

Improving mobile learning environments by applying mobile agents technology

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INTRODUCTION

Availability of high bandwidth infrastructure such as GPRS, 3G and UMTS networks, advances in wireless technologies (Chen and Nahrstedt, 2000; Chiang, et al., 1998; Johnson and Maltz, 1996; Chen and Lai, 2000; Lin and Liu, 1999) and popularity of handheld devices (Microsoft, 2001) provide a new way for education by extending the learning time and space. One important emerging application of handheld devices is mobile learning (Sharples, 2000). With the new paradigm "anytime, anywhere computing", e-learning has been extending to mobile learning (m-learning) (Lehner and Nösekabel, 2002).

In recent years, numerous efforts have been making in the direction of using handheld devices for educational purposes (m-learning project, 2003; MOBIlearn project, 2003; Chen, et al., 2002; Chang and Sheu, 2002; Becta Report, 2003; Megan Fox, 2003). However, while mobile devices are approaching ubiquity today, the m-learning industry is still in its infancy. The current research base is insufficient to wholly explore the value of wireless internet learning devices (Roschelle, et al., 2002). The m-learning has a number of common deficiencies, such as access to course materials is slow; courseware does not adapt to individual students; the real time interaction between student and system is hard to achieve because of the connection unreliability and bandwidth limitations.

Intelligent Agents are one of the "hot" topics in Information Systems Research and Development at the moment. The last ten years have seen a marked interest in agent-oriented technology and a distinct trend has evolved to the research and development work on intelligent agents. This trend relates to the diversification in the types of agents being investigated and most popular types include user interface agents, information agents, multi agent system, and mobile agent and so on. Intelligent agents, and in particular, mobile agents (Cardelli, 1995; White, 1996; Gray, 1997; Aglet system, 2003; Bee-gent and Plangent, 2003; Minar, 2000), have huge potential to address those deficiencies. In this paper, we shall demonstrate how mobile agents can address the problems that limit the potential mobile learning environment development.

MOTIVATION FOR USING MOBILE AGENTS

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 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, so network traffic is reduced (figure 1).
- *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 save network latency.
- *Local processing of data:* Dealing with vast volumes of data when the data is stored at remote locations, the processing of data over the network is inefficient. Mobile agents allow the processing to be performed locally, instead of transmitting the data over a network.

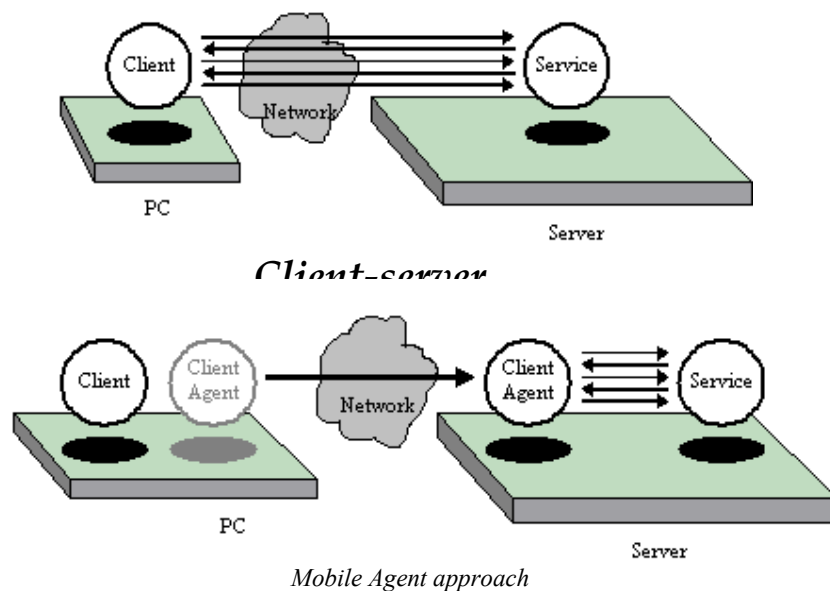


Figure 1: Client-server paradigm vs. Mobile Agent approach.

- *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.

APPLICATION OF MOBILE AGENTS TECHNOLOGY IN MOBILE LEARNING ENVIRONMENTS

After examining the benefits of mobile agents, and considering the limitations of mobile learning environments, it becomes clear how mobile agent technology addresses those limitations very naturally. We discuss below how mobile agents can improve mobile learning environment.

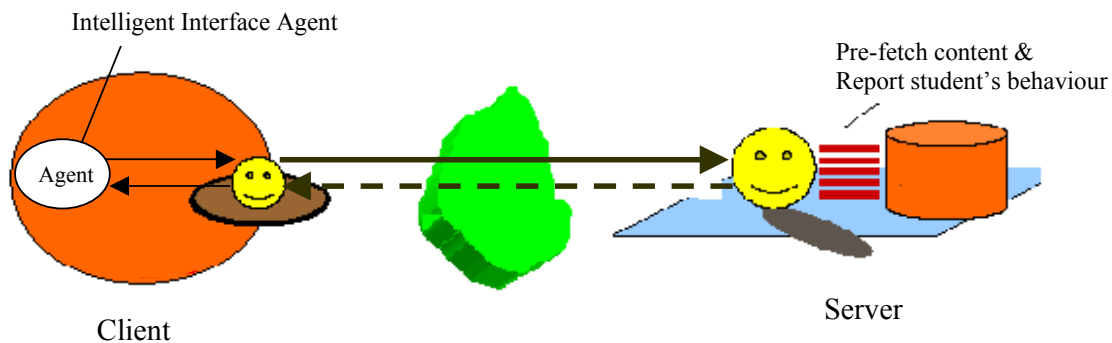


Figure 2: Scenario of mobile agent working

- In a mobile learning environment, as shown in figure 2, mobile agents can be used to pre-fetch the domain content that will be requested shortly by the student, and report student's performance to the central server. This pre-fetch process is based on real-time analysis of the student's behaviour, and calculation of the probability of a request. Depending on the state of the network, an immediate request or a reservation can be fulfilled by the mobile agent. In this way, end-to-end quality of the service can be improved for the delivery of distributed multimedia material, such as that represented by distance education. This agent technology avoids unnecessary networking delays, cope the bandwidth limitation and adapt the representations to students, based on the student performance.

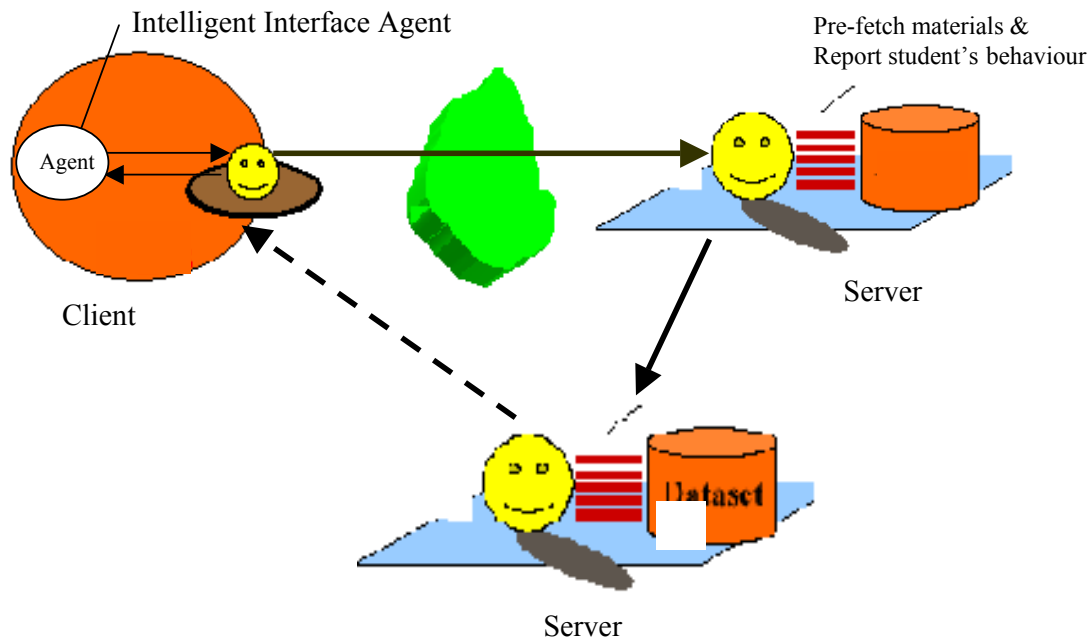


Figure 3: Scenario of mobile agent moving around distributed systems

- In terms of mobile users, portable-computing devices such as laptops, palmtops, and electronic books will access mobile learning environments. These devices have unreliable, low-bandwidth, high-latency telephone or wireless network connections. Mobile agents will be essential tool for allowing such access.
- Mobile agents offer application developers a new programming paradigm with higher-level abstraction and unified “process” and “object”. In terms of scalability of system and easy authoring, these features of mobile agents offer a flexible and effective philosophy on learning environment development, design, and scalability.
- In the future, mobile learning environments can share resources through different systems, as shown in figure 3. Both the computers and networks on which mobile learning systems are built are also heterogeneous in character. As mobile agent systems are generally computer and network independent, they support distributed systems and resources sharing.

DESIGN WITH MOBILE AGENT

Figure 4 shows the architecture of using mobile agent technology to implement the system.

In high-level view, basically mobile agent interacts with client side inference engine to pick up the data. Then mobile agent moves to host (or server) side. At host side, mobile agent performs all the processes needed, such as updating the database, and interacting with database if required. After mobile agent finishes all the tasks at the host side, it gathers all information it needs, and returns to the client side. Then it updates the client side. In addition, mobile agent approach can work in intermittent connectivity between client and host because mobile agent can be dispatched and it can work autonomously even if the sender is not available any more.

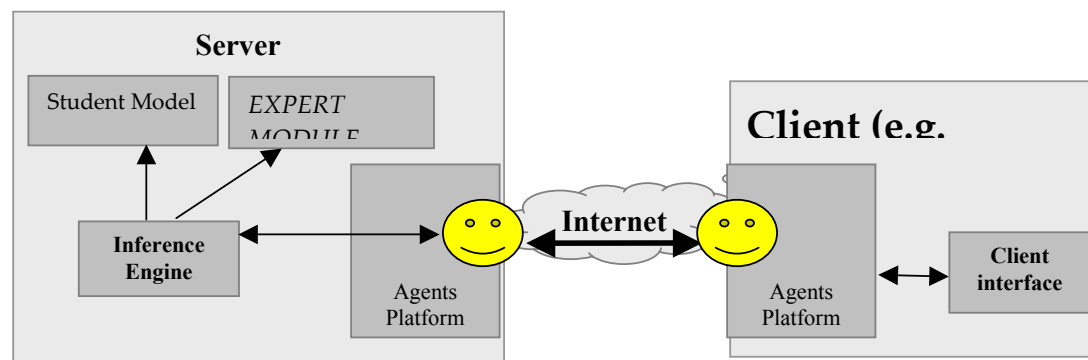


Figure 4: Architecture of mobile learning environments using mobile agents

IMPLEMENTATION BY USING BEE-GENT FRAMEWORK

The Bee-gent framework is used to implement the mobile agents in the system. Bee-gent technology was first released in 1999 by Toshiba (Toshiba, 2003), as a new type of pure agent development framework for the advanced network society. Its communication framework is based on the multi-agent model. The Bee-gent framework is comprised of two types of agents: agent wrappers and mediation agents.

- Agent Wrappers are used to agentify existing applications. The agent wrappers manage the states of the applications, which are wrapped around, and invoke the applications when necessary.
- Mediation Agents support inter-application co-ordination by handling all communications among applications. The mediation agents move from the site of an application to another where they interact with the remote agent wrappers.

The wrapper agents are used to wrap the client and server side systems, and the mediation agents are used to perform the communication and exchange information with the wrapper agents. Figure 5 presents how the Bee-gent is used to implement mobile agents in our system. The main process scenarios within the system are as follows.

- A. At the server side, the inference engine interacts with the student model and expert module through the database interface. If something needs to be sent to the clients, the inference engine notices the wrapper agent with the information that needs to be sent. The wrapper agent creates a mediation agent carrying the information and related program, and launches the mediation agent. If the mediation agent cannot find the target clients, it notifies back the failure and continues the attempts to reach to the target. If the mediation agent reaches the target client, it communicates and exchanges information with the client's wrapper agent and updates the client side.
- B. At the client side, if a request needs to be sent to the server, the client side will notify the client side agent wrapper, and the agent wrapper will create a mediation agent that is able to carry information to the server.

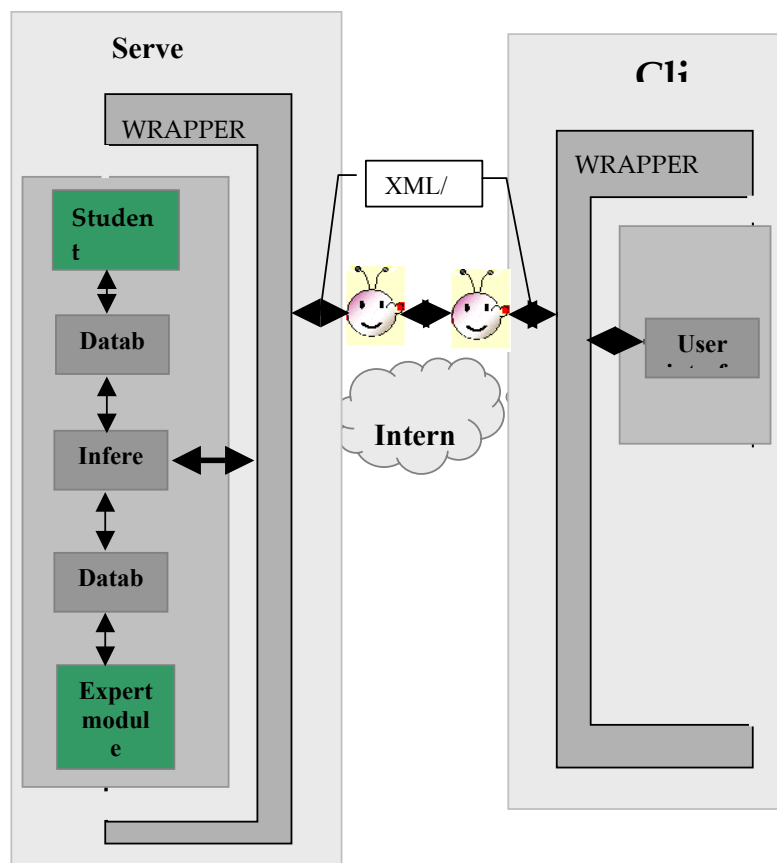


Figure 5: Architecture of using Bee-gent

Figure 5 presents the processes, which happen between client and server. The basic control flow is described below.

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If    the client agent wrapper get notice to send a request
Then the agent wrapper creates and launches a medication agent with the request

    If    the connection is off
        Then keep trying to send the medication agent
        Elseif server is found
            Then notice inference to communicate with the student model or
                expert module to get information or update relevant data
            If any feedback needs to send to client
                Then the server side agent wrapper creates and launches a
                    medication agent with the feedback
                If the client is offline
                    Then keep trying
                    Elseif present the feedback to the client
                End If
            End If
        End If
    End If
End If
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CONCLUSION

The approach that is suggested in this paper supports the use of different end-user devices: with the increasing population of “users on the road”, alternative end-user devices, such as mobile phones and personal digital assistants are getting popular and research has started to focus on their use in the web-based education. These alternative devices usually have unreliable, low-bandwidth, and high-latency

network connections. The use of mobile agents, which have migrate-and-disconnect style of operations, has a lot of appeal in such situations. The mobile agent technologies provide an attractive alternative to implement and improve mobile learning environments. However, a number of research issues are still to be resolved. For example, besides building mobile agent, we also have to provide environment for mobile agent. Although some mobile agent systems, such as Bee-gent, come with wrappers, they are still quite limited. But we hope, mobile agent technology will open a new interesting research area in the mobile learning environment.

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