Intelligent Management of Data Driven Simulations to Support Model Building in Social Sciences

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Overview

- Part 1: Role of AI in DDDAS management
  - Symbiotic Simulation and cognition
  - Conceptual Architecture
  - Autonomous agent vs Assistant agent
- Part 2: DDDAS and social sciences
  - Why AI in social sciences?
  - How can DDDAS be applied to social systems?
  - A case study

Symbiotic Simulation and Cognition

- Cognition is a process of anticipation, continual update and revision
- Internal simulation can be used to anticipate events and generate "what-if" scenarios;
- Adaptation and model revision (or even ontology revision) may happen as a result of interaction with reality. This is the "data-driven" aspect.
- For example:
  - an agent expects to see an object on the table (e.g. cup);
  - expectancy causes direction of sensors and focus of attention;
  - reality of the object may be slightly different from expectancy (e.g. cup is stuck to the table)
  - new data leads to further questions and what-if scenarios (e.g. is the table sticky?)

What Simulation Architecture would AI fit into?

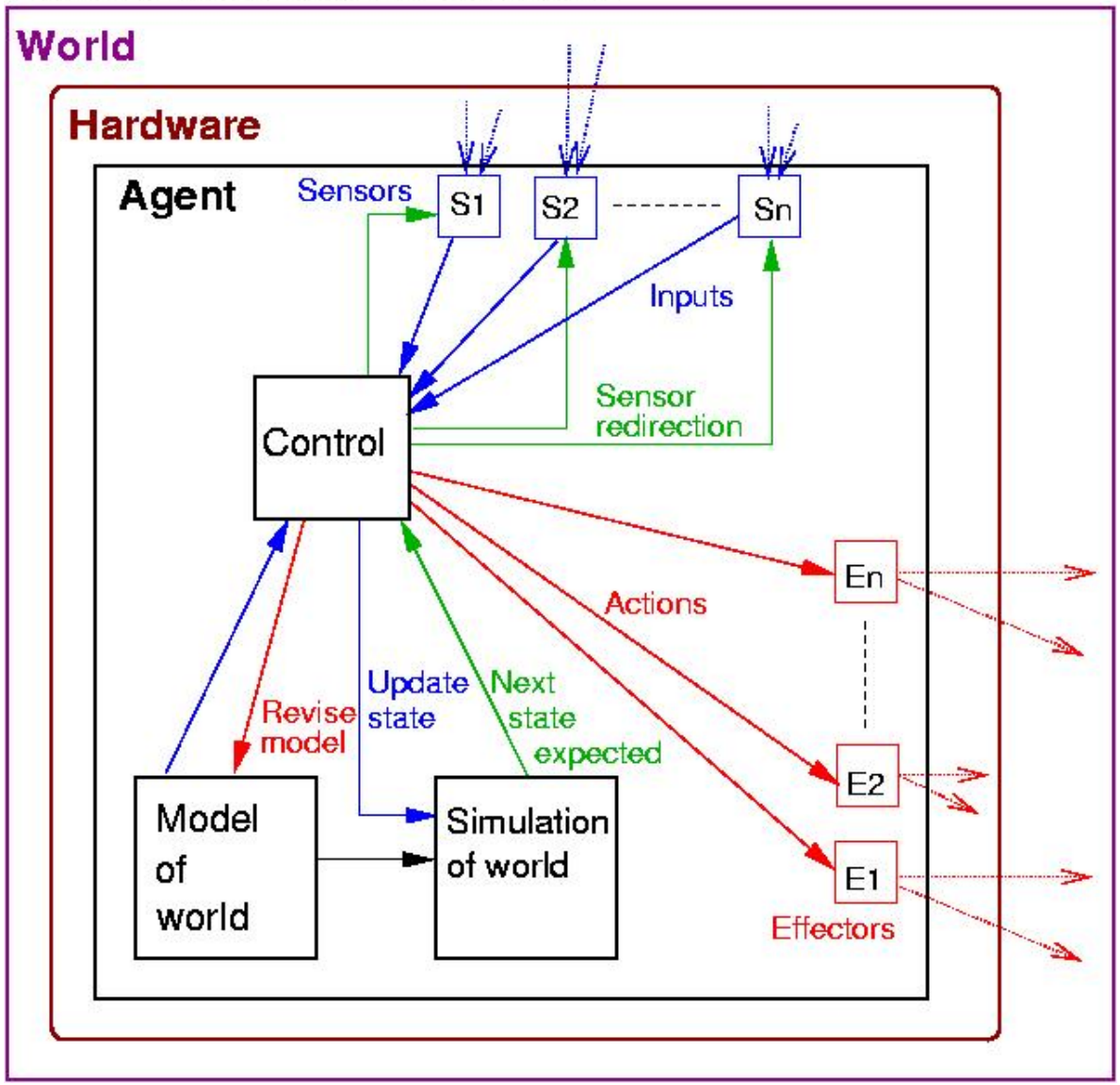
Autonomous agent:

- Simulation is internal and serves the survival of the agent (e.g. predict failure states of its hardware);
- Model on which simulation is based could be revised without human intervention as a result of agent adaptation;
- Agent is situated: it has direct control over sensors and effectors - making exploration easy.

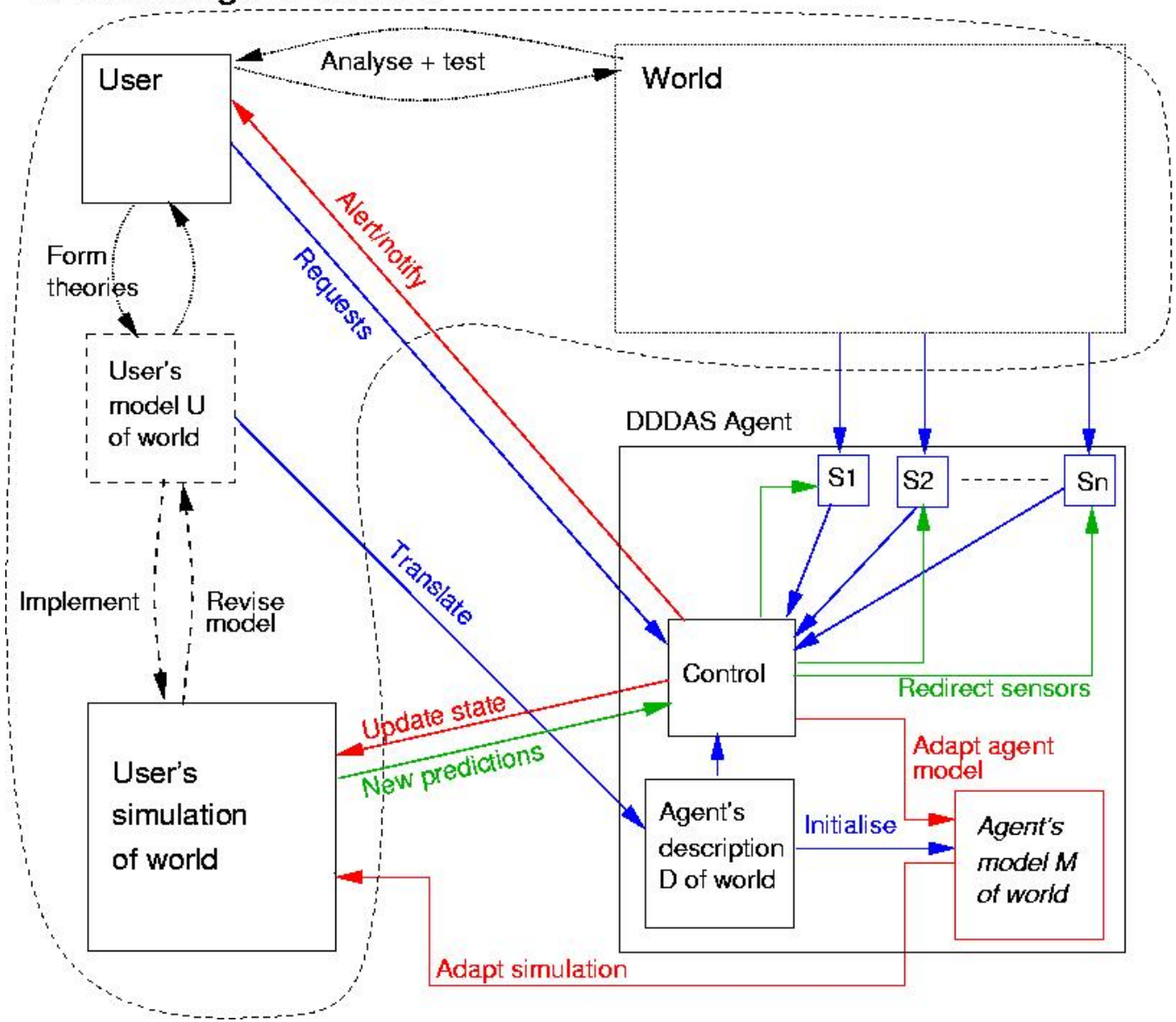
Assistant agent:

- Simulation is external and helps with predictions or "what-if" scenarios for human scientists or decision-makers;
- The model is based on a theory of the world (e.g. climate, society) and is *not* expected to be revised without human interaction;
- Agent is *not* situated: "sensors" are interfaces to software tools such as database query, data mining etc. (no "effectors")

Autonomous agent scenario



Assistant agent scenario



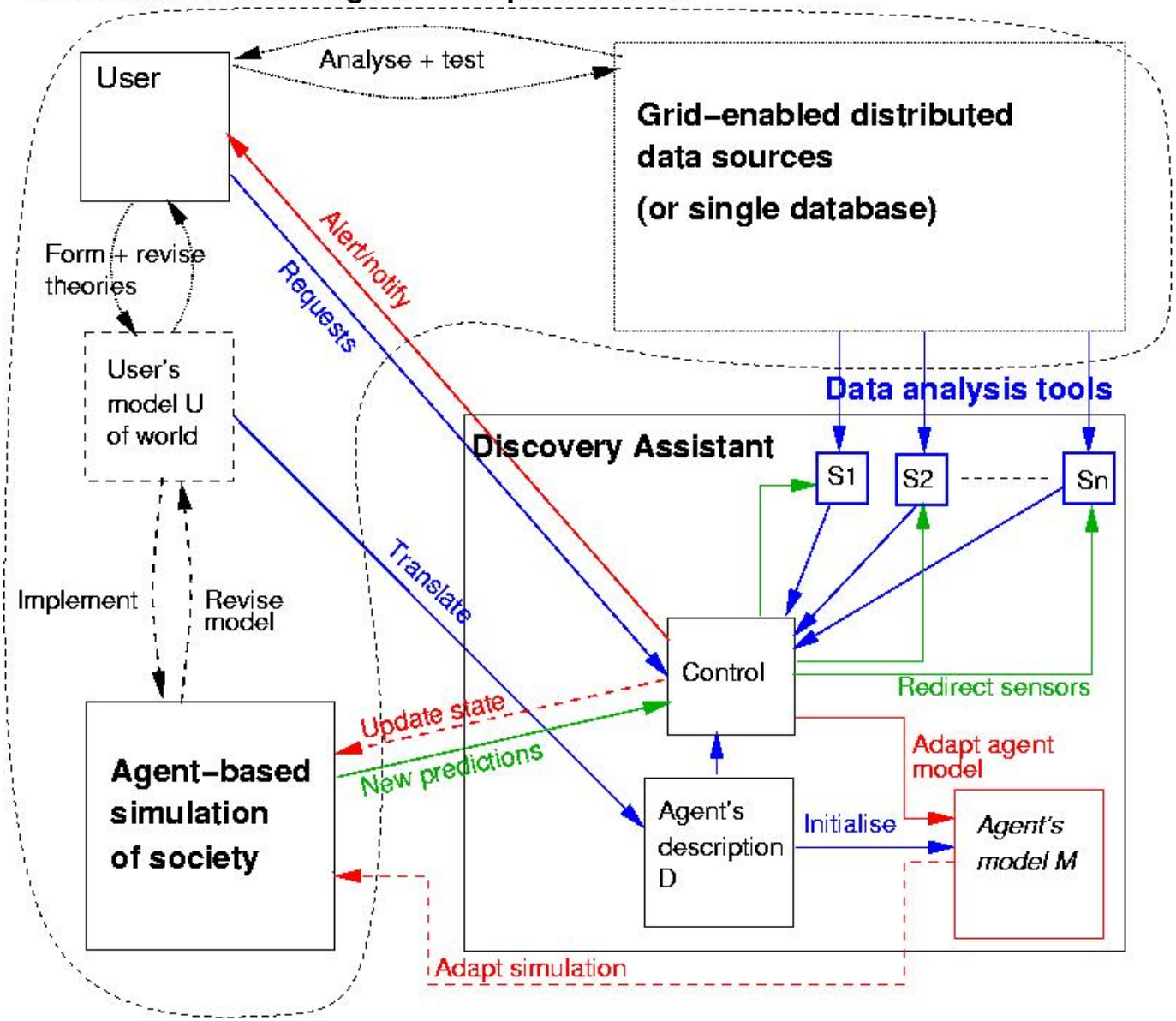
What is being simulated?

- An actual observed system (an instance):
  - simulation states are expected measurements of the real system;
  - direct update from measurements to simulation;
  - simulation may run concurrently with observed system
- A class of systems with similar properties (more likely in social sciences):
  - simulation states are abstract states applicable to this class;
  - model may be revised as a result of generalisations from data;
  - data may be collected from multiple instances of similar systems.

AI in Social Sciences

- Policy decision making requires understanding of a complex system;
- Data-driven simulation can assist with model building and revision;
- Agent-based simulations can predict future states, given current state - or more about present state, given partial state;
  - Also possible to run "what-if" scenarios for policy actions: start with a hypothetical state;
  - Simulated "agents" can represent individuals, groups, organisations etc.
- Note that there are TWO kinds of "agent":
  - the software agent that is building and testing the model (by data-driven simulation)
  - the agents in the world that are BEING MODELLED (which may include other software agents).

Modified Assistant Agent – not pure DDDAS



The AIMSS Project

- Funded by the UK e-Social Science Programme
- A collaboration between Computer Science and Public Policy (The Institute of Local Government Studies and the Centre for Urban and Regional Studies)
- Aim: To explore the feasibility of DDDAS for the prediction of complex Public Policy outcomes
  - Housing Policy scenarios
- In the longer term the project is oriented towards diagnostic interventions and resource management problems in public policy
- *http://www.cs.bham.ac.uk/research/projects/aimss*

Case Study: Housing Policy

- *Problem 1:*
  - Current housing market models are too simplistic;
  - assumptions may not hold in all scenarios
- *Problem 2:*
  - Understanding micro-level behaviour is a multi-dimensional problem;
  - incomplete data;
  - expensive data acquisition;
  - need assistance in determining what kinds of micro-level data are significant for policy goals.

Proposed Solution

- Use agent-based simulation to represent residents making decisions on whether to move house and where.
- Predicted states of the social simulation can be tested by analysing the data;
- The "predictions" are states that would be expected to exist now if the model's assumptions are true;
- Data analysis and mining tools are used to inquire whether the predicted state is actually true;
- DDDAS aspects are as follows:
  - *If insufficient data is available, the discovery agent can suggest new kinds of data that are required in future surveys (Problem 1);*
  - *Persistent discrepancies between the simulation predictions and the results of the data analysis prompts the discovery agent to suggest model revisions (Problem 2)*

Challenges

- Need for suitable ontologies for Social Science data sets
  - What is the meta-data D and how does the Discovery Assistant use it?
- How to specify what is *important* with regard to the policy goals; (e.g. affordable housing).
- Need for suitable data mining and analysis tools.
  - Need for fusion and summarisation;
- Semantic Grounding (longer term): semantics should be developed by interaction with the world and learning (exploration and adaptation)
  - BUT: the discovery assistance architecture may already have the potential to solve this - due to the symbiotic nature of the interaction between simulation and reality

Summary

- DDDAS and in particular symbiotic simulation may be used by a cognitive agent;
- Two kinds of scenario in which an agent can manage a simulation: autonomous agent and assistant agent;
- Modification of assistance scenario: Discovery assistance ine-Social Science: instead of pure “data-driven” simulation, provide interface to data analysis and mining tools;
- Semantic grounding is a fundamental problem BUT the symbiotic simulation architecture may itself provide a way of solving it.