

# Agent-Based Virtual Organisations for the Grid

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## ABSTRACT

The ability to create reliable, scalable virtual organisations (VOs) on demand in a dynamic, open and competitive environment is one of the challenges that underlie Grid computing. In response, in the CONOISE-G project, we are developing an infrastructure to support robust and resilient virtual organisation formation and operation. Specifically, CONOISE-G provides mechanisms to assure effective operation of agent-based VOs in the face of disruptive and potentially malicious entities in dynamic, open and competitive environments. In this paper, we describe the CONOISE-G system, outline its use in VO formation and perturbation, and review current work on dealing with unreliable information sources.

## Categories and Subject Descriptors

I.2.11 [Computing Methodologies]: Artificial Intelligence—*multiagent systems*

## General Terms

Design

## Keywords

Virtual organisations, trust, Grid, quality of service, policing

## 1. INTRODUCTION

The engineering of systems using approaches that establish a fixed organisational structure is not sufficient to handle many of the issues inherent in open multi-agent systems (in particular, heterogeneity of agents, trust and accountability, failure handling and re-

covery, and societal change [1, 2]). Such issues are becoming increasingly important in the context of Grid computing, which aims to enable resource sharing and coordinated problem-solving in dynamic, multi-institutional virtual organisations (VOs) [1]. VOs provide a way of abstracting the complexity of open systems to make them amenable to application development. The organisational structure, participant responsibilities, synchronisation concerns and economic mechanics of the VO are hidden from the VO user.

While the notion of VOs underpins the vision of Grid computing, the conditions under which a new VO should be formed, and the procedures for its formation, operation and dissolution, are still not well-defined. This automated formation and ongoing management of VOs in open environments thus constitutes a major research challenge, a key objective of which is to ensure that they are both agile (can adapt to changing circumstances) and resilient (can achieve their aims in a dynamic and uncertain environment). In addition to traditional constraints that relate to issues such as resource management and bidding strategies, we must also consider softer constraints relating to contract management, trust between VO participants and policing of contracts.

The CONOISE-G project (Grid-enabled Constraint-Oriented Negotiation in an Open Information Services Environment, website at <http://www.conoise.org>) is directed at addressing just these issues. It seeks to support robust and resilient VO formation and operation, and aims to provide mechanisms to assure effective operation of agent-based VOs in the face of disruptive and potentially malicious entities in dynamic, open and competitive environments.

In particular, to operate an effective VO in open, dynamic and competitive environments, it is essential that we also consider how to encourage good interactions, and cope effectively with bad ones. In our view, this requires that QoS levels are monitored, that uncertainty in participant behaviour, possibly arising from self-interest and strategic lying and collusion, is minimised, and that mechanisms for recognising and addressing contract violations once they have occurred are established. Addressing these concerns is integral to the wide-scale acceptance of the Grid and agent-based VOs.

## 2. THE CONOISE-G ARCHITECTURE

In essence, the CONOISE-G architecture comprises several different agents, including *system agents* and *service providers* (SPs), as

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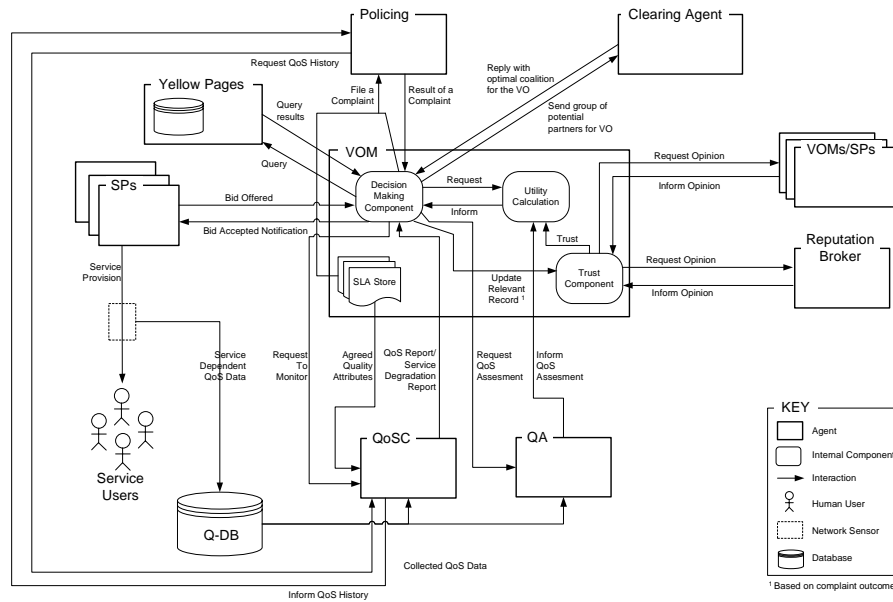


Figure 1: The CONOISE-G architecture

in Figure 1. The former are needed to achieve core system functionality for VO formation and operation, while the latter are involved in the VO itself.

Assuming that service providers have already advertised their services to a YP, the VO formation process starts with a particular SP acting on behalf of a user, the Requester Agent (RA), which analyses the requester’s service requirements, locates the relevant providers through the YP, and then invites the identified providers to bid for the requested services. The quality and trustworthiness of the received bids are assessed by the Quality Agent (QA) and the trust component, respectively, and the outcome is combined with the price structure by a Clearing Agent (CA) [3] to determine which combination of the services/providers will form an optimal VO (in terms of price, quality and trust) for the requester. At this point, the VO is formed and the RA takes on the role of VO Manager (VOM), responsible for ensuring that each member of the VO provides its service according to contract.

During the operational phase of the VO, the VOM may request the QoS Consultant (QoSC) to monitor any services provided by any members of the VO, and any member of the VO may invoke the Policing agent to investigate any potential dispute regarding service provision. Ultimately, our aim is for monitoring to take place to inform the user when the actual service level diverges from the agreed service level. At present, however, this is achieved by configuring the levels of QoS for each service that will cause the QoSC to alert the VOM, using predetermined service provision and quality level simulations. When the QoS provision of a service in the VO falls below an acceptable level of service, or some breach of contract is observed, the QoSC alerts the VOM, which initiates a VO re-formation process; relevant information is fed into the trust component to ensure that the provider concerned is penalised to an appropriate level by updating its record of trust.

In this re-formation process, the VOM issues another message to the YP requesting a list of SPs that can provide the service previously provided by the failed SP. As before, the YP identifies possible SPs, bids are received and evaluated, resulting in the CA determining the best SP to replace the failed provider. At this point, the

VOM re-forms the VO with the new SP replacing the old one, and instructs the QoSC to stop monitoring the old SP and to monitor the new one instead.

### 3. CONCLUSIONS

The work described in this paper takes an approach in which issues relating to the formation and operation of robust VOs in the dynamic environments with unreliable agents are considered. In contrast to the “brawn” of the Grid, we have concentrated on the “brains” [1] — on the development of techniques for autonomous problem-solving in VOs. Thus, we have described an agent architecture for re-forming VOs in the face of unreliable information, through the use of a range of techniques that support robust and resilient VO formation and operation for application to realistic electronic commerce scenarios.

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