

Chapter 4

Body Area Networks: Channel Models and Applications in Wireless Sensor Networks

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ABSTRACT

Nowadays, wireless Body Area Networks (wBAN) have gained more relevance, in particular in the areas of health care, emergencies, ranging, location, domotics and entertainment applications. Regulations and several wireless protocols and standards have appeared in recent years. Some of them, like Bluetooth, ZigBee, Ultra Wide Band (UWB), ECMA368, WiFi, GPRS and mobile applications offer different kinds of solutions for personal area communications. In this chapter, body area network channel modelling will be described; also, a brief description of the applications and state-of-the-art of regulation and standardization processes pertaining to these kinds of networks will be presented. For each topic, the chapter shows not only the main technical characteristics, but also the technical problems and challenges in recent and future research. Finally, the chapter provides an analysis of Body Area Networks, opinions about the future and possible scenarios in the short- and medium-term for the development of standards and applications and their impacts on our daily lives.

1. INTRODUCTION

In recent years, wireless communications have gained greater relevance. They presently play an important role in our lifestyle and quality of home and work life. Ubiquity allows a person to seamlessly connect with anybody who is connected in the world. The expanded uses of wireless

technologies have increased and new applications have been developed. Wireless networks have been classified according to their level of coverage. Consequently, there are wide area networks, metropolitan area networks, local area networks and personal area networks. In personal area networks, there is a lot of interest in body area networks, which are communication networks that are within, near and around a person. Body area networks are the subject of a new research

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field in communications. However, there are some existing technologies that are perfectly adapted to the requirements of body area networks, such as Bluetooth, ZigBee, Ultra Wide Band, etc.

Body area networks (BANs) are small-scale communication systems whose transmissions are performed inside, around or on the human body. Consequently, transmissions of BANs have very specific characteristics. A first characteristic is that coverage is confined to distances of no more than 2 or 3 meters and, secondly, the power transmission levels are very low. Low power contributes to long battery life and reduces the levels of interference with other technologies. Equally important, operating with low power levels reduces health risks.

Body area networks are likely to be used primarily for medicine and entertainment. Medical applications focus on monitoring the human body for disease diagnosis, management and control, intelligent prostheses, surgical assistance, artificial organs, etc. Meanwhile, applications for entertainment and information exchange focus on multimedia, audio, video, and data transfer between two or more users, as well as applications for office, industry and home automation. Positioning and Internet connectivity are also offered by BANs.

Body area networks are classified into two areas according to the characteristics of the propagation medium. The first classification is called ‘in body’ communication, where information transfers are made through human tissue. Consequently, the signals must go through muscle, skin and some other transmission media under special conditions. Clearly, devices that support these applications are often called “invasive.” On the other hand, body area networks can be for ‘non invasive’ or ‘on body’ communications, where all transmissions are made on the surface of the human body, either over the skin or clothing that we wear, or around it. Sometimes, these types of devices can be “worn.”

In this chapter, we present the typical characteristics and trends of body channel models, with

an analysis of the main aspects and challenges of the propagation channel. Then, we present short-term trends in research on body area networks, followed by a brief review of the state-of-the-art of regulatory and technological standards associated with this type of communication system. Next, some applications and operating scenarios for body area networks will be presented. Finally, some findings of the authors are discussed.

2. CHANNEL MODELS

One of the main challenges for new radio technologies is the modelling of the radio channel according to physical parameters like propagation media, frequency, bandwidth, etc. The main challenge is to obtain the impulse response of the channel. Body Area Networks are not an exception to this challenge, especially if we deal with in body systems. However, we will see that on body systems also present interesting challenges for channel modelling, related to the behaviour of the human body and common functions such as breathing, that affect the behaviour of radio waves.

There are two types of models: large-scale and small-scale. Large-scale models estimate the power losses due to propagation in free space, absorption and penetration into the human body. The vast majority of large-scale models are developed using statistical approaches based on measurement campaigns.

In small-scale models, we determine the channel impulse response. With this, we can determine channel distortion, frequency-selective channel fading and stability parameters. This information allows the most appropriate modulation techniques to be designed, finding the optimal transmission rates and equalization schemes in broadband. It is common to find models based on statistical approaches, but deterministic models are also a good option for modelling the channel impulse response.

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