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An Architecture based hybrid approach for Network Management through Mobile Agents

Sayana Catharin Paul, Soumya Thomas, Sreedevi.R, Syamala.s

Abstract -- **Conventional Simple Network Management Protocol (SNMP) based network management is centralized which leads to excessive processing load at the manager and increased bandwidth utilization which in effect reduces the scalability of the network. In order to overcome these problems, a distributed network management framework is developed by adding a layer of mobile agents over the conventional SNMP protocol which makes our architecture a hybrid model incorporating the advantages of both systems. We introduce an architecture consisting of different agents utilizing the features of SNMP for managing various aspects of network management. The Java Agent Development Framework (JADE) is used to develop the platform for the mobile agents. JAVA provides the SNMP support**

Index Terms**— Congestion, Load balancing, Mobile agent, Bandwidth utilization, SNMP, Fault Monitoring**

1. INTRODUCTION

In conventional network models like client/server systems[7], there is a single server managing a large number of clients based on protocols like the Simple Network Management Protocol[1]. Every detail regarding the network management is stored and processed in the manager system which creates an information bottleneck and an excessive processing load at the manager.

A large amount of information that pertains to network management is exchanged through the network which creates congestion and increased bandwidth usage thereby reducing the overall performance and reliability of the network. As the whole network is controlled and monitored by the manager, a manager failure can lead to a network crash. Lack of scalability is another problem associated with centralized approach. It refers to the lack capability to increase total throughput under an increased load when resources (typically hardware) are added. Also for managing a network system, sometimes network administrator needs to locally administer components on multiple nodes in the system.

The traditional network management architecture is inefficient, expensive and difficult to change.

Hence we extend the conventional centralized network management protocol to distributed, by adding a layer atop SNMP. The distributed system reduces the disadvantages associated with centralized system to a certain extent, although it requires some complex coordination mechanisms between management stations.

In this paper, we present a framework for network management using mobile agents. An agent is a software entity capable of acting intelligently in order to perform a particular task. Mobile agents are software programs that can migrate across the network from the client to the server and vice versa carrying logic and data. They are autonomous and can deal with a huge amount of data. A typical mobile agent is autonomous, mobile, persistent, communicative/ collaborative, active /proactive. The advantages of using mobile agents include

- An agent is small in size and can hence reduce the network traffic.
- An agent can easily move across the network.
- Bandwidth conservation.
- Reduction of latency.
- Reduction of completion time.
- Load balancing.
- Dynamic deployment
- Reduction of completion time.
- Load balancing.

Our network management framework is a multi mobile agents system which includes a main agent called producer agent that generates the various agents designed for accomplishing specific tasks, a number of mobile agents traversing across the network carrying information and a SNMP agent that interacts with the mobile agent and the database, Management Information Base(MIB). The architecture has been prototyped based on Java Agent Development Framework (JADE).

The two major aspects of network management onto which we are focusing are performance management and fault monitoring. Performance management involves gathering statistics about network traffic and schemes to condense and present data. It includes activities to ensure that goals are consistently being met in an effective and efficient manner. As we are using mobile agents (unlike the centralized system which includes the exchange of large amounts of data through the network increasing bandwidth utilization) only small amount of data related to performance management is needed to be sent through

- ***Sayana Catharin Paul, Soumya Thomas, Sreedevi.R and Syamala S are*** *currently pursuing master of Technology in Computer Science and Engineering. At Amal Jyothi College of Engineering, Kanjirappally, Kottayam, Kerala , India Emal: sayana0708@gmail.com*

the network. Instead of querying the managed node for every fixed interval and analyzing the performance from management station, mobile agent can be dispatched to analyze the node locally by using either broadcast or itinerary model

Fault monitoring involves finding faults in the devices connected to the system. Faults can be detected by using mobile agents. A mobile agent designed for identifying any sort of abnormalities can be dispatched from the management station to the managed nodes. These agents on reaching the managed nodes, analyses the node locally for any fault such as increased interface usage etc. On detecting which, it sends back a message to the manager. The manager can then perform suitable actions to monitor and restore the system back to the normal state. Since our flexible architecture doesn't lose the advantages of conventional SNMP management techniques, low-level fault detecting schemes based on SNMP could be used in the detection and correction of some faults.

The paper is organized in the following way. We first describe why we used mobile agents, in Section 2. Then we introduce concepts involved in SNMP based network management and then present the mobile agent based network management framework and its components in Section 3. In Section 4, we explain about various mobile agents in our system and their function. In Section 5, interactions between different agents are discussed. In Sections 6 and 7, performance management and fault monitoring respectively are explained. In Section 8, we describe network management patterns using mobile agents and demonstrate the effectiveness of their usage in determination of a "Health Functions" [4]. Finally we have the conclusion and future works.

2. WHY MOBILE AGENTS?

In traditional network management, entire data is transmitted through the network increasing the bandwidth utilization. This causes congestion in the network and reduces the scalability. Data encapsulation is achieved by employing mobile agents [8]. This can minimize the network traffic. Only the requests and responses are transmitted through the network. As a result the various disadvantages of the traditional system are eliminated to an extent. The lifespan of the mobile agents can be set through different behaviors, which in result avoids the possible infinite looping of the mobile agents through the network. Mobile agents can be designed as per the requirement of the manager. An agent is able to cooperate with other agents in order to perform complex or dynamic tasks [9].

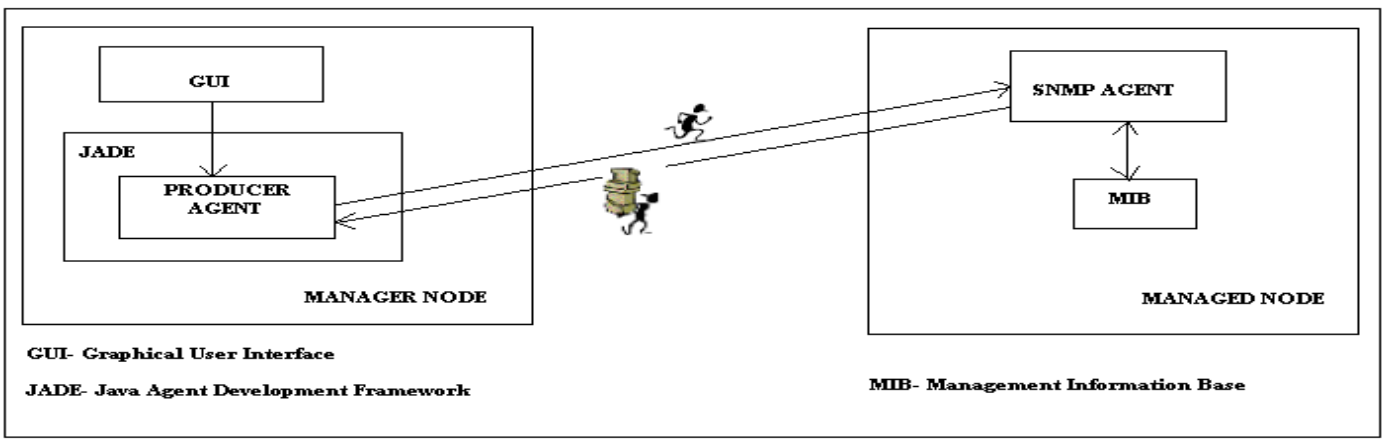
Compared to object oriented objects, mobile agents have their own thread of control, localizing not only code and state but their invocations as well. In other words, agents themselves define when and how to act in the network. However agents require a common platform to communicate with each other. The platform we are using is JADE [5].

Foundation for Intelligent Physical Agents (FIPA) is the most promising standardization effort in the software agent world. The FIPA agent reference model was chosen to provide the normative framework within which agents can be deployed and operate. FIPA specification establishes the logical reference model for the creation, registration, location, communication, migration and retirement of agents.

3. ARCHITECTURE

SNMP is the dominant protocol for network management. SNMP supports various operations like *Get-Request, Get Next- Request, Get-Response, Set-Request, and Trap*. In SNMP a management application uses the manager protocol to communicate with the managed system, which uses the agent protocol to communicate with the MIB and the manager protocol. The whole network is managed from a central management station. Processing of managed data is done at the management station.
Network management stations interact with SNMP agents in managed nodes. Each SNMP agent is essentially a daemon process that responds to requests from management stations. SNMP agents are organized in different ways in different platforms. Our framework [Figure 1] is a hybrid model, which has features of mobile agents as well as SNMP [2]. Mobile Agent based network management gives the manager the flexibility of using SNMP model or mobile agent based management depending on the management activ-

Figure 1. Architecture of our approach



ity that is involved. This architecture has many advantages over the existing architectures.

Our architecture provides Java-compliant interfaces to network management services. It was developed in Java as well because of Java's write-once run- everywhere commitment and its dynamic class loading and object serialization features [3].

The main components are:

- Manager node
- GUI
- Producer Agent
- Mobile Agent
- Managed node
- SNMP agent
- MIB

A. Manager node

It is the server which manages the whole network. It includes the GUI and producer agent developed on the JADE platform [6]. The server sends the requests for managing the network to the client system (managed node). The response received from the client system is used for taking suitable management decisions.

Our architecture is a flexible onesends the requests for managing the network to the client system (managed node). The response received from the client system is used for taking . with a minimum specification can be made server, the only requirement being the installation of the producer agent. Hence, if the server fails any other suitable system in the network can be selected, which replaces the faulty server. All the managed nodes need to register with the manager with the IP address. The manager then lists the available containers in the platform (if same platform is used).

B.Graphical User Interface

The network administrator can enter addresses of the managed node (IP address), can select the travelling patterns (broadcast or itinerary model) of the mobile agents through the GUI. Also, the agents can be generated through the GUI. Also the manager can select the agent suitable for his management application in the GUI.

C.Producer Agent

It generates the different mobile agents by accepting the required parameters from the network administrator and creates the agent and sends it.

D.Mobile Agent

Mobile agents spread intelligence across the network, while they move in a network. The mobility of mobile agents allows them to be created, deployed, and terminated without disrupting the network configuration.

E.Managed Node

All the managed nodes in the network comprises of SNMP agent and MIB. SNMP agent interacts with the mobile agent. The mobile agent performs the functions for which it is designed at the managed node. The result is then sent back to the server or manager. Any number of managed nodes can be included. It must contain the platform to handle the incoming requests.

F.SNMP agent

SNMP agent is essentially a daemon process that responds to requests from management stations.

G.MIB

The management information base preserves various data objects for network management. The information in management information base is ordered in clusters and maintained in a tree-like structure. Thus management information base manage the complex network

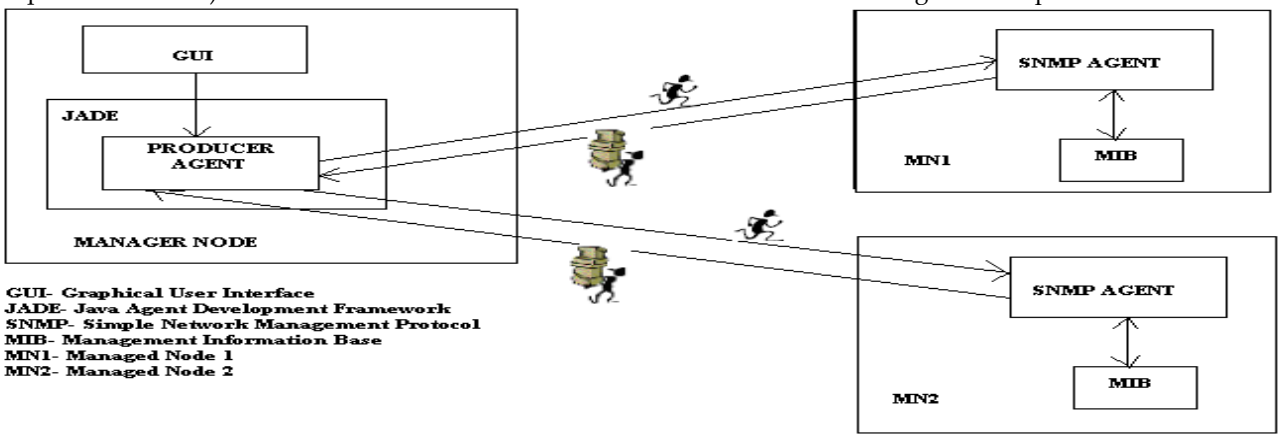


Figure2.BroadcastModel

tasks in the distributed network management environment [12].

4. DIFFERENT AGENTS AND ITS FUNCTIONS

We introduce three main agents in this paper. They are the main producer agent, mobile agent and SNMP agent.

A.Producer Agent

The three important functions of producer agent are:

- To accept the parameters of mobile agent from the network administrator by providing a GUI.
- To create the mobile agent with the accepted values.
- To send the mobile agent to the managed node.

B.Mobile Agent

Mobile agents are those agents which move across the network. Data is in the encapsulated form within mobile agents, thereby ensuring security to an extent. Mobile agents interact with the local SNMP agent of the managed node.

C.SNMP agent

SNMP agent responds to SNMP queries from mobile agents when they visit the managed node and manipulate data locally. SNMP agents interacts with the local MIB for data storage or retrieval operations needed to perform the specific function [11]. Each SNMP agent is essentially a daemon process that responds to requests from management stations.

mobile agents for various functions by setting the parameters of the mobile agents like address of the destination node, community value etc. These parameters are function-specific. The network manager selects the agent for his application. Then the producer creates the mobile agent and sends it by using either broadcast or itinerary model. The proactive mobile agent then travels through the network. At the managed node the mobile agent interacts with the SNMP agent. The SNMP agent communicates with the MIB to store or retrieve the information. The manager node and managed node communicates through a request-reply **mechanism. The manager sends the** request using the mobile agents, which bring back the requested information in a condensed form. The mobile agents can be sent simultaneously through a number of systems. Thus they enable the management of the whole network at the same time.

5. PERFORMANCE MANAGEMENT

One important aspect of network management, which we are considering in our paper, is performance management. Performance management involves gathering statistics about network traffic and schemes to condense and present data [10]. To monitor the performance of a set of managed nodes over a particular interval of time health functions are used, which indicates system state or efficiency of the node and could be viewed as a way to compress management data and evaluate the performance of any element.

A performance management application can use to ifInOctets and ifOutOctets of the interfaces group in MIB compute the percentage utilization of an interface over an interval of time. To perform this computation, two different polling intervals are required: one to find total bytes per second at time x and another to find total bytes per second at time y. The following equation computes utilization, U(t) for the polling interval (x-y) seconds[4]:

$$U(t)=[((ifInOctets_y-ifInOctets_x)+(ifOutOctets_y-ifOutOctets_y)) *8] / (y-x)*ifSpeed$$

where, ifspeed is the bandwidth of the interface, $inOctets_x$ is the bytes received by the interface at time x, $IfOutOctets_x$ is the bytes sent by the interface at time x, (y-x) is the polling interval.

The broadcast model is suitable for performance management.

6. FAULT MONITORING

Fault monitoring involves identifying faults in devices connected to a network. Detection of faults can be achieved through the use of mobile agents. A mobile agent performing analysis of devices connected in a network could be programmed to have the ability to report to the management station about all nodes whose utilization increases a certain threshold. In some cases we need to rely on low-level protocols for detection and correction of fault. Since our flexible architecture doesn't loose the advantage of conventional SNMP management techniques, low-level fault detecting schemes based on SNMP could be used in the detection and correction of some faults. Health function is used to calculate percentages of input and output errors on an interface. It is a cumulative factor of 8 MIB variables[4]:

Percent input errors = ((ifInErrors)/(total packetsreceived))*100,

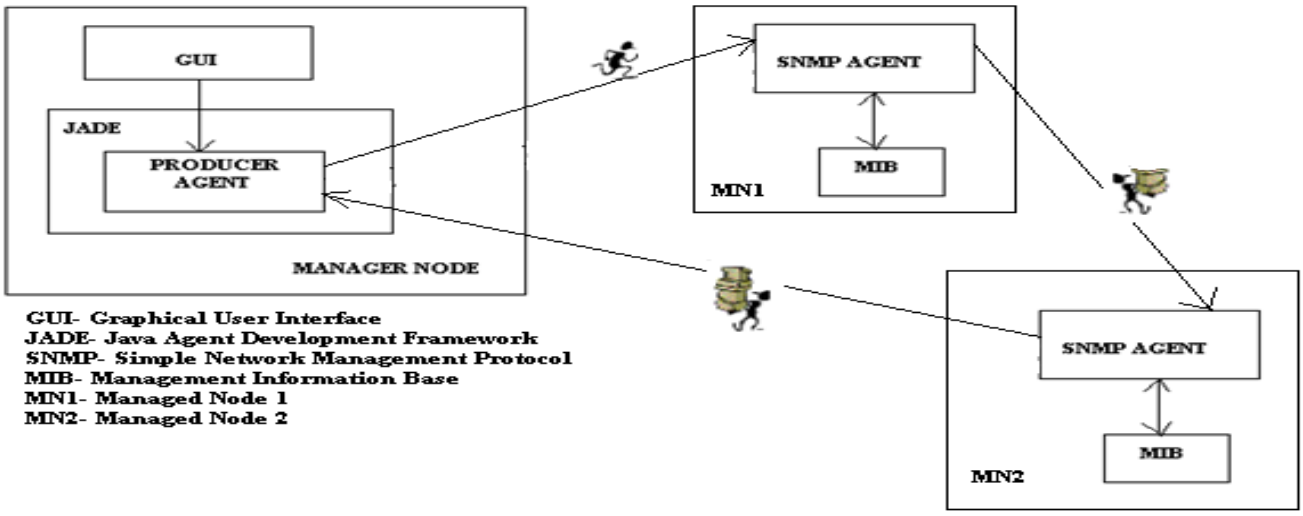
Percent output errors = ((ifOutErrors)/(total packets sent))*100,

Where

total packets received = (ifInUcastPkts + ifInBroadcasts + ifInMulticasts),

total packets sent = (ifOutUcastPkts + ifOutBroadcasts + ifOutMulticasts).

This health function is often used in fault monitoring. If the interface error rate is more than 1%, then there is a problem with the interface of the machine. If the error rate is less than 1% and network shows poor performance, then it could be deduced that there is a problem with the media.



7. TRAVELLING PATTERNS

Two travelling patterns [2] for mobile agents in our framework are broadcast model and itinerary model. In broadcast model, mobile agent is send to all the managed nodes at the same time. This model is best suited for performance management. In itinerary model, the address of all nodes needed to be visited is given to the mobile agent. Mobile agent visits the nodes in sequential manner. It is best suited for fault monitoring.

A. Broadcast model

In this scheme [Figure 2] a MA is dispatched to each managed device. All the dispatched mobile agents stay at their respective node and analyze it for amount of time specified by the producer agent. Mobile agents poll the managed nodes after each polling interval (specified by producer agent). Each mobile agent stays there for an amount of time equal to the total number of polling intervals. It executes its task by interacting with the SNMP agent for each polling interval, performing necessary calculations on obtained management statistics, analyzing them by using some functions equipped into the MA and get back to the manager.

By using broadcast model we could dispatch mobile agent (MA) to each of the managed nodes and MA could calculate the utilization for every polling interval over an extended period of time. Here the MA manipulates the data locally at the managed node. After the time period for which the analysis is required, which is equal to the sum of all the polling intervals, the MA returns to the management station. Here MA's are used to represent a reduced data set and removes information bottleneck and processing loads at the management station.

B.Itinerary model

Itinerary model [Figure 3] is described as roaming management model. In this scheme a mobile agent visits the set of nodes to be managed sequentially. The mobile agent is configured with the list of nodes to be visited during its itinerary and also the SNMP statistics to be analyzed. Configuration of agents is done while MAP dynamically creates the agent at network management station. A mobile agent sequentially visits all nodes to be managed sequentially. At each managed node it obtains required statistics, performs necessary calculation's in analyzing statistics (reduces the amount of management data that it would carry) before it visits the next managed node.

8. CONCLUSION AND FUTUREWORKS

In our paper, we presented an efficient method to manage the network using mobile agents and SNMP. It is a hybrid model exploring the advantages of conventional SNMP based management. We used different agents designed for specific tasks and two travelling patterns for them, from which, the one suiting the managed network can be selected.

The two important aspects of network management, performance management and fault monitoring were done.

We plan to investigate into other aspects of network management like accounting management, configuration management and security monitoring. We also plan to examine the details to manage other components of heterogeneous network like hubs, switches, routers etc.

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