he first generation (1G) of mobile systems pioneered commercial mobile voice services, allowing communication on the move for the first time. Initially, the quality was poor, service was expensive, and penetration was low. The quality improved somewhat, and service became more affordable. Penetration increased significantly. However, the analog infrastructure limited the number of supported concurrent subscribers per cell to small numbers. The quality was still far from that offered by wireline telephony. Shortly, these limitations were eliminated by the advent of second generation (2G) of mobile systems. By using digital technology, 2G systems such as Global System for Mobile Communications (GSM), IS-95, and IS-136 increased the number of supported users within a cell (and the spectral efficiency) and enhanced voice quality significantly. The cost of service kept on lowering, and cellular telephony started replacing wireline telephony. While some data services were offered on analog systems, these services, albeit at low data rates, started proliferating with the digital technologies of 2G. In particular, short message service (SMS) has been very successful and profitable for almost a decade.

2G’s success story prompted development of the 2.5G and third-generation (3G) mobile systems. General packet radio service (GPRS), as a 2.5G service, has focused on higher-speed data services on GSM-type network infrastructure. Unlike 2G and 2.5G technologies, all 3G technologies are code-division multiple access (CDMA)-based. 3G-1x provides higher voice capacity, and 3G-1x-EV-DO provides high-speed data using one IS carrier. Universal Mobile Telecommunications System (UMTS) standards were developed to provide higher voice capacity and high-speed data using a wideband carrier (5 MHz). Higher data rates were designed to provide new innovative services, like mobile videophone, video streaming, and voice over IP. Up to 2 Mb/s data rates were promised by UMTS and further enhancements in 3G Partnership Project (3GPP) standards. Moreover, wider coverage was promised by implementing hierarchical layers of macro, micro, and pico cells, each using different carriers with a penalty of more expensive base stations (the so-called Node B) in small coverage areas. Techniques such as cell sectorization and multiple input multiple output (MIMO) would be employed in 3G to maximize capacity. While 3G-1x has done quite well, higher-speed data penetration and migration to IP-based infrastructure has been disappointing. Voice is still carried over the 2G circuit-switched infrastructure (not the promised IP), and the majority of deployed systems have a maximum speed of 384 kb/s downstream (and only 64 kb/s upstream); thus, the highly advertised streaming video becomes a glorified slide show. For operators with heavy auction costs of 3G (UMTS targeted) spectrum, the lack of inexpensive high-data-rate services has been painful.

Hoping for a better future, the cellular mobile service industry is already looking ahead to the beyond 3G (B3G) and fourth-generation (4G) era. According to the Fourth Generation Mobile Forum, companies will have invested more than $400 billion in 4G by the end of 2008 [1]. Of course, skeptical operators and unsatisfied users would require truly breakthrough technologies and inexpensive but profitable services to buy into 4G. Innovations in air interface technology, data rates of 100 Mb/s or more, end-to-end quality of service (QoS), worldwide seamless mobility of terminals, and wireless personal bubbles are some of the 4G features originally scheduled for 2010, which are now rescheduled for as early as 2006.

In parallel, wireless LAN (WLAN) systems, including IEEE 802.11 a/b/g and HIPERLAN/2, have been deployed independent of cellular systems, targeting much higher data rates, smaller distances, and different traffic parameters and service types. They provide increased capacity (up to 54 Mb/s in standard or even 108 Mb/s in proprietary mode) with a coverage radius of 30 m indoor/150 m outdoors. The main advantages of WLANs are mature technology and very low deployment cost in small areas. Although a significantly larger number of WLAN access points (APs) must be utilized in order to cover the area of a 3G Node B, the cost may be reasonable and the aggregate data rate may be higher. Moreover, WLANs avoid expensive frequency band auctioning, as they operate in unlicensed industrial, scientific, and medical (ISM) spectrum. However, WLANs have their own shortcomings. One issue is uncoordinated interference in the unlicensed spectrum and resulting reduction in the range of radio access and perceived QoS. Thus, mobile broadband wireless access (MBWA) systems (IEEE 802.20) have selected to operate in licensed bands below 3.5 GHz. Another issue is that the small radio coverage of WLANs prohibits the wide coverage benefits of 3G. The ideal deployment scenario for WLANs turns out to be isolated areas with heavy user demand (hotspots, e.g., airports, city centers, conference sites, cafés, hotels, and university campuses). For such applications over limited distances, WLANs are more cost effective than 3G.

Given that there is no single system that is good enough to replace all existing technologies, and the large investments in the deployed wired (PSTN, ISDN, IN) and wireless (2G, 2.5G, 3G, WLAN, DVB) network infrastructure, 4G systems will have to integrate, complement, and unify rather than compete with existing access infrastructures [2].

Besides system and network infrastructure advances, innovative steps are also required in the applications and services domain so that new services and applications can be created and brought to users quickly and reliably. Evolution toward 4G is expected to be similar to what happened to the Internet: from a limited application environment to an integral part of the average person’s business and personal life. As happened in the wireline arena, wireless services will shift from voice only to increasing use of packet data. With higher data rates, decreasing costs, and added security, users will become as addicted to wireless business and financial transactions as they are to cell phones. In addition, mobile Internet, mobile multiparty videoconference, music, e-books/magazines/newspapers, mobile office, mobile VPNs, mobile e-commerce, and so on are among the foreseen future applications 4G is predicted to bring to users. However, none has yet been perceived to be the “killer” application...
that will create explosive penetration of 4G.

According to [3], cellular games will be the most preferred service, with global revenues growing from $104.8 million in 2002 to $7.76 billion in 2007. Many companies talk of mobile tele-presence, remote-controlled cars, and mobile virtual reality. Given experience with 3G data, there are good reasons to be skeptical. On the other hand, the experience with the Internet suggests that a confluence of technologies, an open application development environment, and enthusiastic application developers may collectively bring in the era of ubiquitous penetration of wireless data and multimedia. These may be good reasons for not losing our enthusiasm and inspiration.

Having this enthusiasm, we initiated this special issue aiming to have experts share with the IEEE Wireless Communications audience a vision of the new B3G/4G era by capturing current and future trends in infrastructure technologies designed to facilitate new applications; service creation, execution, and provisioning environments, frameworks, and platforms; the trends toward new value-added applications enabling new business models and new ways of working anywhere, anytime, and in any context. The focus is clearly on services and applications over B3G/4G networks.

This special issue starts with an article entitled “A New Model for Service and Application Convergence in B3G/4G Networks” by M. Muñoz and Carlos García Rubio. The authors propose a model for service and application integration in 4G networks. Taking into account heterogeneous wireless (personal area, WLAN, cellular) networks, the proposed model generalizes the different service and application creation environments to provide a uniform and interoperable framework. The model is based on a hierarchical architecture that provides compatibility for services in different technologies, while capturing the specific details for each particular technology.

Service integration over heterogeneous networking infrastructure is also the subject of the second article, “Services in Interworking 3G and WLAN Environments” by D. Axiotis, et al. Interworking of 3G and WLAN networks will be a major step toward 4G wireless networks, where many radio technologies may coexist. Assuming the availability of various multimode terminal types, the article proposes architectures that enable ubiquitous wireless communications at high data rates and a variety of services with variable bandwidth and QoS requirements, across a wide range of propagation environments and mobility conditions. The article also describes future services in this interworking environment and market forecasts on terminal and service demand growth.

Serviceability and QoS provisioning in future wireless networks is also the goal of the next article, “Novel Velocity and Call Duration Support for QoS Provisioning in Mobile Wireless Networks” by M. Mahfuzul Islam and Manzur Mursheed. The article presents a mobility-based resource reservation and call admission control scheme that exploits three key mobility parameters of mobile terminals: position, direction, and speed. These mobility parameters along with the duration of a call are calculated to estimate the so-called cell visiting probability and identify a cluster of cells that the terminal is most likely to visit. In the proposed scheme each cell in the cluster proactively reserves resources for an estimated time interval, which is adapted depending on the aggregated cell visiting probability of all active units visiting a particular cell. Via simulations, the authors evaluate the scheme and compare it to existing predictive mobility support schemes in terms of three QoS parameters: call blocking rate, call dropping rate, and channel utilization.

Resource management and QoS provisioning in B3G environments is the topic of the next article, “Issues in Introducing Resource Brokerage Functionality in B3G Composite Radio Environments” by P. Demestichas et al. The B3G capability requirements may also include a resource brokerage system, which will enable cooperation among network providers in handling new B3G service area conditions. The article presents a business case that justifies the need for resource brokerage functionality and proposes the integration of a brokerage system into management systems for composite radio environments (MSCRE). Moreover, it identifies the problems that need to be addressed, and discusses approaches for the decomposition of the overall process into smaller problems and tasks (selection of QoS levels, demand volume, prices, etc.).

The increasing migration to next-generation networks (NGNs), however, will result not only from interoperability between different wireless technologies, but from the convergence of the fixed and mobile telecommunications, Internet, and entertainment sectors. Under this rapidly changing telecommunications environment, the value chain model may serve as a proper analytical tool of industry process. The next article, “Fixed and Mobile Service Convergence and Reconfiguration of Telecommunications Value Chains” by Dong-Hoon Yang et al., attempts to provide a better understanding of this convergence by investigating changes in the value chains. Specifically, this article develops a fixed-mobile convergence value chain, and highlights the importance of content and application providers in the new value chain. Some examples of fixed and mobile service convergence in Korea, one of the fastest growing telecommunications markets worldwide, are used to confirm the progress and reconfiguration of the chains.

Technologies to facilitate service creation and delivery over fixed and wireless NGNs are the topics of the last two articles. “A Self-Adaptive Service Provisioning Framework for 3G+/4G Mobile Applications” by S. Karlich et al. proposes an adaptive service provisioning middleware platform that allows seamless adaptive provisioning of multimedia information, entertainment, and communication services to mobile users into the forthcoming highly heterogeneous NGN environment. The proposed middleware is intended to “liberate” applications from space and time limitations, networks, platforms and device dependencies, minimize time-to-market constraints, and eliminate major hurdles that hinder rapid deployment of new mobile services and applications. Key is interworking/integration with current service delivery platforms, such as IN/CAMEL, OSA/Parlay, and the emerging IMS.

Finally, “Software Testing for Wireless Mobile Computing” by Ichiro Sato presents a new approach to test applications for mobile terminals while they are under development. As 4G networks will incorporate different wireless technologies, software running on the mobile terminal may require not only its application logic, but also ambient network information. This may increase exponentially the difficulty of 4G application development and testing. Like existing software platforms, the proposed toolbox supports software-based emulators of mobile 4G terminals. However, it differentiates as it constructs emulators as mobile agents. The mobile agents/emulators can travel between computers connected to the networks to which a mobile terminal is also connected, carry the target software, and allow it to access services provided in the same way as if it was moved with and executed on the actual terminal. The article presents the idea, its implementation, and the author’s experience with a typical application.

Before we leave you to enjoy this special issue, we would like to thank all authors for their highly valuable contributions and also all reviewers, who dedicated their precious time in providing numerous comments, suggestions, and corrections. Last but not least, we would also like to acknowledge the enlightening support of Editor-in-Chief Michele Zorzi. Having the supportive of all of them, we believe that most of our expectations have been fulfilled, and we hope that this special issue offers a considerable contribution in the area of B3G/4G telecommunications systems.

REFERENCES


BIographies

Theodore B. Zahariadis [M] (zahariad@surfer.amc.bell-labs.com) received his Ph.D. degree in electrical and computer engineering from the National Technical University of Athens, Greece, and his Dipl.-Ing. Degree in computer engineering and information science from the University of Patras, Greece. Currently, he is the technical director of Ellemedia Technologies, where he leads R&D of end-to-end interactive multimedia services, embedded systems, and 3G/4G core network services. Since 1994 he has participated in many European co-funded projects. His research interests are in the fields of broadband wireline/wireless/mobile communications, interactive service deployment, management of IP/WDM networks, and embedded systems. He has published more than 30 papers. He has been a reviewer and principal guest editor in many journals and magazines. He is a member of the ACM and the Technical Chamber of Greece.

Bharat Doshi [F] is director of transformational communication at Johns Hopkins University Applied Physics Laboratory. Until September 2003 he was a senior director in the Advanced Communication Technologies Center of Bell Laboratories, Lucent Technologies. He was named a Fellow of Bell Laboratories in 1996 and Distinguished Alumnus of Indian Institute of Technology, Bombay in 2000. He received his B.Tech. from the Indian Institute of Technology, Bombay, in 1970, and an M.S. and a Ph.D. from Cornell University in 1973 and 1974, respectively. He manages and contributes to forward-looking work in the areas of communication protocols, traffic and resource management, network architecture, performance/reliability engineering, network routing, network and service restoration, network security, and performance/reliability engineering for advanced networking technologies. Current work is concentrated on IP-based secure global networking with terrestrial wireless, wireline, and satellite-based network segments. In recent times, he has worked on frame relay, ATM, SONET/SDH, optical networks, 2G, 2.5G, 3G, and 4G wireless networks, and Internet/intranet applications over wireline and mobile access networks. He has been assistant editor of three journals and guest edited many issues of IEEE magazines. He has over 110 publications in a wide variety of technical journals and over 50 patent applications. He has been on the Industrial Advisory Boards of two universities and two government agencies.