Volume 5, Issue 5, MAY 2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Performance Measures for Mobile Agents

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Abstract— Mobile agent technology is a novel paradigm that comprises of program that implements a software agent. This program can suspend its execution on a host computer, transfer itself to another agent-enabled host on the network, and resume execution on the new host. These agents must be smart enough to act efficiently. Their major applications are in field of network management and load balancing. The objective of this paper is to propose a set of measures for evaluating the performance of a mobile agent. These measures may be used to check some aspect of mobile agent's quality.

Keywords — Mobility, Mobile Agent, Performance measures.

I. INTRODUCTION

One of the most popular ways to achieve mobility is by using mobile agent. Mobile agent is an agent that has movable code, data and its state. It can move itself in the environment to achieve its objective. The mobile agent technique is an emerging technology in the context of telecommunications [2]. Static and Mobile multi-agent systems were evaluated using a number of performance metrics to demonstrate the strengths and weaknesses of the respective approach [3]. A novel performance analysis approach has been proposed that can be used to gauge quantitatively the performance characteristics of different mobile-agent platforms [4]. A quantitative performance analysis methodology has been described that has been developed to investigate performance properties of MA platforms and systems [5]. Free Area Mechanism (FAM) has been defined as a new mechanism that increases the mobile agent performance securely. The main idea behind this mechanism is to reduce the mobile agent size [16].

In this paper we have proposed four new metrics for mobile agent. These metrics are analyzed how they can affect the performance of mobile agent. Agent behaviour may change for same input in different cases and thus it is difficult to evaluate the exact quality of an agent.

The paper is structured as follows. The section 2, we discuss about mobile agent and the working of mobile agent in distributed system. Section 3 suggests various metrics required to measure performance of a mobile agent. Section 4 evaluates the proposed metrics of mobile agent on a program. The last section 5 includes some concluding remarks and discusses future research.

II. MOBILE AGENT

Mobile agents are autonomous programs that can travel from computer to computer in a network, at any time and place of their own choosing. In fact, mobile agents have several advantages in the development of various services in smart environments in addition to distributed applications. Benefits of mobile agent are Bandwidth Conservation, Reduction of Latency, Reduction in Completion Time; Asynchronous (disconnected) Communication, Load Balancing, and Dynamic Deployment.

TABLE I EVOLUTION OF MOBILE AGENTS

Mobile Code =	Transfer of Code		
Mobile Objects =	Transfer of Code +	Data	
Mobile Agents =	Transfer of Code +	Data +	Thread and Directive

Table 1 shows the evolution of mobile agents. Mobility can be achieved with various techniques like mobile code, mobile objects and mobile agent. Mobile agent is the latest and most powerful among all these. Functions of a mobile agent can be Migrating, Cloning and Saving itself on some storage medium.

- **Migration**

In an agent system, the migration is initiated on behalf of the agent and not by the system. Agent migration is a mechanism to continue the execution of an agent on another location. It includes the transport of agent code, execution state and data of the agent.

- **Cloning**

It is a technique by which a mobile agent can make a copy of itself which has the same code and data as the original agent at some state. Cloning is done to protect the mobile agent in a network during migration and to protect it from malicious agent server which execute the agent [13].

- **Saving its state**

Migration mechanism of a mobile agent requires the capturing of state information and the reestablishment of the saved state during restart. The state of the running program is saved, by being transmitted to the destination. The program is resumed at the destination continuing its processing with the saved state.

- **Message Passing**

Message passing is a mechanism in mobile agents to coordinate their activities with another agent or user. Communication is done via message passing. Mobile agent supports synchronous and asynchronous mode of communications.

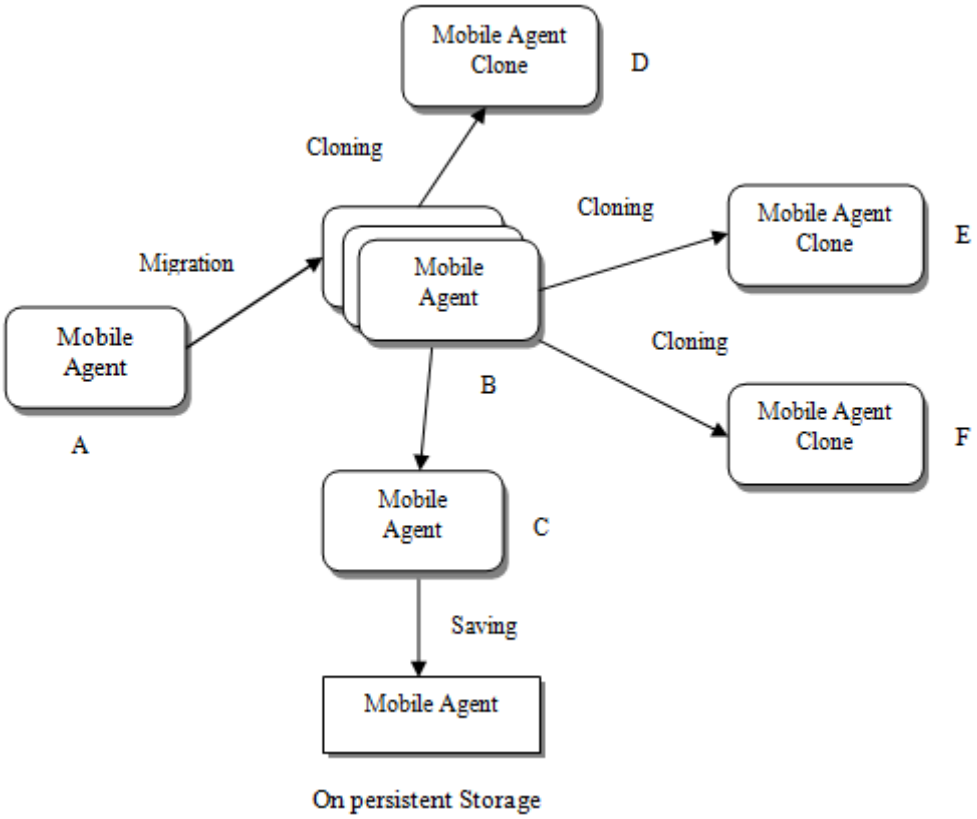

Fig 1 Function of Mobile Agent in Distributed System [11]

As shown in Figure 1, mobile agents can save themselves through persistent storage, duplicate (make clone of) themselves and migrate (mobility) themselves to other computers under their own control (autonomy), so that they can support various types of processing in distributed systems. Where A, B, C, D, E and F are different computers in the distributed system.

III. PERFORMANCE MEASURE FOR MOBILE AGENT

Being mobile agent is a type of software agent, so most of the measures of software agent can be applied on mobile agent. But due to unique feature of mobile agent i.e. migrating itself in environment make it special from a simple agent, so there should be some metrics which can measure these features of a mobile agent. In this section we have proposed some metrics to measure the performance of mobility of an agent.

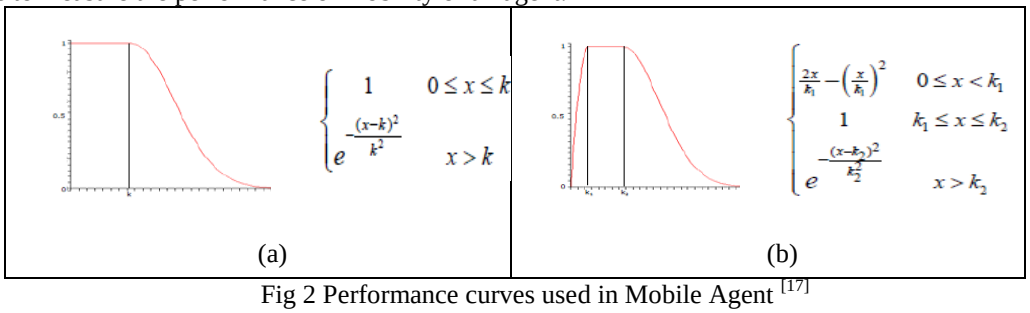

Fig 2 Performance curves used in Mobile Agent [17]

A. Agent Location Visited Factor (ALVF)

It is defined as the ratio of number of locations visited by an agent during its lifetime to total number of locations.

$$\text{ALVF} = \frac{\text{Number of Locations visited(LV)}}{\text{Total number of locations (TL)}}$$

This metrics will follows the curve (a) in figure 2, that is let we assume the minimum number of location, to be visited, be 10 i.e. upto ten locations the performance of the mobile agent be some ideal value say 1(nearly). If more locations have to visit for some reasons the performance will start decreasing as the number of locations starts increasing. This is because the agent spends more of time in searching for the required location rather than in performing the task.

B. Agent Clone Created (ACC)

Clone of mobile agents are created to enhance the security. Cloning is done by creating duplicate of an agent. In a system there can be more than one mobile agent and one mobile agent can have more than one clone.

This metric counts the number of clone created by an agent during its lifetime. It is defined as sum of clones of agents to the total number of agents

$$\text{ACC} = \frac{\sum_{i=1}^{n} f_i}{n}$$

Where, n is the total number of Mobile Agents.
and f_i is the number of clones of i^{th} agent.

Let we assume a system can have 10 mobile agent and the total number of clones of 10 agents are 50, then the value of ACC will be 5. This metric will follow the curve (a) in figure 2, where x is ACC. The value of the measure upto k is optimum i.e. for some k the performance of the system is ideal. Once the ACC get increases beyond k the performance of the system starts decreasing due to increased complexity and more overhead created between various clones.

C. Messages Served by Agent (MSA)

This metric measures the messages served by an agent in response to another agents those are requesting services from the agent.

It is defined as ratio of number of messages served to total number of messages received.

$$\text{MSA} = \frac{\text{MS}}{\text{TRM}}$$

Where, MS is the number of messages served
TRM is total number of messages received.

Suppose total number of message received is 10 and the number of message served is 7, the value of MSA will be 0.7. This measure will follow the curve (b) in figure 2. Initially the performance of the measure increases upto the value k1. If MSA is greater than k1 and less than or equal to k2 the performance is optimum. If it becomes more than k2 the performance start decreasing because large number of exchanged messages may consume more time in message exchanging.

D. Messages Rejected by Agent (MRA)

This measure is defined as ratio of number of rejected messages to total number of messages received.

$$\text{MRA} = \frac{\text{TRM} - \text{MS}}{\text{TRM}}$$

$$= 1 - \frac{\text{MS}}{\text{TRM}}$$

$$= 1 - \text{MSA}$$

Where, MS is the number of messages served
TRM is total number of messages received.

This measure follows the curve (a) in figure 2. The measure is considered optimum if the rejected services are low. The performance starts to fall in excess of quantity k of rejected services, because rejection means agent does not cooperate with other agents.

IV. EVALUATION OF THE PROPOSED MEASURES OF MOBILE AGENT

The proposed measures are applied on mobility program build in JADE platform. In JADE, application developers can build mobile agents, which are able to migrate or copy themselves across multiple network hosts. In this version of JADE which we have used, only intra-platform mobility is supported, that is a JADE mobile agent can navigate across different agent containers but it is confined to a single JADE platform [18].

TABLE II EVALUATING MEASURES ON A JADE PROGRAM

Measures	**Program**
Agent Location Visited Factor (ALVF)	0.666
Agent Clone Created (ACC)	2
Messages Served by Agent (MSA)	0.625
Messages Rejected by Agent (MRA)	0.375

From table 4.3 we can say the value of ALVF is high that is .666. From curve (a) in figure 4.3, if we take on an average k in between 0.4 to 0.6, then in this case x > k. Hence the performance of the system is not good for this value.

Value of ACC is 2. This measure follows the curve (a), if we take k between 4 or 5, so x < k. the performance of the system is ideal for this measure.

Measure MSA has value 0.625. If we take k1 between 0.4 to 0.5 and k2 between 0.6 to 0.7, then the performance is optimum, as value of MSA lies between [k1, k2].

Measure MRA has value 0.325. If we take k as between 0.2 or 0.3, here x > k. hence the performance of the system is slightly less as the number of rejected messages are more than k.

V. CONCLUSIONS

Mobility is the ability of a software agent by which it can move across the network. Mobility can be achieved with the help of mobile code, mobile objects and mobile agent, where Mobile Agent is the latest and powerful in all these approaches. In this paper we have discussed about the mobile agent, working of a mobile agent in a distributed system, various functions of mobile agent such as migration, cloning, saving its state and message passing. From these function of mobile agent we have proposed few measures for mobile agent which can be used to measure to performance of mobile agent. These measures are Agent Location Visited Factor, Agent Clone Created, Messages Served by Agent and Messages Rejected by Agent. We have applied the performances curves on these measures. We also evaluate these new measures on a module of Mobile Agent. The program chosen for the evaluation of metrics supports only intra-platform mobility i.e. JADE mobile agent can navigate across different agent containers but it is confined to a single platform. The values of ALVF and MRA are found to be high as compared to the optimum values hence the performance is affected slightly by these measures. The values of ACC and MSA are found to be good which result in optimum performance of the mobile agent system. The behaviour of agent is not always same for same input so the exact measure is not possible it is just an approximation. Our future work is to apply these measures on some project which support mobility on different platform.

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