

Effective Multiagent Interactions for Open Cooperative Systems Rich in Services

(Extended Abstract)

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ABSTRACT

The benefits of open and cooperative systems, popular because of the functionality they offer for sharing resources free of charge, are only achievable if there is an incentive to cooperate, and if participants are able to make effective decisions about the cooperations in which they participate. In this context, the key contribution of this paper is a framework for non-monetary cooperations among self-interested agents, providing non-monetary incentives for service provision and a means to analyse cooperations. The framework is used to support a partner selection mechanism, for decision-making over interaction partners.

Categories and Subject Descriptors

I.2.8 [Artificial Intelligence]: Problem Solving, Control Methods, and Search—*Heuristic methods*; I.2.11 [Artificial Intelligence]: Distributed Artificial Intelligence—*Multiagent systems*

General Terms

Design, Experimentation

Keywords

Multi-agent Systems, Exchange Values, Cooperation, Partner Selection

1. INTRODUCTION

We see today many cooperative initiatives to make research data and tools, generated both by organisations and by individuals for personal use, available free of charge to global communities through distributed systems on the Internet [1]. However, as the technology matures, and as the rewards to be gained from the research increase, there is a recognised need to move away from an *ad hoc* approach to one in which *cooperation is supported and encouraged*, especially in light of the lack of formal payment systems for services provided and received. In particular, in real, open cooperative systems we must consider the self-interested nature of the entities operating

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in such systems. Since providing a service always incurs some cost, it is likely that a system will have more participants requesting free services than providing them.

Enabling effective cooperation of self-interested agents in open systems with a variety of free services is a key challenge for agent-based research [2]. This is because it is difficult to design agents that cooperate efficiently, since agents must deal with the diversity of available services, the possible resource limitations for service provision, and with finding providers willing to cooperate even in the absence of economic gains. We argue that, to enable effective cooperations in this context, we must develop mechanisms that consider information not only about the properties of services, but also the incentives for cooperation, and the properties of cooperations. Existing mechanisms that support agent cooperation consider either information on the properties of provided services (such as evaluation-based, and trust-based selection) or reciprocal relationships between providers and requesters (such as dependence-based selection). However, in open cooperative systems, both types of information are relevant when choosing partners, and there are few attempts to incorporate these in a single framework.

In this paper, therefore, we propose a framework to allow effective cooperation between agents operating in systems that are open, dynamic and heterogeneous. The key contribution is a *framework for non-monetary cooperations*, necessary for supporting decision-making over interactions between agents in open cooperative systems, based on a non-monetary *exchange values* model.

2. NON-MONETARY COOPERATION

We propose a model for non-monetary interactions between autonomous agents in which the explicit motivation for cooperation follows Piaget's exchange values approach [3]. According to Piaget, in every exchange of actions among two individuals (or groups) α and β there are four exchange values: *satisfaction* (s_β), *renouncement* (r), *credit* (v), and *debt* (t). Here, satisfaction and renouncement values are respectively related to the material gain and investment resulting from service provision and request. A credit is seen as a *reward* that can be drawn upon in the future, and the debt constitutes a promise, in the sense that the individual in debt feels obliged to *return the favour* to the creditor in the future. Importantly, exchange values are based on individual evaluations of provided and received services. The relation between the four exchange values represents the counterbalance of gains and losses in each interaction, so the differences in individual evaluations determine the *balance* of gains and losses in an interaction. If the gains and losses of participants are equivalent, the interaction between them is said to be in equilibrium. (A simplified computa-

tional model of exchange values is described in [4].) Given such an approach, our framework for non-monetary cooperations based on exchange values has the following properties.

- It enables agents to identify properties of alternative services: since exchange values are based on individual evaluations, agents can identify (through service evaluation) differences among providers, such as the quality of service they provide.
- It provides non-monetary incentives for cooperation: through *reciprocity*, since agents can use their credits to ensure compliance with requests.
- It enables agents to identify properties of cooperations in terms of the balance of exchange values: both requesters and providers can identify whether a cooperation is beneficial (when gains compensate for losses) or harmful (when they do not). Such analyses provide a means for agents to choose interaction partners, and to improve their interactions' results.

Having the means for decision making, we now propose a partner selection strategy to effectively find providers in the context of open cooperative systems with services that are free of charge. Finding an available provider might take a long time, since agents may not accept all service requests if they are not willing to cooperate, or may need to limit the number of simultaneous requests they can accept due to computational resource constraints. Given this, our proposed strategy takes into account the following criteria:

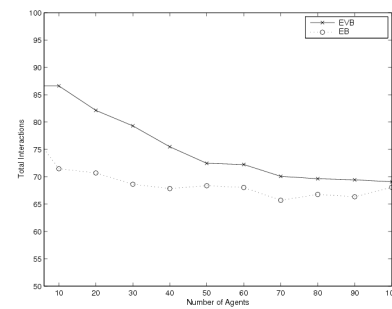
- *individual exchange values* that the requester associates with each candidate provider, enabling the identification of those *more likely to accept requests*, based on the reciprocation implications of credits and debts, and those *more likely to provide good services*, based on the satisfaction value; and
- the *balance of exchange values* of the requester in previous interactions with each candidate provider, enabling the identification of those more likely to be good cooperation partners, in terms of the compensation of the services that are provided and reciprocated.

Ultimately, a list of alternative providers is ordered such that candidate providers more likely to reciprocate (that is, those in higher debt), and to yield better cooperations (that is, those related to higher satisfaction values and to interactions in which exchange values are in equilibrium) are preferred.

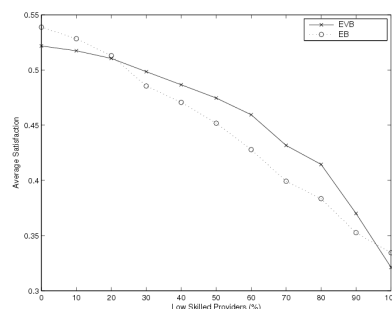
3. RESULTS

To test our proposed partner selection strategy and supporting framework for non-monetary cooperations, in relation to the aspects described above, we undertook empirical evaluation through several experiments. To measure the success of our strategy, called the exchange values-based strategy (EVB), we compared it with a pure evaluation-based (EB) provider selection strategy (which selects providers according to the best quality of service), and observed two things: the agents' *total interactions*, defined as the percentage of accepted requests (from those sent), providing a measure of the ability of requesters to find available interaction partners even though providers may limit request acceptance due to individual preferences and resource constraints; and the *average satisfaction* with received services, providing a measure of whether agents can identify good providers even though there are providers with different skills and good providers may not always be available. For these performance measures, two scenarios were considered: (i) when providers are busy, and (ii) when the number of agents providing poor quality services increases in the system.

As shown in the results in Figure 1(a), the exchange values-based strategy (EVB) performs better than the pure evaluation-based strat-



(a) Total Interactions



(b) Average Satisfaction

Figure 1: Performance measures for partner selection.

egy (EB), achieving a higher number of interactions. The EVB strategy also performs better in the second scenario, having higher average satisfaction than EB, even though the exchange values-based strategy does not consider the quality of service directly when selecting providers, but indirectly through the balance of exchange values; it can select those agents providing better quality services.

4. CONCLUSIONS

With the popularisation of open cooperative systems, the current challenge is to address the dynamism and diversity of participants and services through the development of computational entities that can operate effectively in such systems. In this context, the key contribution of this paper is a framework for non-monetary interaction based on exchange values that provides the necessary information for agents to operate effectively through partner selection. It addresses a need for unified cooperation mechanisms that consider both service evaluations and cooperative relationships, and experimental results show that such a framework can be successfully used to support partner selection, so that agents take efficient decisions over the interactions in which they engage.

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