Constructing an Intelligent Multi-Agent Workflow System

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Abstract: A distributed intelligent agent-based system that manages workflows has been designed, built and trialed. This system manages the processing of applications received by a university department from potential research students. This particular workflow was selected for two reasons. First it involves a range of different types of interaction with the players. Second it involves soft decision making based on the opinions of the users. Workflow systems that employ soft decision making may be controlled to bring their performance into line with corporate strategic priorities. The system design is based on a 3-layer BDI architecture. The implementation uses no physical documents. Documents are available on the world wide web; 'advice' notices are sent by electronic mail. Intelligent workflow systems support considerable flexibility in the structure of decision making environments, including environments that may not be realised in traditional systems.

1. Introduction

In (Debenham, 1997b) an experimental workflow system is described. That system represents documents on the world wide web, delivers messages to the user using email, and manages the (virtual) internal flow of documents with a single knowledge-based system. The choice of a single knowledge-based system meant that any extensions to the functionality of that system could only be accomplished by re-designing the central knowledge base. That system was not particularly robust and was not adaptive. This lead to a re-design of the system as a multi-agent system.

The design, implementation and evaluation of a multi-agent strategic workflow system, called RSA, is described here. Like its predecessor, RSA manages the acceptance and processing of applications from potential research students in a university environment. The processing of these applications by the university staff requires that the staff express their opinion on the application. Decision making is central to this workflow. RSA is more complex than a simple workflow system in which specific tasks are performed completely at each step in the workflow. In RSA all decisions are made to a stated level of confidence. These confidence factors play a key role in controlling the operation of this system to ensure that its performance is in line with determined strategic priorities.

A workflow system is a document transfer and management system in a networked enterprise (Hawryszkiewycz, 1997). A workflow system is typically one of the main parts of a networked enterprise. In any enterprise, management will determine the strategic priorities that control the allocation of resources to the various parts and activities of that enterprise. A strategic workflow system (Debenham,
1997a) is a workflow system whose performance can be controlled so that the quality and cost of workflow processing may be brought into line with determined strategic priorities. Strategic control is provided here by an external user setting control variables on the basis of observing the report variables.

RSA has been designed as a distributed intelligent multi-agent system. A distributed intelligent multi-agent system is a system consisting of a number of autonomous agents distributed at different sites of a network, working cooperatively to achieve a common goal. For RSA the common goal is to make decisions in good time, and of an appropriate quality within specified cost constraints. Each user of the system, including the external applicant, is supported by a personal interface agent. Each interface agent estimates the available processing capacity of its user as well as supporting a basic range of user preferences. Otherwise, the interface agents are "fairly dumb" in their present form.

During the construction of RSA an approach to the design of intelligent agent-based workflow systems has emerged. That approach is illustrated here. It employs a 3-layer BDI conceptual architecture (Rao and Georgeff, 1991) similar to the INTERRAP conceptual architecture described in (Müller, 1996). The control architecture is intended specifically for workflow applications. A key design decision for any multi-agent system is the Agent Communication Protocol which is described below. Having determined this protocol each agent may be constructed separately. This eases construction and is amenable to team work. The choice of a multi-agent architecture is a natural one, and it has the advantage that other workflows or activities may be included subsequently by extending the knowledge of the relevant agents without effecting the rest of the system.

In their present form the agents only manage the RSA workflows. RSA has been implemented in Lotus Notes using a Domino Server. All system documents are HTML documents and the users interact with the system using a Web Browser. This ensures that the system is universally accessible. Evaluation of the system has been carried out within a university department using test applications generated locally. The results of this evaluation are described below.

2. External Operation
A highly simplified description of the external operation of the experimental RSA system follows. Prospective research students are directed to a worldwide web page that contains explanatory material and an application form. If the prospective student (ie the "Applicant") chooses to complete this form, the completed form is submitted. When a form is submitted it is screened automatically to check for obvious errors such as leaving the section "Please suggest a brief title for your proposed research project." blank. If the form fails the automatic screening then a message is sent to the Applicant to request that the detected errors should be rectified. When this initial screening is complete a message is sent to a senior academic (ie the "Supervisor") in the department advising that a form has been screened. The Supervisor will then check the form to ascertain whether the interests of the Applicant are relevant to the interests of the department. If the Supervisor indicates that the interests of the Applicant are relevant then the Supervisor marks the form with any potential supervisors who could be well suited to supervise the proposed work. The form is