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The Conference Center as an Agent-Mediated Institution

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1 Introduction

Social processes and agent interaction always takes place in a specific context, and there is a school of thought in social studies that analyzes them in the framework of institutions [1]. We will present the notion of *agent-mediated institutions* and show how it is relevant for multiagent systems (MAS) in general and, more specifically, for MAS that include human agents and software agents involved in socio/economic interactions. We will show how the social interactions of human and software agents taking place in the COMRIS¹ Project can be described as an institution, the Conference Center institution.

1.1 COMRIS Conference Center

A conference takes place in a physical setting, the conference center, where different activities (scenes) take place at different locations by people (human agents) that take different roles (speaker, session chair, participant, organization staffer, etc.) in the pursue of their respective interests. Along the course of time during the conference people pursue their interests moving around the physical locations, abandoning some activity to take up a new one. In a moment in time people are physically distributed along the conference center and involved in some interactions with other people: this *physical space* is shown on the right of Figure 1. We can easily think about the spatial proximity relations that exist among people in this space. However, if we think about an *informational space* where the past background and current interests of the conference participants are represented, we could think of a new kind of *proximity* relation that is a function of the similarity among people's interests and backgrounds. This *informational* or *virtual space* is shown to the left of Figure 1.

The COMRIS project [4] is about studying and exploiting the synergy of these two spaces, and their relationship, with the objective of supporting and improving the achievement of a participant's interests while attending a conference. The approach of COMRIS is to develop software agents inhabiting the

¹COMRIS stands for Co-Habited Mixed-Reality Information Spaces. More information is available at URL <http://arti.vub.ac.be/~comris/>.

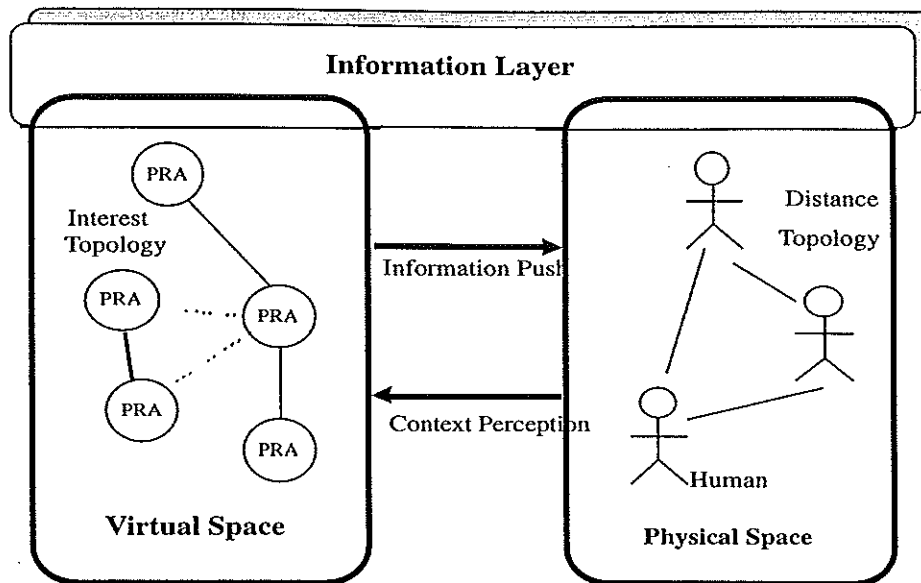


Figure 1: A depiction of the virtual interest-based space and the physical proximity-based space of COMRIS.

virtual space that realizes some specific activities on behalf of some interest of a participant in the conference. Specifically, a Personal Representative Agent (PRA) is an agent inhabiting the virtual space that is in charge of advancing a some particular interest of a conference participant by searching for information and talking to other software agents. An example of a PRA for setting up appointments about a particular topic of interest is later described in §3.

When a PRA has gathered some information interesting for a participant it will try to *push* that information to him or her² In the COMRIS project, the participant is holding a wearable computer device, nicknamed *the parrot*, that runs a speech-generation program and this is able to unobtrusively convey (*push*) that information to him or her using spoken language. It is clear, however, that not any information is relevant for the user (the conference participant) at any point in time. Rather, the physical situation of the person and the concrete activity in which he or she is involved will determine—or at least bias—whether a particular information is relevant for him at a particular moment in time³.

Moreover, several PRAs may compete for access to a person's attention in their "information push" activity. COMRIS develops a *competition for attention* mechanism [3] that deals with both sides of the equation: several information reports that compete to be pushed to the participant and the physical situation of the participant that biases which of these information reports is more relevant for him or her at that moment in time. We can picture this competition for attention mechanism as a process that, biased by the *context information*⁴ of

²As shown in the rightward arrow of Figure 1.

³This relevance is shown as the leftward arrow of Figure 1.

⁴Currently, context information is elaborated by the parrot that determines which other parrots (and hence, participants) are in its immediate physical surroundings.

the physical space selects a “winner” PRA and pushes the information report to his/her *parrot* where it will be orally rendered. For each conference participant there is a Personal Assistant (PA) agent in the virtual space that embodies this process and “owns” the channel communicating with the participant’s parrot.

1.2 Interactions, Rules, and Institutions

Determining the relevance is only a part of the issue: not only people are involved in located activities in the physical space—attending the talks of a thematic session, meeting a colleague to discuss a bout a topic, etc—the software agents are also meeting among them in pursue of some person’s interest. In order to analyze this complex network of agents interacting we will presently introduce the notion of an agent-mediated institution [2].

However, it is first appropriate to consider the kinds of activities that take place into a regular Conference Center: a typical participant pays the registration, registers at the information desk, assists to thematic sessions, makes appointments and later attends or skip them, etc. Although we can imagine whatever activity taking place in a Conference Center it is true nonetheless that some of them occur regularly, and the persons involved know some rules of behavior for these activities—even if most of this rules are tacit. In fact, a conference may be considered as an *institution* both because these recurring activities occur in it and because conferences are indeed set up for supporting and favoring most of these activities—while other activities are discouraged or plainly forbidden.

These activities the Conference Center is willing to favor and uphold are the ones COMRIS is interested in analyzing (with agent mediated institutions) and in providing a computational framework that supports and facilitates them (with the Personal Representative Agents inhabiting the virtual space).

2 Agent-Mediated Institutions

Intuitively, an agent-mediated institution is the computational realization of a set of explicit enforceable restrictions imposed on a collection of dialogical agent types that concur in space and time to perform a finite repertoire of satisfiable actions.

The advantages of using this notion of agent-mediated institution are the following:

- it allows to describe in a comprehensive framework the roles and interactions of both human and software agents in a specific setting (the institution)
- it makes explicit the relationship between the computational framework developed by COMRIS and the existing organization of a conference (the institution we will call the Conference Center)
- it clarifies the difference between
 1. the “rules of the game” enforced by the Conference Center upon human and software agents behavior and

2. the particular strategies the human and software agents may recur to in pursuing individual goals
- it helps to specify the social relationships such as
 1. authority, which agent types (usually roles) can order specific tasks or change specific goals to other agents
 2. entitlements, like which information is accessible and forbidden to an agent type

In the following, we will introduce some notation and definitions concerning agent-mediated institutions.

2.1 Institution

Definition 1 *An Institution, I , is a 3-tuple $I = \langle \mathcal{DF}, \mathcal{PS}, \mathcal{BR} \rangle$, where,*

1. \mathcal{DF} is a dialogical framework
2. \mathcal{PS} is a performative structure,
3. \mathcal{BR} are the rules of behavior to which participating agents are subject to.

2.2 Dialogical Framework

Definition 2 *A Dialogical Framework, \mathcal{DF} , is a tuple*

$$\mathcal{DF} = \langle \text{Agents}, \text{Roles}, \mathcal{SR}, \text{LOC}, L, ML, CL, T \rangle,$$

where,

1. Agents is a set of agent identifiers.
2. Roles is a set of agent types,
3. \mathcal{SR} is a set of relevant social relations and individual distinctive characteristics that may be relevant for the description of an institution,
4. LOC is a set of locations
5. L is an object language (an ontology),
6. ML is a metalanguage,
7. CL is a communication language, and
8. T is a model of time.

In other words, concerning the Conference Center institution, we can summarily exemplify of a dialogical framework \mathcal{DF} as follows:

1. Agents is the set of conference registered persons, conference organization staff, Personal Assistants, and Personal Representative Agents,

2. *Roles* is the set of PA's and PRA's types, as well as the types of registered persons (presenters, listeners, invited speakers, etc) and the types of conference staff members (PC member, session chair, information desk staffers, etc)
3. *SR* is a set of relevant social relations like authority e.g.:
 - authority of conference chair over session chairs
 - authority of a user over his/her PRA and PA
4. *LOC* is a set of locations—the main hall, a session room, a company's booth, or the cafeteria.
5. *L* is an ontology containing the elements of which the agents talk about, e.g. agendas, time-slots, projects, consortiums, topics of interests, thematic sessions, etc.
6. *ML* is the (meta) language used to describe the restrictions the institution imposes on the roles of participants.
7. *CL* is a communication language, that is to say the set of illocutions (performatives) the agents can exchange.
8. *T* is the kind of model of time used for the formalization.

2.3 Performative Structure

A *performative structure*, *PS*, is a set of interdependent located scenes. Each scene is defined as a set of agents who are each to assume a given *role*, each pair of agents who ever exchange an illocution are subject to a common *atomic interaction protocol*.

Protocols are specified as finite state machines where state transitions are labeled by illocutions and states have associated memory stacks (of "commitments").

2.4 Rules of Behavior

Even though scene protocols are necessary to describe agent interactions, they may not be sufficient to make fully explicit the "rules of the game" which all participating agents are supposed to follow in a given institution. These rules will be defined as the *individual rules of behavior* of each agent role. Such rules are, ideally, part of the internal model of each participating agent, but may be required and/or enforced by the institution.

3 Appointment Scenes: An example of agent interaction protocol

We will describe two interrelated scenes needed for arranging appointments among two participants that play the roles of *initiator* and *receptor* of appointment proposals. The formal protocol for each scene can easily be obtained from

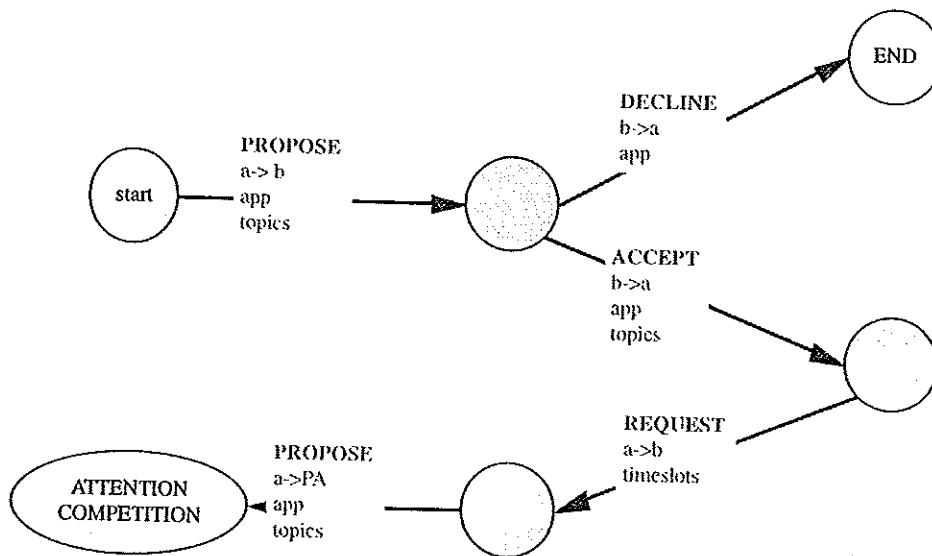


Figure 2: A depiction of the interaction protocol of the Appointment Proposal Scene

the informal descriptions below. Similarly the rules of behavior for each role can also be derived from those descriptions.

The first scene usually precedes the second one for any given participant. The first scene is the Appointment Proposal Scene in which a participant (*initiator*) enables an Appointment PRA to explore the interests and availability of other participants in order to identify the most promising appointments. Those participants with whom an initiator might establish an appointment will be called *receptors*. During the second scene, Appointment Coordination, the initiator enables the Appointment PRA to negotiate with a selected receptor for a meeting time and content.

This first scene for appointments has some prerequisites that are fulfilled in previous scenes (like the Participant Registration Scene) not described here. Some relevant prerequisites are:

- each participant has provided a profile of interest that is accessible in the virtual space by the PRA of other participants
- each participant has an individual agenda with a finite number of time slots that he or she has cleared to be used by his/her PRAs for making appointments (at most one per time-slot)

3.1 Appointment Proposal Scene

The participants of this scene are one initiator and the receptors (in principle, the remaining participants) and is shown in Figure 2. The scene will be described as an interaction protocol between the initiator and one receptor. The scene

takes place in the Main Hall of the virtual space and is composed of the following phases:

1. The initiator enables an Appointment PRA_i (in the role of *initiator*), usually with a list of topics of interest and available time-slots, and commissions it to the Main Hall of the virtual space. The interest topics list is intended to be a refinement of the initiator's posted profile of interests.
2. The Appointment PRA_i looks up the interest profiles of the participants and ranks them according to the match with the initiator's stated appointment interests.
3. The receptor enables an Appointment PRA_r that will handle the requests of the initiator's PRA_i and has knowledge on topics of interest and available time-slots of the receptor.
4. The Appointment PRA_i asks the Appointment PRA_r of each high ranking receptor whether it is willing to set up a meeting with initiator about the initiator topics of interest.
5. For any willing receptor PRA_r , the Appointment PRA_i asks for time slots available for appointments and states potential appointment time-slots.
6. The Appointment PRA_i submits the initiator's PA a ranked list of tentative appointments which will compete for the initiator's attention.
7. For any receptor that has had a potential appointment, its Appointment PRA_r will also submit the corresponding list of tentative appointments to the receptor's PA.

Remark that, up to this point, neither the initiator nor any receptor has made any time commitment—thus no change in the agenda of the user has yet taken place. Moreover, the initiator of this scene can simultaneously be a receptor for the corresponding Appointment Proposal Scene of another participant.

3.2 Appointment Coordination Scene

The precondition for this scene is that a participant has identified the persons he is willing to set up an appointment with (usually as a result of the first scene). Moreover, we assume that an initiator of an Appointment Coordination Scene will uphold the commitments concerning appointments made on his behalf by his Appointment Negotiator PRA. Therefore, the initiator of an appointment is assumed to be committed to meet at any time-slot upon which its PRA reaches an agreement. On the other hand, a receptor will be committed only to those agreements reached by its PRA with an initiator with whom he has stated a willingness to meet. A receptor is committed as well not to meet with any initiator with whom he has stated a unwillingness to meet. Figure 3.2 shows the scene's interaction protocol.

The scene takes place in the Main Hall of the virtual space and is composed of the following phases:

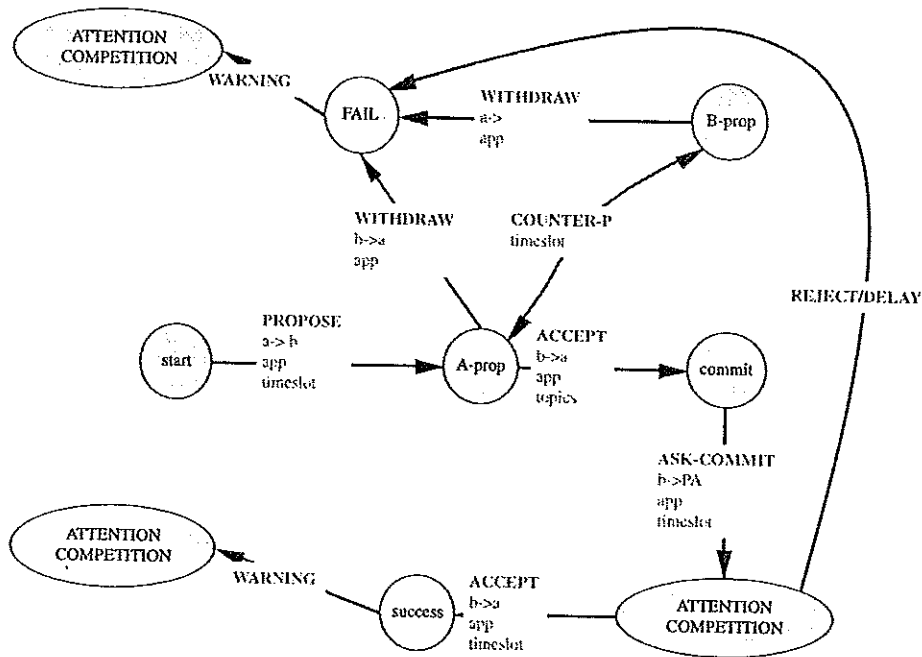


Figure 3: A depiction of the interaction protocol of the Appointment Coordination Scene

1. The initiator enables an Appointment Negotiator PRA_i and instructs it to negotiate an appointment on his behalf a) with a specific person (henceforth the receptor), and b) with a list of preferred time-slots (a refinement of the potential appointment time-slots identified in the previous scene).
2. The receptor enables an Appointment Negotiator PRA_r that will handle the requests of the initiator's PRA_i and has knowledge on available time-slots of the receptor, the potential appointment time-slots identified in the previous scene, and possibly some instructions from the receptor regarding those participants with whom the he is willing/unwilling/indifferent to set up appointments with.
3. Negotiation phase:
 - (a) The initiator PRA_i proposes the receptor PRA_r to have a meeting at a certain time-slot.
 - (b) The receptor PRA_r can either accept, reject, counterpropose a different time-slot, or delay to commit.
 - (c) When the receptor has stated the willingness to meet the initiator and there is a compatible time slot then an accept message is issued. However if either there is no compatible time-slot or the receptor has stated the unwillingness to meet the initiator, a reject message is issued. An accept or reject ends the negotiation phase.
 - (d) A counter proposal switches the roles of initiator/receptor among the two PRAs.

- (e) After a delay to commit, the receptor PRA_r submits the tentative appointment to the receptor PA where it will compete for the user's attention. The user may then accept or reject the standing proposal to meet the initiator. However, if after an standard delay, the user as not made any commitment, the proposal is rejected by default.
4. Upon rejection, the initiator PRA_i submits to its user's Personal Assistant (PA) a notification of the failure to reach an agreement; this notification will compete for the user's attention and may include an explanation for the rejection (unavailable time, unwillingness). After this, the Appointment Negotiator PRA_i terminate the scene⁵.

The receptor PRA_r will only submit a failure notification to the receptor's PA in the case that there was an stated willingness but not available time-slot was found.

5. Upon acceptance, the initiator PRA_i submits a notification of the new commitment to its user's PA where it will compete for the user's attention. The new commitment also requires that the agenda is updated with the appointment time-slot and all active PRA (or all PRAs that monitor this time-slot). A possible finessing of this phase is that the PRA_i also submits to the PA a reminder of the pending commitment that will be competing for attention when the deadline approaches (see §4). After this, the Appointment Negotiator PRA_i exits the scene.

Likewise, the receptor PRA_r will also submit a commitment notification (and reminder) to the receptor's PA.

4 Other Scenes

We are currently specifying other scenes and implementing the PRAs that will carry out the conference participants' interests in those scenes.

1. Proximity Alert: this scene alerts the proximity in real space of a person similar in interests. Variants of this include proximity to exhibitors booth or thematic sessions with topics similar to the user's.
2. Commitment Reminder: this is a type of alert that reminds the user of the proximity of a deadline he is committed to (e.g. an appointment, but also commitments with the Conference organization, like chairing a session that is about to start, or boarding a bus that is about to leave for a tour the user has paid for.)
3. Consortium and Project Formation: one of the more important tasks in conferences like the ESPRIT Week. Similar to appointment scenes but involves several people with different profiles and interests that are relevant to separate aspects of a project-
4. Propagandist: in this scene a PRA from someone like a thematic session chair or an exhibition booth tries to find and attract persons that might

⁵The PRA's *exeunt* does not imply the PRA's termination: it transits to other scenes pursuing the advancement of its user's interests

be interested. Similar to the Appointment scene but there is no need to negotiate a time-slot (session is fixed and exhibitor would prefer to remind the user when he is near and no in a particular time-slot—also similar to Proximity Alert).

5 Discussion

We have described a couple of scenes for making appointments that involved Personal Representative Agents inhabiting the virtual space. This scenes also involved the people inhabiting the physical space through the mechanism of competition for attention. It is worth noticing that two the protocols of interaction described determines basically the illocutions that the agents use (e. g. offer accept, *decline*) and the meaningful relations among them by means of a finite state machine (e. g. a *decline* makes sense only after an offer has been issued). The *propositional content* of each illocution is left open, and even the representation in which this content is conveyed is left open. Indeed a particular implementation of the agent-mediated Conference Center institution would have to decide on the ontology and the representation (KIF, Horn clauses, etc) to be used; however the point is that the current level of abstraction is the adequate to analyze the situations in which we want analyze a social scenario where human and software agents interact in a meaningful way.

The notion of agent-mediated institution also leaves open the internals of specific agents: the preferences and decision procedure by which a software agent makes a particular action (e.g. a particular offer). However only in a particular framework of interaction shared by the involved agents this decision processes can take place, and this is precisely what agent-mediated institutions has to offer.

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