Recent years have witnessed an increasing trend towards the convergence of networks, services, and applications. In contrast to a telecommunications landscape where different services are delivered through separate access technologies, each tailored to a specific application, network convergence aims at providing a unified network platform for the efficient coexistence of previously distinct media accessible through common interfaces on single devices. The convergence trend is further stressed by users’ increasing demand for ubiquitous access to any service anytime, anywhere and on any device. This, however, implies that one device should be able to connect with a multitude of specialized services, access technologies, and possibly different network operators as illustrated in Fig. 1.

As network convergence involves many different parties, its technical and economical success depends on the ability to agree on a common set of standard interfaces. Moreover, the convergence of different access technologies along with users’ increasing mobility and demand for connectivity at all times at high data rates raise the need for new monitoring, control and management approaches essential for providing converged services with quality-of-experience (QoE) assurance. At the same time, network convergence is expected to serve as an enabler for new business models for network operators and service providers, a means to reduce operations and management costs, and a platform for faster deployment of new multimedia applications. Convergence attracted even more interest with the advent of Cloud Computing in the recent few years where a converged view of infrastructure is emerging in which all resources whether computing, storage or networking are viewed as being part of shareable resource pools that can be controlled and managed using the same systems. The converged infrastructure is envisioned to encompass remote datacenters, dense small-cell wireless access integrated with optical backhauling where the traditional point-to-point backhauling may be partly replaced by multi-point technologies, and deployment of a Future Internet architecture. The realization of this vision however faces many technical challenges that need to be addressed in order to ensure failsafe network operations, to efficiently support user mobility, and to guarantee QoE.

This special issue has as its main purposes the presentation of recent developments in the area of network convergence, and providing a view of the field’s state-of-the-art today. It is composed of eleven papers selected from 50 submissions. The contributions span IP multimedia subsystems (IMS), media independent handover (MIH), fixed-mobile convergence, convergence of different wireless standards, vertical handover, quality-of-service (QoS) and QoE, and convergence in the network core.

QoE is the ultimate measure of user satisfaction. In the paper “QoE assurance in converged networks,” R. Stankiewicz and A. Jajszczyk discuss several quality measures, specifically QoS, Grade-of-Service (GoS), and Quality-of-Resilience (QoR), and their impact on QoE assurance in converged networking environments. The authors focus on convergence between fixed and wireless as well as convergence between heterogeneous wireless technologies, and elaborate on the requirements for any service, anywhere, anytime and on any device.

The IP multimedia subsystem (IMS), standardized by 3GPP, plays a key role in network convergence and provides a platform for converged voice, video, and data-applications over fixed and mobile networks based on IP. In the paper “TRIM: An architecture for transparent IMS-based mobility,” I. Vidal, A. de la Oliva, J. Garcia-Reinoso and I. Soto consider IP mobility in IMS networks and show how a new architecture called TRIM extends mobile terminals such that seamless IMS-based mobility can be provided transparently to end-user applications. TRIM support for mobility is evaluated on the basis of an IMS test-bed with 3G and WLAN access networks.

The transition towards new mobile communication standards is characterized by the co-existence of different wireless standards such as GSM and UMTS in addition to 3GPP LTE and IEEE 802.16 during the roll-out of 4G networks. This problem is addressed in the paper “Reinforcement learning for joint radio resource management in LTE-UMTS scenarios.” by N. Vucevic, J. Pérez-Romero, O. Salient, and R. Agusti. In particular, the authors consider the convergence of 3G and 4G networks using the example of co-existing UMTS and LTE technologies and present a dynamic joint radio resource management algorithm spanning both technologies. Based on a reinforcement learning technique, the algorithm determines the most appropriate Radio Access Technology for user sessions in a multi-service scenario under dynamic conditions. The low
complexity of the proposed algorithm makes it a likely candidate for implementation in real-time systems.

Co-existence and convergence of different mobile access technologies implies the need for seamless handover between these technologies commonly referred to as vertical handover. IEEE 802.21 provides a standard framework for vertical handover and defines the mechanisms of media independent handover. In the paper “Context-aware media independent information server for optimized seamless handover procedures.” P. Neves, J. Soares, S. Sargento, H. Pires, and F. Fontes consider vertical handover between IEEE 802.11 (WiFi), IEEE 802.16 (WiMax), 3GPP UMTS, HSPA, and LTE. Their proposal extends IEEE 802.21 media independent handover by introducing a context management server used to dynamically acquire and maintain information from the network and the mobile terminals such as the number of and requirements of currently running services, established radio bearers, user preferences, and others. The context information is then exploited to optimize the handover process, e.g., the handover duration.

On a similar topic, the paper “Autonomic personalized handover decisions for mobile services in heterogeneous wireless networks.” by J.-M. Kang, J. Strassner, S.-S. Seo, J.W.-K. Hong focuses on personalized and automated vertical handover decisions in heterogeneous mobile networks. In this proposal, the handover is not solely based on the signal strength but considers two additional metrics: the access-point-acceptance and access-point-satisfaction. The former is a vector of individual channel quality measures such as delay and power consumption, and the latter combines these individual measures based on the user’s needs. Accordingly, the access point which maximizes these metrics and thereby user satisfaction is selected. The proposal is evaluated through simulations and compared to other decision metrics.

While previous contributions consider the co-existence of different mobile communication standards, the paper “Vertical handovers among different wireless technologies in a UMTS radio access-based integrated architecture” by N. Vulic, S.M. Heemstra de Groot, I.G. Niemeggeers extends the problem to the co-existence of mobile access technologies and broadcast systems. In particular, the authors focus on the integration of UMTS, IEEE 802.11, IEEE 802.16, and DVB-H at the radio access level. The authors describe the necessary handover mechanisms and conduct performance evaluations for different vertical handover scenarios.

Heterogeneous wired/wireless networks rely on complex wired mesh backbones with gateway nodes connecting to the Internet. These gateway nodes act as converging points for heterogeneous network traffic heading to and from the Internet and can turn into bottlenecks once their resources are exhausted. In this context, the paper “Resource competition in a converged heterogeneous networking ecosystem.” by A. Jamalipour, F. Javadi, and K.S. Munasinghe asks the important question of how a system can maintain stability over a period of time in a resource diminishing environment, provided the resources are fairly allocated at the time of admission. To answer this question, the authors conduct an ecologically inspired analysis where the converged heterogeneous network is modeled as an ecosystem of diverse networks with limited resource constraints and competing communication sessions. Based on the result of their analysis and the key observation of competitive exclusion between sessions, the authors...
propose a novel admission control policy to allow fair co-existence among sessions.

In the paper “Evaluation of two integrated signaling schemes for the Ultra Flat Architecture using SIP, IEEE 802.21, and HIP/PMIP protocols.” Z. Faigl, L. Bokor, P.M. Neves, K. Daoud, and P. Herbelin discuss a new network architecture, called UFA (Ultra Flat Architecture), which distributes some of the core network (e.g., 3GPP) functions to the edge (close to the base stations) in order to better scale to the ever growing traffic demand. Specifically the paper extends UFA with support for non-SIP based applications for more flexibility in converged networks as well as legacy Internet applications including IMS compliant applications.

The heterogeneous landscape of wireless access technologies does not only imply the necessity of co-existence but also provides the possibility to integrate different access technologies using the same infrastructure. This not only relates to the radio access but also to the core network, which may be shared by different operators. In “On the role of infrastructure sharing for mobile network operators in emerging markets.” D.-E. Meddour, T. Rasheed, and Y. Gourhant discuss the different options of infrastructure sharing their implications and potential savings of operational expenditures (OPEX) as well as capital expenditures (CAPEX) under technical, practical and regulatory constraints.

The clustering and fixed allocation of the available spectrum over the years has resulted in an inefficient use of the scarce spectral resources. To alleviate this problem, dynamic spectrum management techniques such as cognitive radio have received a lot of attention recently. B. Ishibashi, N. Bouabdallah, and R. Boutaba in their paper “QoS Capacity of Virtual Wireless Networks”, introduce the concept of Virtual Wireless Networks (VWNs) created and operated without obtaining any dedicated spectrum resources of their own. VWNs exploit residual bandwidth left underutilized by licensed users. However, it is unclear whether VWNs can provide QoS guarantees since the residual resources can be reclaimed anytime by the primary users. The authors extend a classical wireless system with cognitive radio capabilities and use Markov chain-based analysis and simulations to demonstrate that VWNs are indeed capable of providing QoS and allowing for new services provided by virtual wireless operators.

In the last paper presented in this special issue “SWISH: Secure WiFi Sharing.”, D. Leroy, G. Detal, J. Cathalo, M. Manulis, F. Koeune, and O. Bonaventure present an efficient and fully deployed solution, SWISH, enabling secure WiFi sharing with visiting mobile users. The key motivation behind the development of SWISH is to enable mobile users to connect to the Internet via a nearby foreign network without jeopardizing the security of the visited network. There exist indeed many WiFi networks with unused resources, which visiting mobile users can use to connect to the Internet if the owners of these networks were not reluctant due to security concerns. Using cryptographic authentication of the involved parties (mobile user, her/home network and the visited WiFi network), the authors demonstrate how WiFi networks can be fully secured with minimal impact on their performance which is demonstrated by deploying and testing their solution in a production campus network.

In presenting these diverse research efforts on converging communication systems and services, we hope to provide some possible directions to future network convergence research and to excite future research explorations in this promising field. It is also our hope that the selected papers have shown to you, the readers, the breadth and depth of the challenges we face and the existence of many open research issues.

We express our gratitude to the Editor-in-Chief, Dr. Harry Rudin, for giving us the opportunity to put together this special issue, and for his continuous support throughout this project from establishing a successful call for papers to the time-consuming editorial work he put on each accepted paper. We also express our thanks to the many authors who responded to the call for papers. We are particularly grateful to the authors of the four invited papers for kindly agreeing to write papers: A. Jajszczyk, A. Jamalipour, D.-E. Meddour, J. W.-K. Hong and their co-authors. All the papers went through a rigorous review process and we are grateful to the many obliging reviewers whose timely efforts were essential for the selection of the papers. As much as we enjoyed working on this special issue, we hope you will enjoy reading it.

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