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Performance Measurement and Analysis of Intranet using DPE-based Performance Management System

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ABSTRACT

The modern telecommunication networks are composed of various network-type and are managed by various management technologies, such as TMN, SNMP, TINA etc. Furthermore, the network user's needs of real-time multimedia services are rapidly increasing. In order to guarantee the user-requested quality-of-service(QoS) and keep the network utilization at maximum, it is required to manage the network performance continuously after the network is deployed. The performance management function should provide the useful information for the network expansion and the capacity reallocation in the future.

In this paper, we propose a DPE-based performance management architecture for the integrated management of the heterogeneous network elements with TMN and SNMP. We propose an approach to provide the Intranet traffic monitoring and analysis function using layered network management concept and distributed processing technology. The proposed architecture has been designed and implemented based on multiprocess and multithread structure to support concurrent processing. To manage the traffic according to the Intranet service categories, we implemented an ITMA(Intelligent Traffic Monitoring Agent) with packet capture library. With the proposed architecture, we could measure and analyze the real Intranet traffic of Yeungnam University.

I. 서 론

Over the past decade the computer network has become fundamental for usual daily life and business activities. The current networks are composed of various high-speed and broadband networks based on various networking technologies, such as ATM, SDH/WDM, and IP networks. Furthermore, the network user's demands for real-time multimedia services are exponentially increasing. As the consequence of this situation, it has become an important issue to maintain the network performance at maximum to continuously deliver guaranteed QoS to users. The performance management function should provide the useful information for the network expansion and the capacity reallocation in the future.

The existing network management standards have well specified the configuration, connection and fault management. But the management functions for performance management and security management are not well defined yet; most of the functions are under standardization or defined as further studying.

In this paper, we propose a DPE-based performance management architecture, implement and evaluate a part of the proposed performance management functions. We present the distributed network management architecture for efficient interworking of the various management functions such as CMIP, SNMP, and TINA. The proposed approach can monitor various kind of Intranet traffic and analyze the monitoring results to provide the useful information for the future network expansion and the capacity reallocation.

The rest of the paper is organized as follows: We first look briefly at the performance management functions of current existing network management architecture such as TMN and TINA.

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We then briefly explain the designed performance management architecture and its functions. In section 4, we describe the consideration points of Intranet performance management and the layered Intranet management concept. We finally evaluate the implemented performance management functional modules.

Ⅱ. Performance Management in Current Network Management Standards and Commercial Products

1. Performance Management Architecture in TMN and TINA

The TMN(Telecommunications Manage- ment Network) has been defined for the management of public telecommunication networks[1,2]. The concepts of TMN management functions are very useful and can be applied to various networks. The TMN describes the performance management as follows: Performance management provides functions to evaluate and to report upon the behavior of telecommunication equipment and the effectiveness of the network or the network element[3]. For these purposes, the components of performance management functions should include the followings[3]:

- *Performance Quality Assurance* that supports decision processes to establish the quality measures that are appropriate to the area of performance management, as the state-of-the art expands and customer needs change.
- *Performance Monitoring* that monitors the continuous performance data of the NE.
- *Performance Management Control* that supports the information delivery to control the operation of the network.
- *Performance Analysis* that evaluates the performance level of the network entity.

The performance management components are implemented with OSI SMF(System management Functions) that includes Metric Monitoring Function and Summarization Function[4,5]. Performance management functions of TMN provide the underlying framework on which our approach is based.

The TINA management architecture is based on the concept of the TMN management functions[6-8]. But TINA has good properties of the distributed management functions and the independence of the managed network technologies. In order to achieve the performance management objectives, the TINA performance management includes following functions[6-8]:

- *Performance Monitoring* that performs the acquisition and maintenance of activity data required for analyzing the performance measurements.
- *Performance Analysis* that analyzes the performance related data, determining the meaningful level of performance.
- *Performance Control* which is associated with the specification of the managed objects under the performance surveillance, and the regulating how performance events are related to the performance management entities for subsequent analysis.
- *Performance Tuning* that reconfigures the managed object attributes in order to maintain the desired level of performance.

2. Performance Management in Commercial Products

Nowadays, network administrators typically use commercial management tools(e.g., HP Open-Veiw[9], IBM NetView[10], SunNet Manager[11], etc.) to monitor and control their networks. However, most of the tools are applicable to the node with SNMP agent only. Typically, these tools provide limited performance management functions of simple traffic monitoring by using SNMP MIB values on a node. So, they dont provide the management functions of network view. Their traffic monitoring method is implement by only polling that increases network traffic with periodical network management message traffic. For instance, the HP OpenView provides the ability to monitor MIB object values on any managed node with SNMP by polling method. It stores the monitored values for the analysis of historical trend. By analyzing the values of key network indicators gathered, we can detect the early warning indication. Its thresholds can then be correspondingly set to alert the operation staff if the warning conditions occur.

As mentioned above, the performance management functions of current commercial products are used for traffic monitoring and the simply non-real time analysis. Also it can use only for the node with SNMP that does not provide the management functions of network view.

In this paper, we propose a DPE-based performance management architecture that supports nodes with various management functions such as CMIP, SNMP, IIOP and nodes without management function. It provides various performance management functions such as monitoring, analysis, and tuning. Of course, it supports both the management functions of the network view and the network element view(NE view). The monitoring methods run by both polling and event-driven. It supports performance analysis and performance tuning in real-time and non-real time mode.

Ⅲ. Design and Implementation of DPE-based Performance Management Architecture

We designed and implemented a DPE- based performance management models based on the definitions of the performance management function in TMN. In the view of the distributed management functions and the independence of the managed network technologies, the proposed performance management functions are compatible with TINA. The performance management functions have been implemented with C++ language and Orbix Art 1.2 that supports CORBA 2.3[12, 13]. To support the concurrent processing, we designed and implemented the functional blocks of the proposed architecture based on the multi-process and multithread structure. To analyze the traffic according to service categories and to support the systems without management agent function, such as PC, we implemented an Intelligent Traffic Monitoring Agent(ITMA).

1. Layered Performance Management Architecture

Fig. 1 shows the proposed layered performance management architecture based on DPE. The proposed performance management architecture includes the functional modules such as Performance Monitoring(PM), Performance Analysis and Control(PAC) and Performance Tuning(PT)[14, 15].

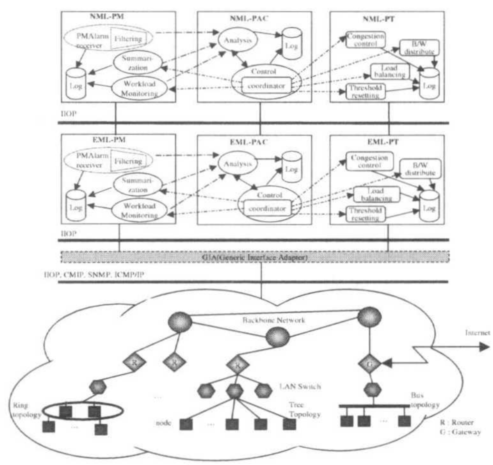


Fig. 1. Layered Performance Management Architecture

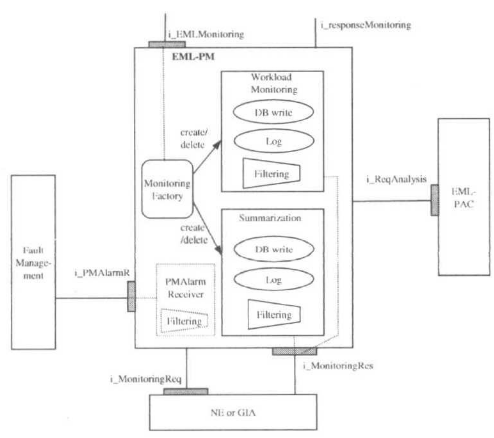


Fig. 2. Proposed Performance Monitoring Architecture

The PM module performs the workload monitoring and the summarization functionality. The workload monitoring is to collect or capture the traffic data of the network resources under observation by polling or event-driven method. Fig. 2 depicts the EML-PM architecture in detail. The NML-PM architecture is similar to the EML-PM. The difference between EML-PM and NML-PM is that NML-PM monitors the resources of network-view (e.g. integrates measured data from each node(NE)) while the EML-PM monitors the resource of a node(NE).

The PAC module executes the data analysis algorithms and delivers the information to control the operation of the network elements, but it does not have direct interaction with NEs. Fig. 3 depicts the EML-PAC architecture in detail. The NML-PAC architecture is similar to the EML-PAC. In Fig. 3, the NPCF(Network Performance Characterization Function) generates the report to characterize the end-to-end performance of the dedicated network, which includes the network interface-to-network interface, and the network interface-to-inter-network interface (point of termination), in relation to the long-term accuracy and the availability objectives. Generally, this function is not used in EML. The NEPCF(Network Element Performance Characterization Function) provides the processed and analyzed performance data from the measurements of the current cell count, and the history counts

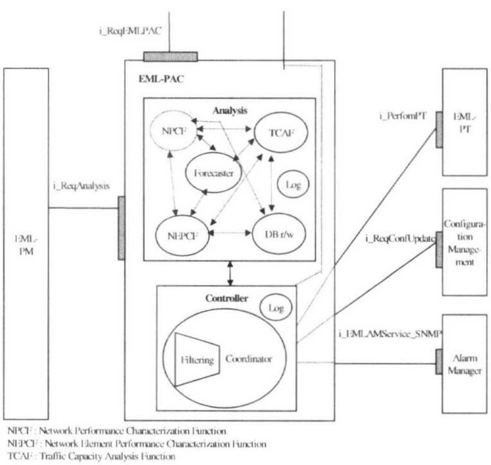


Fig. 3. Proposed Performance Analysis and Control Architecture

and the threshold-crossing alert to support the evaluation of the performance level of the entity. The TCAF(Traffic Capacity Analysis Function) generates the reports of the estimated level of offered traffic that can be carried by the current resources at the desired level of QoS.

The PT module performs the functions to improve the network performance or to compensate according to the PAC results. The performance tuning executes the actions for performance correction. Fig. 4 describes the EML-PT architecture in detail. The NML-PT architecture is similar to the EML-PT. As functions of PT, we consider threshold resetting, bandwidth distribution, load balancing and congestion control.

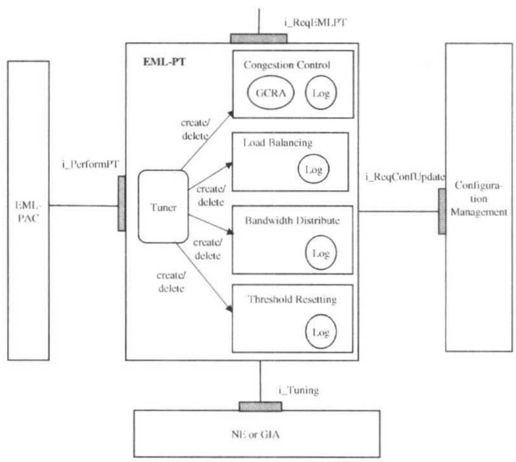


Fig. 4. Proposed Performance Tuning Architecture

The GIA(General Interface Adaptor) in Fig.1 is necessary only for NEs with CMIP or SNMP which do not have distributed processing environment(DPE).

The process of performance management functions are performed according to the performance management policies[14,15]. The performance management function has tight relationships with the configuration management, connection management and fault management. The proposed performance management architecture can be used to enhance the network performance and to provide the guaranteed-QoS to users.

2. ITMA (Intelligent Traffic Monitoring Agent)

The main goal of ITMA is monitoring the network traffic that flows through the LAN segment and measuring the delay between two server systems that could not be measured by SNMP agent[16]. Fig.6 depicts the overall structure of ITMA. It receives the request of traffic monitoring and connectivity check from the agent through GIA. It uses the window version of BPF(Berkley Packet Filter) to capture the network packet. The BPF of window version supports statistic mode that can be used to get the real time statistics on the networks traffic in an easy way and with the minimum impact on the system. This statistic mode is powerful and versatile framework to calculate the statistics on the network traffic because it requires very few system resources: only the BPF filter is applied to every packet, but no copy operation is performed.

The communication between ITMA and ITMA Interface in GIA is accomplished by socket function call. To interact ITMA, we implants ITMA interface in GIA. All requests from the agent are delivered to GIA. And they are delivered to the ITMA through the ITMA Interface.

ITMA consists of two main module: TM (Traffic Monitoring) and CC(Connectivity Check). The TM module consists of several functional modules: Generator, Reporter, and BPF. The traffic-monitoring request is delivered to the TMs Generator module through the GIA. The received request is verified at the Generator module. If there is no error in the request, it generates new monitoring item and new threads that monitor the network traffic and report the statistic data.

The generated monitoring item is stored in the Monitoring Item List. The Generator and the Reporter use the Monitoring Item List. To report the statistic data to the manager through the agent, the monitoring item thread calls the Reporter functional module.

CC module checks the connectivity between the two hosts: from one host with ITMA module to the other designated host. The manager can request two kinds of requests: Instant CC request and Periodic CC request. When the manager requests an instant CC request, the CC module checks the connectivity and reports the result to the GIA immediately. For periodic CC request, the CC modules create CC Item and store it to the CC Item List. And it creates the thread that checks the connectivity and reports in periodic manner.

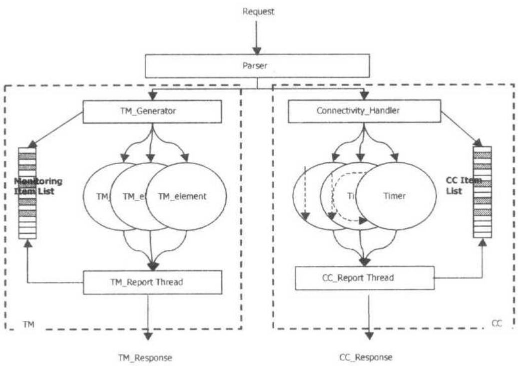


Fig. 5. Overall structure of ITMA

ITMA supports various traffic-monitoring request, such as service types(HTTP, FTP, and so on), protocols(TCP, UDP, IP, etc.) and other things. This characteristic is not provided by other management system. It also provides the connectivity check functionality that is useful to the network manager.

Ⅲ. Intranet Performance Management

1. Consideration Points for Intranet Performance Measurement

To analyze the performance of network and network elements, we consider the following:

- link/port throughput and its utilization rate
- node(NE) throughput and its utilization rate
- network throughput and its utilization
- connection rejection ratio
- transmission error rate
- the probability of the rejection ratio, the

probability of the threshold-crossing (over-load)

- analysis of traffic according to the service categories, such as FTP, WEB, SMTP, etc.

To compute the link/port throughput and utilization, we firstly measure the amount of traffic(such as the number of incoming packets and outgoing packets) on each link or port by the PM. As the next step, the link/port throughput and utilization are computed by the number of measured cells over period and by its throughput over total ones capacity (maximum speed) each other in the PAC. The node throughput and utilization(rate) are computed by the sum of each link/port throughput and utilization(rate) in a node. And the network throughput and utilization are computed by the sum of each node throughput and utilization in network. If MIBs related to the traffic amount of node or network are provided, we can make use of them too. The formulas for performance analysis are defined as show in Table 1.

The connection-rejection ratio and transmission error rate are given by the following formulas:

$$connection\ rejection\ ratio = \frac{\sum rejected\ connections}{\sum accepted\ connections + \sum rejected\ connections} \quad \ldots(1)$$

$$transmisstion\ error\ rate = \frac{\sum erred\ PDUs}{\sum sent\ PDUs} \quad \ldots(2)$$

The probability of the rejection ratio and the probability of the threshold-cross(over utilization) are given by the formulas as shown below:

$$P_r[rejection\ ratio > Treshold_{rej}] = \frac{number\ of\ the\ condition[rejection\ ratio > Threshold_{rej}]}{number\ of\ total\ measurements} \quad \ldots(3)$$

Table 1. The Simple Formulas for Performance Analysis

Type	Formulas
Link or Port throughput, utilization	$link\_port\ throughput_{input/output} = \frac{\sum_t link\_port_i\ throughput_{input/output}}{measurementperiod(t)}$ $link\_port\ throughput_{total} = link\_port\ throughput_{input} + link\_port\ throughput_{output}$ $link\_port\ utilization_{input/output} = \frac{link\_port_i\ throughput_{input/output}}{link\_port\ \max.\ capacity}$ $link\_port\ utilization_{total} = link\_port\ utilization_{input} + link\_port\ utilization_{output}$
Node throughput, utilization	$node\ throughput_{input/output} = \frac{\sum_t amount\ of\ link\_port\ input/ouput\ traffic}{measurementperiod(t)}$ $node\ throughput_{total} = \sum_i link\_port_i\ throughput_{total}$ $node\ utilization_{input/output} = \sum_i link\_port_i\ utilization_{input/ouput}$ $node\ utilization_{total} = \sum_i link\_port_i\ utilization_{total}$
Network throughput, utilization	$network\ throughput_{input/output} = \sum_i node_i\ throughput_{input/output}$ $network\ throughput_{total} = \sum_i node_i\ throughput_{total}$ $network\ utilization_{input/output} = \sum_i node_i\ utilization_{input/output}$ $network\ utilization_{total} = \sum_i node_i\ utilization_{total}$

$$P_r[\textit{utilization rate} > \textit{Threshold}_{util}] = \frac{\textit{number of the condition}[\textit{utilization rate} > \textit{Threshold}_{util}]}{\textit{number of total measurements}} \quad \ldots(4)$$

To analyze the traffic according to the service categories, we need packet capture function. We implemented an ITMA (Intelligent Traffic Monitoring Agent) which supports classification and analysis of traffic according to Intranet services such as FTP, WEB, and SMTP.

We can apply the results of analysis as described above for executing PT or evaluation network expansion and reconfiguration. PAC reports the performance alarm to the fault management if the performance of network or NE degrades. Currently, PAC reports most of results to the network administrator.

2. Performance Management with Layered Network

In order to manage the Intranet efficiently, we need to examine the network equipments and applied technologies in the Intranet. The configuration of the Intranet can be divided by service access(service providing or using) and the transport layer technologies.

Table 2 shows the network equipments and the technologies used in Intranet. We can see that Intranet is composed of heterogeneous networking technologies from the Table 2. In the viewpoint of performance management, traffic characteristics are different for each heterogeneous network, and these different factors cause the network performance management to be realized in difficulty. As a result, it needs to manage Intranet by layered network concept.

Table 2. Network equipments and technologies in Intranet

Category	Equipments and Technologies	Remarks
Intranet Service	Web, E-mail, DNS, FTP server	Internet/Intranet service supported by server
Node, Server	Workstation, PC	Computer server, terminal equipments
LAN segment	BUS, Star/Tree LAN (Fast/Gigabit Ethernet), Ring LAN(Token Ring, FDDI)	Each domain is composed into each segment
Backbone network	ATM Switch, Gigabit Ethernet	ATM, MAC protocol
IP Router, Gateway	Router, ATM LAN Switch, Gateway	IP protocol

2.1 IP Layer Network

Performance modeling in IP LN(Layer Network) is as follows. Basically, in IP LN, we introduce the concept of connectivity which is a virtual path between two IP Termination Point(TP). IP TP is identified by a host or a subnetwork(SNW-domain). With connectivity, we consider two performance-related parameters to evaluate the IP LN performance, which are delay and traffic flow(connectivity). Delay can be measured between two default server systems(DNS or any important Intranet server system) in SNW. Traffic flow also can be measured. These are depicted in Fig. 6. In addition, we can measure traffic generated by each subnetwork and also divide these traffic flow by service(HTTP, FTP, SMTP, etc). Table 3 summarizes the performance model in IP LN.

Table 3. Managed Objects in IP Layer Network.

Object	Remarks	Performance-related parameter
TPs	IP SNW	Total traffic, Traffic by service
Connectivity	Link, Trail	Delay, Total traffic flow

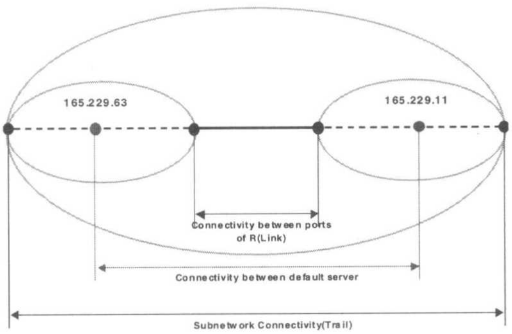


Fig. 6. Connectivity between two subnetwork

2.2 Data Link Layer Network

Data Link Layer(DL) is divided into the

Ethernet Layer and the ATM Layer Network according to the transport technology.

(1) Ethernet Layer Network

Performance modeling in Ethernet layer network is as follows. First, we consider the port of Ethernet LAN card with MAC address as Termination Point(TP). Table 4 summarizes the performance model in Ethernet LN.

Table 4. Managed Objects in Ethernet Layer Network.

Object	Remarks	Performance-related parameter
TPs	Ethernet SNW	Number of collision, Total traffic of LAN Segment
Link	Link	Traffic of the Link

(2) ATM Layer Network

In the ATM LN, the LN can be divided into virtual path(VP) LN and virtual channel(VC) LN. VP LN and VC LN have a server-client relationship. A trail of the server layer becomes a link of client layer. For example, a trail of VPC becomes a VCL. Table 5 summarizes the performance model in ATM LN.

Table 5. Managed Objects in ATM Layer Network

Object	Remarks	Performance-related parameter
TPs	Port with ATM address	Cell count IN/OUT
VPs	Path group	Cell count on this path
VCs	Channel group	Cell count on this channel

2.3 Physical Layer Network

In order to manage the performance of the network resource of physical layer network, we need to concentrate not on the traffic but on the performance of the physical system itself. For example, we can measure the CPU Load or Disk Capacity of the system. Managed objects of Physical LN are the real network equipments. Each equipment is modeled as an Entity as shown in Table 6.

Table 6. Managed Objects in Physical Layer Network

Object	Remarks	Performance-related parameter
Entity	Real network resource	CPU utilization(load status), Disk capacity(utilization)

3. Network Performance Information

To manage the network performance, we must get information related to the network performance. This information can be obtained by using the MIB provided by the management agent in NE. The proposed architecture is based on DPE and supports management of network and NE view. But most of management agent on Intranet/Internet does not support DPE and the network-view MIB yet. From this reason, performance management information of the network-view within the manager must be provided to manage the network performance with the proposed architecture. Also we should map the performance management information between manager and agent. This function is accomplished by the GIA[17]. To implement the performance information, we have used CORBA IDL(Interface Definition Language) and Naming service. Table 7 shows the relationship between the defined performance MO and SNMP MIBs. Fig. 7 depicts

```
Interface   NetworkTrafficDescriptorProfile {
            typedef  string  OID
            .
            enum     AttributeList     {OperateState,
            AdminState, ObjId, . . ., All };

            struct  Obj_Attr {
                        .
                        OID         object_Id;
                        double   inTraffic;
                        double   outTraffic;
                        . . .
                };

            struct Result {
                        string      AttrName;
                        any         AttrValue;
                };

                        . . .
        Results get(·);
                    . . .
};
```

Fig. 7. Pseudo code of the defined performance information

Table 7. Relationship between the defined performance information and SNMP MIB

Performance Information		SNMP MIB (RFC1213, RFC1514)
Object	Attributes	
NetworkTrafficeDescriptorProfile	QoSClasses	None
	TrafficPeakRate	None
	CDVTolerance	None
	Delay	None
	MaxBurstSize	None
	InTraffic	ifInOctets(RFC 1213)
	OutTraffic	ifOutOctets(RFC 1213)
	InError	ifInErrors(RFC 1213)
	OutError	ifOutErros(RFC 1213)
	InDiscard	ifInDiscards(RFC 1213)
	OutDiscard	ifOutDiscards(RFC 1213)
NetworkAccessProfile	TotalBW	ifSpeed(RFC 1213)
	MaxNumActiveConntionsAllowed	None
	AvailableBW	None
	MaxAssignableBW	None
NetworkPerformanceStatisticData	Throughput	None
	Utilization	None
	ConnRejectRatio	None
	PrRejectRatio	None
	TransErrorRate	None
	PrUtilizationThresholdCross	None
	Average	None
	MaxValue	None
	MinValue	None
SystemResourcePerformance	SystemProcessorLoad	HrProcessorLoad(RFC1514)
	SystemDiskStorageCapacity	hrDiskStorageCapacity(RFC 1514)
	SystemNumUsers	hrSystemNumUsers(RFC 1514)
	SystemProcesses	HrSystemProcesses(RFC1514)
	SystemMaxProcesses	HrSystemMaxProcesses(RFC1514)

the example of the defined performance information. In Table 7, we didnt figure out attributes with None in RFC SNMP MIB (RFC1213, RFC1514), but may exist somewhere in enterprise SNMP MIBs.

V. Evaluation of the Implemented Performance Management Functionality

According to the performance management scenario[15], we applied the implemented performance management functionality to the real Intranet traffic of Yeungnam University. The test environment consists of NML-PM, NML-PAC, EML-PM, EML-PAC, GIA, and ITMA. The NML-PM/EML-PM, NML-PAC/EML-PAC and GIA are running in the same UNIX system, while the ITMA is running in the Windows 2000 system.

When the performance management components are instantiated by the configuration management, the *MonitorFactory* thread of NML-PM/EML-PM and the *Analysis* and *Control* thread of NML-PAC/EML-PAC are created. When the monitoring request is received from NML-PM or operator, the *MonitorFactory* thread of the EML-PM creates the workload thread or the summarization thread that handles the performance monitoring. The performance monitoring function performs the counting of incoming/outgoing packet for a router(165.229.11.22). Also it performs the incoming/outgoing packet capturing for a LAN

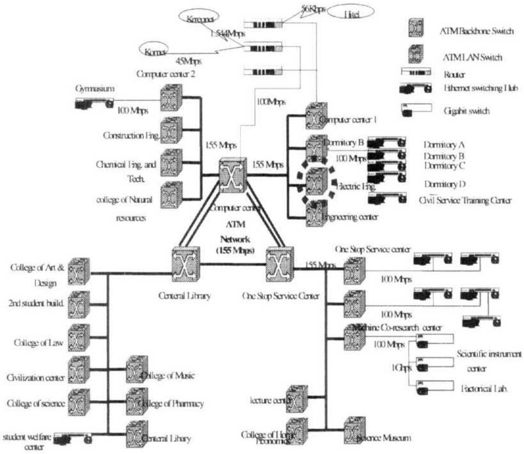


Fig. 8. Yeungnam University Network Configuration

segment through the ITMA. The PAC performed TCAF that analyze the captured and monitored packets. In order to display the monitored packet count and the result of analysis graphically, we implemented a simple network-performance viewer using JAVA. Fig. 8 shows the Intranet of Yeungnam University. The proposed architecture is implemented and installed in the Sun Ultra 1 Workstation with Solaris 2.5.1(165.229.63.27) while the ITMA is installed in the DNS(Domain Name Service, 165.229.63.21) with Windows

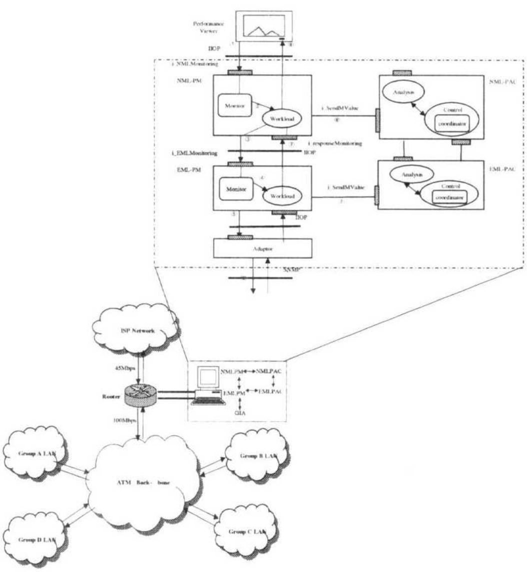


Fig. 9. Performance Monitoring and Analysis Test Flow

2000. The network-performance viewer is installed in the Pentium II PC(165.229.63.104) with NT 4.0. Fig. 9 shows the overall test flow. The viewer gets the initial performance information through the naming service when the network configuration is set up for the performance management function.

The test sequence is as follows:

① The network-performance viewer via i_NMLMonitoring calls the NML-PM.

② The *MonitorFactory* of NML-PM creates the workload monitoring thread.

③ The created workload thread of the NML-PM calls *i_EMLMonitoring* of the EML-PM.

④ The *MonitorFactory* of EML-PM creates the workload monitoring thread.

⑤ The created workload thread of the EML-PM calls *i_MonitoringReq* of GIA. The GIA performs the abstract translation of the operations from requested management function to SNMP function.

⑥ The GIA performs realistic workload monitoring operation (SNMP_Get) on NE.

⑦ The monitored values are reported to EML-PM through *i_MonitoringRes*, which passes the monitored values the workload thread of the NML-PM through *i_responseMonitoring*. For analysis of the network traffic, the monitored values are sent to NML-PAC/EML-PAC also.

⑧ The EML-PAC/NML-PAC analyzes the network traffic, calculates the statistics, and check any threshold-crossing.

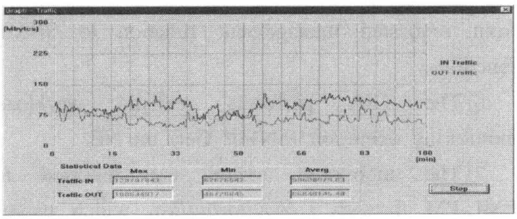
⑨ The viewer displays graphically the monitored and analyzed values.

With the results of measurement shown above, we can analyze the performance of the network or network element using the formulas in the section 3.2. Also we applied the implemented performance functionality to NE with TMN[14]. To carry out the performance tuning, we can dynamically manage the allocated bandwidth of a link or transit path by using the following rule.

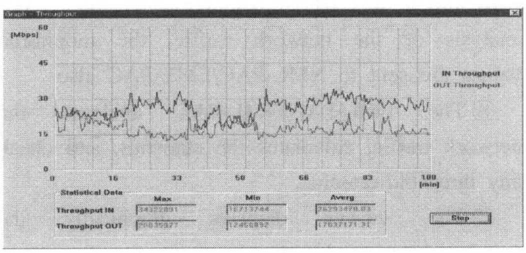
```
if(threshold-crossing on linki)
  if(allocated bandwidth+20% > some limit)
```

```
then
        notify_to_NML_or_operator(·)
 else
 modify_link_capacity(linki, allocated
                        bandwidth + 20%)
```

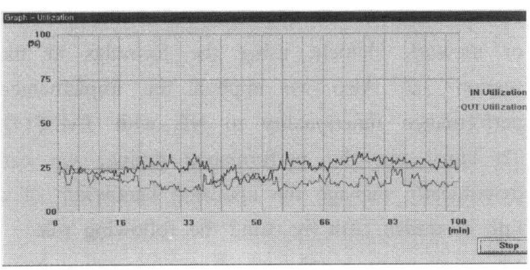
Fig. 10(a)~(c) shows the monitored results of the incoming/outgoing packet counts and its analysis results on a router(165.229.11.22). Fig. 11(a)~(c) shows the result of traffic analysis according to Intranet services(FTP, HTTP, NNTP) on a LAN segment 165.229.63. As shown in Fig. 11, Intranet traffic has bursty characteristics. Especially, on Wednesday evening, soccer game was held in Korea, so many students watched the broadcasting through the Internet. As a result, the monitored traffic amount of HTTP is remarkably higher than other periods. The manager can perform a proper action according to the service-related traffic quantities. Fig. 12 shows the result of connectivity check on IP LN.



(a) Performance Monitoring Result

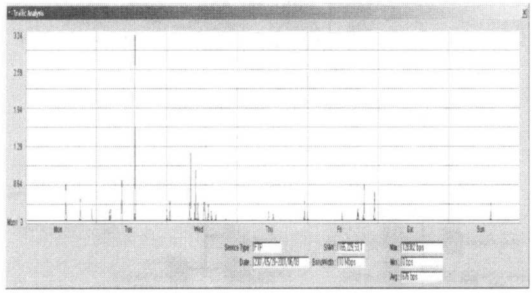


(b) Result of Performance Analysis(Throughtput)

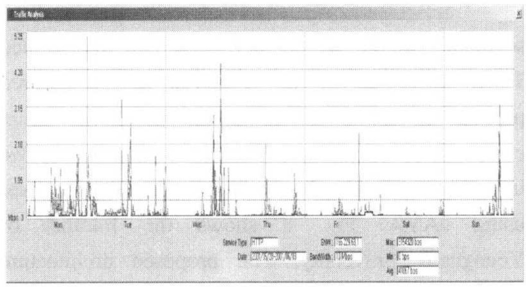


(c) Result of Performance Analysis(Utilization)

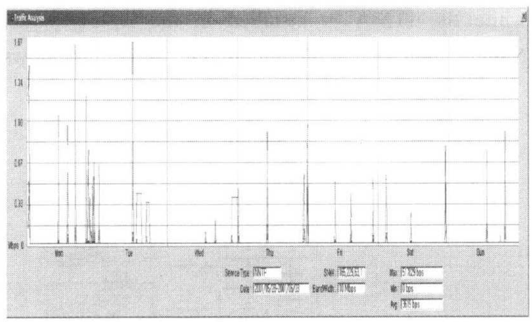
Fig. 10. Results of Performance Monitoring and Analysis



(a) Result of FTP Traffic Analysis on a Week



(b) Result of HTTP Traffic Analysis on a Week



(c) Result of NNTP Traffic Analysis on a Week

Fig. 11. Result of traffic analysis according to Interanet services on a Week (2001/5/28~2001/6/3)

The results are reported to network administrator on a period basis or at a particular time. On the basis of above reporting, network administrator can understand the Network(and NE) Performance Level by measuring Intranet service or protocol traffic amount and network element performance, detecting the bottleneck of network, delay of any service traffic transfer, predicting the demand of network resources. Moreover the reporting function has a Web based interface for the convenience of network administrator[18].

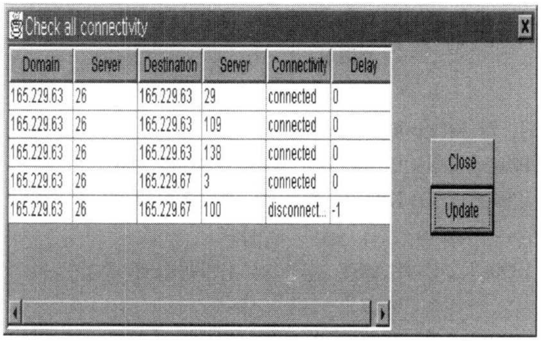


Fig. 12. Result of Connectivity check

Ⅵ. Conclusion

We proposed the performance management architecture based on the DPE and the definitions of the performance management function in TMN. We also presented an approach of Intranet management using the concept of layered network. We designed and implemented functional blocks of a computational component of the performance management architecture based on the multiprocess and multithread structure that supports concurrent process. And we implemented a reporting function with Web interface using servlet. It reports various statistical and/or forecasts data according to the results of PM and PAC to administrator. We implemented the performance monitoring and analysis function according to the proposed architecture, and evaluated its performance. The performance management functions have been implemented with C++ language, JAVA(simple viewer) and Orbix art 1.2 that supports CORBA 2.3[12, 13].

We measured and analyzed the real Intranet performance of Yeungnam University according to the Intranet performance consideration points of section 4. From the test results in section 5, we confirmed that the proposed methods for measurement and analysis of Intranet performance using DPE-based management architecture can be efficiently applied to Intranet which is composed of heterogeneous network elements(with SNMP or TMN).

As further research works, the performance analysis and control (PAC) and performance tuning(PT) will be updated using policy-based management. We will make it possible that performance management can interact with other management functions(configuration, fault, connection management). We expect that the proposed performance management architecture can be applied to enhance the network performance and to provide the guaranteed-QoS multimedia application services to user.

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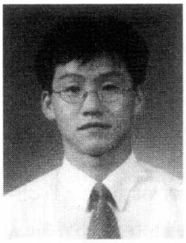

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