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Mobile Agents for Distributed Processing of Electronic Records Archives

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Abstract

Distributive processing of electronic records archives (ERA) could be a niche for mobile agents to outrival established client-server network computing methods. Archival records are usually very large computer files that consume a large bandwidth when they are transferred from one networked computer to another. This paper describes an ideational ERA distributive processing scenario in which advantages of using mobile agents or knowledgeable objects could outweigh disadvantages and overcome some of the hurdles that are facing mobile agents.

Keywords: mobile agents, knowledgeable objects, electronic records archives, distributed processing.

1. Introduction

Mobile agents are software programs that can move themselves from one networked computer to another. Agents are "intelligent" software programs that can be trusted by their users to perform a specific task on a certain type of data. The mobility of an agent enables more flexible uses of agents in mutually trusted network environments. Mobile agents can reduce network overload, overcome network latency, and encapsulate protocols; they also execute asynchronously and autonomously, adapt dynamically, run independently of system software and hardware architecture, and react dynamically to unfavorable situations [1].

Electronic records archives (ERA) are ordered collections of related computer files containing credible evidence of past actions and the participants. Examples of ERA include records of a student's academic performance and personal information, business transactions, and government actions affecting its citizens. Government-generated electronic records are irreplaceable, and therefore, their contents, structure, and context must be authentically and persistently preserved [2]. The term *archives* presented in this paper means unprocessed sensitive archival records. An unprocessed archive refers to a very large computer file (e.g., a *tar* or *jar* file) containing every file residing in a directory, a disk partition, or even a whole disk drive. The stakeholders of the archives consider them sensitive because the archives might contain privileged information. Successful attacks against the confidentiality and the integrity of the archives would hamper the operation of the responsible organizations and deprive future uses of historical events, respectively.

When these sensitive archives are placed on a Web portal for distributive processing, their impact on shared communications channels must be considered besides security concerns. The main purpose of this paper is to suggest the use of mobile agents to minimize the communications costs on shared public channels.

The next section briefly describes distributed ERA processing and presents a hypothetical processing scenario in which the performance of mobile agents could outrival other network computing paradigms. Section 3 addresses some major impeding reasons for the slow adoption of mobile agents. The last section summarizes key ideas and concludes the paper.

2. Distributed ERA Processing

Distributed processing of unprocessed sensitive archival records requires a network of computers and involves a centralized server environment in which raw archival files reside

and from which the files are downloaded to the computers of geographically distant researchers for processing.

The processing of the raw archives mainly consists of searching for types of files, categorizing the types of files and records, and reducing the sizes of the archives. The search might include scanning all the readable embedded documents within an archive to determine whether any of them was a classified document that needs to be in a more secured place than in Web portal.

The categorization of embedded files identifies and determines whether an embedded file is a system file of a particular operating system, an executable file capable of running in a specific environment, a binary file, an e-mail message, a temporary file, or a database and its associated database management system, for example.

The reduction of ERA sizes is accomplished by filtering and eliminating redundancies, unwanted or damaged files, duplicates, and replaceable files (e.g., system files or commercially available files).

The above three main ERA (pre)processing tasks could be accomplished by at least two different methods in a network environment: client-server method or mobile-agent method. The client-server method involves the use of a traditional network tool capable of downloading an archive to a local computer for processing using an appropriate computer program. The mobile-agent method could require the breaking down of the main data processing tasks into smaller and specific subtasks, each of which could be handled by a Java-based mobile agent such as an Aglet™ [1] or a knowledgeable object [3].

The knowledgeable object (KO) approach is a relatively novel, fine-grained approach that was first proposed by Pham and Ye [3] to handle complex heterogeneous data at the lowest level by representing each type of raw data by a KO, which is a light-weight and simple autonomous agent. In their paper, Pham and Ye also delineated seven issues with which must be dealt to build a fully automated business system. These issues include (i) interface automation, (ii) data automation, (iii) analysis automation, (iv) demand-supply automation, (v) transaction automation, (vi) implementation automation, and (vii) workflow automation [3]. The ERA processing scenario using mobile agents also signifies an example of a business automation in which the discussed mobile agents deal with the two issues in a fully automated business system: data automation and analysis automation.

The next paragraphs provide an example of a distributed ERA processing scenario using two comparative network computing methods that were described in the above paragraphs.

Using a traditional network tool such as a Web browser or an *ftp* tool operating in secure mode (Figure 1), a hypothetical scenario of an ERA processing involves five main steps:

- Downloading an index file.
- Selecting an archival file of interest.
- Downloading the interested file from the portal.
- Saving, and then processing the downloaded file.
- Uploading the processed file to the portal.

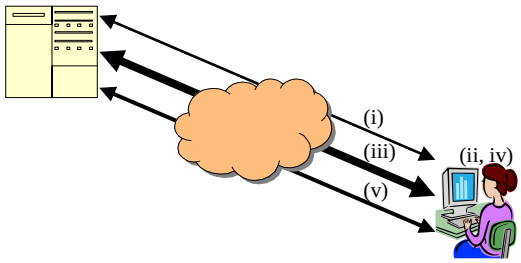

Figure 1. ERA processing using client/server method: (i) downloading the index file from the server, (ii) manually selecting an archival file of interest, (iii) downloading the archive of interest, (iv) locally processing the downloaded archive, and (v) uploading the processed file. Steps (i), (iii), and (v) require two-way interactions with the portal.

Using mobile agents (Figure 2), a hypothetical scenario of an ERA processing consists of the following steps:

- Downloading an index file.
- Specifying a list of criteria for selecting and processing an archival file of interest for an agent complete at the portal.
- Dispatching an agent to the portal to process the file of interest.

- Completing the assigned tasks at the portal by the dispatched agent.
- Receiving and studying the processing results brought back by the returning agent.

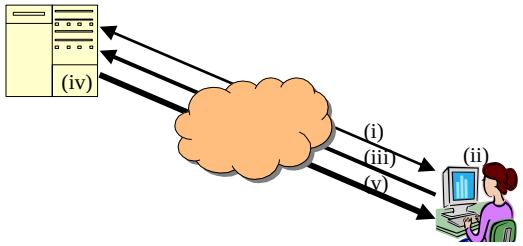

Figure 2. ERA processing using mobile agent method: (i) downloading the index file from the server, (ii) specifying a list of tasks for an agent, (iii) dispatching the agent to the portal for processing the archive of interest, (iv) remote processing at the portal, (v) returning agent with the processing results. The user interacts with the portal in step (i) and interacts with an agent in step (ii).

The following paragraphs estimate the total sizes of data transmitted in a shared communications channel using the two previous methods. Let

U = the size of a raw archival file (e.g., 1 GB)
P = the size of a processed file (½ S = .5 GB)
M = the size of a mobile agent (.01 GB)
R = the size of the agent-generated results (.1 GB)
T_1 = the total size of data transmitted using a Web browser or an *ftp* command
T_2 = the total size of data transmitted using agents (e.g., Aglets™).

Then

$T_1 = U + P$ = 1.50 GB
$T_2 = M + (M + R)$ = .12 GB

The calculations of T_1 and T_2 exclude the sizes of the overhead data transmitted between the two computers in the beginning and in the end of each communication session because they are negligible when comparing them with the sizes of the archives.

The above example uses probable sizes of ERA and simple calculations to show the benefits of using mobile agents to reduce network overload; however, mobile agents might not be suitable for the network applications (i) involving the transfer of shorter sizes of data files, (ii) requiring special security, and (iii) operating in a large public network (e.g., the Internet). Short sizes of archival data files imply $T_1 <= T_2$ or equivalently, *sizeof(U+P) <= sizeof(2M+R)*. Using mobile agents for this particular application could consume more network resources than competing network computing paradigm (e.g., client-server).

Special security requirements refer to a large scale implementation of extensive and complex security measures in an un-trusted, public network. The measures include the establishment of mutual authentication and authorization among visiting mobile agents and the visited hosts and the deployment of defensive technologies, methods, and techniques to protect and secure the integrity of mobile agents and their execution environments.

Running mobile agents in large public networks requires that all participating hosts have the same mobile agent execution environments for interoperability purposes. This requirement is obviously difficult to convince the various stakeholders of the connected hosts to deploy the same technology.

This section provided an example of a distributed ERA processing scenario highlighting the benefits of mobile agents and presented three possible scenarios de-emphasizing the use of mobile agents. The next section summarizes the related reasons that deter the use of mobile agents and provide references to previous studies and experiences about mobile agents in the Internet.

3. Unhurried Adoption of Mobile Agents

A mixture of security concerns, performance problems, and available alternative methods contribute to the slow adoption of mobile agents. Various mobile agent frameworks designed for the Internet have existed for about a decade, but they are still struggling to find a place in the Internet to thrive. Mobile agents so far only find themselves useful in experimental applications running in the laboratories of universities, private industries, and government research entities; in fact, the distributed ERA processing work is also an experimental project. The Internet still has not had many Internet sites that would be capable and

willing to host mobile agents as envisioned by Kotz and Gray in 1999 [4].

Major impeding reasons for using and hosting mobile agents on the Internet include performance problems, security concerns, lack of a ubiquitous infrastructure, lack of a shared language [5], lack of a compelling application, and the shortcomings of the security services available in the Java environment [6].

These negative statements about mobile agents are generally true, but they should not deter the use of mobile agents in the distributed ERA project because (1) mobile agents are capable of reducing network traffic in shared communication channels and (2) the ERA processing environment is a small and trusted distributed environment.

Potentially reduced consumption of shared network resources can be realized by sending mobile agents to the location where very large archival files reside instead of using stationary agents and applications that require the transfer of large archives over a shared network.

A small and secured network environment is relatively easier to set up and maintain than a larger one. The distributed ERA environment is built mainly to serve a small group of ERA researchers and administrators. Such a small network requires only one or two ERA portals, and therefore, a homogeneous mobile agent execution environment can be easily deployed in all ERA portals and all the participating networked computers. The distributed ERA processing environment is also envisioned to be accomplished in a secured and trusted environment for which all basic information assurance services (integrity, confidentiality, availability, authentication, non-repudiation) will be provided [7].

4. Summary and Conclusion

This paper has presented a suppositional distributed processing challenge for which mobile agents could be well suited because they could substantially reduce network overload. The potential benefits of using mobile agents can still be realized in this particular distributed ERA processing scenario because the environment is small and trusted. A small network environment facilitates the deployment of a homogeneous mobile agent infrastructure and the implementation of defensive security products capable of providing reasonable information assurance services.

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Disclaimer

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