MOBILE COMPUTING: An Extensive Review

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*Abstract-*The major problem faced by people on the move is inability to access data and information, that is important for the businessmen, professionals and many more. In this fast growing world, continuous access to data and information through various mobile networks, has become crucial. So, the mobile computing technology helps to solve the problem of ‘mobility’, by making it possible for the users to be able to stay connected and updated, even when they are on the go. “Cellular Digital Packet Data technology” is discussed, that supports mobile data communications.**This paper focuses on another very important technology, the mobile agent technology, that has a role to play in mobile computing. As defined, “Mobile agent technology is an effective paradigm in distributed systems, which improves their design, maintenance and implementation”, we can observe its relevance in distributed systems, and also, how it is used in mobile computing technology, by providing middleware services, that is discussed in detail. This paper shows comparison between the RPC(Remote Procedural call) technology and agent migration, and how they exhibit a similar function, of migrating between(FAM) is discussed, as a way of improving mobile agent performance, in both insecure and secure environment.**

***Keywords* – Distributed System, Mobile Agent, Remote Procedural Call (RPC), Migration**

I. INTRODUCTION

In today’s fast growing world, transfer of data from one medium to another without the use of any fixed physical medium is widely established and is rapidly increasing with a great pace. The principle of working of mobile computing technology is based on the ability of mobile devices to transmit data using the cellular networks that already exist and are evolving fast.  
This provides a solution to the major problem faced by the people such as businessmen, students, professionals i.e. mobility. While people are on the go, mobile computing technology provides an easy way for them to check their mails, carry out transactions, visiting social networking sites.  
This technology keeps all, connected as well as updated, by the transfer of data and making communications possible by using various cellular networks and technologies used, which will be further discussed. Mobile computing consists of communication, hardware and software part in mobiles. Mobile computing is a type of technology which makes use of internet and various known communication links such as WLAN, LAN, WAN etc. Also, mobile agents have an important role to play in mobile computing. A new approach in the field of architecture of distributed systems are mobile agents, which cause data to migrate safely from one computer to another. Mobile agents technology provides an example of a new computing pattern in which a program can move within a heterogeneous network. They perform their execution in one environment and move to another host where they resume execution.

## II. LITERATURE REVIEW

A.***“Heterogeneity in Mobile Computing Environment”*:** According to this paper, the fast increasing growth in mobile computing has created a “Heterogeneous” spread of technologies that affect devices in the mobile computing system. As mobile computing highlights the frequent use of systems that are connected with each other, its important for them to be interoperable. Some techniques to understand the angles of heterogeneity are discussed in this particular paper, that are there in mobile computing system. The most common solution to handle heterogeneity is employment of middleware system in between the application layer and the heterogeneous environment. Also, Mobile Agents is also a way of handling heterogeneity. Mobile agents, apart from providing a uniform interface for the devices, is capable of accepting their service requests, after which it questions the service and then, response is delivered to the request of the device. Since, the mobile agents adapt to the heterogeneous service interfaces , transparent access to heterogeneous services are provided to them, as a result, heterogeneous service is hidden. [1]

B*.****“Efficient migration for mobile computing in distributed networks”*:** This paper talks about the “Elliptical Curve Cryptosystem” in which issues related to access control and key management are considered. In this method, the access control between the mobile agents and the host is secured and also the storage space is economized. Due to this, the mobile agent becomes more efficient in executing its tasks and operates in a safe environment. The Elliptic Curve Cryptosystem was put forward by Miller and Koblitz, in 1985. The most important aspect of Elliptic Curve Cryptosystem is the smaller size of key in comparison to the presently used “RSA cryptosystem”. As an example, size of key in ECC is known to be 160 bits and in case of RSA, its 1024 bits, with the same level of security. So, the smaller key size enables faster execution and lower space consumption. [2]

C. ***“Information security issues in mobile computing”*:** This paper focuses on the *security* of the mobile computing system. The main concern is the security of the *information* that resides within the mobile computing environment. The information present in the “mobile units” and the “integrity” of the data in the mobile units should be secured. As the information migrates through the air, to the stations from the mobile units, its security is also crucial. The techniques and algorithms that ensure the security of this transmission of data demands power consumption, which also has to be thought about. Fresh ways of organizing and storing data are needed. [3]

D. **“*A Survey of Context-Aware Mobile Computing Research*”:** In this paper, “context-aware” mobile computing is talked about. It is defined as “a mobile computing paradigm in which applications can discover and take advantage of contextual information (such as user location, time of day, nearby people and devices, and user activity)”. Also, “context” is defined as “the environmental states that determine behavior of an application, or settings in which an event occurs in an application that a user finds interesting.” According to the paper, that “context awareness” is a major factor that influences fresh and recent applications. [4]

E.TABLE SUMMARY OF LITERATURE REVIEW:

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| --- | --- | --- | --- |
| **S.No** | **Name of Author** | **Research Paper Title** | **Idea discussed in Paper** |
| 1. | Robert Schmohl, Uwe Baumgarten | Heterogeneity in mobile computing environments | “Heterogeneity” is the spread of technologies in the mobile computing system that affect devices. Solution to handle heterogeneity is employment of middleware system in between the application layer and the heterogeneous environment. Also, Mobile agents is also a way of handling heterogeneity. |
| 2. | Kuo-Hsuan Huang a, Yu-Fang Chung b,⁎, Chia-Hui Liu a, Feipei Lai a,c,d, Tzer-Shyong Chen e | Efficient migration for mobile computing in distributed networks | “Elliptical Curve Cryptosystem” is discussed, according to which the access control between the mobile agents and the host is secured and also the storage space is economized. Due to this, the mobile agent becomes more efficient in executing its tasks amd operates in a safe environment. |
| 3. | Thomas Hardjono, Jennifer Seberry | Information security issues in mobile computing | The information present in the “mobile units” and the “integrity” of the data in the mobile units should be secured. As the information migrates through air to the stations from the mobile units, its security is also crucial. |
| 4. | Guanling Chen, David Kotz | A Survey of Context-Aware Mobile Computing Research | “Context-aware”, a mobile computing model that lets an application take advantage of contextual information |

Table 1. Summary of Literature Review

### III. DEVELOPMENT OF DISTRIBUTED APPLICATIONS BY MOBILE AGENTS

Mostly, distributed applications have two programs, a “client-side program” and a “server-side program”. As a mobile agent can carry its information to destination computer, on its own, a single program can be written to define distributed computing. Standalone programs can be easily modified as mobile agent programs, because a mobile agent program doesn’t need to define communications with other computers. Mobile agent go through persistent storage, duplication and migration to other computers controlling themselves on their own, so they are capable of supporting various kinds of processing in distributed systems. This technology improves the design, implementation and maintenance of the distributed systems.[8]

## IV. ROLE OF MOBILE AGENTS IN MOBILE COMPUTING

Mobile agents are capable of moving complex functions from one environment to another where data has to be processed. They are very effective in distributed systems and applications. Mobile agents make it possible for programs to interact with other resources while migrating within a network. Mobile agent technology is more beneficial than the conventional client-server computing, which is based on Remote Procedural Call(RPC) technology. The client-server technology provides no limitation in the bandwidth availability within machines. Mobile agents technology’s properties like mobility and autonomy provide solution for the low bandwidth and resource constrained computer, that is used in mobile computing. Agent mobility makes the time taken in connection between mobile terminals and network more optimal and effective. “Autonomy” makes user action tasks performed by agent independent of each other. Mobile agents continue to work even when the user is not. It completes its work until user reconnects to get the results. Agent has the ability to transmit information that is relevant, so the device doesn’t need to be refined.[9]

V. PROVIDING MIDDLEWARE SERVICES TO MOBILE DEVICES USING MOBILE AGENTS

A Java-based Mobile Agent (MA) platform called SOMA provides various facilities for “communication”, “migration”, “naming”, “persistency”, “security”, and “interoperability”. It provides “*Shadow Proxy”*, any movable device and “*server adapters”,* that are application-specific.[9]

A. *“SHADOW PROXIES”*

These are intermediate software components that are independent of applications. Movable devices on a fixed network are represented by these shadow proxies, that run at a location in the “SOMA domain”, where the device is present at that time. As the movable device migrates to a new domain, “shadow proxy” too moves with it.[9]

#### B. “SERVICE ADAPTERS”

These are application-specific intermediate software components. Depending on the device status, they transform data. Various adapters can function together for one “shadow proxy” and send service requests alongside from that very device. Service adapters are “shadow proxy following mobile agents”.

#### C. “DEVICE-SPECEFIC CLIENTS”

These are the components that function in the mobile devices. When the device enters or exits locality of a network, these device-specific clients announce, shadow proxies are requested for services and service adapter outcomes are received.[9]

#### D. “PORTABLE DEVICE LOOKUP SERVICE(PDLS)”

Shadow proxy for mobile device is found by PDLS by naming service and triggers the “shadow proxy” movement to its network area.

First, “shadow proxy” ask for services, and the required “service

adapter” is identified by PDLS and adapter migration is triggered to the shadow proxy’s location that is requested. Then, a medium between “shadow proxy” and “service component”, that is a reference to the adapter, is provided by PDLS. A service unavailability message is sent by the PDLS, to the device client, if adapters are incompatible with specified profiles.[9]

#### E. “PROFILE MANAGER SERVICE(PMS)”

Profiles of users and devices are maintained by Profile Manager Service(PMS). A partially copied directory service that is specialized foe profiles, is devised by it. Local replications of profile information are kept, and coordinated with PMSs in different “SOMA domains” so that shadow proxies are provided making any registered profile, visible in the system.[9]

VI. RPC(REMOTE PROCEDURAL CALL) AND AGENT MIGRATION

*“Agent migration is similar to RPC(Remote procedural calling) or RMI(Remote method invocation) in function”*.

In “RPC technology”, server programs run in different computers from the client. A procedure is called by the client for the server programs. “Remote Procedural Call” or “Remote Method Invocation”, first passes arguments to a procedure of a program on the server and a value is returned from the server, that is received by the client.[7]

In Agent Migration, the runtime system that is present on the computer that is the sender, suspends the execution of the agent.

The agent is marshaled so that it can be transmitted over a network to the destination computer. The runtime system on the destination computer receives the marshaled agent and unmarshals it to receive the agent.[7]

*This mechanism by which arguments and results are passed through RPC between two computers, is similar to that of the agent migration due to mobile agents between two computers*.

VII. IMPROVEMENT OF MOBILE AGENT PERFORMANCE

There can be many ways of improving mobile agent performance. One of the efficient ways to improve its performance is the “*Free Area Mechanism(FAM)”.* This mechanism leads to the reduction in the size of mobile agent by making it free from unutilized components, from its body, after the agent completes some of its migration journey. As a result, mobility becomes faster due to reduction in mobile agent data. Plus, this reduced size is more easily accepted by the hosts. So, these factors do contribute in improving the performance of the mobile agent. FAM can be used in insecure as well as secure environment.[5]

### A. FOR INSECURE ENVIRONMENT:

There may be some hosts in an insecure environment that may create attacks on mobile agent, when its size is reducing. There are some assumptions in FAM such as:

* During its migration, a mobile agent visits many locations.
* Different actions might be performed by mobile agents in those locations.
* Mobile agents have strong mobility.
* In a system of mobile agent, there are numerous “controllers”, which are distributed in a territory.
* The “controller” is a location for reducing size, which is a safe location, where the mobile agent size is reduced.

There are several components in FAM which have a particular function, such as:

* *“Agent Catalog”:* Agent catalog is a component that has information regarding the status of the elements present in the mobile agents present in the mobile agent. The catalog has three fields: Element ID, place and status. A method or a variable ID is represented by Element ID. The places specify the location on which element has to be used. The status takes value ON or OFF depending on the need on the need of the element by the mobile agent. It shows ON, if agent needs the element and OFF, if it doesn’t. In agent catalog, every component present in the mobile agent is shown as a record. The “mobile agent base” forms and encrypts “Agent catalog” by a mechanism called “Symmetric Encryption mechanism”. To secure agent catalog of any attack only controllers can be considered to handle the security issues.[5]
* *“Controller”:* It is a safe location where mobile agent’s size can be reduced. Some controllers are distributed around hosts by the mobile agent system. During its movement, a mobile agent

can visit various controllers after visiting some hosts, so that it can free some unutilized parts of the agent. A secret key is known to every controller in the system that is used for encrypting agent catalog. This is how it works:

* Decryption of agent catalog using the secret key and updating of agent catalog status according to the migrating record.
* Specification of elements that won’t be used any further, and their deletion.
* Renewal of mobile agent by elimination of the deleted parts.
* A new version rebuild of “agent catalog” in accordance with the new form of “mobile agent”.
* Encryption of “agent catalog” again, with the secret key.
* Enclosing the “agent catalog” with the “mobile agent”.
* Continuation of “mobile agent” migration.[5]

The controller performs its functions using following units:

* “Garbage Collection Unit(GCU)”: In order to reduce the mobile agent’s size, GCU specifies the deleted elements using a “mobile agent”, an agent’s guide and an “agent catalog”.[5]
* “Agent Rebuild Unit(ARU)”: After the specification of deleted parts by GCU, ARU removes them and a new version of it is rebuilt. Also, “agent catalog” is updated according to the previously existing “agent elements”. So, this decreases the agent’s size.[5]
* “Results Summary Unit(RSU)”: “Mobile agent” approaches some hosts before visiting the controller, and so, there some result present in it. RSU summarizes all these results and thus, more elements can be assigned as deleted by the controller.
* “Dynamic Behaviour Unit(DBU)”: Mobile agent may visit some unscheduled places in some situations. So, these agents require certain “behaviours” that can enable them to visit these unscheduled places. “Dynamic Behaviour Unit” is a behaviour provider that fulfills mobile agent’s requirements of visiting unscheduled locations.
* “Communication Unit(CU)”: In this unit, mobile agents are received and dispatched to/from the controllers. It also can provide some urgent results to an agent’s owner. It enables the “controller” to receive many agents through paths, simultaneously.[5]
* Security Unit(SU): “Agent catalogs” and “mobile agents” are encrypted in most of the mobile agent systems for security purposes. SU can decrypt them both when mobile agent visits the controller. Also, it can encrypt them when mobile agent leaves.[5]

B. FOR SECURE ENVIRONMENT:

FAM can be used in a secured environment also. A copy of all the controller components discussed in insecure environment is required. Agent catalog should be necessarily secured in every host. The agent approaches the controller components, hosted by the host, before leaving its present host. These components decrease the mobile agent’s size as discussed in that of the insecure environment. The average agent size is more reduced in the secured environment as compared to the insecure environment.

## VIII. CONCLUSION

Mobile computing technology offers a continuous access to data and information and keeps people connected and updated by connecting them through wireless networks even when they are moving.. Mobile agents have a role to play in mobile computing technology. It acts as a middleware in the mobile computing devices using mobile agents. A platform called SOMA provides various facilities for “communication”,“migration”,“naming”,“persistency”, “security”, and “interoperability”. It provides Shadow Proxy, any movable device and server adapters, that are application-specific. Mobile agents have an advantage, of being able to perform even when there is low connectivity, that might exist say, due to traffic in network. It migrates at its own will to the destination host, even when the system is not functioning. The RPC(Remote Procedural Call) technology is similar to agent migration in function as both of them migrate over two hosts. But, in RPC technology, a procedure is called by the client. Arguments are passed to a procedure and value returned is received by the client, whereas, in Agent migration, there is a runtime system through which marshaled agents are passed to host computers over a network and the host receives it after unmarshaling the agent. Mobile agent performance can be improved by using a Free Area Mechanism(FAM) where the size of the agent is reduced so that its mobility increases and it is easily accepted by the host.

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