Conflict Negotiation Among Personal Calendar Agents

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ABSTRACT

We will demonstrate distributed conflict resolution in the context of personalized meeting scheduling. The demonstration will show how distributed constraint optimization can be used to facilitate interaction between cognitive agents and their users. The system is part of the CALO personal cognitive assistant that will also be explored during the demonstration.

Categories and Subject Descriptors

H.4.1 (**Information Systems Applications**): Office Automation – Time management; I.2.11 (**Artificial Intelligence**): Distributed Artificial Intelligence – Intelligent agents; K.6.3 (**Management of Computing and Information Systems**): Software Management.

General Terms

Design, Human Factors

Keywords

Scheduling, Personal Assistants, User Interfaces

DESCRIPTION OF DEMONSTRATION

The Cognitive Assistant that Learns and Organizes—CALO—is a personal assistive agent designed for a busy knowledge worker. The name was inspired by the Latin word *calonis*, "soldier's servant," because the goal of the project sponsor, the U.S. Defense Advanced Research Projects Agency, is to create a cognitive system that can reason, learn, and respond to surprise in order to assist in military situations.

The CALO project brings together leading computer scientists and researchers in artificial intelligence, perception, machine learning, natural language processing, knowledge representation, multimodal modal dialog, cyber-awareness, human-computer interaction, and flexible planning. The single research focus of all these experts is to create an integrated agent system that can "learn in the wild"—that is, adapt to changes in its environment and its users' goals and tasks without programming assistance or technical intervention.

An integral part of the work of any busy decision maker, whether military or civilian, is the management of her time. In particular, the management of interactions with other people, including colleagues and customers, involves careful meeting scheduling and calendar adaptation. As such, time management and scheduling capabilities are central to the CALO system. CALO exists in an open, unbounded environment, where issues of privacy, authority, adjustable autonomy, cross-organizational scheduling, and uncertain availability of participants abound. PTIME [1] is an autonomous agent integrated within the larger CALO agent [2]. The goal of PTIME is to carry partial responsibility for managing the user's calendar and the scheduling of meetings, thus decreasing the user's need for complex interactions with other humans to plan when to meet or how to reorganize their calendars. PTIME absorbs much of the responsibility for handling negotiations and decreasing the communication overload while keeping the user informed about the state of the process.

PTIME agents in collaboration with their users are autonomous, self-interested entities that manage their users' own calendars. They are, in effect, single-calendar schedulers dependent on other agents to coordinate shared calendar entities. The functional architecture of a single agent is shown in Figure 1. The scheduling task is viewed as a shared goal of the user and the agent. For a PTIME agent, global utility is thus secondary to maximizing the local utility of its user, which typically includes a component valuing cooperation with others [4]. This is in contrast to most distributed scheduling systems [5], which aim to maximize some notion of global schedule quality (e.g., [3]).

Hence, PTIME supports two forms of collaboration: between itself and its user and between itself and the PTIME agents of other users [1]. PTIME also extends the notion of collaboration from inter-agent negotiation to the collaborative dialog between agents and their human users; the collaborative scheduling process is separated from the scheduling algorithms, to enable interaction with the user and other PTIME agents. This interaction forms the framework for learning and adjustable autonomy. The collaborative interface is shown in Figure 2.

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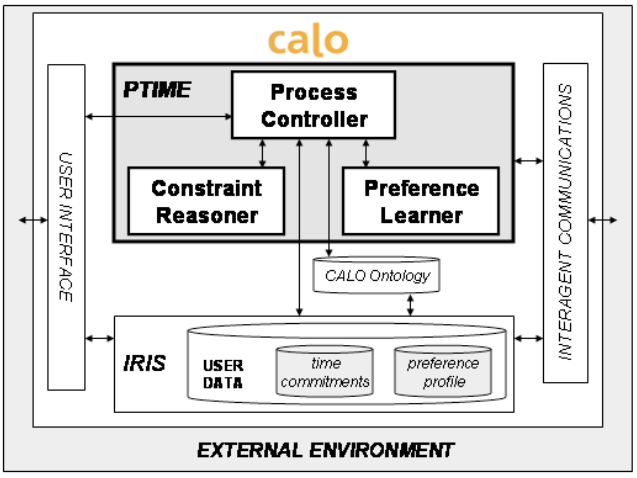

Figure 1: Architecture of a PTIME Agent

User studies confirm that other participants' constraints and preferences often influence the meeting organizer's decisions [4]. When PTIME decides which of many possible schedules to present to the user, it reasons about how each candidate schedule will affect others. This requires PTIME to retrieve from all affected parties their schedules, their preferences, and how the proposed schedule affects them. Once a user selects a schedule from those presented, PTIME must negotiate with the agents of the other parties to resolve conflicts within each schedule.

To determine the effect of a particular schedule on others, PTIME uses a distributed querying mechanism, based on a Distributed Constraint Optimization (DCOP) protocol that obtains a cost reflecting the rescheduling effort required as a result of a proposed schedule. The scope of negotiation within the DCOP algorithm is controlled heuristically. The cost for users that do not respond (i.e., communication with their CALO fails) is estimated using the most recent knowledge about their schedules and their negotiation history.

When the user organizing a new meeting selects a candidate schedule, PTIME invites all other meeting participants, with a justification for the request. All conflicts are then resolved by other users who, in turn, will either resolve the conflicts with other CALOs or choose to not attend.

Our demonstration will take the user through a scheduling task involving the resolution of conflicts with other participants. It will illustrate the PTIME process including the specification of a scheduling problem, inter-agent negotiation, the dialog with the user, and a subset of CALO system functionality.

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Figure 2: PTIME Collaborative Interface

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