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Applications of Mobile Agents : A Canvas

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Abstract: A mobile agent is composition of code and data i.e state capable of reasoning, use the network environment to run in another remote area, explore and assemble the results, collaborate with other sites and return to his origin after completing the assigned tasks. Mobile Agent based applications research activities are enlarged and are applied in a wide range domain areas : E-commerce, network management, traffic control, robotics, data-intensive applications, grid computing, parallel computing and mobile computing. In this paper, a analysis of mobile agent based applications on above realm areas are presented. The major functions which mobile agents are better adapted for these realm areas are described.

Key words: Mobile agents, e-commerce, parallel computing, grid computing and grid services, information sharing, and multimedia.

I. INTRODUCTION

A mobile agent is a code that is self-governing and can move through a heterogeneous network, migrating from a host to host and interacting with other agents. Mobile agents have certain features such as sovereignty, mobility, goal driven, ,intelligence, cooperation, learning, reactivity etc. Mobile agents simplify the development, testing and implementation of disseminated applications because of their ability to hide the communication channels and show the computation logic. They can distribute and redistribute themselves throughout the network and can act as either clients or servers depending on their goals. They can also augment the scalability of the applications because of their ability to move work to an appropriate location.

Mobile agents are a valuable choice for many applications, for several reasons , including improvements in latency and bandwidth of client-server applications and reducing susceptibility to network disconnection. Mobile agents applications are currently being developed by industry, government, and academia for use in such areas as telecommunications systems, e-commerce, robotics , mobile computing, grid computing and grid services, distributed data mining,, service brokering, contract negotiation, air traffic control, parallel processing, and computer simulation. Although no universally used application (normally called killer application) has been developed for them, mobile agents are suitable for the following applications.

II. E-COMMERCE

At present, e-commerce implementation [1] process is the widely used client / server technology. The WWW-based internet technology, the client browser / web server and background data services supported by three structural models even though for the vast majority of e-business solutions and practical application of the system adopted, there is still insufficient. How to create a fast, efficient, and intelligent e-commerce[2] has become a very urgent task. The emergence of mobile agent technology, in order to resolve this issue has brought a new revolutionary way. Mobile agent technology has the mobility, collaboration, security and other features will be better to compensate for lack of WWW technology for the development of electronic commerce to provide better and more space for development.

E-commerce based on mobile agent system model design.

A. *Systems Support Environment*

The model system uses a pure Java technology and Java, JDBC database technology, using Java-based mobile agent platform, Aglet to achieve the agent's mobility and security, etc., using Java, Servlet technology, user-generated dynamic pages and to achieve intelligent user agent related functions. JDBC is used for connecting to the database and send SQL statements to handle the database returns the results.

B. System Framework Design

According to e-commerce transaction process, using IBM's mobile agent platform, Aglet, has designed an e-commerce based on mobile agent technology, system model. The system model to overcome the general e-commerce system transactions inefficient and disadvantages of a passive transaction, buyers and sellers can access and publish information in a timely manner

C. Mobile agent analysis and design

The means of communication. Multi-agent most commonly used method of communication is the blackboard system and message communication, according to mobile agent's own characteristics and application requirements of this system, this system uses the message communication. In message-based, agent messages exchanged between the protocol can be used to establish communication and cooperation mechanisms.

D. The Inn server

Mobile agent in heterogeneous network to migrate from one host to another host, and this agent or resources on the host computer interaction, this interaction does not require a network connection communications support. But the mobile agent to migrate from one host to another host in the process it may be due to network outages can not aim to reach the

host, so this design has an Inn-server architecture,to solve this problem.When the mobile agent can not reach the purpose of the mainframe, it will automatically query the server for this zone Inn, and then move on to the server, and monitor the network connection status.

III. PARALLEL COMPUTING

Mobile agent [8] is an autonomous software entity with the capability of roaming among computing nodes. As described in the following section 3, mobile agent can clone himself, then partition part of his task to the duplicate which moves to a new computing node for parallel computing. The properties of mobile agent are naturally suitable for parallel computing in dynamic, complex Grid environment.

Autonomy(to act on their own) gives opportunities for mobile agent to make a decision whether cloning himself and migrating duplicate to another computing node for part task or do the whole task by himself according to both environment and his goals at runtime.

Re-activity(to process external events) senses the change of environment such as appearing some computing resources, etc., then informs agent that there are some new computing nodes available, and the decision of migration can be made. Re-activity can also accept the synchronization signal from the clone agent. When the clone agent finishes the subtask, he will send the synchronization signal to the original agent. The original agent can perceive the signal, then accept the result returned by the clone agent.

Pro-activity(to reach goals) achieves minimal completion time. Co-operation(to efficiently and effectively solve tasks) is a primary advantage for parallel computing. Mobile agent can co-operate with the duplicate, while the duplicate and the original can also clone themselves again. The process is done recursively, which forms the multi-granularity parallel computing.

Adaptation(to learn by experience) constantly reshapes mobile agent according to the dynamic environment and changes mobile agent's behavior based on experience via machine learning, knowledge discovery, statistical techniques, etc. According to the experience, mobile agent can know the capabilities and reliabilities of all computing nodes, then assign the appropriate computing tasks to them.

Mobility (migration to new places) is convenient vehicle for transporting subtasks from one computing node to another, by which subtasks can be distributed dynamically on different computing nodes at runtime, so that multiple computing nodes can work concurrently for the whole task.

A. *Mobility in Parallel Computation*

In old parallel systems, designers must decide which granularity is the best for parallel computing. Now, designers just need one thing to do, which is how to decompose the problem into two sub-problems with divide-and-conquer framework. The other things leave to mobile agent. Divide-and-conquer algorithm partitions the complex problem into two separate, simpler sub-problems of roughly equivalent size and then combines these solutions into a solution for the whole. This process is applied recursively until the sub-problems are so simple to solve easily, which can be described generally as follows:

Procedure *parallel_compute*(P)
1. if (*atomic*(P)) *// tests if is easy enough to solve directly instead of decomposing again*
2. then
3. return *base*(P); *// give the solutions directly for the final simple problems*
4. else
5. begin
6. (P1 ,P2) :=(*fn1*(P),*fn2*(P)); *// partition the problem into sub-problems*
7. T :=*merge*(parallel_compute(P1), parallel_compute(P2)); *//put the two sub-problems into together for the whole*
8. return(T);
9. end

where P is problem of the whole and P1, P2 are the partitioned sub-problems respectively.

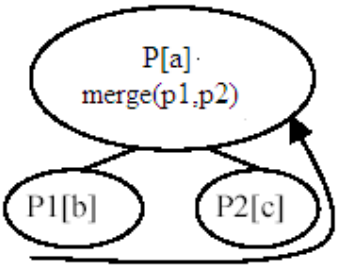

Figure 1

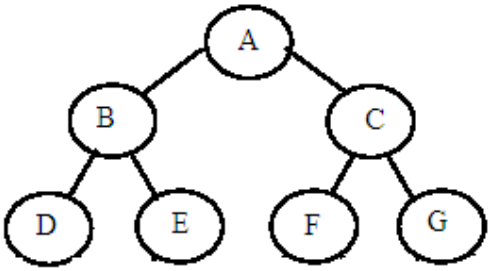

Figure 2

Parallel_compute algorithm can also be represented as Figure 1 with visiting nodes in order: b, c, a. Whilst the recursive solution to the problem is viewed as binary-tree with post-order traversal like Figure 2. The path is E,D,B,G,F,C,A Let suppose that the problem is resolving at computing node A. At the beginning of the process, only the left part of binary-tree is executed and the right part doesn't take part in the process. So there is an opportunity for mobile agent to clone itself and migrate the right branch sub-problem to another available computing node B for parallel computing, at same time, computing node A is noticed that the right branch is treated as the *simple* problem, avoiding overlap computing Furthermore, the origin or the clone can also either resolve the problem itself or clone again. So the parallel computing adapting dynamic partition at runtime is formed.

IV. NETWORK MANAGEMENT

For over ten years, researches are carried out to introduce mobile agents into network intelligent alarm manage-

ment. They also study using mobile agents to reduce the bandwidth. In order to reduce the bandwidth used in network management, Outtagarts et al. [3] propose a solution which is based on mobile agent paradigm instead client-server paradigm based in SNMP protocol. The reducing of network bandwidth occupation with mobile agents is more interested, when network administrators have more than one node to manage. (figure 3)

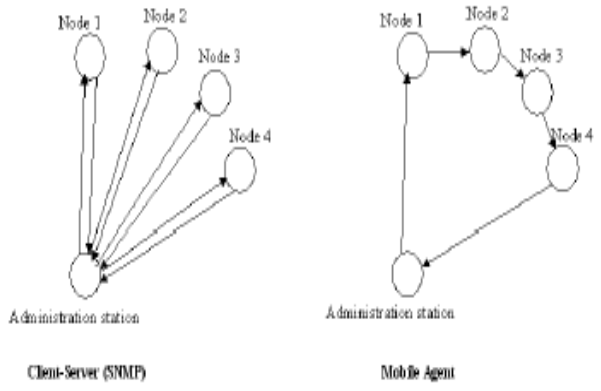

Figure 3–client-server and mobile agent application in network management [3]

Manvi et al. [4] use mobile agent to find multiple QoS paths and select a best path among them to increase call success ratio and network bandwidth. The scheme is simulated in various network scenarios to verify performance. The mobile agent based on-demand quality of service is compared with RSVP-based QoS routing using an internet routing protocol. One of the most significant example of mobile agents applications is the management of commercial telecommunication networks. Currently if an optical cable in the WAN is accidentally cut, the time required to locate the problem may extend ridiculous because of the slow response of the network itself Thanh [5]. Alarms will be sent to all systems attached to this network and data protection can be lost. In addition, these alarms can trigger other alarms and alerts that will spread across the network.This "stream" of alarms due to a single event can take a very long time before fixing the problem and we imagine the financial loss and information that may caused. Agents can change this scenario by instant recognition of the place of the network cut. Also, by using algorithms that can detect secondary alarms caused by the cut, we can eliminate redundant alarms. Research is conducted to introduce mobile agents in products that support event correlation to help stop the alarm in heterogeneous networks Thanh [5]. Based on mobile agent, a routing algorithm with multiple constraints is proposed by CHEN et al. [6] for ad doc network . In the their work, the authors use mobile agents to collect information of all mobile nodes in order to reduces the network delay and the overhead of control messages for routing. They said that their algorithm has lower probability of link failure because it selects links with large link expiration time during route creating phase. Yamaha et al. [7] were interested on flexible peer-to-peer networking technology for information sharing on the Internet (*MiNet*). *MiNet* enables users to share information based on mobile agents (Figure 4), can construct ad-hoc peer-to-peer networks by encapsulating information and sending it as mobile agents. The mobile agents *MiNet* beyond firewalls, proxies, and NATs in LANs. The mobile agent can migrate via HTTP protocols.

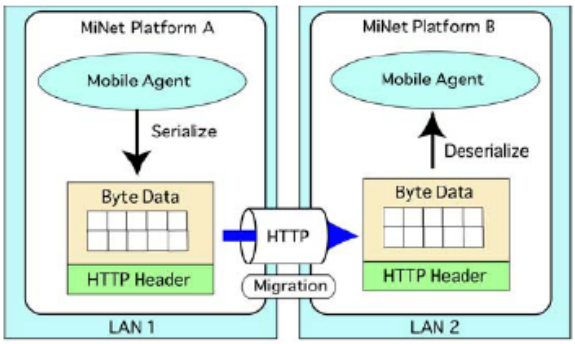

Figure 4 - A Migration of MiNet agent [7]

V. WIRELESS MULTIMEDIA SENSORS

Several works have been done in wireless multimedia sensors using mobile agent. Shen et al. [11] analyze the strengths and weaknesses of mobile agent based middleware. They have proposed mobile agent based publish/subscribe middleware, which improves the efficiency of transmitting agent by using the publish/subscribe mechanism to build interest route. Tu et al. [12] have focused on modeling and designing two mobile agent methods in wireless sensor networks : Static Mobile Agent Planning and Dynamic Mobile agent Planning. Three metrics (energy consumption, network lifetime, and the number of hops) are used in the simulation to quantitatively measure the performance of different itinerary planning methods. Simulation results show that “Dynamic Mobile agent Planning” has overall advantages in terms of energy consumption, network lifetime, and the number of hops. Chen et al. [9], [10] have studied image processing applications over wireless sensor networks, where multiple hops may exist between target source nodes, and the sensory data packets may not be aggregated efficiently.

Agilla is the first system to bring the mobile agent programming model into a real wireless sensor network. By integrating the mobile agent and tuple space programming models, Agilla enables applications to be locally and autonomously self-adaptive. The Agilla programming model and middleware architecture meet the challenges unique to wireless sensor networks, for example, severe resource constraints and unreliable wireless connectivity.

VI. INFORMATION SHARING

An information sharing technique[13] is proposed that employs MA to help knowledge workers, and information seekers to search for and share specific information scattered around a network of nodes.An MA can perform many operations such as (a) navigating through the current network, (b) searching

in a dynamic routing table for specific *registered* devices and (c) returning the IP and the name of those computers. MA can then check the status of these devices (e.g. online or offline) and about their open ports. Using MA, it is possible

to, based on some predetermined authorized access, control the software and data content of a device without the need to involve the device users. An MA has the ability to protect itself by changing its name. Additional protection can be provided by setting a password on the MA or by changing the port. Agent's mobility presents distinct challenges that are not handled by traditional, distributed and/or communication framework. Naturally, an MA changes its location over time which makes communication with it difficult to achieve. That is, a communication infrastructure must handle the case when an MA may be migrating while a message is sent.

An infrastructure is given below that allows navigating MAs to connect different networks, as required, and that satisfies the communication requirements which are specific to MAs. The infrastructure should enable efficient control and monitoring of the MAs and has to facilitate MAs collaboration and coordination. MA-IST consists of a number of the following two components:

A. Network Navigation Component (NNC)

When an MA sends to an appropriate computer C0 (e.g. server) the IP, IP1, of the computer C1 on which it is located, then IP1 is used to retrieve the port number P1 in order to connect to C1 directly according to the security procedure. We have a mechanism that assign to every IP a name. We have also a mechanism that allows us to activate a computer given its IP and port number.
Figure 5 illustrates the functions of **NNC**.

B. File Handler Component (FHC)

Once a connection with a remote device is established using NNC, FHC will be enabled.. The objective of FHC is to allow
(i) remote exploration of the directories and files of the remote device.
(ii) the performance of various operations on files and directories such as copying, deleting and moving on the remote device.

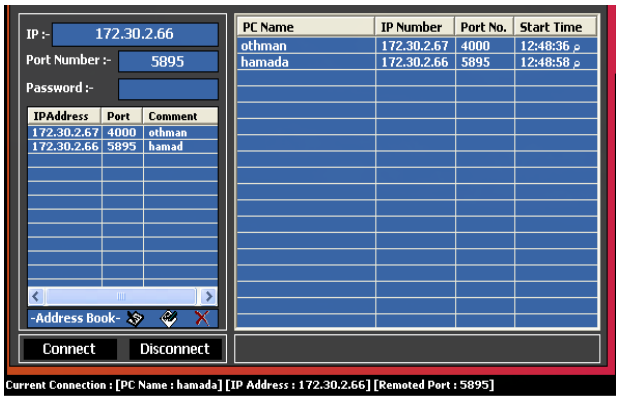

Figure 5: Illustrating Functions of NNC

(iii) the performance of various operations on files and directories between two remote devices. For instance, Assume that C1 is connected, using NNC, to C2. The performance of the operationUpload File-name1 on C1 will copy File-name1 that exists on C1 to C2. However, The performance of the operation Download File-name2 on C1 will copy File-name2 that exists on C2 to C1. Figure7 illustrates FHC.

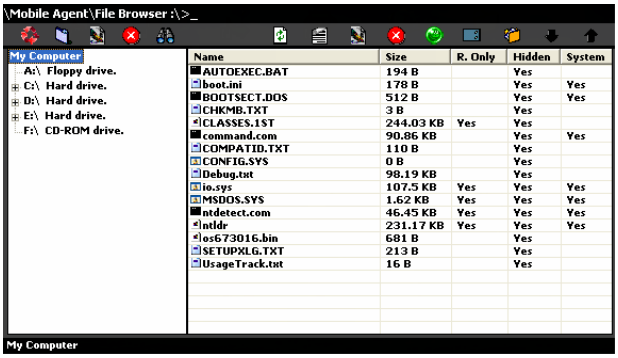

Figure 6: *File Handler Component (FHC)*

The algorithm of FHC is as follows:
1. Find the open port and IP numbers for client device.
2. Check the open port and IP numbers to ensure that the device is online.
3. Check the password for the MA to ensure proper secure work.
4. If the previous three steps are Ok then connect to the device using the port number, IP
number and password.
5. Find all the drives for the client device.
6. Search for the needed information using FHC.
7. If any error occurs while retrieving files then the connection is closed automatically.
8. In the end, close the connection and exit the client device.

VII. GRID COMPUTING AND GRID SERVICES

Grid computing allows different organizations (virtual organizations) to share resources which are geographically distributed in order to get common goals. Mobile agent technology has been used by Aversa et al. [14] to develop agent based Grid services. The service are delivered using a standard interface which is compliant with the common services. Agents use the ACL (Agent Communication Language) message to migrate in Jade platform [15]. In order to enter the Grid node, the agent must be transmitted as a SOAP message. The agent can migrate from the Grid node the any nodes outside the Grid by the http default transmission protocol used by Jade (Figure 7). Tong et al. [16] propose a prototype system, the Geographic Information Grid System (GIGS) based on mobile agent. This system provide services and improve sharing distributed resources. In the context of grid architecture [17], [18], Wang et al. [17] present a knowledge grid architecture based on mobile agent in order to implement knowledge grid services. An other architecture is proposed by Tveit [18] to enables routing and handling of FIPA ACL messages.

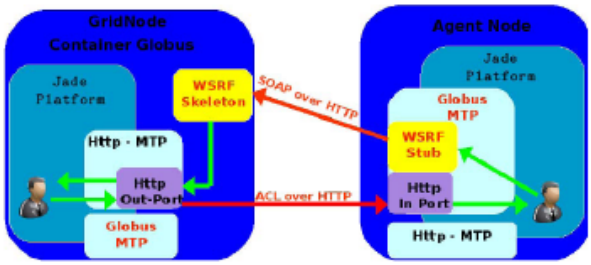

Figure 7 - Agent migration to a Grid Node [14]

VIII. MULTIMEDIA

Recently Picard [19], [20] have study in his thesis the search of images in distributed databases using multi-agent systems. The mobile agents roam in the network to search relevant images and mark the relevant pat guide to the interesting sites. His strategy is based on the behavior of ants and their marking of the environment by using pheromones. The author re-use the marks done during previews session in new research sessions. This learning during different session allows agents to find more easily the sites containing the relevant images. Haider et al. [21] present a solution based on Mobile Agent and introduces the concept of Middleware for dynamically discovered, location dependent multimedia services for mobile devices. Mobile Agents perform tasks on behalf of mobile device over a fixed. The action performed by the mobile agent are : configuration and reconfiguration, communication, downloading multimedia to mobile device and Quality of service handling.

IX. CONCLUSION

In this paper, a survey of mobile agents based applications in different domain areas and implementation platforms have been presented. Research on mobile agents have started for over a decade in general and in the fields of network management and electronic commerce in particular. With the development of new networks, the increasing of networks bandwidth and innovation in cloud computing in recent years, there has been an upsurge in the use of mobile agents in different research areas described above. The major functions which mobile agents are better adapted are : gathering, filtering, sharing, monitoring, recommending, comparing information, guiding Web surfers, email filtering, auto responders and negotiating.

X. FUTURE WORKS

Distributed computing involving several computers in a network can be achieved using message passing or remote procedure calls (RPC). The recently developed mobile agent technology adds a new dimension to distributed computing. Experts suggest that mobile agents will be used in many Internet applications in the years to come. However there still exist many technical hurdles that need to be tackled, the most important of them being security. Only when security issues are properly addressed, will the mobile agent technology be widely accepted.

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