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MOBILE AGENTS, MOBILE COMPUTING AND MOBILE USERS IN GLOBAL E-COMMERCE

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ABSTRACT

Mobile agents may reside in a host or client computer, and can also roam other computers, networks or the Internet to execute their tasks. In this paper, we will examine the implications of mobility in three aspects: mobile code, mobile hardware and mobile users. The impact of mobility on electronic commerce in the areas of security issues, export controls, legal jurisdiction, taxation and international issues is also analyzed. Mobile agent technologies and mobile computers will play an important role in the new cyberspace economy, however many issues need to be addressed before the technology can be fully implemented.

INTRODUCTION

The Internet is now the main communication platform in the new digital society. Internet communications are efficient and low cost. The Internet and electronic commerce activities involve multinational sourcing of information and both have helped stimulate the flow of information across international borders in recent years. The architecture of the Internet is based on the principle of geographic indeterminacy. The mobile agent model seems to provide one of the most suitable technologies for distributed systems in order to integrate the Internet in a synergetic way (Corradi et. al. 1998). Mobile agents may reside in a host or client computer, and can also roam other computers, networks or the Internet to execute their tasks. In this paper, we will examine the implications of mobility in three aspects: mobile code, mobile hardware and mobile users. The impact of mobility on electronic commerce in the areas of security issues, export controls, legal jurisdiction, taxation and international issues is also analyzed.

THE MOBILITY CONCEPT

Tolksdorf (1999) applies the notion of mobility to different classes of entities in information systems. He distinguishes passive versus mobile information, active versus mobile agents, and the concept of mobile human users. We can distinguish between three categories of mobility: hardware mobility, software mobility and user mobility.

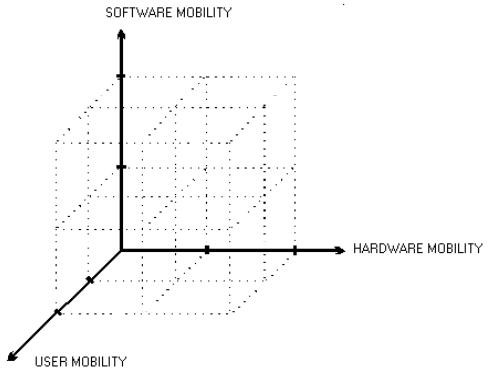
Mobile hardware: Mobile computing provides the ability to connect to the Internet and have access to a variety of resources while away from the home base. Examples of computers that are often disconnected from the network are: mobile computers, laptops, personal digital assistants, and modem-connected computers.

Mobile users: In this highly computerized era, users are highly mobile and relatively more transient. Hence, there is a need to manage the infrastructure so that remote users can access needed resources in order to accomplish their jobs (Murch and Johnson 1999).

Telecommuting is becoming more widespread as a growing percentage of employees are working from home. This convenience is made possible by using dial-up lines and telecommunication links. Both mobile networking and mobile agents facilitate another work modality that can be called “mobile working”. Mobile working has grown significantly thanks to the widespread adoption of laptop computers and mobile phones, especially among salespeople. (Australia 2000).

Mobile software: Mobile agent technology introduces the notion of moving an active entity over spatially different places. Systems may combine static agents with mobile agents (Kearney 1998). Mobile computing has been already very successful, and mobile agents are now revealing that software can also be mobile.

We can use the three dimensions of mobile/static computers, mobile/static software and mobile/static users to plot a three-dimensional matrix. Different applications can be differentiated in this basic classification matrix based on the criteria of computers, software and users.



Personal computers, mainframes and computing centers are examples of static computing environments. The following table describes sample scenarios combining the three dimensions.

Hardware	Software	User	Sample Scenario
Static	Static	Static	A PC user at home.
Static	Static	Mobile	A User at the Computer center.
Static	Mobile (Agents)	Static	A user launching Mobile agents at the Computer center
Static	Mobile (Agents)	Mobile	A user launching agent from several static computers
Mobile	Static	Mobile	A salesperson using a laptop with office software.
Mobile	Mobile (Agents)	Mobile	The optimum configuration

MOBILE AGENTS

The mobile agents metaphor is analogous to how most people conduct business in daily activities, visit a place, use a service, perform a task, and finally move on (Johansen et. al. 1998). In addition, mobile agents are applications that can move through a

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network carrying out a given task on behalf of the user. According to Nwana and Ndumu (1998), a mobile agent can roam wide area networks (WANs) such as the World Wide Web. Mobile agents interact with foreign hosts, performing tasks on behalf of their users and subsequently return to the original computer after achieving the goals.

According to Chen (2000) mobile agents can provide ubiquitous access to information, data, and applications. Ubiquitous access refers to the ability of users to access these computing resources from almost any terminal. This ubiquitous access is made possible by the latest Internet developments and the development of cross-platform languages, such as Java. Java can be used for the deployment of applications that can be executed across multiple platforms and networks.

MOBILE AGENT APPLICATIONS

Some examples of mobile agents are Telescript (White 1997), developed by General Magic, D'Agents (Brewington et. al. 1999) designed at Dartmouth, IBM's Aglets, Grasshopper and Mobiware.

Gehmeyr et. al. (1998) propose the combination of the use of mobile agent techniques for information retrieval. Mobile agents are also useful for the implementation of information gathering systems exploring the World Wide Web (Hanachi et. al. 1999). A serious problem with search services is the amount of network traffic they generate. Mobile agents can be used to reduce network load when searching information in the Web. Mobile agents can encapsulate the filtering function and perform the filter process at the respective data server locally (Theilmann and Rothermel 1999). Mobile agents could be used to enforce copyright protection laws. An agent could roam servers and sweep through the server files to find copies of copyrighted material (Murch and Johnson 1999).

MOBILE AGENTS IN E-COMMERCE

Mobile agents can be the best medium to conduct e-commerce transactions in a mobile computing scenario. In a mobile computing scenario, browsing an on-line catalog can be extremely expensive, given the high-priced wireless channels. However, the consumer can send a mobile agent out as both a broker and negotiator, and subsequently disconnect, and later reconnect to obtain the results.

Wang, Lam and Yi (1998) have proposed the use of mobile agents for e-commerce brokering, negotiation and payment. Current payment mechanisms like SET require the user to be connected to the Internet during the purchase transaction. This requirement might be costly when using cellular connections and mobile computers. The high cost of connection charges can also become an obstacle for electronic commerce purchases. Romao and Mira da Silva (1998) have proposed the alternate SET/A payment mechanism based on mobile agents, in which the cardholder can send a request, disconnect and later reconnect to receive the response from the merchant. The user can save his or her mobile computer battery, and costly network connection costs. Instead of using the user's computing resources, a mobile agent can consume service providers' resources (Plu 1998). After the user's mobile computer or PDA is turned off, the agent should move to a host that it is on-line (Huhns and Singh 1998).

A mobile agent could be sent out on behalf of its owner to find information. However the information may not be freely available, and a payment may be required. The solution would be a mobile agent equipped with electronic commerce capabilities (Vogler et. al. 1998). The agent would be an autonomous entity in the electronic marketplace, with the ability to search for a product or service, compare prices, negotiate and deal with payment mechanisms.

MOBILE COMPUTING AND WIRELESS NETWORKS

Nowadays, it is vital to be able to be active regardless of the geographic location, and this need has been fulfilled by wireless and cellular technology. In recent years, PDAs, laptop computers and communicator devices are providing a convenient platform for e-commerce transactions. Communicators are the next generation of cellular phones which include functionality of PDAs and palmtop computers such as e-mail, web browsing, and scheduling (Singh et. al. 1999).

Mobile agents are particularly useful in mobile-computing environments that need to deal with low-bandwidth, high latency, and unreliable network links. An agent can continue interaction with a resource or user even if the network connections go down temporarily (Brewington et. al. 1999). A mobile agent can travel in the Internet and retrieve information on behalf of a consumer. Later on, the mobile agent can return to the user's laptop and report the results when the laptop is reconnected to the network (Zhang 1999).

Mobile devices have low-bandwidth, high latency and high cost connections (Wang, Lam and Yi 1998). In addition, mobile computers have limited storage and processing capacity. A mobile agent can perform information retrieval, filtering and processing activities at a server, and return only the relevant (and reduced) information (Chess et. al. 1995) This approach can significantly decrease the volume of data handled by the mobile computer connection. Gray et. al. (2000) define mobile agents as programs that can move through a network under their own control, migrating from host to host and interacting with both other agents and resources on each host.

MOBILITY AND SECURITY ISSUES

Agent mobility might create security concerns. Unreliable agents may visit or request information from a system. Some server administrators will want to prevent agents to visit their web sites and use special software to block their entry (Murch and Johnson 1999). A malicious mobile agent could attack a server, and on the other hand, a malicious server can delete a mobile agent, or modify it so it produces abnormal results (Huhns and Singh 1998). The first security problem is easier to overcome, however, in the second case, in order to be executed the agent has to open both its code and data to the server and be exposed to alteration.

MOBILITY AND LEGAL JURISDICTION

Jurisdiction is a legal term for the restriction on the ability of a court to resolve disputes. According to this definition, companies (or individuals) from foreign countries can be sued in a U.S. court if the organization has had some minimum contacts with the U.S. Electronic actions through the Internet such as sending an e-mail, downloading data, or executing a mobile agent might satisfy the minimum contact requirement. The reverse situation might also be true: U.S. citizens may be sued in foreign courts with a similar minimum contact requirement for on-line activities (Perritt, 1996).

Typically, states' jurisdictional limits are related to geography. However, geography is a virtually meaningless construct on the new e-commerce marketplace. Distance and geographic location are irrelevant for the capabilities of the electronic marketplace (Reidenberg 1998). Data input, data processing, and data storage may take place at very different locations.

In mobile code systems, programs may come from unknown or unreliable sources. Current cyberlaw treats a program as an extension of the user or programmer; however, this assumption may not be true for mobile agent systems. Determining responsibility

for data protection is very complex given the open nature of the distributed architecture of the Internet.

A mobile agent could be used to collect private information located in multiple sources and consolidate it. A single sequential operation might involve cross-border data flows. Notice that in a mobile code scenario, the owner of the hardware, the user of a program, and the author of the software can be all distinct entities, possibly at different nations under distinct security regulations (Tschudin 1999). The activity of a mobile agent with access, collection and processing in several countries simultaneously offer many nations prescriptive jurisdiction in order to define the terms and conditions of fair information practices (Fordham 2000)

It is likely that companies and individuals might try to evade the jurisdiction of one nation by using mobile agents and mobile computers to relocate information and services to another nation. The Internet network architecture certainly blurs the meaning of the concept of "border". Jurisdiction may be an anachronism in a borderless world where time and distance have little meaning (Katsh, 1995).

Kitamura et. al. (1999) have proposed that one way to deal with this dilemma is to create virtual "places" for electronic communication on the Internet. In this Place-oriented communication model, an agent is authenticated before it is allowed to enter a virtual meeting place. This approach provides a meaningful model for agent authentication and the creation of virtual communities.

MOBILITY AND DATA EXPORT CONTROLS

The objective of export control implementations is to protect national security and avoid the unregulated dissemination of certain sophisticated encryption technologies. Given the existing barriers on the export of intangibles, people may try to circumvent controls by using mobile technology or mobile agents. One may try to embedded encryption technology inside an intelligent agent, or in the case of equipment, as part of a mobile computing device. Because mobile software and equipment traverse from one location to another, this equipment might be used for transferring controlled technologies (Bohm, Brown and Gladman 2000).

A mobile agent can be used to overcome limitations on cross-border data transfers. By moving to the location of an information resource, a mobile agent can search the resource locally, eliminating the network transfer of data (Brewington at. al. 1999). Hence, instead of bringing data into an application, one can send the application (the mobile agent) to process data at the resource, and subsequently return with consolidated results that are not the same as the primary data. As a result, we are not exporting private primary data (which is not allowed), but the results obtained by running the mobile agent (which is considered conglomerated or derived data). We are moving the computation (agent) to the data, rather than the data to the computation. The agent will filter the data it reads. Hence there is almost no need to transmit raw data from one site to another, and therefore cross-border data flows can be kept to a minimum (Johansen 1998). Using a mobile agent is very useful when moving the data is often not feasible or difficult, moving the computation to the data with a mobile agent is a convenient and efficient alternative (Rus et. al. 1997).

Just as mobile agents can be used to circumvent security controls they can also be used to help implement data export controls. Tschudin (1999) describes how a database owner can offer a flexible interface without losing control over the amount and type of data that is exported. Mobile agents can be allowed to freely browse the full database content, but they would be prevented to leave the server, and would be terminated after the agent had obtained its results. These results could be transformed by the host into a query result and sent back to the client.

MOBILITY AND TAXATION

The application of current tax regulation to e-commerce is very difficult. In the United States, a state can assess sales taxes on a company when the company establishes "nexus" in the state. Nexus is a concept of physical location; therefore a company must have a branch in the state in order to pass the nexus test. Nexus is the most important issue of taxation relating to e-commerce (Castellucio 1996).

Hellerstein (1997) states, "To ask about the 'location' of e-commerce is to ask a question that is not worth answering", whereas Posch (1997) asserts that, "Electronic commerce has dissolved the linkage between an income producing activity and geographic boundaries"

Mobile agents could be used to evade taxes. Both Weiner (1997) and Fox and Murray (1997) point out that e-commerce capital is much more mobile than other forms and is highly sensitive to tax differentials. Taxpayer compliance in electronic commerce transaction may be really difficult. Tax rates vary by state, and some companies or consumers may utilize mobile agents to evade taxes. A mobile agent may be sent to a host computer at another location where tax rates are lower or even avoid paying state sales taxes altogether.

The U.S. Department of Treasury is specifically concerned about the following e-commerce mechanisms: electronic money, identity verification, record keeping and integrity, and disintermediation (Levey, O'Donnell & Powers). Esser (1997) raises the concern that inappropriate Internet tax regulations might reduce the volume of collected taxes, and subsequently reduce the available state resources for safety, health and education services.

MOBILITY AND INTERNATIONAL ISSUES

Individual consumers are now able to buy across national borders without even leaving their own country. If a dispute arises, there are not many applicable laws for international arbitration of a consumer's dispute with a merchant. Kido (1999) describes several potential cross-cultural issues in the cooperation of agents and humans in a global network. These issues include language differences, differences in human-computer interaction, negotiation strategies depending on the culture, the importance of culture-adaptive web sites. Because mobile agents may interact with users or users' agents in diverse cultures, they should be customized to deal with different negotiation strategies or languages depending on the culture.

CONCLUSIONS

Mobile agents have several characteristics, which can be applied, in mobile wide area network architectures and in several aspects of electronic commerce. Mobile agent technologies and mobile computers will play an important role in the new cyberspace economy, however many issues need to be addressed before the technology can be fully implemented.

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