Hierarchical Location Management Schemes for Mobile Multi Agents Communication

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Abstract

Mobile Agent (MA) roaming in a network is still a current research topic. Mobile Agent is self-directed entity which moves from one computer to another in the open network under its own control. Due to the roaming nature of MAs, it is very tough to get the location of MA until it comes back to origin host after completing its itinerary. When multiple agents interact with each other they make a multi agent environment. For the interaction of MAs first they need to know the location of each other. This paper presents a Hierarchical Location Management Scheme (HLMS). Here global network is divided into different regions. In each region, there is a centralized component responsible to maintain the location of all MAs presently executing in its region. It also records the address of the regions where MA is migrating. This paper details the different communication mechanisms of MAs. There are two different ways of communication. First is message passing and second is mailbox approach. In message passing MAs can easily communicate through sending a message to each other. In a mailbox approach, again there are two cases first is communication between the same base host MAs and communication between the different Base host MAs. In the literature search and update method has already proposed. But these approaches are not cost effective. Search takes less time but this is a very long process and update is a fast process but the update cost is very high. Hence this paper combines the both search and update method.

Keywords- Mobile Agent (MA), Location Management (LM), Mailbox.

Introduction

A Multi Agent System is a system collected of numerous interacting intelligent agents. MA contain by the Multi Agent System can launch by launch by same host or by different hosts or combination of MAs and software agents. Multi Agent System is used to solve problems which are hard or unfeasible for an individual agent to solve. But for a Multi Agent System the two main issues are Location management & communication. Lots of Mobile agent systems have been proposed in the literature. But most existing MASs do not provide a complete, proficient or useful location management approach. Hence, there is a need of a mechanism to locate any type of mobile agent at anytime from anywhere. Communication is also a necessary component of scattered systems and this is no exception for multi-agent systems (Aggrawal, *et al.,* 2013; George *et al.,* 2002; Heman *et al.,* 2014). This paper proposes the improve mechanism to locate MAs for both cases mentioned earlier as well as provide a communication mechanism between the MAs.

Hierarchical Location Management Scheme (HLMS)

Location management becomes necessary requirements for mobile multi agent environment. For communication, there is a need to locate MA first before communication starts among the MAs. The

location management mechanism consists of location updates, searches and search updates. When a mobile agent changes its location the update process occurs. When a mobile agent needs to be located a search process occurs. After a successful search operation, a search–update process occurs. The cost of location update and search is a big issue of the management in mobile agent computing. The goal of an efficient location management strategy should be to provide low cost of location search and updates (Lin, *et al.,* 1997; Bar-Noy *et al.,* 1995). The cost of a location update and search is characterized by the time taken for each operation, number of messages sent, size of messages, or the distance the messages need to travel. A proficient location management scheme should effort to minimize the combined cost of the location Search and update. At one extreme, up-to-date information of the exact location of all mobile agents is maintained at each and every node in the network. This decreases the search time to locate the mobile agent. But every time the location of the mobile agent changes, a huge number of associated location databases must be updated, which absorbs cost of location update. At the other extreme, no information is stored at any site of the network. To locate a mobile agent, a global search at all network sites must be initiated; however, when the mobile agent moves, no cost is associated with updating the location database. Between these two boundaries, various approaches that equilibriums the cost of search against the cost of updates are possible. (Patel, *et al.,* 2010; Pathak, *et al.,* 2014).

Our work is inspired by (Patel, *et al.,* 2010; Patel, *et al.,* 2004; Pathak, *et al.,* 2012; Pathak, *et al.,* 2012; Serugendo, *et al.,* 2003; Xinyu, *et al.,* 2001; George, *et al.,* 2002). All these approaches divide the network into regions and in charge of that region keep track of all mobile agents in each region. Search, update or combinations are then used to locate MA. Regions may be in one, two or multiple levels. Hierarchical location Management Schemes (Pathak, et *al.,* 2012) assumes that internet is network of networks where networks are connected with each other via router. Each router maintains an Agent Table which contains all the MAs currently executing on the network and their *HostId*. When a MA moves from one host to other within the same network Agent Table is modified. When MA moves from one network to other, receiving router launch an Update Agent to inform the Base Host about the new network location of the MA. So in this approach Base Host always knows the current network of its MA. To communicate with MA, Base Host sends message to the MAs router, where router locate the MA by searching the Agent Table and deliver the message. In this way this approach combines both search and update schemes. In this paper, we will extend this scheme for mobile multi agent where instead of base host, MAs launched by same host or different host locate each other before initiating the communication.

In the proposed Hierarchical Location Management Scheme (HLMS) for Mobile Multi Agent System, there are various components namely Router, Hosts, mobile agents and their mailboxes. Each host runs a Mobile Agent System (MAS) which is used for the execution of MAs. It also provides communication, mobility and security support for mobile agents. All the hosts are connected by the network and can communicate with one another by sending messages on the network. Here we are using the case of FM for the migration of Mailbox of MAs.

Communication Process

An agent is an entity which executes an algorithm: it can move from place to place (with some data and its algorithm) through communication links and it can make local computations on a place (a place provides tools for local computations: data, memories and process). Inter agent communication is an issue that has been addressed in a limited manner by the mobile agent's community. Agent communication languages (ACLs) have been developed as tools with the capacity to integrate disparate sources of information and support interoperability but have achieved limited use by mobile agents (Yannis, *et al.,* 1999).

In the literature, different techniques are used for the communication of mobile agents. Mailbox

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techniques, Broadcast & black board were three most popular techniques used for communication. A mailbox (R. B. Patel et al., 2004), which is a message buffer used to store incoming messages destined to an agent, can be detached from its owner agent in the sense that the mailbox can reside at a location different from the current location of the owner agent. Every mobile agent in the system is allocated a mailbox. Incoming messages sent to the agent are inserted into the mailbox first. The communication between agents is divided into two steps: the *transmission* of a message from the sender to the receiver's mailbox and the *delivery* of the message from the mailbox to its owner agent. If an agent wants to send a message to another Agent, it simply sends the message to the receiver's mailbox. Later the receiver receives the message from its mailbox using either pull or push. In the push mode, messages stored in the mailbox will be delivered to the mobile agent, while with the pull mode; the agent fetches messages from its mailbox any time it decides to do so (Xinyu, *et al.,* 2001).

Notice that, for a frequently migrating agent, its mailbox can migrate at a much lower frequency. There are three main aspects are for the MAs communications are: (Jiannong, *et al.,* 2004) the first approach is Frequency of Mailbox Migration. In this approach A Mobile Agent is always moving on the path but it does not carry its mailbox with itself. It leaves its mailbox at its Base Host. This technique is called No Migration (NM); or MA might carry its mailbox with its migration path. This pattern is known as Full Migration (FM); or MA might determine the location of its Mailbox dynamically upon each migration, this technique is known as Jump Migration (JM). The second approach is message Delivery from Mailbox-to-Agent. In this approach MA receives the messages from its mailbox using either a push or pull operation. In the Push (PS) mode, the mailbox keeps the address of its owner and forwards every incoming message to it. In the Pull (PL) mode, the mobile agent keeps the address of its mailbox and retrieves messages from the mailbox whenever needed. The third approach is Synchronization of Migration-Delivery. In this approach Delivery of a message can be reliable according to the need of the user. If users demand high reliability, they can overcome message loss by (1) Synchronizing the Host's message forwarding and the Mailbox's migration (SHM), or by (2) Synchronizing the Mailbox's message forwarding and the Agent's migration (SMA), or (3) both, known as Full Synchronization (FS). NS denotes the extreme case of No Synchronization being performed.

Component of the System

The different Components (Pathak, *et al.,* 2012; Pathak, *et al.,* 2014) of our improved Hierarchical Location Management System for Mobile Multi Agent are:
Router: It is a component which connects the different network with each other. All MAs are migrating from or entering into a local area network via router. Instead of just receiving and forwarding the MA, router in this mechanism plays an active role. The different component installed on the router is:

Location Management System (LMS): It is a system which manages the location of the MAs.

Log Manager (LM): It manages the arrival and departure time of the MAs.

Host: A host in the global network is identified by number known as ***HostId***.

Mobile Agent: Every MA in the system is identified with unique ***AgentId***. It carries Parent ***HostId*** and certificate of verification SC (String, Destination ***HostId***) for communication and another agent for communication.

Search Agent: In order to locate a MA, its base host launches a Search Agent (SA).
Update Agent:- When a MA arrives at a network, an Update Agent (UA) is created to inform BH about the new network location of MA. It is also used to update the location to the Central repository.

Packet: Agents move from one part of the network to other via global network in form of packet. A packet consists of an Agent, sender ***HostId***, destination ***HostId*** and type of agent MA, SA or UA.

Base Table: Every Network maintains a Base Table, which is the list of AgentId and the current NetId of the MA.

Agent Table: Every network maintains an Agent Table which is the list of ***AgentId*** of MA and ***HostId*** of the hosting Node.

Log Table: For all MAs received at the router an arrival entry is logged in LogTable similarly before leaving a network departure entry is logged to the Log Table.

Agreement Table: It contains the ***HostId*** of the hosts with which agreement has been signed. It also contains the Date time and duration of agreement.

Different Methods to Locate Mobile Agents in HLMS

Case 1- For the Same Base Host

This section proposes a mechanism to locate different MAs launched by same Base host. Every host maintains a Base Table which stores network Ids of all the active MAs launched by it. Base Host always knows the current network location of MAs (Aggarwal, *et al.,* 2013). So if a MA wants to communicate with other MA launched by same base host, The algorithm is as follows:-

1. The process **GetNetId()** launches a MA to visit the base host to collect the ***NetId*** of the target MA.
2. The process **ReturmNetId()** returns the Network id of the target MA.
3. The process **GetHostId()** initiates a search procedure to visit the ***NetId*** of target MA and search the local Agent Table to get the ***HostId*** of target MA.
4. The process **ReturmHostId()** returns the ***NetId*** of the target MA.
5. The process **SendMessage**() is initiated when mailbox address of the target agent is known, it drops the message to the mailbox of the target MA.
6. The process **GetMessage**() is initiated by the target MA. Here target MA wants to get the message from its mailbox. To get the message MA use push and pull approach as shown in figure1. In the Push (PS) mode, the mailbox keeps the address of its owner and forwards every incoming message to it. In the Pull (PL) mode, the mobile agent keeps the address of its mailbox and retrieves messages from the mailbox whenever needed.

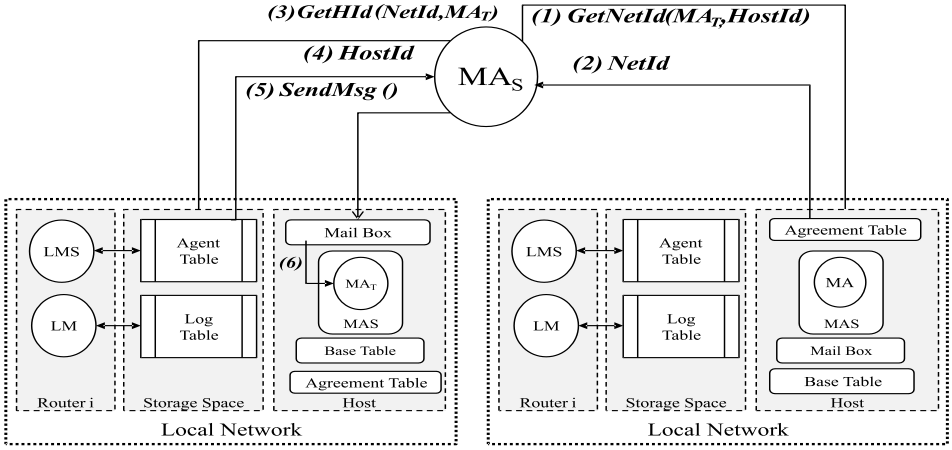

Figure 1: MA communication for the same Base Host

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Case 2: - For Different Base Host

A. Two-way communication

Sometimes there is a need to communicate among different MAs launched by different hosts. MAs launched by two different hosts can communicate with each other only if both the hosts trust each other and have signed an agreement to allow their respective MAs to locate and communicate with each other. For signing an agreement every host contains and Agreement Table which contains the ***HostId*** of the signed Host Through agreement each MA carries with it the Base Host of itself as well as the HostId of the Host with which agreement has been signed.

According to (Pathak, *et al.,* 2012) every host maintains a Base Table which stores the ***AgentId*** and its current ***NetId***. Hence to communicate with any MA, source MA requires the current *NetId* of target MA. Since it already knows the Base Host of the target MA it will send a request to the Base Host of target MA to get its current NetId. For the security purpose, it should not be allowed for any MA to locate and communicate with any other MA. When MA send a request for the *NetId* to the target Host then target host will only allow access of *NetId* to the trusted MAs. So, if a MA wants to communicate with another MA launched by the different base host, the algorithm is as follows: -

1. The process **GetNetId**() launches a MA to visit the Base Host of target MA to collect the ***NetId*** of the target MA.
2. The process **ReturnNetId()** returns the ***NetId*** of the target MA.
3. The process **GetHostId()** initiates a search procedure to visit the ***NetId*** of target MA and search the local AgentTable to get the ***HostId*** of target MA.
4. The process **ReturmHostId()** returns the ***NetId*** of the target MA.
5. The process **SendMessage()** is initiated when mailbox address of the target agent is known, it drops the message to the mailbox of the target MA.
6. The process **GetMessage()** is initiated by the target MA. Here target MA wants to get the message from its mailbox. To get the message MA use push and pull approach as shown in figure2. In the Push (PS) mode, the mailbox keeps the address of its owner and forwards every incoming message to it. In the Pull (PL) mode, the mobile agent keeps the address of its mailbox and retrieves messages from the mailbox whenever needed.

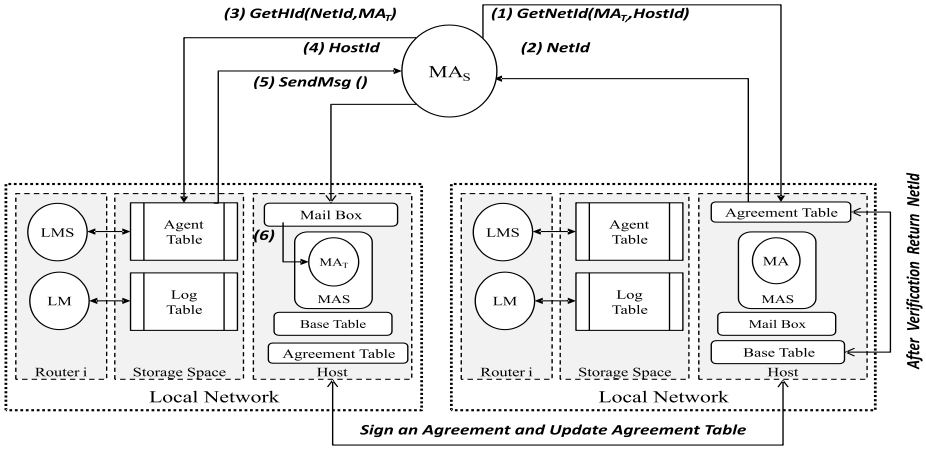

Figure 2: MA communication for the different BH

But this method has a limitation of high cost associated with the tracking of location of MA. It is a kind of two-way communication between the different MAs which increase the cost of searching and update. For the solution of this problem we can use a centralized data base approach for storing the location of MAs.

B. Centralized Approach

All hosts in a network make an agreement for a centralized place holder at a particular Host. Hence all MAs and Host update the location of all MAs on a particular CPH of a host which signed by the agreement. When a MA wants to communicate with other MA, MA will send a request for getting the agent location from the CPH. Hence CPH *w*ill provide the actual location of the target MA to the source MA. Hence if a MA wants to communicate with another MA launched by the different base host, the algorithm is as follows: -

1. The process **GetNetIdandHostId()** initiates a search procedure to visit the ***NetId*** of target MA and search the Location Table to get the ***NetId*** and ***HostId*** of target MA.
2. The process **ReturnNetIdandHostId**() returns the ***NetId*** and ***HostId*** of the target MA.
3. The process **SendMesg()** is initiated by the source MA when mailbox address of the target agent is known; it drops the message to the mailbox of the target MA.

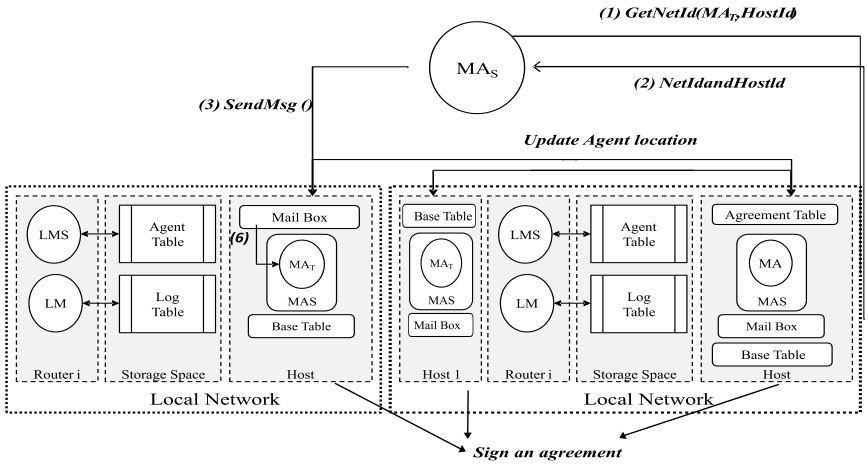

Figure 3: MA communication by CPH

4. The process **GetMessage()** is initiated by the target MA. Here target MA wants to get the message from its mailbox. To get the message MA use push and pull approach as shown in figure3. In the Push (PS) mode, the mailbox keeps the address of its owner and forwards every incoming message to it. In the Pull (PL) mode, the mobile agent keeps the address of its mailbox and retrieves messages from the mailbox whenever needed.

Conclusion

Communication among the MAs is a very important issue of mobile agent computing. It determines how much information is exchanged between agents. According to the amount of information available to an individual agent we can make the decision-making process effective. In an open environment, agents are mobile and may leave or enter the system. Hence two closely related agent communication problems

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occur, namely efficient message passing and service agent discovery. For the communication, track the location of MAs are very important. Our work is based on this approach. Here we gave two different ways of communication for MAs Here global network is the network of networks. The different networks are connected with each other via Router. All MAs are migrating from or entering into a local area network via router. Host can be the part of any network in the global network. If Base host of different agent are same so there is no need to find the *NetId* of the MA because Base Host already knows it but if Base Host are different, first Both the host sign an agreement between each other than the agent can communicate. But in this case searching cost is very. Here we are giving a new approach of MAs communication through location management.

Future Work

Our work is based on the location of MA's and their communication in a multi agent environment. Here a new mechanism to locate MAs and its solution has been proposed. We also have explained the different cases of Mobile agent communication. We will simulate it in our next paper using CPN tool. We are working on it and trying to give a better result in terms of cost. We will also propose some solutions and problems of these approaches.

References

Aggrawal, S., Pathak, H. 2013. Analysis of Location Management Mechanisms forMobile Multi Agents. *International Journal of Information and Computation Technology (IJICT),* 3 (9), 917-926.

Bar-Noy, A., Ilan, K., Moshe, S.1995. Mobile users: To update or not to update?. *Wireless Networks* 1(2), 175-185.

Feng, X., Jiannong, C., Jian, L, Henry, C. 2001. An efficient mailbox-based algorithm for message delivery in mobile agent systems. *International Conference on Mobile Agents*, 135-151.

George, S., Spyrou C., Pitoura, E., Marios, Dikaiakos. 2002. Tracker: A universal location management system for mobile agents. *Proc. The European Wireless 2002 Conference, Next Generation Wireless Networks: Technologies, Protocols, Services and Applications, Florence, Italy,* 572-580.

Jiannong, C., Liang, Z., Xinyu, F., Das, SK. 2004. Path pruning in mailbox-based mobile agent communications. *J. Inf. Sci. Eng.* 20 (3), 405-424.

Lin, Y. 1997. Reducing location update cost in a PCS network." *IEEE/ACM Transactions on Networking (TON)* 5 (1), 25-33.

Patel, R.B., Nikos, E., Garg, Kumkum. 2010. Mobile agent location management in global networks." *Annals of" Spiru Haret". Economic Series,* 10 (2), 123-135.

Pathak, H. 2012. Colored Petri Net based Modeling of Hybrid Location Management Mechanism for Mobile Agents. *Journal of Information Systems and Communication (JISC)*, 3 (1), 291-294.

Pathak, H. 2014. Search and Update Based Solutions to Locate Mobile Agents in the Global Network" in

International Journal of Mobile and AdHoc Network (IJMAN), ISSN (Online): 2231:6825 ISSN (Print), 2249–202X, 4 (1), 75-79.

Pathak, Heman. 2012. Comparative Performance of Hierarchical Location Management Mechanisms for Mobile Agents. *Journal of Information Systems and Communication (JISC)*, 3 (1), 278-281.
Rama, S., B, Rama., Garg, K. 2008. Location update schemes for mobile agents." *INFOCOMP Journal of Computer Science* 7(2), 37-43.

Serugendo, G., Romanovsky, A. 2003. Designing Fault-Tolerant Mobile System, *International Workshop on Scientific Engineering for Distributed Java Applications*, 185-201.

Yannis, Labrou., Finin, Tim., Peng, Y. 1999.The interoperability problem: Bringing together mobile agents and agent communication languages. *Systems Sciences, Proceedings of the 32nd Annual Hawaii International Conference,* 10.

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