Millimeter Waves in Bioelectromagnetics and Body-centric Applications

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***Abstract*— Millimeter-wave technologies are considered as very promising for 5G short range communications as well as for body-centric applications including wireless sensors networks and wireless body area networks. The corresponding new usages and services will involve near-field interaction of radiating devices with the human body, both in terms of body impact on wireless device performance as well as in terms of user exposure. This presentation will provide an overview of main features and recent advances in the field of millimeter-wave technologies for biomedical electromagnetics from on-body antennas and propagation for body-centric communications to tissue-equivalent models, characterization, and advanced exposure systems for in vitro and in vivo studies.**

BODY-CENTRIC wireless networks constitute an extremely attractive next-generation wireless technology representing a cognitive interface to higher-level networks (WPAN, WLAN, WMAN, etc.). These emerging systems open new possibilities in the fields of wireless communications, remote monitoring and sensing of the human body activity, detection and localization for a great number of applications (medical, entertainment, defence, smart homes and cities, sport, etc.). They could also play a key role in wireless sensor networks (WSN) and internet of things (IoT) whose economic impact is growing exponentially. Body-centric wireless networks have emerged as an alternative or add-on to traditional wired network systems (e.g. in medical environments), and new exciting applications are now under development (e.g. high-data-rate body-to-body streaming, remote monitoring of patients at home).

The upper limit of the spectrum used for wireless networking has been recently progressively shifting towards the millimeter-wave (MMW) band due to the increasing need in network capacity and high data rates [1]. Wireless data traffic is rising exponentially (nearly a threefold increase in traffic is expected from 2018 to 2021 according to the Cisco global mobile data traffic forecast [2]). Recently, the 60 GHz band has been identified as highly promising for body-centric wireless communications including body-area network (BAN) technologies. One of the main features differentiating the 60 GHz BAN from a lower frequency BAN is confidentiality and low interference with neighboring networks, which has been demonstrated to be crucial for body-centric and inter-BAN communications [3], for instance in military scenarios where communication security is vital [4]. Limited operating range in this band (e.g. shifting the frequency from 70 / 80 GHz to 60 GHz decreases the operating range from 3 km to 400 m [5]) is mainly related to the strong oxygen-induced atmospheric attenuation (typically 16 dB/km). Besides, high data rates can be achieved [beyond several Gb/s], which is extremely attractive to support the increasing demand in data traffic and high data rate transmissions. In addition, the 60 GHz band provides other advantages, such as miniature size of antennas and sensors compared to their counterparts in the lower part of the microwave spectrum. Today, MMW circuits and antennas can be implemented with a high level integration and reasonable cost.

The implementation of 60 GHz technologies, including body-centric applications, is an unavoidable evolution of wireless networks, and first commercial solutions have already emerged for WPAN (e.g. Dell Latitude 6430u, first ultrabook using Qualcomm / Wilocity 60 GHz chipset). The 60 GHz band is unlicensed. Different spectra are allocated depending on countries (e.g. 57–66 GHz in Europe, 57–64 GHz in North America and South Korea, 59.4–62.9 GHz in Australia, 59–66 GHz in Japan [6]). Note that the available bandwidth is hundreds times higher compared to existing wireless technologies at lower microwave frequencies.

A massive deployment of wireless devices equipped with 60 GHz Tx / Rx modules is foreseen in coming years. The corresponding new usages and services will unavoidably involve coupling of radiating devices with the human body, both in terms of the body impact on wireless device performances as well as in terms of user exposure [7]. This includes the near-field interactions of wearable and mobile devices operating in the vicinity of the human body.

This presentation will provide an overview of main features and recent advances in the field of millimeter-wave technologies for biomedical electromagnetics from on-body antennas and propagation for body-centric communications to tissue-equivalent models, characterization, and advanced exposure systems for in vitro and in vivo studies.

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