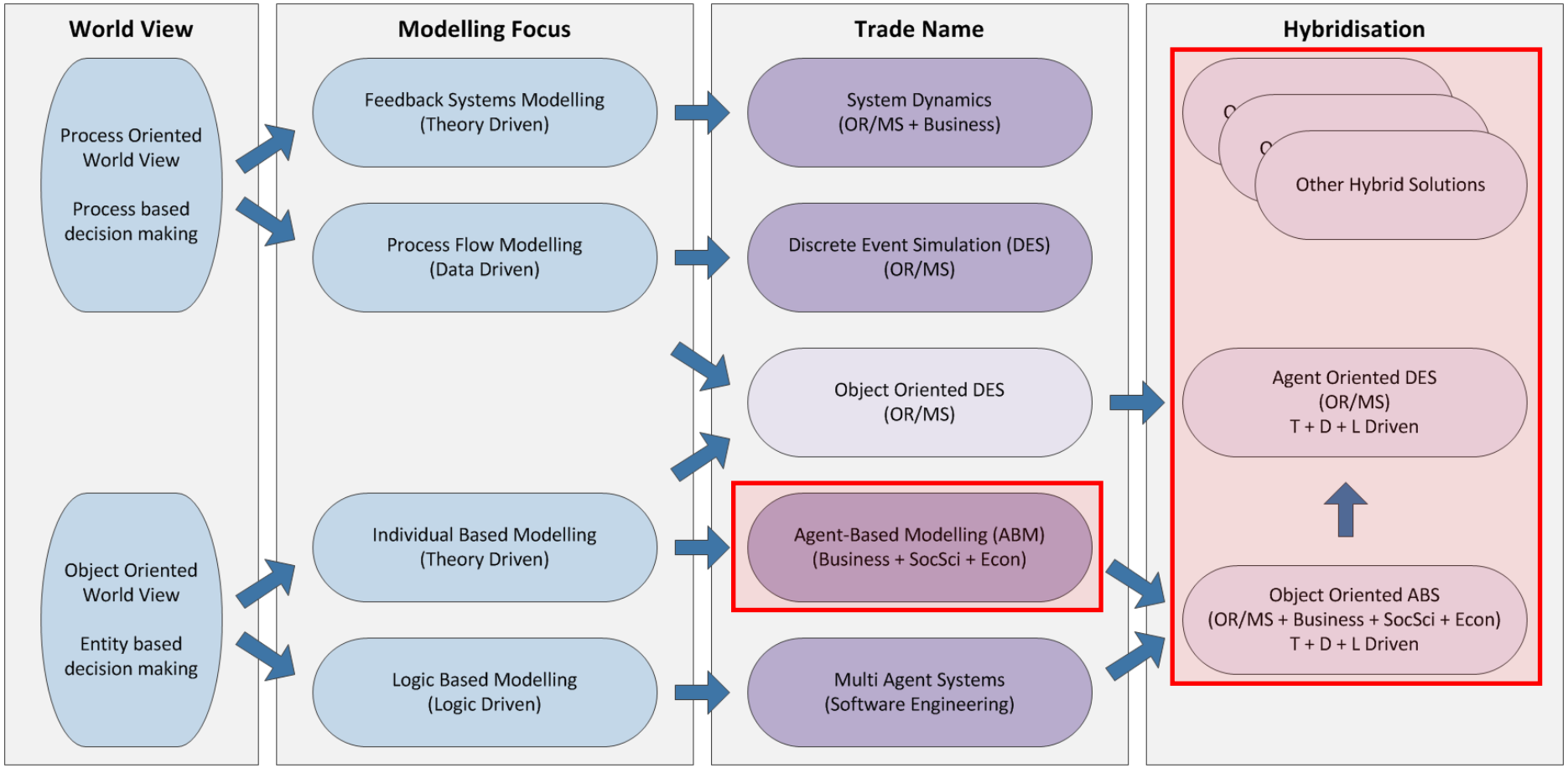
EABSS Workshop 2023

Co-Creation of Agent-Based Social Simulation Models

Agent-Based Modelling and Simulation & Hybrids

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Simulation Modelling Framework



Theory Driven: Theories for model formulation; data for model validation
Data Driven: Data for model formulation (can be quantitative and qualitative); data for model validation
Logic Driven: Logic for model formulation; data for model validation

Simulation Modelling Framework

- Object Oriented Agent-Based Simulation (OO-ABS)
  - Study of non-queuing systems (organised in terms of objects and their interaction)
  - Behaviour of proactive entities can be defined via a state chart
  - **Decisions (based on behavioural/logic models) are made within the entities**

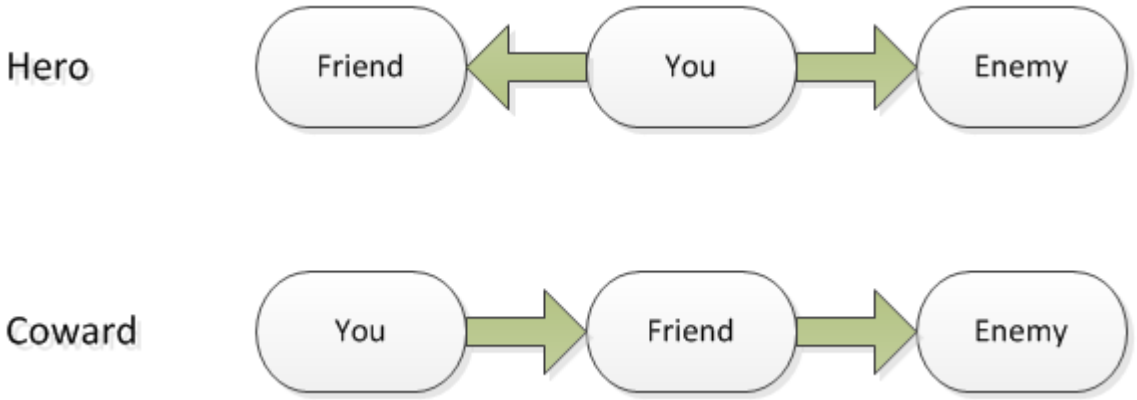
- Agent Oriented Discrete Event Simulation (AO-DES)
  - Study of queuing systems (organised in terms of queues and flows)
  - Behaviour of proactive entities can be defined via a state chart
  - **Process decisions (based on predefined rules) are made within the process model**
  - **Object decisions (based on behavioural/logic models) are made within the entities**

Agent-Based Modelling

https://www.youtube.com/watch?v=OMov1aMWscw (full video)

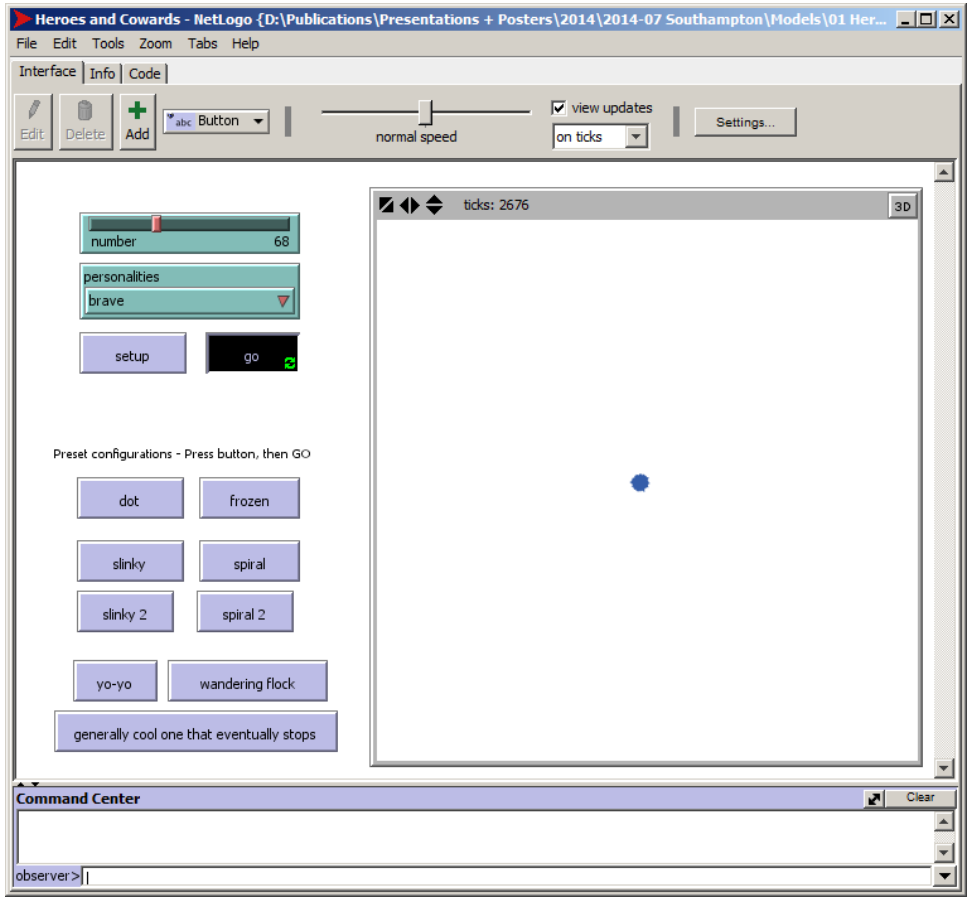
Agent-Based Modelling

- Heroes and Cowards Game [Wilensky and Rand 2013]



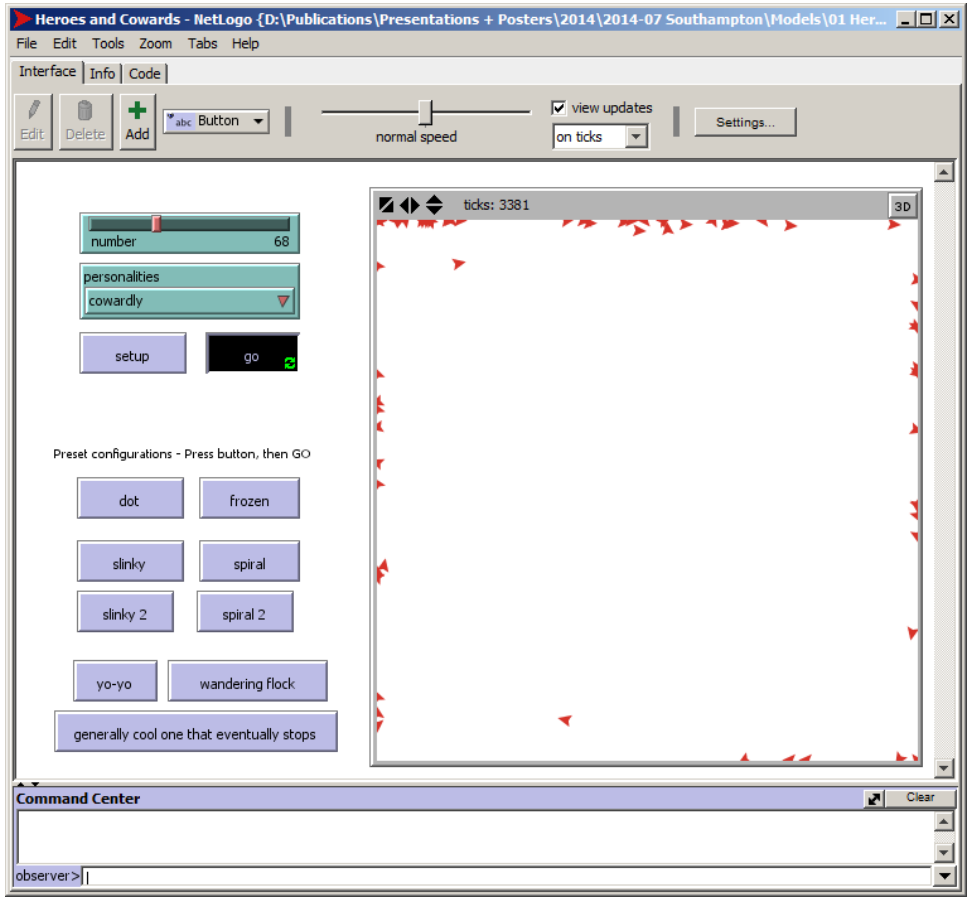
Agent-Based Modelling

- Heroes and Cowards Game : All heroes



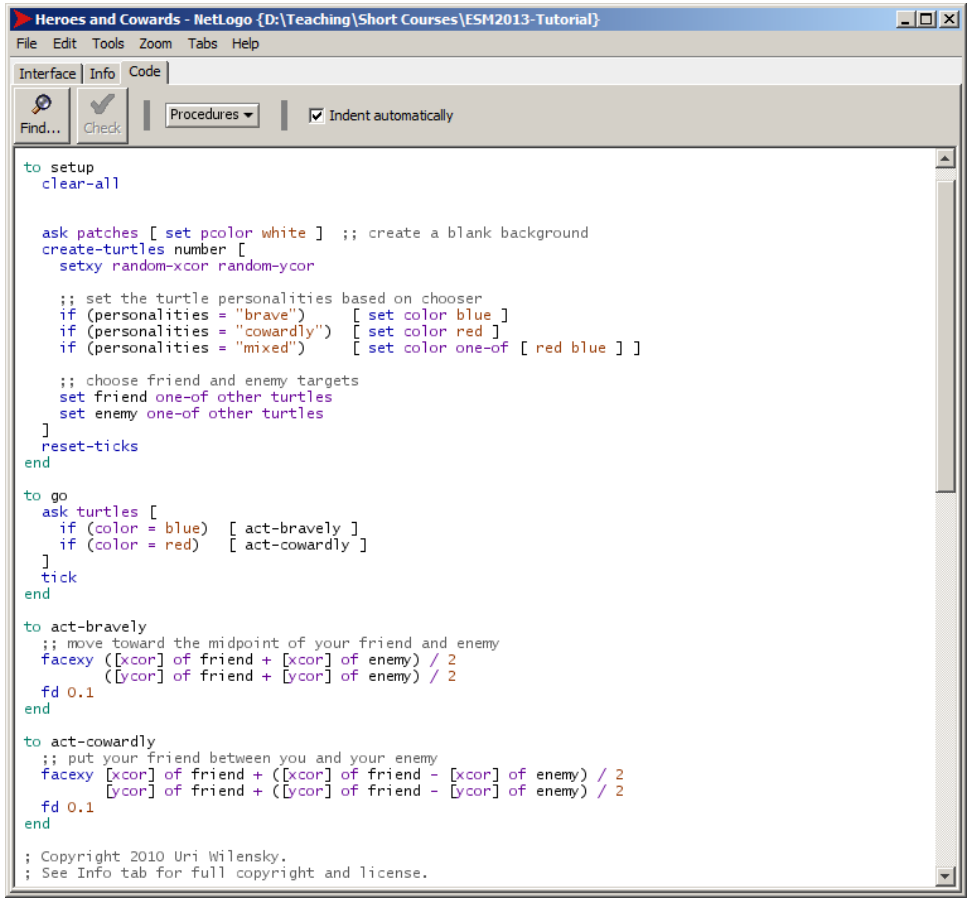
Agent-Based Modelling

- Heroes and Cowards Game: All cowards



Agent-Based Modelling

- Heroes and Cowards Game: Source Code




```
to setup
  clear-all


  ask patches [ set pcolor white ]  ;; create a blank background
  create-turtles number [
    setxy random-xcor random-ycor

    ;; set the turtle personalities based on chooser
    if (personalities = "brave")     [ set color blue ]
    if (personalities = "cowardly")  [ set color red ]
    if (personalities = "mixed")     [ set color one-of [ red blue ] ]

    ;; choose friend and enemy targets
    set friend one-of other turtles
    set enemy one-of other turtles
  ]
  reset-ticks
end

to go
  ask turtles [
    if (color = blue)  [ act-bravely ]
    if (color = red)   [ act-cowardly ]
  ]
  tick
end

to act-bravely
  ;; move toward the midpoint of your friend and enemy
  facexy ([xcor] of friend + [xcor] of enemy) / 2
         ([ycor] of friend + [ycor] of enemy) / 2
  fd 0.1
end

to act-cowardly
  ;; put your friend between you and your enemy
  facexy [xcor] of friend + ([xcor] of friend - [xcor] of enemy) / 2
         [ycor] of friend + ([ycor] of friend - [ycor] of enemy) / 2
  fd 0.1
end

; Copyright 2010 Uri Wilensky.
; See Info tab for full copyright and license.
```

Agent-Based Modelling

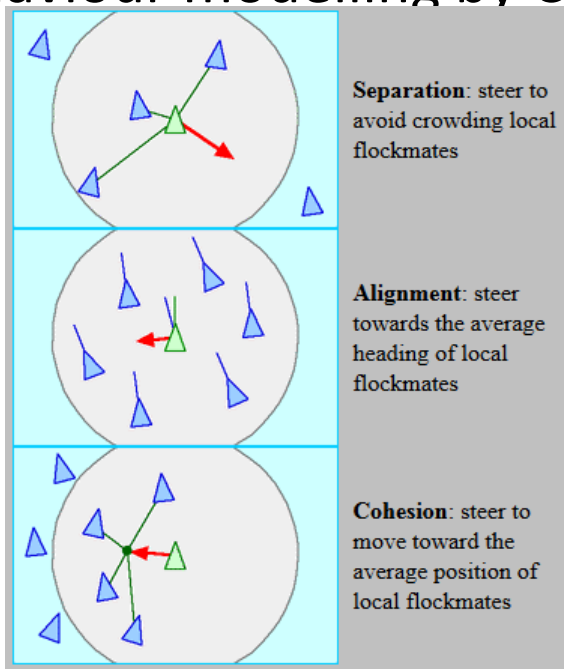
- Software used: NetLogo
  - https://ccl.northwestern.edu/netlogo/

Agent-Based Modelling

- Flocking behaviour

Agent-Based Modelling

- Flocking behaviour modelling by Craig Reynolds [url]



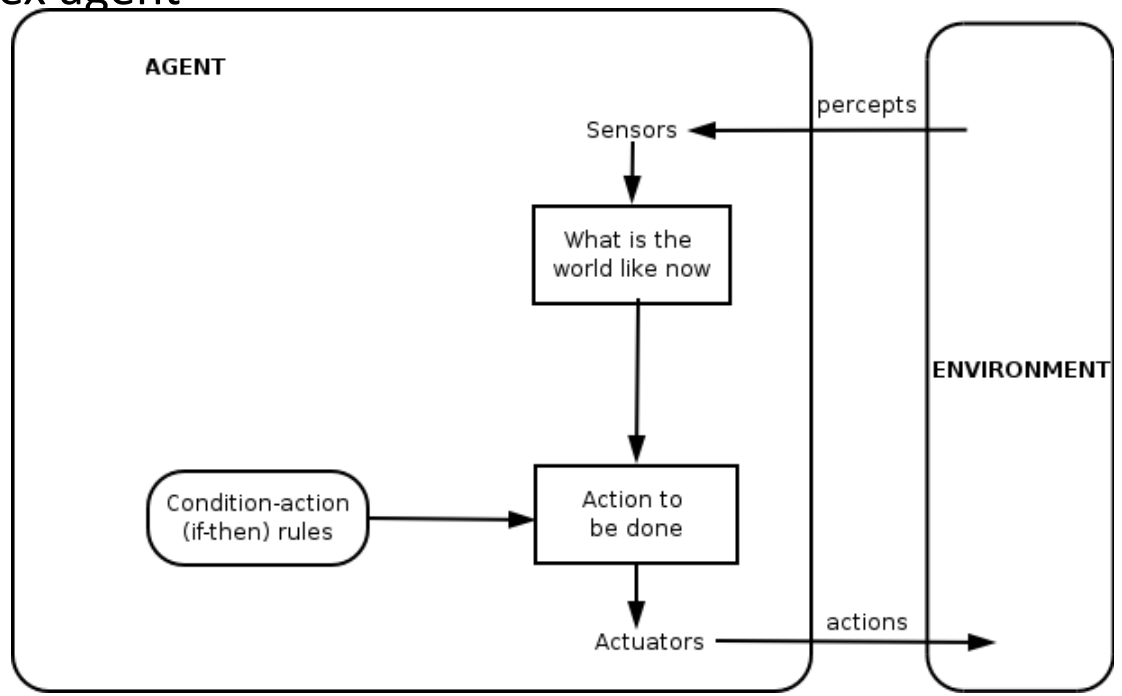
http://ayearincode.tumblr.com/post/107414487116/this-morning-i-added-some-new-rules-to

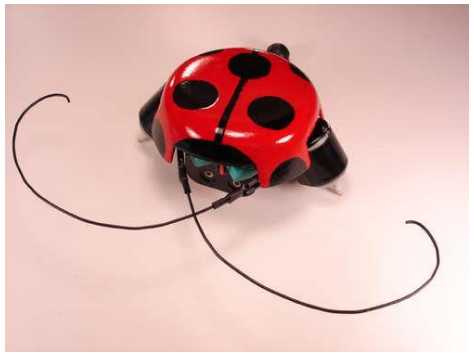
Agent-Based Modelling

- In Agent-Based Modelling (ABM), a system is modelled as a collection of **autonomous decision-making entities** called agents. Each agent individually assesses its situation and makes decisions on the basis of a **set of rules**.
- ABM is **a mindset more than a technology**. The ABM mindset consists of describing a system from the perspective of its constituent units. [Bonabeau 2002]
- ABM is **well suited to modelling** systems with heterogeneous, autonomous and proactive actors, such as **human-centred systems**.

Agent-Based Modelling

- Borrowing from Artificial Intelligence: From simple to complex
  - Simple reflex agent

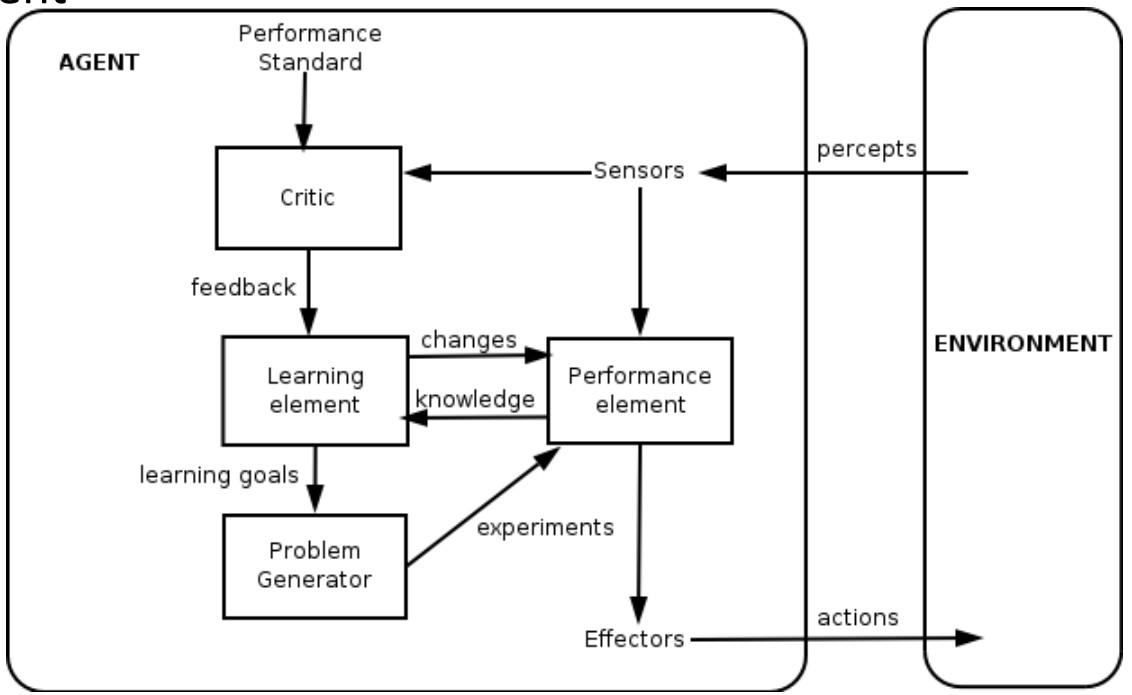




Russell and Norvig (2003)

Agent-Based Modelling

- Borrowing from Artificial Intelligence: From simple to complex
  - Learning agent



Russell and Norvig (2003)

Agent-Based Modelling

- What do we mean by "agent"?
  - Agents are **"objects with attitude"** [Bradshaw 1997]

- Properties:
  - Discrete entities
    - With their own goals and behaviours
    - With their own thread of control
  - Autonomous decisions
    - Capable to adapt
    - Capable to modify their behaviour
  - Proactive behaviour
    - Actions depending on motivations generated from their internal state

Agent-Based Modelling

- Agents can represent individuals, households, organisations, nations ...
  - Discrete entities; autonomous decisions; proactive

- ABMs are essentially **decentralised**; there is no place where global system behaviour (dynamics) would be defined

- Instead, the individual agents **interact** with each other and their environment **to produce complex collective behaviour** patterns

Agent-Based Modelling

- Benefits of ABM
  - ABM provides a natural description of a system
  - ABM captures emergent phenomena

- Emergence
  - Emergent phenomena result from the interactions of individual entities. **The whole is more than the sum of its parts** [Aristotle BC] because of the interactions between the parts
  - An emergent phenomenon can have properties that are decoupled from the properties of the part (e.g. patterns appearing)
  - Example: Traffic Jam Dynamics

Agent-Based Modelling

- When to use ABM (examples)? [Siebers et al. 2010]
  - When the problem has a **natural representation as agents** - when the goal is modelling the behaviours of individuals in a diverse population
  - When entities have **relationships with other entities**, especially **dynamic relationships**
  - When it is important that entities have **spatial or geo-spatial aspects** to their behaviours
  - When it is important that entities **learn or adapt**, or populations adapt
  - When entities engage in **strategic behaviour**, and anticipate other entities' reactions when making their decisions

Agent-Based Simulation

Agent-Based Simulation

- Little Computer People (LCP) @ C64 @ 1985
  - This "House on a Disk" is based on the theory that every computer has an "occupant"; every occupant is different
  - You could communicate with your occupant by asking him what you want him to do
    - "Please play with me"
    - "Please play piano"
    - "Please write a letter to me"
    - "Please talk to me"

Agent-Based Simulation

- The Sims: Interactive Organisational Agent-Based Simulation

Agent-Based Simulation

- Building an ABS model (OR/MS)
  - Identify active entities (agents)
  - Define their states and behaviour
  - Put them in an environment
  - Establish connections
  - Test the model

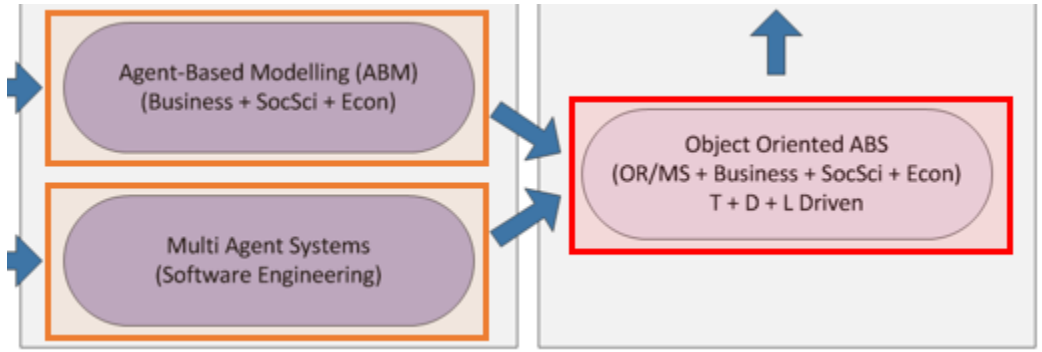
AnyLogic Help (2013)

- Alternative (e.g. Ecology)
  - Formulate the question
  - Assemble hypothesis
  - Choose model structure
  - Parameterise the model
  - Implement the model
  - Analyse the model
  - Communicate the model

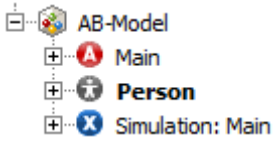
Grimm and Railsback (2005)

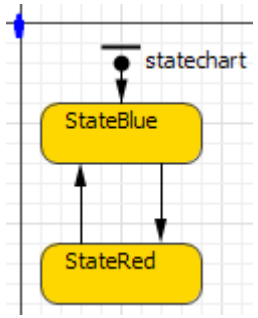
- Validating an ABS model
  - System behaviour is an emergent property
  - Validation at micro level
  - Plausibility check of emerging patterns at system level (e.g. comparison to observations)

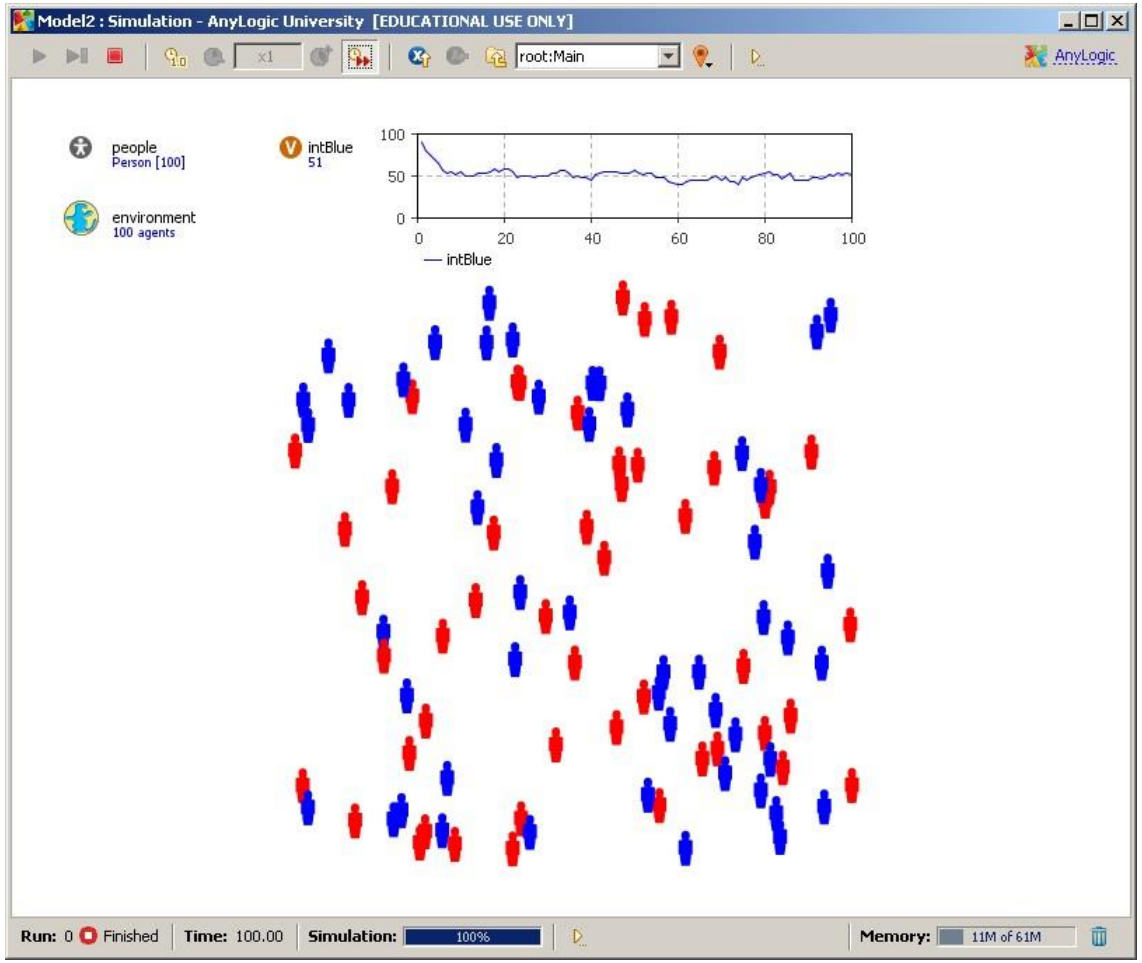
Hybrids: Object Oriented ABM

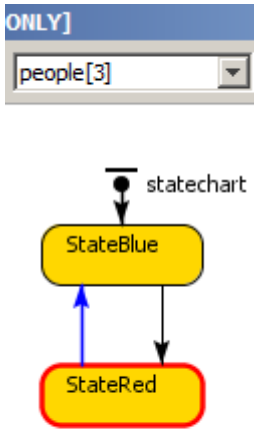


Simple Agent-Based Example







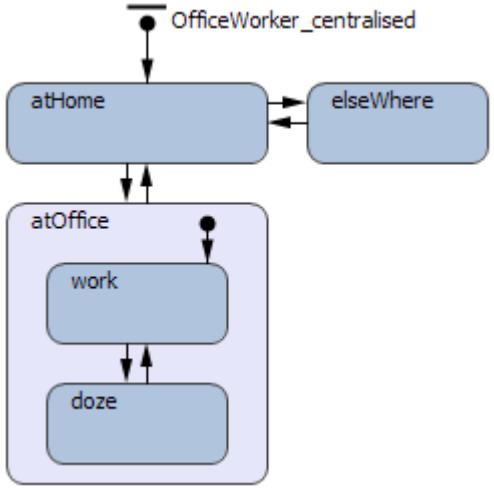


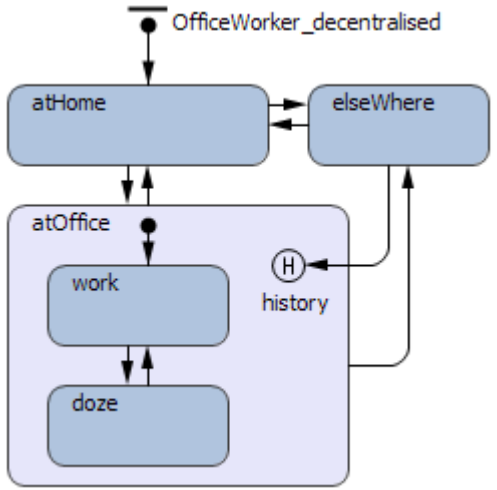
Building Simple State Charts Step-by-Step

- Simulating an office scenario
  - What question would you like to answer?
    - Consider "What-If" or "How Many" type of questions and choose one to continue
  - Who are the actors relevant to your question?
    - Come up with 2-3 actor types based on their roles
  - What are the key locations you can find them?
    - Keep it simple (approx. 3 locations)
  - What are key time consuming activities they get involved in?
    - Keep it simple (approx. 3 activities)
  - Define a state chart for one of your actor types
    - Consider key locations and key time consuming activities relevant for this actor type

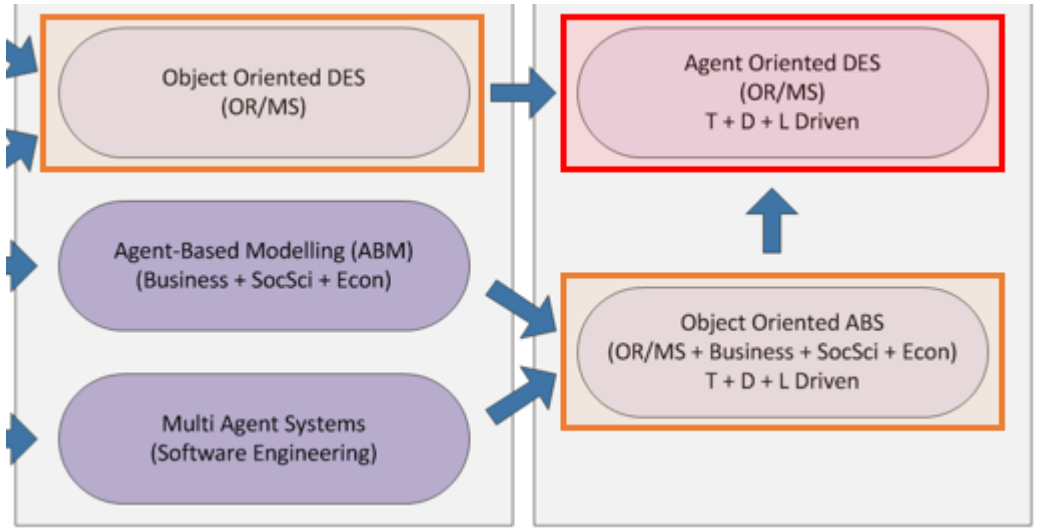
Building Simple State Charts Step-by-Step

- What is the principal difference between these solutions?





Hybrids: Agent Oriented DES



Object Oriented DES > Alternative 1: Study of queuing systems + active objects

Case Study

Modelling Staff Proactiveness in Retail Simulations

Hybrids: ABM & SDM

Case Study

Hybrid Climate Assessment Modelling

Any Questions?

References

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