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Wireless and mobile networking (Foreword)

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This Special Issue consists of extended versions of selected papers from the 2nd Joint IFIP Wireless and Mobile Networking Conference (WMNC 2009), held on September 9−11, 2009, and hosted by Gdansk University of Technology, Poland. It was a successful attempt by IFIP WG 6.8 to merge three series of conferences: MWCN (Mobile and Wireless Communications Networks), PWC (Personal Wireless Communications), and WSAN (Wireless Sensor and Actors Networks) into a universal forum for discussion between researchers, practitioners, and industry representatives involved in the development of wireless, mobile, and sensor networks. And nowadays more than ever, there seems to be a lot to be involved in. While admiring spectacular achievements in wireless communications that have recently changed our lives in so many ways, we realize that the rapid evolution of wireless systems comes with a price tag—the pursuit of increasing functionality, reliability, availability, security, and service diversity implies design and standardization challenges that our research community is now facing. Among these challenges, distribution of multimedia contents over QoS unfriendly environments, coexistence of heterogeneous wireless technologies within unlicensed bands, exploration of underutilized wireless spectrum under the cognitive radio paradigm, self-organization, cross-layer protocol optimization, uncooperative behavior, making ad hoc and mesh networks deliver on their early promise, convergence of telecommunication and context-rich web services, and exploration of beyond GSM/UMTS concepts like 3GPP Long Term Evolution (LTE) are just a few. As novel wireless network architectures are invented and implemented, system operators and planners rethink their business models to attend to the growing expectations of their customers. Most of the above, and many other topics were reflected at WMNC 2009.

Of the total of 65 regular papers submitted by authors from 20 countries, less than half were accepted and included in a proceedings volume published by Springer [1]. All submissions were evaluated by the program committee members assisted by external reviewers—at least three per paper. After the conference, the steering committee carefully examined the presented papers, paying attention to the reviews and the quality of presentation. Eight papers were selected for this Special Issue, and their extended versions were next solicited from the authors conditional upon adequately addressing any critical remarks made by the reviewers. Below each of the papers is briefly introduced.

The rise of the Universal Mobile Telecommunications System (UMTS) to a fully-fledged cellular technology has prompted scientific research into its basic channel access schemes. Among them, Enhanced Uplink (EUL), introduced by 3GPP to govern the communications from multiple mobile stations to a base station, creates a number of design issues, a key one being how the base station is to allocate the transmission opportunity and power budget among the mobile stations it controls. In the paper *Uplink packet scheduling in cellular networks with relaying—a comparative study*, D.C. Dimitrova, J.L. van den Berg, and G. Heijenk address the potential benefits and costs of inserting a relay station in the uplink. Both wireless and fixed-line relay-to-base station connections are considered. As the authors point out, relaying uplink traffic in a cell given a constant number of active users affects the resulting performance in two opposite ways, increasing the data rates due to higher received signal power, and decreasing effective data rates due by imposing extra transmission overhead. Superimposed on these factors

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is the time-varying number of active users in the cell, which the authors take into account using Markovian modeling of user data flows. The paper focuses on the packet scheduling aspect of EUL design, namely how to divide the time and power budget among the mobile stations and the relay station so as to maximize the overall data rate and minimize the flow transfer delays. Several round-robin schedulers, some of them novel and some previously earlier published by the authors, are analyzed and compared on a packet and flow level. An expected conclusion is that relaying improves the network service perceived by remote users; a less expected one that only the flow-level analysis reveals is that improvement is also observed by those users who choose to communicate with the base station directly.

Wireless computer networking and QoS sensitive traffic such as video or voice calls have never got along, the problems with the lossy and interference prone transmission medium being aggravated by the randomness inherent in the popular IEEE 802.11-based wireless technologies. Yet users' demand, pressure from competing cellular phone systems as well as the growing segment of home and last-mile WLANs stimulate efforts aimed at streaming multimedia packet flows even across QoS unfriendly wireless environments. Most research in this direction has been based on extensive simulation experiments, often using advanced modeling techniques, whose results are universally accepted as a valid rendering of real-world performance. The paper *Performance analysis of multimedia transmissions in IEEE 802.11 b/g/n testbed environment* by Krzysztof Gierlowski, Aleksander Kostuch, Jozef Wozniak, and Krzysztof Nowicki takes a different approach, abandoning simulation in favor of a series of testbed experiments in which a Wi-Fi based WLAN carried real-time multimedia traffic, mainly unicast/multicast streamed video and unicast VoIP calls to mobile devices, generated by a variety of state-of-the-art codecs. The main questions addressed in the paper are: how well are various WiFi devices prepared for these types of traffic, and what subjective audio/video quality (as measured by the usual Quality of Perception/Excellence or Mean Opinion Score criteria) can be expected at the output? Among the many interesting and sometimes surprising results of note are differences between the carrying capability of multicast and unicast streams, and the poor performance of an IEEE 802.11n installation, which the authors attribute to the still immature firmware in the network adapter. Finally, client-observable WiFi network characteristics relevant to VoIP performance are listed and their weighting is proposed.

Taking the issue of accommodating multimedia traffic to multihop wireless topologies such as Mobile Ad Hoc Networks (MANETs) introduces new dimensions of complexity. In the paper *End-to-End Bandwidth Allocation Scheme for Voice Traffic Support over MANETs* by Ghalem Boudour, Zoubir Mammeri, and Cédric Teyssié, the point of departure is the observation that support of integrated voice/data service in a MANET requires that channel access protocol should achieve a high channel utilization and bounded channel access delay. As this seems an impossible task for contention-based access schemes, plagued by the inevitable bandwidth wastage due to RTS/CTS exchange and packet collisions, multimedia applications look for contention-free access schemes e.g., global time synchronization- and control message exchange-based slot assignment within a predefined timeframe. The authors note that such schemes are slow to catch on among the industrial and standard-making bodies, the underlying inter-node coordination and cooperation mechanisms still being costly and inefficient. Of the two related challenges, namely how to protect reserved slots from colliding traffic and how to provide for consistent network-wide slot allocation and breakage handling, the latter is considered the less recognized so far, and met with an original end-to-end resource reservation protocol. The proposed solution builds upon a MAC-layer point-to-point slot reservation scheme on top of IEEE 802.11e EDCA, as well as on the reactive Dynamic Source Routing protocol in the network layer, to achieve low end-to-end delay, and dropping rate for voice traffic, especially when the node mobility is not too high.

It is well-known that wireless spectrum is a scarce resource mainly because it is poorly utilized, most bands being statically allocated to particular operators or applications; in particular, coexistence of different wireless networks in the same band has only recently evolved into the concept of cognitive radio. Before this concept takes root and is converted into household reality, coexistence of different wireless technologies operating in the common unlicensed ISM band is a challenging issue. The paper entitled *A new role-switching mechanism optimizing the coexistence of Bluetooth and Wi-Fi networks* by T. Klajbor, J. Rak, and J. Wozniak addresses mutual interferences between IEEE 802.11b (Wi-Fi) and Bluetooth (BT) networks that can seriously degrade the performance unless coexistence mechanisms are applied. While much work has been devoted to such mechanisms, both collaborative (requiring information exchange between Bluetooth and IEEE 802.11b devices) and non-collaborative (e.g., Adaptive Frequency Hopping), there remain ways of facilitating the coexistence that can be explored entirely on the BT side. The authors observe that the asymmetric (master/slave) functionality of BT devices can be assigned arbitrarily using the BT role-switching mechanism, and propose an optimization whereby the role of a master node is assigned to BT devices located far from coexisting IEEE 802.11b networks and other BT piconets, hence causing, and exposed to, less interference. A suitable Interference Aware BLUEtooth Scatternet (RE)configuration Algorithm (IBLUEREA) is developed and an integer linear

programming solutions are presented that lead to a promising 50% reduction of the overall frame error rate especially if combined with existing coexistence mechanisms.

As the vision of a mobile terminal connected to multiple access networks and free to transport data over a network of choice is rapidly taking shape, handover mechanisms between heterogeneous wireless technologies have become the subject of serious research, standardization, and implementation efforts. The IEEE 802.21 standard specifies services that support handover decisions, while standards being prepared by 3GPP aim at seamless handover solutions for IP-based mobility. In general, the decision which available network a terminal is to access at a given moment is dictated by a large number of factors involved in the actual technologies used, and can be taken at either side of the terminal-network connection. The paper *Data Collection in Future Mobile Networks* by Marc Fouquet, Christian Hoene, Morten Schläger, and Georg Carle points out that decisions taken by a mobile terminal are more grounded in the current signal quality of the nearby base stations, whereas network-centric handover management is able to optimize the decisions based on a global view of the traffic load; in doing so, it can save the mobile terminal the precious energy spent on scanning for available access points. The authors let the mobile terminal follow its local preferences when selecting a network, at the same time envisage and design a Network Resource Management (N-RM) engine that resides in the core network and implements a number of algorithms to provide the terminals with handover recommendations. To protect backhaul (base station to core network) links from excessive load of the underlying management and control traffic, an earlier developed publisher-subscriber-type Generic Metering Infrastructure (GMI) is applied and tested extensively through simulation. The authors conclude that GMI permits to take good handover decisions with relatively little data collection and distribution overhead.

Ubiquitous computing, another vision fulfilling the dream of Internet access made possible any time and anywhere, has much more to it than user mobility; the ultimate goal is the uninterrupted provision of user-defined and user-customized services in a context-aware fashion, thereby improving the users' Quality of Experience (QoE). Examples of such services deployed today include location and presence, but systematic design of distributed context-aware service development platforms is still an active research field. A suitable environment supporting such services is the Internet Multimedia System (IMS), an overlay control subsystem over heterogeneous networks that permits to easily incorporate diverse wireless access technologies into a single architectural framework. In the paper titled *Contextualized User-Centric Multimedia Delivery System for Next Generation Networks*, Jose Simoes and Thomas Magedanz focus on the key functionality of triggering a reaction to the occurrence of a specific event or set of events. They build on their earlier work to introduce an enhanced version of Context-Aware Triggering System (CATS), a user-centric multimedia delivery service created over an IMS environment. A high-level overview of the used components and communicating protocols is given and relevant functionalities are described using a top-down approach, organized around the Service, Control and Connectivity Layers with an emphasis on the latter. The paper also outlines some crucial design decisions and envisages a number of real-world business scenarios of context-aware service provision.

Wireless sensor networks (WSNs) capable of monitoring the environment, especially for various threats or out-of-the-ordinary parameter values, are of keen interest to local governments and commercial operators alike. The next paper, *Resilient Data Gathering and Communication Algorithms for Emergency Scenarios* by Daniele Munaretto, Chunlei An, Joerg Widmer, and Andreas Timm-Giel, looks at WSNs in their native application field, namely emergency management and disaster recovery. Specifically, continuing the work within EU sponsored wearIT@work project in which some of the authors participated, the paper analyzes a scenario where a building on fire is being penetrated by a group of firefighters equipped with sensor dispensers to leave a virtual trace of their movements ("virtual rope"). The sensor network thus deployed has a chain-like topology and supports exchange of short voice messages with a command post located outside the building as well as collection and dissemination of relevant environmental data. For this most challenging environment, featuring the firefighters' irregular movements, node exposure to extreme temperatures and variable transmission range, the authors design a resilient adaptive communication scheme, which they next verify via simulation and experiments for X- and Y-shaped "virtual ropes". The vital components of the scheme are: an energy efficient broadcast-type routing protocol responsible for delivery of the voice messages, a sensory data collection scheme using network coding for increased reliability, and a buffer management scheme that permits to store a few generations of collected data and recover past data despite limited buffer sizes. They conclude that the message exchange and data collection functions can coexist without a significant performance degradation.

Although they draw heavily upon the generic design experience in wired and wireless computer networking, WSNs also pose unique challenges that for the past years have slowed down standardization processes and stimulated active research. Among the challenges, especially the traffic asymmetry (with one sink node absorbing data from all other sensor nodes) and extreme scarcity of battery power call for novel routing and data compression and suppression techniques. The paper *Power-aware agent-solution for information communication in WSN* by Ahmad Sardouk, Rana

Rahim-Amoud, Leïla Merghem-Boulahia and Dominique Gaïti addresses these topics by attempting at integrating DSR-type routing with information importance- and local cooperation-based data collection among neighboring sensor nodes. Noting that in a wireless environment intra-node data processing is far less energy consuming than inter-node communication, the authors develop a data forwarding scheme whereby each node seeks next-hop neighbor cooperation in order to both advance the data transfer towards the sink and merge a node's data with those of the next-hop neighbor. In this way the proposed scheme transforms a sensor network into a multiagent system, at the same time, for scalability reasons, dispenses with any form of network-wide cooperation e.g., mobile agent message circulation or collective formation of a routing tree. To maximize the mean time to first partitioning (MTTFP) of the network, the scheme also differentiates node functionality relative to the node position in the network topology. By reducing the average power consumption by the sensor nodes, the scheme also improves the packet delivery ratio at the cost of a moderate extra latency.

The above papers have been selected in the hope they provide a representative view of the topics discussed at WMNC 2009, and that they all of them make useful reading for wireless network specialists. On behalf of the authors as well as WMNC 2009 organizers, I wish to express gratitude to the Editor for consenting to publish WMNC 2009 material in the Telecommunication Systems Journal.

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