International Journal of Wireless Networks and Broadband Technologies
Volume 7 • Issue 1 • January-June 2018

On the Selection of Optimum Threshold Bound of Body Surface to External Communication in Body Area Network

Sukhraj Kaur, ECE Department, GNDU Regional Campus, Jalandhar, India
Jyoteesh Malhotra, ECE Department, GNDU Regional Campus, Jalandhar, India

ABSTRACT

This article investigates the optimum threshold bounds for the signal travelling through a body surface to external nodes of a body area network. An ultra-wideband system ranging from 3.1-10.6 GHz is used for the observations of the signal transmitting through different body directions using NICT's statistical model. Through simulative investigation, the link performance is evaluated by calculating outage probability using sub-optimum Rake receivers, which are based on either partial combining (P-Rake) or selective combining (S-Rake). The optimum numbers of Rake taps are also identified. The obtained results give an assessment to better understand the effect of body direction and Rake structure on the selection of optimum threshold bounds for a channel model CM4 of body area communication.

KEYWORDS

Body Area Networks (BAN), Channel Model, Outage Probability, Rake Receiver, Ultra Wideband System (UWB)

INTRODUCTION

According to the report presented by Department of Economic and Social Affairs of the United Nations (2015), the estimated average annual rate of population change is 1.18% for the year 2010-15. This increasing world population impose much restriction in the way of the medical experts to provide effective health care facilities to all. Moreover, the ever-increasing involvement of advance technology in the daily life of people reduces their physical activities and made them lazy and more prone to harmful disease. So, to counter these problems, there is a need to establish a network that can allow a doctor to look after the patient from the far location and that's even continuously. And this cannot be possible without employing the wireless technology in the health care field. Moreover, applying the wireless technology will provide greater mobility and hence more comfort level to the patient. The growing uses of the portable devices like smart phones, tablets etc. around the human body can help in developing the end-to-end link establishment from the patient to the doctor.

The employing of the Wireless Body Area Network (WBAN) in the medical field can help in continuous and remotely monitoring of the patient. The WBAN network includes number of sensors that are either implanted in the body or are placed on the surface of the body. These sensors work in coordinated

DOI: 10.4018/IJWNBT.2018010102

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manner and send the measured information about the physiological sign of the body to the most powerful sensor called control unit (CU) placed on the surface of the body. The information from the control unit is then transfer to the personal device like smart phone of the patient from where it is directed toward the medical team via internet. The medical team can then trigger the treatment procedures in return.

Zimmerman (1996) is the first person to pronounce the term, Personal Area Network (PAN). Later the term PAN has been modified to Body area Network to represent all communication around the human body. In April 2009, IEEE P802.15 working group established for wireless Personal area networks (WPAN) has developed a task group IEEE 802.15.6 for WBAN. And the development of this Task group opens a new area of research to eliminate the issues related to the body area communication and to establish a network that can allow the reliable communication around the body. The development of a competent and affordable system for WBAN is not possible without developing the simple and generic model for its channel models. The IEEE P802.15.6 for WBAN includes four channel models i.e. CM1 (implant-to-implant link), CM2 (implant-to-on-body link), CM3 (on-body-to-on-body link) and CM4 (on-body-to-off-body link). In this paper, the focus is to contribute for the channel model CM4 of WBAN system for ultra-wideband (UWB).

The Ultra-wideband transmission employed here is widely used for short range wireless communication. The potential of UWB system includes extremely wide transmission bandwidth and limited power spectral density which results in accurate position location and ranging, high multipath access ability, immunity to fading, high multipath resolvability and covert communication (Qui, Lui, & Shen, 2005; Proakis, 2001). The additional benefit of UWB system is to not provide any EMI (electromagnetic interference) risk to other narrow band systems and medical equipment because of its limited transmitted power and uncongested frequency. The list of advantages provided by ultra-wideband enforces its use for body area communication.

Kaur & Malhotra (2016) studied the important statistical attributes such as complementary CDF of RMS and mean delay spread of PDP of body surface to external link with different body directions in UWB frequency range. The PDF and CDF of output SNR distribution has been investigated for 2 and 16 tap rake receiver structure.

The work related to WBAN is mostly focused on proposing solutions for the issues of the network so that its practical application became possible. This study continues the work presented in Kaur & Malhotra (2016). The focus of this paper is to contribute for the selection of Optimum threshold bound for normalized power to be used for channel CM4 of wireless body area network in ultra-wideband. The rake receiver structure for different rake taps are compared for better signal reception in body surface to external link.

The organisation of paper is done as follow: In the next section, brief description of WBAN system and channel model is followed by the simulation methodology and environment. Subsequently, the simulation results and Discussion are given in next section. The paper is finally concluded in the last section.

WBAN SYSTEM AND CHANNEL MODEL

Overview

Yazdandoost and Sayrafian (2009) present the final document of the IEEE 802.15 TG6 channel modelling subcommittee and provide the list of channel model to be used for Body area network. These channel models are used as a common platform for evaluating the performance of physical layer of body area network. A list of the channel model can be drawn from three types of nodes:

- *Implant nodes* that are placed below the skin or deeper inside the human body;
- *Body surface nodes* that are placed on the surface or at the 2 cm away from the human body;
- *External nodes* that are placed between few centimeters to at most 5 m away from human body.

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