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Guest editorial

Wireless IP through integration of wireless LAN and cellular networks

Wireless Internet technology will be the next milestone for modern telecommunications technology. In order to provide Internet connectivity over a wide geographical area, it is necessary to utilize the advanced features of modern cellular systems—known as third generation wireless cellular (3G)—such as Universal Mobile Telecommunication System (UMTS) and cdma2000 and their future evolutions. One obstacle is the current technological shortcomings of cellular systems that limit the data rate and quality of service (QoS) provisioning, particularly for real-time multimedia applications. One interim way to bypass this limitation is to use wireless local area networks (W-LAN) in cooperation with cellular networks. W-LAN is a very cost-effective alternative to cellular access networks in hot spot areas, such as business centers, supermarkets and airports, as the equipment cost is relatively low and they operate in the unlicensed industrial, scientific and medical (ISM) band. Data rates provided by the W-LAN standards, such as IEEE 802.11 and HiperLAN2 are far above the targeted 144 kbps of GPRS and 384 kbps–2 Mbps of the UMTS cellular systems, making the W-LAN an important and attractive, yet easy to implement add-on service to the usual 3G cellular systems. As a result, most cellular system providers have now considered the integration of the W-LAN with their wide area cellular network in order to cope with the ever-increasing demand from high-speed data applications at least in hot spot and indoor environments. At the same time, such integration will ultimately reduce the cost and provide service affordability to mobile data users. This initiative is becoming so attractive that many people believe that it will ultimately result in fourth generation mobile networks (4G) where heterogeneous networks are cooperating to achieve ultimate mobility together with QoS through a common core network.

Inter-networking of the W-LAN (as an extension of the wired LAN) with the mobile cellular technology, however, will not be a straightforward task. As a first step, an architecture that can provide adaptation of different elements implemented in the two systems must be designed. The European Telecommunications Standards Institute (ETSI) has already specified two generic approaches toward the integration of the W-LAN and GPRS/UMTS systems, known as loose coupling and tight coupling. Although the two approaches are promising, there is no final decision on whether the future integrated network would use either of those approaches or a completely different one. The first step will be followed by many other steps such as mobility management, data security, user authentication and authorization, traffic and congestion control, quality of service guarantee, real-time and constant/variable bit-rate support for voice and video. Without all these steps, a seamless inter-networking between the two systems would not be feasible.

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This special issue of the Computer Networks is devoted to the research activities within industry and academia leading toward the integration of the W-LAN and cellular 3G systems. Articles for this special issue have been solicited through an open call-for-papers and invitation to experts in the field from industry and academia. The special issue has tried to accommodate in-depth research and tutorial papers discussing different aspect of the W-LAN, cellular systems for Internet connectivity, integration of the two systems, and performance analysis. The response to our open call-for-papers was so overwhelming that we could not include all good papers submitted to the special issue. As a result, we included only the best ranked papers after a strict peer review process. This shows the importance of the topic among the research community all around the world.

As the Guest Editor, I would like to thank all the authors who responded to the call-for-papers, regardless of whether their paper has been included in this issue or had to be rejected due to space limitations. I would also like to express my sincere thanks to all the reviewers who did an excellent job. The result of all these efforts is the following nine papers that passed the requirements. I would like also to thank Harry Rudin, our Editor-in-Chief who provided me with a space in the Journal.

The first paper, "802.11-Based Wireless-LAN and UMTS Interworking: Requirements, Proposed Solutions and Open Issues" by Giuseppe Ruggeri, Antonio Iera and Sergio Polito provides a thorough review of the topic of integration of W-LAN (focusing on the IEEE 802.11 standards) and UMTS cellular systems. This paper explains why such integration is necessary and overviews alternative architectures and methods for the integration. The paper also highlights open research topics in the field as well as authorization, authentication, accounting (AAA) and QoS considered in the integrated system. Interworking between W-LAN and UMTS is discussed over different layers of the network protocol stack. Several scenarios for the integrated network are also discussed in the paper. The paper was considered as a good tutorial start to the special issue.

The second paper, "An Adaptive QoS Framework for Integrated Cellular and WLAN Networks" by Xin Gang Wang, Geyong Min, John E. Mellor, Khalid Al-Begain, and Lin Guan looks at end-to-end QoS establishment in an integrated W-LAN and cellular environment where the two systems have necessarily different characteristics of bit rate, delay, and so on. A generic reservation-based QoS model for the integrated cellular and WLAN networks is thus proposed in the paper. After providing analysis and a simulation model, and illustrating some numerical results, the authors show that the new scheme can considerably improve the system resource utilization and reduce the call blocking probability and handoff dropping probability of the integrated networks while maintaining acceptable QoS to the end users. A review of QoS in the two networks is also provided with new discussions on how those QoS metrics could be mapped for the integrated system.

In the third paper, "Analysis of Handoff in a Location-Aware Vertical Multi-Access Network", Mika Ylianttila, Juha Mäkelä, and Kaveh Pahlavan look at another important issue—the mobility management requirements in the integrated system. The paper provides an architecture for seamless location-aware integration of W-LAN hot-spots into cellular networks and also an analysis for the optimal handoff decision in moving-in and moving-out of a hot-spot. A location-aware architecture is proposed to support vertical roaming among heterogeneous wireless access networks. This paper also includes a description of a preliminary system architecture and procedures and algorithms needed to implement mobility and location management. In conclusion, a comparison is given for power and dwell-timer-based handoff algorithms in moving-in and moving-out transitions, and their sensitivity to mobile velocity and handoff delay.

The fourth paper, "Mobility and Quality of Service across Heterogeneous Wireless Networks" by Andrea Calvagna, Aurelio La Corte, Sabrina Sicari reconsiders the topic of mobility and QoS in heterogeneous networks. A QoS framework which extends the existing QoS standards from IETF, ETSI, I-TUT is proposed to focus on the new scenario of integrated heterogeneous systems.

The proposed framework easily allows metering and comparing the level of support for seamless mobility that a wireless IP access environment, possibly heterogeneous, is actually providing. A case study is also discussed which consists of an example of proposed the framework to enable wireless/mobile IP users to experience service continuity while moving in heterogeneous wireless access environments.

The fifth paper, "Improving TCP Performance in Integrated Wireless Communications Networks" by Kai Xu, Ye Tian, and Nirwan Ansari looks at the important topic of performance for the commonly used transport layer, TCP, not just for wireless channels but for heterogeneous networks. The paper first provides a thorough performance overview for four TCP techniques, namely TCP New Reno, TCP SACK, TCP Veno, and TCP Eastwood, under different link conditions. Later, a new form of protocol called TCP Newjersey is proposed. The proposed protocol is claimed to be capable of distinguishing packet losses from wireless error and network congestion, thus improving TCP performance in integrated networks.

In the sixth paper, "Providing Quality of Service Guarantees in Wireless LANs Compliant to 802.11e", Thanasis Korakis and Leandros Tassiulas consider a technical contribution to the standardization activities for QoS W-LAN, underway in the IEEE 802.11e group. The authors propose a scheduling scheme for QoS provisioning that exploits and is fully compliant with the specifications of 802.11e. The scheduler operates at the access point and relies on the measurement and control parameters available in the fields of the 802.11e header to determine access during the evolution of PCF called HCF. The proposed scheme takes channel conditions into consideration in making these decisions. They show significant performance improvement of the proposed scheme compared to earlier schemes that do not take channel conditions into consideration in making scheduling decisions.

The seventh paper, "An MPLS-based Architecture for Scalable QoS and Traffic Engineering in Converged Multiservice Mobile IP Networks" by Francesco Palmieri considers the Multi-Protocol Label Switching (MPLS) technology as a versatile solution to address QoS. It is a technology that can deliver a unified control mechanism with connectionless multi-protocol capabilities, running over mixed media infrastructures, and defining evolutionary signaling mechanisms to support both QoS and traffic engineering and to allow fine control of traffic flows in the network. The purpose of this paper is to show how MPLS technology can be employed to address all the required functions of tomorrow's converged wireless/wired networks, from initial IP-level authentication and session control to sophisticated resource reservation, traffic distribution, quality of service, and policy management.

In the eighth paper, "Load Mitigation in Cellular Data Networks by Peer Data Sharing over WLAN Channels," Kang-Won Lee, Young-Bae Ko, and Thyaga Nandagopal propose a new architecture called cellular-based ad hoc peer data sharing that can reduce the load on cellular networks while improving the wireless data access latency. The ad hoc network included in the proposed architecture acts as a virtual cache enabling data sharing among mobile hosts. Simulation results showing performance improvement are also provided.

The special issue is concluded by the paper "On-demand Media Streaming to Hybrid Wired/Wireless Networks over Quasi-geostationary Satellite Systems" by Tarik Taleb, Nei Kato, and Yoshiaki Nemoto. This paper extends the topic of special issue to global satellite networks. The satellite systems are considered as the gateway of cellular and other communications systems such as W-LAN in order to achieve the ultimate in mobility. This paper focuses on delivery of video-on-demand services through quasi-stationary satellite systems and provides a good and practical example as to where future heterogeneous systems are heading. The paper was considered as a suitable closing to this special issue dealing with the integration of heterogeneous networks.

As the Guest Editor of this special issue, I hope the readers find it interesting and consider it a useful guide in research and development activities toward efficient integration of W-LAN and cellular systems and a milestone on the road to

4G heterogeneous systems. This is not the first special issue on this important topic and would not be the last one. The topic of efficient inter-networking will remain an important and strategic challenge for all researchers in the field of computer and telecommunications engineering for years to come.

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