GUEST EDITORIAL

Fourth Generation Wireless Networks and Interconnecting Standards

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Third-generation wireless systems, or so-called 3G networks, will begin service in Japan by the end of this year, and in other countries the following year. These systems are planned to follow the successful implementation of the circuit-switched 2G wireless networks such as the Global System for Mobile Communications (GSM) and IS-95, with enhanced features such as high-speed data and Internet access, multimedia data transmission, and a packet-switched core network (potentially an IP core network). Research and studies on 3G networks began in the early 1990s, initially under the name Future Public Land Mobile Telecommunications System (FPLMTS) and then renamed International Mobile Telecommunications (IMT-2000). However, we cannot ignore the recent rush in design of those systems, which has finally resulted in some technical shortages that ask for another generation.

In early talks on 3G systems, there were some drawbacks in 2G networks, specifically low-speed data transmission on the order of tens of kilobits per second at most, low efficiency in handling packet-oriented services such as the emerging Internet, and multiple standards that prohibit roaming between regions. 3G systems have been planned to improve the data transmission speed of wireless networks, and also increase mobility of users and roaming between different networks. However, in the end, IMT-2000 came with several standards based on Universal Mobile Telecommunications System (UMTS). Also, the data rate of the 3G network is far below what was expected. All these issues call for a new generation for wireless networks, namely 4G, on which research efforts have already started within academia and industry. This special issue is devoted to some of these studies.

Although 4G wireless cellular networks will include new IP-based and mobility supporting features, they will still suffer from a divergence between standards that limits the roaming of users between different networks. Quality of service (QoS) issues such as perceived data rate, delay for message delivery, and cost are yet to be addressed completely in 3G wireless networks. Interconnection of wireless cellular networks of different standards with wired networks and other types of wireless networks, such as satellite networks, in an efficient and cost-effective way call for a new generation of wireless networks. It is worthwhile to mention some good points that have been considered in 3G systems, however, such as in UMTS compared to its predecessor GSM. These include wideband access and higher bit rates toward mobile multimedia applications; a uniform way to offer cross-domain services to users; service portability across networks and terminals; and enhancing creativity and flexibility for new services through standardization of the blocks that make up services and not services themselves.

This special issue can be considered the first in a series of similar special issues on beyond 3G systems to come in the next few years, and addresses the state of the art of proposals and research activities toward 4G networks and how these networks can provide global seamless roaming between heterogeneous wireless, satellite, and wired networks. Introduction of the interworking units (IWUs) between networks of different standards (e.g., 2G, 3G, and 4G) and between satellite and terrestrial wireless networks could be considered the main issue in these networks. How 4G networks can change the roaming capability of the previous generations at affordable cost and perceived quality, and how they boost progress toward real personal communications are the issues to be discussed in this special issue.

At this stage, when the standards for 3G systems are being completed and we are looking forward to the actual services provided by those promising systems, it really could be too early to say what will be in the 4G networks. However, we can still define 4G networks based on the issues that couldn't be addressed completely in 3G systems and the services required in the next decade. That is, the 4G mobile networks could be systems characterized by:

- Horizontal communications between different access technology including cellular, cordless, WLAN, short-range connectivity, and wired
- A common platform to complement other services
- Connection through a common, flexible, seamless, IP-based core network
- Advanced media access technology that connects the core network to different access technologies
- Global roaming and interworking between different access technologies; both horizontal (intrasystem) and vertical (intersystem) handover
- Seamless service negotiation including mobility, security, and QoS

This special issue looks at different technologies, protocols, and network architectures that would be supported in 4G wireless networks. It also tries to give a balanced overview on research activities toward 4G networks from academia and industry perspectives as well as in different geographical parts of the world. Two articles from academia in Europe and Australia and four articles from industry located in North America, Japan, and Europe should be a good combination to summarize

these activities. The guest editors had to choose from numerous papers submitted in response to the call for papers. All papers were reviewed by experts in the field, and many good papers could not be included in this special issue due to space limitations. The guest editors would like to thank all authors and reviewers who made this special issue a unique edition of novel activities in this field.

In the first article, "Future Generation Wireless Networks," Magnus Frodigh, Stefan Parkvall, Christiaan Roobol, Per Johansson, and Peter Larsson from Ericsson Research, Sweden, provide a nice tutorial on 3G networks and what will be in 4G systems. The article discusses two major trends for future-generation wireless networks including seamless roaming between different air interfaces and continuous development of the current 3G standards. Wideband CDMA is considered as the example for the air interface evolution, and then ad hoc networking and multihop networks are discussed. In the second article, "IP-Based IMT Network Platform," Hideaki Yumiba, Kazuo Imai, and Masami Yabusaki from NTT DoCoMo, Japan, describe a network platform based on IP techniques for future-generation wireless networks. The article presents a vision for beyond IMT-2000 in terms of requirements for service and network capabilities. The general architecture of the IP-based IMT network platform (IP^2) is also introduced.

In the third article, "IP-Based Base Stations and Distributed Soft Handoff in All-IP Wireless Networks," Tao Zhang, Jyh-Cheng Chen, and Prathima Agrawal from Telecordia Technologies, Inc., discuss the challenges in realizing an all-IP network for the future wireless network, specifically soft handoff. Two major problems that need to be solved for supporting soft handoff are discussed: multiple streams of the same IP traffic that have to be distributed via multiple base stations to a mobile station; and pieces of data arriving at the mobile station at the same time from different base stations that need to be copies of the same data in order for the mobile station's radio system to correctly combine these different pieces into a single copy. The article presents a new approach to soft handoff in distributed all-IP wireless networks. The fourth article, "Network Architecture for Mobile Communications System beyond IMT-2000," by Toru Otsu, Ichiro Okajima, Narumi Umeda, and Yasushi Yamao of NTT DoCoMo, Japan, describes suitable network architecture for mobile communication systems beyond IMT-2000. The article gives a forecast of market trends in mobile communications in order to identify requirements of mobile communication systems beyond IMT-2000, and then considers the network architecture of those systems beyond IMT-2000 to satisfy those requirements.

The fifth article, "Mode Switching and QoS Issues in Software Radio," by Hamid Aghvami, T. H. Le, Nikolas Olaziregi, and Ian Groves of King's College London, United Kingdom, provides a comprehensive description of software radio technology, a key component in the development of future (4G) wireless communication systems. The article raises the issue of the failure to agree on a unique radio access mode worldwide for user terminals and a telecommunications infrastructure to support it. The article discusses the concept of software radio as a solution to this problem and is based on the work of the European Union Research Project TRUST. The last article, "Traffic Management and Providing QoS in Future Wireless IP Networks," by Jade Kim and Abbas Jamalipour of the University of Sydney, Australia, provides a detailed description of the QoS requirements in future-generation wireless networks and how traffic management techniques such as admission control can provide QoS in those systems. Measurement-based techniques for the application of 3G and beyond networks are discussed.

The guest editors of this special issue hope that the readers find it interesting and consider it a useful guide for research and development activities toward next-generation wireless networks and the new telecommunication era.

Biographies

ABBAS JAMALIPOUR [S '86, M '91, SM '00] (a.jamalipour@ieee.org) has been with the School of Electrical and Information Engineering at the University of Sydney, Australia, since 1998, where he is responsible for teaching and research in data communication networks and satellite systems. He received his Ph.D. in electrical engineering from Nagoya University, Japan, in 1996. He was an assistant professor at Nagoya University before moving to Sydney. His current areas of research include wireless broadband data communication and wireless ATM networks, wireless IP networks, mobile and satellite wireless communications, traffic modeling and congestion control, switching systems, and switch design. He is the author of the first technical book on LEO satellites, *Low Earth Orbital Satellites for Personal Communication Networks* (Artech House, 1998). He served as Registration Chair at GLOBECOM '98 held in Sydney. He is an organizing committee member of the joint IEEE NSW Communications and Signal Processing chapter. He is the recipient of a number of technology and paper awards and the author of many papers in IEEE and IEICE transactions and journals as well as in international conferences. He also serves as Secretary of the IEEE ComSoc Technical Committee on Satellite and Space Communications.

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