A multi-agent system for service discovery, selection and negotiation

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ABSTRACT

Service-oriented computing can benefit from multi-agent system technologies by adopting the coordination mechanisms, interaction protocols, and decision-making tools designed for multi-agent systems. We demonstrate here the use of a fully decentralised multi-agent system supporting the discovery, selection, and negotiation of services.

Categories and Subject Descriptors

Academic software [**Multi-agent software systems**]

Keywords

Grid, SOA, Argumentation, Negotiation.

1. OVERVIEW

Service-oriented computing is an interesting test bed for multiagent system techniques, where agents need to adopt a variety of roles that will empower them to provide services in open and distributed systems. Moreover, service-oriented computing can benefit from multi-agent systems technologies by adopting the coordination mechanisms, interaction protocols, and decision-making tools designed for multi-agent systems. We demonstrate the use of a fully decentralised multi-agent system supporting agent-automated service discovery, agent-automated service selection, and agent-automated negotiation of Service Level Agreements (SLAs) for the selected services. The system integrates

- GOLEM [1] (Generalized OntoLogical Environments for Multi-agent systems), an agent environment middleware [2]
- MARGO [2] (A Multiattribute ARGumentation framework for Opinion explanation), an argumentation system for decision-making [5]
- PLATON [3] (Peer-to-Peer Load Adjusting Tree Overlay Networks), a Peer-to-Peer platform supporting multi-attribute and range queries [4]

This system is used for service composition and orchestration within the ARGUGRID project [4]. As discussed in [7], in ARGUGRID the GOLEM+MARGO+PLATON system demonstrated here is interfaced with a semantic composition environment, allowing users to interact with their agents, and the GRIA grid middleware for the actual deployment of services. For the purposes of this demo, however, we will disregard the semantic composition environment and GRIA.

2. THE SYSTEM

Service discovery..

The retrieval of services is based on the semantic match between a declarative, semantic description of the service being sought and a declarative, semantic description of the services being offered. The users (i.e. service providers and requesters) delegate the service selection to agents "representing" them. These agents exchange messages which convey information in accordance with explicit domain ontologies.

Our requester agents discover services by discovering the provider agents for these services, supported by (i) semantic descriptions of these services and their agents in (multiple, distributed) registries, and (ii) the PLATON peer-to-peer platform allowing multi-attribute and range queries and load-balancing of peer resources. Load-balancing is necessary in order to guarantee logarithmic querying time and scalability.

Service selection..

Requester agents select services according to their suitability to fulfil high-level user requirements. These agents

[1] http://www.golem.cs.rhul.ac.uk

[2] `http://margo.sourceforge.net`

[3] http://platonp2p.sourceforge.net

[4] `www.argugrid.eu`

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use argumentation in order to assess suitability and identify "optimal" services. They argue internally using an argumentation framework [5] linking decisions on selecting services, (a possibly incomplete description of) the features of these services, the benefits that these features guarantee (under possibly incomplete knowledge). Our system uses the MARGO tool for multi-attribute qualitative decision-making to support the decision on suitable services. Using this tool, arguments can rely upon assumptions to fill in gaps in the information available to the agents, as soon as these assumptions can stand against criticism, in the spirit of assumption-based argumentation [1].

SLA Negotiation..

As soon as the requester agents identify a suitable service, it engages in a negotiation process with the provider agent for that service. The negotiation aims at agreeing a SLA on the usage of the identified service, and is conducted using a realisation of the minimal concession strategy of [3]. According to this, agents start the negotiation with their best offers. During the negotiation, an agent may concede or stand still. It concedes minimally if the other agent has conceded in the previous step or it is making a move in the third step of the negotiation (after offers by both agents have been put forward). It stands still if the other agent has stood still in the previous step. This strategy has useful properties: it is guaranteed to terminate and it is in symmetric Nash equilibrium. Both requester and provider agents use MARGO, during negotiation, in order to decide their offers and whether to concede or stand still.

Agents.

Agents are hosted within GOLEM. This allows to specify declaratively interactions amongst agents within the environment. As a result, this environment is programmable at runtime and can be changed at run-time, e.g. by adding or removing agents and services, without having to restart the overall system. Agents consist of a "body" and a "mind". The mind is divided in three main modules [6]: (i) the individual decision making module, allowing to shift from user requirements (their goals, preferences, and constraints) to an internal and abstract representation of the userŠs needs (respectively competencies); (ii) the social decision making module, allowing to shift, by means of negotiation, from these abstract representations to concrete ones, in terms of contracts; (iii) the social interaction module, managing the communication between agents given social rules of interaction (protocols).

3. THE DEMO

The demo makes use of a concrete "earth observation" setting whereby a user needs a satellite image in order to track an oil spill. The corresponding requester agent will select a suitable satellite (and appropriate sensors) from one of the available ones. The image needed by the user is described in terms of its resolution, price and response time (namely the time by which the image is needed). The user may additionally (and optionally) specify the organisation(s) to which the providers of the requested service should belong. The requester agent then queries PLATON to discover a set of candidate suitable providers. The query to PLATON is composed of three attributes: 1) the organisation(s), e.g. ESA; 2) the domain of knowledge, e.g. earth observation; 3) the service type, e.g. oil spill detection , image clipping, fire detection. The domain is "decided" by the requester agent, according to its expertise. The service type and organisation directly result from the user query. In the particular case of the demo, the agent searches for agents that can provide oil spill detection images in the domain of earth observation, leaving the organisation as a variable, because it is not a requirement for the user. In the demo the agents discover three potential providers as a result of the query to PLATON. In order to select the best provider for the negotiation, the requester agent evaluates the three retrieved services using MARGO. Then, the requester agent and the provider agent "representing" the satellite conduct a negotiation on the price component of the SLA. The outcome is an agreed satellite image at a given price. This negotiation (and how MARGO and GOLEM support it) is illustrated in the accompanying screen shots.

4. CONCLUSIONS

Rather than focusing on a complex problem, the demo concentrates on stressing the interactions between the different components of the system. Indeed, the benefits of our system arise from these interactions and the positive properties of its components. To the best of our knowledge, our system is the first implemented system integrating argumentation for qualitative decision-making and game-theory-inspired negotiation within a fully decentralised and adaptable multi-agent middleware.

5. ADDITIONAL AUTHORS

6. REFERENCES

[1] A. Bondarenko, P. M. Dung, R. A. Kowalski, and F. Toni. An abstract, argumentation-theoretic approach to default reasoning. *Artif. Intell.*, 93(1–2), 1997.

[2] S. Bromuri and K. Stathis. Situating cognitive agents in GOLEM. In *Proc. EEMMAS*, pages 76–93. Katholieke Universiteit Leuven, 2007.

[3] P. M. Dung, P. M. Thang, and F. Toni. Towards argumentation-based contract negotiation. In *Proc. COMMA'08*. IOS Press, 2008.

[4] L. Lymberopoulos, S. Bromuri, K. Stathis, S. Kafetzoglou, and M. Grammatikou. Towards a p2p discovery framework for an argumentative agent technology assisted grid. In *Proc. of the CoreGRID Workshop on Grid Programming Model, Grid and P2P systems Architectures, Grid Systems, Tools, and Environments*, 2007.

[5] M. Morge and P. Mancarella. The hedgehog and the fox. an argumentation-based decision support system. In *Proc. ArgMAS*, 2007.

[6] M. Morge, J. McGinnis, S. Bromuri, F. Toni, P. Mancarella, and K. Stathis. Toward a modular architecture of argumentative agents to compose services. In *Proc. EUMAS-2007*, 2007.

[7] F. Toni, M. Grammatikou, S. Kafetzoglou, L. Lymberopoulos, S. Papavassileiou, D. Gaertner, M. Morge, S. Bromuri, J. McGinnis, K. Stathis, V. Curcin, M. Ghanem, and L. Guo. The ArguGRID platform: An overview. In *Proc. GECON 2008*, volume 5206 of *LNCS*, pages 217–225. Springer, 2008.