A multi-stage negotiation architecture for sharing resources amongst logic-based agents (extended abstract) ⋆

Fariba Sadri[1], Francesca Toni[1], and Paolo Torroni[2]

[1] Department of Computing, Imperial College
180 Queens Gate, SW7 London, UK
{fs, ft}@doc.ic.ac.uk

[2] DEIS, Università di Bologna
Viale Risorgimento 2, 40136 Bologna, Italy
ptorroni@deis.unibo.it

In earlier work [1] we proposed a framework for agents negotiating for resources. The framework was based on abductive logic programming. The knowledge of the agents consisted of a tuple $< \mathcal{B}, \mathcal{R}, \mathcal{I}, \mathcal{D}, \mathcal{G} >$ with $\mathcal{B}$: *beliefs* about the world, such as the information about the self and the partner agents, and the negotiation policies of the agent; $\mathcal{R}$: initially owned *resources*; $\mathcal{I}$: *intentions*, i.e., the plan that the agent intends to carry out, in order to achieve his goals and the required resources for that plan; $\mathcal{D}$: store of past *dialogues*; and $\mathcal{G}$: agent *goals*. It was assumed that all the missing resources in the plan in $\mathcal{I}$ would have to be acquired at the start before the plan could be carried out, but there was no explicit reference to time windows for actions and durations of actions in the plan. Furthermore, it was assumed that once a resource was acquired by an agent it was his indefinitely.

The idea of the present work is to relax these assumptions to provide a richer framework for negotiation that allows better sharing of resources. We allow agent plans to be partially ordered sets of activities specified within time windows and with each activity of the plan specifying its required resources. An activity a in a plan can be specified as $< a, R, D, Ts, Te >$ denoting that activity a has duration D, earliest start time Ts, latest end time Te, and requires resource R. Without loss of generality, we assume that each activity needs only one resource. It is possible to model activities requiring multiple resources by putting together more activities to be carried out in parallel.

These extensions enable us to develop negotiation policies that allow agents to exchange resources and strike deals for agreed time windows so that (non-consumable) resources can be shared, thus allowing solutions for a wider range of resource re-allocation problems.

In [2] we introduce a multi-stage process of negotiation, where a higher stage involves more information passing between agents and more sophisticated negotiation and possible re-planning by the agents aimed at trying to help satisfy each other's constraints and requirements.

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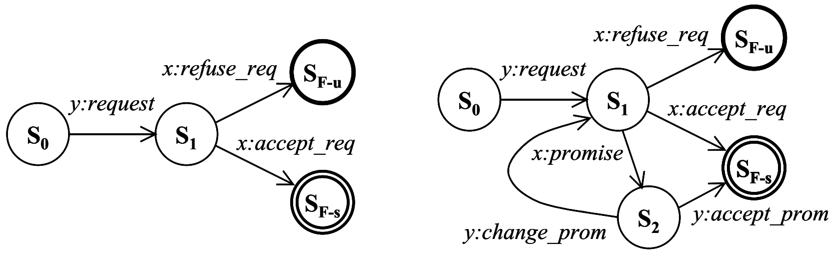

protocol for Stages 1 and 2 ***protocol for Stage 3***

Fig. 1. Examples of negotiation protocols

Due to lack of space, we do not define here any formal framework nor we show any result, but we only introduce the idea of multi-stages by example.

Example There are two agents, x and y. a is an activity in x's intentions, i.e. $< a, r, 3, 1, 5 > \in \mathcal{I}_a$. y has in its intentions an activity b which also requires r. x has r from time 1 to 3 and from time 5 onwards, and y has r from time 3 to 5. Agent x needs to obtain r for at least 3 consecutive time slots between 1 and 5, but he currently has r only for 2 time slots. Let us consider three different scenarios for y's intentions.

1. y's activity is to be carried out between 4 and 10, and lasts 1 slot: $< b, r, 1, 4, 10 > \in \mathcal{I}_b$. The problem will be solved by y agreeing to give r to x for $[3, 4]$.
2. $< b, r, 1, 3, 10 > \in \mathcal{I}_b$ and suppose y has an initial concrete schedule for b to be carried out between 3 and 4. The problem is solved by y agreeing to postpone his schedule by 1 time slot and giving r to x for $[3, 4]$.
3. $< b, r, 2, 3, 10 > \in \mathcal{I}_b$. y cannot give r away, because otherwise b becomes unfeasible. The problem can be solved by an exchange: y agrees to give r away to x for $[3, 4]$, in return for x giving r to y for $[5, 6]$. $\Box$

Dialogues at different stages follow different protocols. Some examples of protocols are shown in Figure 1. We define dialogues conforming to protocols, and propose a logic based formalism (an extension of the work of [1]) to define dialogue policies, which "induce" dialogues conforming to some protocol.

In [2] we show how it is possible to find a resource allocation and a scheduling of activities such that all agents' goals can be achieved (when it is possible from the current resource/activity allocation and constraints of the system) by using agents that negotiate by means of dialogue, and whose reasoning activity is based on abductive logic programming and an agent cycle. We propose 3 different negotiation stages, following different protocols and policies. For each stage we prove formal results regarding termination and conformance of policies to protocols, we define the class of problems that such stage allows to solve, and we show that each stage subsumes the previous one.

References

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