Managing Network Elements in the Computer Network

Nenad Jovanovic, Suzana Markovic, Oliver Popovic, Zoran Jovanovic

Abstract - **This paper describes the process of development network management application in the IT infrastructure using the Java Management Extension (JMX). Control system, based on SNMP protocol, consists of management applications, management agents and managed devices. Agents are software modules that are managed on the devices. They collect information about the managed objects, send the information for management application and manage with the managed devices, in accordance with the feedback that they receive from management applications.**

Index Terms-**IT Infrastructure, Management, Network Elements**

I. INTRODUCTION

Managing network infrastructure consists of a set of functions for control, planning, allocation, development, coordination and control of network resources. Network management are divided into two basic functions: transport through the management information system and management of information related to the network elements

There are three different approaches to the implementation of management solutions:

- isolated approach,
- coordinated approach and
- integrated approach.

In isolated approach, isolated tools are created for each management problem. Tools work independently one from another based on independent data and independent user interfaces.

With coordinated approach, tools are still independent, but they provide functions that are coordinated. For example, this means that the result of one tool is used as input for another tool. Script is used for the interaction of different programming tools.

If components are managed in a heterogeneous environment, and if access to information is enabled in an independent way, then we speak about the internationals approach to management. This information is accessed through well-defined interfaces and protocols.

If we use the management platform for the integrated management in the heterogeneous environment, it must be specified for the following aspects:

- Description of managed objects (informational model)

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- Treatment and support of organizational aspects, roles and corporation forms (organizational model)
- Description of communicational processes in managerial purposes (communicational model)
- Structuring management functionality (functional model)

The self-management vision, which has raised much interest in recent years, is only an operational aim that does not provide any solution in its definition on how to attain this management autonomy[1].

II. LAYER NETWORK MANAGEMENT

FCAPS is a network management functional model defined by ITU-T and ISO in specification M.3400. It partitions the network management into five functional areas: network device and application fault management, network device and application configuration management, network utilization and accounting management, network performance management, and security management.

1) **Fault Management** — Detect, isolate, notify, and correct faults encountered in the network.
2) **Configuration Management** — Configuration aspects of network devices such as configuration file management, inventory management, and software management.
3) **Accounting Management** — Usage information of network resources.
4) **Performance Management** — Monitor and measure various aspects of performance so that overall performance can be maintained at an acceptable level.
5) **Security Management** — Provide access to network devices and corporate resources to authorized individuals.

Because of some overlap, that brought confusion, in the classification of products for network management, ISO (International Organization for Standardization) is prescribed a layer model (fig.1.) that can help in classifying the appropriate product in the process of synchronization of network resources and business goals.

Stratified layers model of network management are:

- **Management of elements**; installation, configuration and maintenance of individual network elements.
- **Management of operations**; administration of the network, status monitoring, management mistakes and alarm correlation

- **Service management**; this is a delivery management service for user. For example: the service provider would include access management capacity, data storage and delivery application.
- **Business management**; this is the business management aspects of the network. For example: management of budget/resources, planning and contracts, business services, modeling and capacity planning.
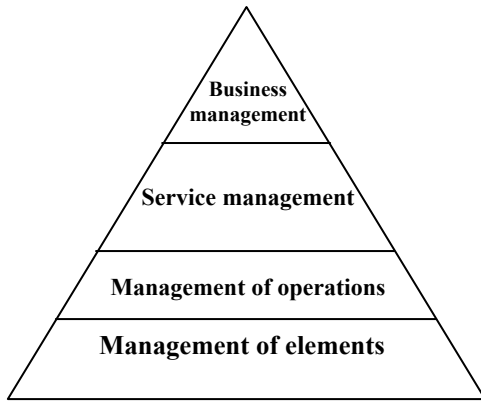

Fig.1. layer network management

Layers are meant to clearly and rationally define the boundaries of TMN system, to simplify the definition, design and implementation of software applications and management systems.

This structure has access top-down, to majority of abstract components (business management) at the top of the hierarchy and most specified, concrete components (network element management) at the bottom of the hierarchy (fig.1.).

Alignment of tools, depending on the business goals increases with each subsequent layer. The organization must reach maturity in the management of the lower layers before they go into the scale management to the level of service management and business management. In this way, the components are more abstract, their application, measurement and information about them is changing. Therefore, at the bottom of the hierarchy (network elements, and elements and network), management is applied using variables and parameters, and at the top of the hierarchy (services and business) management is applied using abstract terms, the rules and policies. This is common for all the components of architecture and could be concluded that the policy can be applied to all components.

Management of elements. Tools developed by the manufacturers of network devices such as:

- Alcatel OmniVista,
- CiscoWorks,
- Syndesis Company,
- Lucent Technologies' Navis iEngineer,
- Nortel Networks' Optivity,

dominate in this layer.

These tools are typical for the monitoring of network components and very often provide photorealistic view of the control devices. The trend of companies in the adoption of homogeneous network solutions leads to reduction of complexity and diversity of tools for managing elements.
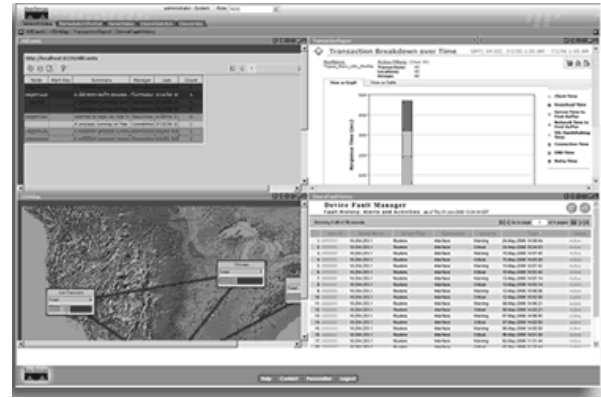

Fig. 2. CiscoWorks LAN Management Solution

CiscoWorks LAN Management Solution (LMS) (fig. 2.) is a suite of powerful management tools that simplify the configuration, administration, monitoring, and troubleshooting of Cisco networks. It integrates these capabilities into a best-in-class solution for:

- Improving the accuracy and efficiency of the network operations staff
- Increasing the overall availability of the network by simplifying configuration and quickly identifying and fixing network problems
- Maximizing network security through integration with access control services and audit of network-level changes

Management of operations. Tools in this layer are helping in understanding of the relationship and dependence between the network components of various manufacturers. They provide day-to-day administration of the network and provide features such as detection of network topology, status monitoring, fault management, etc.

HP (Hewlett-Packard) is a leader at the market in this segment with its OpenView Node Manager (fig. 3.)[2]. Other manufacturers that share this market are: Aprisma, Computer Associates, Remedy, IBM Tivoli, Ipswitch, Micromuse, RiverSoft Technologies, and Smarts.
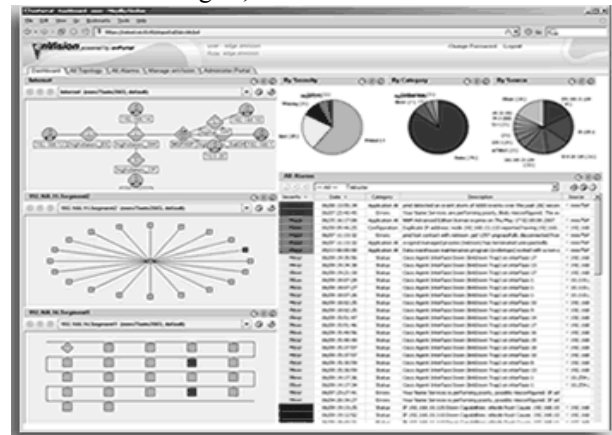

Fig. 3. OpenView Netwok Node Manager

Management of services. This level of management focuses on QoS and guarantee to service problems that are related to network management. Tools of this class are expected to be focused on comparing the quality of network

resources with the existing results. They collected data on performance in time and include features such as: Trend analysis, Analysis of the use, Reports on the level of service. Sophisticated and automated tools are compared with the current level of service previously defined, calculated or derived metrics, prescient when the level of service is not as prescribed and to warn network manager about upcoming problems. The best-known manufacturers of tools for service management are:

- Compuware,
- Concord Communications,
- HP,
- Micromuse,
- InfoVista,
- Lucent and
- NetScout Systems

Many products that are focused on the management services are expanded, and include measurement service to a wide range of elements. These data are necessary to control the level of service end-to-end. Micromuse Netcool/Monitors family (fig.4.)[3] of products collects and consolidates information about the performance and availability which are necessary for advanced management services .
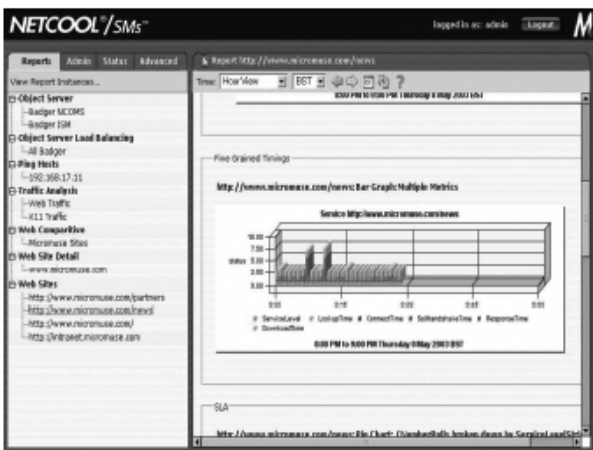

Fig.4. Micromuse Netcool

Business management. This layer refers to the harmonization of network and other IT infrastructure with business processes. On the basis of fundamental discussion between ISO and business factors to define high-priority business processes, ISO is a mapped service in the IT supply basic chain network and infrastructure components. Tools in this layer:

- Document relationship and dependence of business services and IT components
- Directly monitoring or integrating with existing monitoring tools to collect information about the status and performance of components
- Establishing a link between problems in the IT components to business services.

Manufacturers that offer tools that represent the business impact of the network problems are:

- Aprisma,
- HP,
- IBM
- Tivoli,

- IT Masters,
- Managed Objects,
- Opticom,
- Proxima Technology,
- Smarts and Systar.

Other tools in this layer focus on network planning and design.

Manufacturers such as Compuware and Opnet Technologies offer tools that perform the simulation, prediction, application modeling (allows the application to be tested for the network performance before it is created), capacity planning and tuning suggestions for applications and infrastructure to achieve business goals.

OPNET Panorama (fig 5.)[4] delivers comprehensive performance management for critical Java and NET applications throughout the application lifecycle, beginning with development and QA, and continuing through deployment and operations.
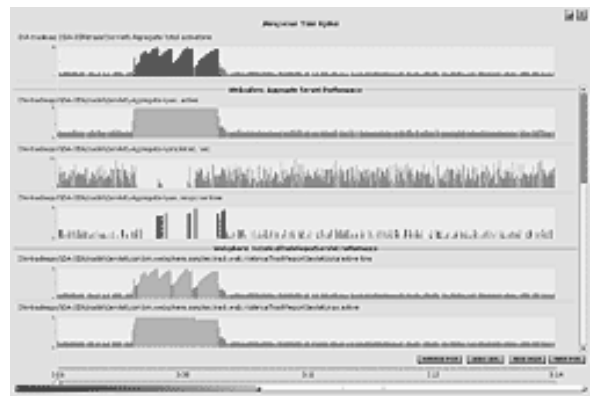

Fig. 5. OPNET Panorama

III. PROTOCOL FOR NETWORK MANAGEMENT

SNMP (Simple Network Management Protocol) is application layer protocol that allows the exchange of management information between network devices. It is a part of the TCP/IP protocol family. SNMP enables network administrators to manage network performance, find and solve the problems in the network and to plan network growth. Almost all modern network management tools are based on SNMP. SNMP is used as a communication channel. SNMP network management consists of three key components: managed devices, agents and network management system (**NMS**).

Managed devices are network nodes that contain the SNMP agents. Managed devices collect and store management information and make this information available to the NMS with the SNMP. Managed devices are sometimes called network elements and can be routers, access servers, switches, bridges, Hub's, computers, printers…

Network management system executes the application that control and monitor managed devices. NMS provides the memory and processing resources necessary for managing the network. NMS is a network control center. It is common for one independent system that exist only in one NMS, whereas many large networks of multiple-NMS are hierarchical moderated. Most modern NMS's works on the specialized UNIX or Microsoft servers.

Agents are network-management software modules that are in the managed devices. An agent has local knowledge of management information and translates that information in a form compatible with SNMP. Agents are small software modules that are managed on the device and can be set to collect certain pieces of information about the device. Most of this information is aggregated information: the total number of bytes, the total number of packets, the total number of errors and so on. The idea is to appoint agents to all devices in the network and manage it in accordance with the feedback they get from NMS. Part of the hardware with the uploaded SNMP agent is called the managed device (or network element).

The process of collecting information of any agent is called the managed object. Managed object is a variable characteristic of managed devices. For example, the total number of UDP connections open on a managed device can be controlled object. One open UDP session on a particular instance of the interface object,, is a managed object.

Word 'Simple' in the name of the **Simple Network Management Protocol** comes from that this protocol has only a few basic commands. They are used for setting and loading parameters in the SNMP configuration file device in the network. SNMP commands are shown in Table 1.

TABLE I SNMP COMMANDS

Command	Meaning
get-request	It is used for instances of the object agent
get-next-request	It is used for the following instances in the first instance
get-bulk-request	Read a larger amount of data (e.g. tables)
response	Response to previous requests
set-request	It is used to set values for the instance objects within the agents (such as thresholds)
inform-request	New command for SNMP version 2; using it commanded in the NMS to the information collected to the trap command to one or more other NMS's
snmpv2-trap	It is used for issuing orders to one agent to inform the NMS was an event (response activated some event)

Agents keep control and status information about the facilities in specialized syllables database, called MIB (management information base). MIB is part of SNMP agent software in which is data kept. Information stored in the MIB is called the variables (including attributes).

Management information accessible via SNMP is organized in the Management Information Base (MIB). Many management applications are based on management information within an MIB table[7].

MIB's are set to perform different tasks often called MIB objects. Basic MIB`s usually comes as integrated in the operating system of network devices. For example, the IOS is supplied with the MIB objects for the majority of the network management.

Names that are used for the MIB variables are taken from the name of ID space facilities managed by ISO and ITU (Fig 6). The main idea is based on the ID name space object to provide space, in which names will be able to mark all possible facilities. This name space is not limited to names that are used in network management. Current standard MIB is MIB-II, which contains close to 200 standard MIB objects. Standard is implemented in a hierarchy which starts from the root and continue to the branch, from the original MIB to the Internet MIB. We see in the picture that each branch is marked with the number and the name (numbers are used for building ID objects).

The name of the object in this hierarchy is series of numerical labels on the node path from root object. It is written with a number of points that separate components of the names. For example, the name indicates **1.3.6.1.2** node sub tree **mgmt** for Internet management. In sub tree **mgmt MIB** has a node with the **mib** denote and numeric value 1. After all the **MIB** variables are under the knot, all their names begin with **1.3.6.1.2.1.** prefix.

Development of Control Applications. Java management Extension (JMX)[5][6] developed by Sun and the industry is leader in network management defined operating framework that enables the development of automated, intelligent and dynamic solutions for network management. JMX defines the architecture, project plan, the API and services for applications management and network monitoring in the Java programming language.
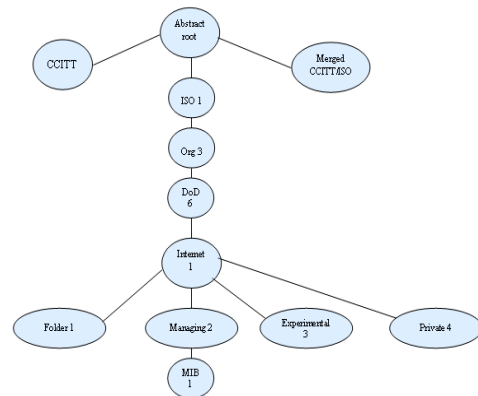

Fig. 6. Hierarchical name space for the MIB variable

The management of the corporate information technology (IT) environment is rapidly increasing in complexity as server logic architecture becomes more distributed and the number of entities deployed increases, forcing enterprises to resort to thick, complex and expensive high-end integrated systems and network management solutions. Investing in such systems can be inefficient for small and medium corporations, since the vast majority of management tasks performed are routine tasks, while personnel specialization requirements and costs are high [8].

JMX provides support for existing management protocols (such as SNMP) in a way that JMX can integrate them into existing management solutions.

There are many implementations of JMX standards. One of that implementation is Sun's Java Dynamic Management Kit (JDMK).

Java Dynamic Management Kit provides a set of Java classes and tools that are used for the development of dynamic management solution.

This product is suited to Java management extensions (JMX), v1.2 for maintenance and JMX management API, the v1.0. For the development of dynamic solutions for network management using JDMK is necessary to download JDMK first from:

http://java.sun.com/products/jdmk/

Files **jdmkrt.jar** and **jdmktk.jar** must be added to the **CLASSPATH** in order to be able to compile and execute examples.

At the beginning, it is necessary to generate a file that contains a list of facilities which will be managed and can be referred to JDKM code. Using a **mibgen -d**. **-mo mib_II.txt** generates the file *RFC1213_MIBOidTable.java*. This file is generated with reference to the specified standard **MIB** file (mib_II.txt). Generated Java file contains definitions of managed objects. Some definitions from generated files are shown in the following list:

// Definitions for managed objects
new SnmpOidRecord("ifInOctets",
"1.3.6.1.2.1.2.2.1.10", "C"),
new SnmpOidRecord ("ifSpeed", "1.3.6.1.2.1.2.2.1.5",
"G"),
new SnmpOidRecord ("ifInErrors",
"1.3.6.1.2.1.2.2.1.14", "C"
new SnmpOidRecord ("sysDescr", "1.3.6.1.2.1.1.1",
"S")

Symbols in each **SnmpOidRecord** can be directly accessed through the network management software.

Using JDMK, we can create software and monitore events and proactively read the state of the device by selecting and searching values that require some MIB variables in the interface at the end of the link. These are the standard objects that are held in SNMP entity which is active in the device. Sometimes, SNMP entity is not active by default. We assume that SNMP agents are activated on the observed devices.

Basic Java class is called **Manager**. It uses the following JDMK resources:

// JDMK resources
import
com.sun.management.snmp.SnmpDefinitions;
import com.sun.management.snmp.SnmpOid;
import
com.sun.management.snmp.SnmpVarBindList;
import

com.sun.management.snmp.manager.SnmpPeer;

It is now necessary to initiate the SNMP Manager API. This allows access to generated table mentioned in the introduction.

final SnmpOidTableSupport oidTable = new
RFC1213_MIBOidTable();
SnmpOid.setSnmpOidTable(oidTable);

Then we need to make a **SnmpPeer** object. This object is agent that will interact with management applications.

final SnmpPeer agent = new SnmpPeer(host,
Integer.parseInt(port));

Now we have to make a communication session with the remote entity. For this, it is necessary to specify the SNMP communication parameters for reading and writing (Community name). The parameters associate with the agent.

// Specify the community name for reading and
writing
final SnmpParameters params = new
SnmpParameters(community_r, community_w);
agent.setParams(params);

Then make SNMP session, which will manage the demand for data and then we're ready to make a list of requests for data. Add a list of the observed object.

// Make the session
session= new SnmpSession("SyncManager session");
// Agent is connected with SNMP session.
session.setDefaultPeer(agent);
// Make a list of variables for which you want to
place a query
list = new SnmpVarBindList(" SyncManagervarbind
list");
list.addVarBind(OID);

When we specify agent, SNMP operation, the list of objects and the session can make SNMP request.

// SNMP request specified operation snmpOp
rez =(String)request(agent,snmpOp,list,
session,host,port);

The requested object is packed in a single SNMP **getRequest** message and sent to the agent in the following way:

// GetRequest make SNMP request and waiting for
the result
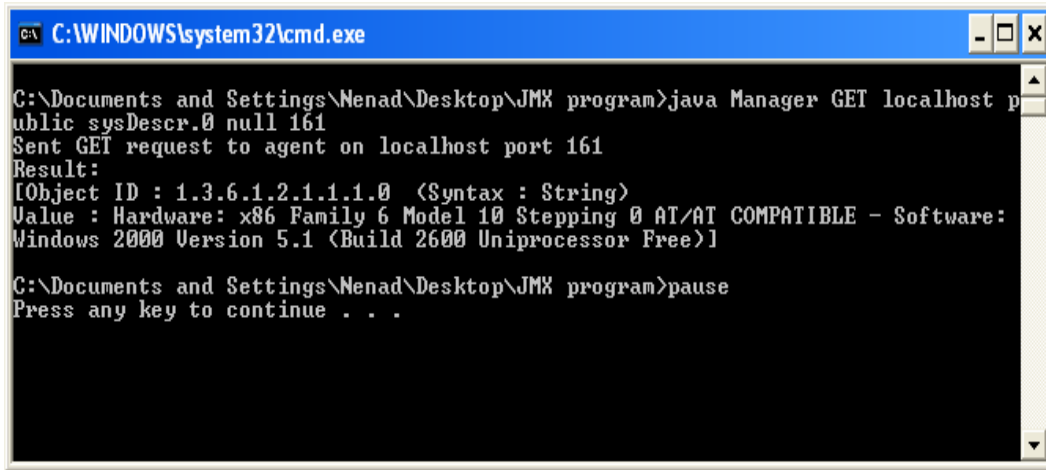**request = session.snmpGetRequest(null, list);**

Fig. 7. Value of MIB object sysDescr

SNMP agent receives a request, reads the value of MIB variable, which is specified in the list of variables, and the result of the required values is sent back to the management application that can display the result (Fig.7, fig.8.). The results are processed and displayed either in datasheet or chart view. (fig. 9.).
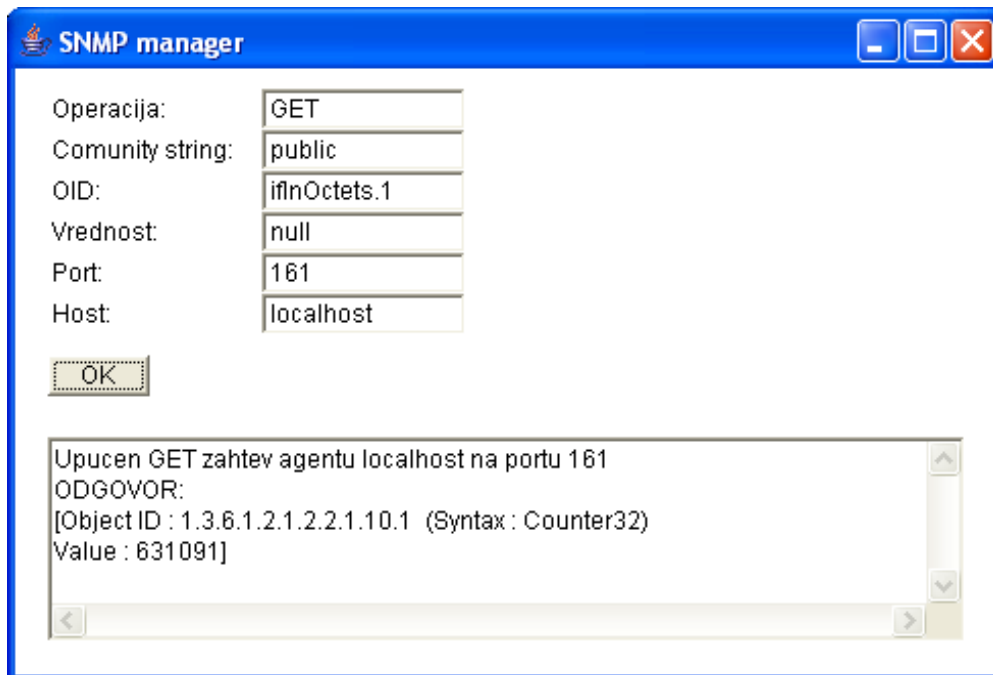

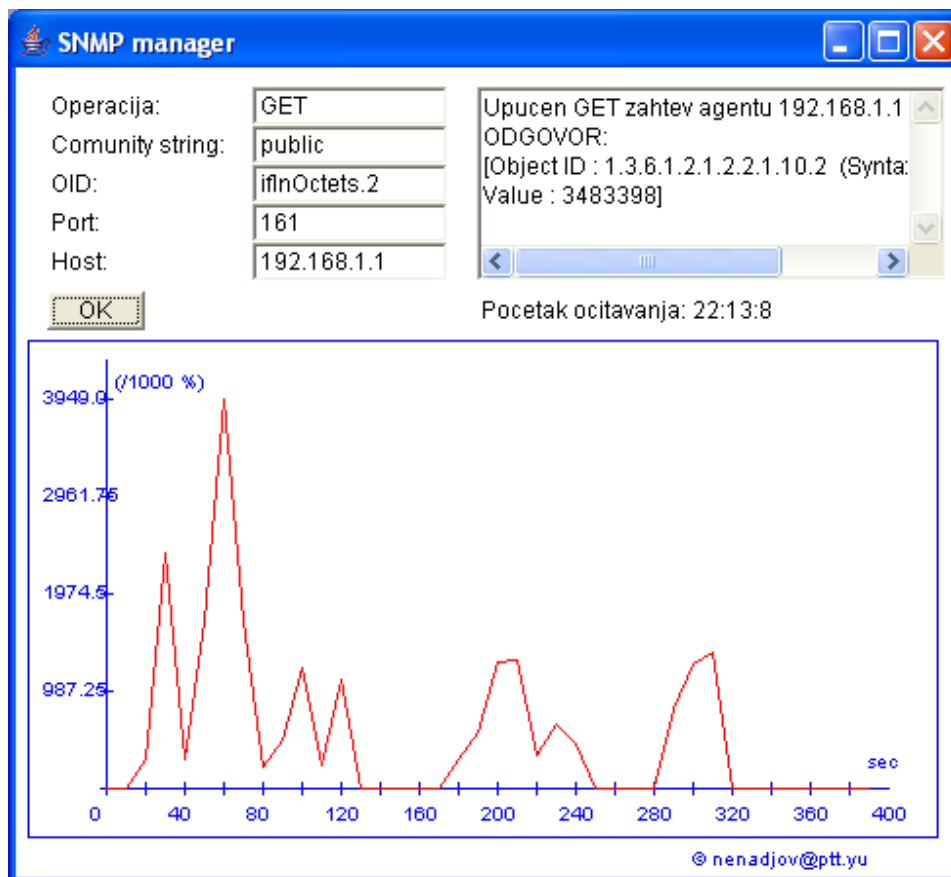Fig. 8. Graphical user interface for the results review.

Fig. 9. Processing results and a graphical display

I. CONCLUSION

The monitoring and management of IT infrastructure becomes increasingly difficult as these networks grow in size and complexity. Moreover, several new functional requirements appear for these network management systems in the emerging field of digital multimedia networks[9]. Management of IT infrastructure should not be always considered only from the technical perspective. An integrative approach must be based on the management pyramid, but it is also necessary to adjust management of corporational structure. This requires:

- Defining the management process that supports business process
- Defining the domain of specific management policies and procedures in which it will be implemented.
- Specify the interface between domains in order to enable the exchange of management information and call management actions.
- Planning and establishment of infrastructure management
- Establishment of operational and organizational structure, to specify the areas such as administration, planning, analysis ...

One important necessity in the business of every network administrator is the identification of weak points in the network. This requires careful data collection. Each network has its own world. The network links may periodically become overloaded. There are numerous systems for network Management (HP OpenView) that offer a wide range of application use. They have many useful features, including automatic detection and mapping of network devices, receiving messages as well as the possibility of adding other software components. JMX enables the development of their own management applications and customizing specifics of each network at a very low price.

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