Applications of Mobile Agents: A Survey

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Abstract:

A mobile agent is a computer program or software that has the capacity to reason, it can use network infrastructure to make use of an remote site as its hosts so as to run over it, it can search and get information, it can cooperate with each other and also with other sites after which it can return to its home site after it completes its assigned task. Mobile Agent based applications are rapidly increasing as they are in recent research activities and the fact of its wide application areas. The domains where mobile agent play an vital and important role are as follows: e-commerce, network management, energy efficiency and metering, Wireless Multimedia Sensors, Grid Computing and services, human tracking, security, e-learning, reference and semantic web services, affective computing, climate environment and weather. In this paper, a survey of mobile agent based applications is presented. The functions of the mobile agent are best suited for the domains that are mentioned above.

Key words: Mobile agent, application, networking, energy efficiency, grid computing, e-commerce.

Introduction:

In general, an agent is an autonomous program or entity that is capable of performing one or several tasks to achieve a specific goal. In networking , an agent can possibly run even if the network gets disconnected. There are few agents that run in the dedicated servers and few run in standard platforms. There are many agents that are available these days and they have come to focus more increasingly with the development of internet [1]. Thus an agent can be defined as "any fairly autonomous entity unit that is capable of performing actions in an deployed environment sensed by it". It is also important to note that it is a computer entity which can be acting through hardware or software which is more synonymous with a robot. The applications of robotic agents are called as: softbot, taskbot, knowbot, etc.

Using a set of criteria agents can be classified as:

→ 1)Collaborative,
→ 2) Interface,
→ 3) Mobile,
→ 4) Information,
→ 5) Reactive,
→ 6) Hybrid and
→ 7) Intelligent.

In the beginning agents were largely used in personal computer in almost all environments, networks and homogeneous UNIX platforms. This made their behavior a limited one as they were deployed in the limited environment and the task was to be achieved in a predetermined time slot. In the recent decades, technology has seen a huge leap that has made the agent technology to be applied in many interesting areas of application. The one of which is the mobile environment where the agent is called a mobile agent. They are named mobile as they can travel through different computers using the network.

Mobile agents represent a set of agents whose main functions are transmission capabilities between the nodes of the same network or of different network which is an added property than to the properties of an stationary agent. Stationary agents represent a basic framework or a basic design of the agent information management. Mobile agents can also be viewed as direct extension of the client server paradigm [2]. In the client- server approach the function of the client and the server is well defined and is fixed. The server is a repository of

services from which the client receives the necessary services that it wants. This in-turn makes a dependency between the client and the server. The dependency can be matched as the client directly depends on the services that are provided by the server. The communication between the client and the server is made possible with the use of messages. With this in mind the programmer is to provide an address to both the entities so as to make the communication possible between them. The Sun Microsystems developed a way of possible communication between the two entities with the help of RPC (Remote Procedure Call)[3]. This was developed to simplify the operation that takes place between the client and the server by just simplifying the programming method. The services that are offered makes the user think that he is using a local application. These are generally called stubs. The server location, the initiation of the transport service and the obtained results are handled in a plain manner to the client. However the fundamental problem persists with the communication between client server systems. The problem with the client server system is managing the information that is distributed. If the server fails to give the exact service as requested by the client then it may result in an increased waiting time. In general, RPC approach uses the bandwidth of the network for each message, it requires the continuous communication with the network for a specific service for a given duration of communication. There are other client server architecture like CORBA (Common Object Broker Architecture) architecture [4] makes use of the object oriented principles to make the

communication possible between the client and the server and the Distributed Environment RPC that provides an equipment, security and authentication interface with the help of threads instead of using sockets to gain a high level of abstraction.

The mobile agent approach overcomes the problems that are with the client server paradigm. Specifically, the ability to be mobile is the most important feature that is enabled with mobile agent. The features include the following [5]:

1) Efficiency: The movement of an agent towards the node where the resources are available, then the movement of the agent causes traffic. This also reduces local traffic and makes the agent decide rational as what are the important resources that are to be transferred. This plays a crucial role in the utility of the of an user in the lower bandwidth.

2) Persistence: Once the mobile agent is launched the connection with the creator node is not possible once again. Additionally that an agent will not be affected when the network involved in the creation of the node fails.

3) Peer to Peer Communication: The agents that are mobile are considered as the peer entities and they can act as client or the server based on the need of the people.

4) Fault Tolerance: In the client server paradigm the communication between the user and the client server based on the mobile agent and it also needs to stay in

touch with the network permanently. However when the network fails the mobile agent will keep running.

In the mobile computing, am application is a collaborative and an internal way of examination. If it is necessary, agents can be able to move to from location towards the stationary or an agent that is idle to make the communication.

The approach of an agent:

1. Use the available bandwidth when the agent is mobile

2. The agent can be able to its work of sensing even after they leave node.

3. Traffic reduction in network in the network

4. Parallel distributed applications of the mobile agents.

5. Reliability, mobility and autonomy makes the agent mobile and allows the agent to provide the services that are required

In this paper, we present a survey on the application domain, platforms or frameworks, implementation details. We also discuss that the agent used in different applications are benefitable.

2. Applications based on Mobile agents:

In this section, the applications domains that are discussed are follows: the domains include the following, e-commerce, network management, energy efficiency and metering, Wireless Multimedia Sensors,

Grid Computing and services, human tracking, security, e-learning, reference and semantic web services, affective computing, climate environment and weather.

2.1 Network management:

For more than two decades many researches are being carried out in order to insert or place a mobile agent into an network intelligent alarm management. The study has also focused on how to use mobile agents to reduce the bandwidth utility. To reduce the utility of bandwidth used in the network management Outtagarts et al. [6] proposed a solutions which was based on the mobile agent approach rather than the client server approach used in SNMP protocol. The reduction of network bandwidth with mobile agents is of more interest when compared to handling one node to manage. The authors have made a demonstration of the of the benefits of the mobile agent by analyzing the performances of both approaches. The authors have also demonstrated theoretically and experimentally that the use of bandwidth is reduced by which the utility of the bandwidth is reduced and is saved with the help of the mobile agent rather than the client server approach.

Using mobile agents Manvi et al.[7] finds the multiple QoS paths and selects a best path among them. This is done so as to increase the success ratio of the call and the best utilization of the network bandwidth. The scheme was simulated in multiple network scenarious to verify the evaluation of the performance. Mobile agent based on demand QoS was compared with the RSVP

based quality of services routing that uses internet routing protocol.

In the current possible way if the WAN cable is cut the time required to loacte the problems may extend since there is aslow response of the network Thanh et al.[8]. Research is conducted to make a mobile agent be available in products that support event correlation for stopping the alarm in an heterogeneous networks Thanh [8]. A routing algorithm was proposed by CHEN et al[9] which uses multiple constraints. For a adhoc network. The authors have used mobile agents for collecting information about all the mobile nodes for reducing the delay in the network and the overhead of using the routing control messages. The authors have also claimed that their system has lower probability of link failure as the selection of the sink is done with the help of large link expiration time during route creation phase. Yamaha et al.[10] were interested in finding flexible peer to peer network technology for collecting information based on the mobile agents that are used in the system (MiNet). MiNet is one in which the users are enabled to share information based on mobile agents. The agents that are used in the MiNet works fine woth firewalls, proxies and NATs in LANs. A mobile agent has the capacity to migrate via HTTP protocols.

2.2 E-Commerce:

The significant part of the network infrastructure is the commercial activity which allows services to be in an open market. The implementation of an mobile agent in e-commerce for searching and

filtering the information that is to be concentrated in an electronic market was done by Al-Jaljouli et al [11]. The authors have described a method for the robust security techniques to ensure a better security is being provided to the information that is gathered throughout agent's life against various security attacks, as well as truncation attacks. The sequence of processes carried out during the agent's lifetime is also described in the paper. The authors have also utilized two agents which can co-operate with each other. The cooperation is done so to get the initial verification done with the terms being securely stored in a secondary agent (SA) that rests at the initiator and functions in hand with the major agent (MA) that which has the capacity to travel throughout the network and gather information about the network.

The authors in Nipur et al. [12] proposed a fault tolerant comparison method for internet shopping system BestDeal. The author have also performed the model by initiation more than eight mobile agents that are capable of shopping. These agents are are capable of doing the visiting to supplier sites. Each agent can visit a maximum of five supplier sites so as to capture the best deal that in internet market for a different products that are sold in the market. The methods that are used for the measuring the performance are in terms of the steps taken for execution and the time that is taken for the execution that is taken for the simulation to complete. The survival of the mobile agent possible even when there is a 80% of failure rate. The paper also discusses the fact that the higher the rate of failure, higher is the degradation of the performance of the system. Mobile agent in M- commerce platform is studied by Li et al. [13]. This

paper contains details about the design of the mobile agent and its implementation for M-commerce applications. The paper says that the advantage of accepting mobile agents in M-commerce is to boost up to large, lively world market places that are distributed throughout the world of internet. This can also ease the access and to make mobile users participate in the M-commerce platform.

2.3 Wireless Multimedia Sensors:

Wireless Multimedia Sensors are a area of active research as several works [14], [15], [16], [17], [18], [19], [20], [21] has been done in this specified area. The strengths and weakness of the mobile agent that acts as middleware is discussed by Shen et al. [14]. as per the discussion the authors have given a mobile agent that can perform the publish/subscribe middleware. The use of middle ware helps the process efficiency by a great deal. This middleware can improve the efficiency of the agent that is transmitting data by using this publish/subscribe mechanism. This is used to build routes in the interest. The experimental results as shown in the proposed mechanism are more effective for agents transmission and also shows that it improves the reliability of the entire application. Tu et al. [16] have focused on the important factor of modeling and designing two mobile agent methods that are used in wireless sensor networks: Static Mobile Agent Planning and Dynamic Mobile agent Planning. The experimental results are measured quantitatively by using three metrics. The metrics are energy consumption, network lifetime, and the number of hops. These are used in the simulation to measure the performance in terms of quantitatively by the itinerary planning methods. The results that are got by simulation shows that the Dynamic

Planning of the Mobile agent has an overall has an advantage in terms of network lifetime, the number of hops and energy consumption. Chen et al. [17], [18] have considered image processing applications in wireless sensor networks where there are multiple hops between the target source node and the sensory data packets which are not efficiently aggregated. The authors have also proposed an architecture for mobile agent that are based on the Wireless Multimedia Sensor Network. The results generated shows that with proposed architecture they have got better performance when compared to the client server architecture in terms of the energy consumption and the packet delivery ratio.

2.4 Energy efficiency and metering

In the background of energy metering and control, several works [22], [23], [24], [25], [26] has been done with mobile agent paradigm. Controlling power of distributed generations in an isolated micro grid have been applied using mobile agent technology in Arai et al. [22], [23]. In the solutions obtained, there are three roles for a mobile agent: obtain operation data and equipment parameters from distributed power, regulate the output power order for every source and allocate the output power order evenly to all the power sources. Chang et al. [24] have proposed an approach on how to use mobile agent to adapt knowledge recovering in the context of mobile grid. The approach proposed is also built on resource estimation models, time estimation model and energy consumption model. By using this approach the authors have evaluated the resources of mobile grid including the calculation of power bandwidth and energy consumption that are used to determine the place of power mining. A multi-agent system has been developed by Suriyakala et al. [25]. They

have developed the system that enables the functionalities even beyond the abilities of any sole mobile agent in the system which can perform a particular task. The authors have demonstrate that the load balancing and delay in propagation time was reduced by using multi agent system.

2.5 Grid computing and grid services

Aversa et al. [27] has used a mobile agent technology to develop an agent based Grid computing services. Using a standard interface the services are delivered to the recipient. The services which are compliant with the common services are used through the interface. ACL (Agent Communication Language) is used to migrate the messages in and out of JADE platform [28]. For the purpose of getting into the Grid node, the agents in the system must perform the transmission of the SOAP messages. The migration of one grid node from one system to the other is nodes outside the grid is dine with the help of the default http transmission protocol that is used in Jade platform. A system prototype and an agent for the Geographic Information Grid System was proposed by Tong et al. [29]. The system that is proposed provides services and are capable of improving the sharing of the distributed resources. [30], [31 are in]context of a grid computing architecture. Wang et al. [30] presented a paper in context of the how to implement mobile agent architecture. This system aims on how to implement world services in grid computing. Tveit[31] proposed a paper that enables routing and handling of data that's of FIPA and ACL messages.

2.6 Distributed data mining

For several reason distributed data mining plays a vital role in data mining. In this the resources are distributed over the network as well as the data mining process takes place simultaneously. The survey done by Moemeng et al. [32] has the ways of how to integrate a multi-agent system in the process of data mining. There were various issues that were surveyed in the paper. The issues like trends, open issues, research on software engineering on system and users. A study was done by Hou [33] in distributed data mining structure in e-commerce platform. The e-commerce platform has a web based and web services integrated heterogeneous mobile environment. Based on this study mobile agents were capable of handling problems of integration and communication. A study was also carried out by Yubao et al. [34] on mobile agent technology and its various applications in the field of distributed data mining. A new method was proposed by Kulkarni et al. [35]. As of this method, it explores the abilities of the mobile agent and an algorithm that is correct for the distributed data mining and its applications. The authors have presented the performance analysis and its comparison with the existing method.

2.7 Multimedia

Picard [36], [37] has studied the search of images in distributed databases that uses multi-agent system. The free roaming mobile agents in the network are used to search for the images and mark the relevant images and their path. This is done in order to guide the search into interesting web sites. The strategy used by him is based on how the ants behave especially how they mark their environment. The author also has reused the marks done in previous sessions for a new research. This type of learning

allows agents to find out the sites having relevant images more easily. The paper submitted by Haider et al. [38] presented a solution that is based on mobile agent and it also uses the concept of middleware for dynamic discovery, location dependent multimedia services that are offered for mobile devices. There are many issues that considered in this paper. The mobile agents that perform tasks for mobile device for a fixed time slot. The actions that are performed by the mobile agent are: Configuration and Reconfiguration, communication, QoS handling and downloading multimedia data into mobile device. There are many issues that considered in this paper.

2.8 Human Tracking

Human tracking is an important field that has lot of importance in real life tracking system. In order to improve the quality of video monitoring system in human tracking system Kakiuchi et al. [39] has introduced a paradigm that uses mobile agents in it.The agent in the paradigm is capable of utilizing the algorithm of finding the neighbor video camera to continue the human tracking efficiently. The emotional intelligence of an human is never considered in e-learning system as an instruction. Wang et al. [46] constructed an emotional intelligent system that utilizes mobile devices. The emotion of the student is recognized by the facial expression that is captured by the camera that closely watches the student. This is done so as to learn the student psychology by reading the facial expression.

2.9 Other applications and recent researches:

Bouchemal et al. [47] has proposed an architecture for protecting mobile agents in dynamic network. The idea behind the

proposal was protection and it requires two agents namely a mobile agent and a clone agent which has all the properties of the mobile agent with which it was cloned. The implantation is done in Jade platform that uses FIPA messages. The clone agent is sent to the network by protecting the mobile agent. The authors have claimed that the proposed method minimizes the damages that is done to mobile agent. Jhuria et al. [48] has proposed an algorithm to improve the performance of the DSR protocol by applying mobile agent in the vanet environment. The authors have said that the new approach makes the program execute on the node by utilizing the resources that are available for it in the network instead of directly accessing the nodes program. The authors have performed the result analysis and the implementation issues. Zubair et al. [49] have made a survey on the network management and the fault tolerance mechanisms that are prevalent in networking domain that uses mobile agent. They have also made a survey on the applications which are using network management and mobile agents. Mishra et al. [50] have made a survey on the application of mobile data in distributed network management. The paper also deals with the advantages of using the mobile agents in network management systems and comparisons are also made by the authors. Benchara et al. [51] have made the implantation of the AVPE algorithm in big data domain with the help of mobile agent. Mitra et al. [52] have proposed a scheme for applying mobile agent in vanet. The authors idea is to use mobile agent to measure the data that is available in the vanet environment. The authors have simulated the results and have claimed that they cannot compare the results since there is no common metric that is previously being used for the application. Abdel-Naby et al. [53] have made an investigation on the recent advances in wireless communication

that can integrate the use of mobile agent and agent base services applications. The authors have presented two agent based mobile service that can embed software agents into them. Adberrahim et al. [54] have presented an attempt of combining the two concepts of component and mobile agent. The authors have tried to take advantage of the capacities of the mobile agents by involving them in the verification of the structural and the functional validity criteria. Dong et al. [55] have proposed an architecture by using agent induction to measure the mobile application. The authors have claimed that the proposed architecture will be helpful to the app developers. The authors have also made an evaluation process to check on the validity, reliability and efficiency of the architecture.

4. Conclusion

In this paper, a review of mobile agent based applications in different domain areas has been done. For the past decade research on the mobile agent in the field of networks and network management in particular. With the new developments and ideas in the network, with increasing bandwidth utility and the concept of cloud computing has made an increase in the different research areas and proposal of new ideas. The future work is to focus on the usage of mobile agent in upcoming research areas and to focus on the new trends that come into the existence.

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