ITS 시스템을 위한 Radio Access의 Technological 이슈

Technological Issues in Radio Access for the ITS (Intelligent Transport System)

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목 차

Ⅰ. Introduction

The rapid growth of wireless networks and services, accelerated by the third-generation mobile communication system (in short, hereafter, 3G system) research, is ushering in the era of the fourth-generation mobile communication system. Wireless communication systems are evolving to meet the ultimate goal, to allow 'anywhere, anytime, anything, by anyone' communication customized to a particular subscriber's preferences, location, and social behavior [1-3]. To reach this goal, much effort is still underway.

In order to accommodate new needs of the subscribers, a great many efforts on a new wireless system (hereafter, we call it 4G system) and ITS (Intelligent Transport System: hereafter, we call it ITS) are being made in many countries and organizations including Japan, U.S.A, and ETSI (European Telecommunication Standards Institute). Although the new wireless system is currently called 'system beyond IMT-2000,' the name is expected to be harmonized to the '4G system' in the near future. Since the research on the integration both 4G wireless system and ITS are in its very early stage, there are little results showing the perspective framework of 4G services and systems.

This paper aims to shed some light on the overall framework of the 4G systems through suggestion and envisioning of a variety of system/network aspects. In this paper, we propose a perspective framework of the 4G system and ITS in an overall system/network viewpoint. The focus of the paper is to define and identify what the enabling radio access technologies will be in the 4G system and ITS.

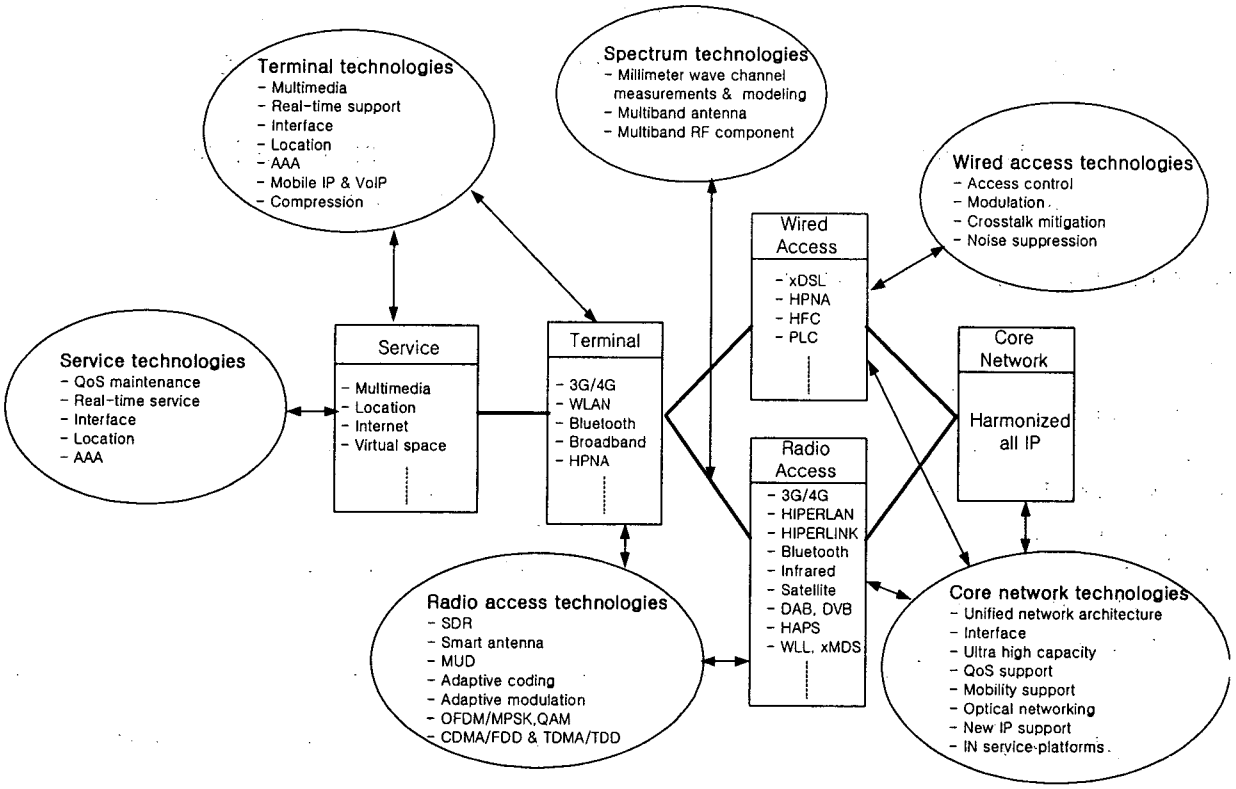
Ⅱ. Concept of 4G System

Since the start of discussion on "system beyond IMT-2000"by ITU-R in 1999, the 4G system has been primarily triggered by a number of following factors:

I) Rapid growth of mobile systems and services,
ii) Exponential spread of the internet and intranet,
iii) Emergence of nomadic computing,
iv) Convergence of communications and broadcasting,
v) Deregulation and liberalization of telecommunications, and
vi) Openness and integration of different networks.

In this section, we describe a conceptual framework of the 4G system from these aspects. In Fig. 1, the conceptual diagram of the 4G system is depicted showing the relationship among system components and required technologies. Furthermore, the comparison between the 3G and the 4G systems is made in Table 1 from the various kinds of standpoints.

Fig. 1. Conceptual diagram of the 4G system.



	2G system	3G system	4G system
Smart antenna	Not considered	(partially) expected	(strongly) promising
Multiuser detection	Not considered	(partially) expected	(strongly) promising
Software defined radio	Not considered	(partially) expected	(strongly) promising
Channel coding and error control	Convolutional	Convolutional/turbo Hybrid ARQ	Convolutional/turbo Adaptive coding Hybrid ARQ
Modulation	QPSK series (IS-95) GMSK (GSM)	QPSK series (3GPP) QPSK series (3GPP2)	Adaptive modulation (OFDM/MPSK, QAM)
Demodulation	Forward: coherent Reverse: noncoherent	Forward: coherent Reverse: coherent	Forward: coherent Reverse: coherent
Power control	Forward & Reverse	Forward & Reverse	Adaptive power control (Forward & Reverse)
Diversity	Rx diversity	Tx/Rx diversity	Space-time processing (Tx/Rx diversity)
Handoff	Soft/Softer handoff (Intra-system)	Soft/Softer handoff (Intra & inter system)	Soft/Softer handoff (Intra & inter system)
Multiple access/Duplex	CDMA/FDD (IS-95) TDMA/FDD (GSM) TDMA/TDD (PHS)	CDMA/FDD,TDD (3GPP, 3GPP2)	CDMA/FDD,TDD TDMA/FDD,TDD

Table 1. Comparison of radio access technologies among 2G, 3G, and 4G systems.

III. Radio Access Technologies

Towardsthe 4G system, many radio access technologies are now arising as promising solutions to enhance the spectrum efficiency and system capacity. In Table 1, the radio access technologies between the 2G, 3G, and 4G systems are summarized and compared.

1. Smart Antenna

A smart antenna consists of many antenna elements whose signals are processed adaptively in order to exploit the spatial dimension of the mobile radio channel.It is widely accepted that an adaptive antenna array will offer potential solutions to a number of the key requirements since it provides many promising features such as high capacity, high spectrum efficiency, and more degrees of freedom to adjust cell coverage characteristics, leading to more efficient use of radio resources [4].

2. Multiuser Detection

To overcome the near-far problem and mitigate the MAI, concept of multiuser detection (MUD) (also called "Interference Cancellation (IC)") has been proposed [5]. In the 4G system, the MUD is a very promising solution for improving receiver performance as well as system capacity and coverage in both uplink and downlink, while in the standardization of the 3G system, the MUD has not been actively discussed. In the uplink, interference estimation and subtraction based MUD appears to be the most promising one for practical implementation.

3. Software Defined Radio

The SDR represents 'radio functionalities defined by software.' The capability of processing a signal corresponding to a wide range of frequencybands and channel bandwidths in a cost-effective manner may also be a critical issue in the roadmap of the 4G system [6]. The digital signal processing technology has led us to a point where it is feasible to change characteristics of a radio depending onthe software loaded into it. It really seems that the SDR can provide promising solutions for implementation of the 4G system as well as for that of the 3G system.

4. Channel Coding

In the 2G systems, the convolutional code was primarily selected as the channel coding scheme, while in the 3G system, the convolutional and turbo codes have been alternatively employed for low and high rate data transmissions. In the 4G system, this kind of trend in the 3G system is expected to continue, however, the use of coded modulation and adaptive coding schemes may be challenging issues to improve spectrum efficiency and to adapt to changing channel conditions, respectively. In addition, for service applications which can tolerate delay, ARQ (automatic repeat request) can be applied for the error control in the MAC (medium access control) layer.

5. Tx/Rx Diversity

So far, a number of transmit diversity techniques have been proposed for the downlink. It has been recognized that transmit diversity on the downlink can provide a means to achieve similar diversity gain as for the receiver diversity without complexity of extra receiver. The major transmit diversity includes orthogonal transmit diversity, time switch transmit diversity, and selection diversity. In the 4G system, these kinds of transmit diversity will be surely considered for enhancement of the downlink performance.

6. Modulation/Demodulation

In the 4G system, a high rate data up to a few hundred Mbps in a static user should be supported for transmissions of speech, fax, data, video, etc. One of the approaches is multicarrier transmission technique [7]. With the projected demand for multimedia services, the ability to provide spectrally efficient and flexible data rate access is one of the important design considerations of the 4G systems. One of the approaches to satisfy both of these requirements is to adapt the modulation (called 'adaptive modulation') and transmission power according to the instantaneous propagation conditions.

7. Power Control

To mitigate these shortcomings, diversity is widely used in the current and upcoming systems. In a wide sense, gating and DTX (discontinuous transmission) can be seen as another way of power control. In the 2G/3G system, the step size and frequency of power control are fixed once the propagation channel is identified, however, in the 4G system, they can be varied according to the channel propagation environments through enhanced channel estimation. This kind of technique is typically called adaptive power control, and is a promising approach for the 4G system implementation.

8. Handoff

In a mobile cellular system, handoff is performed for link quality maintenance and for reducing interference in the system. For seamless networking of multiple interworking systems, handoff will be a very essential issue of the 4G system. In the 2G and 3G systems, the major handoff is the

intra-network handoff based on physical layer characteristics such as signal strength, BER, range, etc. However, in the 4G system, inter-network (inter-system) handoff may be a critical issue as well as the intra-network handoff.

9. Multiple Access and Duplex

Unlike voice communications, the primary service in the 4G system will be various kinds of multimedia applications in which system capacity is limited by the downlink traffic. To cope with the problems caused by traffic imbalance between uplink and downlink, the TDD can be a viable solution in the sense that it permits one toallocate communication resources more flexibly compared to the FDD (frequency division duplex). For an environment with the imbalance between uplink and downlink traffics, the CDMA and the OFDM/TDD may be strong candidates as the multiple access and duplex schemes for the 4G system

III. Conclusions

The concepts and ideas in this paper have just scratched the surface of the potentialities for the 4G system and ITS. A number of challenging issues listed below should be resolved:

I) Development of innovative air interfaces,

ii) Channel modeling and measurements above 2GHz band for decision of operating bands,

iii) Deployment of layered network architecture,

iv) Development of multimode reconfigurable terminal/ appliances,

v) Management and integration of different networks/ systems, and

vi)Generation of new services (business models).

In the era of the both 4G and ITS systems, as witnessed in the 3G system, the different world regions need to cooperate particularly in the field of standardization, regulation, and spectrum allocation to ensure widespread availability of advanced and affordable wireless services and applications.

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