LSP Congestion Control methods in ATM based MPLS on BcN

Chul soo Kim*, Na jung Park*, Gwi im Ahn**, Jung tae Lee*** ***Regular Members***

ABSTRACT

ATM based MPLS(Multiprotocol Label Switching) is discussed for its provisioning QOS commitment capabilities, Traffic engineering and smooth migration for BcN in Korea. At this time, due to the comprehensive nature of ATM protocol, ATM has been adapted as the backbone system for carrying Internet traffic[1,2,3,4]. This paper presents preventive congestion control mechanisms for detecting HTR(Hard-To-Reach) LSP(Label Switched Path) in ATM based MPLS systems. In particular, we have introduced a HTR LSP detection method using network signaling information in an ATM layer. MPLS related studies can cover LSP failures in a physical layer fault, it can not impact network congestion status. Here we will present the research results for introducing HTR LSP detection methods and control mechanisms and this mechanism can be implementing as SOC for high speed processing a packet header. We concluded that it showed faster congestion avoidance abilities with a more reduced system load and maximized the efficiency of network resources by restricting ineffective machine attempts.

I. Introduction

IP was used for transferring user information, but it will transfer control and management information as well. All IP network concepts were introduced by a wireless telecomm. standardization bodies in a few year ago, it finally appears as NGN that is new telecommunication fever in a moment.

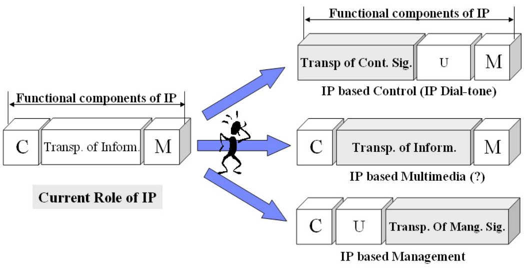

Fig 1. Changing Role of IP

Fig 1. show changing role of IP. Traditionally, IP was used for transporting user information. But in NGN, IP over everything trial was introduced for integrating existing networks for reducing OPEX. This makes expanding IP capabilities and one of good example is manageable IP in ITU-T SG13.

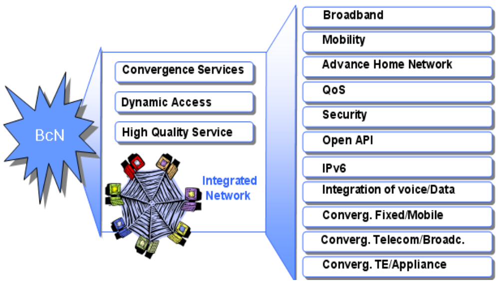

Fig 2. BcN Definition

As shown in the Fig 2, BcN is Korean name of NGN that is a packet-based network that is able to provide telecommunication services make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related

* Inje University, ** Dong Eui University, *** Pusan National University
논문번호 : KICS2004-12-304, 접수일자 : 2004년 12월 6일

technologies[20],[21].

It offers unrestricted access for users to different service providers. It supports generalized mobility, which will allow consistent and ubiquitous provision of services to users. There are several migration strategies toward BcN. Packet switching is the protocol of the new network paradigm. IP, ATM and MPLS will collaborate to ensure that multiservice networks will be able to offer a multiple quality of service

In the past few years, ATM has found a home in backbone networks with synchronous optical network/synchronous digital hierarchy(SONET/SDH). Its primary contribution has been the ability to provide quality of service functionality such as service-level guarantees as well as packet prioritization for real-time voice and multimedia traffic. QOS guarantees vs. utilizations are evitable issues for the telecommunication researcher. Traditionally, Circuit switching is good for a QOS guarantee service like voice traffic in PSTN, but low utilization and an explosive data traffic increment have introduced a new paradigm, namely NGN (Next Generation Network). From the late 1980's, ATM was introduced for integrating all services as digital networks. For achieving high utilization, ATM provides ABR(Available Bit Rate) for a QOS guarantee in data traffic and UBR (Unspecified Bit Rate) for best effort services.

In IP, for guaranting QOS, IP introduces Bandwidth reservation mechanisms. e.g. RSVP.

Lately, there's also the market leading multi-protocol label switching(MPLS) system, which promises to give best-effort IP QoS capabilities that rival ATM. As such, many think that IP has advanced to the point that it can run at the core of the network, running on SONET/SDH, or even running directly over dense wavelength division multiplexing(DWDM). Unfortunately, every country has a different deployment strategy for their next generation networks depending on their under-laying network architecture.

Many operators are still buying ATM equipment to improve core network performance. Some incumbent Telecom operator has also been building ATM backbones to offload their Internet traffic from their legacy public switched telephone networks. For example, in Europe, carriers like BT and Ireland's telecom now provide proprietary call control and signaling over ATM backbones for Internet offload or trunking applications. ATM based MPLS will be first the step for BCN networks and more studies should follow for providing Traffic management/OAM aspects for GMPLS.

Ⅱ. MPLS and Congestion

MPLS integrates a label swapping framework with network layer routing(L2). The basic idea involves assigning short fixed length labels to a packet at ingress to an MPLS domain. Throughout the MPLS domain, the labels attached to packets are used to make forwarding decision. For forwarding packets, IP routers are classified packets for the FEC(Forward Equivalence Class) which routes the same destination or to have the same QOS. Such routing paths are called LSP(label Switched Path) which is established by LDP (Label Distribution Protocol) procedures.

There are fault conditions in a primary paths, packets will be rerouted to the alternate path to provide robustness. This is called path restoration. Several studies were done on path restoration mechanisms. Haskin proposed static and local restoration algorithms, which may lead to packet sequence errors[23].

Makam[24] used static and global restoration algorithms which may lead to a packet losses during a path fault and fault recognition. The main problem for the above studies is bandwidth consumption. Reserved bandwidth for alternate path is expressed in the following formula

$$R(L) = Max[0, \text{max of } P(Y|L) - D(Y|L)$$

Where L : Link, Y: a failed node

P denotes the bandwidth of Link L when node Y is in a fault condition. D denotes the loss bandwidth of Link L when node Y is in a fault condition.

These studies investigate a Hard To Reach LDP detection method which uses network signaling information. In this time, ITU-T SG13 developing MPLS related recommendation. Two categories of MPLS networks are considered:

- TE-LSP : Traffic Engineering Label Switched Path, or configured LSP. These are point-point paths.
- LDP-based LSP : This includes point-to-point and multi-point to point LSPs

Still, They do not consider any of HTR related study.

A session for which the session completion ratio is lower than normal, is called a HTR session. This idea came from PSTN(Public Switched Telephone Networks) networks. A Conventional PSTN is directed to check the call completion ratio with regard to the candidate code that was inputted by an operator[28]. In current MPLS, LSPs(Lable Switched Path) are setup using CR-LDP or RSVP-TE. During a communication periods, if some fault conditions occur, protection and restoration mechanisms are activated in a case of physical layer fault. Alternate paths are determined statically or dynamically. And a decision for protection and restoration is done by a periodic transmission of a hello message. Normally the transmission period of a hello message is 25-30 seconds. The main problem for the MPLS protection and restoration mechanisms is late response and an ability to reflect a congestion state of network elements.

Most of the traffic congestion on a communication network occurs due to an overload in the network exchange system.

This communication concentration or overload of the switching system occurs due to an overload of a specific switching system or due to a domino effect that occurs when many calls are requested at the same time. Such communication traffic congestion can also occur in a specific terminating system due to an unexpected communication equipment failure. [1,2,3].

Congestion control concepts are applied for circuit switching network equipments and these concepts should be applied to a packet switched network elements. On an IP networks, congestion impacts on all traffic, including premium services, are due to random data discarding.

The main goals for controlling HTR LSPs are to conserve network resources by restricting ineffective machine attempts; And this information should be impacts routing information and also this information should be propagate to the neighborhoods network elements to adjust a routing table.

Ⅲ. Proposed HTR LDP detection algorithms in an ATM based MPLS system

Except for a physical layer faults e.g. LOL (Loss Of Light), Restoration triggering is done by periodic transmission of a Hello Messages. In ATM based MPLS systems, we can gather several kinds of network status information during communication. This information tells the network congestion status, critical transmission problems, and session establish/withdrawal status. The following are HTR related data when the transmission channel is activated.

3.1 PTI(Payload Type Identifier)

In the ATM cell Header, there is a PTI (Payload Type Identifier) value indicating the payload type that also indicates a congestion notification mechanism, which may be used to assist the network to avoid and recover from a congested state. It determines if it is a user cell or a system cell and the status of the cell that are the cells experiencing congestion as they transit through the system. This is a 3-bit field used to indicate whether the cell contains user information and LSP association layer management information [30]. It is also used to indicate a network's congestion state or for network resource management in ABR or ABT services. The detailed coding and use of the PTI field is shown in the following table.

Table 1. PTI Coding in ATM cells

PTI code	Interpretation	Category
000	User data cell, congestion not experienced	User cells
001		
010	User data cell, congestion experienced	
011		
100	VCC segment OAM F5 flow cell	Non User cells
101	End-to-end OAM F5 flow cell	
110	Resource management cell	
111	Reserved for future standardized functions	

The use of this mechanism by the CEQ(Customer Equipment) is optional. A network element in a congested state may indicate an explicit forward(to the downstream) congestion indication in the cell header such that this indication may be examined by the destination CEQ. For example, the source and destination CEQs may use this indication to implement protocols that adaptively lower the cell rate for that connection when congestion occurs. A network element that is not in a congested state will not modify the value of this indicator. If the number of session for a specific LSP is EFCI/ EBCI state, then the LSP can be an HTR candidate by including additional information in the switch. A detailed threshold may be implementation specific. On the contrary, backbone node congestion will impact the majority of a user's inconveniences. Explicit routing is used for a session setup phase. It does not use shortest path that was conventional primary routing policy in router. Routing will be done as a customer's requested QOS requirement and the path will be determined. During communication phase, there is no service restriction along the routed path. Our algorithms activate congested paths that were already established by routing policies.

3.2 AIS/RDI

AIS/RDI(Alarm Indication Signal/Remote Defect Indication) cells are fault management techniques that are responsible for detection, isolation and recovery from problems that can result in failure[30]. These cells reflect the physical layer fault like LOS(Loss of Signal), LOP(Loss Of Pointer), LOF(Loss Of Frame) etc. and ATM layer faults.

Table 2. OAM cells and functions

OAM Function	Main Application	Type
AIS	For reporting defect indications in the forward direction	Mandatory
RDI	For reporting remote defect indications in the backward direction	Mandatory
Continuity Check	For continuously monitoring continuity	Optional
Loopback	For on-demand connectivity monitoring For fault localization For pre-service connectivity verification	Optional
Forward PM	For estimating performance	Optional
Backward PM	For reporting performance estimations in the backward direction	Optional
Activation/ Deactivation	For activating/deactivating Performance Monitoring and Continuity Check	Optional
System Management	For use by end-systems only	Optional

VP/VC-AIS cells are generated and sent downstream on all affected active VPC/VCCs from the ATM network element, which detects the VPC/ VCC defect in order to indicate an interruption of the cell transfer capability at the VP/ VC level. The generation frequency of VP/VC- AIS cells is nominally one cell per second and shall be the same for each VPC/VCC concerned. VP/VC-AIS cell generation shall be stopped as soon as defect indications (ex. transmission path AIS defect) are removed[30]. A VP/VC-RDI cell is sent to the far-end from a VPC endpoint as soon as it has declared a VP/VC-AIS state. This information is used for determining the HTR LSP.

Ⅳ. HTR LSP Control mechanisms

When a primary path is in a critical fault condition, all of the packets should be rerouted to the alternate path; but it needs a duplicate paths and bandwidths. In SONET/SDH networks, over-engineering has been already accomplished in large backbones for added network robustness. No telecom operators want to prepare duplicate paths for the upper layer stability.

If network elements are no other than critical fault conditions, lower QOS services are restricted

Call restriction was used for the circuit switching system. Session restrictions and selective packet discard mechanisms will be useful for the BcN networks. In this paper, when HTR LSPs were detected by signaling information, and alternate paths were not provided, we propose a session admission control mechanisms when network elements are congested.

4.1 Related control mechanisms

There are two congestion control mechanisms used by PSTN, that is "Automatic call gap" and "percentage based" congestion control. These mechanisms are based on the call incompletion ratio. The time difference between congestion recognition and proper control action creates improper call/connection restrictions. The nominal time difference is 5 minutes for most conventional PSTN exchanges. We will apply this mechanism for controlling HTR LSP .

4.2 Automatic Session Gap(ASG) Control mechanism

When an ASG control is initiated, a duration timer should be set to mark the duration of the control. Permissible values for the control's duration are 0.1, 0.25, 0.5, 1, 2, 5 , 10, 15, 30, 60, 120,300, 600 sec. as well as an infinite interval[26]. When the duration timer expires, the control should be removed. When an ASG control is initiated, a gap timer should also be set for a period called the gap interval. All subsequent sessions to the controlled code should be blocked until the gap timer expires. The next attempt to arrive after the gap timer expires should not be blocked. This attempt should be processed normally, and if it fails then the gap timer should be reset to start another blocking period. This cycle should continue until the duration timer expires. When the duration timer expires, the control should be removed immediately without waiting for the gap timer to expire.

4.3 Percentage based control mechanism

The percentage session blocking algorithm is also useful for immediate traffic control[27]. A conventional percentage session blocking algorithm uses the predefined input of an 8 class limit ratio from 0% to 100% with a 12.5% incremental unit for each congestion level. A percentage which is entered by an operator can also be accepted. Therefore, the system can be down when excessive session requests become concentrated. Fig 3 shows simulation result with Call gap control(0.1 sec, 0.25sec, 0.5sec) and Percentage control(12.5%, 25%). Generally, within the engineered capacity, control was prohibited. Beyond the engineered capacity quite different results are generated.

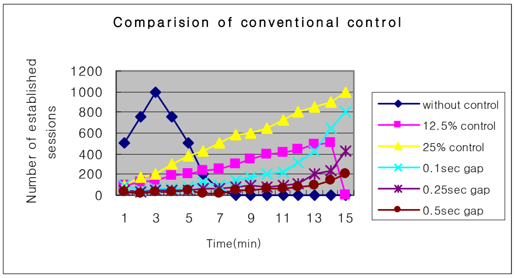

Fig 3. Comparison of Conventional control

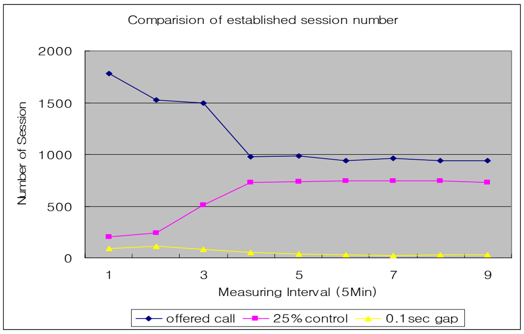

Fig 4. Measuring interval vs. session processing

Ⅴ. Performance Evaluation

5.1 Simulation Model

As shown in fig 4. IP traffic is quite different traffic_pattern than PSTN. Burstiness and long session duration are one of characteristic on IP. when we apply traditional control methods, the results are following. As session is increase, percentage control method shows good performance than call gap control.

We use the following HTR LSP control methods.

- they does not block any session at the LSR, LER. We then know the system will be down when the session requests exceed the engineered capacity.
- When the duration timer expires, the control is removed. When an ASG control is initiated, a gap timer is also set for a period called the gap interval. All the subsequent sessions to the controlled FEC will be blocked until the gap timer expires. The next attempt to arrive after the gap timer expires will not be blocked. We use three session gap times 0.1, 0.25 and 0.5sec for the purpose of simplification.
- Almost all existing HTR LSP control methods measure the USR(Uncompleted Session Ratio) of the HTR codes every 5 to 10 minutes. After that a system operator applies a 12.5%, 25%, 37.5%, 50% 62.5%, 70%, 82.5% and 100% Session blocking rate according to the congestion level.[26] There is some difficulty in determining the congestion level necessary to control the HTR FEC. In this simulation we only use two blocking rates for simplification(12.5% and 25%).
- In this paper, we use NCS(Network Congestion Status) and CNCS(Change of Network Congestion Status) as two inputs, to create a FCV(Fuzzy Control Value). The first input, NCS indicates the network congestion status and is gathered during data transmission. This information is contained in the ATM cell header. The second input CNCS is the change in the network congestion status, i.e., the difference between the current NCS and the previous NCS. The CNCS is used to predict the next NCS. If the CNCS is negative, then the NCS will tend to decrease and the blocking rate will also tend to decreased. The scaled inputs for NCS and CNCS, and the output FCV(Fuzzy Control Value) each have their own fuzzy values in the most popular set{NB(Negative Big), NS(Negative Small), ZO(ZerO), PS(Positive Small), PB(Positive Big)}. The elements of each fuzzy set have their own triangular shaped membership functions.

Using heuristic knowledge to decide the call blocking rate, we present the next three rules.

- If NCS is high, then it increases CNCS fast.
- If NCS is not high, but not too low neither, when CNCS is positive, it increases the Call Blocking rate fast, but if it is negative or equal to zero, it holds the current Call blocking rate
- If NCS is low, when CNCS is positive, it increases the call blocking rate moderately, and when CNCS is negative or equal to zero, it decreases Call blocking rate slowly.

The simulation model used in our research consist of a local exchange and its adjacent toll/ tandem ATM exchanges. This Toll/tandem exchange can process 1000 concurrent calls and the non-blocking switch has a scalable capacity of 2.5 − 160Gbps that was developed by ETRI.

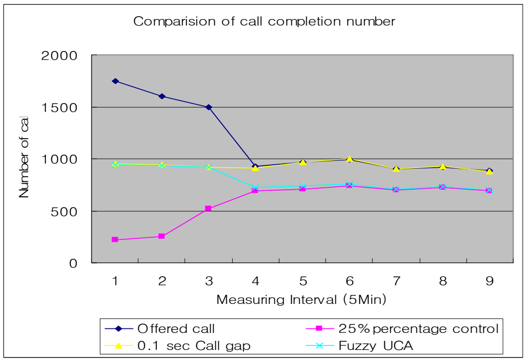

Fig 5. Measuring interval vs. call processing

- As shown as Fig 5, We dynamically use the network status information during the communication. Therefore the reaction time is short and even for a temporary congestion, the performance is better than any other control methods. This method is the key concept of this paper.

5.2 Simulation Results

Simulation results show that all of the above simulation results have the same performance when sessions are under the engineered capacity. However, beyond the engineered capacity quite different results are generated.

If there is no HTR control, the system will go down gradually due to excessive session processing. In the case of session gap control, it is conducted based on an operator's experience. This shows each of the call completion rates. Generally, session gap control algorithms show high performance when sessions at a peak within a short period. Similar to the session gap control, percentage control is also based on an operator's experience. It works well for light burst traffic but if the total allowed sessions exceed to the system engineered capacity, the system will shut down.

Ⅵ. Conclusions

The IP network is typically deployed on the top of an ATM infrastructure. This layer-2 network is completely independent from the IP network.

ATM has found a home in backbone networks, riding on top of a synchronous optical network/ synchronous digital hierarchies(SONET/SDH). Its primary contribution has been the ability to provide quality of service functionality such as service-level guarantees, as well as packet prioritization for real-time voice and multimedia traffic. This study investigates a Hard To Reach LSP detection method using network signaling information. During a communication period, if some fault conditions occur, protection and restoration mechanisms are activated in a case of a physical layer fault. Alternate paths are determined statically or dynamically. The main problems for the MPLS protection and restoration mechanisms are late response and an ability to reflect a congestion state of network elements. The proposed mechanisms can more accurately control the network in the congestion state. It is therefore possible to maximize the efficiency of network resources by restricting ineffective machine attempts. In high speed packet switching system environments, a fast HTR FEC detection mechanism is necessary and this mechanism can be implementing as SOC for high speed processing a packet header.. This mechanism can be also used for the RSVP(Resource ReserVation Protocol) that is used for Internet Protocol.

REFERENCES

〔1〕 Chul Soo Kim "Rare probability connection call registration method using payload type indication field information for ATM switching system" US patent number 5,982.751, Nov. 1999

〔2〕 Chul Soo Kim "Rare probability connection call registration method for ATM switching system" US patent number 5,946,296, Aug. 1999

〔3〕 Chul Soo Kim "Rare probability connection call registration method using incomplete call causation message for ATM switching system" US patent number 5,862,204, Jan. 1999

〔4〕 Chul Soo Kim "procede de commande d'appel avec utilization de l'lintervalle d'appel de functions de transfert en mode de transfert asyncrone ATM pendant la surcharge d'un reseau de commutation ATM" France patent number 2773030, 1998

〔5〕 S. Ahn "Concept of data communication", Cheongiksa, 217-237, Mar.1985

〔6〕 A. Atai and J. Hui, "A Rate-Based Feedback Traffic Controller for ATM networks", IEEE ICC'94, New Orleans, 1605-1615, 1994

〔7〕 C. Chang and R. Cheng, "Traffic control in

an ATM network using fuzzy set theory", IEEE INFOCOM'94, Vol.40, 1200-1207, 1994
〔8〕 ATM Forum, "UNI 4.0", 1997
〔9〕 ITU-T Recommendation Q.2931,"B-ISDN User-Network Interface Layer3 protocol, 1998
〔10〕 R. Jain, "Congestion control in computer networks: issues and trends", IEEE Network, Vol.4, No.3, 24-30, May 1990
〔11〕 W. Kim, "ABR traffic control scheme based on periodic rate adaptation", Master thesis, Chungnam Univ., Aug. 1994
〔12〕 A. Kwok and McLeod, "ATM congestion Control Using A Fuzzy Neural Network", Canadian Conf. on Electrical and Computer Engineering, 814-817, 1996
〔13〕 H. Kwon, A. Tuntiang and G. Pujolle, "A simple flow control mechanism in ATM network with end to end transport", INFOCOM '93, Vol.2, 654-661, Mar.1993
〔14〕 S. Lee and H. Choi, "Traffic flow control of B-NT for prevention of congestion in B-ISDN UNI", KICS J., Vol.19, No.6, 1085-1094, June, 1994
〔15〕 S. Lee, J Choi and H.Choi, "Traffic flow control of broadband network termination for prevention of congestion in ATM networks", 8th JWCC, Dec.1993
〔16〕 E.H Mamdani, "Application of fuzzy algorithms for control of simple dynamic plant", IEE Proc. Control & Science, Vol.121, No.12, 1585-1588, Dec.1974
〔17〕 W. Matragi and K. Soharaby, "Combined reactive/preventive approach for congestion control in ATM networks", ICC '93, Vol. 121, No.12, 1585-1588
〔18〕 D. McDysan and D. Spohn, "ATM theory and applications", McGraw Hill, New York, 1994
〔19〕 P. Newman, "Traffic Management for ATM local area network", IEEE Comm. Mag., Vol.32, NO.8, 44-50, Aug.1994
〔20〕 Chae Sup Lee, "NGN: The Convergence Platform", All Star Network., TD, June, 2004
〔21〕 A. Pitsillides, Y.A. Sekercioglu and G.Ramamurthy, "Fuzzy backward congestion notification (FBCN) congestion control in asynchronous transfer mode(ATM)", IEEE GLOBECOM'95, 1995, 280-285
〔22〕 Rajiv Kapoor, "Management Plane Requirement", ITU-T SG13, NGN-JRG, June 2004
〔23〕 Dimitry Haskin, Ram Krishinan, "A Method for Setting a Alternative Label Switched to handle Fast Reroute", IETF Dfart, May 2000
〔24〕 Srivas Makam, Ken Owens, Vishal Sharma, Chancheng Huang, "A Path Protection/restoration Mechanism for MPLS Networks", IETF Draft Oct.1999
〔25〕 S. Wang, K. Lee and K. Hong, "A predictive link-by-link rate-based flow control and buffer management architecture for ATM networks", JWCC '93, F1-3-1-F1-3-10, Oct. 1993
〔26〕 LSSGR NTM Network Management section 16, Bellcore
〔27〕 Mahnhoon Lee, Chul Soo Kim, "Fuzzy HTR code control in ATM network
〔28〕 Chul Soo Kim, "Comparison of communication mechanisms for B-ISDN charging information" ITU-T SG3, Delayed contribution, June, 1999
〔29〕 ITU-T Rec. I.371, "Traffic control and congestion control in B-ISDN", 1998
〔30〕 ITU-T Rec. I.610, "B-ISDN Operation and Maintenance Principles and Functions", 1998

김 철 수 (Chul soo Kim) 정회원

1985년~2000년 한국전자통신연구원
1993년~ ITU-T SG3, SG11, G13 한국대표위원
2000년~2003년 ITU-T SG3 Q.6 의장
2004년~현재 ITU-T NGN charging 의장
2001년~현재 인제대학교 컴퓨터공학부 조교수

박 나 정 (Na jung Park) 준회원

2003년 인제대학교 컴퓨터공학부 졸업

2004년~현재 인제대학교 전산학과대학원 재학

안 귀 임 (Gwi im Ahn) 정회원

1983년 부산대학교 계산통계학과 학사 졸업

1986년 서울대학교 전산과학과 석사졸업

1995년 서울대학교 전산과학과 박사 졸업

1989~현재 동의대학교 컴퓨터과학과 교수

<관심분야> 클러스터링 컴퓨팅, 유비쿼터스 컴퓨팅, 컴퓨터 네트워크

이 정 태 (Jung tae Lee) 정회원

1976년 부산대학교 전자공학과(학사)

1983년 서울대학교 컴퓨터공학과(석사)

1989년 서울대학교 컴퓨터공학과(석사)

1977년~1977년 한국과학기술원 연구원

1977년~1985년 한국전자통신연구소 선임연구원

1985년~1988년 동아대학교 공과대학 조교수

1992년~1983년 일본 NTT연구소 초빙연구원

1988년~현재 부산대학교 컴퓨터공학과 교수