What are agent-based models?

http://encefalus.com/general/agent-based-models/

Lecture 2

Nigel Gilbert

Centre for Research in Social Simulation
University of Surrey

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Outline

SIMIAN
Simulation Innovation: a Node

- Ingredients of agent-based models
- Some examples of agent-based modelling
- The defining features of agent-based models

What's it about?

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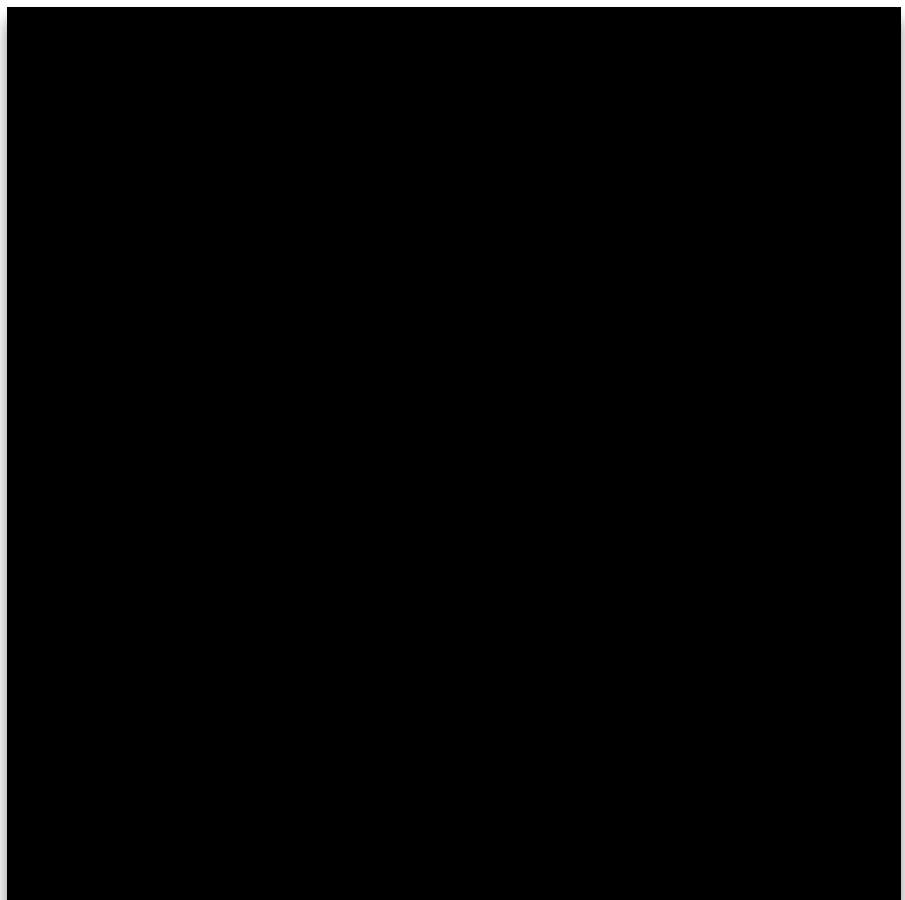
Simulation Innovation: a Node

In the beginning there was nothing . . .



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Ingredients of ABM

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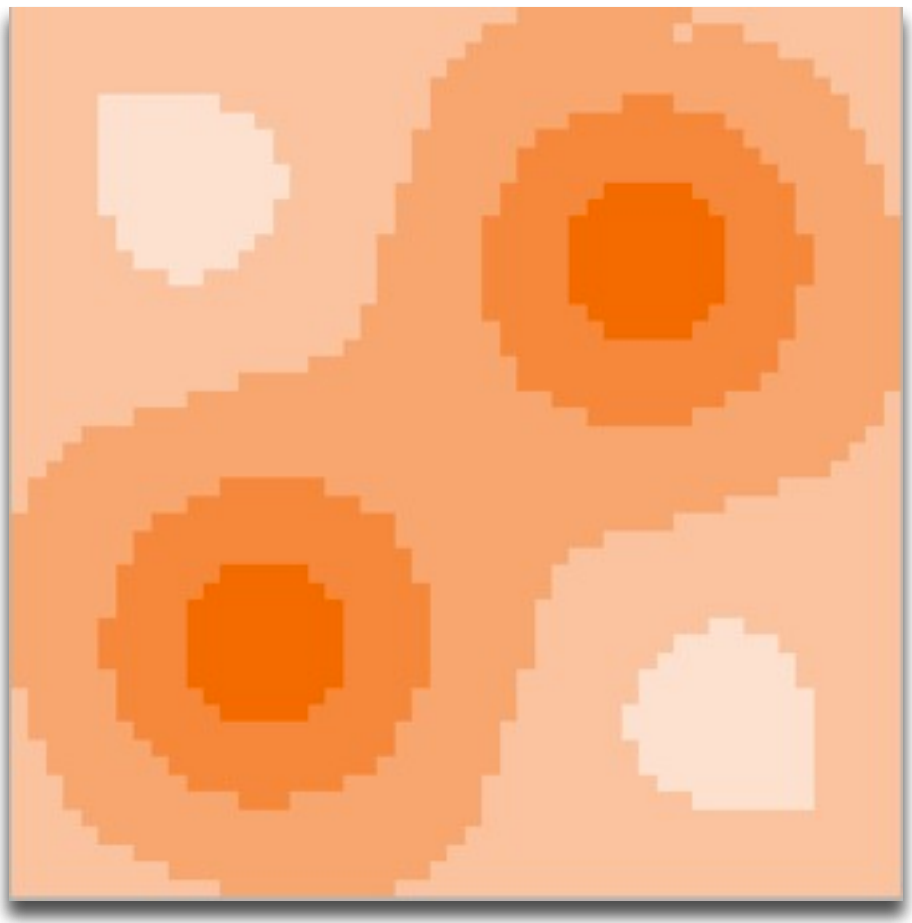
. . . but then grew the . . .



Environment

geographical space

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Ingredients of ABM

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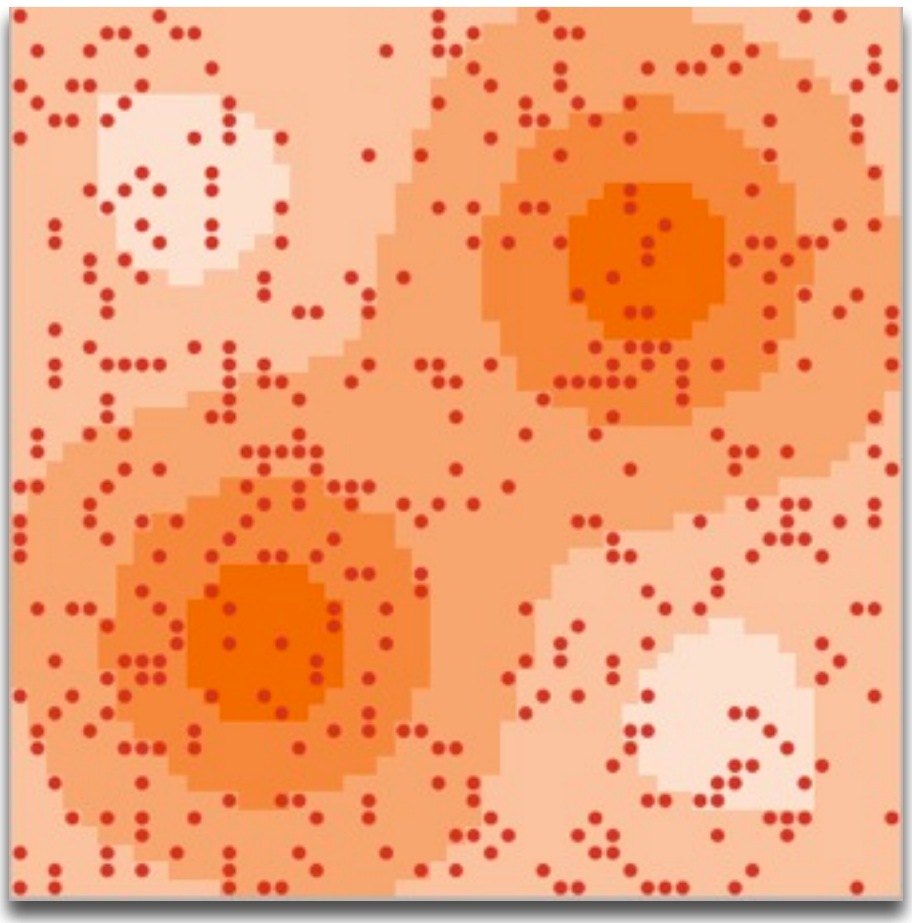
. . . which was populated by . . .

Agents

Environment

geographical space



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Ingredients of ABM

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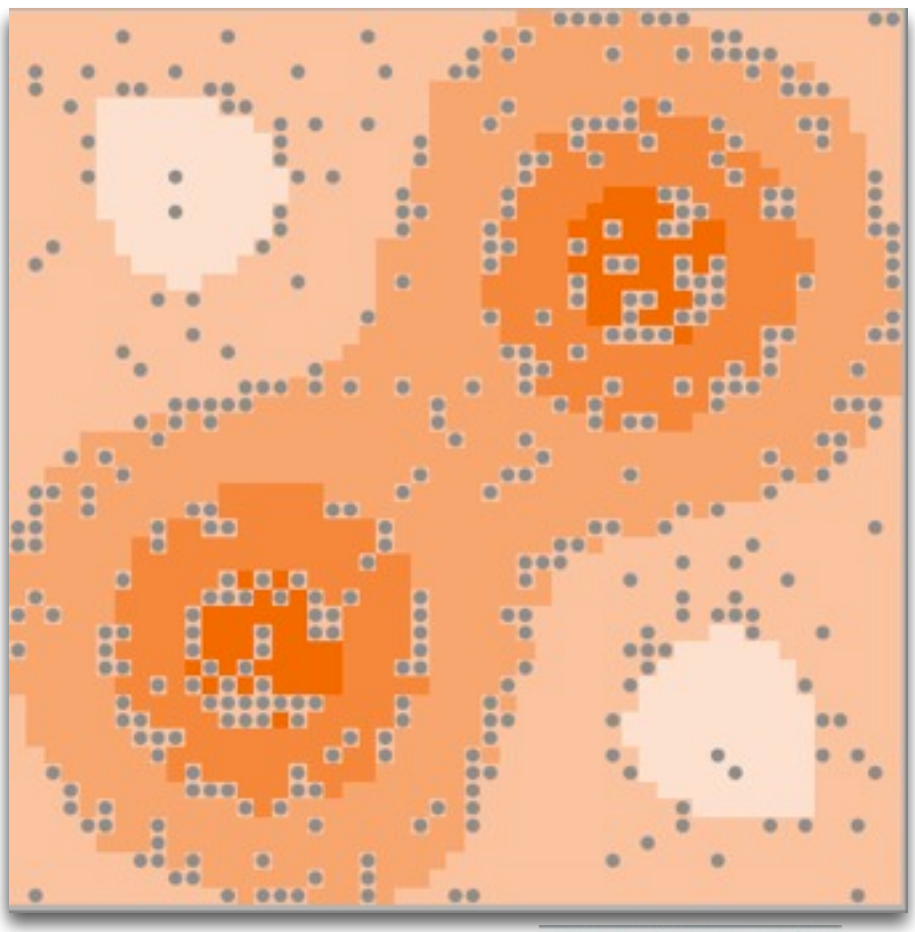
. . . who moved about . . .

Agents

Autonomy

Environment

geographical space



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Ingredients of ABM

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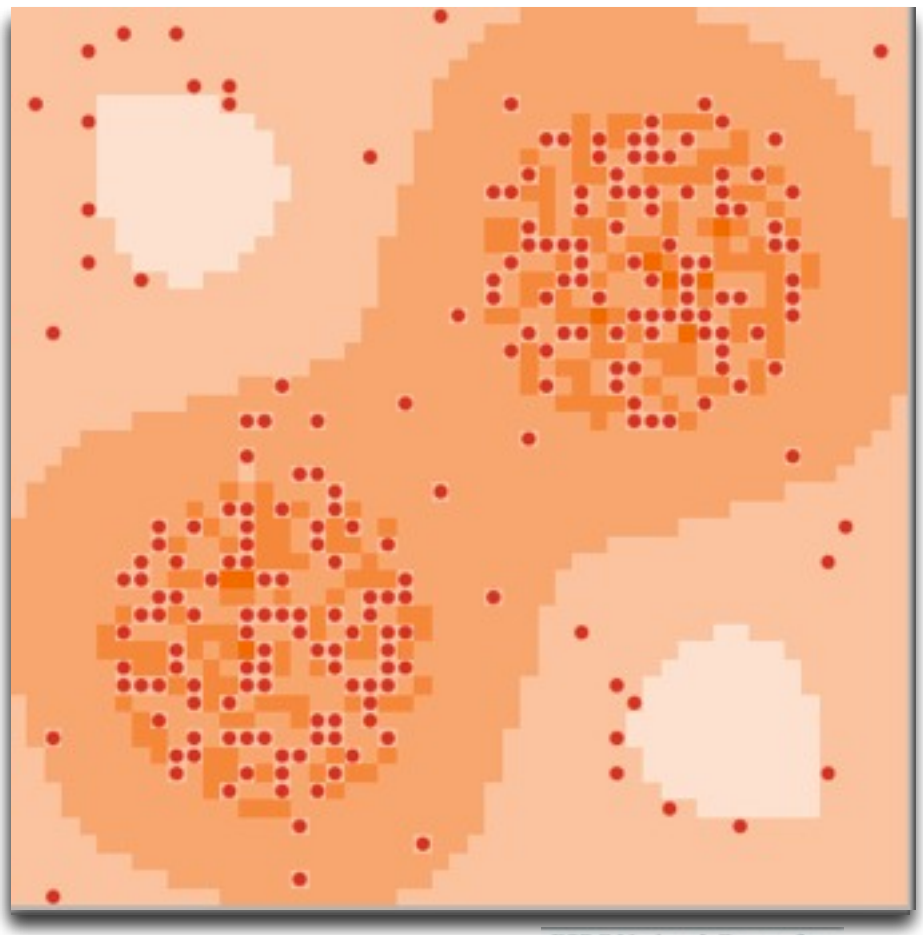

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Ingredients of ABM

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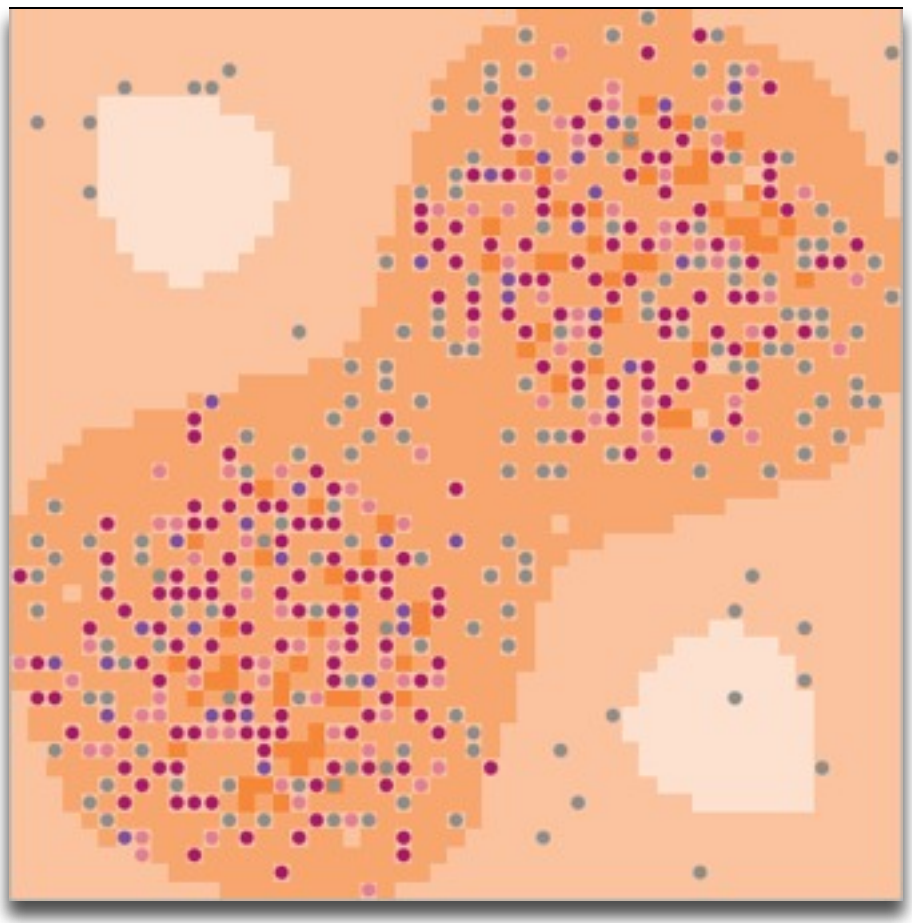
. . . and interacted with each other building a society . . .

- Agents
- Autonomy
- Interactions
- Environment
  - geographical space



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Ingredients of ABM

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. . . or exhaust resources and dissociate.

Agents

Autonomy

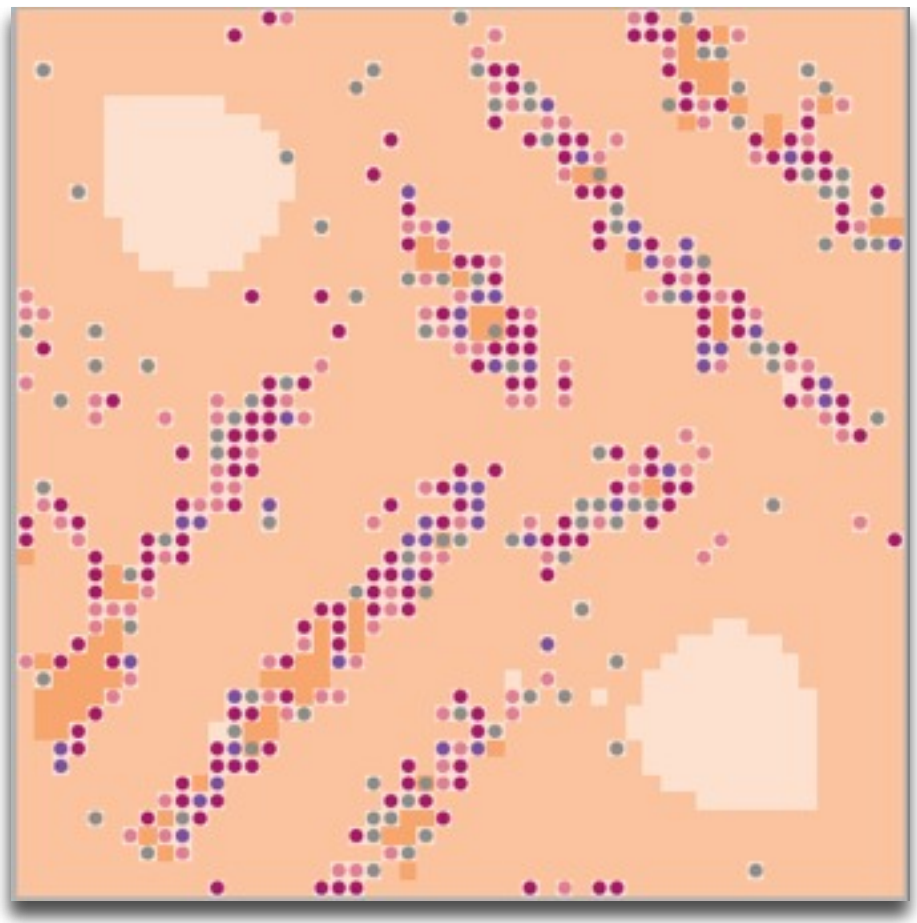
Interactions

with the

Environment

geographical space

social space



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A few examples of ABM

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- Markets
- Opinion dynamics
- Industrial networks
- Supply chain management
- Participative modelling

Markets

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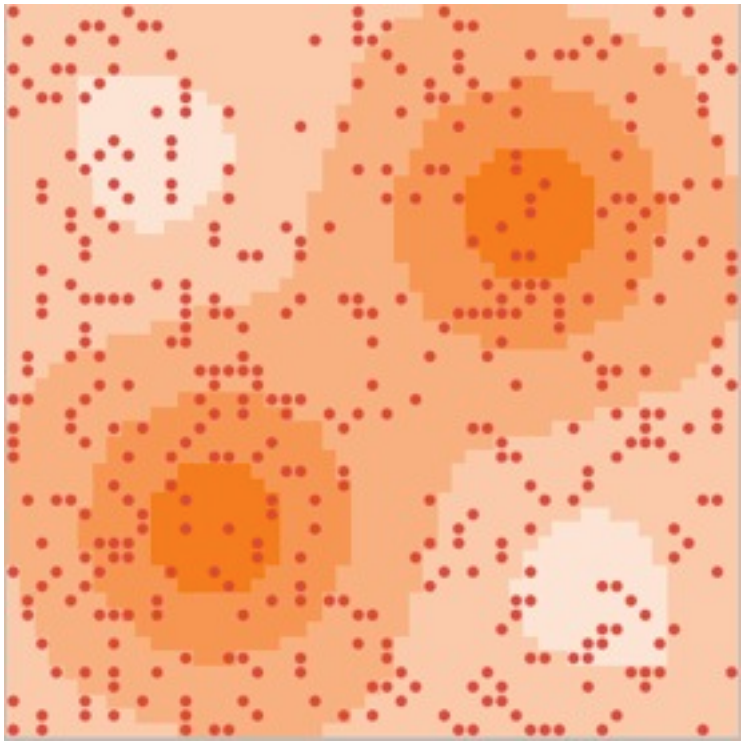
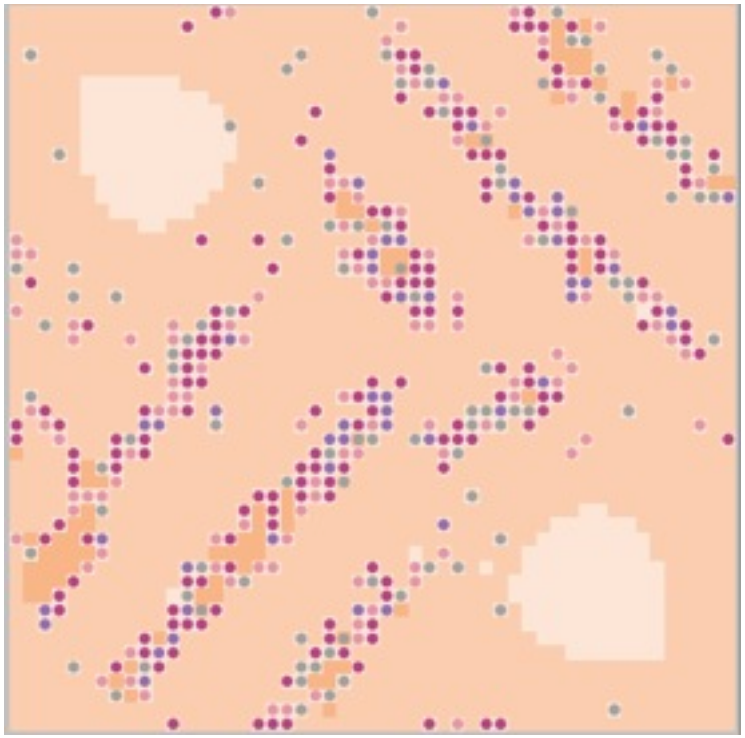
- Many agents trading with each other
- Each trying to maximise its own welfare
- Neo-classical economics assumes that markets are at equilibrium, where the price is such that supply equals demand
- Simple neo-classical models disregard geography: anyone can trade with anyone else
- But with agents, we can model markets in which the price varies between localities according to local supply and demand

Example: Sugarscape



- Agents located on a grid
- Trade with neighbours
- Two commodities: sugar and spice. All agents consume both these, but at different rates
- Each agent has its own welfare function, relating its relative preference for sugar or spice to the amount it has 'in stock' and the amount it needs

Agent strategies



- An agent moves to the cell it prefers that is within its range of vision to replenish sugar and spice stocks
  - But can also trade (barter) with other neighbouring agents
- Agents trade at a price negotiated between them when both would gain in welfare

Example: Sugarscape

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Example: Sugarscape

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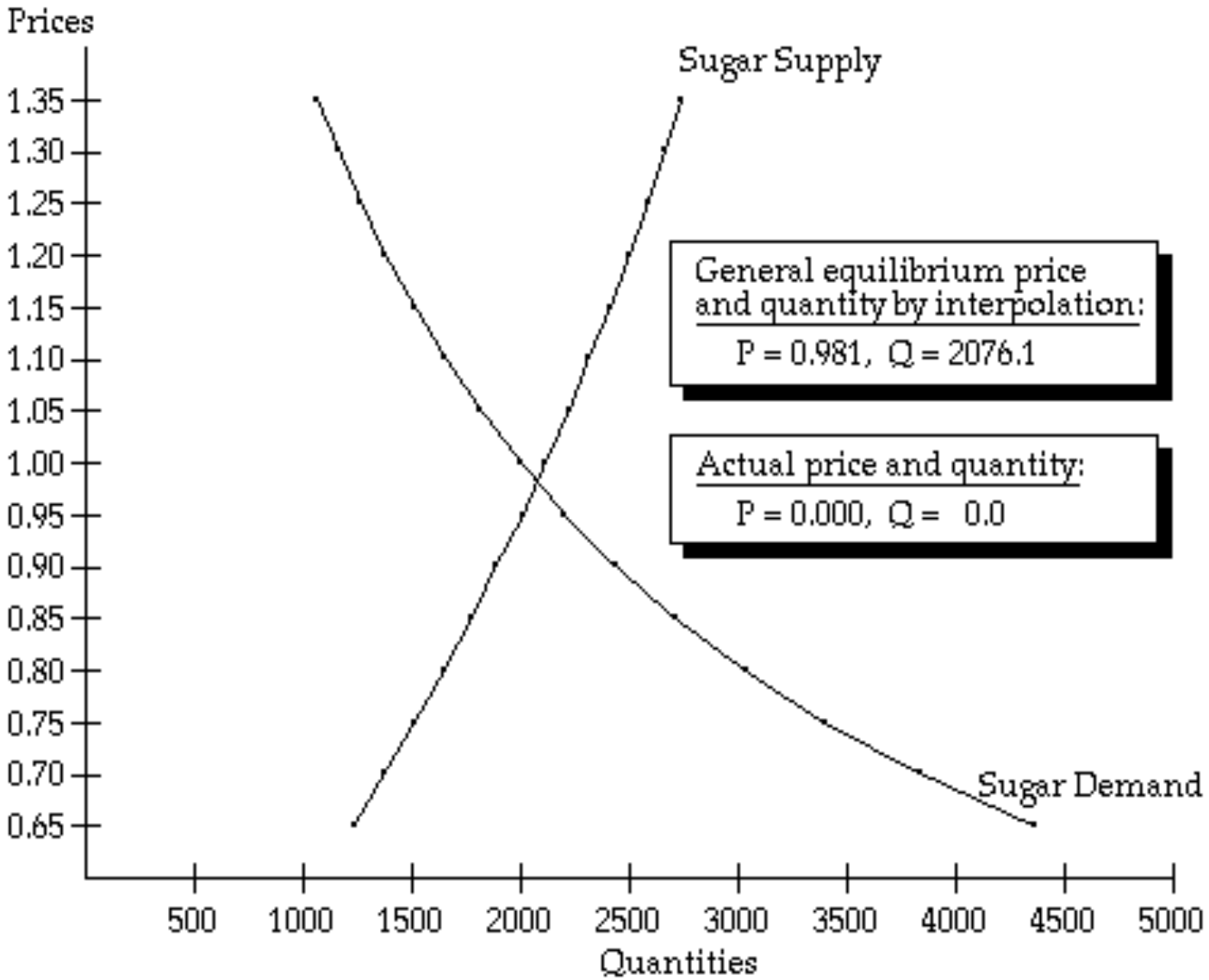

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Results

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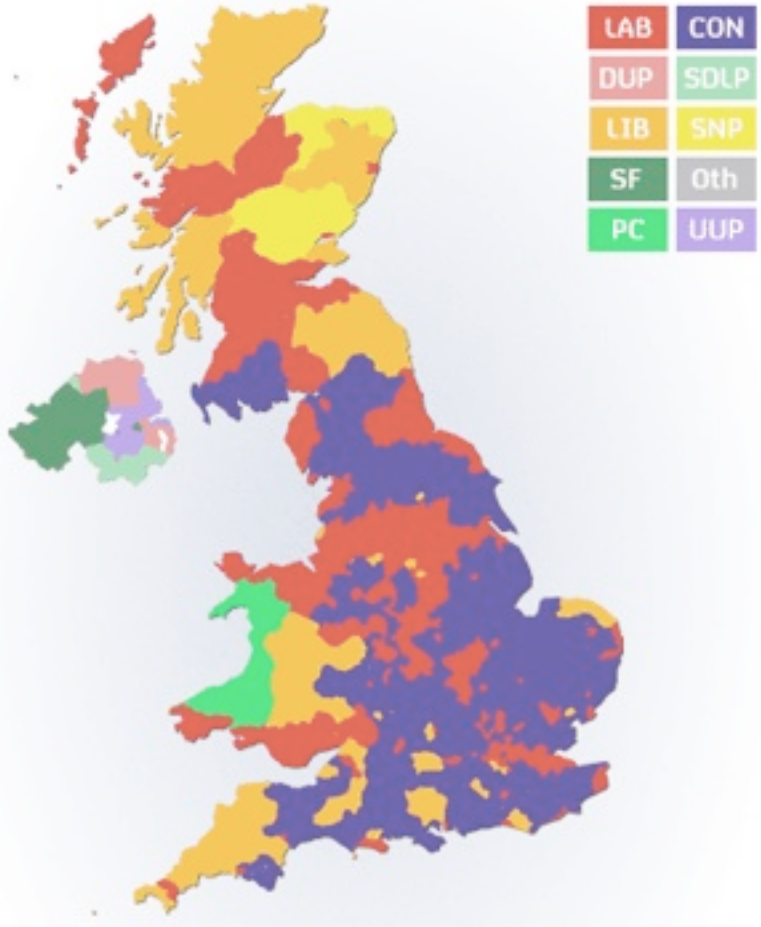
- The expected market clearing price emerges from the many bilateral trades (but with some remaining variations)
- The quantity of trade is less than that predicted by neo-classical theory

  since agents are unable to trade with other than their neighbours

Markets

- **Environment:** resources
- **Agents:** consumers (individuals, households, companies)
- **Properties:** wealth, metabolism, taste
- **Interaction:** trading

Opinion dynamics



- Studies of opinion dynamics
  - How (political) opinions change due to people influencing each other
- Agents have
  - An opinion (-1 to +1)
  - An uncertainty about their opinion (0 to ∞)
  - An opinion segment (opinion ± uncertainty)
- Agents meet randomly and if their opinion segments overlap, their opinions influence each other, by an amount proportional to the difference between the opinions, and inversely proportional to the influencing agent's uncertainty. So uncertain agents influence little, and certain ones influence a lot.

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Deffuant model of opinion dynamics

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Guillaume Deffuant, Frédéric Amblard, Gérard Weisbuch and Thierry Faure (2002) How can extremism prevail? A study based on the relative agreement interaction model *Journal of Artificial Societies and Social Simulation* vol. 5, no. 4 <http://jasss.soc.surrey.ac.uk/5/4/1.html>

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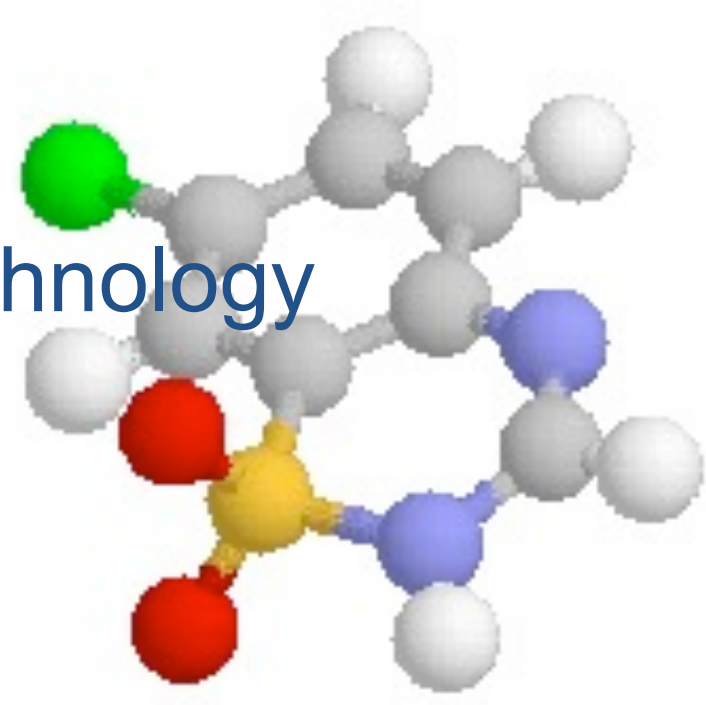
Opinion dynamics

- **Environment:** opinions
- **Agents:** individuals
- **Properties:** opinion, uncertainty
- **Interaction:** opinion assimilation

Industrial networks



- Innovation networks in biotechnology

  Knowledge level

    Firm: Innovation

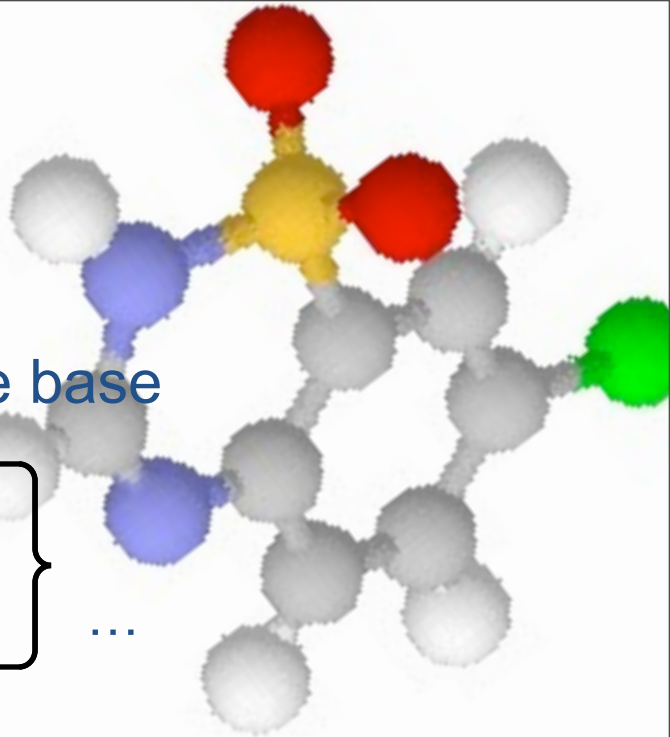
    Sector: Collaboration

  Market level

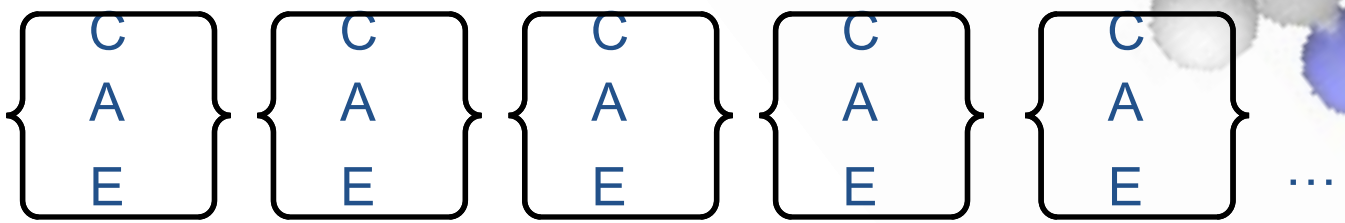
    Firm: Costs and profits

    Sector: Trade

Knowledge



- the *Kene* (compare *gene*) is a firm's knowledge base



- a kene is a collection of C/A/E-triples:

  capability C in a scientific, technological or business domain (e.g. biochemistry), an integer

  ability A to perform a certain application in this field (e.g. a synthesis procedure or filtering technique in the field of biochemistry), a real number

  expertise level **E** of the firm concerning A, an integer

Results

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- Firms succeed if and only if they
  - Find suppliers to produce required inputs
  - Find customers to buy products ***and***
  - Sell at a profit
- To continue to do so, they must innovate
- It is hard to do this for long periods, so start-ups are very important
- Some firms are very successful, most fail
  - Power law distribution

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Industrial networks

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- **Environment:** links
- **Agents:** industrial units (factories, firms, etc)
- **Properties:** kenes (capability, ability, expertise)
- **Interaction:** collaboration and competition

Supply chain management

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- A supply chain
  - Component manufacturers *sell to*
  - Assemblers *sell to*
  - Distributors *sell to*
  - Retailers *sell to*
  - Customers
- Each has its own policies for inventory control and order fulfilment
- How can the throughput be maximised at minimum cost?

The beer game

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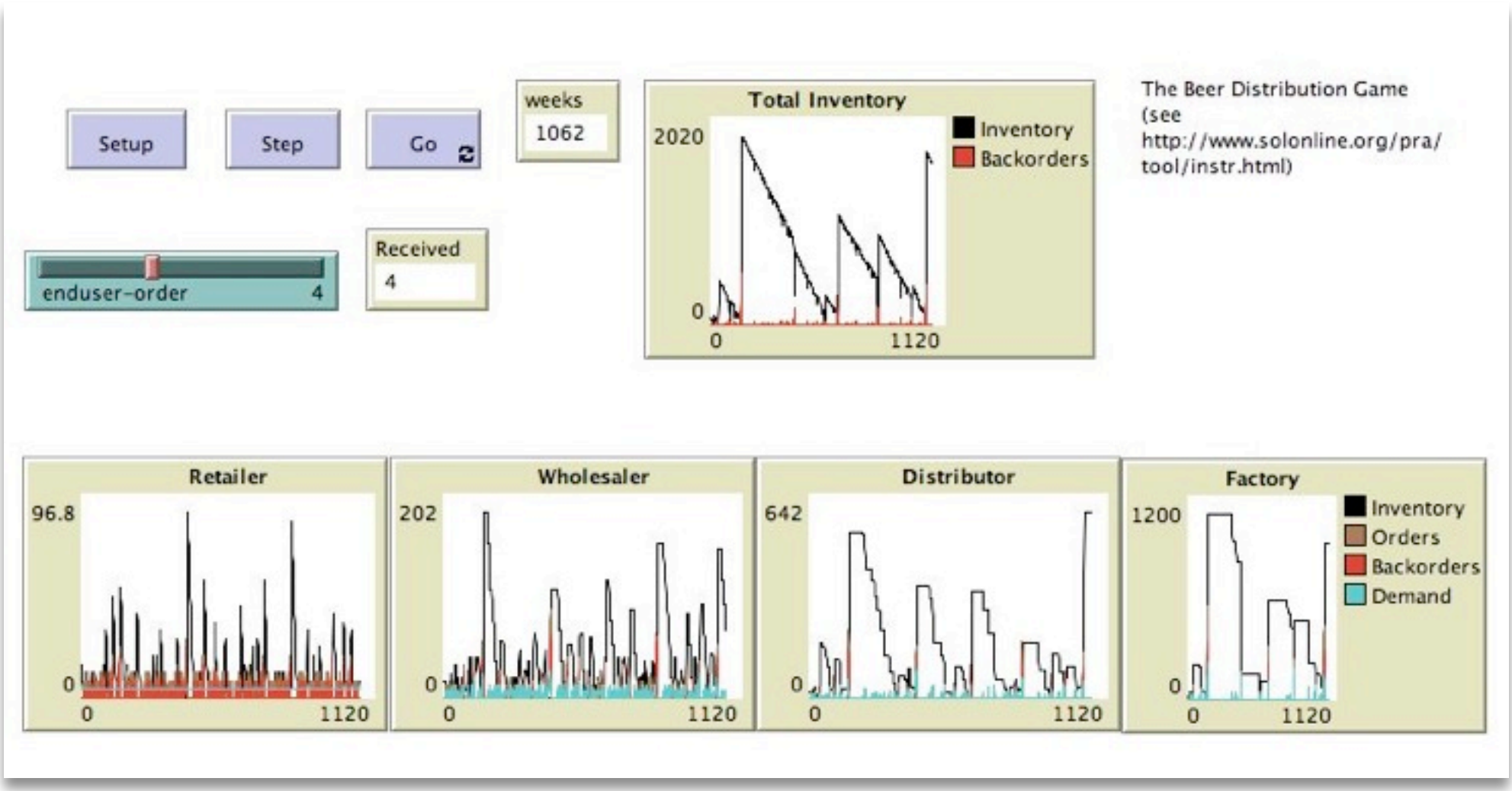

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Supply chain management

- **Environment:** links
- **Agents:** supply chain units (factory, wholesaler, consumer, etc)
- **Properties:** capacity, schedules
- **Interaction:** throughput

Humans and agents, all in the same system

- Some agents can be people
- Other agents in the same simulation can be computational
- This gives the humans a ‘bottom up’ view of what it is like to be an agent in the simulation
  - Compare with a flight simulator
- This can be useful for
  - Training (Serious Games)
  - Participative modelling (Zurich Watergame)
    - Users/stakeholders are involved in the design and implementation
  - Data collection (‘knowledge elicitation’)

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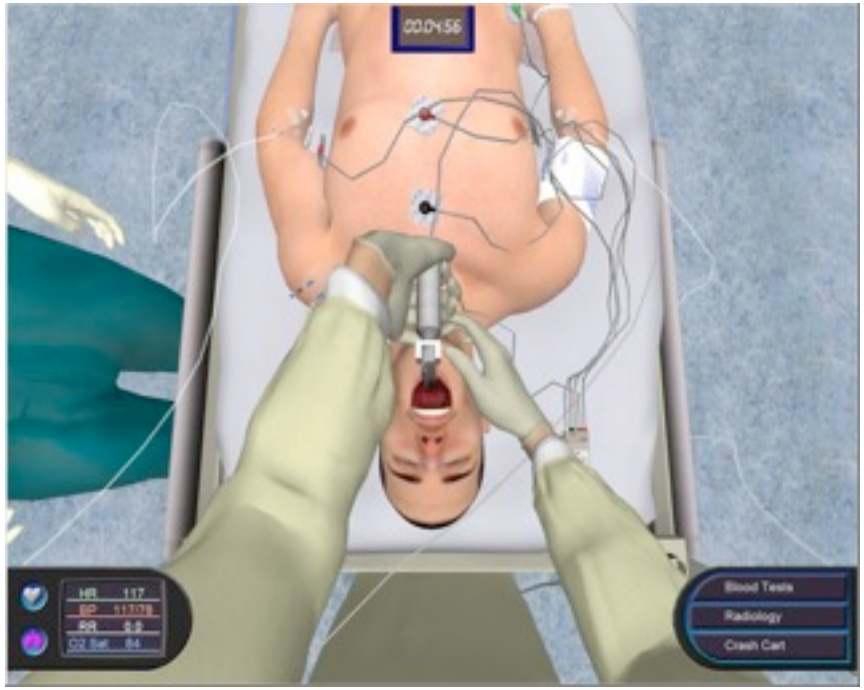
Humans and agents, all in the same system



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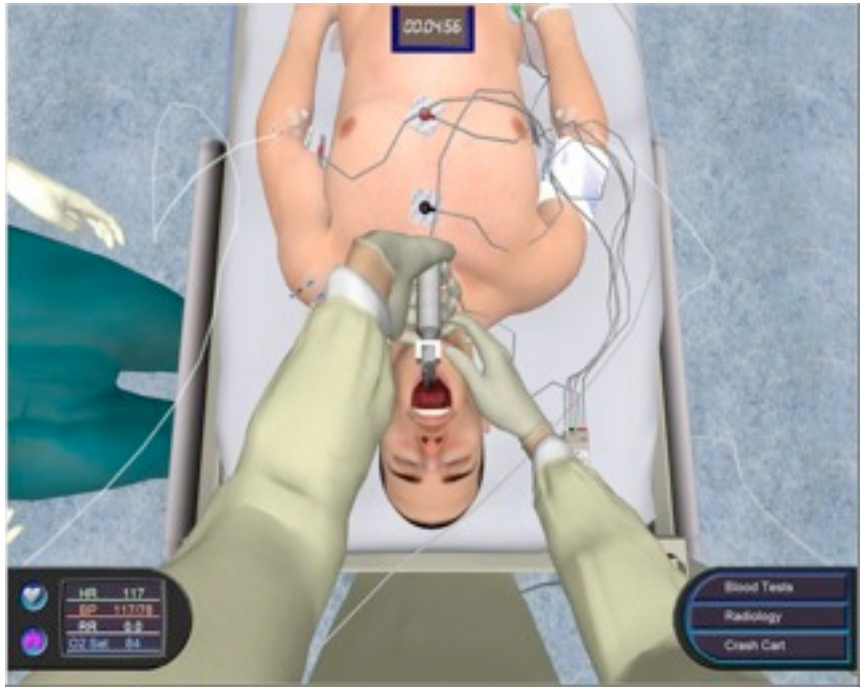
Serious Games



- *Some Pulse!* is a serious game for learning complex medical practices and technical knowledge
  - diagnose types of illnesses
  - Emergency services
  - complex surgical procedures

- Simulations of complex situations such as *Some Pulse!* validate the knowledge that have been acquired in traditional modes of learning.
  - medical history
  - physiological responses to drug treatments
  - procedures and reactions

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Synthesis

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- Environment
- Agents
- Interaction

Environment

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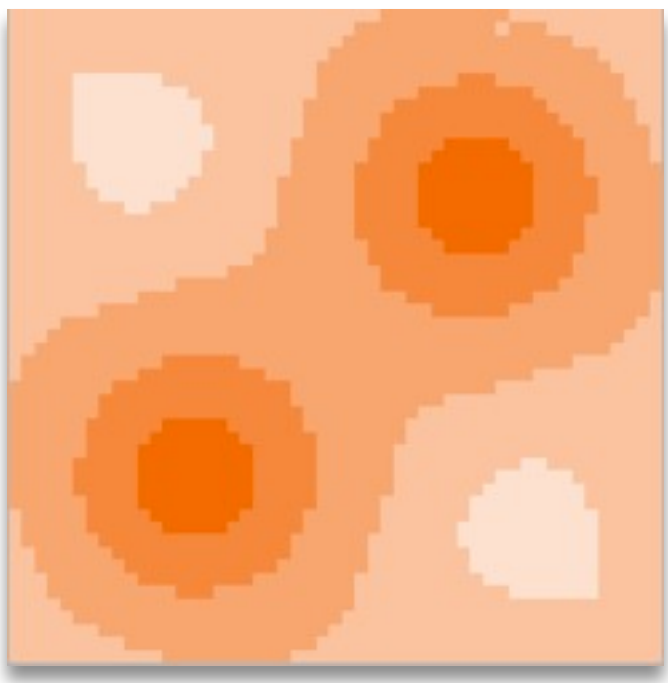
- Options:
  - Geographic space
  - Analogues to space e.g. knowledge space
  - Social space (e.g. neighbours)
  - Network (links, but no position)
- The environment provides
  - Resources
  - Communication



Agents

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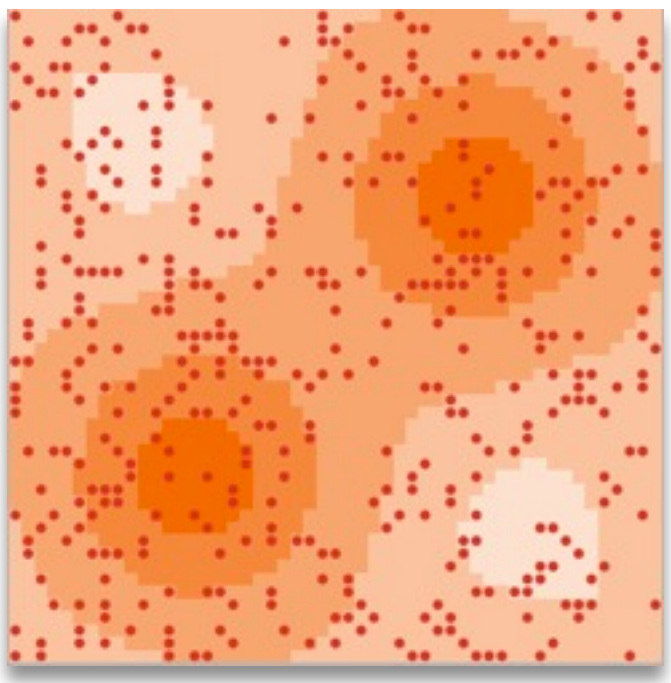
- Agents may model any actors
  - Individuals
  - Firms
  - Nations
  - etc.
- Properties of agents

  Perception

  Performance

  Policy

  Memory



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Interaction

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- Agents interact
- Information is passed from one agent to another

  (coded) Messages

  Direct transfer of Knowledge

  By-products of action e.g. chemical trails or *pheromones*

  Etc.

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Questions?

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