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A SNMP Graphical Network Monitor with Automatic Topology Discovery

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Abstract

The management task in network environment is becoming more and more vital, as these environments grow, getting interconnected and increasing the number of hosts. This work presents a graphical monitor system for computer network management, which meets the requirements of such a task.

The monitor has a graphical interface which follows the XWindow standard. The windows present graphical information, such as the map of networks, which are inside the management domain, and the components of a given network, providing a spacial vision of the managed networks. The informations used to discover the networks are dynamically obtained by the SNMP protocol and some Unix networking resources. Additionally, information such as routing table, active connections and Internet protocols information per host are provided.

The system was designed to be the kernel of a network management system, the MultView, which incorporates multimedia resources. For example, the presentation of digitalized images of selected objects, or a picture of the administrator of a given network could be provided.

The system was developed using the public domain software 4BSD/ISODE SNMP, the interface generator DevGuide and the toolkit XView to implement the graphical interface.

Keywords

Network management, SNMP protocol, graphical user interface.

1. Introduction

The network monitor system, the Multview 2.0, was developed in order to produce a network management system which, besides the management functions, incorporates multmedia resources to increase both, the view of the networks' components and the functionality of the system.

The development of the Multview was based on four points:

- the use of a standard management protocol, in this case, the SNMP protocol [Ca90] [Ro91];
- the design of data structures, flexible enough to accommodate the dynamic nature of networks;
- the dynamic discovery of networks in the management domain;
- the use of a graphical user interface;

Currently, the Multview presents a graphical user interface based on the XWindow standard [Sc90], where management functions are provided through menus, or by directly double clicking on the icon. The system discovers the networks and their components (hosts and gateways) which are inside the management domain and presents them graphically. Network information like routing table, data of network interface and protocol statistics are presented textually.

The monitor runs on Sun Sparc Station, running SunOS 4.3 under Openwindows.

2. The Multview's Architecture

The system follows the Internet Management Model, which comprises network elements that implement SNMP agents and MIBs [Ro91], where management information are stored; a management protocol, the SNMP; and a manager, in this case, the Multview.

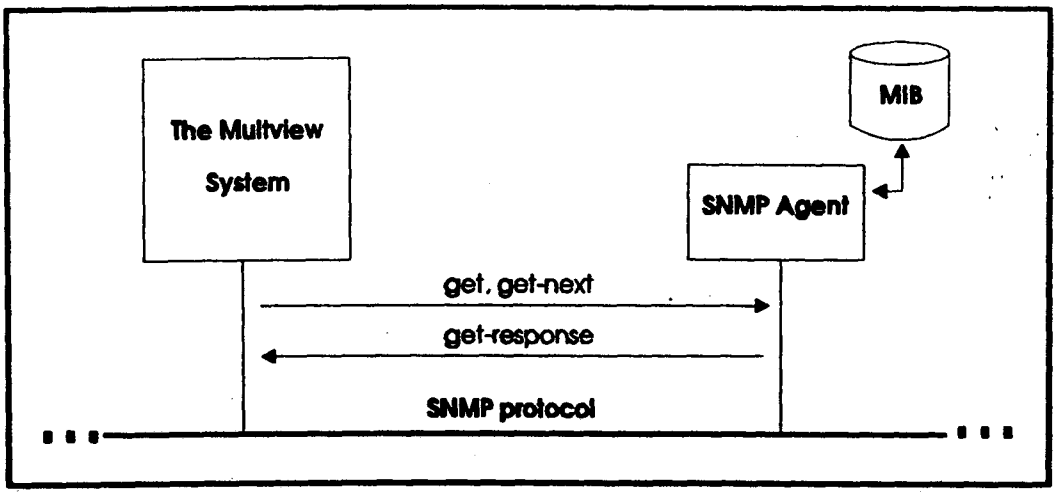

Figure 1 - The Multview's architecture.

Since the Multview is a monitor, it does not implement the *set* operation of the SNMP protocol.

For rapid prototyping of network management applications, a public domain package, the 4BSD/ISODE SNMP, which implements a network management structure for Berkeley Unix system and includes a complete implementation of a SNMP agent was chosen. One of the tools used to get management information from MIBs, is the Gawk SNMP-capable language, a GNU implementation of awk language [Ke84] with some extentions, capable of retriving management information from MIBs through a simple *printf*. The 4BSD/ISODE SNMP comes inside the ISODE package [On89].

3. Data Structures

There are two main data structures responsible for storing information concerning gateways and networks (including their hosts). From these data structures the map of managed networks and the components of a given network are drawn.

The list of gateways stores the following information: name, physical location, type of equipment, the (x,y) position where the gateway is drawn on the screen and network interface information (Internet address, physical address, netmask and a pointer to the network node where the gateway is connected by the interface).

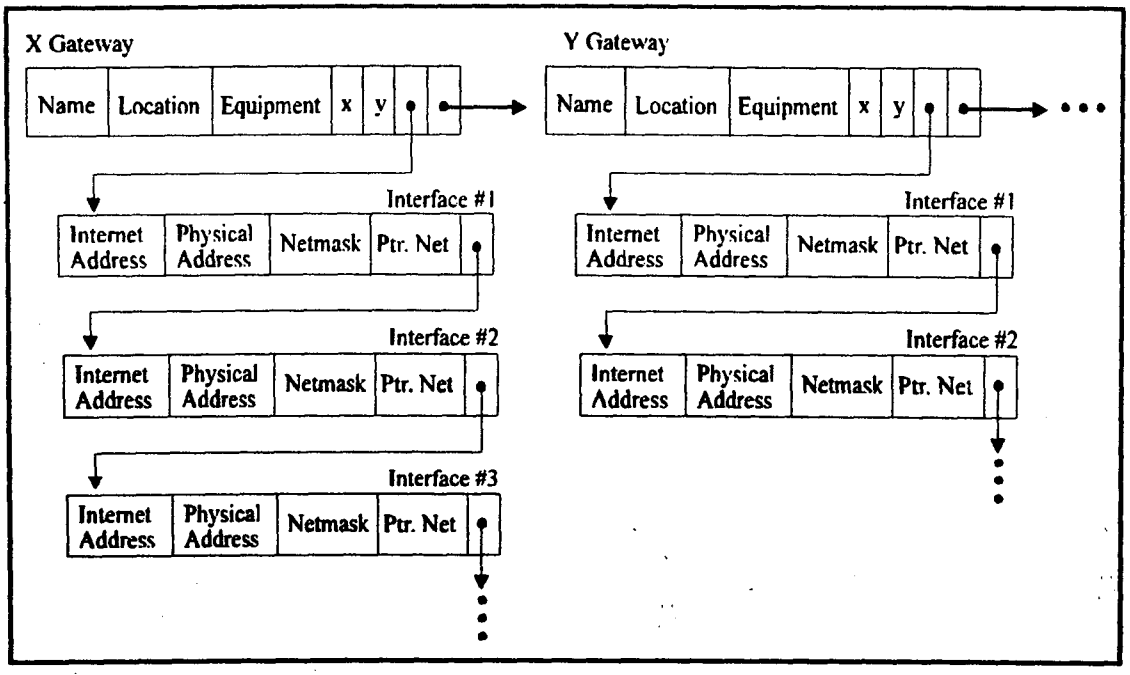

Figure 2 - The list of gateways.

The list of networks is made up from the list of gateways and has the following fields for each network: name, Internet address, netmask, technology (TCP/IP, Novell, Lan Manager, etc), a pointer to the list of its hosts, number of its hosts, a pointer to the gateways that are connected to it and the (x,y) position where the network is drawn on the screen, and the number of found hosts and gateways which are connected to the network.

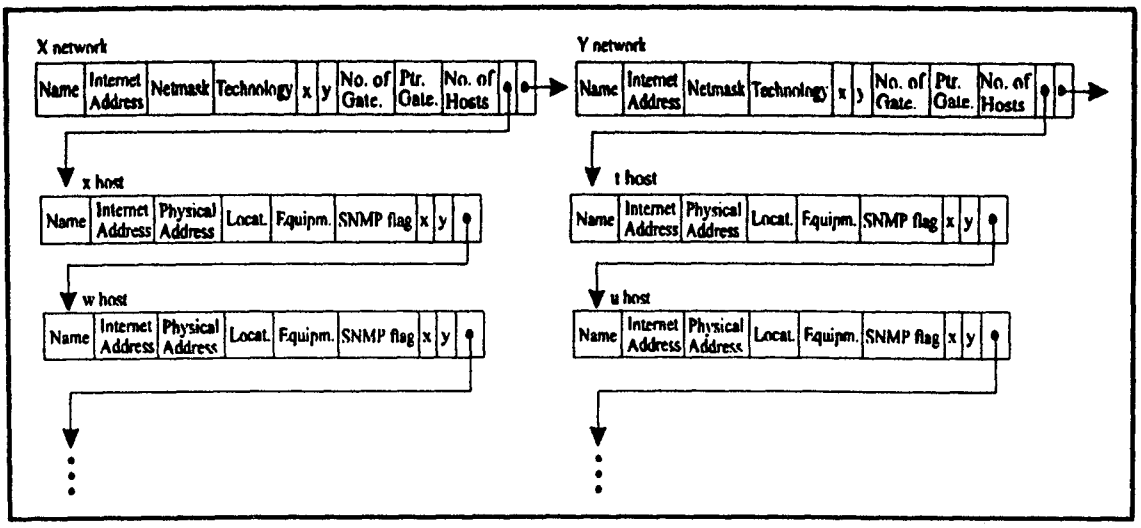

Figure 3 - The list of networks.

4. Network Dynamic Discovery

The Multview system makes use of information from MIB II [Ro90] and Unix system files (/var/etc/hosts and /var/etc/networks) to discover the networks which are in the management domain as provided by the network's manager. The domain is defined in a file, named *conf*, whose entries are the first three parts of Internet addresses of the networks. For example, if the *conf* file has the addresses 143.107.224, 143.107.225, 143.107.230 and 143.107.231, the system tries to discover all the networks that have this prefix in their Internet address. All the MIB's objects are obtained through programmes written in gawk SNMP-capable language (TSNMP, TGATE, THOSTS, TLOCAL and TOGATE).

The dynamic discovery follows five steps. First, the system filters the /var/etc/hosts file to get only hosts and gateways which are inside the management domain. The hosts are stored in a general list of hosts and gateways in a file called *gate* file. In order to discover the gateways, the system tries to get, for each address defined in the filtered file of /var/etc/host file, the *ipForwarding* MIB object. If the value 1 is returned, the address pertains to a gateway, otherwise, the address is supposed to be a host. Since the /var/etc/host file can keep in the form of comments, information such as type of machine and location, it was adopted as a standard for comments:

<Internet address> <name> <alias> #<type of machine> <(location)>.

Ex.: 143.107.231.1 xavante #Sparc station 2 (room 27-J).

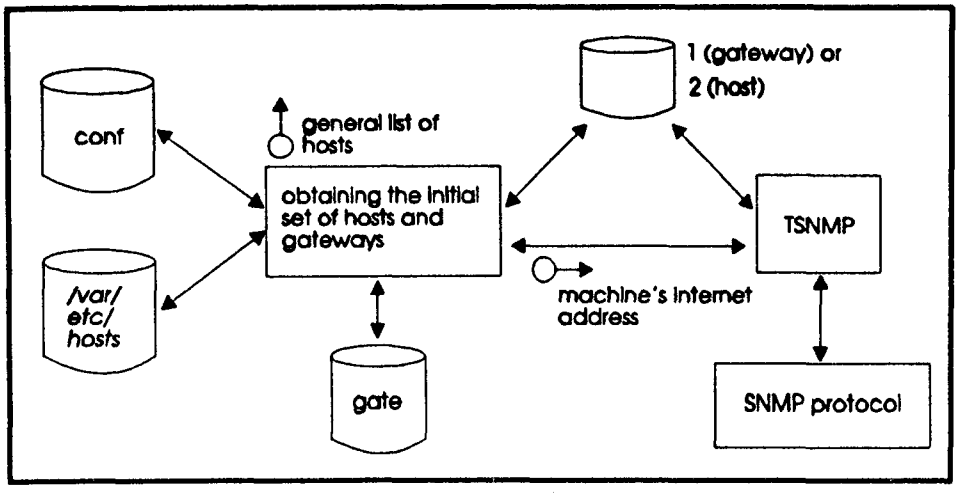

Figure 4 - Scheme illustrating the inital obtantion of hosts and gateways.

Following that, the second step is executed whereby the system searches for each gateway, within the *gate* file, objects of MIB related to its network interfaces: *ipAdEntAddr* (Internet address), *ifPhysAddress* (physical address) and *ipAdEntNetMask* (netmask). Next, the gateway is stored in the list of gateways.

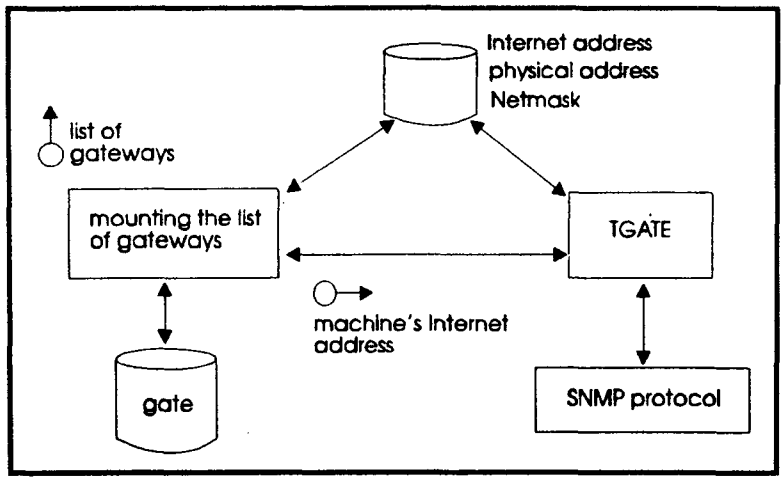

Figure 5- Scheme illustrating the obtantion of information about gateway's network interface.

Since not all of the hosts are listed in the /var/etc/hosts file, in the third step the Multview scans through each found gateway, looking for the objects related to the ARP table as defined in the MIB; and asks for the *ipNetToMediaNetAddress* (Internet address) and *ipNetToMediaPhysAddress* (physical address) which are objects of new hosts. These hosts are stored in the general list of hosts.

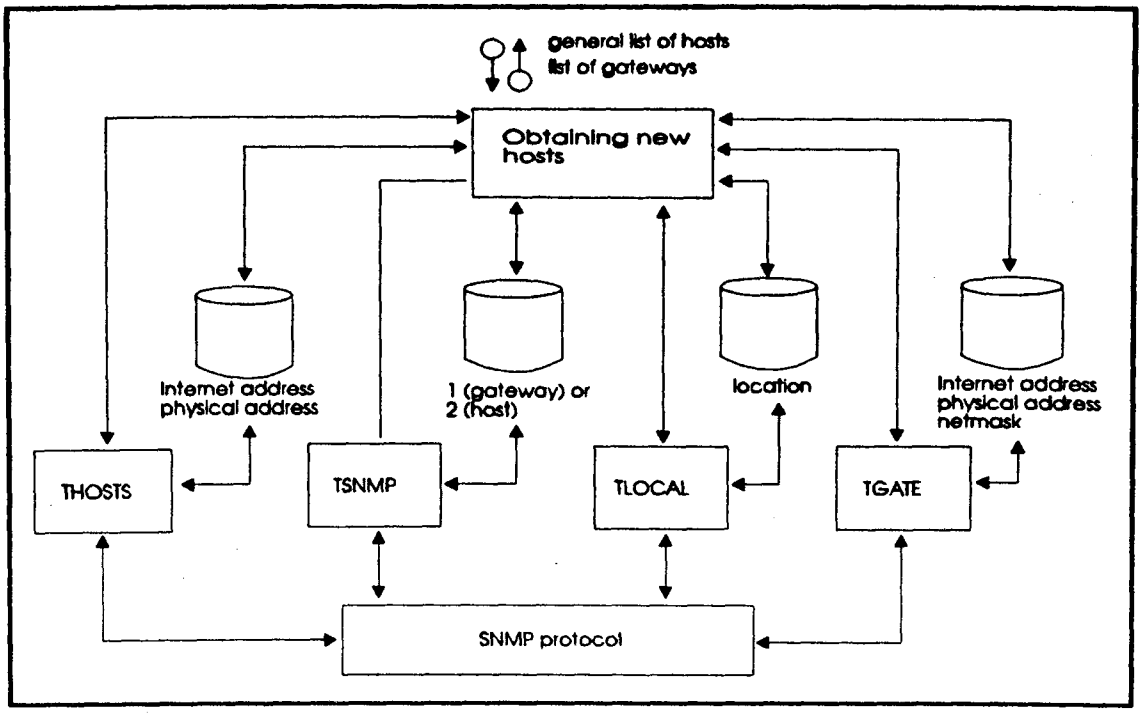

Figure 6- Scheme illustrating the obtention of new hosts.

In the fourth step, other gateways can be found by the system through searching for the object *ipRouteNextHop*, in the gateways which implement the SNMP agent. This object corresponds to the next hop address of the routing table. For each found gateway, information about network interface is obtained. These gateways are also stored in the list of gateways.

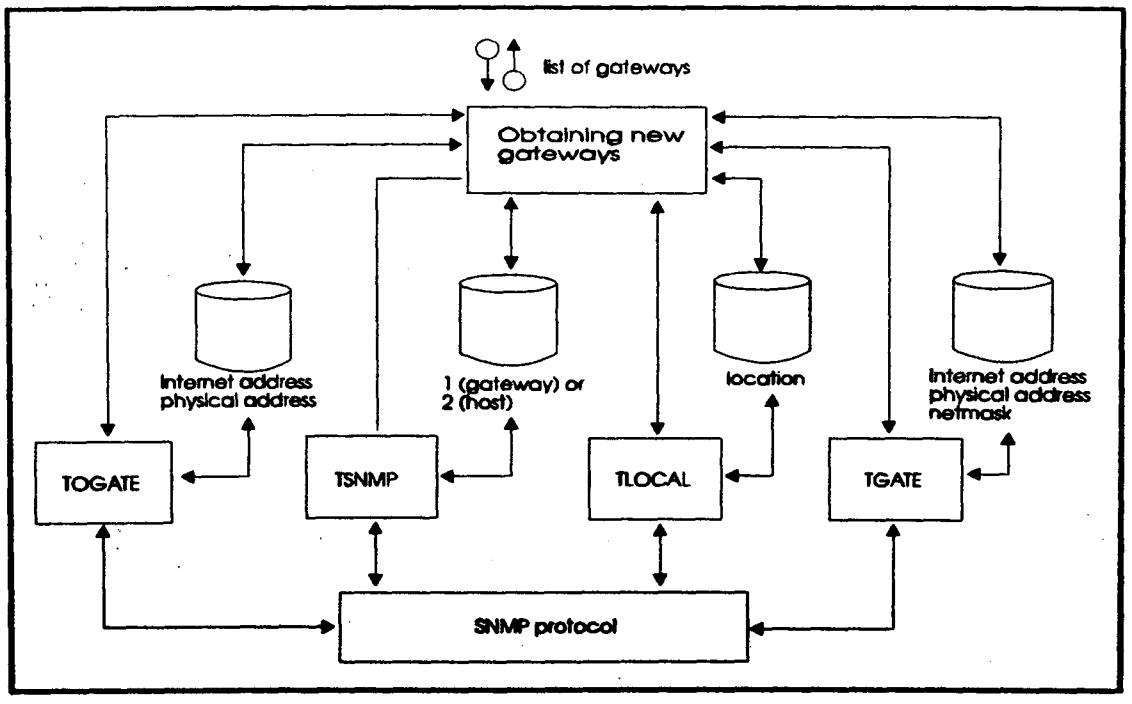

Figure 7- Scheme illustrating the obtantion of other gateways.

Finally, in the fith step, the list of networks is assembled form the list of gateways. The Internet addresses of networks, where the gateways are connected, are determined through the netmask and Internet address of the gateways' network interfaces. For example, suppose that an interface of a gateway has 143.107.231.66 as Internet address and 225.225.225.192 as netmask. The decimal number 192 has as binary number the value 11000000, which means that there can be 4 subnets (143.107.231.0, 143.107.231.64, 143.107.231.128 and 143.107.231.192) with 62 hosts each. Therefore, the 143.107.231.66 address is located in the 143.107.231.64 subnet. The hosts which compose this subnet are those whose Internet addresses are between the range 143.107.231.65 and 143.107.231.126. Once a subnet is determined, the system scans the /var/etc/networks file to get the subnet's name (if the subnet is defined there) and searches, in the general list of hosts, for those that pertain to the subnet. The subnets are then stored in the list of networks.

5. The Multview's Functionality

The main function of Multview is the dynamic discovery of networks, gateways and hosts, and their graphical representaion, as shown in figure 8 and 9. Once the data structures are completed, the system draws the map of networks and presents it in the Main window, figure 8. The user interface follows the OpenLook Graphical User Interface, and is implemented using the interface generator DevGuide [Su90] and the XView Toolkit [he90], both from Sun Microsystem.

The Main window presents the drawing of the managed networks, representing each network by a blue rectangle with its Internet address defined in it. The gateways that make connections between the networks are represented by yellow squares with the letter G. The gateways to which the system has the names, are also written in the drawing. On the right hand side of the window, there are icons which are related to the multimedia functions or other management functions to be implemented in the future.

- *Display*: presents the networks map;
- *Graphical editor*: activates a graphical editor that can be used to modify the networks' map drawing, or to insert new gateways, networks and connections that the system could not discover by itself (this editor is under development);
- *Request editor*: the request editor is used to get objects from MIBs, where the MIBs and objects are presented via menus. Therefore, the user does not need to write anything, simply to select the desired type of MIB in the MIB menu, and the objects from the object menu, which appear after the selection of the desired MIB;
- *Sound*: the sound icon opens a connection between two machines to transmit on line or recorded sound;
- *Video*: this icon opens a connection between two machines to transmit on line or recorded images;
- *Zoom*: applies a zoom to a region of the map of networks;
- *Statistics*: shows graphics of statistics related to performance and utilization of networks and machines.

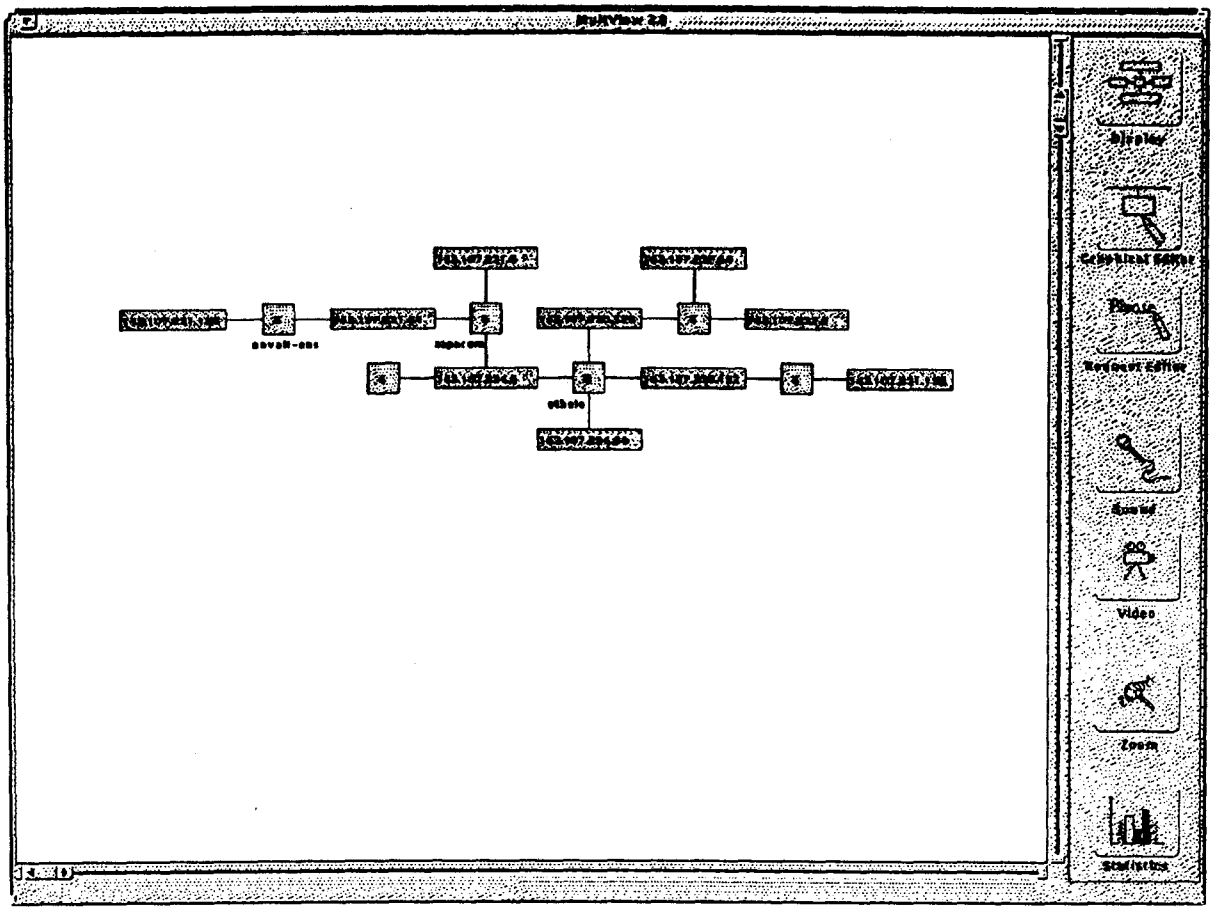

Figure 8 - The Main window.

To see the components of any network presented in the Main window, the user selects any network by clicking once the *select* button of the mouse. A window showing the components of the selected network then appears, already indicating, with different colors, the hosts that are alive (green) or those not alive (red). For instance, selecting the 143.107.231.0 network, the following window appears.

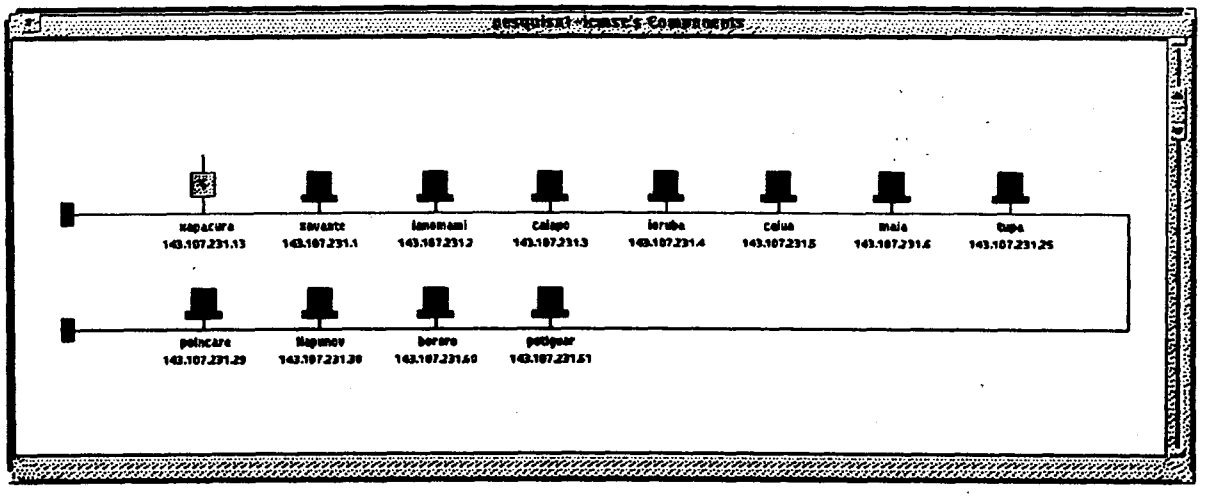

Figure 9 - The Network's Components Window.

Clicking the *select* button on a host or on a gateway, a pop-up window appears showing information about it. For example, figure 10 presents information of gateway xapacura.

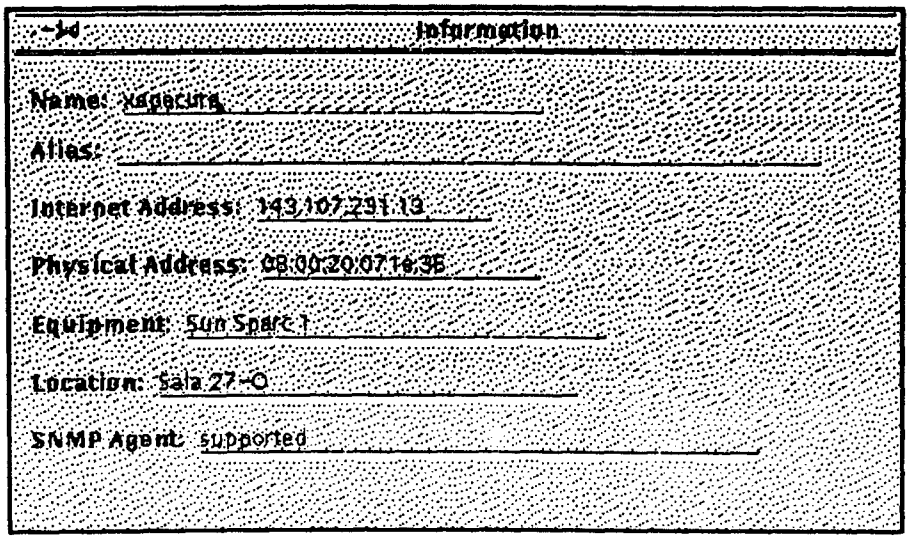

Figure 10 - The Information Window.

Besides the dynamic discovery of networks, the Multview system incorporates some network monitoring functions, written in gawk SNMP-capable language, that have come with the 4BSD/ISODE SNMP package. These functions are activated via a menu and present information related to:

- the routing table;
- the network interfaces;
- the active connections;
- statistics about TCP/IP protocol;
- the device where the SNMP agent is implemented;
- and if the host's operating system is 4BSD Unix, the system provides information about mbuf allocation, printing table and system users.

To illustrate an example of such functions, the window that gives information about the routing table is presented in figure 11.

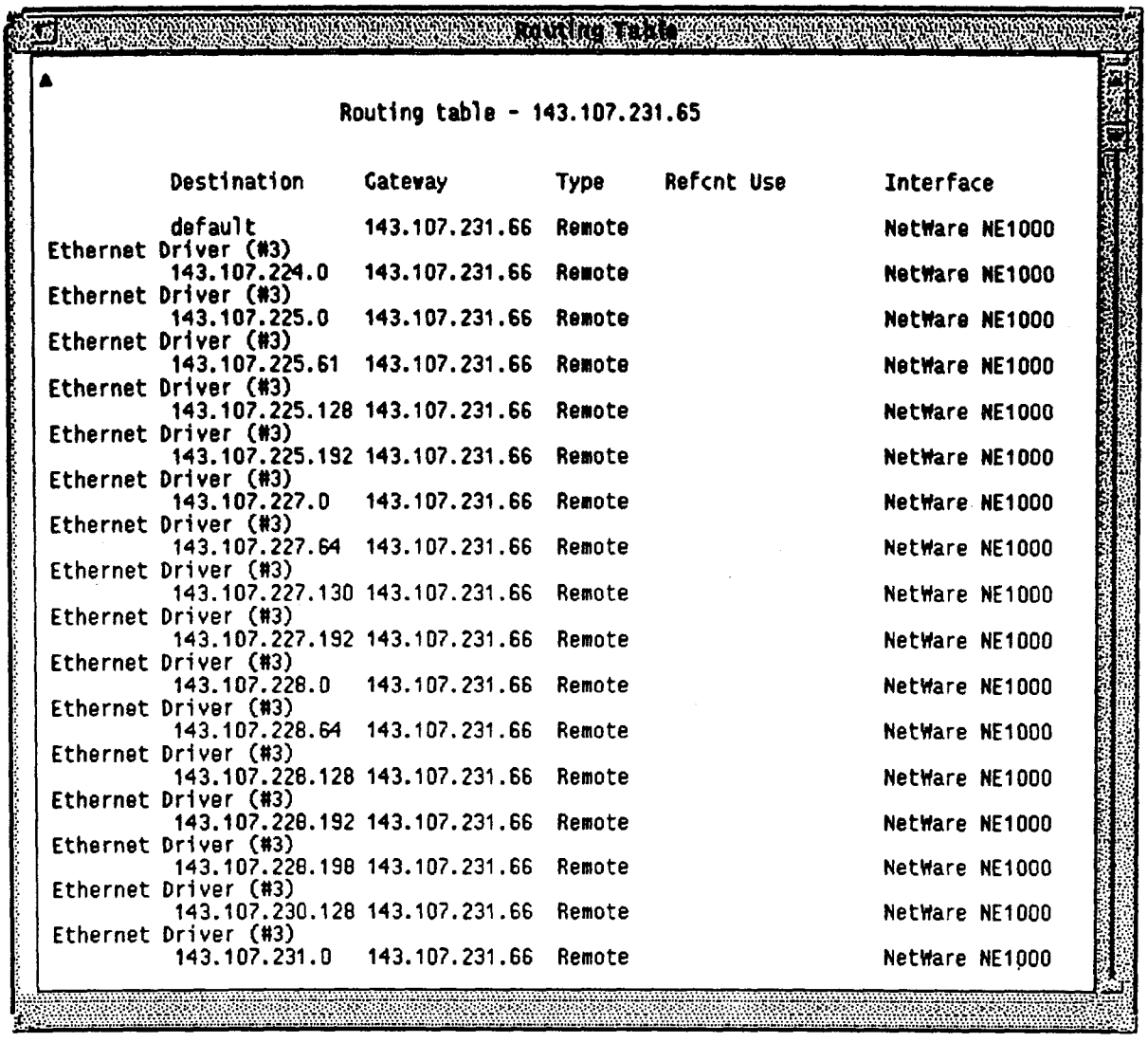

Figure 11- The routing table Information Window.

Where the fields are:

Destination: destination address to this route;
Gateway: Internet address of the next gateways for this route;
Type: routing type;
Refcnt: number of sockets using this routing entry;
Use: number of time that this entry was used;
Interface: outputting interface to this route.

6. Conclusion

The management of networks is a complex task that can be facilitaded by the use of management tools like network monitors, analysers, and integrated management systems. The Multview is a network monitor system with a graphical user interface, designed to be an integrated management system with multmedia resources. Therefore, the data structures were carefully designed to store not only the information of the networks but also the graphical position of each one, in order to identify them by their position on the screen. This is useful for the display of information like the digitalized image of a gateway or host, by selecting it with a double clicking.

The development of the Multview made it possible to show that this kind of system can be developed using public domain software and without the necessity of great resources.

The Multview system and its manuals are available through anonymous ftp at xavante.icmsc.sc.usp.br (143.107.231.1) in the directory /pub/multview.

7. Acknowledgements

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