Chapter 1

Introductory Chapter: The Future of Mobile Communications

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1. Introduction

The availability of mobile communication links has become an integral part of modern societies even, or perhaps especially, when other infrastructure is lacking [1]. Moreover, projections of mobile data traffic growth indicate that there will be five times as much traffic by 2030 even in a low-growth scenario, and it is quite likely that data traffic will be ten times greater than today [2]; to address this expansion requires increased system capacity. The now ubiquitous wireless systems in modern life operate using carrier frequencies below 6 GHz. The current, fourth-generation (4G) systems have been in use for over a decade and are reaching their limits given the increased data traffic demands. Thus, it is time for fifth-generation (5G) mobile communication networks to be introduced.

Previous cellular mobile networks were developed primarily to optimise voice or video streams and supported other services such as Web browsing as additional features. However, the emergence of many new applications, typified by autonomous vehicles, smart cities, virtual reality and ubiquitous remote control to name a few has placed extra requirements on the mobile infrastructure. As a consequence, 5G is a paradigm shift from the cellular network of 4G to a 'network of everything', connecting people and machines in a service-based architecture. The International Telecommunication Union Radiocommunications (ITU-R) Standardization Sector has thus specified a number of goals for 5G in the standard International Mobile Telecommunications 2020 (IMT-2020) [3]. The aims include a 20 Gbps peak data rate and 100 Mbps user experienced data rate coupled with high density and low latency and the accommodation of high-speed mobility. Progress towards these design goals has been led by the Third Generation Partnership Project (3GPP) [4], an umbrella standards body that has defined the 5G standard, often referred to as new radio (NR). This standard is currently undergoing development of its 16th release following the completion of release 15 in 2018. The latter concentrated on enhanced mobile broadband to provide high data rates for consumer applications such as video on demand. The former, currently underway, considers ultra-reliable low-latency communications for uses such as remote surgery and the need to support a large number of devices for machine to machine communications in the Internet of Things (IoT) [5].

The targets of 5G are challenging and require the development of technology in many areas. In this book, some of the aspects of 5G are addressed to accommodate the increased services, data rates and reliability promised by this next generation of mobile communications.

Physical layer developments are the focus of Leeson and Higgins, who consider the movement towards new wavelength ranges for future communication systems driven by increasing bandwidth demands as 5G comes to fruition. In particular, using two topical technologies offer substantial transmission bandwidth via high carrier frequencies, namely, optical wireless and millimetre-wave transmission. Following an introduction to the relevant portion of the electromagnetic (EM) spectrum for these technologies, a short history of their development is given. Significantly, a performance comparison for 5G outdoor point-to-point and indoor hotspots is presented. This indicates that optical wireless is the better option for distances up to approximately 50 m outdoors and an indoor 10 m hotspot radius. Time will tell if these two approaches will become established as 5G implementation becomes a reality, but they offer a possible future for future wireless data demands using untapped and unlicensed bandwidth in relatively free portions of the EM spectrum.

The introduction of 5G systems introduces requirements for a range of antennas that are discussed by Pedram et al. in their chapter. Novel approaches are necessary to address 5G antenna provision for a collection of frequency bands, usually in the GHz range. Although it is true that most transmission and reception constraints due to antenna design have been removed from existing systems, this is not true for the additional demands of 5G. The chapter is organised into three subsections that cover antennas below 15 GHz, antennas operating between 15 and 30 GHz and higher frequency antennas. New antenna technologies such as metamaterial structures, substrate integrated waveguide structures and microstrip antennas with various feeding networks are considered as appropriate in the 5G frequency ranges stated. The trade-offs needed when choosing the frequency of operation, such as size and bandwidth, are also discussed.

Delivery of high-quality communications also requires the use of modern coding methods without which wireless communication would be impossible at the rates needed for 5G. Thus, Alqahtani provides a chapter that presents a rateless space-time block code (RSTBC) for massive multiple-input multiple-output (MIMO) wireless communication systems. The principles of rateless coding compared to the fixed-rate channel codes are discussed, followed by presentation of a literature review of rateless codes (RCs). Furthermore, the chapter illustrates the basis of RSTBC deployments in massive MIMO transmissions over lossy wireless channels. In such channels, data may be lost or are not decodable at the receiver end due to a variety of factors such as channel losses or pilot contamination. Massive MIMO is a breakthrough wireless transmission technique proposed for future wireless standards due to its spectrum and energy efficiencies. The chapter thus presents details of a technology that is central to the implementation of 5G.

With the introduction of communication between machines in 5G systems, Xu et al. provide a chapter that considers the accurate positioning of the diverse range of 'things' that may be connected to form the Internet of Things (IoT) in 5G communication networks. With the expansion of mobility provided by objects such as automobiles and drones, knowledge of the location of these entities is taking on a growing importance for future mobile networks. The chapter provides an overview of the mobile radio positioning techniques that have been used by the various generations of mobile communication systems. This gives the most detail concerning 4G positioning employing user equipment and base stations, since this will most likely be extended for 5G. The use of higher transmission frequencies in 5G will enable more accurate measurement of time of arrival to determine distances. In addition, the proliferation of connected devices will enable more cooperative working and further contribute to high-accuracy positioning.

So, this collection of leading research chapters is intended to provide information for researchers and practitioners in communication systems. It may be used as a reference for the latest developments in 5G, and as a pointer to developing topics for advanced students looking for insight into topics for dissertations and future research.

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