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Application of Mobile Agents in Web-based Student Modelling

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Abstract

In recent years, educational information on the web has increased exponentially, and web-based learning environments are becoming mainstream applications on the Internet. But these environments face some common deficiencies, such as slow access, no adaptivity to individual student, limitation by bandwidth, and so on, which need to be resolved. Meanwhile, the research in Intelligent Agents technology has received a lot of attention in Information Systems Research and Development area. This project investigated mobile agents technology and its benefits, and applied this technology to address the problems that limit the potential of web-based learning environments.

This project has developed a system, using mobile agents technology, to capture interactions over the Internet and to provide a continuous interaction pattern for a given student, even in off-line mode or in the case of unreliable connection. The mobile agents technology is used as the communications channel between client and server instead the traditional approaches. The system uses two-step student modelling architecture, which consists of the local and central individual student models and central group student model. There are primarily three parts of student model in the system: local individual student model that resides in student's machine, central individual student model that resides on the central server, and central group student model that sits on the central server. This two-step modelling mechanism largely improves capturing interactions of a given student in the web-based learning environment, even in off-line mode, and enables the system to provide adaptation at different granularity.

The combination of two-fold student modelling and mobile agents technology provides an attractive alternative to implement and improve web-based learning environments. The methodology used in this system addresses the problem of adaptation, which is one of the main bottlenecks that limit the development of web-based intelligent educational systems.

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Chapter 1

Introduction

1.1 The Context of Web-based Environments

The proliferation of computers, the advent of Internet and the steady gain in popularity of Distance Education greatly influence our educational environment. Educational information on the web has been increasing exponentially, and Web-based learning is currently an important research and development area. Web-based learning environments are strongly driven by information revolution and the Internet. The educational systems, especially the Web-based learning environments, are becoming mainstream applications on the Internet, but they have a number of common deficiencies, such as the lack of adaptivity for individual student, connection limitation and slow access to course, which need to be resolved. A number of attempts, such as static intelligent interface agents, have been made to solve some of these problems, but solution to one problem often impedes solutions to the remaining problems. The emerging intelligent mobile agents have huge potential to address those deficiencies.

1.2 Intelligent Agents and Mobile agents

Intelligent agent is a computational entity, which acts on behalf of other entities in an autonomous fashion, performs its actions with some level of proactivity and/or reactivity, and possesses some key attributes such as learning, co-operation and mobility. The concept of agents came in mid 1970s (Hewitt, 1977). These few years, the strong trends in the Internet technology and distributed systems have lead to the point, where agents technology, in particular the mobile agents technology, is one of the "hot"

topics in Information Systems Research and Development.

Application domains, in which agent solutions are being applied to or investigated include workflow management, network management, air-traffic control, business process re-engineering, data mining, information retrieval/management, electronic commerce, education, personal digital assistants (PDAs), e-mail, digital libraries, command and control, smart databases, scheduling/diary management, and so on.

The newcomers – mobile agents, which emerged in the mid 90s, can move from one computer to another. These few years mobile agents technology has been highlighted by many big research groups, e.g. Telescript (White, 1996), AgentTCL (Gray, 1997), Aglet system (Chang and Lange, 1996), Bee-gent and Plangent (URL1, 2001), Hive (Minar, 2000). There are various reasons why mobile agents are highlighted more than static agents in recent years. These include their potential to address the problems of latency and bandwidth of client-server applications and the vulnerability of network disconnection, to fit into the coming dynamic and mobile age of computing, etc. They are bringing together telecommunications, software, and distributed system technologies to create new ways of building computing systems. The benefits of mobile agents, especially on the web, directly address the problems of Web-based learning environment as discussed in chapter 5.

1.3 Motivation for the Research

1.3.1 The Context of The Research

In general sense, a Web-based learning environment should interact with the students, adapt to the needs of individual students, support interaction with teachers and other students, and be user-friendly to the authors. A prototype of Web-based Intelligent Tutoring System, Student Modelling and Adaptivity in Web-based Learning System (SMAWLS) has been built successfully to exploit the student adaptivity in Web-based

environment by using traditional client-server technology (Han, 2001). This system benefits from the collaborative learning on the web by having two separate student models: *Individual students model* for each student; and *Group student model* for generalizing the attributes of a group of students. However, the potential of the mechanism of the individual student model and group student model in the SMAWLS was not exploited fully, and it also has the common deficiencies of Web-based learning environments.

1.3.2 Motivations

Although it is possible to propose an alternative, based on an existing technology, to almost every mobile agent-based function (Chess et al., 1995), in certain cases mobile agents have significant advantages over conventional approaches at the design, implementation and execution stages. The motivation for using mobile agents stems from the following anticipated benefits:

- *Efficiency and reduction of network traffic:* Mobile agents consume fewer network resources since they move the computation to the data rather than the data to the computation. Also mobile agents can package up a conversation and ship it to a destination host, where the interactions can take place locally, hence reducing the network traffic (figure 1.1).

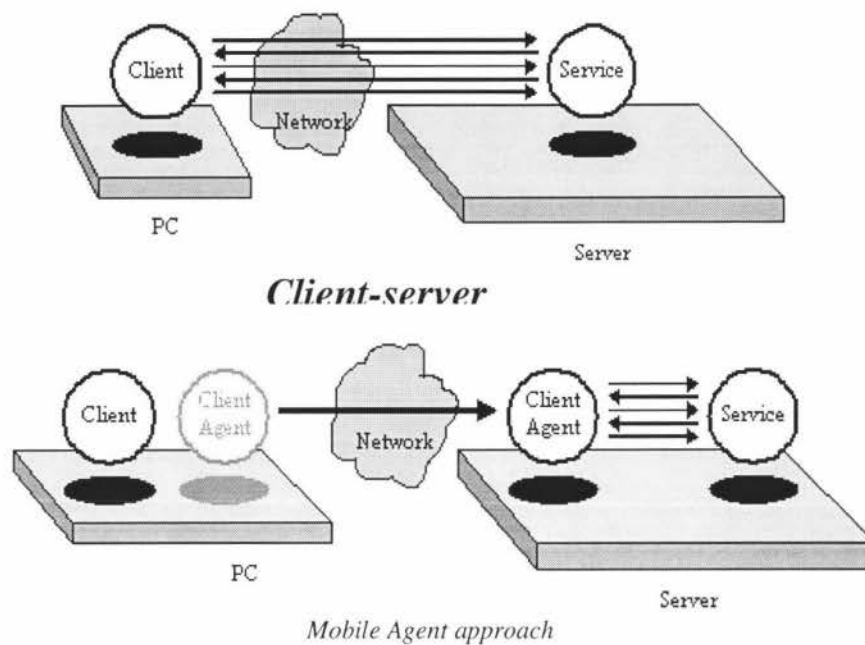


Figure 1.1: Client-server paradigm vs. Mobile Agent approach

- *Asynchronous autonomous interaction:* Tasks can be encoded into mobile agents and then dispatched. The mobile agent can operate asynchronously and independent of the sending program.
- *Interaction with real-time entities:* Real-time entities require immediate responses to changes in their environment. Controlling these entities from across a potentially large network will incur significant latencies. Mobile agents offer an alternative to reduce or even eliminate network latency.
- *Local processing of data:* Processing of vast volumes of data over the network becomes inefficient when the data is stored at remote locations. Mobile agents allow the processing to be performed locally, instead of transmitting the data over a network.

- *Support for heterogeneous environments:* Both the computers and networks on which a mobile agent system is built are heterogeneous in character. As mobile agent systems are generally computer and network independent, they support transparent operation.
- *Convenient development paradigm:* The design and construction of distributed systems can be made easier by the use of mobile agents. Mobile agents are inherently distributed in nature and hence are natural candidates for such systems.

In term of motivation, this research attempts to empower the mechanism of individual and group student models, and investigate possibility and potential of using mobile agent technology to facilitate the communication between student models to improve the student adaptivity in Web-based learning environments.

1.4 The Research Steps

The project is broken into five phases, as described below:

- Phase 1: overviews the development of Web-based learning environments and discusses its student adaptivity and its existing problems.
- Phase 2: overviews the intelligent agents and has a closer look at mobile agents, and matches the benefits with the problems of Web-based learning environments.
- Phase 3: investigates and exploits the mobile agent framework – Beegent framework.
- Phase 4: investigates and develops the architecture of communication between central and local student models using mobile agent.
- Phase 5: develops a prototype that implement the mechanisms of communication between central and local student models by employing Beegent framework, Java 2, and InstantDB.

1.5 Structure of the Thesis

The structure of the thesis follows closely the phases in the research steps. Chapter 2 contains the review of the Web-based learning environments. In Chapter 3 the intelligent agent history and technology are reviewed. Then the details of the mobile agents technology is discussed. Chapter 4 reviews the existing application of intelligent agents in educational systems and matches the benefits of mobile agents with the problems of Web-based learning environments. Chapter 5 describes the context system of application of mobile agent, and discusses the architecture of using Beegent to implement the communication between central and local student models. Chapter 6 contains the overview of main technologies used by the prototype, and the implementation of the prototype that demonstrates the use of mobile agents in student adaptivity in the Web-based learning environments. Chapter 7 presents the early evaluation and concludes the thesis by reviewing the work done by the project and discussing further research directions.