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Mobile Agents for an Electronic Marketplace

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Abstract: The mobile agent (MA) paradigm has garnered a significant amount of interest over the course of the recent past few years. In spite of the fact that MAs have been the source of a substantial amount of enthusiasm in the academic community, they have not yet produced a significant number of applications in the real world. One of the most important reasons for this is that there is a dearth of research that quantitatively compares and contrasts the efficacy of conventional methods with that of mobile agents. The study presents an implementation of an e-commerce application that makes use of mobile agents and makes a contribution to such an assessment. The current mobile agent apps that are used in the field of e-commerce are categorized, and the underlying mobility patterns are uncovered. These, in turn, establish a number of different implementation options that make use of the conventional client-server and mobile agent paradigms. This paper outlines the implementation method that should be used when integrating mobile agents into an electronic marketplace. Mobile agent may boost e-commerce and give new approaches for designing intelligent applications. The fundamental elements of e-commerce agents are their autonomy, their flexibility, their capacities to observe, analyze, and act in their encompassing surroundings, as well as the power to interact with other mobile agents to solve complicated issues. The autonomy of agents implies the adaptation to participate in conversations governed by processes not known in advance, while their mobility means such discussions taking place at distant places. This work attempts at integrating adaptability with mobility by explaining the mobile agents emerging in the system and their fundamental interactions. Furthermore, this study explains the reasons why utilization of mobile agents inside the recommended framework.

Keywords: Asymmetric algorithm, Coordinating server, Digital signature, Hash function, Mobile agents, RSA, Symmetric algorithm, Trusted server.

I. Introduction

Computer systems have effectively progressed over time from centrally located monolithic computing units enabling stationary programs to client-server setups that enable sophisticated distributed computing models. The early remote job input terminals used to submit programs to a central computer and the most recent Java applets downloaded from web servers into browsers are examples of limited types of code mobility that have happened throughout this progression. In order to create a massive, loosely connected distributed system, cooperative programs may now move completely across supported platforms in a new phase of development that goes one step further. It remained to be seen if this developmental branch succeeds in moving ahead or finally disappears. However, the technology is interesting and presents a novel computer framework that cannot be easily ignored.

Mobile software agents—programs with a specific aim and the ability to move from one platform where they are suspended to another platform where they restart execution—are the driving forces behind this evolutionary route. A software agent, more specifically, is a program that has the ability to act on behalf of a person or group of people, operate independently to accomplish a task, and communicate with other agents. Auctions, trading, and contract and service negotiation are examples of possible interactions between agents. Agents may either be mobile, able to move between platforms at various periods, or immobile, constantly residing on a single platform. This essay primarily focuses on the security concerns that occur when mobility is involved.

The potential changes of moving code and state information, such as the values of instance variables, the program counter, the execution stack, etc., correspond to a spectrum of varying mobility [1]. A basic agent created as a Java applet, for instance [2], has code mobility thanks to the transfer of class files from a web server to a browser. However, no information on the linked state is given. The Java-based Aglets [3], created by IBM Japan, enable the values of instance variables to be transferred with the code when the agent moves, but not the program counter or execution stack. [4] Created Sumatra that enables Java threads to be carried together with the agent's code during relocation. This provides a more robust kind of mobility than previous methods. Within the mobile agent systems that are the subject of this study, the transfer of code and state information is required.

The proliferation of the World Wide Web (WWW) and the development of applications for electronic commerce (e-commerce) have led to the birth of new business models that are based on the internet. E-commerce being supported has resulted in a need for novel application structure methods that may produce models that are both cost-effective and scalable. These models may be delivered as a consequence of the demand

for innovative application structure approaches. The use of agents in online commerce is, more than any other possibility, the one that has the potential to be the most successful. Applications for electronic commerce make extensive use of the idea of an agent to do a substantial percentage of the work. Agents, which may be thought of as bits of code that carry out activities on behalf of users, are responsible for the bulk of the work, but not all of it. The inclusion of mobile agents into the design of e-commerce application software has only received a modest level of attention so far due to the small amount of work that has been put into it. When it comes to online commerce, it is very important to maintain a clear distinction between traditional agents and mobile agents. As a result, client-server ecosystems have given way to mobile agent systems that make use of a wide variety of distributed computing techniques throughout the course of recent years in the evolution of electronic commerce. In order to construct a large-scale distributed system that is only loosely connected, mobile agents provide the complete mobility of applications that are cooperating across all supported platforms. Mobile agents are goal-oriented and competent software programs that are able to pause execution on one platform and resume operation on another. Mobile agents can also transfer data across platforms. To be more explicit, a mobile agent is able to move freely between different systems and autonomously carry out tasks on behalf of a customer. To put it another way, mobile agents acquire the ability to function autonomously toward the achievement of a goal and to interact with other mobile agents. Agents may either be static, in which case they are confined to a single platform, or dynamic, in which case they are free to roam around between multiple platforms at varying periods.

Mobile agents are also called transportable agents. They are categorized into two types:

- Mobile Agents having a pre-defined route: They have a static migration path.
- Mobile Agents having unknown pathways, i.e., Roamers, have dynamic migration paths. The mobile agents pick their course according to the existing network circumstances.

The pre-defined trajectories of the mobile agents are taken into consideration in this research. When a mobile agent is equipped with capabilities for e-commerce, it is very necessary to take precautions to prevent the agent from being misplaced or duplicated along its journey. Therefore, the development of a dependable, fault-tolerant, and secure agent transfer mechanism that guarantees the performance of mobile agent duties for electronic commerce was the primary objective of the framework's design.

The arrangement of the paper's remaining sections will go as follows, starting with the introduction: The impetus for doing this study is discussed in Section II, which examines the development of mobile agents that assist e-commerce platforms throughout the course of the last ten years. In the next part (Section III), we will explore the suggested framework for the MA navigation of the electronic marketplace. In the Section IV, a more in-depth discussion on the advantages of making use of the suggested framework is presented. The findings of the study are reported in Section V, followed by a discussion of those findings.

II. Literature Review

There has been a significant amount of research conducted in the past about the integration of mobile agents with e-commerce. The section outlines the chronological path of the research on the emergence of mobile agents. [5] stated that distributed systems are increasingly incorporating mobile software agents. Mobile agents could be used for electronic commerce and information retrieval. The most difficult aspect of the issue to resolve is attacks on agents by malicious hosts.

[6] claimed that the broad usage of mobile agents is still hampered by security-related problems, particularly integrity protection in mobile agent technology. The integrity of mobile agents should be guarded against intrusions from malicious hosts and other agents. The authors advocate the usage of dynamically upgradeable agent code as opposed to the conventional belief that mobile agents are made up of invariant code components. Secure mobile agent systems (SMAS), which involve communication between mobile agents and mobile agent servers, were the subject of a research by [7]. The authors suggested that a security shell module in the framework for mobile agents be in charge of mobile agent security. [8] mentioned that in order to support agent-based applications, a fresh distributed reputation management system was proposed. The system assesses the reputation of dependable third-party hosts in real-time using a transaction feedback mechanism. [9] stated that mobile agent systems' main characteristics are intelligence, autonomy, and mobility. The integrity of mobile agents should be guarded against intrusions from malicious hosts and other agents. The authors introduced the Flexible Mobile Agents (FMA), which are made up of flexibly upgradeable agent code portions, allowing for the addition of new agent code modules as well as the deletion of unnecessary code modules based on the needs of the application being executed. The trustworthy server was used by [10] as the intermediary between mobile agents and ecosystem nodes. The authors noted that the trusted server, which manages the security mechanism, controls the system's security. [11] mentioned that the security flaws in mobile agent systems have embarrassed their widespread use. Because the distant hosts that house the mobile agents launch various attacks, mobile agents that move throughout the network are not secure. So the most difficult unsolved issue is mobile agent security. [12] stated that mobile agent security is a key consideration in the design of mobile agent-based e-marketplaces. The system is created to offer a secure and reliable trading environment based on the defined and outlined needs and evaluation criteria. [13] claimed that the

use of mobile agent technology in distributed real-time systems has changed the paradigm. One of the most significant areas of use for mobile agent technology is electronic commerce. A business or firm can use e-commerce and mobile commerce to expand its market to any location. [14] mentioned that the security of mobile agents is a crucial concern in the majority of applications. Mobile agents must be ready to run on various hosts under a variety of security settings. A review of current methods for creating a mobile agent that can defend itself is provided in this study, though the study did not propose the new models for mobile agent's security. [15] mentioned that mobile agents are protected by both recognition and preventive methods. While identification methods are used to look into potential security violations, prevention mechanisms refer to the protection of mobile agents. Code modifications are used to obfuscate the code, making it extremely difficult to analyze and protecting it from reverse engineering. According to [16], a lot of infrastructure support is required for the security of mobile agents, including security, trust, and agent matching protocols. [17] Mobile agents can be used in a variety of contexts, including network administration, electronic commerce, and information retrieval. Security is the biggest issue with mobile agents. This thesis focuses on the ability of mobile agents to make secure purchases. [18] provided a forward-secure undetectable digital signature concept (FS-UDS). Mobile agents who generate digital signatures under the proposed approach are not required to carry the signing key. The necessity of the original signer is combined with the encrypted function at the same time. [19] stated that the total amount of computing time required to confirm the legitimacy of the users might be decreased by using an anonymous authentication technique. Our suggested anonymous authentication method offers greater security and efficiency in terms of calculation cost as compared to earlier anonymous authentication methods. [20] mentioned that when generating digital signatures under the method, mobile agents are not required to carry the private key. The original signer's requirements are merged with the encrypted function to avoid abuse of the signing algorithm. [21] stated that due to their potential to replace conventional client-server applications, mobile agents are attracting academic interest. The authors stated that a mobile agent can migrate independently from one server to another. Network administration, information retrieval, and electronic commerce are among applications that benefit from mobile agents. [22] mentioned that commercial transactions between businesses and customers raise serious issues since they involve a lot of data and sophisticated information. An agent-based analysis of e-payment transactions and associated switching activities is presented in this work.

The scope of the review included relevant research publications published between the years 2000 and 2020. As a direct consequence of the work that is mentioned in this portion, it has been seen that great progress has been achieved in the field of mobile agents, which is an advancement that has been observed. On the other hand, the studies that were discussed earlier provide a solution to the issue by integrating a variety of strategies for ensuring the safety of mobile agents. Up to this point, researchers have experimented with and evaluated a variety of alternative security techniques for mobile agents. On the other hand, each of the research suggested a fresh approach that included novel mechanisms and procedures. This presents a challenge for businesses that make use of mobile agents because every time they are compelled to employ new ways, those methods are laborious, they take a long amount of time, and there is only a small possibility that they will be successful. The research gap that was discovered as a result of this study is that there is an intentional lack of studies studying the up gradation of the current models and not offering totally new methods. This was found to be the case after the study was conducted. The dialogue is then continued by discussing the workflow of the suggested model. The proposed study starts with the presentation of the framework, which is a mix of proposed models.

III. Proposed Framework of the Mobile Agents in an Electronic Marketplace

In this section, we will first determine the types of mobility that are at the foundation of existing MA applications in the field of e-commerce, and then we will define existing MA applications that are used in the field of e-commerce. We explore a wide variety of possible implementations for each of these pattern types by using the time-honored client-server (CS) and model-view-controller (MA) paradigms. The mobility of mobile agents is shown in proposed framework (Fig. 1) that is intended for use in e-commerce.

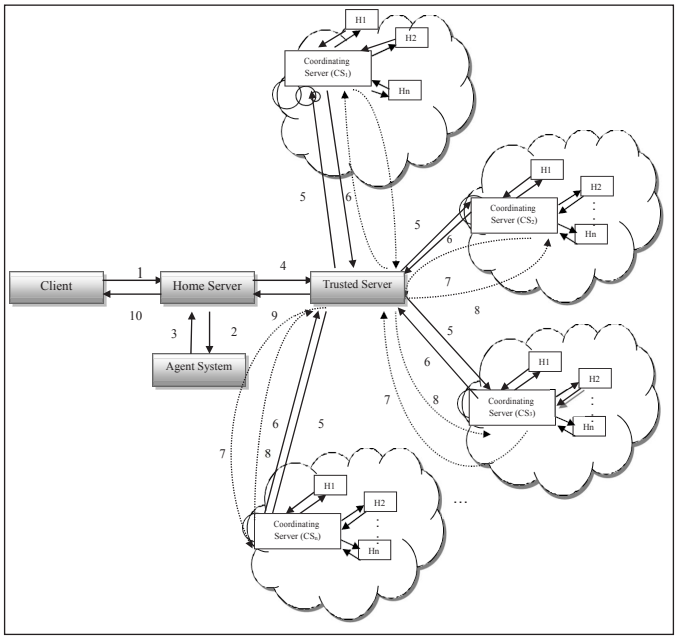

Fig. 1: Architecture for Electronic Marketplace: Branching Pattern

A. Work Flow of the Mobile Agents in an Electronic Marketplace

The complete functionality of the MAs in an electronic marketplace can be described in the following steps:

1. The client first registers itself with the Home Server (HS). In the said architecture, the HS has a built-in Agent System. The HS registers the client for every new request. Once the registration is completed, a Mobile Agent (MA) is created, which traverses from machine to machine to gather information on behalf of the user and is terminated once the process is completed.
2. Along with the request to create the MA, HS also receives the client query.
3. Once all the information has been received from the client, HS sends the service requirements to the Agent System (AS). The AS checks whether the required service exists, and upon confirmation, sends the addresses and names of the service providers to the HS. Upon receiving the response, HS generates the route list for MA.
4. The request is then transferred to a Trusted Server (TS) to device the security mechanism MA.
5. After the security mechanism is put in place, MA is sent to the number of Coordinating Servers (CS), which has a number of Mobile Seller Agents (MSA). It must also be noted that each CS has a number of MA attached to it.
6. The MA from each CS generates the responses based on the client query.
7. When MAs from each of CS gets finished with the required task, CS informs the TS about the completion and updates the MA code.
8. The TS gets notification, updates its directory and notifies each of the CS about the updated status of MAs.
9. The TS then compiles all the responses, and generate response for the HS.
10. The HS evaluates the security status of each MA, updates its directory with the status and responds to client.

Throughout the progression of our study, we uncovered MA as a potentially useful design paradigm for the e-commerce. Our work offers a systematic approach to the deployment of a whole e-commerce-based application over the World Wide Web. The proposed framework elaborates two logical areas of MA implementation in an electronic marketplace.

B. Evaluation Qualitative of the Several MA Design Paradigms

Existing MA applications in e-commerce were categorized, underlying mobility patterns for these applications were discovered, and viable implementation techniques for these mobility patterns utilizing client-server and mobile agent paradigms were examined. According to our previous experience and the findings of this study, the patterns of mobility play a significant part in determining the implementation method that should be used for high-performance applications. We conducted tests to quantitatively analyze the efficacy of these various tactics, making use of the model architecture implementation framework that was recommended. The applications that are most suited for sequential client-server implementations are those in which just a limited quantity of data has to be collected from a small number of distant data sources and the level of processing that is needed is relatively minimal (our experiments provide a good quantitative indication of these parameters). However, these prerequisites do not hold true for the vast majority of uses of e-commerce in the actual world. We find that MAs are an ideal technology for constructing e-commerce applications because they scale well across the aforementioned criteria, and since scalability is one of the requirements of net-centric computing. When there is a substantial amount of information processing that adds to the turnaround time, parallel implementations are beneficial. We demonstrate that mobile implementations are only beneficial when the cost of shipping a mobile agent is lower than the cost of exchanging messages, and this condition is not always met. We also noticed that the enormous quantity of message exchanges (catalogs) and the great number of interactions are typical features of e-commerce systems, and that these qualities are favorable to the deployment of mobile agents. Based on the results of our studies, we were able to determine the performance cross-over points for a variety of implementation methodologies and design paradigms. We are of the opinion that, in the long run, an implementation of the client-server and mobile agent paradigms using a hybrid model would provide outcomes that are superior in terms of performance.

C. Concerns with Software Engineering

Our experience with the deployment of MA reveals that MAs are a superior design paradigm for many real-life e-commerce application development situations. This conclusion was reached as a result of our involvement with MA. Direct mapping between the design of the program and the things in the actual world. MAs provide a great deal of freedom in application design, as well as extendibility and a straightforward method for integrating new functions. It has come to our attention that mobile e-commerce offers a solution that makes marketing both more efficient and more expedient. Users are able to do laborious, repetitive tasks and time-consuming activities such as product finding and comparisons with the assistance of MAs. Because the MA is traveling about to various stores and engaging with people there, the message exchange is taking place locally rather than across the network, which results in a lower burden on the network. We have a quicker reaction to changes because to the fact that the MA is located with all of the logic at the shop, which also offers support for detached operations. MAs

are responsible for the introduction of concurrency, and since the agent carries the client's product filtering logic, we are able to provide support for client-specific functionality at the shops. We were able to establish a causality relationship between the conclusions drawn from our qualitative evaluation experiments and the observations made with the application implementation of the proposed framework with the help of measurements and observations that were provided by our performance analysis experiments that utilized the application mobility pattern. These measurements and observations were in the form of observations and measurements. The framework that has been suggested provides support for client-server as well as mobile agent implementations and has the ability to switch between the two.

IV. Advantages of the Proposed Framework

The following is a list of some of the distinguishing characteristics that mobile agents have in the framework that has been proposed:

- Adaptive learning was suggested as a method of instruction for MAs within the framework. As a result, MAs are able to monitor traffic, find bottlenecks, and choose paths that are more efficient in order to reach the subsequent host.
- The framework used the mechanism of autonomy, in which MAs had the freedom to pick both the next host that they will migrate to and the date of when they would migrate to the next host.
- The ability to wander freely from one host computer to another inside a network is what we mean when we talk about MAs having mobility.
- The data collection methodology was also presented by the framework. According to this framework, MAs could be dispatched to each individual client to perform data analysis and then relay the results back to the server. This would result in a reduction in the amount of strain that was placed on the network.

V. Conclusion

This research is an investigation of the many security measures that are being used for cutting-edge multi-agent systems at the present time. We gathered many articles pertaining to this topic, investigated them, and then presented and analyzed their security ideas. These suggestions included identification, authentication, confidentiality, integrity, and access control techniques for multi-agent systems. We are of the opinion that further research can and should be done in this sector, and we have suggested a framework for MAs to operate within an electronic market. In general, we believe that multi-agent systems are a useful paradigm for carrying out data transactions in a safe manner. Because it is able to facilitate the flow of sensitive data across various nodes, it is capable of resolving a variety of security challenges, including authentication, confidentiality, integrity, and access control. In order to accomplish this goal, a variety of distinct cryptographic methods and approaches are used, each of which is designed to address a particular challenge. We think that a hybrid model implementation of the client-server and mobile agent paradigms would result in a superior application model from a performance standpoint. This is because hybrid models include aspects of both paradigms. The hybrid model would employ a measure of performance cross-over points across many factors to determine the best cost-effective implementation for a certain work at hand. A real-time learning method would help further develop and refresh the knowledge of our performance measure, hence assisting in the better choice of a design paradigm for a work with a given set of parameters. This would be beneficial. Instead of offering a general framework that enables mobility, we think that MA frameworks need to be tailored to the mobility pattern of an application. In order to improve performance, we need an application-specific framework that is tailored to a certain group of mobile apps and the behaviors they exhibit. The safety features of mobile agent systems are taken into consideration by our framework, which is used for the construction of e-commerce-based applications employing MAs. This work is going to be further developed with a comprehensive analysis for payment methods that are compatible with MAs. It is essential to investigate the compatibility of the currently used electronic payment methods with mobile agents.

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