BSc Projet Assignment 4

Janosch Haber - 10400192
University of Amsterdam (UvA)
janoschhaber@gmail.com

Supervisor: Roberto Valenti

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All models are wrong, but some are useful. *- George Box*

1 Introduction

In 1959, British theorist and economist Stafford Beer developed the Viable System Model (VSM), a conceptual description of indispensable properties common to *all* systems that are capable of surviving in a changing environment. Besides being applicable to all kinds of systems in Biology, Physics or Sociology, Beer was especially interested in its application to economic systems, coining the term *Management Cybernetics*.

A decade later, Salvador Allende became the first socialist president of Chile. In his course of political change and restructuring, entire branches of the Chilean economy were nationalized and put under the control of the *Corporación de Fomento de la Producción* (CORFO), the state development agency. This agency was led by young Chilean engineer Fernando Flores - a convinced student of Beer's ideas. So Beer was invited to come to Chile and instruct a team of researchers in building a computer system that would apply an automatized cybernetic management approach to the government-owned industry sectors.

Being baptized CyberSyn[1], for two years academics and engineers of different background worked on a network consisting of a number of Telex machines left over by the previous government, some central mainframe contingency in Santiago - and a futuristic control room close to the president's palace. In 1973 however the government was toppled, Allende was killed and CyberSyn's OPS-room was destroyed. The researchers working on the CyberSyn project were either imprisoned or lucky enough to flee the country.
Despite being approached by other (rather dubious) regimes after this tumultuous events, Beer never again tried to realize a system like CyberSyn.

[1] CyberSyn is a synthesis of the main concepts *cybernetics* and *synergy*

2 Problem Definition (Preliminary)

Beer's Viable System Model describes a recursive set of autonomous agents arranged in a five-layer hierarchy. Together they form a social system that is placed in an environment which provides it with resources. The agents are largely independent in regard to choosing their goals and actions and Beer proposes that they will base their deliberations on the algedonic feedback they receive after deciding for a given action. This feedback can be either a reward (in the form of pleasure) or a punishment (pain). In the social-economic setting, the form and intensity of feedback will be related to the amount of demand for and supply of certain resources in the system: In order to increase reward, agents will try to fulfill the highest resource demands. This process then can be steered by higher-order tiers through generating additional demand and thereby increasing the expected reward for fulfilling it.
The CyberSym[2] project aims to simulate such a multi-agent system through the means of AI's Distributed Intelligence (DI) as a Multi-Agent Simulation (MAS). By doing so, we hope to answer the (preliminary) research question

> *Under which parameter settings can a simplified economic system based on Beer's Management Cybernetics approach develop a balance in its internal resource distribution?*

Words: 196

2.1 Keywords

Agent-Based Simulation (ABS), Multi-Agent Simulation (MAS), Distributed Intelligence (DI), Artificial Social Simulation, Embedded Agents, Emergent Behaviour, Reinforcement Learning

3 Concept Map

For a detailed structure of the proposed project approach, please see the concept map in figure 1.

4 Annotated Bibliography

Medina (2006) establishes a thorough overview of the historical background of the original CyberSyn project and its effects on the Chilean society. And even though she focuses on describing the historical developments, Medina also accomplishes to draw one of the most detailed pictures of the actual configuration and implementation of Beer's system. Especially in her prize-winning book 'Cybernetic Revolutionaries: Technology and Politics in Allende's Chile' (Medina,

[2]Made up from *Cybernetics* and *Symbiosis*

2011), the fundamental ideas about the Viable System Model (VSM), Management Cybernetics and their application on the Chilean nationalized industry sectors are described exhaustively.
With regard to the short duration of this project, our primary simulation design will be based on these elaborations rather than a study of the works of Beer himself. On another note, Medina also explicitly stresses the enormous complexity of the CyberSym system - should it have been implemented. We take this as an early warning to not attempt the impossible and rather progress in a step-by-step fashion.

With regard to the proposed social system simulation and the implementation thereof, we will draw on the work published in the relatively young field of Multi-Agent Systems (MAS). Castlefranchi, Miceli, and Cesta (1992) first develop the central thesis that "human interactions are neither unpredictable nor bounded, but they are undertaken autonomously on the grounds of a number of basic principles and conditions" (p. 1). Based on this assumption they introduce the concept of dependence in multi-agent networks and its relation to the closely linked idea of influence though dependence. Ten years later, Sichman and Conte (2002) propose a revision of the concept of dependence-networks, arguing that "dependence networks are inadequate for representing decentralised structures" (p. 1). In their paper they describe an exhaustive list of possible directed dependency structures emerging in a multi-agent setting.

Drogoul and Ferber (1994) also contributed fundamental work to the foundations of MAS. In their paper they develop the thesis that "interactions performed between several individuals at the *micro* level are responsible of measurable general situations observed at the *macro* level," which allows social researchers to interpret computer models as "simulated laboratory" (p. 1). In the second part of their paper they develop a first overview of different types of agents that can be used in MAS. Of these different proposed types they take the most simple one and in the last part of their paper develop a first simulation of an ant colony steered by Reinforcement Learning (RL).
Conte, Gilbert, and Sichman (1998) make a case for the simulation of more complex social settings in MAS. They draw their arguments from the strong similarities between MAS and social simulation. Likewise, Goldspink (2002) defends the idea of social simulation in computers - especially when the original settings are highly complex and models thus are likely to be only partial descriptions and thus not testable in the real-world setting. He also stresses the need for reliable validation: "As emergent phenomena are frequently counter-intuitive, 'surprising' results must be demonstrably the result of the model, not artefacts or errors built into or resulting from the simulation" (p. 6). We will keep this in mind when designing the simulation for the CyberSym project.

For the overall use of creating models and simulations, we refer to Epstein (2008). In his article called 'Why model?' he lists an impressive list of 17 rea-

sons[3] that all underline the importance and implications of modelling complex settings. Most of all, he claims that "simple models can be invaluable without being "right," in an engineering sense. Indeed, by such lights, all the best models are wrong. But they are fruitfully wrong. They are illuminating abstractions." (p. 3). An invaluable insight at the starting point of our endeavour. On a more practical level, Richiardi, Leombruni, Saam, and Sonnessa (2006) attempt to create a unified standard for publications about Agent-Based Simulations (ABS) and MAS, as they often are too complex to be described in the limited space provided by regular scientific journals. In order to do so, they propose to distinguish "between four different issues: link with the literature (section 2), structure of the models (section 3), analysis (section 4) and replicability (section 5)" (p. 3). While large parts of this article are too specific for our concerns, some of the higher-level insights can come in quite handy. The same applies to the paper of Cioffi-Revilla (2010) who describes a methodology especially for approaching complex simulation projects.

Siebers and Aickelin (2008) provide a thorough introduction to the state of the art in ABS and MAS, summarizing some of the key concepts identified above. They also give a useful definition of our simulation problem (p. 2): "A simulation model consists of a set of rules that define how a system changes over time, given its current state. Unlike analytical models, a simulation model is not solved but is run and the changes of system states can be observed at any point in time. This provides an insight into system dynamics rather than just predicting the output of a system based on specific inputs." As this paper is a more high-level description of the field itself, it can also be seen as a review paper of some kind, providing a good starting point for further literature research. Bandini, Manzoni, and Vizzari (2009) on the other hand try to map and describe simulation sciences from an informatics perspective - very handy for inexperienced AI students. It also lists a number of frameworks that can be used for implementing ABS and MAS computationally. One of them is MASON[4] as introduced in Luke, Cioffi-Revilla, Panait, Sullivan, and Balan (2005), which we are currently planning on using for the project.

A number of possibly relevant articles have been identified but not yet read. For example, Dawid, Gemkow, Harting, Van der Hoog, and Neugart (2012) report in detail about a relatively recent economic modelling project. This might provide us with some valuable insights for the approach of our own project. Vanhée, Dignum, and Ferber (2014) investigate agent collaboration in complex social systems, something that might also be of interest in our model.
As mentioned before, with regard to the expected complexity we propose to use a stepped approach to obtain reportable intermediate results. One of the later stages in this process (as can also be seen in the concept map) will be comparing different strategies of Evolutionary Game Theory. Hartshorn, Kaznatcheev, and

[3] He still remarks they spontaneously came "off the top of [his] head" (p. 2)

[4] "It stands for Multi-Agent Simulation of Networks... or Neighborhoods... or something like that. N's are hard." (p. 16)

Shultz (2013) provide a comparison of these models. Another subsequent step will be implementing inventions in the MAS setting. When we reach this stage, the article of Antonelli and Ferraris (2011) will become relevant, otherwise it can be used to set out a direction for future work.

5 Research Territory Mapping (RTM)

The articles listed above can be brought into relation by a technique called *Research Territory Mapping*. The result of this mapping can be seen in figure 2.

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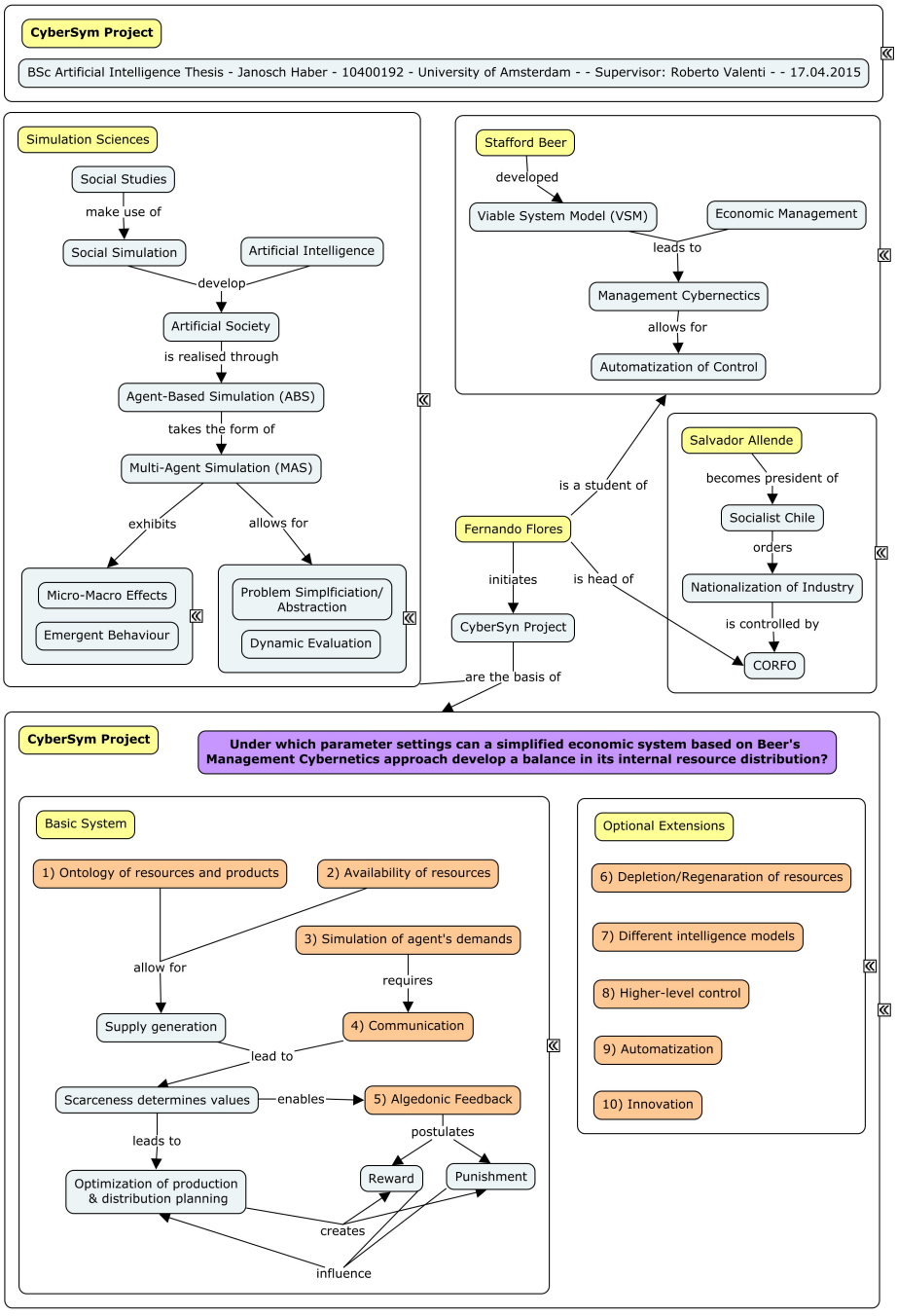

Figure 1: A Concept Map of the CyberSym Project approach

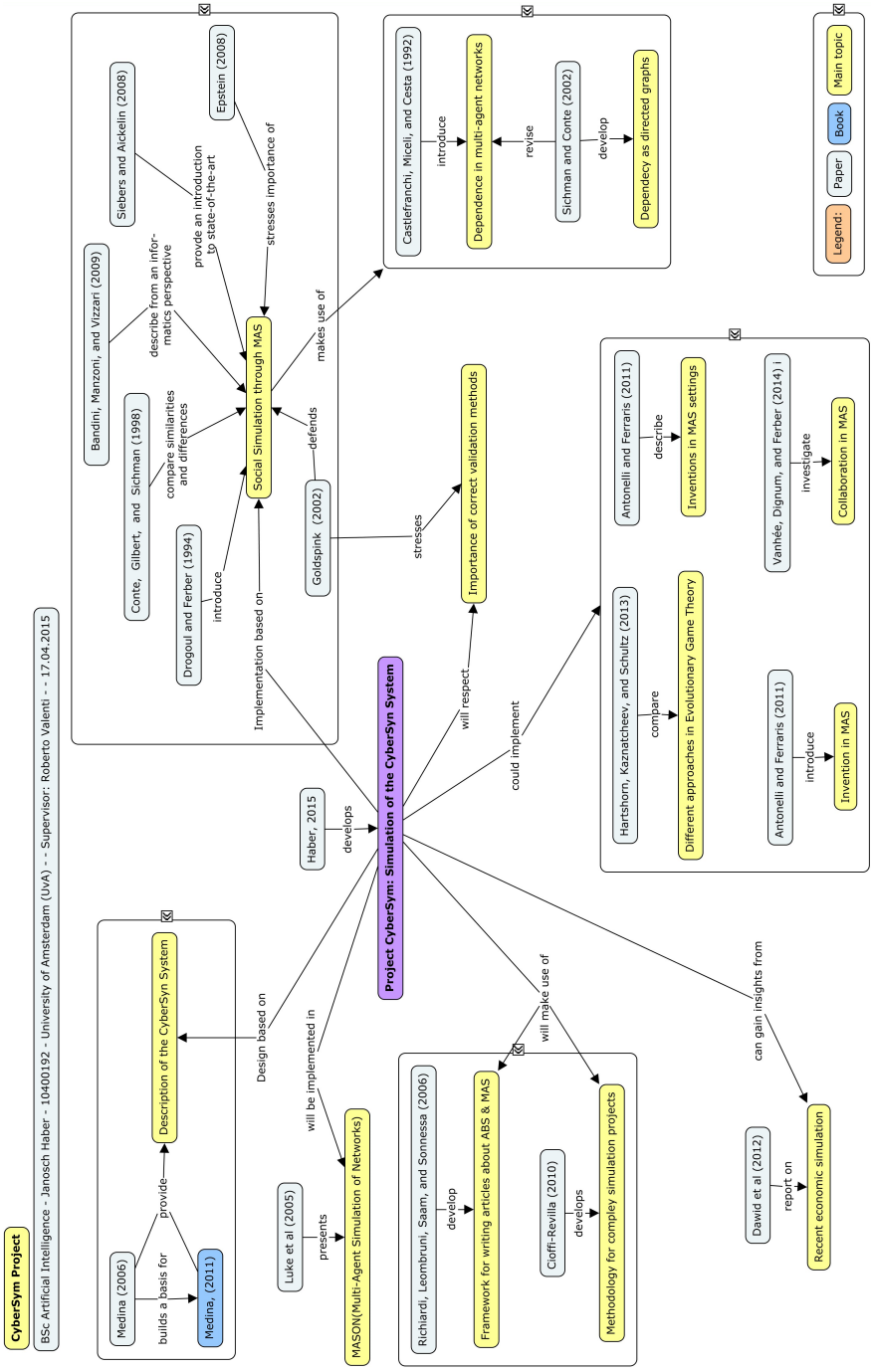

Figure 2: A Research Territory Mapping of the CyberSym Project in relation to encountered articles