Special Issue on Wireless Gigabit Technologies

Editorial

The use of the Internet for more entertainment-like services, which is a major component in the dramatic change of broadband services and expectations, is leading to a continued growth in the demand for higher capacity in wireless systems. This is one of the reasons that are driving the wireless industry to strive harder for designing more bandwidth efficient system. As an example; music file swaps and downloads are growing at an annual rate of 50% to 60%, and video downloading and streaming are so bandwidth intensive that they may already account for 50 to 60% of all wireless traffic at this moment.

This fast-rising demand for bandwidth will reach the limits in terms of data rates not only for currently available technologies such as Wi-Fi and 3G, but even for upcoming high data rate systems, such as UTRA-LTE and WiMAX systems, which can achieve much higher bandwidth efficiencies compared to previous systems, such as GSM, WCDMA, etc. Moreover, the growth in capabilities of consumer devices (e.g., 60 frames/s Ultra-HDTV targeted for a mass market 10 years from now) and futuristic applications such as 3D Internet, virtual and augmented reality and telepresence will lead in the forthcoming years to capacity needs of the order or multi-gigabits per second. These data rates are today only achievable with optical fibers. Within the realm of wireless communication, a first step towards this goal is represented by IMT-Advanced (IMT-A) systems, currently specified by the International Telecommunications Union (ITU).

IMT-A systems are expected to provide peak data-rates in the order of 1Gbit/s in local area and 100Mbit/s in wide area scenarios. The deployment of these kinds of systems at mass market level is believed to take place around year 2015 and these systems will facilitate what has already been a buzzword for the last decade, namely “4G”. The ability to offer such high data rates in 100MHz bandwidth requires overall a very high spectral efficiency, and hence the need for multi-antenna techniques (MIMO) with spatial multiplexing, fast dynamic link adaptation and packet scheduling, wideband access techniques, and most likely non-contention based spectrum sharing among multiple operators. Moreover, to achieve this performance level, major advancements in the state-of-the-art are required in several key technologies, spanning all the layers. Flexible spectrum usage through carrier aggregation and cognitive radio solutions, and cooperative relaying are some of the most promising solutions. Many of these required technology components and techniques are well researched and established. What we now need to consider is how we can integrate and optimize their use in providing the target cell data rates with high availability, thus, new research on multifaceted system level design is very important for realizing the dreams of ‘4G’.

As presented in Paper 1, “The Evolution of LTE towards IMT-Advanced”, by S. Parkvall and D. Astely, some of the above-mentioned technologies are included in the Long Term Evolution-Advanced (LTE-A) air interface as defined by the Third Generation Partnership Project (3GPP). LTE-Advanced systems have a target peak data rate which satisfies the requirement as specified for IMT-A. Some key technology components for future LTE-A systems are presented in this tutorial paper. While Paper 1 gives an overview of the advanced techniques that are foreseen in LTE-A systems,, Paper 2, “On the Feasibility of Precoded Single User MIMO for LTE-A Uplink”, by G. Berardinelli et al., focuses on one specific feature that is expected to be included in LTE-A: the use of uplink single-user MIMO (SU-MIMO). In particular, the paper discusses several channel-aware precoding techniques applied to both orthogonal frequency division multiplexing (OFDM) and single-carrier frequency division multiplexing (SC-FDM), covering both spatial multiplexing and transmit diversity. SU-MIMO only considers access to the multiple antennas that are physically connected to each individual terminal. In a multi-user scenario, it might be interesting to exploit the availability of multiple independent radio terminals in order to enhance the communication capabilities of each individual terminal (e.g., to get some diversity gain). The so-called multi-user MIMO (MU-MIMO) technique is considered in Paper 3, “Distributed Scheduling Algorithm for Multisuer MIMO Downlink with Adaptive Feedback”, by L. Zhao et al.. The distributed scheduling algorithm with adaptive feedback proposed for the downlink is shown to achieve higher system capacity than existing schemes. Finally, it is well known that the performance of MIMO techniques is strongly related to the physical channel properties experienced at the both of ends of transmissions. One such issue is the spatial correlation between the channels seen at different antenna terminals. Paper 4, “Performance of Spatial Modulation in Correlated and Uncorrelated Nakagami Fading Channels”, by A. Alshamali and B. Quza, in fact derives the exact integral expressions for calculating the symbol error rate of M-QAM modulations of spatial multiplexing schemes in correlated and uncorrelated Nakagami fading channels.

Targeting gigabit per second communications requires very high spectrum allocation, in the range of 100MHz. Therefore, techniques that allow an efficient and flexible use of the spectrum are of paramount importance. Cognitive radio (CR) networks, which are able to sense the environment and adapt their communication to it, can be used to exploit unused licensed spectrum without interfering with incumbent users. Papers 5, “Accumulative Interference Modeling for Cognitive Radios with Distributed Channel Access”, by M. Timmers et al., deals with the modeling of the
accumulated interference generated from a large scale CR network. This accurate modeling evaluates how the density of the network affects the sensing requirements of the CRs in meeting a certain interference constraint.

Cooperative relaying is another important enabling technology for gigabit per second communications. On the one hand, when the terminal is a small node of a sensor network, and it is impractical to equip it with multiple antennas due to size and power limitations, cooperative relaying represents an interesting alternative to achieve high data rates. In cooperative relay networks, a diversity gain is achieved from virtual antenna arrays consisting of a collection of distributed antennas belonging to different relays. Paper 6, “A Hybrid Cooperative Relay Selection Algorithms for Fixed Relay Based Cellular Networks”, by J. Fan et al., presents a hybrid cooperative relay selection algorithm for fixed relay-based cellular networks that can dynamically choose different cooperative strategies according to current user conditions in the cell.

On the other hand, cooperative communications can help in enhancing the efficient wireless bandwidth utilization, meant as a reduction of overheads and data retransmissions. Paper 7, “Exploiting Cooperation for Performance Enhancement and High Data Rates”, by T.K. Madsen et al., discusses an approach to increase the bandwidth utilization based on a cooperative network architecture, referred to as cellular controlled peer-to-peer (CCP2P). In CCP2P networks, a group of terminals in close proximity form a cooperative cluster; those terminals are connected with the “outside world” using cellular links. Performance gain can be achieved by exploiting the cooperative behavior of the terminals in the cluster.

Finally, Paper 8, “Turning the Cellphone into an Antipoverty Vaccine, by D. Raha and S. Cohn-Sfetcu, includes a review of the social impact that cell phone has represented and can represent in the near future. In particular, it focuses on the issues facing the application of wireless technologies on the huge scale and at the costs required for access by the poor and illiterate masses of the world. As such, the article poses the challenges faced by the technology world in achieving the success of the Mobile Revolution.

The editors would like to thank reviewers and authors, who, in different ways, have contributed to this Special Issue. We would like to acknowledge all the other authors who have submitted their contributions for this issue.

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Nicola Marchetti was born in Legnago, Italy, on October 2, 1978. In 2003 and 2007 he received the M.Sc. degree in electronic engineering and the Ph.D. degree in wireless communications from University of Ferrara, Italy, and Aalborg University, Denmark, respectively. From July 2003 to April 2004 he was a research assistant at the University of Ferrara and he worked a PhD Researcher from May 2004 to May 2007 at Aalborg University Denmark. Since June 2007, he is a Research Assistant Professor at Aalborg University. He is a member of the Advisory Committee on Applied Mathematics at Aalborg university (AMAAU). In 2008, he was TPC-chair of the First International Workshop on Cognitive Radio and Advanced Spectrum Management (CogART) and General Co-Chair of the First International Symposium on Applied Sciences in Biomedical and Communication Technologies (ISABEL). He was lecturer in Electric Communication at the University of Ferrara, and he has been successfully supervising nine M.Sc. students. He is currently supervisor of three Ph.D. students. His research interests include: multiple antenna technologies, single- and multi-carrier modulations, radio resource management, cognitive radios and advanced spectrum management techniques, applied mathematics for wireless communication.

Muhammad Imadur Rahman was born in Bangladesh on 30 January 1976. He obtained his PhD degree in Wireless Communications from Aalborg University Denmark on September 2007. Prior to that, he obtained his B.Sc degree in Electronics Engineering in 2000 from Multimedia University Malaysia and MSc degree in Radio Communications from Helsinki University of Technology Finland in 2003. Currently he is with Ericsson Research, Kista, Sweden since January 2008 working as a research engineer in Access Technologies and Signal Processing department. He is primarily involved in 3GPP standardization research from PHY and MAC layer issues on TDD based future wireless systems. From March 2003 until December 2007, he was employed as a researcher in Aalborg University. He was an assistant professor in the same university in 2007, where he taught a number of MSc level courses in mobile communications, supervised 10 MSc students and 3 Phd students. In 2007, he was also attached to System Competence Team of Nokia-Siemens Networks in Aalborg, Denmark as an external researcher when he managed a project, ‘Local Area TDD solutions for future Gigabps wireless systems’, funded by Nokia Siemens Network and Danish Research Council. He has authored (and co-authored) two books, more than 40 research papers and 6 patents till March 2009. His main research interest is multiple access techniques, multi-antenna issues, spectrum sharing and radio resource management in wireless systems. Throughout his research career, he has also been involved in a number of EU funded projects and other projects financed by Danish research councils. He has been involved in a number of conferences and workshops as organizing and technical committee member. He is an active IEEE volunteer, led many projects in student and recent graduates activities under IEEE Denmark section. More recently, he is involved in IEEE Sweden section as the Secretary of Sweden Section for 2008-9. He was one of the initiators and first General chair of Aalborg University IEEE Student Paper Conference in 2007.

Ernestina Cianca received the in Electronic Engineering Laurea degree cum laude at the University of L'Aquila nel 1997. She got the Ph.D. at the University of Rome Tor Vergata in 2001. She has been employed by the University of Aalborg, Denmark, in the Wireless Networking Groups (WING), as Research engineer (2000-2001) and as Assistant Professor (2001-2003). Since Nov. 2003 she is Assistant Professor in Telecommunications at the URTV (Dpt. of Electronics Engineering), teaching DSP, Information and Coding Theory and Advanced Transmission Techniques. She has been the principal investigator of the WAVE-A2 mission, funded by the Italian Space Agency (ASI). She is currently the coordinator of the scientific activities for several projects with the European Space Agency (ESA) and ASI. She has been involved in several European and national projects. Her main research interests include Novel Air Interfaces for future wireless systems, in particular MIMO in Single carrier systems with Frequency Domain Equalization, Multicarrier Systems, satellite communications in EHF bands (in particular, W-band), energy efficient wireless systems, power control and resource management, heterogeneous networks, and UWB for biomedical applications. She is currently TPC Co-Chair of the conference European Wireless Technology 2009 (EuWIT2009), joint event with the European Microwave Week 2009. She is also TPC Co-Chair in the conference Wireless Vitae 2009 (http://www.wirelessvitae2009.org). She is author of about 50 papers, on international journals/transactions and proceedings of international conferences.