

Protocol-based Communication for Situated Agents

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1 Introduction

Collaborations in situated, behavior-based agent systems typically have to emerge from the individual selected actions of the agents. Usually, communication happens indirectly, e.g. by depositing pheromone trails in the environment. In this paper we outline an approach for situated agents to set up explicit collaborations.

2 Roles and situated commitments

Explicit collaborations are reflected in mutual commitments. We use the notion of a *situated commitment* as a basis for collaboration. Contrary to the traditional approaches on commitment that take a *psychological* viewpoint, i.e. commitments are based on the agents' mutually dependent mental states and a goal-oriented plan, a situated commitment is a *social* attitude, i.e. situated commitments are based on the *roles* of the involved agents and the *local context* they are placed in.

We use a model for action selection that is based on a hierarchical, free-flow architecture. The hierarchy is composed of *nodes* which receive information from internal and external stimuli in the form of *activity*. The nodes feed their activity down through the hierarchy until the activity arrives at the *action nodes* where a winner-takes-it-all process decides which action is selected.

Existing free-flow architectures are designed from the viewpoint of individual agents. They lack *explicit* support for social behavior. We extend free-flow architectures with the concepts of a role and a situated commitment to enable explicit social behavior. A role may consist of a set of sub-roles, and sub-roles of sub-sub-roles etc. All roles of the agent are constantly active and contribute to the final decision making by feeding subsets of actions with activity. However, the contribution of each role depends on the activity it has accumulated from the affecting stimuli of its nodes.

A situated commitment defines a relationship between one role, called the *goal* role, and a non-empty set of other roles, i.e. the *source* roles, of an agent. Situated commitments are characterized by a well-known *name*, a *relations* set, a *context*,

an *activation condition* and *deactivation condition*. The relations set contains the identity of the related agent(s) in the situated commitment. The context describes contextual properties of the situated commitment such as descriptions of objects in the local environment. Activation and deactivation conditions are boolean expressions based on internal state, perceived information or information derived from a received message. When the activation condition becomes true, the situated commitment is activated. The situated commitment then injects an additional amount of activity in the goal role relatively to the activity levels of the source roles. As such, the agent gives preference to the goal role over the source roles. As soon as the deactivation condition becomes true, the situated commitment is deactivated. Then the situated commitment no longer influences the activity level of its goal role. Contrary to traditional approaches of commitment (e.g. a joint commitment) where the agents have the obligation to mutually communicate with each other when the conditions for a committed cooperation no longer hold, for a situated commitment it is typically the local context in which the involved agents are placed that regulates the duration of the commitment. This approach fits the general principles of situatedness and robustness of situated multi-agent systems.

3 Protocol-based communication

Communication in multi-agent systems is traditionally based on speech act theory. Speech act theory treats communication as actions, however the communicative acts are considered in isolation. E.g., the original KQLM specification only suggests an implicit sequencing of messages in agent interactions. In practice speech acts are mostly part of logically related series of communicative acts. In addition, communicative acts are typically specified in terms of mental states which imposes consequences on the nature of the agents. Communication specified in terms of protocols shifts the focus of communication from reasoning upon individual messages towards the relationship between the exchanged messages.

A *communication protocol* specifies a well-defined sequence of messages, each message referring to a speech act. We consider both binary and n-ary communication protocols. *Protocol-based communication* is the interaction between agents based on the exchange of messages according to a specific communication protocol. We use the notion of a *conversation* to refer to such an ongoing interaction. A conversation is initiated by the *initial speech act* of a communication protocol. At each stage in the conversation there is a limited set of possible speech acts. *Terminal states* determine when the conversation comes to an end. During a conversation agents typically modify their state implied by the communicative interaction.

Explicitly naming roles and situated commitments enable agents to set up explicit collaboration. During collaboration setup, agents exchange messages. If the agents agree, i.e. when the conditions prescribed by the protocol hold, this results in mutual situated commitments. A situated commitment affects the agent's decision making in favor of the role it plays in the collaboration. The collaboration typically ends when the context of the involved agents changes such that the conditions to continue the collaboration expire.