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FIPA-compliant agents for real-time control of Intelligent Network traffic

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Abstract

Autonomy, adaptability, scalability, and flexible communications are all attributes of agents and multi-agent systems which suggest that they may offer timely solutions for dealing with the growing complexity of the tasks of traffic control and resource management in telecommunications networks. However, if agent-based solutions to network management problems are to be successful then it will be important that heterogeneous agents and agent platforms inter-operate in accordance with internationally accepted standards. Although standards of this nature are being developed, they are not tailored specifically to the needs of the telecommunications domain, with the result that important issues, such as support for the operation of agent systems in real-time constrained environments, do not seem to be adequately addressed. We present two agent-based systems for control of traffic load and resource allocation in Intelligent Networks. One of these strategies is based on the concepts of 'Market-based Control', the other on the concepts of 'Ant Colony Optimisation'. Using the market-based strategy as an example we show that enhancements to existing FIPA specifications would be required to implement these strategies in order to satisfy their real-time operation constraints. We also suggest a number of potential enhancements to FIPA specifications that would alleviate some of the identified problems.

Keywords: Agent technology; Intelligent network; Load control; Market-based control; Ant colony optimisation; FIPA; ACL; Real-time enhancement

1. Introduction

Two distinguishing characteristics of contemporary telecommunications are the increased complexity of the marketplace and of the underlying technology. The industry is being 'pulled' by market factors such as deregulation, federation of multiple service providers, and the trend towards service-oriented operations; and being 'pushed' by technological advances allowing service profiling from alternative network access points, integrated multi-service broadband networks, and interoperable telecommunications and computer network infrastructures. These factors mean that the complexity and level of connectivity of networks is continually growing, in order to support the range and volume of information produced by users. Increases in network complexity

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and information volumes suggests that approaches to the management of telecommunications systems, services and networks will need to be more responsive, adaptive, proactive, and less centralised. As these are properties of *agents* and *multi-agent systems* many in the telecommunications research community have recognised that agent-based technology appears to offer a timely solution to the growing problem of designing efficient and flexible network management strategies.

An important prerequisite for the introduction of agent-based systems into telecommunications networks is the availability of internationally agreed agent platform interoperability standards. Work in this direction is taking place within the Foundation for Intelligent Physical Agents (FIPA) [7] and within the Object Management Group (OMG) [18]. The OMG have produced the Mobile Agent System Interoperability Facility (MASIF), which focuses on *mobile agent* (object) technology, in particular allowing for the transfer of an agents code and state between heterogeneous agent platforms. The FIPA'97 and FIPA'98 specifications, on the other hand, deal with interoperability between (more or less) static agent classes that rely on agent 'intelligence' and agent co-operation based on high-level speech act communication. This standard is thus based on research on *intelligent (deliberative) agents* that has emerged from the Distributed Artificial Intelligence community.

Existing MASIF and FIPA standards have been developed with a wide range of application domains in mind and thus important non-functional requirements of agent-based telecommunications management systems may not be adequately addressed. These requirements can relate to the system's reliability, scalability, security, ability to meet performance targets and ability to satisfy real-time constraints. The ACTS–MARINER project [15] is investigating how FIPA standards can be enhanced in order to provide the support necessary to meet the real-time and performance requirements of telecommunications applications. The project is developing a FIPA-compliant agent system for Intelligent Network (IN) load control (a problem particularly suited to agent technology-based solutions) in order to identify areas in which FIPA specifications could be beneficially enhanced.

In this paper we present two agent-based IN load control strategies, one based on the concepts of 'Market-Based Control' [5], the other on the concepts of 'Ant Colony Optimisation' [6] and identify some of the relevant real-time and performance constraints placed on the agents that implement them. We show that compliance to existing FIPA specifications would make it difficult to satisfy these requirements and suggest a number of potential enhancements that would alleviate the identified shortcomings. It is to be emphasised that we do not contend that existing FIPA standards are necessarily 'incorrect', rather that because they were developed to cover the needs of specific applications (none of which include real-time constraints) there is a need for enhancements when applying them to the type of applications discussed here.

The outline of the paper is as follows: Section 2 provides an introduction to the area of IN load control and provides arguments in favour of agent-based strategies; Section 3 introduces 'Co-operative Market' and 'Ant-Based' IN load control strategies; Section 4 is implementation-oriented in nature, outlining how the co-operative market strategy can be realised as a FIPA-compliant multi-agent system; Section 5 reports on a number of deficiencies in the FIPA'97 specifications identified when applying them to the MARINER load control strategies and provides pointers towards suitable enhancements to FIPA standards; finally Section 6 draws a number of conclusions and outlines future work topics.

2. Intelligent Network load control

The Intelligent Network architecture was developed as a means to introduce, control and manage services both rapidly, cost effectively and in a manner not dependent on equipment/software from particular equipment manufacturers. An IN network consists of four node types: Service Switching Points (SSP), Service Control Points (SCP), Service Data Points (SDP) and Intelligent Peripherals (IP). These node types typically communicate with each other via a Signalling System No. 7 (SS.7) network. SSPs facilitate end user access to services by means of trigger points for detection of service access codes. SCPs form the core of the architecture, they receive service requests from SSPs and execute the relevant