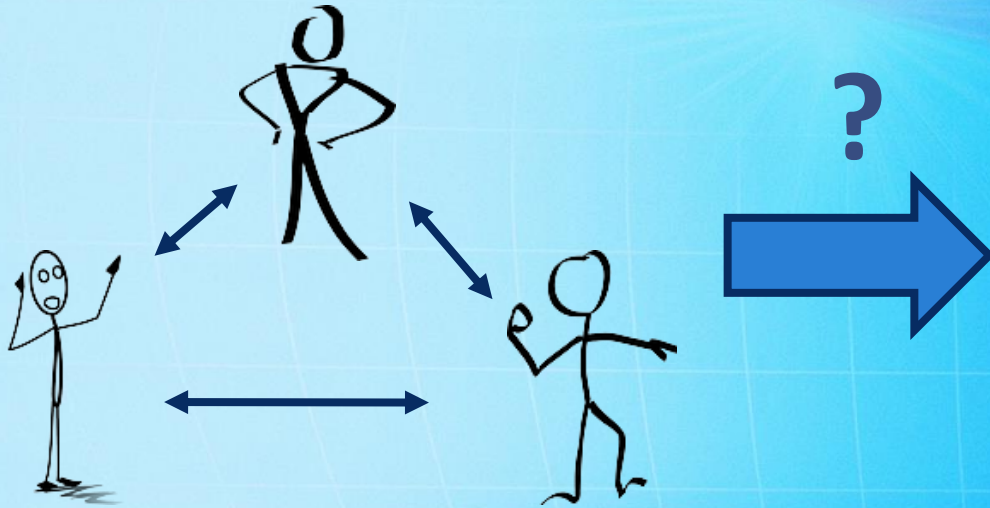


# Generative Science

- 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.”

# Generativist Question

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



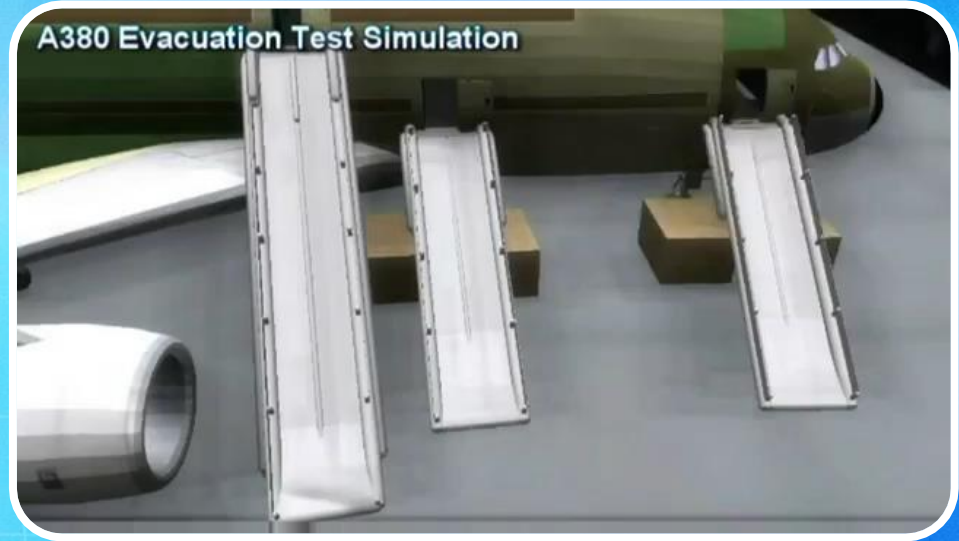
# Generativist Experiments

1. 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.
2. Given a well understood, well described population of agents, what kinds of behavior are they capable of under different conditions



# Example uses

- Short term:  
*Operations*
  - E.g. Airbus A380 emergency evacuation simulations



<https://www.youtube.com/watch?v=kVOikppwgxw>



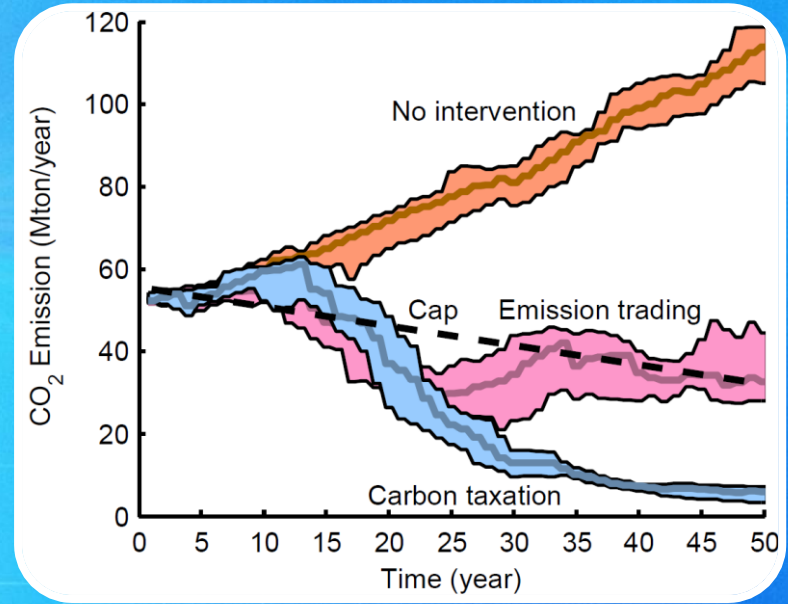
# Example uses

- Medium term:  
*Option testing*
  - E.g. Simulating the best purchasing strategy for a oil refinery to minimize disruptions due to shipping delays.



# Example uses

- Long term:  
*Systems evolution*
  - E.g. Simulating the effects of carbon tax vs carbon trading on power generation in NL.



(Chappin, 2011, p. 110)

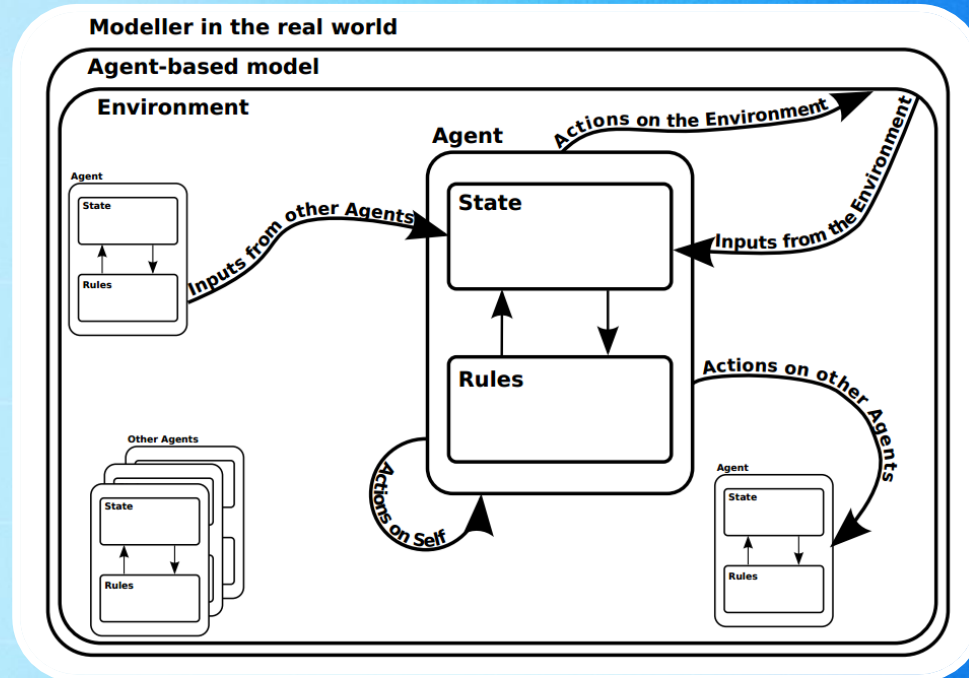


# Agent Based Model

- 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.

# Agent

*“Agent is a thing that does things to other things”*



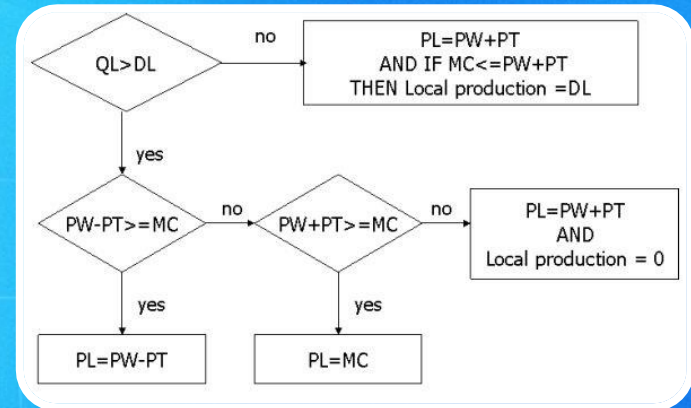


# States

- Agent state and behavior and Model state and 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
  - E.g.: Profits, color, location,
- State of an agent is a composite of internal and local and global

# Decision rules

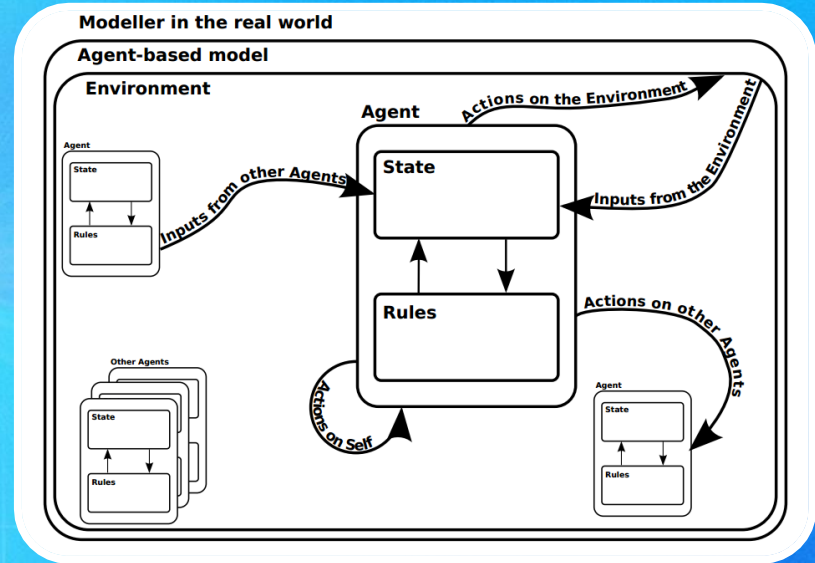
- Agents “internal models”
- Decision and transformation rules → from inputs and states to action and behavior
- Can be static or dynamic





# Actions

- Agent will perform (or not perform) some **action**, based on
  - Input from other Agents
  - Own states
  - And its internal decision rules
- **Action** can
  - Affect other Agents
  - Own state
  - Own rule
  - Environment



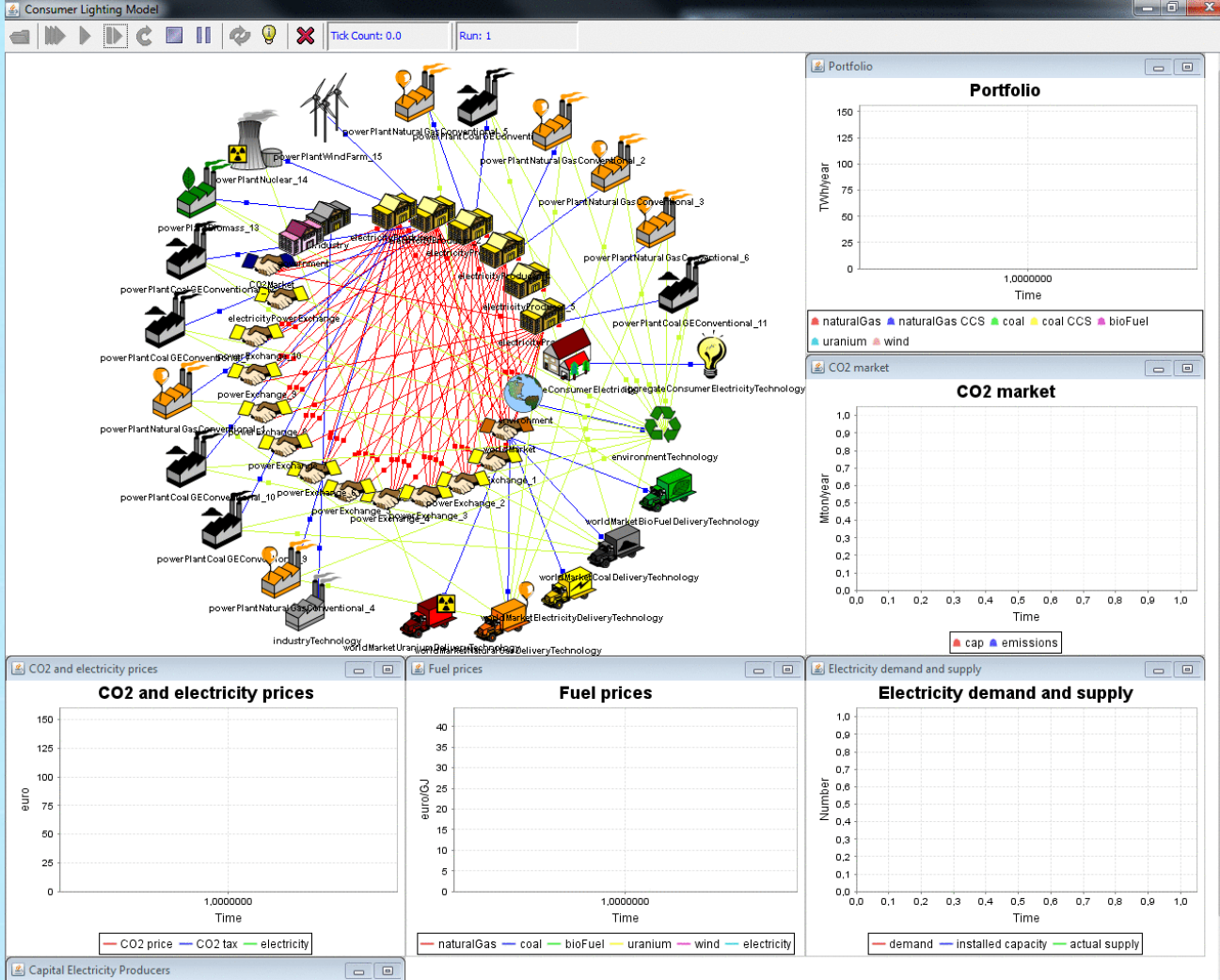
# Environment

- 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.





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# Further reading and resources



- NetLogo – a great free and open source Agent Based Modeling environment with lots of examples
  - <http://ccl.northwestern.edu/netlogo/>
- Generative Social Science: Studies in Agent-Based Computational Modeling - Joshua M. Epstein
  - <http://press.princeton.edu/titles/8277.html>
- Agent-Based Modelling of Socio-Technical Systems, K.H. Van Dam, Z. Lukszo, I. Nikolic
  - <https://www.springer.com/computer/theoretical+computer+science/book/978-94-007-4932-0>

# Thank you for your attention!

Please post any questions you may have  
on our discussion forum



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