A Software Engineering Approach To Designing Agent-Based Models

NIBS Presentation

v3.1 from 18 Oct 2013

Collaborators

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Prologue

- Quote from [Gilbert 1995] talking about AI and Sociology

"Every discipline is **based on a unique foundation of epistemological assumptions and concepts**. This means that even when one discipline develops so that it begins to share its concerns with another, there may be **little or no contact** because the practitioners are, literally, speaking **different languages**."

"Even if contact is established, the neighbouring disciplines may still have nothing to say to each other because, while a topic may be common, the **questions being asked** and **what count as interesting answers** differ so greatly."

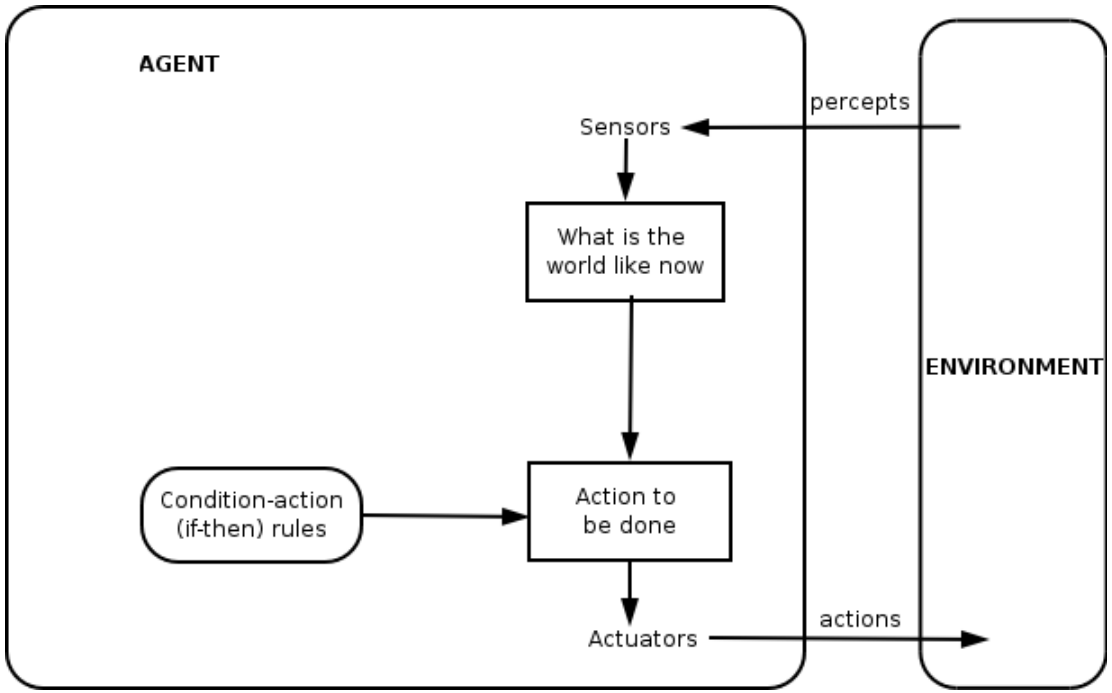
CompSci Definitions [Wooldridge and Jennings 1995]

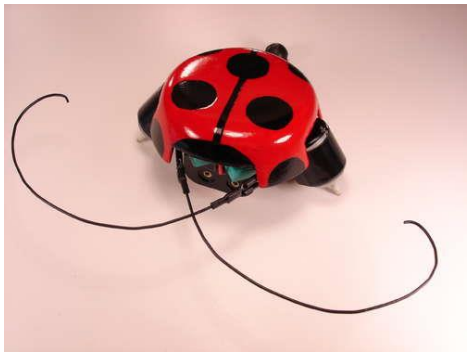
- Agent: Computer system situated in some environment
  - Capable of **autonomous action** in this environment in order to meet its design objectives

- Intelligent Agent:
  - Capable of **flexible autonomous action** in order to meet the design objectives, where flexible means ...
    - reactive: perceive their environment and respond in a timely fashion to changes that occur in it
    - pro-active: able to exhibit goal-directed behaviour by taking the initiative
    - social: capable of interacting with other agents

CompSci Definitions [Russell and Norvig 2003]

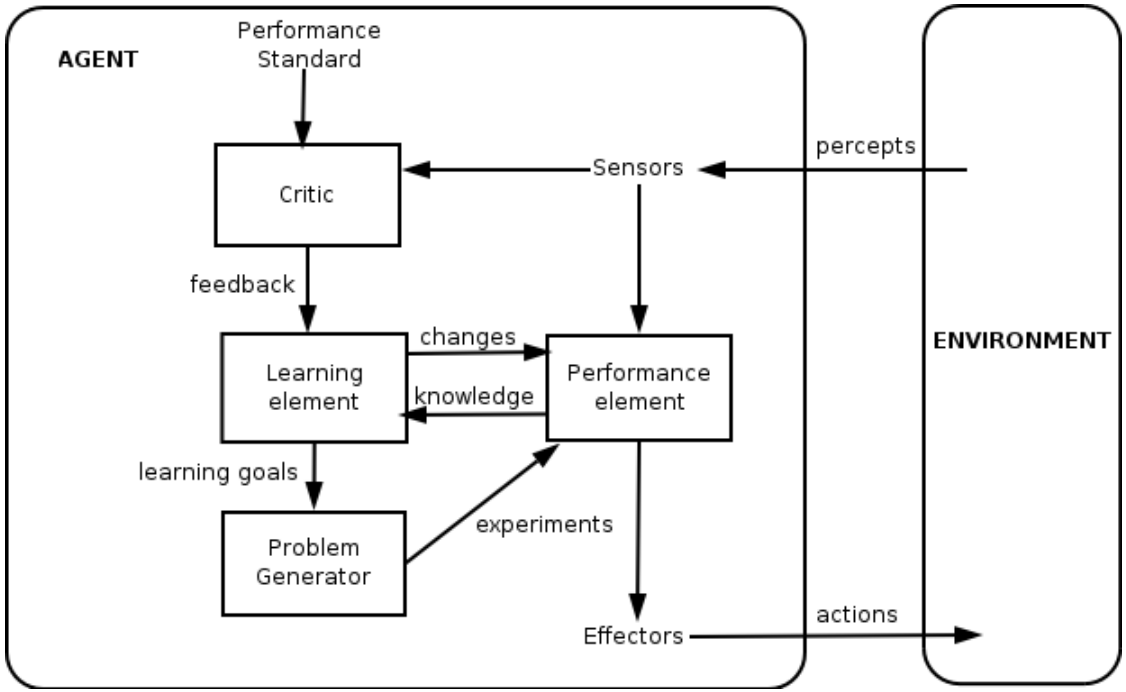
- Example of an "Agent"
  - Simple reflex agent





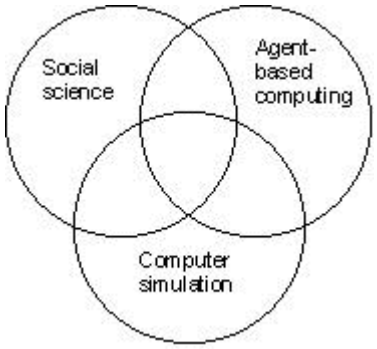
CompSci Definitions [Russell and Norvig 2003]

- Example of an "Intelligent Agent"
  - Learning Robo-Dog (SONY's AIBO)



Agent-Based Social Simulation [Davidsson 2002]

- Social Sciences: A large set of different sciences that study the interaction among social entities
  - e.g. economics, political science, psychology, sociology

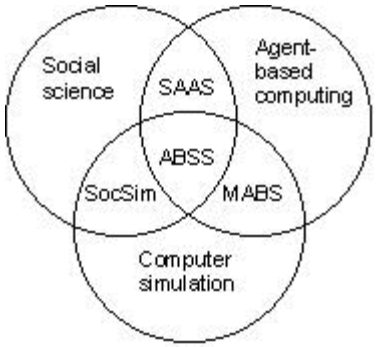


- Agent-Based Computing: Research area mainly within Computer Science
  - e.g. agent-based modelling, design, programming

- Computer Simulation: Study of different techniques for simulating phenomena on a computer
  - e.g. discrete event simulation, equation-based simulation

Agent-Based Social Simulation [Davidsson 2002]

- Agent Based Social Simulation: Investigate the use of agent technology for simulating social phenomena on a computer
  - Through its inter-disciplinary flavour, ABSS has a unique potential for providing cross-fertilisation between the participating fields of research



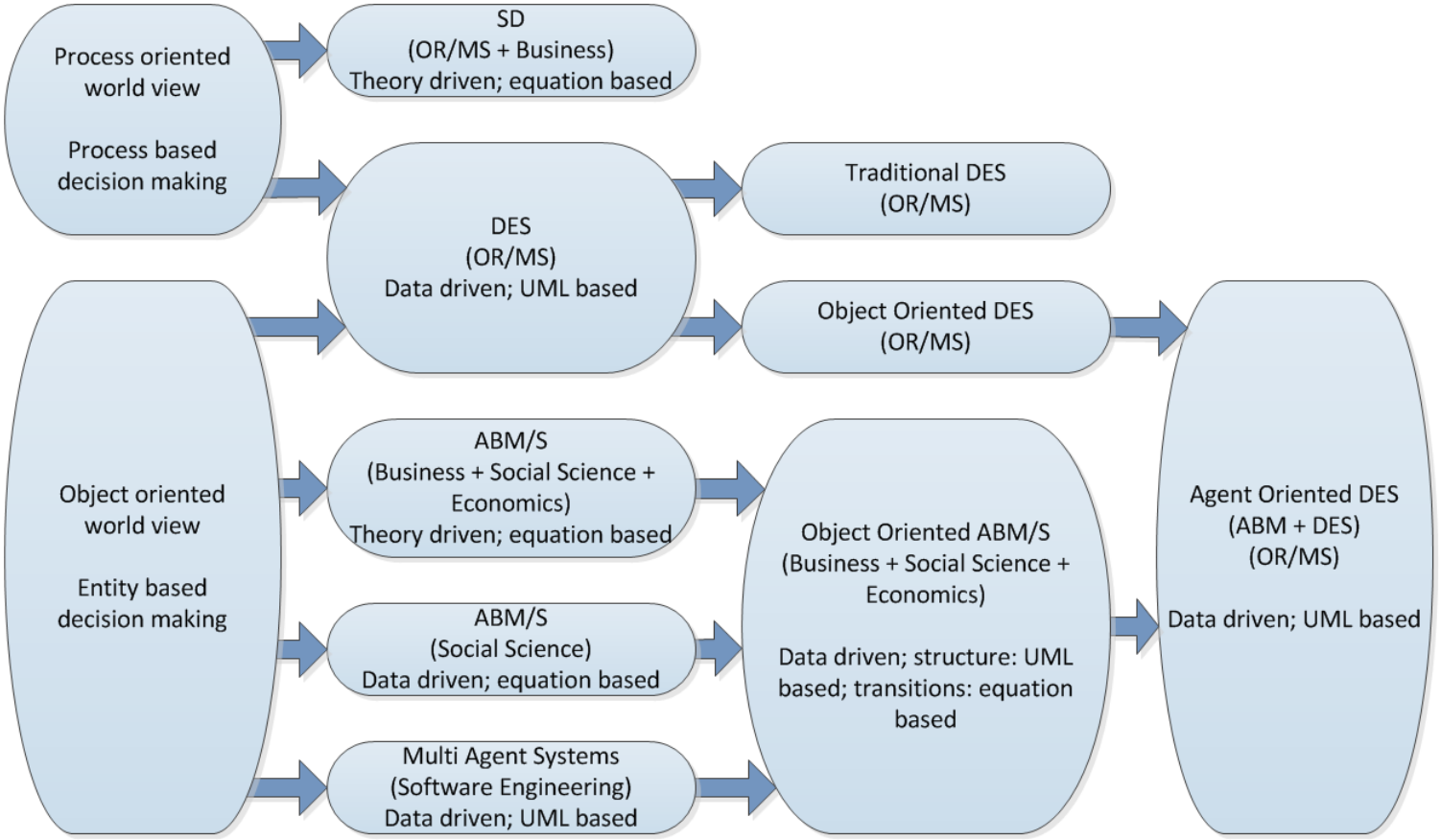
Agent-Based Social Simulation [Siebers et al. 2010]

- When to use ABSS?
  - When the problem has a **natural representation as agents** - when the goal is modelling the behaviours of individuals in a diverse population
  - When agents have relationships with other agents, especially **dynamic relationships** - agent relationships form and dissipate, e.g., structured contact, social networks
  - When it is important that individual agents have **spatial or geo-spatial aspects** to their behaviours (e.g. agents move over a landscape)
  - When it is important that agents **learn or adapt**, or populations adapt
  - When agents engage in **strategic behaviour**, and anticipate other agents' reactions when making their decisions

Agent-Based Social Simulation [Bersini 2012]

- Even though ABSS is frequently used for modelling social dilemmas, one thing that is not often considered is to use tools from software engineering to develop these models
  - Consider object oriented (OO) design principles and patterns
    - See agents as active objects that consist of attributes (individual copy for each agent) and operations (shared copy for each class of agents)
  - Consider Unified Modeling Language (UML) for modelling
    - Platform independent
    - Implementation can be automated
    - (Relatively) easy to understand and communicate

Simulation Paradigms and Worldviews



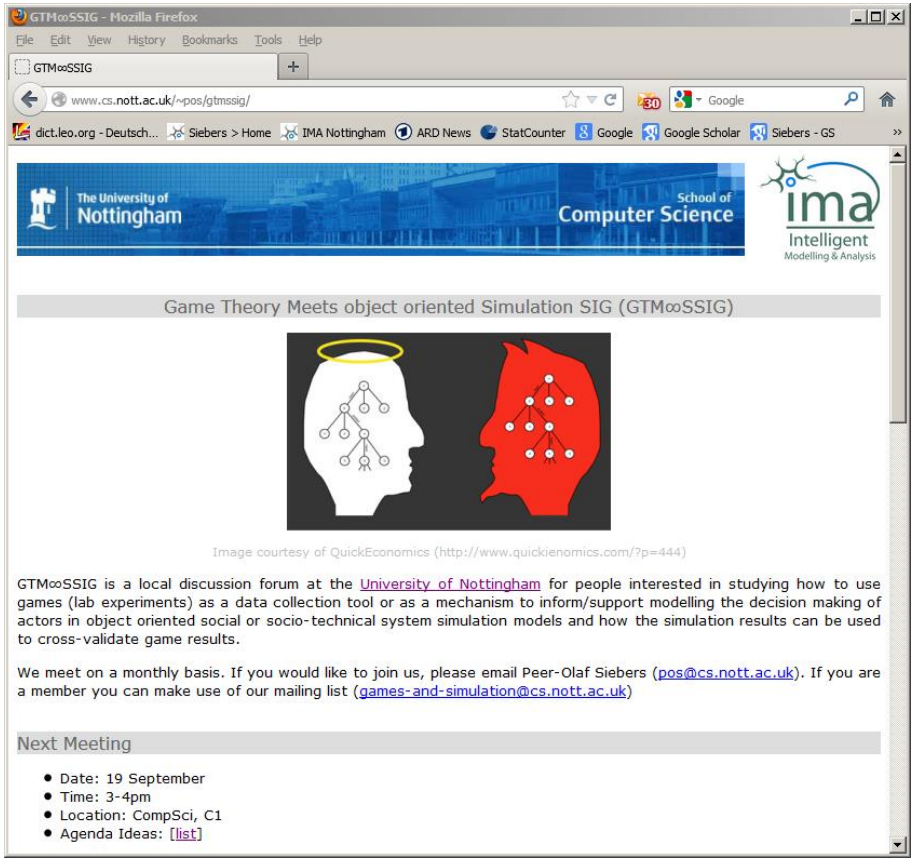
Data driven: Data for model formulation (in Social Sciences can be quantitative and qualitative); data for model validation
Theory driven: Theories for model formulation; data for model validation

Our Mission

- Mission
  - To promote cross fertilisation (btw. Behavioural Science and CompSci)
- Short term goal
  - To consider different world views for tackling the same problem
- Long term goal
  - To develop a framework for supporting cross fertilisation
  - To promote the use of UML in the behavioural sciences

Our Approach

Game Theory Meets object oriented Simulation SIG



Our Approach

- News group discussions
  - Useful and reliable measures in the different sciences
  - How to link GT and OO ABM (where to use GT within OO ABM)
  - Additional insight from OO ABM (compared to traditional methods)
- Literature review
- Workshop organisation
  - Conceptual modelling of OO ABM considering different world views
- Case studies (e.g. public goods game)
- Generalisation of design methods
  - A template that can be used for different games
- Deliver a framework to support behavioural science research

News Group Discussion [SimSoc]

Subject: Game Theory meets Object Oriented Simulation
From: Peer-Olaf Siebers <pos@CS.NOTT.AC.UK>
Reply-To: Peer-Olaf Siebers <pos@CS.NOTT.AC.UK>
Date: Tue, 13 Aug 2013 09:06:00 +0100
Content-Type: text/plain
Parts/Attachments: text/plain (10 lines)

Reply

Dear all

I would like to use state-based agents (finite state machines) for investigating changes in social norms over time. As an example I have chosen to build an object oriented agent based version of the public-goods game (modelling cooperators and free-rider as agents - i.e. learning entities). The specific application we are trying to model will be the life in a shared house (as I have plenty of experience with this). Does anyone know of examples where state-based agent models have been used for investigating social norms?

Please note that I am a computer scientist and not an expert in economy or psychology. So if the above does not make any sense, or if I used the wrong terminology, please also get in touch and let me know. The whole is part of the initiative "Game Theory meets Object Oriented Simulation" (http://www.cs.nott.ac.uk/~pos/gtmssig/) where we discuss how to use games (lab experiments) as a data collection tool or as a mechanism to inform/support modelling the decision making of actors in object oriented social or socio-technical system simulation models and how the simulation results can be used to cross-validate game results.

Many thanks for your tips!

Regards
Peer

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News Group Discussion [SimSoc]

Subject: What do YOU gain from "Public Goods" game investigations? Reply
From: Peer-Olaf Siebers <pos@CS.NOTT.AC.UK>
Reply-To: Peer-Olaf Siebers <pos@CS.NOTT.AC.UK>
Date: Sun, 1 Sep 2013 09:19:23 +0100
Content-Type: text/plain
Parts/Attachments: text/plain (18 lines)

Dear all

I am trying to understand the different motivations of Game Theorists, Experimental Economists, Agent Based Computational Economists, and other agent based modellers (e.g. Social Scientist, Psychologists) for using the "Public Goods" games during their investigations.

I have two categories of questions for the different groups:
(1) What are you trying to learn from it? What kind of question are you trying to answer? Are your answers case-based or generic?
(2) How do you collect evidence for accepting or rejecting your hypotheses? Which metrics do you use? Do you normally focus on providing average outputs (result) or are you also interested in collecting information about the evolution of the system over time (time plots)?

In your response please do not forget to state which group you belong to ;-).

Cheers
Peer

--
Dr. Peer-Olaf Siebers
School of Computer Science
The University of Nottingham
http://www.cs.nott.ac.uk/~pos/

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Literature Review (WIP)

- Tuong Vu (PhD Candidate) is working on this
  - Social dilemmas
    - Fischbacher and Gaechter (2010) Social preferences, beliefs, and the dynamics of free riding in public goods experiments
    - Gotts et al (2002) Agent-based simulation in the study of social dilemmas
    - Smith and Conrey (2007) Agent-based modelling: A new approach for theory building in social psychology
  - Software engineering
    - Ghorbani et al (2013) MAIA: A framework for developing agent-based social simulations
    - Bersini (2012) UML for ABM
    - Kardas (2013) Model driven developments of multi-agent systems: A survey and evaluation

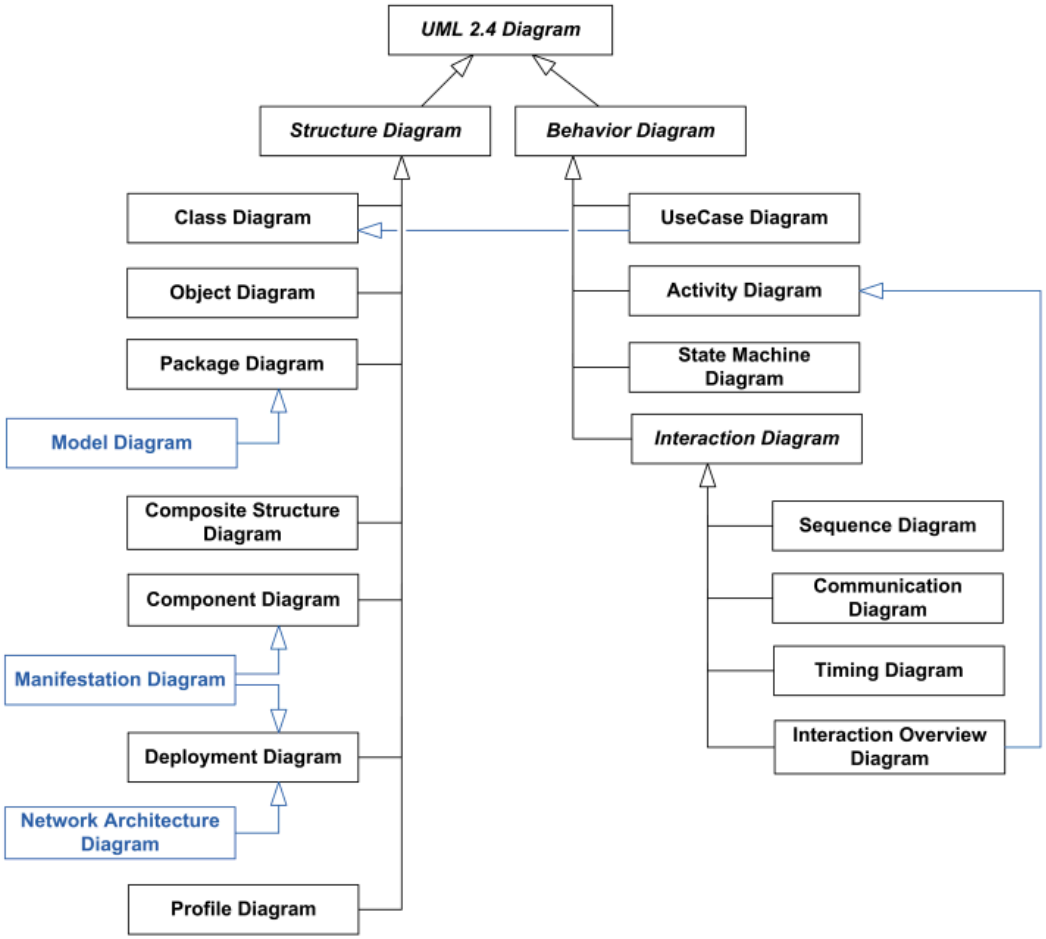
Literature Review (WIP)

- Interactive Public Goods Game using OO ABM

Workshop Organisation

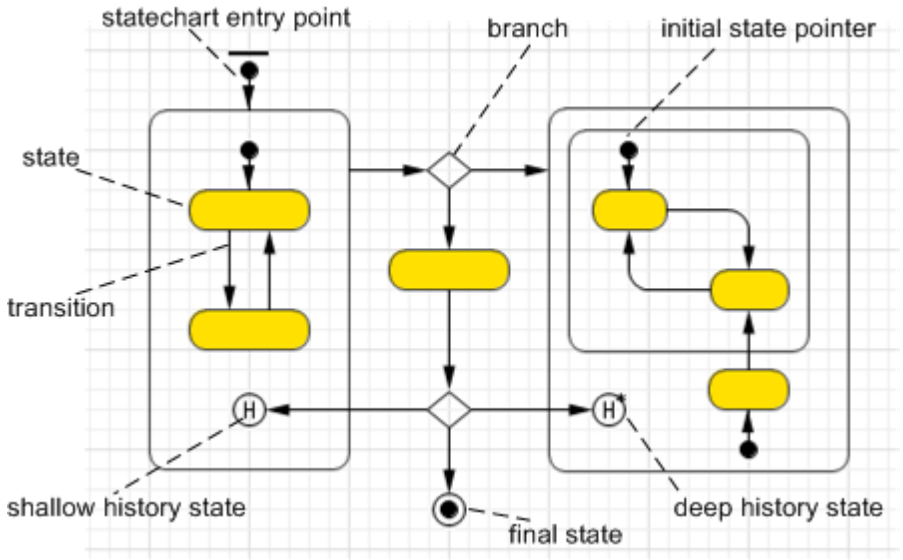
- Small team brainstorming session
- Currently in the process of setting up a workshop
  - Discuss data needs and availability
  - Find out what theories to apply and how to apply them
  - Conceptual modelling using UML

UML Introduction



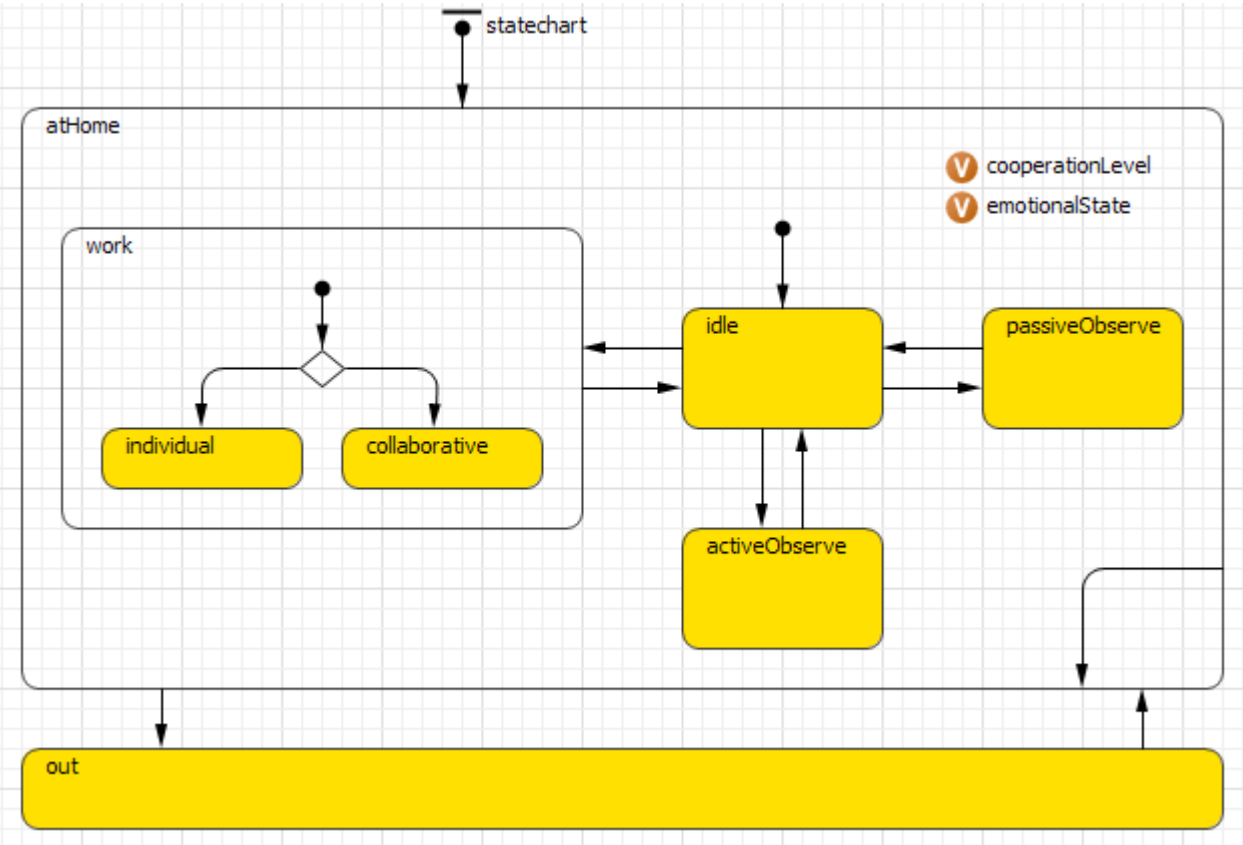
UML Introduction

- State Machine Diagram



UML Introduction

- Public Goods Game OO Agent



Feedback from NIBS

- Some points to think about ...
  - UML is completely unknown in Behavioural Sciences
    - Perhaps we should organise a workshop "UML for Economists"
  - We need to learn more about the goals of the different stakeholders
    - Object oriented models are not build for the purpose of testing a hypothesis but are a "what-if" analysis tool
  - There seem to be different types of states someone can be in
    - High level (mental) state (e.g. non-adopter, adopter) vs. low level (physical) state (e.g. eat, sleep, shoot)

Feedback from NIBS

- Some points to think about ...
  - Translation from equations to UML is not a straight forward job
    - When using UML one starts with defining the structure of an entity rather than the rules of behaviour
      1. Defining possible states an entity can be in and the state transitions
      2. Defining ways of interactions between different entities
      3. Think about how to populate the agent transitions with behavioural rules
    - The best way to start is not to look at the utility function but to think about the daily routines of a person related to the problem; the utility function can perhaps help to determine the threshold for the transitions but it is not wise to use it directly in the model

Feedback from NIBS

- Some points to think about ...
  - Shelling's segregation model: Even the OO ABM does not have states
    - For our purpose we must pick examples where a state based approach makes sense and provides a substantially different architecture and opportunities compared to the equation based approach

Questions

- Motivations of different groups of scientists for using the "Public Goods" games during their investigations

1. What are you trying to learn from it? What kind of question are you trying to answer? Are your answers case-based or generic?

2. How do you collect evidence for accepting or rejecting your hypotheses? Which metrics do you use?

3. Do you normally focus on providing average outputs (result) or are you also interested in collecting information about the evolution of the system over time (time plots)?

Resources and References

- GTMooSSIG Website
  - http://www.cs.nott.ac.uk/~pos/gtmssig/
- Object-Oriented Programming Concepts
  - http://docs.oracle.com/javase/tutorial/java/concepts/index.html
- Lecture Slides on UML (G64OOS) and Agent-Based Simulation (G54SIM)
  - http://www.cs.nott.ac.uk/~pos/g64oos/2012-2013/slides/G64OOS-Lec03%202013%20r01.pdf
  - http://www.cs.nott.ac.uk/~pos/g54sim/2012-2013/slides/G54SIM-Lec05%202013%20r01.pdf
- References
  - Bersini (2012) UML for ABM
  - Fischbacher and Gaechter (2010) Social Preferences, Beliefs, and the Dynamics of Free Riding in Public Goods Experiments
  - Ghorbani et al (2013) MAIA: A Framework for Developing Agent-Based Social Simulations
  - Gilbert (1995) Emergence in Social Simulation
  - Gotts et al (2002) Agent-Based Simulation in the Study of Social Dilemmas
  - Kardas (2013) Model Driven Developments of Multi-Agent Systems: A Survey and Evaluation
  - Russel and Norvik (2009) Artificial Intelligence: A Modern Approach (3rd Edition)
  - Siebers et al (2010) Discrete-Event Simulation is Dead, Long Live Agent-Based Simulation
  - Smith and Conrey (2007) Agent-Based Modelling: A New Approach for Theory Building in Social Psychology
  - Wooldridge and Jennings (1995) Intelligent Agents: Theory and Practice