

INTERNETWORKING WIRELESS LAN AND CELLULAR NETWORKS

Cellular communication networks provide a wide range of mobility with added value services and features to their users compared to traditional fixed telephony systems when they are used as a means for voice communications and short message services. However, when they start to service data applications, particularly bandwidth demanding ones such as videoconferencing, high-resolution image, and large file transfer, they fail to compete with the wired Internet. Neither throughput nor the cost of a cellular mobile network would be comparable with those provided by the available alternative systems mainly emerged from IP networks where high-speed data communications is concerned. The new generation of cellular networks, the so-called third-generation (3G) mobile communications systems, could not make a significant change in increasing the bit rate either.

As a result, research toward beyond 3G (B3G) systems is now underway, and several proposals for their architecture and enhanced air interface have already been published. The wireless communications fundamental restrictions, including the Shannon information theorem, however, limit our expectations for the wireless channel being comparable to its wired counterpart. While the channel restricts the wireless network, there would be no restriction in involvement of mobile services using wireless and wired channels together in a heterogeneous configuration, and this has become the main topic of interest in B3G systems. This means that while research on improvement of the physical layer (e.g., channel coding) is still important for future high-speed data communications, more must be done at higher layers of the network protocol stack in order to harmonize and internetwork different systems of mobile and nonmobile or less mobile nature.

The Third Generation Partnership Projects (3GPP and 3GPP2) have already started to look at the future heterogeneous networks and their architecture for seamless interconnections and service mobility. The new architectures of tight and loose coupling were the result of a series of feasibility investigations for integration of the high-speed low-mobility wireless local area network (WLAN) with low-speed highly mobile cellular networks. Together with these architectures, the IP multimedia subsystem (IMS) has found its position within the 3GPP Release 6 as a standard for seamless handover in an integrated WLAN/cellular network. The conclusion is that while the wireless channel restrictions are hard or impossible to remove, the nature of service availability and service need would justify a multisystem environment where a single service could be offered at different speeds at different locations/times via separate systems. As long as this service seamlessly moves among the networks and the network change is transparent to a mobile user with acceptable quality of service (QoS) levels, we can achieve the goal of a ubiquitous high-speed mobile network. Such a network will be the core part of next-generation mobile networks or fourth-generation (4G) systems.

Toward such evolution, this Feature Topic issue presents four interesting research articles on internetworking between the WLAN and cellular networks. The first article, by Frank H. P. Fitzek, Michele Zorzi, and Petar Popovski, "A Symbiotic Perspective on Low-Cost Cellular and Multihop WLAN Internetworking Solutions," looks at multihopping, a concept for reducing cabling and installation costs for new access points. The article looks particularly at the medium access control (MAC)



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layer of the IEEE WLAN standard 802.11, which has less capability in multihop scenarios.

The second article, by Sofoklis A. Kyriazakos, George T. Karetsos, Evangelos Groustiotis, Felicità Di Giandomenico, and Ivan Mura, "A Hierarchical Radio Resource Management Framework for Integrating WLANs in Cellular Networking Environments," describes the radio resource management framework for an integrated WLAN/cellular system. A global management unit (GMU) is introduced in the article as the core component of hierarchical resource management. The proposed management

technique is shown to be useful in seamless internetworking of cellular and WLAN systems irrespective of their operators.

The third article, by Jun-Zhao Sun, Jukka Rieki, Marko Jurmu, and Jaakko Sauvola, "Adaptive Connectivity Management Middleware for Heterogeneous Wireless Networks" discusses the design and implementation of a channel-based architecture for context aware connectivity management in heterogeneous networks. The proposed connectivity management middleware (CCM) provides interfaces for applications to query network QoS and availability status, and adaptive resource management based on a policy mechanism.

The Feature Topic concludes with the article "Analysis of the Integration of IEEE 802.11e Capabilities in Battery Limited Mobile Devices" by Xavier Pérez-Costa, Daniel Camps-Mur, and Toshiyuki Sashihara. In this article the new IEEE 802.11e standard is considered as a basic element toward integration of WLAN and cellular due to its QoS support that can be used in applications such as voice over IP. Also, the power save mode of IEEE 802.11 is considered an important element in systems with battery-limited devices. The article thus analyzes possible implications of the interactions between the IEEE 802.11 power save mode and the IEEE 802.11e QoS mechanism.

As Guest Editor for this Feature Topic issue, I would like to thank the magazine's Editor-in-Chief, Michele Zorzi, for assisting in approval and space allocation for this issue. I would like also to thank the magazine's publications staff at IEEE and anonymous reviewers for their hard work to control and enhance the quality of papers submitted to this issue.

BIOGRAPHY

ABBAS JAMALIPOUR [S'86, M'91, SM '00] (a.jamalipour@ieee.org) is with the School of Electrical and Information Engineering at the University of Sydney, Australia, where he is responsible for teaching and research in wireless data communication networks, wireless IP networks, network security, and satellite systems. He holds a Ph.D. in electrical engineering from Nagoya University, Japan. He is the author of the first technical book on networking aspects of wireless IP, *The Wireless Mobile Internet — Architectures, Protocols and Services* (Wiley, 2003). In addition, he authored another book on satellite communication networks with Artech House in 1998 and coauthored three other technical books in wireless telecommunications. He has authored over 130 papers in major journals and international conferences, and given short courses and tutorials at major international conferences. He has served on several major conferences' technical program committees, and organized and chaired many symposia at international conferences. Currently he is chair of the Wireless Communications Symposium, IEEE GLOBECOM 2005, and a Co-Chair of symposia at IEEE ICC 2005, ICC 2006, and GLOBECOM 2006, as well as a Vice-Chair of IEEE WCNC 2006. He is a Fellow Member of IEAust; Chair of the Satellite and Space Communications Technical Committee; Vice Chair of the Asia Pacific Board, Coordinating Committee Chapter; and Vice Chair of the Communications Switching and Routing Technical Committee, IEEE Communications Society. He has organized several special issues on the topic of 3G and beyond systems as well as broadband wireless networks in IEEE magazines and journals. He is a technical editor of *IEEE Wireless Communications*, *IEEE Communications Magazine*, and *Wiley's International Journal of Communication Systems*.