Preface

Mobile Communication Networks offer great achievements and numerous opportunities for applications and services in communication and information related technologies. These accomplishments rely primarily on the progress of many fundamental areas such as: communication and information theory, signal processing and computer, micro-electronics and related technologies. Nowadays, there is a plethora of independent radio access technologies that can be considered as mobile communication network applications and each supports coverage (from macro cell to small cell), mobility capabilities, data rates and quality of service. The next-generation mobile communication networks will confront with the increasing demand for mobile radio connectivity due to the co-existence and synergy of ultradense populations of mobile smart phones and sensors in various devices and systems Cardona (2013).

The implementation of International Telecommunication Union’s vision for optimal connection of the mobile devices, anywhere and anytime has gained increased interest with the advent of the new devices and the necessary cooperation of multiple radio access technologies ITU-R M.1645 (2003). All the future mobile communication networks will create a coalition of radio access technologies that will provide excellent behavior of the essential Figure of merit of connectivity Pitsiladis et al. (2012) for the application of the Internet of Things (IoT) technology. The main objective of IoT is the transparent integration of a variety of heterogeneous network technologies and smart devices under the Internet umbrella. Coverage capabilities and exploitation of millimeter wave technology are of utmost importance Panagopoulos et al. (2003), Panagopoulos et al. (2007). The base of large scale integration among a vast number of different devices achieving interoperability and scalability is the development of a universal platform taking into advantage the flexibility of the radio communication advances and the software defined network principles.

The next generation gateway platforms will have an adaptive architectural reference model that will be adjusted to the applications. It will be connected seamlessly through heterogeneous technologies on the level of autonomous IoT gateway nodes. The platform’s operational framework should incorporate different communication protocols and manage a variety of traffic/data patterns generated from smart objects (such as sensors, RFID and M2M devices) and widespread user terminals (e.g. laptops, tablets, smartphones), providing access to cloud computing and compatibility with future internet applications.

The IoT gateways will be equipped with a variety of radio communication modules (e.g. IEEE 802.11, IEEE 802.15.4, ZigBee, 6LoWPAN, Bluetooth). According to the proposed scalable reference architecture different groups of IoT devices are associated with a single gateway and massive access of M2M devices can be addressed adequately. In addition, the IoT gateways are spatially distributed in smart cities, industrial plants, environmental habitats etc., handling TCP transactions on behalf of its associate devices (handshakes, IP association), interconnecting via tunneling protocols with the core network.
Novel physical layer techniques in radio networks and re-configurable software defined networks are addressing the needs for seamless coverage and connectivity of the IoT gateways. Backhauling capabilities using either millimeter wave technologies or satellite capacity will be available and developments in software defined radio and FPGA platforms will be employed.

A major challenge emerged from dense IoT infrastructures is the dynamic bandwidth provisioning of capillary networks by the gateways. The bandwidth associated with activity of Legacy systems can be reused efficiently. Moreover, efficient power management, network connectivity as long as efficient access schemes should be proposed for enhancing systems performance. Finally, software and virtualization solutions such as Network Functions Virtualization (NFV) and Software-Defined Networking (SDN) could be implemented for efficient low-cost managing of heterogeneous devices and IoT gateway configuration.

Moreover, many applications of next generation mobile communication networks require e.g. the installation of sensors over areas, where there are no terrestrial infrastructures or broadband wireless terrestrial communications, such as forests, open sea, islands, etc. In these common applications, the employment of satellite communication technologies is the only efficient and feasible solution to achieve the desired communication. Additionally, the current advances of satellite communication networks Maini et al. (2011) (e.g. the use of Ka-band frequencies for capacity and high communication data rates) lay them as an inevitably promising solution in remote area WSN applications Celandroni et al. (2013). However, the co-existence of these two types of communication networks has led to the necessity of the efficient design and implementation of unified satellite-based WSN architectures. The propagation phenomena play a very important role in the reliable design of the satellite communication networks that will support future mobile communication networks and wireless sensor networks Panagopoulos et al. (2004).

One of the most significant subjects in the areas of mobile communication networks is the quality. It is difficult to ignore the quality of the end-user experience and the quality of provided mobile services which are defined and assessed both by business and technical perspectives. QoE (Quality of Experience) is the term that characterizes the users’ perceptions of cellular services performance, while QoS describes the provision of the negotiated and demanded quality between user equipment (UE) and the radio access network (RAN) as well as the core network (CN). At this time there are many radio access technologies (RAT) in use for mobile services delivery. The issue of QoS has received considerable critical attention in the converged communications environment Pitas et al. (2013).

**THE CHALLENGES**

Since the LTE/4G cellular networks will take up most of the telecommunication market in the nearest future, there is an increasing interest in technologies that will define the next generation 5G telecommunication standards. There are many technical challenges that have to be addressed in this direction, such as:

- The employment of ultra-dense networks for wireless access, their performance and radio resources management optimization.
- The design of new radio access network architectures in order to offer cloud-based, multi-tenant and access from heterogeneous technologies as services.
- The employment of software defined network technologies in next generation mobile networks in order to be directly programmable, open and agile.
The incorporation of radio access technologies to various complex radio environments such wireless body networks, vehicular radio networks etc.

The optimum deployment of massive and millimeter wave MIMO systems, from many perspectives such as low cost hardware development, fast signal processing techniques, new precoding techniques based on next generation channel models.

The maximization of spectral and energy efficiency of new wireless architectures using spectrum sharing and efficient transmission scheduling algorithms.

The design of secure and confidential services in pervasive computing systems.

**GENERAL DESIGN ISSUES**

In future mobile communication networks there will be the capability to the users of choosing from various multiple radio access technologies, consequently the procedure of benchmarking is very crucial. Benchmarking is the process of identifying “best in performance class” in relation to both the technologies and the operators by which mobile services are delivered and experienced Pitas et al. (2013). The quest for “optimum/best in performance class” can take place in various (populated spots, cities, highways, malls) as well as all around the country. The goal of the benchmarking procedure is to understand and evaluate the current position or “status quo” of a mobile operator in relation to “optimum/best in performance class” and to identify areas and means of performance improvement. Benchmarking involves outside a mobile network provider to examine how other operators achieve their performance levels and to understand the technologies they use. To this direction benchmarking procedure helps to explain the technologies behind excellent performance. Application of benchmarking involves four key steps:

- Study in detail existing Radio Access Technologies and Radio Access Networks as well as all the provided services.
- Analyze the engineering processes of others
- Compare own performance with that of others analyzed.
- Implement the optimization steps necessary to close the performance gap.

Benchmarking should not be considered as an one-off exercise for the mobile communication networks providers but in order to be efficient and effective, it must become an ongoing, an integrated part of an ongoing improvement process with the goal of keeping abreast of ever-improving best practice.

Cooperation incentives will be proposed among various technologies in order to enhance the cooperation of the mobile users in order to succeed the best result for all the system (mobile operators, users). Cooperative transmission techniques will be proposed in order to improve the system performance in terms of availability, coverage range and throughput and minimizing the energy consumption. Radio channel and physical communication characteristics are of paramount relevance to the optimum design of efficient cooperative communications and mobile computing technologies.

Summing up, the next generation mobile market will be very competitive, and the next generation mobile services consumers shall be well informed about the perceived QoS and QoE levels. A beneficial role of regulatory authorities is to supervise and conduct transparent and dependable benchmarking of mobile sector as well as to open-publish all QoS information objective reports. The set of performance indicators shall be comprehensive and comparable. The next generation mobile network technologies
as well as mobile services beyond voice and video telephony shall be under total quality performance evaluation via existing or new common accepted by operators and mobile community and standardized methodologies.

ORGANIZATION OF THE BOOK

The book is organized into three Sections and twenty chapters. A brief description of each of the chapters follows at this point.

The Section I is devoted to the Physical Layer Aspects of the Next Generation Mobile Communication Systems including advances in the Multiple Antennas, Propagation and on the employment of the relays. More specifically:

Chapter 1 presents the channel models and the propagation issues for 5G mobile communication systems. It also identifies the most popular scenarios and architectures of the next generation mobile systems. Finally, future directions for the propagation and channel model prediction for the next generation mobile communication systems 5G millimeter wave cellular systems are analyzed.

Chapter 2 presents next generation MIMO-OFDMA cellular networks with relay transmission strategies based on the requested content. Privacy and security issues in these novel architectures are also analyzed.

Chapter 3 shows the applications of innovative reconfigurable antenna methodologies for the development of 4G devices. Methodologies such as phased and fully adaptive arrays are analyzed. Future applications are finally described.

Chapter 4 discusses the recent trends in interference mitigation technologies that will change the design of the future 4G and beyond (5G) of mobile and wireless communication systems. More particularly, the coordinated multi-point MIMO systems, smart terminal devices techniques, millimeter-wave communications and massive MIMO systems are presented.

Chapter 5 presents various relay selection policies based on spectral efficient techniques for the next generation mobile systems. Successive opportunistic relaying that leverages the half-duplex constraint of conventional relays through concurrent transmissions is also described, while proposing techniques to reduce the effect of inter-relay interference. Finally, open problems in spectral-efficient opportunistic relay selection policies are discussed.

Chapter 6 presents the state-of-the-art of Software Defined Radio (SDR) platforms. The current chapter concentrates on these design challenges exploiting the system scenario methodology, proposing solutions especially for wireless communication systems. Finally, the tradeoffs between the representativeness of the scenarios (clustering overhead), the implementation of the scenario detection (detection overhead) and the platform tuning cost (switching overhead) are studied.

The Section II is devoted to Multiple Access Techniques and the Radio Resources Management Strategies including M2M networks, D2D networks, Mobile Wireless Sensor Networks and energy efficient allocation algorithms. More specifically:

Chapter 7 is devoted to Machine-to-Machine communications presenting the current M2M standardization activities and their implementation in 4G/LTE networks. Moreover, random access management schemes for M2M communications are described while spectrum sharing methods and M2M clustering techniques are also discussed. Finally, energy efficiency issues and connectivity issues of the future M2M communication systems are described.
Chapter 8 identifies the problem of optimal power allocation in HARQ systems with a limit on the maximum number of allowed transmissions for a data packet is considered. More specifically, the problem of minimizing the rate-outage probability is considered and to reduce the complexity of finding a solution, the rate-outage probability expressions are approximated, using which, the non-convex optimization problems are converted into geometric programming problems (GPPs), for which the closed-form solutions are derived.

Chapter 9 describes the scheduling algorithms of LTE networks. More specifically, this chapter presents a study of the resource allocation process in LTE networks. This study starts with an overview of the main concepts involved in the LTE resource allocation, and brings two new proposals of scheduling algorithms for downlink and uplink, respectively. Simulations are used to compare the performance of these proposals with other scheduler proposals widely known and explored in the literature.

Chapter 10 is devoted to Device-to-Device (D2D) communication networks that offer major improvements to network-assisted connectivity by utilizing both licensed and unlicensed spectrum bands and achieving benefits in key performance areas like cellular traffic offloading, spatial spectrum reuse and energy efficiency. Finally, the emergence of new paradigms such as proximity and location-based services, turn D2D communications to a significant boost for all relevant stakeholders.

Chapter 11 introduces the topic of mobile wireless sensor networks (MWSNs) as applications of next generation mobile communication systems. It then explores the potential applications of the technology and discusses the challenges and requirements of the communications systems with a focus on routing. It also looks at performance metrics and evaluation techniques in terms of mathematical analysis, simulations and test bed implementations.

Chapter 12 presents recent proposals in Wireless Grids on the subjects of resource discovering, monitoring and job scheduling for next generation mobile communication systems. The highlights of the review in this chapter includes: the use of agent technology; solutions oriented to applications composed of independent tasks and the lack of studies using either real platforms or real data in simulation models.

Chapter 13 provides a comprehensive investigation of current research efforts in the field of Self-organized Networks (SONs) in the upcoming 5G mobile communication networks. It goes through SON functionalities and discusses their cyclic behavior. Moreover, the chapter investigates in detail the construction of a unified SON framework to self-organize future networks, which are expected to have a high degree of heterogeneity.

The Section III is devoted to Quality of Service and Security Provisioning for next generation mobile communication platforms. More specifically:

Chapter 14 reviews security and privacy issues in Next Generation (NG) networking of future mobile communications systems. A general categorization of various popular NG networks and services is presented. Then, the security and privacy threats identified for each category are examined, along with a brief review of the related security requirements and mitigation strategies described in the recent literature.

Chapter 15 describes a tool called Hybrid Simulated-Emulated Platform (HySEP) which offers simulation/emulation tools of a heterogeneous network infrastructure. This platform can be used to validate and test algorithms and policies for traffic control as well as for Quality of Service (QoS) assurance.

Chapter 16 highlights the benefits of pervasive computing in next generation mobile communication systems. More specifically, this chapter presents the approach being employed by the SOCIETIES project to protect the privacy of sensitive user data and ensure the trustworthiness of delivered services via social and pervasive computing systems. This framework has already been designed, implemented and evaluated via real user trials engaging wide and heterogeneous user populations.
Chapter 17 is devoted to Firefox OS an operating system for mobile devices. It is developed by Mozilla and is based on web technologies. Developed applications are therefore not tied to a given type of hardware. Mozilla works on standardization of Web APIs, so that the device hardware could be accessed more easily. It also introduced its sign-in system for the Web and furthermore, it wants to redefine the way payments work for mobile applications.

Chapter 18 identifies the new interactions between the mobile networks and the fixed access networks. This chapter describes the main IP mobility protocols and presents a novel classification, which relates the integration of the mobility protocol with the access network. The chapter also presents analytical models to evaluate the registration updates cost and the packet loss rate of the classified protocols.

Chapter 19 presents the basic information and the vision about the usage of mobility in medical domain to ease healthcare and make it more effective. The mobile technologies used in the healthcare information systems, together with the challenges, problems and regulations are explained.

Chapter 20 presents a holistic approach in quality of service (QoS) and quality of experience (QoE) characterization and prediction in modern mobile communication networks. System Quality of Service (SQoS) parameters are metrics that are closely related to the network status, and defined from the viewpoint of the service provider rather than the service user. Moreover, E2E Service Quality of Service (ESQoS) parameters describe the QoS of the services and they are obtained directly from the QoE parameters by mapping them into parameters more relevant to network operators, service providers and mobile users.

As conclusion, this Handbook of Research on Next Generation Mobile Communication Systems is devoted to almost all the main aspects of current research and advances on the subject from channel models and physical layer techniques, to radio resources management and quality of service and security provisioning in next generation mobile communication systems.

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REFERENCES


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