MERGING IP AND WIRELESS NETWORKS

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This issue of *IEEE Wireless Communications* is about the topic of merging Internet Protocol (IP) and wireless networks. In the past few years, we have witnessed great demand for mobile communications services as well as tremendous improvements in wireless technology. While the first generation of mobile communications systems aimed mainly to provide voice service to their mobile users using circuit-switched networks, the most recent technology, called the third-generation wireless communications, or 3G, looks for more enhanced multimedia services built on packet switching and IP routing, where the voice communications would ultimately share only a small part in overall services.

During the period when mobile communications technology was evolving from its first generation to 3G, the Internet has also achieved great popularity; at the same time technology for high-speed access has improved dramatically. The protocols configuring the Internet stack have been modified so that higher-speed and more reliable data transmission could be achieved. Transport protocol, network protocol, and link layer protocol have been enhanced so that new applications and services could be deployed, which in turn has increased the popularity of the Internet.

After all those enhancements in Internet technology, the Internet has become part of people's lives, so they want to have it ready to use not only on their desktop computers but also in their mobile devices. Wireless local area networks (WLANs) have become a popular source of mobile networking, thanks to the development of IEEE 802.11 standard family and the use of unlicensed spectrum. The achievement of WLAN in providing high-speed Internet access was so impressive that it has been accepted as a co-player in provision of data services for indoor users of 3G systems, and thus is being integrated in some 3G networks. WLAN not only made it possible to bring more high-speed Internet access to palm devices, but also complemented the usual cellular services in hot spot traffic areas.

WLAN is a direct extension of the wired LAN, that is, the fundamental piece of the global Internet. IP remains the main network protocol for the WLAN and the Internet, so when the WLAN integrates with cellular 3G systems we will need to consider how the two technologies can work together. However, merging IP and wireless networks will not stay at this level.

IP had great success in designing the network architecture of the Internet. The hierarchy and scalability together with simplicity observed in IP were the keys to its success. IP, however, always had two restrictive elements: mobility and quality of service (QoS). Using the advantages of IP in cellular networks is thus on condition that these two shortcomings of the protocol can be resolved. Especially when cellular network providers have to commit a certain level of service to their users, including bandwidth, delay, and security, the best effort service of IP will not be acceptable at all.

So the main issues in merging IP and wireless cellular that have to be resolved are mobility and QoS. Mobile IP, among other solutions, was invented to ease the fixed IP address configuration that avoids IP moving into the mobile environment. While it has certain deficiencies, Mobile IP has been researched to resolve its problems. As a result, one of the main 3G systems, cdma2000, is using enhanced Mobile IP in its core network architecture.

The issue of QoS for IP networks has been researched for many years and there is still much work to be done. Integrated services (IntServ) and differentiated services (DiffServ) are the two main directions in providing QoS in the Internet. While each method has its own advantages and disadvantages, the Internet Engineering Task Force (IETF) is also looking at a hybrid scheme of IntServ over DiffServ to tackle the end-to-end QoS problem.

For realization of a merged wireless IP network, we need first to find out how the issues of service quality and mobility can be managed. In the meantime, we also need to find out how the architecture of such an integrated network can be designed, knowing that the Internet and cellular systems have been designed and implemented by people with completely different backgrounds in computers and communications, respectively, so their interworking will not be an easy task. Such integration, however, can be considered the first step toward next-generation networks, where heterogeneous networks are to work together in order to provide differentiated services to users in a seamless and transparent manner.

In order to elaborate state-of-the art research activities within industry and academia and provide a reference for future researchers in this field, we have put together this special issue through an open call for papers. Our call for papers, as expected, received an overwhelming response. A total of 29 papers from all around the world were submitted. These articles covered different topics of QoS, routing protocols, integration of IP and telephony networks, mobility management for IP and cellular networks, ad hoc networks and multihopping, radio access enhancement, and more. We could confirm that the topic is very important and is worked seriously in industry and academia all around the world. All articles went through peer reviews in order to ensure technical correctness, significance, and relevance to the special issue. We would like to thank all authors who responded to our call for papers, regardless of whether their article has been included in this issue or was rejected due to space limitations. In the latter case, we hope that their work will find the intended audience through another magazine, journal, or conference proceedings, and that the feedback provided by the peer reviews will help this happen sooner and more efficiently.

We would like also to express our sincere thanks to all the reviewers, who did an excellent job, not only justifying their recommendations to the editors, but also providing detailed and helpful suggestions to the authors on improving content and presentation. They bore on their shoulders the unexpected load of a high submission volume. It is their expertise and time that helped this issue happen. The peer review has led our special issue to comprise eight articles categorized into three separate but related groups of multihop network configuration, quality of service control, and mobility management techniques. We think these topics cover the bulk of research requirements in merg-

ing IP and wireless networks. While none of the articles discusses the framework and architecture of future heterogeneous networks specifically, they give conceptual understanding of such network architecture.

The first group of articles is related to multihop networks and includes three articles. The main concept behind multihop networks is that the coverage of wireless networks can be increased through implementation of intermedium nodes. Thus, each user node operates not only as a host but also as a router to forward packets received from other users. The idea is very similar to ad hoc networks. This technique could be considered an improved scheme for increasing cellular and WLAN geographical coverage without much of new infrastructure. The first article in this group, "The Nominal Capacity of Wireless Mesh Networks," by Jun and Sichitiu uses this concept in a mesh-configured network for broadband Internet access. The article tries to provide a formula to determine the nominal capacity of such a network. Upper bounds on throughput of a node in such configuration are calculated in this article too.

The second article in this group, "Cell Hopping: A Lightweight Architecture for Wireless Communications," by Hassan and Jha covers a similar concept but for cellular networks, namely cell hopping. The base stations in their network architecture are connected via wireless links. The article particularly looks at the location management and how to reduce the database periodic updates.

The last article in this group, "High-Performance Architectures for IP-Based Multihop 802.11 Networks," by Acharya, Misra, and Bansal tries to examine the wireless IP routers in multihop networks. In particular, the article proposes a wireless IP forwarding architecture that uses multi protocol label switching (MPLS) with modifications to the IEEE 802.11 medium access control (MAC) in order to improve the efficiency of packet forwarding.

The second group, consisting of three articles, emphasizes QoS in IP and cellular networks. The first article, "A Framework for Dynamic SLA-Based QoS Control for UMTS," by Chakravorty, D'Arienzo, Pratt, and Crowcroft proposes an extension to the IST Creation and Deployment of End-User Services in Premium IP Networks (CADENUS) framework for effective wired-wireless QoS translation, efficient QoS control and management, and dynamic SLA policy-based QoS provisioning. The authors describe how their dynamic SLA-based control can be used to achieve end-to-end QoS in the wired/wireless UMTS environment.

The second article in this group, "DiffServ Extensions for QoS Provisioning in IP Mobility Environments," by Moon and Aghvami looks at the issues related to the utilization of DiffServ in mobile radio access networks. The authors propose a mobility-aware drop precedence scheme for flows experiencing handover events. The last article, "Analysis of the Evolution to an IP-Based UMTS Terrestrial Radio Access Network," by Venken, Vinagre, and Vriendt addresses the introduction of IP transport in UTRAN. The article overviews the definitions of an efficient protocol stack, provisioning of QoS, and strategies for IP-ATM interworking. Application of pseudo-wires is also described to allow interworking with dual-stack nodes over an IP-only backbone.

The last group covers the mobility management topic and consists of two articles. The first article, "Mobility Support in Wireless Internet," by Banerjee, Wu, Das, Dawkins, and Pathak addresses the mobility management protocols utilized at different layers of the network protocol stack. In particular, they have specified that although the mobility can be managed at any of the link, network, transport, or application layers, the application-layer mobility management is superior in terms of delay and signaling overheads for next-generation heterogeneous networks. The article also provides a comprehensive review on available mobility management techniques.

In the second article, "A Multilayered Mobility Management Scheme for Auto-Configured Wireless IP Networks," Wong, Dutta, Burns, Jain, Young, and Henning, after considering shortcomings of the Mobile IP in dynamic auto-configured networks and advantageous of Mobile IP with location registers (MIP-LR) and the Session Initiation Protocol (SIP) in recovering those shortcomings, present a multilayered mobility management scheme for auto-configured wireless IP networks. The proposed scheme together with an enhanced form of cellular IP has been noted as a solution to macro- and micromobility in ad hoc and other auto-configured wireless networks.

As the Guest Editors of this special issue, we hope that the readers find it interesting and consider it a useful guide in R&D activities toward merging IP and cellular wireless networks and the realization of the wireless IP. We would like to thank all authors and reviewers who made this special issue a unique edition of novel activities in this important field.

BIOGRAPHIES

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 for the first technical book on networking aspects of wireless IP, *The Wireless Mobile Internet — Architectures, Protocols and Services* (Wiley, 2003). In addition, he has authored another book on satellite communication networks with Artech House in 1998 and co-authored two other technical books on wireless telecommunications. He has authored over 100 papers in major journals and international conferences, and given short courses and tutorials in major international conferences. He has served on several major conferences technical program committees, and organized and chaired many technical sessions and panels at international conferences including several symposiums at IEEE GLOBECOM, ICC, WCNC, and VTC. He is currently Vice Chair of the Satellite and Space Communications Technical Committee, Vice Chair of the Asia Pacific Board, Coordinating Committee Chapter, and the Secretary to the Communications Switching and Routing Technical Committee and 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 to *IEEE Wireless Communications*, *IEEE Communications Magazine*, and *International Journal of Communication Systems*.

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