Cognitive Agent Programming

Semantics and Logics

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ABSTRACT

This is a summary of the thesis entitled "Cognitive Agent Programming: Semantics and Logics".

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Intelligent agents, languages and structures*; I.2.5 [**Artificial Intelligence**]: Programming Languages and Software; F.3.2 [**Logics and Meanings of Programs**]: Semantics of Programming Languages; F.3.1 [**Logics and Meanings of Programs**]: Specifying and Verifying and Reasoning about Programs—*Logics of programs*

General Terms

Theory, Languages

Keywords

Agent programming languages, operational semantics, denotational semantics, dynamic logic, plan revision, declarative goals

1. BACKGROUND

An important line of research in the multi-agent systems field is that of *cognitive agents*. These are agents endowed with high-level mental attitudes, such as beliefs, goals and plans. In this thesis we are concerned with programming languages for programming these cognitive agents. The challenge of designing such a language is finding language constructs that "appropriately" implement the various mental attitudes. The issue of when an implementation can be considered appropriate, can be approached from different angles: one could for example consider how well the implementation complies with the (designer's) intuitions about the mental attitudes, whether certain properties as specified by the BDI logics are satisfied, or how well the language supports the practical programming task.

One way of getting a handle on these kinds of issues is the study of *formal semantics* of cognitive agent programming languages. The study of formal semantics can be used to precisely specify the meaning of a language. The properties of different semantics can then be investigated rigorously, which can be used to identify which semantics have the more desirable features, in general or for certain kinds of applications. Further, the formal semantics of an agent programming language can serve as a basis for designing a specialized logic for reasoning about agents programmed in this language. Also, characteristics of the mental attitudes could be compared to the characteristics of these concepts as specified in the various (BDI) logics. This could help to clarify the relation with these logics. The study of formal semantics of cognitive agent programming languages comprises the main part of this thesis.

AAMAS'05, July 25-29, 2005, Utrecht, Netherlands.

2. THESIS SUMMARY

Most of the work in this thesis is based on the cognitive agent programming language 3APL, as first introduced by Hindriks. In the first part of the thesis, we propose an extension to 3APL, adding the notion of *declarative goals* to the already existing beliefs and plans.

In the second part, we further explore this notion of goals. In particular, we propose a semantics for goals that is based on *default logic*, and that uses rules that specify which new goals can be adopted on the basis of existing goals and certain beliefs (see paper in this proceedings). We establish properties of this semantics, and compare it with a simpler semantics that does not use default logic.

Further, we explore possible semantics for *subgoals* as used commonly in the plans of agents.

The third part focuses on the language construct of plan revision rules as introduced by Hindriks. First, we argue that the definition of a *denotational* (i.e., a compositional) semantics for plans is problematic due to the non-compositional operational semantics of plans, arising from the fact that plans can be revised during execution by means of plan revision rules. We show that it *is* possible to define a denotational semantics for a *meta*-language or deliberation language of 3APL, and we establish equivalences with the object-language.

Second, we discuss two approaches for *generating* and *executing* the plans of cognitive agents, respectively.

Finally, we present a *dynamic logic* for a propositional version of 3APL. Due to the plan revision capabilities of 3APL agents, plans cannot be analyzed by structural induction as in for example standard propositional dynamic logic (this is related to their non-compositional operational semantics). We propose a dynamic logic that is tailored to handle the plan revision aspect of 3APL. For this logic, we give a sound and complete axiomatization and we investigate the relation with the semantics of procedure calls.