개방형 정보검색시스템의 설계 및 성능분석

김 동 원† · 류 원† · 전 경 표† · 배 현 덕††

요 약

본 논문은 현재 정보검색 서비스를 제공하고 있는 통신처리시스템인 ICPS(Information Communication Processing System)의 구조 및 성능을 살펴보고, 정보 통신 시대에 효율적으로 대처하기 위해 보다 다양한 공중망과의 접속 및 새로운 서비스를 제공할 수 있는 개방형 정보통신 기반 구조 구축 방안을 제안하고자 한다. 고속의 ISDN 및 인터네트와 같은 정보 통신 사용자의 욕구를 충족 시키고 가입자 망 접속 번호를 사용자 식별 번호로 이용한 과금회수 대행 기능과 복수 부가가치 통신망의 동등 접속을 보장하기 위해 필요한 구조 및 방식을 제안 하였다. 이를 기반으로 대용량 통신처리 시스템인 AICPS(Advanced Information Communication Processing System)를 설계 및 구현 하였으며, 서비스 성능을 검증하기 위해 시스템 성능 모델을 폴링 시스템으로 가정하고 해석한 결과 288,000 패킷/초 처리가 가능하며, V.34 28.8 Kbps 모뎀 사용자를 약 10,000명 을 동시 수용이 가능한 처리 용량이다. 따라서 대용량통신처리시스템 설계 규격인 960명 사용자를 동시에 수용 처리할 경우보다 10배정도 상회하여 서비스가 가능함을 확인 하였으며, 이러한 충분한 시스템 처리 용량은 고속의 ISDN 망, 인터네트망 뿐만 아니라 다양한 새로운 망과의 서비스 확장을 가능하게 하였다.

Design and Performance Evaluation of Open Information Retrieval Service System

Dong Won Kim† · Won Ryu†† · Kyung Pyo Jun†† · Hyeon Deok Bae†††

ABSTRACT

In this paper, firstly we describe the structure and the performance of our ICPS (Information Communication Processing System) which currently provides information retrieval services, and then make a proposal for the construction of the open-networking information communication infra-structure which enables us to fully prepare for the emerging information society. In detail, the structure and the methodology needed for the implementation of the billing function on behalf of all information providers by using the user access network number as a user identification number while guaranteeing the equivalent access to the multiple value-added networks, are suggested. Based on the above ideas, the AICPS (Advanced Information Communication Processing System) has been designed and implemented. Final system performance evaluation with the assumption of a polling system as a system model, shows that our system can handle 10,000 user simultaneously who are using V.34 28.8 kbps modems and the processing capacity is 288,000 packet/sec. This result is so far superior to our target performance established during the designing procedure. Namely, our system was originally designed to accommodate only 960 users at the same time. By taking advantage of this excessive high performance of our system, many

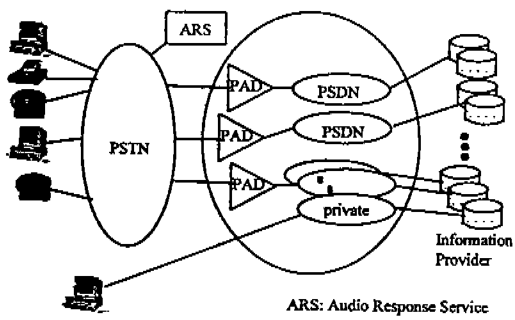
† 정 회 원: 한국전자통신연구소 지능망연구부
†† 정 회 원: 충북대학교 전자공학과
논문접수: 1996년 10월 15일, 심사완료: 1996년 11월 13일

other users can easily access the new services which are accessible only through the ISDN or the Internet.

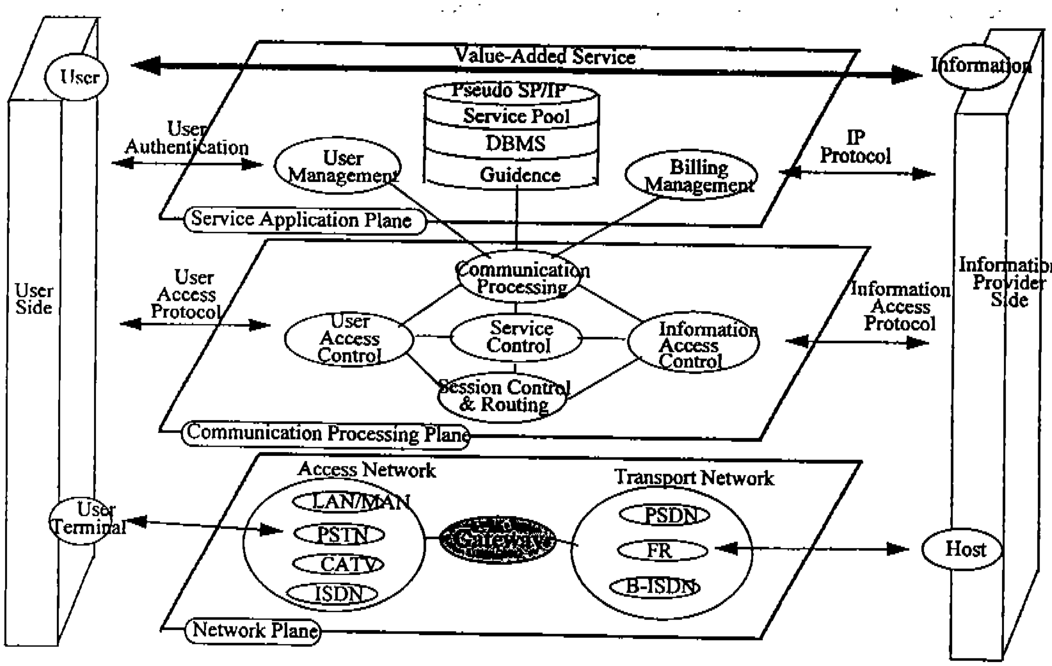
1. Introduction

The traditional service mechanism, as shown in Figure 1, had many problems and the increasing heterogeneity on VAN environments has been an obstacle to the growth of VAN services[1, 2]. For example, end users have to keep their passwords separately whenever they register for new services, and cannot easily access another VAN service systems without redialing. Moreover, it is difficult to know where the desired information is. From information providers' perspective, they must keep the large database of subscribers and have problems in charging for service usage and installation budget. From common carriers' perspective, they often have experienced congestion and overload problems on local exchange site that connected with information provider's hosts or PAD (Packet Assembly Disassembly) by means of subscriber loop as a result of mixture of voice and data traffic.

To cope with these problems and support open network service, we introduce the concept of open VAN. Also, we discuss the ICPS[3] already developed for an information retrieval service, and an improved version AICPS that is under development.



(Fig. 1) Traditional closed VAN environment



(Fig. 2) Platform Architecture for an open VAN architecture.

2. Open VAN Concept

We propose the concept of open VAN[1, 2] which allows global information accessibility and efficient VAN system construction and a platform which can provide an infrastructure of open VAN.

We take an approach of integrating diverse facilities that are scattered over a variety of VAN service systems in a closed VAN environment into a set of well-defined basic service facilities and interfaces which could be used to construct all kinds of VAN service systems. And then, we allocate those facilities to network elements to build a platform that can provide a foundation for an open VAN environment.

So, we can figure out the functional architecture for the platform with three horizontal planes that have different functional facilities as shown in Figure 2. Each of the three horizontal planes is described below.

Plane 1 : Network Plane

Network resources such as transmission facilities, switching facilities and gateway are contained in this plane. Access network serves users with access lines to a gateway that interconnects two types of networks into one information network that carries out transparent information delivery functions of the platform. This plane provides lower-level network service functions corresponding to the layers 1, 2, and 3 in OSI 7-layer architecture.

Plane 2 : Communication Processing Plane

High-level network service functions corresponding to the layer 4~7 of OSI 7 layers such as communication processing and service control facilities, and service and session control functions are located in this plane. This plane provides the necessary infrastructure for the value-added service applications.

Plane 3 : Service Application Plane(Business Support)

In this plane, information service is visible to terminal users. This plane may include the service supporting function such as the guidance, user management, etc. And also, this plane may include information processing facilities, so called service pool for various service applications, for example pseudo Service Provider(SP) which can accommodate various independent IPs (Information Providers).

All kinds of service functions which can reside in network domain and be useful to VAN system application may constitute a platform. In an open VAN, we group those functions into several service facilities such as gateway, communication processing, service supporting and service pool, and session control function and service control. Details of those facilities and functions are as follows.

Gateway facilities connect the user access networks to data network or host system directly, and make various heterogeneous networks act as a homogeneous end-to-host information network. Communication processing facilities provide advanced value-added features : media conversion, code translation, voice recognition, multimedia handling and group communication. Service supporting facilities provide all kinds of service-related assisting functions such as billing, guidance, and user administration. Service pool facilities provide pseudo SP/IP and also can share the load of information processing facilities of heavy-loaded SP/IP. Session control functions control access to terminal and host, and support interworking between terminal users and various service providers including service facilities of platform. Service control functions keep their own system or service configuration records for a variety of VAN service providers playing under open VAN environment, and control their services according to the records.

Those service facilities in a gateway are open to VAN system providers via standard interfaces as shown in Table 1.

Open VAN service concept which can provide a wide variety of value-added services providing the proxy function of user management and billing processing on behalf of all the IPs by ICPS, also, has several requirements as follows.

〈Table 1〉 Interface Specification

Layer	Interface	Specification
Network Plane	IF11 (PSTN-GW)	T1/E1, R2MFC, V.42, V.34, V.27ter
	IF12 (CATV-GW)	Optic, Coaxial, LAN ch., reverse ch.
	IF13 (ISDN-GW)	S/T, UNI, SS No.7 (ISUP)
	IF14 (PSDN-GW)	X.21, LAPB, X.25PLP
	IF15 (FR-GW)	Q.922 Core, I.431
	IF16 (ATM-GW)	S_B, UNI, AAL3/4/5, Q.2931
Comm. Proc. Plane	IF21 (User Access)	VT220, Videotex, G3fax (T.70), DTMF, SLIP/PPP
	IF22 (Information Access)	V-PAD, FRAD, OSI4~7, TCP/IP
	IF23 (Network Management)	ML protocol, TMN-Q3
Service Appl. Plane (Business Support)	IF31 (Information Management)	IP protocol (P1)
	IF32 (Guidance)	IP protocol (P2)
	IF33 (Billing Management)	IP protocol (P3)
	IF34 (Security Management)	IP protocol (P4)
	IF35 (Service Pool)	IP protocol (P5)

1) Information charge is imposed on telephone subscriber number rather than service account.

2) ICPS must know the state(i.e., service start/end) of IP to generate billing data.

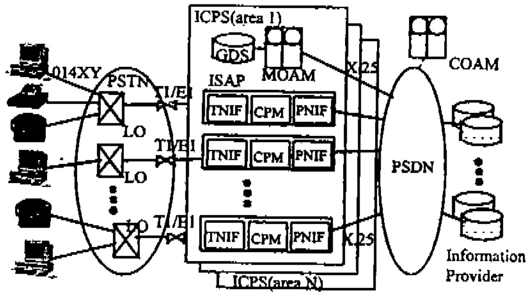
3) ICPS must confirm the billing attributes of the selected information service.

The IP protocol is designed to solve the above issues. The IP protocol consists of four protocols: P1, P2, P3 and P4. P1 defines communication procedures between ICPS and IP for the detailed billing data. P2 is invoked when the ICPS inquires the registered information(i.e. billing grade, access address, service type, etc.) of the selected service from the Guidance System(GDS). P3 transfers the authenticated billing data from the ICPS to the Account Manager of the network management system. P4 is invoked for user management and authentication.

3. ICPS and Open VAN

3.1. ICPS Structure

The overall network configuration of the nation-wide Open VAN service supported by the ICPS is shown in Figure 3.



(Fig. 3) ICPS network

User terminals include telephone sets with DTMF, VT220 mode data terminals including personal computers with V.22/V.22bis or V.34 modems, group 3 facsimiles and HiTEL terminals with North America Presentation Level Protocol Syntax(NAPLPS) videotex mode.

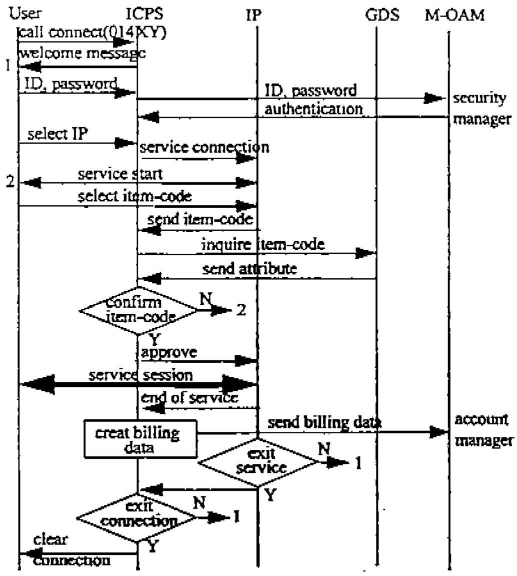
ICPS has a gateway function between PSTN and PSDN, communication processing functions and various service assisting functions. ICPS is composed of multiple ISAP(Information Service Access Point) and M-OAM(Mediation OAM). ISAP is composed of TNIF (Telephony Network Interface), PNIF (Packet Network Interface), and CPM (Communication Processing Module). TNIF provides T1/E1 trunk interfaces and R2MFC signaling. By means of the R2MFC signaling- originating number identification function, user subscriber number is used as a service charging ID. PNIF provides ITU-T X.25 interfaces for a packet network. CPM has a modem pool, VPAD (Videotex Packet Assembly and Disassembly) function, access and session control, and various service supporting functions. M-OAM provides the entire service network management and guidance functions. Database centers of IP are connected with packet network which have X.29 standard protocol and provide various types of information.

3.2. Service call procedure

Figure 4. shows the procedure of accessing an information provider via ICPS[4]. A user dials '014XY', the number designated for ICPS. When a user is connected to the ICPS, ICPS identifies 'XY' and the telephone subscriber number using R2MFC signaling, and displays a welcome page depending on the number of 'XY' to the user terminal. If a user inputs login name and password, ICPS authorizes the user according to the P4 protocol. If a user selects a desirable IP from menus or list of initial message, ICPS makes a session without requiring service account from the user to select IP according to the P1 protocol. After these sequences, all transmitting/receiving data obey this protocol structure. When a session is established, information services start and IP displays the menu list on the user terminal. If the user selects a desirable information unit(we call this unit as a item-code) from the menu, IP sends item-code to ICPS. As soon as receiving the item-code from IP, ICPS requests GDS to confirm billing attributes of the item-code using the P2 protocol. It is the step for the IP protocol to decide accounting method. After inquiry sequence is finished and arranged the way of collecting information, ICPS sends confirmation message to IP. And then billing function starts the accounting procedure at the same time.

When a user wants to disconnect session with an IP, ICPS generates billing data at that time. Generation of billing data is processed whenever session made with an IP. However, even though a user disconnects session with an IP, ICPS can maintain the channel path on PSTN. Therefore, the user can select another IP without releasing connection. The bill for information services is imposed on originating telephone subscriber number. Billing data has two types, one of which is time based and the other is data usage based.

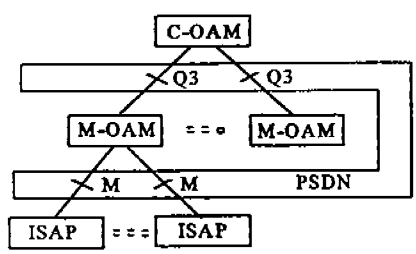
The generated billing data through a service processing unit in ICPS must be transferred to M-OAM using the P3 protocol at each connection time. M-OAM and ICPS are connected through the semi-permanent path over PSDN. All transferred billing data are accumulated at M-OAM. To demand accounting of billing data from telephone subscriber number, Accounting Management(AM) function records them on magnetic tape depending on predefined detail billing format.



(Fig. 4) Call procedure

3.3. OAM Configuration

Figure 5. depicts configuration of OAM in a hierarchical fashion[5, 6]. Nation-wide integrated OAM is constructed in a hierarchical 3-layer architecture based on TMN(Telecommunication Management Network) concepts. The 3-layer is consist of C-OAM(Center



(Fig. 5) OAM Architecture of ICPS

OAM), M-OAM(Mediation OAM), and Built-in OAM of ISAP. M-OAM manages multiple ISAPs in a regional area. C-OAM in a center manages all M-OAM in country. M-OAM and Built-in OAM are connected through PSDN. M-OAMs and C-OAM are also connected through PSDN.

In this configuration, we still have many problems since ICPS was designed to operate only in a single service provider environment. It is necessary for the system to be improved as follows. Service control function to support multiple VAN systems and multiple Service Providers(SPs) must be added. Since there exist around tens of PSDNs in Korea and ICPS has only maximum 8 X.25 links, ICPS should be expanded to have more links in order to interconnect PSDNs and PSTN. Also guidance service function should be improved to support multiple service providers and independent information providers with a host computer. Therefore, we are currently developing an Advanced ICPS which satisfies all of the above requirements.

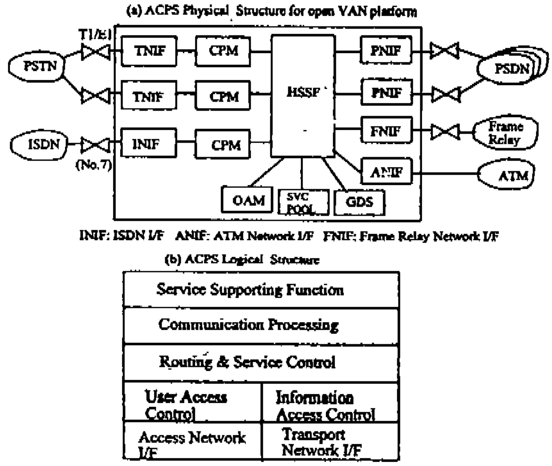
4. AICPS Structure for the improved service

A gateway system should have a flexible architecture to accommodate the various existing network types and emerging network technologies, and sufficient processing power to handle service control and support functions for a large number of users simultaneously. A system should have switching capability to interwork among various network service modules [7, 8, 9].

As a consequence, a general reference architecture for an Advanced ICPS(Figure 6) is proposed, and it meets the manifold requirements mentioned above and exploits the emerging communication technologies such as ISDN and ATM.

4.1. AICPS Structure and Service Function

This system consists of a high speed interconnection network, called High Speed Switching Fabric (HSSF) and various service and network interface modules. The service and network interface modules are connected to HSSF for service interworking. HSSF is designed for applications of high-speed and highly reliable distributed computing systems for data communication services. Adoption of such a modular architecture makes it possible to accommodate easily various types of network and service functions. As a result, TNIF, PNIF and CPM modules of ICPS can be used in AICPS with slight modification by attaching communication adaptor card. In current situation, major network interface types in consideration are PSTN, ISDN, PSDN, Frame Relay, and LAN, which are commercially available now in Korea. ATM interface module is under development for incorporating future multimedia and VOD(Video On Demand) services. Main specification and supportable service functions of the system are shown in Table 2.



(Fig. 6) AICPS structure

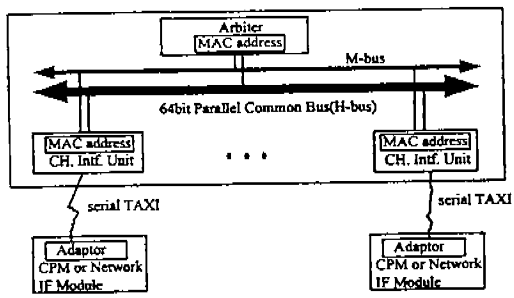
4.2. Performance Modeling of AICPS

Performance evaluation of the system under development is very important to see whether or not it fulfills the requirement of QoS. User traffic arriving at modems from PSTN are multiplexed into CPM and are transmitted to HSSF by serial TAXI. In general, 〈Table 2〉 System Specification and Service Function

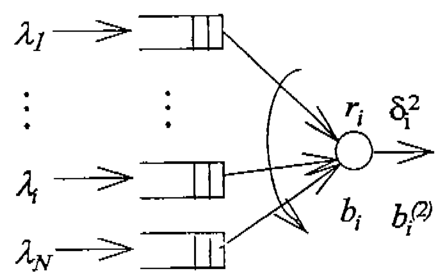
Subsystem	Capability
TNIF	– 4T1 or 3E1 per TNIF (96 modems) – 10 TNIF module per System – Total 960 PSTN user ports – R2MFC Signaling – V.42, V.34, V.27ter, DTMF telephone
CPM	– Service Control – Session Control – Communication Processing
PNIF	– 16 X.25 link(56Kbps) per PNIF – 16 PNIF module per System – Total 256 X.25 links
HSSF	– 32 X 32 Switching Capacity – 640Mbps Throughput – Routing – PTP/Broadcasting/Multicasting
OAM	– Built-in OAM – Mediation Function – Ceneter OAM
Service Function	– Videotex – Text-to-Speech Conversion (Audiotex) – Text-to-Image Conversion (FAX) – Internet Gateway (SLIP/PPP) – Service Pool (Server Cache) – Guidance – Proxy of Billing on behalf of IP – User/IP Administration

CPM can be modeled by a M/M/1 queuing system. But, the topology of HSSF is a high speed common bus named H-bus as shown in Figure 7. Because each CPM and Network Interface Module is connected to Channel Interface Unit of HSSF, they can communicate with each other through HSSF. Arbiter of HSSF plays a role of polling processor which searches a transmission ready channel, and give permission of transmission via M-bus.

Hence, AICPS performance mainly depends on HSSF switching capability. So, we can model AICPS as a cyclic service system with multiple queues which are polled in cyclic order by a single server. In other words, the server(HSSF's arbiter) polls all CPM queues in a cyclic manner to transmit those packets in the queues to H-bus. Service discipline of queues is determined by packet window size as follows: When packet window size is equal to k, limited-k service is assumed. For a window size of 1, the server can transmit one packet at a time. Therefore, this discipline is identical to limited-1 service. To simplify system modeling, traffic is assumed to be symmetric, and to be independent and identically distributed in statistical terms. The service discipline is limited-1. Therefore, the system can be modeled as a single server multi-queue system with cyclic service discipline. The queuing model of the AICPS is shown in Figure 8.



(Fig. 7) HSSF structure



(Fig. 8) Queuing model of AICPS

As shown in Figure 8, messages arrive at the i^{th} queue according to the Poisson process at a rate λ_i, $i=1,\ldots,N$. Service times of messages at the i^{th} queue are independent and identically distributed random variables with the first and the second moments denoted by b_i and $b_i^{(2)}$, respectively. Walking times between consecutive queues are i.i.d random variables with mean r and variance δ^2. Utilization of the server at the i^{th} queue is defined as: $\rho_i = \lambda_i b_i,\ i = 1,\dots,N$. Total utilization of the server is then given by: $\rho = \sum_{i=0}^{N} \rho_i$.

For symmetric case, average message waiting time Wi at the i^{th} queue is given by: [10, 11]

$$E[W_i] = \frac{\delta^2}{2r} + \frac{N[\lambda_i b_i^{(2)} + r(1+\lambda_i b_i) + \lambda_i \delta^2]}{2[1 - N\lambda_i(r+b_i)]} \quad (1)$$

The stable condition of the above equation is

$$\rho < 1,\ \max(\lambda_i) N r < (1-\rho) \quad (2)$$

Then total average message delay is given by:

$$T = E[W_i] + b_i + Nr/2,\ i = 1,\dots,N \quad (3)$$

Here we present numerical results to demonstrate the AICPS performance effects depending on the source input traffic. The following parameters are assumed for our numerical examples:

- H-bus speed: 640Mbps
- Packet length: exponential distribution with average length of 256bytes.
- Walking times between consecutive nodes are iid random variables with mean $r = 0.1\,\mu s$.
- The number of nodes(N): 32

〈Table 3〉 AICPS performance

Input traffic (λ_i = packet/s)	E[Wi] (μs)	T (μs)	Utilization (ρ)
1000	2	7	0.102
2000	3	8	0.204
3000	4	9	0.307
4000	5	10	0.409
5000	7	12	0.512
6000	10	15	0.614
7000	15	20	0.716
8000	28	32	0.819
9000	93	98	0.921
-			unstable

Based on the above assumptions and the analytical formula obtained above, the AICPS performance is evaluated in Table 3.

According to the target design specification, the estimated average source input traffic is about 1350 packets/s per CPM(e.g., 28.8Kbps modem x 96 channel). From the result of Table 3, AICPS can maximally handle 288,000 packets/s in steady state. It is sufficient to satisfy the target design specification and it is possible to extend a service such as ISDN access and Internet gateway service.

5. Conclusion

In this paper, we described the structure and the performance of our ICPS which currently provides information retrieval services, and then make a proposal for the construction of the open-networking information communication infra-structure which enables us to fully prepare for the emerging information society. In detail, the structure and the methodology needed for the implementation of the billing function on behalf of all information providers by using the user access network number as a user identification number while guaranteeing the equivalent access to the multiple value-added networks, are suggested. Based on the above ideas, the AICPS has been designed and implemented.

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Acknowledgment

The authors wish to thank Dr. Byeong Uk Park, Dr. Se Hyeong Cho, and all the colleagues in our development team. This project has been sponsored by Korea Telecom.

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김 동 원

1983년 경북대학교 전자공학과 (학사)
1990년 경북대학교 전자공학과 (석사)
1994년~현재 충북대학교 전자공학과 박사과정
1983년~현재 한국전자통신연구소 고속통신접속연구실 선임연구원 개방형통신처리구조연구 과제책임자
관심분야: 고속연동망, B-ISDN, 신호처리

류 원

1983년 부산대학교 계산통계학과 졸업(이학사)
1988년 서울대학교 대학원 계산통계학과 졸업(이학석사)
1996년 성균관대학교 대학원 정보공학과 박사과정
1989년~현재 한국전자통신연구소 고속통신접속연구실 선임연구원
관심분야: 통신망 관리, 데이터 통신, 멀티미디어 통신

전 경 표

1975년 서울대학교 산업공학과(학사)
1979년 한국과학기술원 산업공학과(석사)
1988년 미국 North Carolina State Univ. Raleigh, 산업공학과(박사)
1979년~현재 한국전자통신연구소 지능망연구부장
관심분야 : 지능망, ATM트래픽 모델링 및 성능분석

배 현 덕

1977년 한양대학교 전자공학과(학사)
1980년 서울대학교 전자공학과(석사)
1990년 서울대학교 전자공학과(박사)
1987년~현재 충북대학교 전자공학과 교수
관심분야 : 디지탈신호처리, 적응신호처리, Wavelet 변환, 통신망기술