Protocols Among Computational Agents: Towards a Model based on the Success and Satisfaction

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Abstract

To design protocols among computational agents, we have adopted Searle and Vanderveken model of speech acts because this model is a rich theory which can give important properties of protocols that we can formalize properly. To achieve this, we are working on an adequate formalism (the situation calculus) for representing this model in the context of multiagent systems.

Introduction

According to Singh (Singh 1991), a major bottleneck in the design of multi-agent is the design of the protocols of communication among agents. While agents are usually specified in terms of high-level concepts (belief, intentions, etc.), existant protocols for the communication among those agents are generally poor. These protocols are generally based on TCP/IP and similar techniques or on KQML and similar ad-hoc protocols. Such protocols lack rigourous theory of the interactions among agents and are generally disconnected from the high level concepts in which the agents are specified (belief, intentions, etc.). These reasons lead to the recognition of speech acts theory as a foundation for communication among agents. Among the proposed approaches, the Searle and Vanderveken (S&V) model of speech acts (Searle and Vanderveken 1985; Vanderveken 1990) is an adequate model for the design of communicating agents. We examine this model very briefly, and we propose an adequate formalism (the situation calculus) for representing it in the context of multiagent systems. This representation is a first step toward the computation of Searle and Vanderveken model in the domain of multiagent systems.

S&V Theory of Speech Acts

The most central type of interactions among intelligent agents are communications that we can expressed using *speech acts*. Using speech act theory, one can reformulate as follows their analysis of the meaning of most current types of sentences: *declarative, interrogative, imperative, exclamatory and conditional acts.*

In order to analyze the logical form of illocutionary acts, one must define recursively their conditions of success and of satisfaction, as well as the truth conditions of their propositional content. The *conditions of success* of an illocutionary act are the conditions that must be obtained in a possible context of utterance in order that the speaker succeed in performing that act in that context. For example, a condition of success of a promise is that the speaker commit himself in carrying out a future course of action. The *conditions of satisfaction* of an illocutionary act are the conditions that must be obtained in a possible context. For instance, a condition of satisfaction of a promise is that the speaker carries out in the the world the future course of action represented by the propositional content.

In speech act theory the notion of satisfaction is a generalization of the notion of *truth* that is is needed to cover all possible illocutionary forces. Just as an assertion is satisfied if and only if (iff) it is true, a promise is satisfied iff it is kept, a request is satisfied iff it is granted, a question is satisfied iff it is answered, etc. In case of satisfaction of an illocutionary act, there is a success of fit between language and the world. The propositional content is true in the sense that it represents an actual state of affairs in the world of utterance.

According to S&V, each illocutionary force can be divided into an illocutionary point, a mode of achievement of that point, propositional content, preparatory and sincerity conditions, and degree of strength. For details about these components see (Vanderveken 1990).

Illocutionary Logic

In Searle and Vanderveken's theory of speech acts, elementary speech acts of the form $\langle F, p\rangle$ (F is the illocutionary act and p is the propositional content) have conditions of success and of satisfaction and their conditions of satisfaction include the truth conditions of their propositional contents. For study respectively propositions and illocutionary acts, it is needed to use both intensional and illocutionary logics.

Previous Extensions of Montague Grammar

Some logicians or linguists have recently proposed formal treatments of illocutionary force markers or performative verbs in empirical extensions of Montague grammar (Montague 1974). In fact, these applications of Montague grammar to fragments of English have failed. First, they have not succeeded in characterizing adequately the logical structures of the sets of illocutionary forces, of propositions, and of speech acts. Second, they have also neglected many important success conditional aspects of sentence meaning. In particular, they have ignored or failed to predict many fundamental laws of illocutionary entailment and of incompatibility that hold for the various types of sentence in the use and comprehension of language. In addition, they have multiplied doubtful or false semantic predictions for sentences of the same type with logically related propositional contents. Finally, they have not recognized to its full extent the variety and the wealth of actual forms of expression for speech acts.

To remedy to the failure in the achievement of Montague's research, Searle and Vanderveken (Searle and Vanderveken 1985) and Vanderveken(Vanderveken 1990) proposed a general success and truth conditional semantics which is compatible with Montague grammar.

Illocutionary Logic

Searle and Vanderveken theoretically enrich Montague's intensional logic in order to have an adequate logic for the analysis of speech acts and the interpretation of sentences of all types. To achieve this, they enrich the theoretical apparatus of formal semantics in various ways. First, they distinguish two types of meaning: linguistic meaning and meaning in context as in Kaplan's logic of demonstratives. Second, they formulate a non-standard definition of the logical type of proposition that takes into account the cognitive aspects of meaning in the apprehension of propositions. Third, they admit success as well as truth values in the formal ontology of semantics and they enrich the expressive capacities of the ideal object-language of formal semantics by adding to its theoretical lexicon new logical constants expressing the few primitive notions of illocutionary logic. Finally, they formulate recursive definitions of success and of satisfaction made by induction, and they ramify fundamental semantic notions as entailment and consistency.

Toward a Computational Approach Based on the Situation Calculus

An important aspect of multiagent reasoning is the ability to reason about change. Generally, reasoning about actions and processes is difficult. There are two important characteristics of domains that make the reasoning hard: 1) it is not possible to anticipate all possible problems, when situations are sufficiently rich; 2) it is not possible to anticipate all possible worlds (i.e. circumstances) in which the reasoner might find itself. In facts, domains with these characteristics give rise to three classical problems (frame, ramification and qualification problems).

Situation calculus seems to be the adequate formalism for reasoning about actions and their effects on the world since recently, Reiter (Reiter 1992) has given a set of conditions under which the explicit specifications of frame problem can be avoided. With situation calculus, we can also encode messages which depend on the words and the *situation* in which the words are uttered. In this perspective, just as in situation calculus, the encoding and decoding functions take an extra argument representing the current situation.

We pursue the perspective of situation calculus for reasoning about actions in multiagent systems, and specially the reasoning about speech acts for the communication between agents. To achieve this, we are working on a framework which incorporates semantics of intensional logic and illocutionary logic in situation calculus. This framework aims to: (1) justify some *perspective claims* about how agents should communicate given their beliefs, intentions, commitments and so on; (2) elaborate a protocol for communication between agents, for which one can verify the "success" and "satisfaction" notions; (3) extend this protocol using the *recursiveness* notion; (4) give a clear semantics to KQML based on "success" and "satisfaction" notions.

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