Biasing the Behavior of Organizationally Adept Agents

(Extended Abstract)

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ABSTRACT

An *organizationally adept* agent (OAA) adjusts its behavior when given annotated organizational guidelines. More importantly, it can also determine when such guidelines become ineffective and proactively adapt its behavior to better achieve organizational objectives. We present the high-level aspects of this architecture and analyze its effectiveness using call-center OAAs striving to extinguish fires in RoboCup Rescue scenarios.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Multiagent systems, Coherence and coordination*

Keywords

multiagent organizations, organizational control and adaptation, agent reasoning architecture

1. ARCHITECTURAL OVERVIEW

Designed agent organizations [3, 6] provide agents with organizational directives that, when followed, reduce the complexity and uncertainty of each agent's activity decisions, lower the cost of distributed resource allocation and agent coordination, help limit inappropriate agent behavior, and reduce unnecessary communication and agent activities. These directives contain general, long-term guidelines, in the form of parametrized role assignments and priorities that are subject to ongoing elaboration into precise, moment-to-moment activity decisions by the agents [2]. Following organizational directives is beneficial when agent directives can be designed that perform well over a range of potential long-term environment and agent characteristics. On the other hand, blindly following directives when the estimates used in their design are incorrect or have changed over time can be worse than not having directives at all.

This work addresses the challenges of enabling agents to adapt their behavior in order to perform effectively in an organization when the design of that organization is not ideal, either because the assumptions used to develop that design were inaccurate or because the organization's environment has changed. This is a difficult problem that requires a level of quantitative self-awareness, awareness of other agents, and organizational adaptability that is not present in existing agent architectures. Specifically, an *organizationally adept* agent (OAA) must be able to: 1) operate reasonably without organizational guidance; 2) adjust its activity decisions to conform with organizational guidelines when they are provided; 3) make activity decisions using belief values that are updated by experience and can be seeded by expectations conveyed in guideline annotations; 4) assess the appropriateness of guidelines based on deviations from annotated estimates developed during organization design; 5) stop following guidelines deemed to be inappropriate; and 6) propose and negotiate agreements with other agents to use in place of inappropriate guidelines.

Creating an OAA involves a number of essential features, the most important of which is providing each OAA with information about the assumptions made by the organization designer (whether designed by a human or by an automated designer process [3, 6]) and the range of conditions the OAA should expect if the organization is operating as intended. This sharing of the designer's intent with the OAAs is accomplished by augmenting the organizational guidelines given to each OAA with designer-expectation annotations. The use of guideline annotations is an important innovation developed in this work. Annotations include the assumed range of environmental characteristics (e.g., expected task-arrival rates) and performance estimates (e.g., task-completion time and agent-interaction amounts). These annotations help an OAA determine when the expectations that were used when designing the supplied guidelines do not hold (e.g., the environment is not within the anticipated range of characteristics or task performance differs from expectations) and when the OAA should abandon following guidelines in favor of proactively adapting its behavior. In addition, seeding agent beliefs using annotation values enables the designer's estimates to be used immediately by the agent, rather than having the agent learn them over time as it operates in the organization. We next describe the important characteristics of the OAA architecture.

Organizational control requires deep ties into an agent's operational and domain reasoning. A central tenet in the OAA approach is a clear separation between *operational decision making*, the detailed moment-to-moment behav-

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ior decisions made by agents, and *organizational control*, expressed through annotated guidelines that bias and inform operational decision making. This separation allows an agent to distinguish decisions influenced by the guidelines from choices that would have been made without them. The separation enables the OAA to stop following guidelines when the estimates used in their design were incorrect or when the environment changes over time and to propose and negotiate agreements with other OAAs to replace such guidelines. The heart of the OAA architecture is an event-driven, BDI-like operational decision-making engine that adjusts its activity decisions when it is provided with parametrized role priority assignments specified in organizational guidelines. The OAA receives *percepts* both from the external environment (e.g., sensor reports or messages from other agents) and from its internal decision-making process and task-execution performance (e.g., plan failure or inability to achieve a goal). These percepts cause changes in the OAA's *beliefs*, and those changes can trigger the creation and modification of *goals*. Goals that pertain to normal operational activity decisions (e.g., to extinguish a specific fire), to operational adaptation (e.g., to borrow a fire-brigade resource), and to organization adaptation (e.g., to negotiate an agreement to replace inappropriate guidelines) can be instantiated from external or internal percepts. An OAA uses an organizationally *biased utility* estimate $BU(g, p, t)$ of an *intention* (goal g to be achieved by non-preemptable plan p starting at time t) to make activity decisions. This estimate considers: the importance of the goal, biased by any guidelines; the expected utility of achieving the goal; the expected degree of satisfaction using the plan; and the opportunity cost associated with using resources in the plan. Resource and goal exchanges (borrowing and asking for help) complicates opportunity cost estimation, as each OAA must consider the potential activities of nearby agents that are close enough to exchange resources or goals with the OAA (and, transitively, the opportunity cost estimates of those agents must consider further exchange possibilities, and so on).

A key feature of the OAA approach is *using belief values as parameters in operational decision making.* These beliefs start out as initial value settings that reflect the unsituated expertise of competent agents, and they are repeatedly updated by the OAA based on experience. The evolving values allow the OAA to make reasonable decisions (that potentially improve with experience in the current environment) in the absence of organizational directives. The annotations to organizational guidelines include designer-estimated values that are used to seed the OAA's beliefs to values that the designer assumes the agent should experience when agents are following the parametrized role assignments and priorities contained in their guidelines. Such seeded belief values are also updated by the OAA based on experience, but at a slower rate than unsituated (unseeded) values. Space constraints prevent describing how OAAs perform deviation detection and how they negotiate long-term agreements with nearby OAAs when guidelines are inappropriate (see [1] for detailed descriptions of these and other aspects of the OAA architecture).

We evaluated the performance of our OAA architecture using the fire-extinguishing portion of RoboCup Rescue. Each call center was an OAA agent. We assessed two hypotheses, showing them to be true: 1) following guidelines whose annotations are coherent with the environment improves performance and 2) following guidelines whose annotations are not coherent with the environment decreases performance to levels that can be even worse than when the agent operates without guidelines. Confirmation of the second hypothesis shows the importance of OAAs being able to detect deviations from the expectations contained in guideline annotations and to stop following those inappropriate guidelines as quickly as possible [1].

In related work, the ALIVE system [5, 7] also deals with adapting organizational structures, but based on failure events rather than deviation from the designer's expectations as conveyed using guideline annotations. ALIVE also takes a centralized, versus negotiation among peers, approach to adaptation. MOISE+ [4] includes a nice conceptualization of the need for organizational change but takes a top-down approach to reorganization.

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