MOBILE AGENT PLATFORMS IN UBIQUITOUS COMPUTING APPLICATIONS AND SYSTEMS (A LITERATURE REVIEW)

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ABSTRACT: Technology revolution has been occurred rapidly over the last past thirty years According to the moor's law power of microprocessors double every eighteen months. And also a parallel increase can be observed in some other technological sectors such as network communication, bandwidth, storage, capacity. These remarkable trends make us to predict that in future computer will become considerably smaller, cheaper and more pervasive. These result a creation of small things that can access the internet in order to optimize their intended purpose. It gives birth to new technology trend called "Ubiquitous computing". Ubiquitous computing is an emerging technology that brings new dimensions to distributed computing. It uses a wide variety of smart, ubiquitous devices throughout an individual's working and living environment. When it comes to ubiquitous computing, mobile objects and mobile agents are forerunners. Mobile agents are considered a very interesting and emerging technology to develop applications for mobile and distributed computing. Since they present a combination of unique features, such as their autonomy and capability to move to remote computers to process data there and save remote communications, they can be widely used in ubiquitous computing. Many mobile agent platforms have been developed since the late nineties. In this millennium era they are now influenced in many aspects of technology such as localization of technology, internet connection, voice recognition etc. This literature review focuses on Mobile agent platforms in ubiquitous computing applications and systems.

Keywords: Ubiquitous Computing, Mobile Agent Platforms, Mobile Applications, Mobile Agent, Pervasive Computing

1. INTRODUCTION

Ubiquitous computing is the new era in computing, where the widespread use of new mobile technology implements wireless communications such as personal digital assistants (PDAs) and smart phones enable a new type of advanced applications. In the past years, the main focus of research in mobile services has aimed at the "anytime, anywhere" principle (ubiquitous computing). However, there is more to it than that.

Meanwhile the increasing demand for distributed problem solving led to the development of multi-agent systems. The latter are formed from a collection of independent software entities whose collective skills can be applied in complex and real-time domains. The target of such systems is to demonstrate how goal-directed, robust and optimal behavior can arise from interactions between individual autonomous intelligent software agents. These software entities exhibit characteristics like autonomy, responsiveness, pro-activeness and social ability. Their functionality and effectiveness has proven to be highly dependent on the design and development of the application domain or context.

2. WHAT IS MOBILE AGENT

Mobile agents are programs that travel autonomously through a computer network in order to perform some computation or gather information on behalf of a human user or an application. And we can define in a different way like “software entities that can migrate between servers or mobile agent environments of the network accomplishing various tasks on the behalf of their owners”(Lange, n.d.)

3. MOBILE AGENT ARCHITECTUREIN UBIQUTOUS COMPUTING

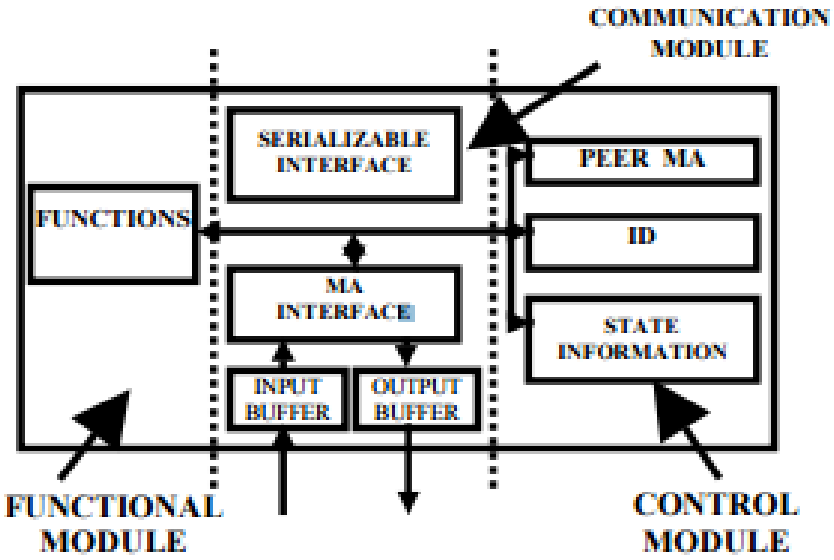

Figure 01- Basic mobile agent architecture.(David Levine, n.d.)

The basic architecture of a mobile agent is depicted in Figure 1. Mobile agents consist of three modules: functional module, control module and communication module:

The *functional module* contains the functions the mobile agent should perform; the functions can receive input from the host, or from other agents. The *control module* consists of three sub-modules maintaining information about the mobile agent. The ID sub-module is responsible to carry the MA identity. The Peer sub-module maintains a list of peer mobile agents. The State sub-module stores the state information of the MA. The communication module maintains a common framework for communication with the software architecture. The MA Interface sub-module allows simultaneous reception and transmission of messages between agents. The input buffer provides buffering for incoming data, while the output buffer does the same for outgoing data. The serializable interface serves the agent in preparing for migration to another host by suspending all parallelism.

A UML representation of a mobile agent is given in Figure 2. In order to enable migration, mobile agents have to have a serializable interface to suspend parallel behavior for the duration of the migration. Mobile agents should also have a uniform MA interface with a standard framework for mobile agent communication.

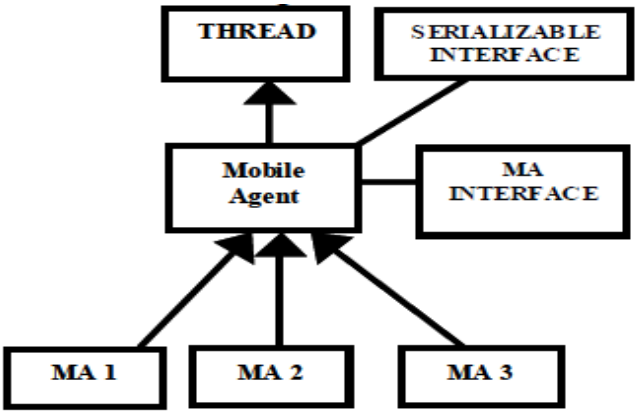

Figure 2. UML representation of mobile agents.(David Levine, n.d.)

4. MOBILE AGENT PLATFORMS

A mobile agent platform is an environment that allows agents to execute and provides them with different services, such as communication and mobility facilities. There are many available mobile agent platforms. Someare developed by research groups and others by private companies. Voyager, Grasshopper, and Swarm, Odyssey(Luís Moura Silva, n.d.)are among the most popular alternatives. Most of the existing platforms have been developed in standard Java because it provides benefits such as platform independence (a key condition to allow agents to travel among heterogeneous mobile devices)(Luís Moura Silva, n.d.), secure execution, dynamic class loading, multithreading, and object serialization. Due to the impossibility of saving and restoring the execution stack in a standard Java system, they usually implement weak mobility. The communication and mobility services that a platform must provide are interrelated. Particularly, mobile agents must be able to communicate among themselves via remote method invocation or message passing, even if they move across computers. Location transparency, defined as the ability to communicate with mobile agents independently of their current locations, is a desirable feature.

5. WHAT IS UBIQUITOUS COMPUTING

Ubiquitous computing (also called Pervasive computing) is the current growing trend towards embedding technology in everyday life of human. The word ubiquitous mean "existing everywhere." Ubiquitous computing devices are completely connected to the internet and have mobility.

Ubiquitous computing relies on the convergence of mobile agent technologies, wireless technologies, advanced electronics and the Internet. The goal of researchers working in pervasive computing is to create *smart* mobile products that communicate unobtrusively. The products are mobile and connected to the Internet and the data they generate is easily available

An example of a practical application of pervasive computing is the replacement of old bill paying mechanism. In the past bill payment need to be manually done by a user. But now those bill payments can be done electronically just using computing device such as a smart mobile phone. Mobile bill payment usage in real-time over the

Internet. They will also notify the company when there is a payment was being done according to the payer's directives, send messages to display messages as well.

6. DEFINITION OF UBIQUITOUS COMPUTING

Ubiquitous computing suggests countless very small, wirelessly intercommunicating microprocessors, which can be more or less invisibly embedded into objects. Equipped with sensors, these computers can record the environment of the object in which they are embedded and provide it with information processing and communication capabilities

7. DEFINITION OF AGENT TECHNOLOGY

An abstract or physical autonomous entity which performs a given task using information gleaned from its environment to act in a suitable manner so as to complete the task.(Prakash V. Rajguru, 2011)

8. CLASSIFICATIONS OF AGENT TECHNOLOGY

A. **Collaborative Agent:** Collaborative agents, thus enabling the ensemble to function beyond the capabilities of any of its members. Implementing efficient ways of cooperation among agents is actually one of the central issues for Multi-Agent Systems development (Yashpal Singh, 2012)

B. **Interface Agent**: An *interface agent* can be considered as a program that can also affect the objects in a direct manipulation interface, but without explicit instruction from the user. The interface agent reads input that the user presents to the interface, and it can make changes to the objects the user sees on the screen, though not necessarily one to-one with user actions. The agent may observe many user inputs, over a long period of time, before deciding to take a single action, or a single user input may launch a series of actions on the part of the agent, again, possibly over an extended period of time. The essential characteristics of an interface agent include responsiveness, competence and accessibility. (Yashpal Singh, 2012)

C. **Information Agent:** Information agents are special kind of so-called intelligent software agents. Software agent technology originating from distributed artificial intelligence is inherently interdisciplinary. Thus, the notion of agency is quite broadly used in literature; it might rather be seen as a tool for analyzing systems, not an absolute characterization that divides the world into agents and non-agents. However, intelligent agents are commonly assumed to exhibit autonomous behavior determined by its pro activeness, means taking the initiative to satisfy given design objectives and exhibit goal directed behavior, reactive or deliberative actions, and means perceiving the environment and timely change management to meet given design objectives, and social in groups with other agents and/or human users when needed. It depends on the concrete application domain and views on potential solution for a particular problem what an intelligent agentin practice is supposed to do. (Yashpal Singh, 2012)

D. **Reactive Agent:** Capable of maintaining an ongoing interaction with the environment, and responding in a timely fashion to changes that occur in it. Note that the term is now widely used to mean a system that includes no symbolic

representation or reasoning: such an AGENT does not reflect on the long-term effects of its actions, and does not consider the co-ordination of activity with other agents. Thus, a reactive agent will always respond in a timely fashion to external stimulus. (Yashpal Singh, 2012)

E. **Smart Agent:** New forms of software agent that interface with other agents forming an artificial Intelligence system. The acronym" SMART" stands for "System for Managing Agents in Real Time".(Yashpal Singh, 2012)

F. **Intelligent Agent:** The term intelligent agent can refer to any agent that exhibits some amount of intelligence and there is no requirement that the agent have the ability to work with other agents. (Yashpal Singh, 2012)

G. **Cognitive Agent:** It is a software agent that is also an intelligent agent which performs a task with minimum specific directions from the user. It evolves from the concept of virtual personal assistant, a cognitive assistant that learns and organizes. (Yashpal Singh, 2012)

H. **Courier Agent**: It transfers a folder to a specified agent on a specific machine. (Yashpal Singh, 2012)

I. **Diffusion Agent**: It executes an agent locally and then creates a clone of itself. At every site. Scheduling allows the enforcement of policies that tells when and where an. agent is executed. (Yashpal Singh, 2012)

J. **Broker Agent**: It maintains the database of service providers. An Agent needs a given service always consult a broker to identify which agent provides that service. [2]

9. CHARACTERISTICS OF AGENTS

The invasion of various approaches under the banner of agents caused a need to classify and define this term. However, it quickly became apparent that everyone had their own definition due in part to the historical relationship with the AI community and the vague notion of intelligence. Numerous definitions for the agents have been proposed, but in core most have a set of defining characteristics that every agent must demonstrate. (Yashpal Singh, 2012)

Autonomous: An agent is able to take initiative and exercise a non-trivial degree of control over its own actions.
Interactive: means Mobile Agents should communicate with other agents and their environment. In addition, mobility is the most important property in the Mobile Agent concept, where agent migrated from one node to another within the same environment or in different environment.
Coordinative: Perform data transfer with other agents in a given environment.
Proxy: Mobile agents may act on behalf of someone, so they should have certain degree of autonomy.
Ragged: Mobile Agents should have the ability to deal with the errors whenever occurred.
Proactive: They should be goal oriented.
Cooperative: Coordinate with other agents to achieve a common goal. Mobile Agents should have the capability of learning the current environment and modify its behavior based on this information.
Intelligent: Means Mobile Agent should be too smart in order to act efficiently.

10. CONCLUSION

Agent technology has been used in many critical applications such as personal information management, electronic commerce, business process management, artificial intelligence, interface design, distributed processing and distributed algorithms. Besides its bright side, the technology has encountered many security threats.

These problems are faced during the itinerary period of an agent traversing from platform to platform in the network.

Apart from that mobile agent technology which has been used in many areas from network management task to information management, mobile agents have significantly used in the wireless environment because it supports the disconnected mode. As the mobility has been migrated from the PDA (Personal Digital Assistant) to the network, the PDA could be disconnected and when the mobile agent finishes its job then they can reconnect in the network with the desired result from the agents. This gives advantage over conventional communication methods such as client/serverModel, RPC etc. Mobile agent technology is frequently used in other applications such as data warehouse, software updates, and information management tasks such as searching for information.

In this review paper, we have analyzed theoretical view of Mobile agent technology and ubiquitous computing and various recent developments, researches and proposals related to the field of agents and ubiquitous computing and have thrown some light on the delicate areas that needs to be paid more attention to promote growth in optimistic direction.

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