

AN SNMP-ENABLED AND WEB-BASED NETWORK MANAGEMENT SYSTEM APPLIED TO INTERNET TELEPHONY

Ming-Yuhe Chang¹, Chung-Ming Huang², and Ben-Son Yu²

¹Department of Information Management,
Southern Taiwan University of Technology, Tainan, Taiwan, R.O.C.

²Department of Computer Science and Information Engineering,
National Cheng Kung University, Tainan, Taiwan, R.O.C.

E-mail: changmy@mail.stut.edu.tw

ABSTRACT

We present the development of an SW-NMS (SNMP-enabled and Web-based network management system) and the applied Internet Telephone network management system in this work. Employing the SNMP facilities Window NT provides, the SW-NMS can detect the status of system components, monitor the activities of SNMP-enabled system components, and distribute the system load into each system component. The SW-NMS encapsulated into an ActiveX object, stored at any WWW server site, which can be downloaded to and then reused at any web client site operating on Window NT, is Web-based. We have implemented the SW-NMS system and equipped the corresponding ActiveX object on a WWW server. Via connecting to the Web-based SW-NMS system, a network administrator applying Microsoft Internet Explorer can customize their network managements from any Web client site.

1. Introduction

Since accessing Internet services becomes our part of daily activities, the network traffic on Internet is getting heavy. Being able to benefit from providing Internet services to users under such a network environment with heavy traffic, an ISP (Internet Service Provider), ICP (Information Content Provider), ASP (Application Service Provider), or organization should effectively use their limited network resources, e.g. limited network bandwidth, to support their Internet services, e.g. WWW services, Internet Telephony, etc. Without a good network management system, the thinking is unrealistic. In the literature, the network management systems[1,2] can distribute the system load into their hierarchical components to get better performance in network management. Applying the SNMP-enabled network management systems[5,6], a network administrator can manage heterogeneous network systems that are

SNMP-enabled. Employing the Web-based network management systems[3,4,5,7,8], a network administrator can remotely process their network management.

In this work, an SW-NMS (SNMP-enabled and Web-based network management system) is presented. The SW-NMS has the following features: (i) inter-party management, (ii) zone management, (ii) on-line customizable management, (iii) Web-based distributed management, (iv) automated log management, and (v) fault management. Thereby, the administrator can obtain more effective network management and economize the scarce network bandwidth.

SW-NMS uses an inter-party management scheme, in which the managed object database recording network status is shared by several party entities, i.e. servers and clients. Applying the shared managed object database stored at the server party, SW-NMS can simplify the computation required to maintain data consistency and security. All the client party entities can contribute their computation power needed for obtaining the whole network status to get better system performance and response.

Traditionally, the network management system always inquires all the managed objects in a time and disregards which types of managed objects are necessary or redundant. Obviously, the redundant managed objects induce unnecessary network traffic. To improve this situation, an on-line customizable network management is proposed. Based on the customizable network management scheme, a network administrator can customize a combination of the managed objects necessary for performing a specific network management. SW-NMS provides the capability of network management customization for network administrators to flexibly determine what information of MIB (Management Information Base) is concerned during the period of management activities. Notably, the customizable management can be operated concurrently. That is, the customizable services can be dynamically invoked without the need to stop the

system.

On the other aspects, SW-NMS provides the zone management scheme for network administrators to manage a large network environment. All entities within a large network can be logically classified into several smaller zones. Each of zones is hosted by a special entity, i.e. an SW-NMS client. In contrast to the centralized management system, the zone management scheme can obtain a better performance from localizing and shrinking the overall network traffic.

Additionally, SW-NMS supports Web-based distributed management via providing a network administrator with a unified and distributed system user interface. The SW-NMS system is encapsulated into a self-contained ActiveX object, stored at a WWW server, which can be downloaded to any web clients using Microsoft Internet Explorer applying HTTP (hypertext transfer protocol). At a web server site, there executes an SW-NMS server, stores the SW-NMS ActiveX object, and maintains the managed object database. At a web client site, the downloaded SW-NMS ActiveX object can be initiated as an SW-NMS client using Microsoft Internet Explorer operating on Windows NT. After an SW-NMS client is initiated, it is capable of gathering the status information of managed network devices using SNMP and updating the status information to the corresponding SW-NMS server through Winsock communication facilities. Via the SW-NMS client, the administrator can monitor the overall status information of managed network devices and can operate on the managed object database stored at the server site. Thereby, an SW-NMS server and all clients can work together to complete the network management by exchanging data and messages with each other.

SW-NMS is capable of dealing with automated log management. Applying the automated log management scheme, SW-NMS can automatically and/or periodically record the status of a managed device according to user-defined system criteria, e.g. the occurrence of system fault and response time out in 10 seconds.

SW-NMS has the capability of fault management. Fault management is in charge of reporting network anomalies caused by some malfunctioning network devices and/or network packet loss. Using the fault management scheme, SW-NMS can prompt a network administrator the event that some network anomalies occur. After that, the administrator can avoid some unnecessary network traffic that is used to detect the MIB information on a dead network device.

The remainder of this work is organized into six Sections. Section 2 depicts the system environment and architecture. Section 3 depicts the working principle of the system components in steps. Section 4 presents the development of the proposed SW-NMS. Section 5 describes the usage of the SW-NMS system by an illustrative example. Section 6 depicts the applied network management system on Inter-

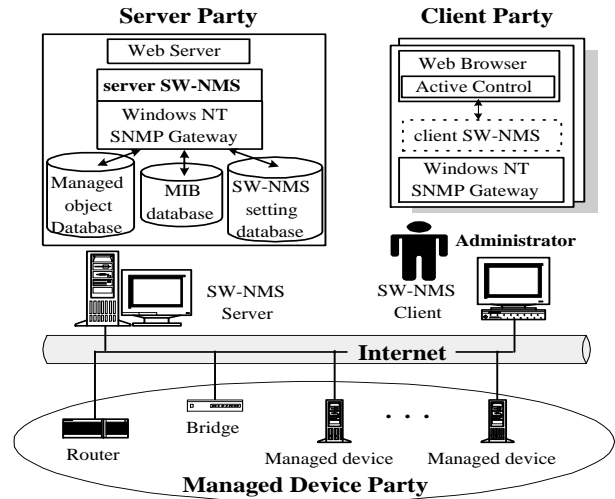


Figure 1. The environment and abstract architecture of SW-NMS.

net Telephony deploying the proposed SW-NMS. Section 7 concludes this work.

2. System Environment and Architecture

A client-server based SW-NMS operates on Windows NT to perform network management in the WWW environment. In this section, we present the environment that an SW-NMS works with, and the system architecture that an SW-NMS adopts to manage all network devices over Internet. Figure 1 depicts the environment and abstract architecture of the SW-NMS system.

The 3-tier network environment consists of three parties: server, client, and managed device. Each of parties consists of several entities. For example, the server party consists of a computer host, which serves as a WWW server. The client party is composed of several computers and network administrators who monitor the activities of network devices using Microsoft Internet Explorers operating on Windows NT. The managed device party consists of several SNMP-enabled network devices. The three parties are interconnected over Internet.

The abstract architecture is built upon a client/server model. The components of the client/server based architecture are as follows.

- (1) Server party consists of four main components, i.e. a web server, a server SW-NMS, an SW-NMS setting database, a MIB database, and a managed object

database, which performs on Windows NT operating system.

- (2) Client party consists of several client sites and network administrators. Each of client sites contains a web browser, a client SW-NMS, and the Windows NT SNMP Gateway, for a network administrator to monitor the activities of managed network devices.
- (3) Managed device party consists of a set of managed devices that are SNMP-enabled and interconnected with a network.

Server party serves as an information center in the SW-NMS system. A web server can delegate the requests, including the requests of downloading some web page documents and ActiveX SW-NMS objects to a client site, from any client sites using the web browser, i.e. a Microsoft Internet Explorer. A server SW-NMS can send the initial setting data, which is necessary to enable the downloaded SW-NMS object to be created as a working instance at the client site, to the client site. Additionally, the server SW-NMS is capable of manipulating databases, i.e. the managed object database, MIB database, and SW-NMS setting database, and delivering the corresponding responses to the client site. Client party serves as a network management workstation. Using the web browser operating on Windows NT, a network administrator can load an ActiveX SW-NMS object from server party and create a working instance to monitor the activities of managed devices.

Managed device party is a set of SNMP-enabled network devices interconnected with a network. Based on the SNMP communication scheme, each of the managed devices can report the MIB-structured status information, which is called managed objects in this work, to the client party.

3. Working Principle

Figure 2 depicts the working principle of the SW-NMS system. Initially, using the web browser, the network administrator can visit the web page carrying out the SW-NMS network management service (Step 1.) An ActiveX SW-NMS object is downloaded and is then created as a working instance referred to as a client SW-NMS at the SW-NMS client site. Using the client SW-NMS, the network administrator can monitor the activities of the managed network devices by measuring the managed objects from the managed devices (Step 2.) After that, the client SW-NMS can report the measurement to the server party for update or retrieve other managed objects from the server party, which is intended to be displayed at the client site (Step 3.) The

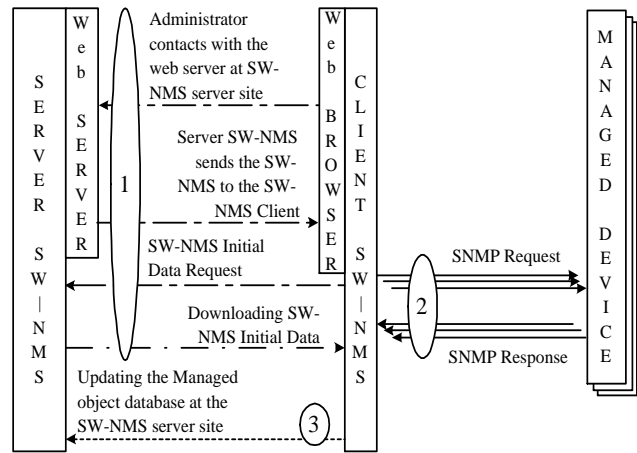


Figure 2. The messaging flow between a server SW-NMS, a client SW-NMS, and managed devices.

SW-NMS system repeats Steps 2 and 3 until the network administrator exits from the system.

Specifically, an SW-NMS plays different roles on performing the client/server network management. At a client site, the SW-NMS serves as a network management station capable of (i) retrieving the managed objects of each managed device via networks, (ii) requesting the managed object database information from a server site, (iii) handling the event notification when some system fault occurs, and (iv) displaying the response from a server site. At a server site, the SW-NMS performs the following tasks: (i) Send initial data to create the client SW-NMS instance to work, (ii) Reply requests from each client SW-NMS, and (iii) Maintain the managed object database. Employing this method, server party can maintain the overall managed objects and provide responses to the client party. Client party can also retrieve the status information from the managed object database and display the information to the network administrator. Therefore, the inter-party management and Web-based distributed management can be achieved. Based on the working principle, other management functionalities, i.e. zone management, on-line customizable management, automated log management, and fault management, can also be achieved.

4. System Development

To achieve the SW-NMS functionalities, i.e. (i) inter-party management, (ii) zone management, (iii) on-line customiz-

able management, (iv) Web-based distributed management, (v) automatic log management, and (vi) fault management, the SW-NMS is realized as three major processes: monitoring process, zoning process, filtering process. The monitoring process is capable of carrying out the Web-based distributed management, on-line customizable management, and fault management. The zoning process is capable of operating the inter-party management and the zone management. The filtering process can handle the automated log management.

Using the monitoring process, the network administrator can customize the styles of the network management, which is intended to be performed, and monitor the network status. According to their interests, network administrators can customize the options of their network management, in terms of managed objects in MIBs database, to be monitored. The network management can be performed instantly or routinely in real time. A network administrator can perform the routine network management in two modes: timing and timeless. Applying the routine management with timing, the network administrator can acquire the measurement of the customized network management every period of time, e.g. 5 seconds. Employing the routine management in the timeless mode, the network administrator can start or stop receiving events that managed devices perform the operations, e.g. cold start, warm start, link down, link up, etc. Based on the customized network management, the selected monitoring contents and styles are carried out and presented to the network administrator at the client site.

Using the zoning process, the network administrator can customize a zone that consists of several managed devices, i.e. entities, to be monitored. All SNMP-enabled entities in a large network environment can be divided into several zones to be managed applying the SW-NMS system.

Using the filtering process, the network administrator can compose some constraints referred to as criteria to determine which managed objects are abnormal and/or worthy to be logged and monitored.

By utilizing the monitoring process, the zoning process, and the filtering process, a network administrator can flexibly customize a user-defined network management with the support of inter-party management, zone management, Web-based distributed management, on-line customizable management, automated log management, and fault management.

5. System Usage

In this Section, we illustrate the usage of SW-NMS on a network configuration. Based on the proposed 3-tier model, the experimental network configuration consists of a server party, a client party, and a managed device party over Inter-

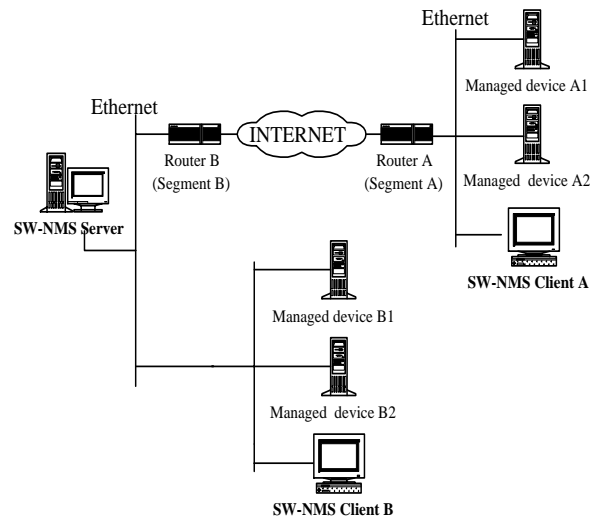


Figure 3. An SW-NMS network configuration.

net. The server party, i.e. the SW-NMS server, consists of a computer host executing a server SW-NMS software and a web server on the network segment A. The client party is composed of two client computers, i.e. SW-NMS Client A and SW-NMS Client B. Each of the two client computers executes a client SW-NMS software. All the entities of the server party and the client party adopt the operating system Windows NT. Additionally, the managed device party consists of four SNMP-enabled devices, i.e. managed devices A1, A2, B1, and B2. At the network segment A, the SW-NMS Client A monitors the managed devices A1 and A2. At the network segment B, the SW-NMS Client B monitors the managed devices B1 and B2. Router A plays the role of connecting the network segment A to Internet. Router B connects the network segment B to Internet. Both of the network segments A and B are Ethernet LANs run on 100Mbps. The SW-NMS server operates on Windows NT 4.0 service pack 3 with SNMP facilities. Applying the dual-protocol communications, i.e. Winsock TCP and SNMP, the SW-NMS Server and those SW-NMS Clients exchange data with each other.

Using a client SW-NMS, the network administrator can customize the network management in terms of variables/parameters selected from MIBs, zone entities, response time interval, etc. Currently, the Windows NT supports SNMP with the MIB-II, i.e. RFC1213 - Management Information Base for Network Management of TCP/IP-based Internet. Based on the MIB-II, we devise three MIBs, i.e. an ISDN MIB, a T1/E1 MIB, and a private MIB, to apply to the Internet Telephony network management.

Initially, a network administrator should complete the following steps to set up the SW-NMS system to work.

- Step 1. Employ the SW-NMS server to generate the SW-NMS initial data to be stored in SW-NMS Setting database and connect to the managed object database.
- Step 2. Enable the Trap service and determine the Trap entities hosted by the SW-NMS server.
- Step 3. Open and tune the configuration of web browser to work in lowest security mode to execute the downloaded ActiveX SW-NMS object.
- Step 4. Set the configuration of SW-NMS Client to determine the connected server entity, zone entities, and download the desired SW-NMS initial data from the server entity.
- Step 5. Use the client SW-NMS on the SW-NMS client site to manage the SNMP-enabled network devices in all zones.

In Step 5, the network administrator can customize the configuration of network management by performing several processes, i.e. monitoring, zoning, and filtering processes, at a client SW-NMS.

6. Application on Internet Telephony

Traditionally, the PSTN (public switched telephone network) is the backbone of telecommunication services. However, the cost of taking an international phone call is expensive via the PSTN. With the worldwide spreading penetration, Internet is an alternative to be a new telecommunication backbone today. Internet Telephony[8,9,10] is a information technology to carry telephonic information over Internet between callers and callees. Internet Telephony applications employ various types of Internet phone systems: pc-pc (personal computer to personal computer), pc-phone (personal computer to telephone), and phone-phone (telephone to telephone). Applying these Internet phone systems, the cost of taking an international phone call can be cheaper than that of using PSTN. Using the pc-pc Internet phone system, a caller can phone a callee utilizing a personal computer. Via the pc-phone Internet phone system, a caller can phone a callee using a personal computer or a telephone set.

In Figure 4, applying the phone-phone Internet phone system, a caller can phone a callee through Internet using a telephone set. Notably, a caller or callee of the phone-phone Internet phone system does not need to change their individual phone behaviors in PSTN. An ITG (Internet Telephony Gateway) is capable of providing connectivity between Internet and PSTN. Specifically, an ITG bridges the caller and the callee via an Internet-and-PSTN connection. Therefore,

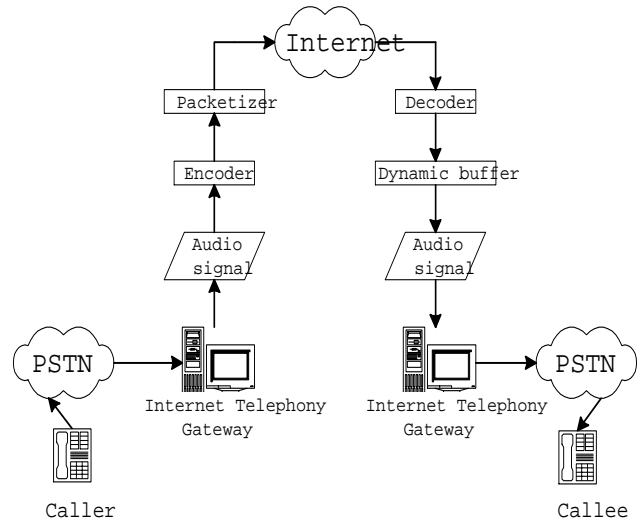


Figure 4. The call flow of phone-phone Internet phone system between a caller and a callee.

ITGs play the important roles of transforming and transporting the telephonic information between callers and callees across Internet and PSTN.

To transport the telephonic information over a UDP/IP network, the caller ITG encodes the telephonic information into data packets with sequence numbers and timestamps. Then, the ITG pumps the encoded data packets into Internet. The callee ITG receives the data packets decoded in sequential order from the Dynamic buffer, and transfers the telephonic information to the callee in PSTN. Employing this method, the caller and callee can communicate over Internet and PSTN.

To guarantee a good performance in the phone-phone Internet phone system, the network administrator refers to the following system parameters, including bandwidth, packet delay, and packet loss, which are reported from ITGs.

- **Bandwidth:** Applying the ITU codec (code/decode) scheme, an ITG can encode the telephonic information into data packets with equal size. Therefore, the necessary bandwidth of a communication channel required for a call is fixed. The network administrator can manage the bandwidth in terms of the numbers of communication channels with fixed bandwidth, which are reported from ITGs.
- **Packet Delay:** Ideally, data packets that are transported from the caller ITG to the callee ITG would have almost equal packet delay when the system performs on the network environment with normal traffic. There-

fore, a normal packet delay indicates that a pair of well functioning ITGs, i.e. the caller ITG and the callee ITG.

- Packet Loss: The parameter of packet loss can reveal two facts: the level of network congestion in Internet or the performance of the functioning ITGs. Therefore, packet loss is a important parameter for measuring the call quality applying the ITGs.

By deploying the ITGs over Internet, an ISP can provides the Internet phone services to PSTN users. The ISP providing the Internet phone services referred to as an ITP (Internet telephony provider). To keep those ITGs functioning well, we apply the proposed SW-NMS system to manage the resources of ITGs.

The purpose of the management on ITGs is twofold: (i) Provide a good call quality at an acceptable level to the user and (ii) Guarantee the necessary cost of a call. How to provide a good call quality in the communication environment depends on an excellent codec and network management schemes. An excellent codec can shrink the necessary transfer scale in bandwidth without quality degradation between callers and callees. Applying an excellent network management scheme, a network administrator can maintain ITGs functioning well according to some performance criteria. For example, a network administrator of an ITP can employ the network management scheme to monitor the activities of all managed devices so as to obtain the condition of the network traffic. When finding the heavy network traffic, the network administrator can perform some process, e.g., dynamic adding extra ITGs and/or widening the transmission bandwidth in the network area with heavy traffic.

Figure 5 depicts the phone-phone Internet phone system deploying the proposed SW-NMS management system. Applying the SW-NMS, the network administrator of ISP or ITP can manage the performance of their phone-phone Internet phone systems. In order to manage the phone-phone Internet phone systems, the SW-NMS provides three types of managed objects: ISDN (RFC 2127 Integrated Services Digital Network Management Information Base), T1/E1 (RFC 1407 Definitions of Managed Objects for the DSI and E1 Interface Types) and Private MIBs. An ITG uses the PSTN dialogic cards or the ISDN cards to receive the telephonic information from PSTN or ISDN callers. An ITG can record the working status of PSTN and ISDN cards into the private and ISDN managed objects, respectively.

In order to connect to Internet, an ITG uses the T1/E1 cards. Employing the T1/E1 MIB, an ITG can record the traffic status of Internet into the T1/E1 managed objects. Applying the proposed SW-NMS to the ITG, a network administrator can use the ITG with SW-NMS serving as a network management station to manage the phone-phone Internet phone system. Employing the ITG with SW-NMS, the network

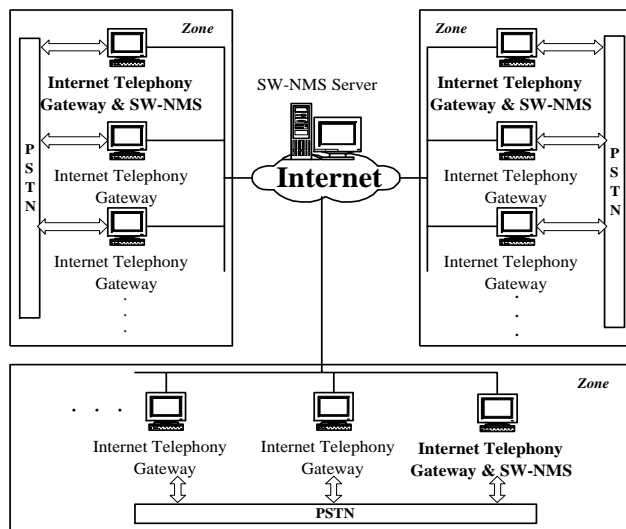


Figure 5. The phone-phone Internet phone system deploying the SW-NMS.

administrator can manage the phone-phone Internet phone system according to the measurement of bandwidth, packet delay, packet loss, and so on. For example, when the bandwidth in terms of the number of communication channels available is deficient in supporting the desired calls, the network administrator can improve this situation by configuring extra ITGs into the managed zone to offer additional communication channels. With configuring extra ITGs into the system, the network administrator can dynamically distribute the system load into the extra ITGs, which are physically located in different local networks. Employing this method, the network administrator can dynamically shorten the packet delay and shrink the packet loss rate, which are resulted from the shortage of communication channels or network bandwidth in a managed zone. Notably, each of ITGs with SW-NMS equipped in the phone-phone Internet phone system can manages all the entities in zones.

7. Conclusion

In this work, the development of SNMP-enabled Network Management System and the application on Internet Telephony are presented. Employing the SW-NMS, a network administrator can remotely manage network systems using the Microsoft Internet Explorer operating on Windows NT. Applying the SW-NMS, a network administrator can remotely perform the network management in the styles of inter-party management, zone management,

on-line customizable management, Web-based distributed management, automated log management, and fault management to a network system. Employing the SW-NMS, a network administrator can remotely self-constitutes their network management from any location.

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