論文 97-22-8-4

The Architecture of Future Integrated Network of Mobile into B-ISDN

Kyeong-Hoon Kang*, Jea-Hoon Yoo*, Yoon-Ju Lee*, Soo-Joong Kim** *Regular Members*

차세대 광대역 유무선 통합망의 구조 설계

正會員 강 경 훈*, 유 제 훈*, 이 윤 주*, 김 수 중**

ABSTRACT

Next generation mobile networks will be demanded to support high speed data and multimedia services in addition to existing services including voice communications. In this paper, we discuss the requirements of the wireless service with broad range of applications, and present several types of architecture for future mobile network. After a brief comparative analysis, we propose a most practical and feasible one. And also, we discuss possible interworking scenarios between radio access system and intelligent network. In consideration of the selected infrastructure and scenario, we present protocol architectures and basic functions of radio access system. Based on the architecture, we believe that the integrated system can be realized with such advantages of easy interworking, high feasibility on common services, easy introduction to new services, and unified operation.

요 약

광대역 무선 서비스가 가능한 차세대 이동망의 효율적인 구축을 위해서는 지금부터 망 차원의 시스템 설계가 시작되어야 한다. 본고에서는 차세대 이동망을 구축하기 위해 필요한 무선 서비스의 특성을 검토하고, 구현 관점에서 대별되는 독자망과 통합망의 장단점에 대해 비교하였다. 통합망은 경제성, 유지보수, 통합 서비스 측면에서 장점을 가진다. 또한 본고에서는 현시점에서 실현 가능한 차세대 유무선 통합망의 하부 구조를 제시하고 비교 검토하며, 유연성, 인터워킹의 용이성, 서비스의 확장성을 지원할 수 있는 하부망 구조하에서 이동성 서비스 지원을 위한 지능망과의 인터워킹 시나리오들을 검토한다. 하부망 구조와 상대적인 비교분석을 통해 선택된 시나리오를 기본으로 광대역 유무선 통합 무선 접속 시스템의 프로토콜 구조와 기본 기능을 제시한다.

Ⅰ. Introduction

On-going worldwide researches for future mobile systems aim at supporting various types of services such as voice, data, still and moving image, and multimedia communications beyond the capability of conventional cellular systems. In order to provide com-

*한국전자통신연구원 이동교환연구실
**경북대학교 전자공학과
論文番號:96304-0930
接受日字:1996年 9月 30日

mon services both for wired and wireless users, it may be essential that future mobile systems be integrated into B-ISDN. In addition, considering current worldwide activities for development of future mobile systems such as future public land mobile telecommunications system(FPLMTS) and universal personal telecommunications(UPT), it is expected that integrated broadband networks will be established to support mobility functions with an enhanced intelligent network(IN) capability [1]. Whereas, on the standpoint of the fixed network, the asynchronous transfer mode(ATM) has been taken as a transfer technique for B-ISDN by ITU-T because of its flexibility and efficiency. This indicates that the future mobile network will be based on the ATM infrastructure [2, 3].

At present, most of worldwide researches in advanced mobile systems have been mainly focused on the study for logical aspects such as the requirements of integrated broadband services and the general concepts of integrated network [1, 2]. We believe that it is timely to start designing physical network architecture and protocol standardization. As a research of such physical aspects, this paper presents an architecture of the integrated mobile network into fixed B-ISDN. We first consider several issues for designing the architecture of future mobile networks. The characteristics and quality of broadband mobile services would be similar to those of B-ISDN/ATM except the maximum allowable bit rate in which the restriction is due to the bandwidth limitation of radio interface. The diversity of traffic has a direct impact on the multiple access method of the air interface. Thus, it becomes an important issue in the design how to develop multiple access technique by which various wireless broadband services such as voice, data, and image are effectively integrated. Another issue is implementation options between standalone and integrated system. We rather recommend the integrated network than the standalone network in consideration of several factors.

Future mobile networks consist of RAS(Radio Access System), IN, and B-ISDN. The fixed B-ISDN is responsible for call and bearer control in cooperation with RAS. Whereas, IN supports mobility features. We discuss several infrastructures capable of providing broadband services for wireless users in Section III. The choice among different interworking scenarios depends on a full consideration of various factors such as flexibility, easiness of interworking, cost effectiveness, domestic environments, and so on. After a brief review of mobile access infrastructure based on ATM, we discuss the interworking scenarios between radio access system and IN. And finally, we present protocol architectures and basic functions of wireless access system in Section IV. Based on the architecture we proposed, we believe that the WATM system can be realized with such advantages of easy interwoking, high feasibility on common services, easy introduction to new services, and unified operation.

II. Design issues

1. Services

Next generation wireless systems will support user data services based on constant and variable bit rates. The first and second generation mobile systems in worldwidel service have been implemented to support speech and limited data services. Whereas the third generation mobile system such as FPLMTS is currently being designed to support further services such as multimedia service with bit rates up to 2 Mb/s in microcellular coverage areas. It is expected that users' demand on the transport capability with higher speed data will grow continuously. However, wireless broadband service would be restricted by the following two constraints in relation to radio environments; Firstly, the required spectrum on the radio interface will be increased in proportion to the amount of transmission data through air, and, consequently, the maximum allowable bit rate will be restricted by the limited bandwidth on the radio interface. In order to acquire bandwidth efficiency under these limited spectra, more efficient source coding techniques such as speech and image coding(e.g. VSELP, MPEG) are essential[4]. However, these techniques with compressed coding scheme bring forth more strict requirements on the performance. These also will influence on the compatibility of communications between wireless and wired user which result in adding some load(e.g. transcoding) to the wireless access node. The other constraint is that wireless users will expect a quality of service similar to that provided by fixed network. However, it is impossible for the wireless network to emulate the performance of B-ISDN in the physical link layer because of the radio propagation environment and inherent terminal mobility. In order to overcome these constraints, more powerful error correction such as ARQ should be employed in high protocol above layer 2.

Typical applications of integrated broadband services include mobile specific applications such as emergency medical service, city guidance as well as mobile extension services of the fixed B-ISDN such as videotelephony, multimedia library access. Table 1 summarizes characteristics and quality of typical wireless boradband services. As shown in Table 1, the characteristics and quality of applications are highly various. For example, voice transmitted with bitrates less than 32Kbps is sensitive to delay, but insensitive to bit error rate(BER). But, file transfer carried out with various bit rates, and is insensitive to delay, but sensitive to BER. These various requirements make a great impact on the design of wireless access system, especially multiple access and traffic control techniques.

2. Multiple Access Techniques

The multiple access technique used in wireless networks is of great importance for the design. To control various applications and to effectively utilize limited radio resources, the multiple access approach should be based on the packet switched method. It is impossible to reuse circuit based TDMA or CDMA, which are currently used in digital cellular networks, because of their inefficiency and non-flexibility. At present, many of algorithms, such as dynamic TDMA, packet CDMA, enhanced PRMA, are available in the literature [2, 5, 6, 7, 8]. All of them are based on the packet access method to support integrated transmission of voice and data. The detailed explanation on the algorithm is beyond the scope of this paper. But, it is only assumed to be the ATM-like packet access method in consideration of compatibility between wired and wireless user interface, and easiness in protocol conversion in the interworking node.

3. Implementation options

Future mobile system can be implemented either as standalone system or integrated system with a fixed network. The relative advantages and disadvantages among the two implementation options are summarized in Table 2. The former corresponds to the one evolved from the current PLMN, which has an advantage of independence on the fixed systems in its

Table 1. Characteristics and quality of wireless services

services	type	bit-rate (bps)	delay	delay variation	max. BER
voice telephony	CBR/ VBR	2.4-32 K	sensitive	less sen.	10-3E
G4 Fax	CBR	64 K	less sen.	less sen.	10-6E
high-quality audio	CBR	128-940K	insensitive	less sen.	10-6E
video conf. (compressed VCR)	VBR	1-6 M	sensitive	sensitive	10-7E
HDTV(compressed)	VBR	15-20 M	sensitive	sensitive	10-7E
file transfer	VBR	0.1-10 M	insensitive	insensitive	10-8E

implementation. Accordingly, in the viewpoint of wireless network, the standalone system can be implemented with optimized functions, infrastructure, protocols, and so on. However, this system may not be a effective solution, as it requires expensive cost and a great deal of efforts due to giving up most of fixed environments. Although standalone system has the severe disadvantage, it may be as a best candidate in cases that the fixed network and radio network are operated separately by different operators.

On the other hand, one main advantage with the integrated system is cost reduction in the implementation [9]. By the integration, the protocols and functions as well as infrastructure can be reused [10]. Therefore, we prefer the integrated network to the standalone network because it provides cost savings, unified network maintenance and operation, and common service both for wired and wireless users.

Table 2. Relative comparisons between standalone and integrated network

	Standalone	Integration
Cost	Expensive	Inexpensive
Operation &maintenance	Complex	Simple
Introduction of common services	Difficult	Easy
Wireless access network	Efficient	Less efficient
Network evolution	Negative	Positive

Ⅲ. The Architectures of Integrated Broadband System

Figure 1 shows the conceptual model of future integrated mobile system. These networks consists of RAS, IN, and B-ISDN. RAS is responsible for radio resource management. And also, RAS have relationship with fixed B-ISDN for call and bearer control. Whereas, IN is applied to support mobility features.

1. Overall network architectures

Figure 2 shows three different overall architectures of the integrated broadband system. As shown in figure 2, the radio access system is constitute of RAP, Multiplexer, and ATM switch in type A and B;

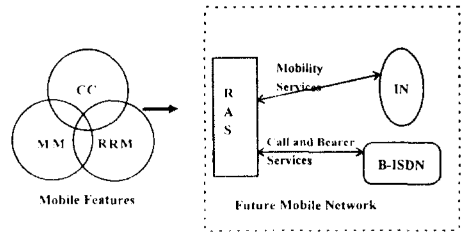
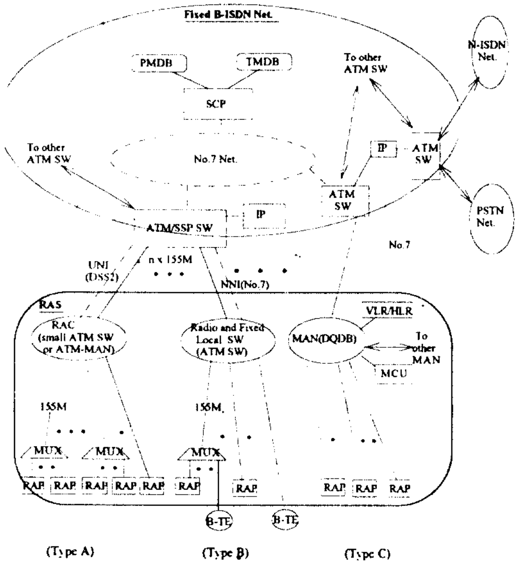


Fig. 1 The conceptual model of future integrated mobile network

Whereas, type C shows a distributed architecture based on IEEE 802.6 MANs [1]. Type A and B have several advantages such as (1)easy interworking with ATM backbone network, (2)the capability large enough to support services to the extent that the fixed B-ISDN provides, and (3) less difficulties in the evolution toward unified wired and wireless functions. Whereas, type C suffers from the limited capacity due to shared medium and non-commonality of access system between wired and wireless, even though it is possible to avoid bottleneck of signalling processing by distributing wireless control functions to each node interface unit. Therefore, type C can be applied as an intermediate phase in the course of the evolution [12].

The difference between type A and B is in the depth of integration. Radio access system of type B is incorporated into B-ISDN user access system. Whereas, type A supports only radio access subscribers and employs B-ISDN UNI protocols for the communication with ATM switch in the backbone network. Of course, type B is the best system from the viewpoint of the integration, but it seems impossible that this type can be practically used in the near future. This is because it requires functions and protocols among different access points, namely, wireless and wired access points to be unified, and accordingly, B-ISDN UNI protocol to be newly established. These impose an extra burden on the local exchange. It may also cause an undesirable result even to degrade overall



B-TE : Terminal Equipment for B-ISDN	DSS2 : Digital Subsrciber Signalling 2
IP : Intelligent Peripheral	HLR : Home Location Register
MAN : Metropolitan Area Network	MCU : Mobile Control Unit
PMDB : Personal Mobility DataBase	RAC : Radio Access Controller
RAP : Radio Access Port	RAS : Radio Access system
SCP : Service Control Point	SSP :Service Switching Point
TMDB : Terminal Mobility DataBase	VLR : Visitor Location Register

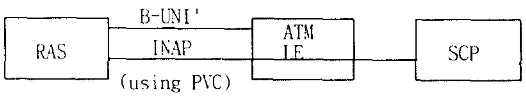
Fig. 2 Three different types of architectures of the integrated broadband system

network capacity. Of course, the decision to select an architecture among different network architectures mainly depends on domestic network evolution. However, careful considerations of several situations discussed above lead to a conclusion that type A is an realistic and promising architecture to support integrated broadband services by the time B-ISDN starts operation.

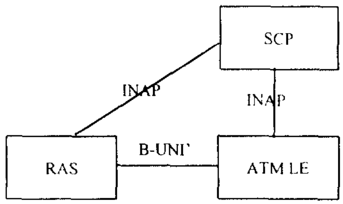
2. Interworking scenarios between RAS and IN

It is also noted that future mobile network will be based on enhanced IN capabilities as well as B-ISDN in order to ensure easy introduction of new services and separated control of mobile specific features. Fig. 3 addresses three interworking scenarios between RAS and IN. Type A presents indirect interaction scheme via local exchange. The others present direct interaction scheme by Permanent Virtual Circuit(type B) or physical trunk(type C). Table 3 summarizes relative comparison of three cases. Scenario A is simple and may work with conventional signalling network, but it has several defects as considering a great deal of mobility signalling traffic. Especially, it brings force higher delay due to indirect path and extra burden to local exchange. Whereas scenario B and C have relatively small delay compared to A. Scenario C in contrast with B has the severe disadvantage of inefficient resource utilization due to redundant physical path. It may be not realized because of expensive costs and impact on network planing. As compared in Table 3, though B imposes an extra load on RAS, we believe that type B is an practical and optimistic scenario by offering several significant advantages such as low delay, efficient resource utilization, and promising architecture for common UNI protocol.

(A) Via Local Exchange(CCF/SSF)



(B) Using PVC(Permanent Virtual Circuit)



(C) Directly using physical interface

Fig. 3 Interworking scenarios between RAS and IN

Table 3. Relative comparisons of three interworking scenarios

	Type A	Type B	Type C
Interaction scheme	Indirect	Direct	Direct
Implementation Load in ATM LE due to mobility services	Increase	Not change	Not change
Implementation Load in RAS due to mobility services	Not change	Increase	Increase
Physical resource utilization	Efficient	Efficient	Inefficient
Impact on network planning	Insignificant	Insignificant	Significant
Delay for mobility services	High	Moderate	Low
Impact on common UNI protocol	Significant	Insignificant	Insignificant

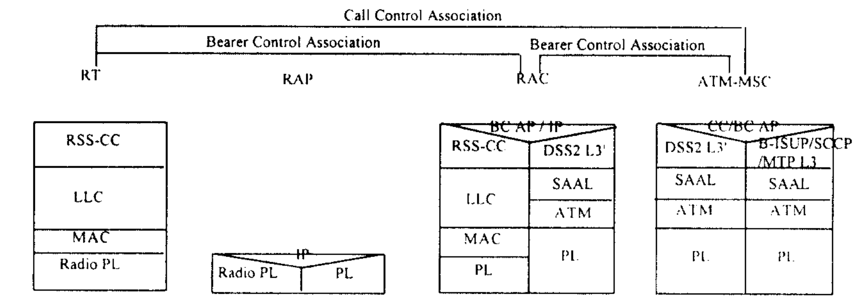
Ⅳ. Protocol Architectures and Basic Functions

Wireless access network transfers user data units and signalling messages between Radio Terminal(RT) and ATM LE/SCP. Based on the selected infrastructure and scenario above, figure 4 shows protocol architectures of the wireless access system, focused on CC signalling, user data, and MM signalling respectively. The basic approach for these structure is to align with ATM protocol stack. It provides unified modular structure and easy interworking. The signalling for wireless access will consists of most of current B-ISDN signalling and some radio specific part. The functions of each layers except B-ISDN protocol and physical layer are summarized below.

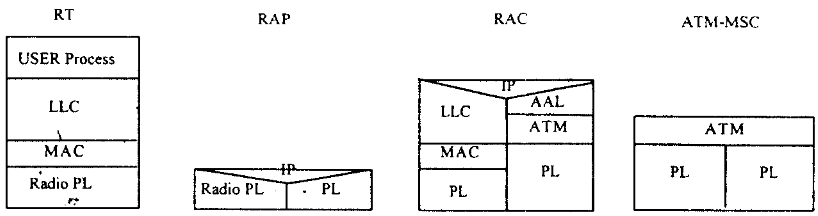
- MAC
  - · Shared medium access control
  - · Burst level admission control (including priority control)
  - · Macro-diversity/Multi-bearer connection, etc.
- LLC
  - · ATM/AAL-like functions
  - · Logical link establishment, release, and maintenance
  - · Error control such as ARQ
- RSS
  - · DSS2 L3-like functions
  - · Radio specific functions (e.g. LR, authentication)
- DSS2 L3'
  - · Enhanced DSS2 L3 for mobility control

In figure 4, RAC is responsible only for bearer control function and makes over call control function to ATM LE. Accordingly, RT has directly relationship with ATM LE for call control. It is also noted that interworking in wireless controller during data transfer phase will be much simpler by performing VP/VC (Virtual Path/Virtual Channel) routing if ARQ scheme is not employed and ATM cell is used over radio. If so, RAC will support the same capability as Network Termination(NT) in case of connection handling. As shown in figure 4 (C), RAS has directly relationship with SCP using VP switching of local exchange in order to handle the signalling for mobility functions such as location management, authentication, and so on. It implies ATM LE has no share in mobility control.

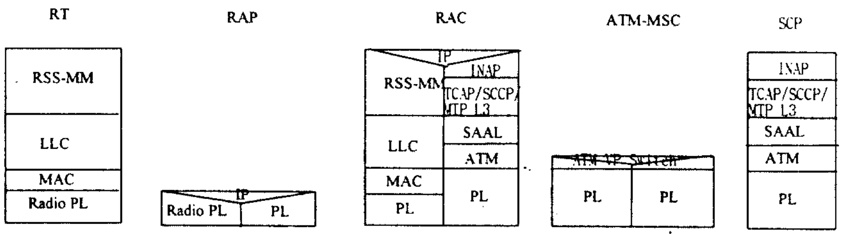
Overload in radio access system results in loss and



(a) Signalling Protocol Architecture for Call Control



(b) User Data Protocol Architecture

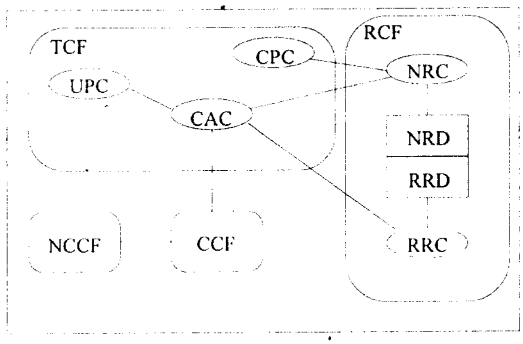


(c) Signalling Protocol Architecture for Mobility Management

AAL : ATM Adaptation Layer	AP : Application Process	BC : Bearer Control
B-ISUP : Broadband ISDN User Part	CC : Call Control	IP : Interworking Process
INAP : Intelligent Network Application Part		LLC : Logical Link Control
MAC : Medium Access Control	MM : Mobility Management	MTP : Message Transfer Part
PL : Physical Layer	RAP : Radio Access Port	RAC : Radio Access Controller
RSS : Radio Subscriber Signalling	RT : Radio Terminal	SALL : Signalling AAL
SCCP : Signalling Connection Control Part	TCAP : Transaction Capabilities Application Part	

Fig. 4 Protocol Architectures of Radio Access System

delay of traffic. In order to prevent the allocated radio resources per RAP from becoming overloaded, some resource management and congestion control scheme for future wireless system will be required. Like Connection Admission Control(CAC) function in ATM network, some negotiation between radio terminal and RAS will be needed when connection is initially established, or reestablished during handover. Usage Parameter Control(UPC) is also provided with a view to assuring mobile terminal's conformity to the



NRD : Network Resource Data
RRD : Radio Resource Data

Fig. 5 Functional Architecture of Radio Access Controller.

negotiated values.

Figure 5 illustrates the functional model of RAC. It consists of four functions such as Connection Control Function(CCF), Non-Connection Control Function (NCCF), Traffic Control Function(TCF), and Resource Control Function(RCF). CCF is responsible for establishing, maintenance, and releasing the connections, handover and paging execution, etc.. Whereas, NCCF handles mobility control functions such as location updating. As shown in figure 5, RCF which is responsible for the management of overall transmission resources can be divided into two parts, Radio RCF(RRCF) and Network RCF(NRCF). The RRCF also handles dynamic resource assignment among RAPs. The TCF performing congestion control is composed of CAC that judges whether the requesting connection can be accepted or not, UPC, and Cell Priority Control(CPC) that resides in the output buffer. Of course, the decision of connection admission depends on both radio and network available resources.

Ⅴ. Conclusion

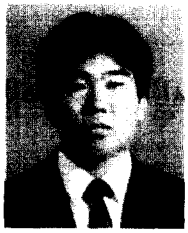
Future mobile network will be required to cover broadband services including multimedia applications. A basic approach for wireless broadband services was presented in this paper. For cost savings and common services, future mobile networks will be integrated into B-ISDNs rather than standalone system. In addition, these networks will be based on an enhanced IN capability to support mobility functions.

In this paper, we presented several possible network architectures in a network evolution point of view. After a brief comparative analysis, we proposed a most practical and feasible one. And also, we discussed possible interworking scenarios between RAS and IN. In consideration of the selected infrastructure and scenario, we presented protocol architectures and basic functions of radio access system. Based on the architecture we proposed, we believe that the integrated system can be realized with such advantages of easy interworking, high feasibility on common services, easy introduction to new services, and unified operation. Finally, we note that future efforts should be made to clarify the fundamental issues such as multiple access, radio traffic control technique, and signalling requirements in detail.

References

1. M. H. Callendar, "Future Public Land Mobile Telecommunication Systems," IEEE Personal Communications, pp. 18-22, Fourth Quarter 1994.
2. Davide Grillo, et al., special issue on "The European Path Toward Advanced Mobile Systems," IEEE Personal Communications, pp. 2-63, Feb. 1995.
3. D. Raychaudhuri, "ATM Based Transport Architecture for Multi-services Wireless Personal Communication Networks," Proc. ICC, pp. 559-565, May 1994.
4. P. Mermelstein, et al., "Integrated Services on Wireless Multiple Access Networks," Proc. ICC, pp. 863-867, May 1993.
5. Newman D. Wilson, et al., "Packet CDMA Versus Dynamic TDMA for Multiple Access in an Integrated Voice/Data PCN," IEEE JSAC, Vol. 11, No. 6, pp. 870-884, Aug. 1993.
6. Fayu Li and Lazaros F. Merakos, "Voice/Data

Channel Access Integration in TDMA Digital Cellular Networks," IEEE Trans. on Vehicular Tech., Vol. 43, No. 4, pp. 986-996, Nov. 1994.
7. D. J. Goodman, et al., "Network Control for Wireless Communications," IEEE Comm. Mag., pp. 116-125, Dec. 1992.
8. M. J. McTiffin, et al., "Mobile Access to an ATM Network Using a CDMA Air Interface," IEEE JSAC, Vol. 12, No. 5, pp. 900-908, June 1994.
9. J. A. Korinthios, et al., "Scenarios for Integration of the Universal Mobile Telecommunication System (UMTS) into Broadband ISDN," Proc. VTC'94, pp. 1596-1600, Jun. 1994.
10. Toon Norp, "Aspects of Integrating Mobile and Fixed Communications," Proc. ICUPC, pp. 281-285, Sep. 1994.
11. D. J. Goodman, "Cellular Packet Communiations," IEEE Trans. Comm., Vol. 38, No. 8, pp. 1272-1243, Aug. 1990.
12. K. Kang, et al., "A study on the architecture of future mobile network toward integrated broadband services," ICEIC, pp. 235-238, Aug. 1995.



강 경 훈(Kyeong-Hoon Kang) 정회원
1984년 2월 : 경북대 전자공학과 졸업(학사)
1986년 2월 : 경북대 전자공학과 졸업(학사)
1986년 1월~현재 : 한국전자통신연구원 이동교환연구실 선임연구원
1992년 3월~현재 : 경북대 대학원 전자공학과 박사과정
※주관심분야 : IMT-2000, WATM, ISDN, No.7신호방식

유 제 훈(Jea-Hoon Yoo) 정회원
통신학회논문지 제21권 10호 참조

이 윤 주(Yoon-Ju Lee) 정회원
통신학회논문지 제20권 6호 참조

김 수 중(Soo-Joong Kim) 정회원
통신학회논문지 제21권 1호 참조