Evaluating the Network Performance Management Based on Mobile Agents

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Abstract This paper aims to investigate mobile agent scalability in network management, in order to find when mobile agents improve the management efficiency. We compare the performance of two different solutions to gathering MIB-II variables on managed elements: a mobile agent-based one and SNMP. By analyzing response time results, we can say that the mobile agent performs better than the SNMP when the number of managed network elements ranges between two limits: an inferior bound, associated with the number of messages that pass through a large scale network, and a superior bound, related to incremental size of mobile agent.

1 Introduction

Currently, most network management systems use the Simple Network Management Protocol (SNMP) [14] and the Common Management Information Protocol (CMIP) [15], which are based on a centralized paradigm. These protocols use the client-server model, on which the management station acts as a client that provides a user interface to the network manager and interacts with agents, which are servers that manage remote access to local information stored in a Management Information Base (MIB). In these protocols, the operations available to the management station for obtaining access to the MIB are very low level.

Performance management is one of the management functional areas identified in OSI Systems Management and addresses the availability of management information, in order to be able to determine the network load [5]. This management needs access to a large quantity of dynamic network information, which is collected by periodic polling.

The fine grained client-server interaction and the periodic polling generate an intense traffic that overloads the management station, resulting in scalability problems. In this sense, mobile agent is an option to distribute and scale

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the network management. Mobile agents decentralize processing and control, and, as a consequence, reduce the traffic around the management station, turn asynchronous agent-manager communication (useful when there are unreliable or lossy links), distribute processing load, and increase the flexibility of the management agents' behavior.

Research activities related to mobile code in network management are recent [10]. Magedanz et al. [8] have been one of the first researchers to present issues for the deployment of mobile agents in telecommunications and network management. Management by Delegation (MbD) [7] has been the first paradigm to address decentralization and automation of management tasks by dynamically delegating management functions to agents. Pagurek et al. [4] implement a code mobility infrastructure and a suite of simple tools that interact with agents located on network components. Puliafito et al. [11] use mobile agents to collect information about the state of the network and to perform a micro-management of network devices through multiple variables. Morin et al. [13] implement a management architecture that consists of a set of servers and managers communicating with SNMP agents located on the managed network elements.

The performance of mobile agents in network management is also being investigated. Baldi et al. [2] evaluate the tradeoffs of mobile code design paradigms in network management applications by developing a quantitative model that provides the bandwidth used by traditional and mobile code design of management functionalities. Bohoris et al. [5] present a performance comparison of mobile agents, CORBA, and Java-RMI by using one network element on a ATM network. An array of objects (not real data) is used in order to obtain the response time and bandwidth utilization. Gavalas et al. [6] analyze bandwidth utilization for the SNMP and the mobile agent. Experimental implementation results are presented in terms of bandwidth consumption and response time to obtain an aggregation of multiple variables on a LAN of a few nodes. Sahai and Morin [13] perform measurements of bandwidth utilization of mobile agent and client-server applications on an Ethernet LAN of a few nodes. They also present a single case comparison of response time for the mobile agent and the client-server. Rubinstein and Duarte [12] simulate management tasks performed by mobile agents and SNMP ones, comparing both the approaches, on a topology that consists of a LAN of managed network elements connected to the management station by a bottleneck link.

In this paper, we analyze the scalability of two network management approaches: a mobile agent-based one and one only based on the SNMP. A prototype implementation is evaluated on a topology that consists of a LAN of managed network elements connected to the management station by the Internet. The number of managed network elements is up to 250. Response time results show that the management performance increases when using mobile agents.

This paper is organized as follows. Section 2 presents two implementations of a performance management application: the mobile agent-based one and the one only based on the SNMP. Section 3 describes the methodology of the experimental study and Sect. 4 reports the obtained results. At last, concluding remarks are presented in Sect. 5.

2 Implementation of a Performance Management Application

We compare two different solutions to gathering MIB-II [9] variables on managed elements: a mobile agent-based one and one only based on the SNMP.

2.1 The Mole Platform and the AdventNet Library

The Mole infrastructure [3] is used in the mobile agent implementation. This system provides the functionality for the agents to move, to communicate with each other, and to interact with the underlying computer system. In Mole, a weak migration scheme is provided, where only data state information is transfered. As a consequence, the programmer is responsible for encoding the agent's relevant execution states in program variables.

Two different types of agents are provided. System agents are usually interface components to resources outside the agent systems. They have more rights than non-system agents (e.g., only system agents can read or write to a file), but they are not able to migrate. User agents are agents that have a "foreigner status" at a location, that means that they are not allowed to do something outside the agent system as long as they can not convince a system agent to give them access to outside resources. Mole uses TCP to transfer mobile agents.

In order to use SNMP functionalities, the AdventNet SNMP library [1] and the snmpd from Linux are also used. The AdventNet SNMP package contains APIs to facilitate the implementation of solutions and products for network management and the snmpd is an SNMP agent that responds to SNMP request packets.

2.2 The Two Solutions

The mobile agent solution (Fig. 1) consists of two agents, one stationary and one mobile. The mobile agent migrates to a network element and communicates by Remote Procedure Call (RPC) with the translator agent that converts the mobile agent request to the SNMP format. This static agent is utilized since in Mole, mobile agents are not allowed to access the resources outside the agent system. The translator agent sends a request to the SNMP agent and obtains the response, which is passed to the mobile agent. Then, the mobile agent goes to the next element and restarts its execution. After finishing its task, the mobile agent returns to the management station.

In the SNMP solution, we have created a fixed agent (the manager) in the Mole infrastructure that sends an SNMP packet to an SNMP agent that responds to this manager (Fig. 2). The manager sends requests to all elements to be managed (one after receiving the response from the other).

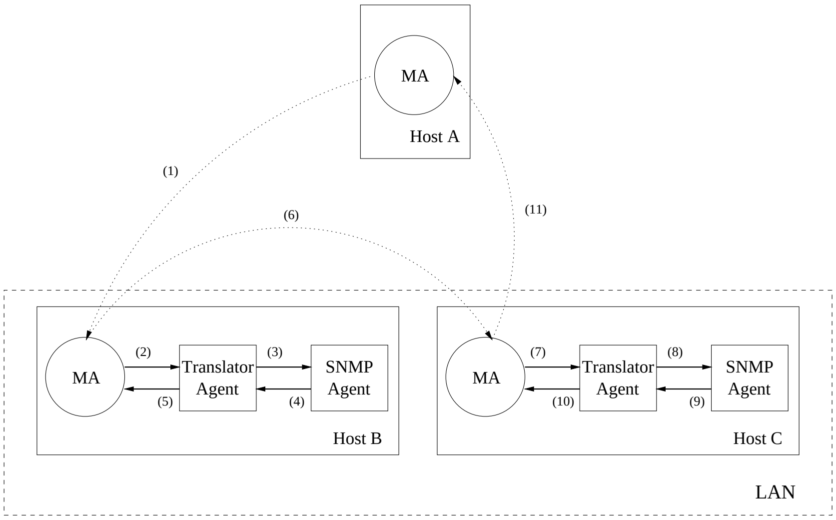

Figure 1. Mobile agent managing two elements.

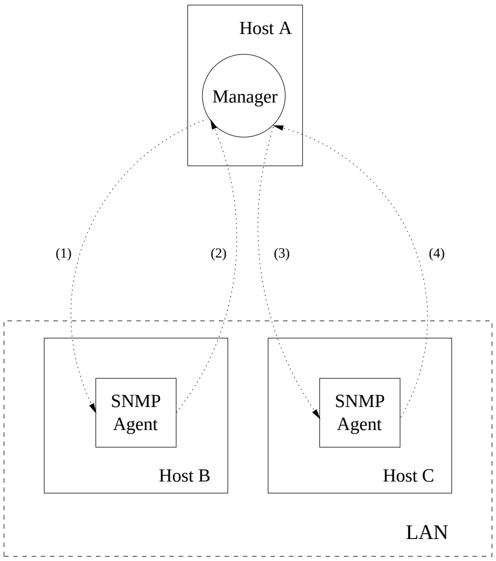

Figure 2. SNMP managing two elements.

3 Experimental Study

We perform an experimental study in order to evaluate the scalability of the two solutions.

The topology consists of two managed network elements (hosts B and C) that belong to a LAN interconnected to the management station (host A) through the Internet (Fig. 1). All the three machines are located in France, two at the PRiSM laboratory and one at the LIP6 laboratory.

In order to evaluate the performance for a great number of managed elements, we alternately repeat the two machines that belong to the LAN, e.g., if we want 5 elements to be managed, we use an itinerary like B, C, B, C, and B.

The considered performance parameters are the average bandwidth consumption on the management station and the average response time in retrieving the MIB-II [9] variable *ifInErrors*, which denotes the number of received packets discarded because of errors, from the elements to be managed.

The tcpdump program is used to measure TCP and UDP packet sizes. All measurements have been performed early in the morning or at night in order to limit the variations of the network performance and to avoid retransmissions of SNMP packets, which would influence the response time results.

Both the solutions have been tested in the same conditions, using the same itinerary. We have made all the tests with the engines (agencies) running uninterruptedly. The number of managed network elements has been varied from 1 to 250 and all the experiments have been repeated ten times.

4 Results

We evaluate here the effect of the number of managed network elements on bandwidth utilization and response time.

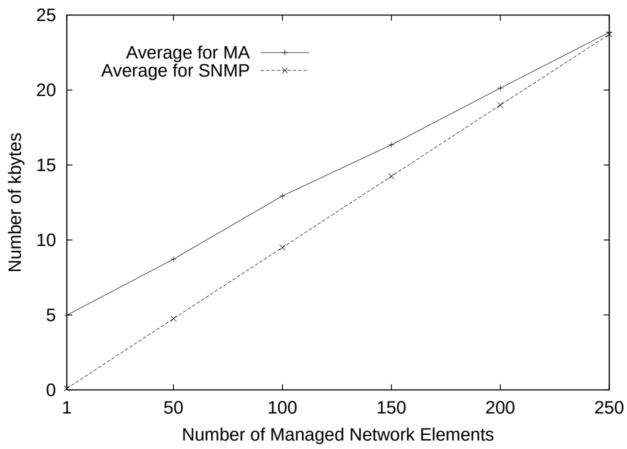

Figure 3. Bandwidth consumption per number of managed elements.

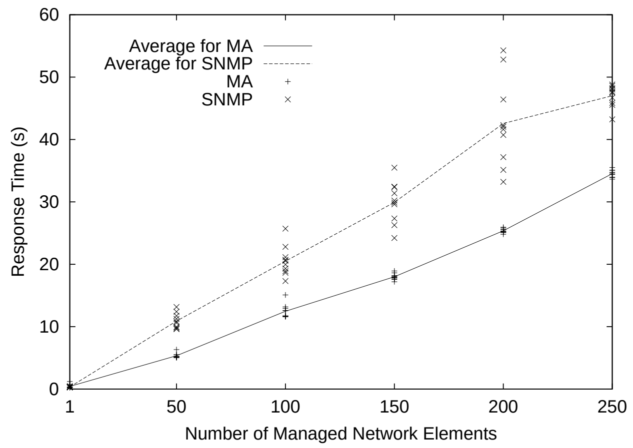

Figure 4. Response time per number of managed elements.

For a small number of managed network elements, the SNMP uses fewer bytes than the mobile agent to perform the task (Figure 3). Nevertheless, as the number of managed elements increases, the overhead associated with several retrievals (PDU GetRequest and UDP's headers) turns mobile agent utilization more suitable, as we can presume by extrapolating the analysis. According to Fig. 3, the initial size of the mobile agent is approximately 2.5 kbps, since it traverses twice the large scale network.

Figure 4 shows that the mobile agent is less sensitive to the network variations (SNMP points are more distributed over time), since SNMP packets traverse oftentimes the large scale network whose performance varies more than the LAN performance. Figure 4 also presents the average response time. For a small number of managed elements, the SNMP performs better than the mobile agent, due to the fact that the SNMP messages are smaller than the initial size of the mobile agent. As the number of managed elements increases, response time for the SNMP grows proportionally, since the time to manage a network element is approximately the same for all network elements. For the mobile agent, response time increases faster when the number of managed elements grows, due to the incremental size of the mobile agent. By extrapolating the analysis, we can conclude that the mobile agent performs better that the SNMP when the number of managed network elements ranges between two limits. The superior bound seems to be high, since it could not be observed in our experiment.

5 Conclusion

This paper has analyzed the scalability of mobile agents in performance management. We have implemented and compared two solutions to gathering MIB-II variables on managed elements: a mobile agent-based one and the pure SNMP.

By analyzing response time results, we can say that the mobile agent performs better than the SNMP when the number of managed network elements ranges between two limits: an inferior bound, associated with the number of messages that pass through the large scale network, and a superior bound, related to incremental size of mobile agent, which turns migration difficult.

Response times for the mobile agent decrease up to 51%, when comparing with using the SNMP.

We conclude that the mobile agent paradigm significantly improves the network management performance when most of the agent movement is inside high bandwidth LANs; in other words, when only a small percentage of the agent movement is inside large scale networks.

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