HIGH-PERFORMANCE 4G SYSTEMS

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A key element of the high-level vision for the future development of the next third-generation (3G) mobile/personal telecommunications system, known as International Mobile Telecommunications after 2000 (IMT-2000) is that there will be a steady and continuous evolution and enhancement of IMT-2000 capabilities by operators, separately deploying and upgrading their chosen 3G wireless applications over at least the next several years.

Terrestrial 3G systems are being enhanced; for instance, many will incorporate "all-IP" networks, while at the same time wireless access will offer increased capabilities up to 10 Mb/s. These are only initial enhancements with further enhancements envisaged beyond this, such as the support of service bit rates of up to 30 Mb/s under favorable circumstances.

While 2G was mainly designed for voice, and 2.5G for packet-switched data, 3G is needed to support multimedia applications in addition to all services of previous generations. The convergence of services and delivery platforms in the ongoing enhancement of 3G wireless will lead to more intelligent use of the communications media, where 3G will be able to offer users what they need in any specific mobile environment. The range of applicability of 3G wireless is very much wider than earlier mobile systems and is expected to include future enhancements, which will offer increasingly superior capabilities and performance in low-mobility environments.

Systems beyond 3G (or 4G mobile) will support a wide range of data rates according to economic and service demands in multiuser and multicell environments, with terminals moving at vehicular speeds, and support 50-100 Mb/s maximum. 4G mobile will support a wide range of symmetrical and asymmetrical services, and also provide quality of service (QoS) for real-time services and efficient transport of packet-oriented services, as well as efficient support of broadcast and distribution services.

Future mobile networks will mainly be characterized by a horizontal communication model, where different access technologies such as cellular mobile, broadband wireless access, wireless LANs, short-range connectivity, and wired systems will be combined on a common platform to complement each other in an optimum way for different service requirements and radio environments.

Some examples of possible key areas within which to identify technology trends are as follows.

System-Related Technologies: Voice over IP; software-defined radio; broadband wireless transceiver; system platform for mobile service; highly reliable network architecture; all-IP wireless; security, cryptography, billing, authentication, and mobile electronic commerce; mobile ad hoc network technologies.

Application-Related Technologies: Next-generation coding/compression technology; dynamic variable-rate codecs; mobile agent technology; man–machine interfaces including "intelligent" mobile terminals; streaming data communication technology; contents description language; application development environment technology.

Advanced Wireless Access: Dynamic QoS control; error control and extra-high-speed cell search; multicast; IP mobility control; seamless IP packet transmission; link adaptation; entrance link; radio on fiber.

Efficient Utilization of Frequencies: Exploitation of the microwave frequency band; common usage of frequency band and frequency sharing; adaptive dynamic channel assignment; technologies against interference and fading; high-density 3D cell structure, advanced adaptive array antenna, and multiple-input multiple-output (MIMO); technologies of adaptive high-efficiency multilevel modulation; orthogonal frequency-division multiplexing (OFDM).

Advanced Mobile Terminals: New power management technology; wearable terminal technology; highly functional display device technology; voice recognition technology; next-generation semiconductor device technology; enhancement of sensitivity; system platform for mobile terminals; security enhancement technology for mobile terminals.

All these issues are the emerging topics of future mobile communications, the converged system of broadband wireless access and wireless mobile.

As examples in this wireless series, we selected three articles to report the newest developments in the above-

mentioned all-IP mobility, space-time coding for broadband wireless transmission, and MIMO-OFDM-based 4G systems. We welcome more submissions on other key issues toward global interest in this emerging wireless technology. For submissions, please email to Willie W. Lu at wwlu@ieee.org.

The first article by F. Chiussi *et al.* discusses all-IP mobility management. In all-IP wireless networks, IP can be deployed in either transport or native mode. This IP duality has a significant impact on wireless network efficiency and performance.

The second article by N. Al-Dhahir *et al.* describes new technologies that support increase data rate in mobile/wireless LANs. It presents an overview of a component of signal processing that is related to space-time coding of a channel. In particular, it focuses on channel estimation, equalization, and interference cancellation. It also discusses the effect of physical layer space-time coding gains on higher layers.

Increasing demand for high-performance 4G systems calls for use of multiple antennas at both base station and subscriber wireless terminal. Multi-antenna technologies enable high capacities and better spectrum utilization, and dramatically increase range and reliability. In the third article, J. Tellado *et al.* describe a MIMO-OFDM test system that finally proves the superb performance of MIMO technology for beyond 3G wireless communications. Increased capacity, coverage, and reliability are well evident from the field test.

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BIOGRAPHIES

WILLIE W. LU [SM] (wwlu@ieee.org), is a senior principal wireless architect at Siemens-Infineon and a member of the Technological Advisory Council of the United States Federal Communications Commission (FCC). He is also an internationally recognized senior expert in emerging wireless technologies and has been a technical advisor for over 20 wireless communication authorities in more than 10 countries. He is an independent technical examiner for lots of high-tech venture capitals in the United States, Europe, Asia, and other places, and is listed in major Who's Whos in the world. He has guest edited around 25 special issues on emerging wireless communications in IEEE, IEICE, ACM, and other major publications, and has had over 130 papers published in major professional publications. He has been chair of numerous IEEE conferences including GLOBECOM, WCNC, VTC, and WWC, and is a Wireless Communications Editor of *IEEE Communications Magazine*, *IEEE Transactions on Wireless Communications* (former *JSAC Wireless*), and others. He is a frequent keynote and featured speaker at lots of global technical fora, and a well-known wireless pioneer in Silicon Valley. He is a member of IEEE, ACM, IEICE, CIC, and Sigma Xi, and an adjunct professor at many world-class universities in the world.

MOSHE ZUKERMAN (m.zukerman@ee.mu.oz.au) received his B.Sc. in industrial engineering and management and his M.Sc. in operation research from the Technion, Israel Institute of Technology, and a Ph.D. degree in electrical engineering from the University of California at Los Angeles (UCLA) in 1985. He was an independent consultant with IRI Corporation and a postdoctoral fellow at UCLA, 1985–1986. During 1986–1997 he served in Telstra Research Laboratories (TRL), first as a research engineer and between 1988–1997 as a project leader managing a team of researchers providing expert advice to Telstra on network design and traffic engineering, and on traffic aspects of evolving telecommunications standards. He was the recipient of the Telstra Research Laboratories Outstanding Achievement Award in 1990. In 1997 he joined the University of Melbourne where he is a professor responsible for promoting and expanding telecommunications research and teaches in the Electrical and Electronic Engineering Department. Since 1990 he has also taught and supervised graduate students at Monash University. He served on the editorial board of the *Australian Telecommunications Research Journal* 1991–1996. He also served as a Guest Editor of *IEEE JSAC* for two issues: Future Voice Technologies and Analysis, and Synthesis of MAC Protocols. Presently, he is serving on the editorial boards of *IEEE/ACM Transactions on Networking*, *International Journal of Communication Systems*, and *Computer Networks*, and as a Wireless Communications Series Editor for *IEEE Communications Magazine*. He submitted contributions to and represented Australia in several ITU-T/CCITT standards meetings. He has over 170 publications in scientific journals and conference proceedings, and has been awarded several national and international patents.