GUEST EDITORIAL

European R&D on Fourth-Generation Mobile and Wireless IP Networks

The increase in digital wireless and mobile communications as well as Internet users in the last few years has been tremendous. Although there is some short-term market uncertainty related to third-generation (3G) mobile systems and the telecommunications sector overall, there is no doubt that good research and development work continues to produce new breakthroughs. Wireless communications and Internet technologies are indeed very exciting research areas with enormous business opportunities.

This special issue of *IEEE Personal Communications* is devoted to the presentation of some wireless communications research activities underway in Europe. European operators have deployed General Packet Radio System (GPRS) (2.5G) mobile systems and are moving toward deployment of 3G systems. The auctions for 3G spectrum have generated high revenues, a lot of publicity, and some controversy. However, the first step for 3G system deployment, securing spectrum, has been completed.

Researchers, on the other hand, have started to talk about fourth-generation (4G) systems. It is clear that people are using the term 4G with different meanings. We feel, however, that the period of mobile market turbulence and a not yet fully defined 4G R&D agenda is an excellent time to produce a special issue on how European researchers are defining the wireless communications agenda for the coming years.

One repeated theme seems to be the vision that 4G is not really a new air interface, but more important is about heterogeneous wireless networking with a hierarchical overlay of networks of potentially different technologies. There is also a clear trend toward using Internet Protocol (IP) technology in the core network and providing better end-to-end IP services. The business model and application domain work still need a lot of extra analysis in order to understand economical boundary conditions and requirements for 4G. However, it is also clear that new air interfaces and wireless radio solutions will be required and developed both for cellular and WLAN use. The present vision is for 1 Gb/s indoor bursts and 100 Mb/s outdoor connectivity as the next steps.

A new international initiative that originated in Europe, developing a research agenda for the future of wireless communications, is the Wireless World Research Forum (WWRF, http://www.wireless-world-research.org). WWRF publishes the "Visions of the Wireless World." The *Book of Visions* was published in 2000 and is available on the above-mentioned Web site, while the 2001 version is currently in final draft form.

Overall, it is clear that there is a lot of interesting and high-quality work going on toward 4G systems. In fact, the visions between European researchers and their colleagues throughout the world, in particular in the U.S.A. and Asia, seem to be quite consistent and similar. Fourth-generation technologies and wireless Internet systems require an increasing amount of interdisciplinary systems-level R&D in order to provide better systems with the appropriate optimizations to exploit the scarce wireless resources, while remaining true to the Internet model and compatible with today's and tomorrow's Internet.

The articles included in this special issue give a good overview of many different R&D aspects that must be accounted for in the forthcoming systems. We were particularly happy to include articles describing hardware projects and financial aspects, as these are also critical ingredients for overall system success.

The first article by Theo Kanter describes the adaptive personal mobile communication paradigm in 3G and beyond. The article gives a critical overview of the situation with 2.5G/3G and describes how to deal with heterogeneous 4G networking scenarios. It also presents results from an urban wireless testbed consisting of WLAN extensions to a Gigabit Ethernet network in Stockholm.

The article by Prasad *et al.* reviews quality of service (QoS) mechanisms for IP-based heterogeneous networks that are becoming more important, for example, for various wireless streaming applications in 4G. Gessler *et al.* then present an interesting overview of various 4G scenarios. The authors also outline some specific research challenges for 4G wireless infrastructures.

The next article, by Mähönen *et al.*, deals with platform-independent IP transmission over different wireless networks. The authors present a 4G scenario where heterogeneous wireless networks provide seamless IP services, and link-layer dissimilarities are effectively handled by a wireless adaptation module.

Kellerer *et al.* discuss services and system architecture issues for future wireless communication in the vehicular environment. They consider the problem of wireless network heterogeneity and propose a communication gateway architecture as an essential building block for future automobile systems.

The article by Grass *et al.* is different from the other articles. It describes a hardware and software project to build a low-cost low-power IEEE 802.11a and HiperLAN/2 compatible system on a chip for the 5 GHz band. The multimode low-cost chips and advances in microelectronics will be driving the 4G wireless communications to become even more ubiquitous in the future.

Finally, Katsianis *et al.* provide "the financial perspective of the mobile networks in Europe." This article presents the techno-economic perspective of 3G technologies, aiming to provide guidelines for strategies toward broadband mobile services. The analysis was carried out in 2000 and was based on 3G rollout scenarios in two "typical" European countries with contrasting profiles. With the hindsight of the 3G spectrum license auctions and today's uncertainties in the telecommunications sector, interdisci-

plinary work and collaboration between business experts and technology experts seems important to make the visions stronger and realizable.

We received a large number of excellent contributions for this issue from which, after peer review, these articles were selected. Because of space constraints, we were unable to include all the good papers submitted. The high-quality work of the authors and reviewers has made our job challenging, but also enjoyable. We thank all the authors who submitted excellent manuscripts and the reviewers for their outstanding work.

Biographies

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