이종 전산망의 통합성능 관리 방법

황 준† 권 혁 인††

요 약

분산된 정보 및 컴퓨터 자원들에 대한 접근 요구가 증대됨에 따라 네트워크 상호연결요구 또한 커지고 있다. 네트워크 성능관리 도구들을 포함한 많은 네트워크 관리 패키지들이 이미 개발되었지만 이종 네트워크 환경에서는 그다지 적합하지 않다. 이종 네트워크의 성능을 효율적으로 감시하고 제어하기 위해서는 우선적으로 모든 성능 매개 변수를 정의해야 한다. 그리고 관리 시스템의 성능 분석 행위를 지원하기 위해서는 성능 분석 모델과 성능 판단 기준도 필요하다. 본 연구에서는 OSI 관리 체계에 기반을 둔 이종 네트워크 환경에서 사용할 수 있는 중앙 집중식 성능 관리 시스템을 설계하였다.

A Design of Performance Management System in Heterogeneous Networks

Jun Hwang† and Hyeog-In Kwon ††

ABSTRACT

As the needs for accessing distributed informations and computing resources are increasing, the need for network interconnection is growing. There are many of the network management packages including performance management tools; but, most of them are not appropriate to be used in heterogeneous interconnected networks. To monitor and to control efficiently the performance of heterogeneous network, first, we have to define all performance parameters in general meaning. We need models and criteria for supporting performance analysis activities of the management system. In this study, we have designed a centralized performance management system based on the OSI management, which can be used in heterogeneous networks.

1. Introduction

As computer communication technologies is progressing, the complexity of data networks is increasing. Various kinds of computer networks, LANs, MANs, and WANs, are interconnected. Separate network management tools provided by different manufacturers are available, but they provide management functions in their own terms. There are equipments provided by multi-protocols' vendors. In addition, as user needs more services, the need for network interconnections is growing. Therefore, the integrated network management covering interconnected heterogeneous networks is a critical issue today.

System management functions are classified into 5 areas by ISO: fault management, configuration management, accounting management, performance management and security management [1]. The performance management in heterogeneous networks (Ethernet, X.25 and ATM as a future network) is the main concern of this paper.

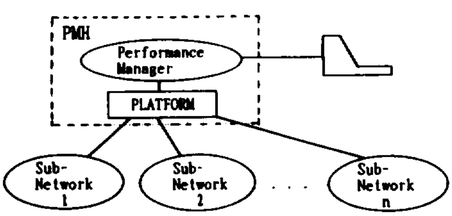
The goal of performance management is to maintain the customer's service level and to ensure that the communication network is operating effectively. The decision making process to support this goal can be divided into operational decisions based on short term conditions, tactical decisions based on medi-

† 정 회 원 : 서울여자대학교 전산학과 조교수
†† 정 회 원 : 중앙대학교 사회과학대학 조교수
논문접수 : 1994년 6월 8일, 심사완료 : 1995년 3월 3일

um-term conditions, strategic decisions based on long-term conditions [10]. To support efficiently these processes in heterogeneous context, we need a centralized performance management system that can collect, evaluate and control the performance parameters through unified view.

The performance management activity consists in monitoring the status of the networks, in extracting and evaluating performance parameters, in analyzing the situation and in tuning the system. In other terms, it consists of gathering statistical data, of maintaining and examining logs of system state histories, of determining system performance under natural and artificial conditions, and of altering system mode of operation [1, 2].

The management standards are mandatory in heterogeneous environment and they should meet as wide a set of needs as possible. The standard bodies such as ISO, CCITT, and OSI /NM Forum are preparing management standards working in open systems. A huge progress has been achieved in this field [1, 2, 3, 4, 5, 6, 7, 8]. The proposals of these standard bodies are well organized, particularly about the interworking between open systems. But, the definitions of important performance parameters and measurement variables that can be used in heterogeneous context, are not completed. They must be defined deliberately in generic terms like throughput, arrival rate, etc. To solve the heterogeneity problems,



(Fig. 1)Relationship between platform, PMH, and sub-networks

(manufacturer heterogeneity, architecture heterogeneity, etc.) we use the IDEA methodology, which is developed by the MASI Lab. [9], as the basis of Performance Management system in Heterogeneous networks (PMH). IDEA methodology provides a unified view of the heterogeneous networks (cf. (Fig. 1)). This unified view is called a "platform".

In this paper we have designed a performance management system PMH that uses an Advanced Information Processing (AIP) technology, Knowledge Based System, and Object Oriented database.

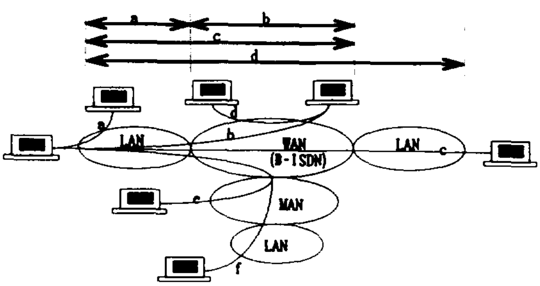
In section 2, we explain the requirements of performance management system. In section 3, the architecture of PMH and the relationships between PMH, platform, and agents are explained. In section 4, the Platform is presented. In section 5, performance evaluation models of each network are presented. This last issue is excluded from standardization subjects examined by standard bodies. Finally, in section 6, we discuss about the performance management application.

2. Requirements of the Performance Management System in Heterogeneous Networks (PMH)

(Fig. 2) shows a possible configuration of interconnected networks. In this paper, we consider only the interconnection of LANs and WANs. We included ATM networks at the same place as X.25 networks because they should become a future public network for integrated services. Although the relationships of ATM network with the OSI layered architecture are not exactly defined yet, we treat the ATM network as a kind of subnetwork under the end-to-end transport layer. Indeed, in an interconnected network environment, the ATM layer provides an independent pathway like X.25 and Ethernet.

For managing the performance of interconnected heterogeneous networks, we have to solve heterogeneity problems, performance heterogeneity, manufacturer heterogeneity, responsibilities heterogeneity, architecture heterogeneity and data heterogeneity [9]. The performance heterogeneity problem could be tackled at the performance management application and the remaining problems at the platform.

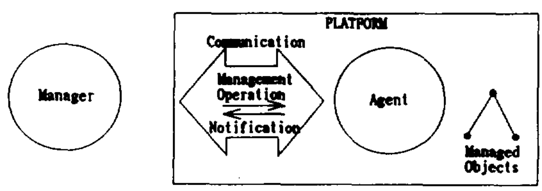
As important ingredients of a performance management application, there are generic performance parameters to be measured from real networks, performance evaluation models to be used when the network performance must be evaluated, decision criteria concerning the network performance.



(Fig. 2) Interconnection of Heterogeneous Networks

The user's view of the network performance is different from that of network managers. A user is generally more interested in the performance at the interface of the network than in internal network performance. Throughput, error rate and average packet delay are examples that qualify the user's point of view. The network manager's view is wider in scope. The network manager is interested in user satisfaction by the network performance and in the actual performance compared with the planned performance. But the meaning of performance parameters is a little bit different in each subnetwork. Therefore, for interconnected heterogeneous networks, we have to define the different parameters in consistent way. The network performance (NP) parameters are network provider oriented and QOS parameters are user oriented [20]. We have defined NP parameters and QOS parameters considering the available standards in this field [18, 19, 20, 21, 22] (see the reference 27 for performance parameters). About the performance models, we shall cover this subject in more details in section 5.

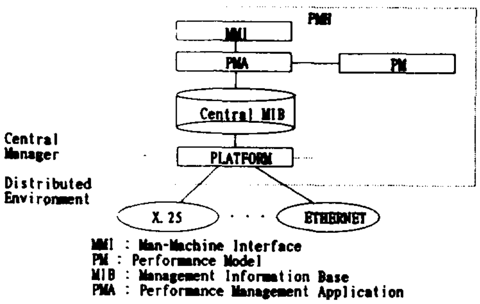
The performance management system should be changeable and expandable to cope with the rapid technology enhancement. There are several kinds of networks that will appear at the market of communication network in the near future (e.g., ATM, DQDB, etc.). The concepts and characteristics of the future networks are very different from the traditional ones. For example, in ATM network, it is used a fixed size PDU (called cell) and there is no flow control at ATM layer.



(Fig. 3) Relationship between manager, agent and platform

3. PMH Architecture

PMH is based on the system management architecture specified in ISO System Management Overview [4]. Managed objects are abstract representation of the network resources to be managed. These managed objects are under the control of agents, as described in (Fig. 3). The agent performs local management operations on the managed objects on behalf of the manager and notifies the results to the manager. The functions of the communication between the manager and the agent, and between external agents will be included in the "platform" that is an implementation of IDEA methodology [9]. Through the platform, the manager gets necessary performance parameter values. The platform allows the manager to view the distributed heterogeneous network environment in a unified manner.



(Fig. 4) PMH architecture

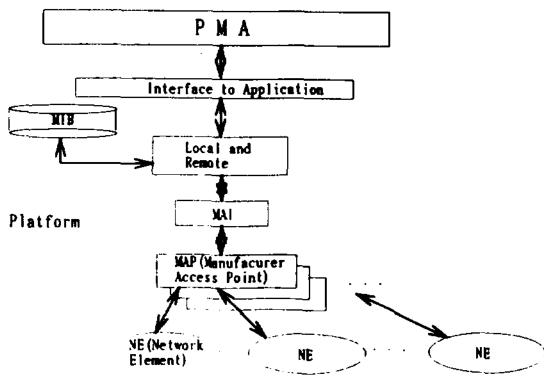
(Fig. 4) shows the functional components and the geographical configuration of PMH. The PMH is composed of the centralized performance management function blocks and the distributed environment.

In the central site, there are the Man-Machine Interface (MMI), the Performance Management Application (PMA), the Performance Model (PM) and the Central MIB (see section 4). PMA performs the following functions : continuous monitoring of the sub-networks, assessment of the situation, tuning and supporting the human manager's management activities.

PM's duty is evaluating the subnetwork's performance. We can consider it as a part of the PMA's function, but to stress the importance of its role, we have separated it from the PMA. It will calculate the optimum performance parameters, e.g. window size of the sliding window protocol, required by PMA with actual data measured from real subnetwork or artificial data provided by human performance manager. We shall see in the next section more about the MIB and function blocks.

4. Platform

The platform provides transparency to the heterogeneous world (manufacturer heterogeneity, network architecture heterogeneity, data heterogeneity, etc.). The platform consists of the following main components.(See (Fig. 5))



(Fig. 5) The architecture of the PMH

– LRO (Local and Remote Operation)

The management of the set of local activities is performed. For remote operations, an administrative Exchange Administration Protocol (EAP) is provided to permit information exchanges between distributed processors.

– MIB (Management Information Base)

The MIB supports the integration and the management of network performance data. Physically, PMH's MIB is divided into a central database (Central MIB) and several local databases (Local MIB). A Local MIB memorizes three kinds of performance information about the corresponding subnetwork : static data, e.g. network configuration data; dynamic data, e.g. number of packets received; and statistical data, e.g. throughput for a certain period of time. The Central MIB is the repository of the performance data managed by the PMA. A part of this database is the duplication of the "Local MIBs". For example, the basic configuration data of each subnetwork will be duplicated in this Central MIB. Some kinds of data are unique in the Central MIB.

– MAI (Manufacturers' Access Interface)

The functions of this part are composed of a physical access to a node or manufacturer management center, a logical access to a manufacturer administration, a syntax translation to provide a syntactic unification of the manufacturers' commands and a semantics translation of the manufacturers' management. We name this part as Agent for simplicity. For futher details of the resolution of the heterogeneity problems, refer to IDEA architecture [9] which proposes a methodological way to handle those problems. We shall discuss necessary functional components of the agent as follows.

- We need an administration interface through which we create and modify the local Object-Oriented Data Base (Local MIB).
- We need a communication interface through which the agent answers to the request of the PMA and informs events to the PMA. The communication interface will be implemented using CMIS operations.
- An agent takes in charge a subnetwork. It collects and extracts necessary informations from the subnetwork.

5. Performance Models (PM)

To cope with the performance degradation, we need to evaluate the network performance parameters optimizing the overall network performance. For supporting the decision-making process, (for example, capacity planning) we need to calculate the optimum values of the performance parameters with artificial data such as network configuration data, arrival rate, error rate, etc. All of these calculations will be done in the "Performance Model" (PM) module of the PMA. The INTEL–ANALYZER module will use the performance models for calculating the optimum values of some performance parameters. But the real decisions about the network status and the configuration change will be made by the INTEL-ANALYZER module.

The analysis of the performance models of the computer networks may be performed by using one (or a combination) of the following three techniques : approximate analytical methods, exact analytical methods and simulation methods.

We can choose a particular performance model for a protocol model considering the tradeoff between the computing time one wishes to spend on a model and the accuracy of the model. The analytical model reduces the accuracy and appropriateness of the model but requires less computing resources than the simulation model. In this paper, we have considered only analytical performance models for reducing computing times. In the sequel, we introduce the performance models of the OSI transport layer class 4, Ethernet, X.25 and ATM networks, with some criteria for choosing the models.

– OSI Transport Layer class 4 (OSI/TP4)

There are not so many analytical models published for OSI/TP4. Pujolle's model [17] was chosen for evaluating end-to-end response time and throughput.

– X.25

Fdida's et al. model [11] has been chosen. The main reason is that their model takes into account what really happens to the packets which find a saturated window. Papers [15] and [16] are also chosen for simplicity. Throughput and mean response time are calculated.

– Ethernet

We decided to use the model of K. Sohraby et al. [12] to obtain the throughput of Ethernet. They analyze a 1-persistent CSMA/CD scheme in an asynchronous manner that seems to be a quite accurate Ethernet model. We use also the model of T. K. Aposlotopoulos and E.N. Protonotarios [13, 14] that seems relevant although it is a p-persistent CSMA/CD access method. From this last model we can obtain the value of many parameters, for example, average cycle length, average queue length, average backlog, real input rate and rejection probability.

– ATM

For defining the QOS parameters of the ATM network, we have to understand the following technical aspects that are considered by the standard bodies (mainly CCITT).

- **statistical multiplexing,**
- **congestion control.**

In an ATM network, congestion can be caused by unpredictable statistical fluctuations of traffic flows and fault conditions within the network [23]. For solving the congestion problem, preventive congestion control schemes, connection admission control (call admission control) and usage parameter control (policing, flow enforcement control), is considered in CCITT [23].

The call admission control (CAC) scheme keeps the excess traffic load out of the network and ensures that the instantaneous cell loss rate and the average cell delay time are kept below a threshold value at all the switching nodes on the path to a destination. For certain services, e.g. data service, the cell loss rate is a very important QOS parameter to be negotiated before the service begins (e.g. less than 10-9); a quite large cell response time can be tolerable. On the contrary, the small cell response time is a stringent requirement for the other kinds of services, e.g. voice, HDTV, etc. When a new call arrives, we calculate the blocking probability at the VP (Virtual Path) or at the trunk group and the call is accepted if the resulting blocking probability is acceptable. We call this blocking probability as "Call Blocking Probability".

Based on the above discussion, we have chosen the following performance parameters as the QOS parameters to be provided to the ATM network users and to be calculated by the performance evaluation models:

- **call blocking probability,**
- **cell loss probability,**
- **average cell response time**

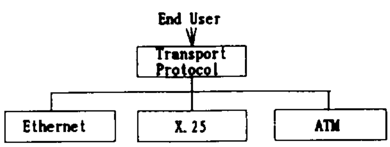
We have chosen an evaluation model [25] for call blocking probability, a model [24] for average cell response time and another model [26] for evaluating cell loss probability, given a switch architecture.

For end-to-end users, the performance heterogeneity is covered by the end-to-end transport layer (refer (Fig. 6)). We could calculate some end-to-end performance parameters as follows.

End-to-end Performance parameter=f (N1, . , Ni, . ,Nn, #)

Ni : a performance parameter of a sub-network where the end-to-end connection pass through

: some other performance parameters for the end-to-end connection



(Fig. 6) The relationship of Protocols

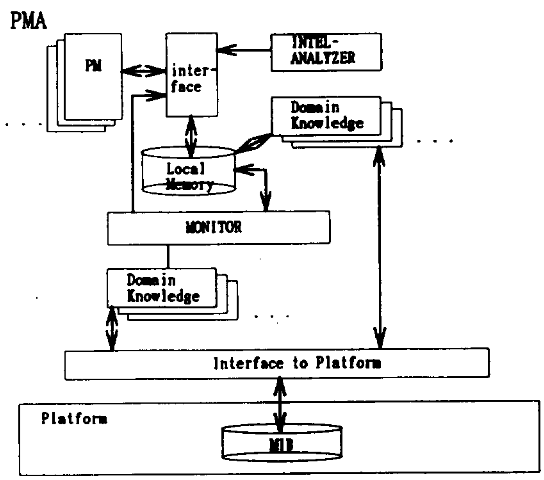
For example, the response time of an end-to-end connection is calculated based on Ethernet service time, X.25 network service time, etc. Therefore, the configuration of interconnected networks is transparent for the user of an end-to-end connection.

The module PM calculates the performance parameters requested by the module INTEL-ANALYZER using the performance parameters monitored by MONITOR or artificial performance parameters. The INTEL-ANALYZER will choose the best performance model with its knowledge about performance models. It compares the real situation of the network and the assumptions of the network performance model.

6. Performance Management Application

PMA is a performance manager in term of OSI. It takes the role of monitoring, analyzing, and controlling the subnetworks. In other words, these functions are collecting the network status information (performance parameters), assessing the situation and adjusting the configurable performance parameters. These are not easy works. It needs the use of expertise.

In PMH, the Knowledge Based System (KBS) may be adopted as an implementation method of PMA. The PMA consists of the three sub-function modules (PM, MONITOR, and INTEL-ANALYZER). (Fig. 7) shows the PMA architecture and the interface to the platform.



(Fig. 7) The architecture of PMA

The MONITOR is working on the status of the networks to detect performance degradations. Its work is carried out in two ways: the polling of management agents of the subnetworks and the receipts of the reports from the management agents. The reports that come from an agent can be those generated by the agent on a regular basis or those generated incidentally when a threshold is reached. If a certain performance parameter value is out of the allowable range, the MONITOR has to inform the intelligent analyzer of this problem. The INTEL-ANALYZ-

ER will find the cause of the problem by using an expertise or by cooperating with a human manager.

When the MONITOR requires the analysis of the network status, it performs a performance evaluation using the Knowledge Base (KB), the MIB and the performance parameters provided by the MONITOR. The INTEL-ANALYZER can order more information to the MONITOR when the informations is not sufficient to decide an action. If necessary, the INTEL-ANALYZER may decide to ask to a configuration controller (it is out of our scope in this paper) or to a human manager. Depending on its degree of intelligence, the INTEL-ANALYZER can solve the problem of performance by itself or in cooperation with the human manager. The knowledges which are included in KB are : basic knowledges about the protocols and the platform knowledges for problem recognition.

The basic knowledge is further divided as follows:

- protocol knowledge,
- platform knowledge.

The knowledges for problem recognition are further divided as follows.

- load knowledge,
- auditing knowledge,
- investigation knowledge.

The load knowledge is for analyzing the applied load and judging if the performances could be acceptable or not. The auditing knowledge examines event data to be used for evaluating the flow control mechanism, the transmission timer adequacy, etc. The investigation knowledge is for localizing and identifying performance degradation sources. Local loop-back tests, echo tests, performance monitoring at intermediate connection points in case of ATM, performance evaluation using PM module with artificial data are some examples of facilities which can be used for finding the performance degradation sources.

The design concept of PMA is based on a modular structure. The modules for a given network (knowledge module, PM module, etc.) can be modified or appended without affecting the other modules except some modules that are mandatory concerned with. In (Fig. 7), for example, the dotted boxes are weakly influenced when we modify or append the (black) boxes for ATM. The other modules are not influenced.

7. Conclusion

As the decentralization of the computing power is going on and the demand for a distributed access to the information is growing, the necessity of sizing the network is now crucial. In heterogeneous networks, the network performance management activities do not deal with easy problems. It needs to solve the heterogeneity problems between networks and to define generic performance parameters and performance decision criteria. It is a good point if we can include the expertise of a human expert into the performance management application by using recently developed artificial intelligence techniques.

We have designed a performance management system adopted to heterogeneous networks, called PMH. The system architecture and the relationships between the function blocks in the system have been described. The role of the performance evaluation model and the use of some possible models have been presented.

References

[1] ISO IS 7498-4,"Basic Reference Model -

Part 4-OSI Management Framework", August 1987.

[2] ISO N4981, "Information Processing Systems-Open System Interconnection-Systems Management-Performance Management", July 1990.

[3] CCITT Recommendation M.30, "Principles for a Telecommunications Management Network", April 1991.

[4] ISO DP 10040, "Information Processing Systems-Open Systems Interconnection-Systems Management Overview", June 1990.

[5] ISO DIS 9596-2, "Information Processing Systems-Open Systems Interconnection-Management Information Protocol-Part 2 : Commun Management Information Protocol", June 1989.

[6] ISO DIS 9595-2, "Information Processing Systems-Open Systems Interconnection-Management Information Service Definition-Part 2:Commun Management Information Service", June 1989.

[7] ISO DIS 10165, "Information Technology-Open Systems Interconnection-Management Information Services-Structure of Management Information", March 1991.

[8] OSI/NM Forum, "Forum Architecture", Issue 1, January 1990.

[9] J.P. Claude et al, "Management of Open Networks in Heterogeneous Context", Proc. of the IFIP TC6/WG6,4a Int. Symp. on the management of Local Commun. Systems, Canterbury, U.K., pp. 81-100, Sep. 1991.

[10] Kornel Terplan, "Communication Networks Management", Prentice-Hall, 1987.

[11] S. Fdida, H.G. Perros, A. Wilk, "Semaphore queues : modeling multilayered window flow control mechanisms", IEEE Trans. on Commun., Vol. 38, No. 3, pp. 309-317, March 1990.

[12] K. Sohraby et al., "Comment on Throughput Anaysis for Persistent CSMA Systems", IEEE Trans on Commun., Vol. COM-35, No. 2, pp. 240-243, Feb. 1987.

[13] T. Apostolopoulos, E. Sykas, E. Protonotarios, "Performance Analysis of a Retransmission Control Algorithm for Local Area Networks", Computer Commun., Vol. 8, No. 3, pp. 128-140, June 1985.

[14] T. Apostolopoulos, E. Protonotarios, "Queuing Analysis of Buffered CSMA/CD Protocols", IEEE Trans. on Commun., Vol. 34, No. 9, pp. 898-905, Sep. 1986.

[15] M. Schwartz, "Telecommunication networks: Protocol, Modeling and Analysis", Addison Wesley, 1987.

[16] Kadaba Bharath-Kumar, "Optimum End-to-end Flow Control in Networks", IEEE Proc. on Commun., 1980.

[17] G. Pujolle, C. Vu Duy, "Evaluation du Temporisateur du Protocol de Transport", Laboratoire Masi, Internal Report.

[18] CCITT Recommendation X.134-X.137, "Performance Parameters for Packet Switched Data Communication services", Blue book.

[19] CCITT Recommendation X.140, "General Quality of Service Parameters", Blue book.

[20] CCITT Recommendation I.350, "Quality of Service and Network Performance Principles", Blue book.

[21] CCITT Recommendation X.212 - X.214, "Data Link Layer, Network Layer, Transport Layer Service", Blue book.

[22] CCITT Draft Recommendation I.35B, "Broadband ISDN Performance", December 1990.

[23] CCITT I.311, "B-ISDN General Network Aspects", Geneva, May 1990.

[24] G. Pujolle, "Discrete-Time Queuing Systems For Cell Switching Performance Evaluation", ITC-13, Copenhagen, 1991.

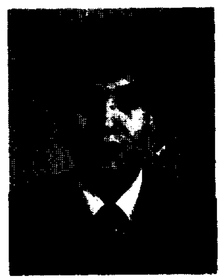
[25] Jeseph Y. Hui, "Resource Allocation for Broadband Networks", IEEE Journal on Selected Areas in Commun., Vol. 6, No. 9, pp. 1598-1608, December 1989.

[26] M.G. Hluchyj and M.J. Karol, "Queuing in Space-Division Packet Switching", Proceeding of INFOCOM'88, pp.334-343.

[27] J.P. Claude, H.I. Kwon, G. Pujolle, A. Tubtiang, "Integrated Performance Management in Heterogeneous Networks", Tech. Rep. MASI, University Pierre et Marie Curie, 1992.

황 준

1985년 중앙대학교 공과대학 전자계산학과 졸업(학사)
1987년 중앙대학교 공과대학 전자계산학과 시스템 소프트웨어 전공(석사)
1991년 중앙대학교 공과대학 전자계산학과 시스템 소프트웨어 전공(박사)
1992년~현재 서울여자대학교 전산과학과 교수
1992년~현재 한국정보과학회 컴퓨터시스템 연구회 운영위원
관심분야 : 운영체제, 분산 시스템, 컴퓨터 네트워크



권 혁 인

1983년 중앙대학교 공과대학 전자계산학과 졸업(학사)
1985년 중앙대학교 전자계산학과 시스템 소프트웨어 전공(석사)
1994년 프랑스 paris 6 대학 전산학과(박사)
1985년~90년 한국 국방연구원 연구원
1995년~현재 중앙대학교 사회과학대학 교수
관심분야 : ATM 네트워크에서의 트래픽제어, 네트워크 관리, 분산처리