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The Qualitative Study on Input – Output Channel Configurations in Wireless Body Area Network

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Abstract.

Increasing interest in wireless networks and the electrical devices with the help of semiconductor technology has empowered the active participation of people in the development of Wireless Body Area Networks. Sensor network's environment for using free space is different from that of Wireless Body Area Network as it transmits signals through body parts. There are lots of areas which need to be taken care of during the transmission of signals. One of the predominant points is fading.This manuscript deals with simulating transmissions over fading channels and presents a comparative study of various input-output channel characteristics in Wireless Body Area Network. The power profile of Wireless Body Area Network with various input-output channel configurations is generated using Weibull characteristics according to NICTA's (previously known as National ICT Australia Ltd) measurement in MATLAB software. It is known that as the distance increases fading occur in the signal as well as in the channel. This work basically deals with the various type of power profile which will be achieved by changing input and output channel configurations. Moreover, channel's power profile has been plotted to get mean fading values using carrier frequency, relative body movement, and scattering density. Here few of the mitigation methods to remove the effect of fading are also discussed.

Keywords: Wireless Body Area Network; Channel Gain; Fading; Input-Output Channel Configurations,;MATLAB

1 Introduction

For researchers, in academics as well as in industry Body Area Networks (BAN) being an emanate technologywhich has its significant applications in various fields including health industry, entertainment, sports etc. Body Area

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Networks (BAN) contains devices that can sense signals even with low power; process data after collecting signals and then transfer data to centralized unit commonly recognized as sink/hub [6, 18]. Various sinks/hubs can be connected in WBAN (Wireless Body Area Network); hence it is considered as a capable interdisciplinary approach which possibly will have a vast influence in advancing healthcare technology [6].Wireless Body Area Network reduces the number of wires and monitoring devices around the human body, thereby improving the quality of life of those who use it for medical requirements [12,13,14,15,16]. Now some essential related to wireless body area network can be discussed as:

Smart Antenna Technology: A wireless technology which uses more than one antenna at the transmitter side and more than one antenna at the receiver side in order to transmit more data simultaneously is known as Multiple-Input Multiple-Output (MIMO) technology [17]. MIMO technology uses a radio wave based multipath phenomenon. In this phenomenon, the information which is transmitted from the input side reaches the destination through receiving antennas at slightly different times and different angles as it bounces off walls, ceilings, and other objects.

1.1 SISO

SISO (Single Input Single Output) is one of the simplest radio link defined so far. This is explained simplest in the context of MIMO. SISO is one of the effectively used standard radio channels. As shown in Figure 1, both transmitter and receiver ends operate with one antenna. None of the diversity technique neither further processing is requisite for this technology.

1.2 SIMO

The SIMO or Single Input Multiple Output is the technique in which transmitters have one antenna and the receiving end have numerous antennas. Such technique is called receiving diversity [7]. It enables the receiver system so that SIMO technique accepts signal from numerous autonomous origins. This will mitigate the fading-effects. To mitigate the impact of ionosphere fading and interference SIMO has been used for many years with shortwave listening (receiving) stations.

Figure 1: SISO - Single Input Single Output

Figure 2: SIMO - Single Input Multiple Outputs

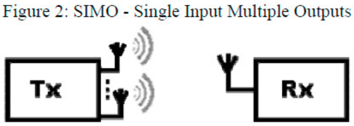

Figure 3: MISO - Multiple Input Single Outputs

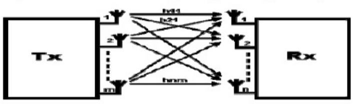

Figure 4: MIMO – Multiple Input Multiple Outputs

Fig.1Multiple Input Multiple Output

1.3 MISO

MISO (Multiple Input Single Output) is also known as transmitting diversity. In MIMO technique, multiple antennas are used to transmit data redundantly. At the destination end, optimum signal is obtained by the receiving antennas which can be then used to extract the required data and processed accordingly

1.4 MIMO

MIMO is adequately used as radio antenna technology. In this technique, multiple antennas are used at the transmitter as well as at receiver end ensuring that a wide range of signal paths are available to transmit and receive data. It enables multiple signal paths method by opting different paths for each antenna as shown in fig 1

In this section, we represent the introduction of WBAN followed by various types of smart antenna technologies. Beyond this; paper is organized as follows: Section 2 represents work done in the related area. Motivation behind writing this article has been discussed in section 3. Section 4 deals with the analysis of various antenna technology parameters using Jakes model. Section 5 covers the result analysis of the simulation and finally in section 6 conclusions are drawn with the remedies to combat distortion in tabular form (including appendix A).

2 Literature Survey

When the signal is picked from WBAN then it is necessary to find out which antenna technology is best to pick signals from the sensors positioned on human body; as signals from the body are of shorter range. The most ordinary matter in all wire-less technology used till time has been the coexistence of various wireless systems. For example, Wireless Body Area Networks are used in hospitals, home, and public areas where other devices using Wi-Fi may exist and interfere. Mostly Wireless Body Area Networks (wireless technologies) operates at 2.4 GHz ISM band causing them to interfere with other nearby wireless technologies operating on the same band [6]. In [12], authors generates power profile for WBAN and showed fading in WBAN using varying carrier frequency and scattered frequency. It is known that the human body is made up of different material like soft tissues and bones which have their own conductivity and permittivity. Nimay et al. [11] explained MIMO's performance with respect to SISO, SIMO & MISO. In that work, it was explained that at high SNR, as the no. of antennas increases the capacity of the system also increases linearly in MIMO. Israa et al. [8] defined routing protocols for reducing path loss using OMNET++. Chao He [2] defined the performance of MIMO in vivo WBAN. He explained 2x2 MIMO system capacities in vivo WBAN in comparison to SISO. He also suggested that after putting antennas on both sides of body better system capacity could be achieved. Radio propagations emitted from sensors employed either inside or near the human body affects the tissues more as compared to other environmental effects. So, channel model designed for Wireless Body Area Network are dissimilar from other environment models. During transmission of data, transmitting and receiving unit is the most important part of WBAN channel. Some models namely static path loss and impulse response are either implantable or wearable sensors [9]. These models use IEEE 802.15.6 technology. As they are a demographical model; all the estimations are done by NICTA (National ICT Australia Ltd) at a particular frequency of 820 MHz [19]. By doing statistical distributions of data in narrowband channels, first-order small-scale statistical modelling has been done [15] to remove interference and in the same any of the fading technique (Rayleigh, normal, lognormal, Rician, Nakagami-m, Weibull, gamma) can be used and calculate channel gain [1, 3, 4, 10]. Hence, this section discusses about literature work related to wireless body area network. Now, next section discusses about motivation behind using of wireless body area network in this article.

3 Motivation

Generally a body area network (BAN), or a wireless body area network (WBAN) or a medical body area network (MBAN), al are synonyms for a body sensor network (BSN). It is a type of wireless network (containing wearable computing devices in human body). In this network, collection of data is being done through connected devices in human's body connected through internet. Using such networks, we can analyse, predict various important decisions related to human being's health (like in e-healthcare applications). Through this, we can save life of millions of human being. Hence, such things motivate us to write something on this respective/ emerging area.

4 Proposed Model

Jakes model can be explained as a sum of sinusoids model. Whenever a model is designed it is necessary to use some standard measurements and parameters. In this comparative study of various channel configurations various parameters such as sample rate, distributed bandwidth etc. are taken from NICTA channel measurements [11]. Performance scrutiny of Wireless Body Area Network recipient has been analyzed using Jakes model [5] (refer table 1, appendix A).

3.1. Algorithm

Based on NICTA measurements channel gain [11] for various input-output configurations, i.e., channel gain is plotted with respect to time using the following steps as shown in fig 2:

Step1: An appropriate dataset of random numbers based on Weibull distribution are created with respect to NICTA parameters.

Step 2: Rayleigh based fading power profile is created through Jakes model.

Step 3: Fade durations and level crossing rate are measured.

Step4: The calculations are then applied on the initial signal to match its fade statistics with NICTA's measurements

Step 5: The mean of the final signal is adjusted according to the mean value as desired by the user.

Step6: Channel gain Vs time is plotted for all input-output configurations.

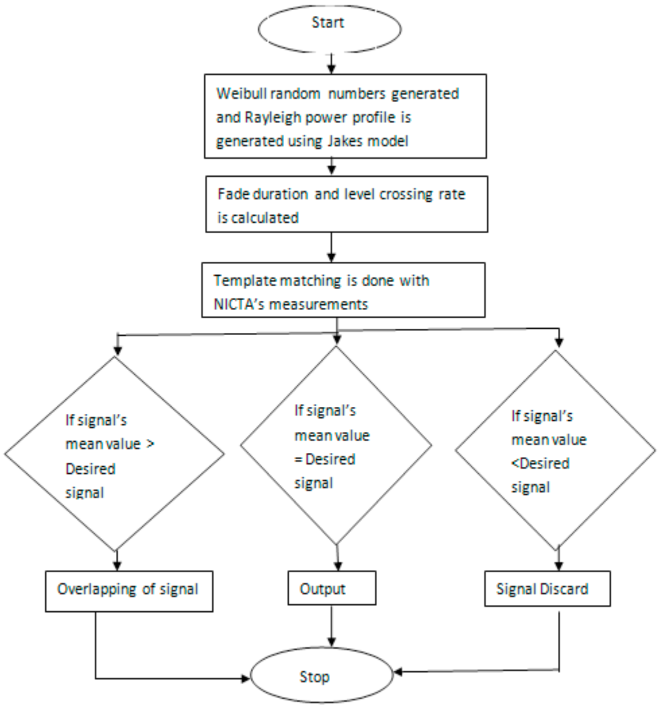

Fig.2. Flowchart for Plotting Input-Output Configuration

5 Experimental Results

It has been observed from Figure 3-6 that the channel gain increases in case of MIMO systems; as compared to all the other configurations. Simulation is done using MATLAB tool. The increase in capacity with various antenna configurations in all the MIMO techniques is plotted as shown in Fig.3-6.

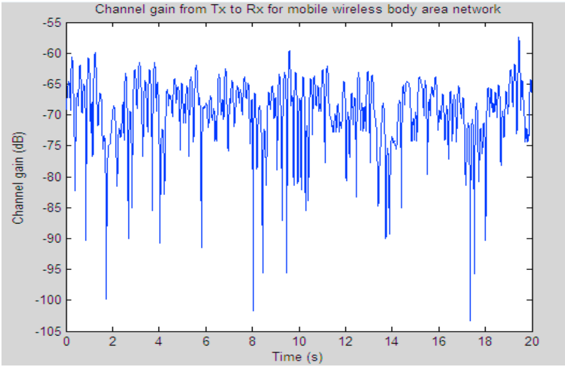

Fig.3. Analysis of Channel gain Vs Time using MIMO

Figure 3 shows that if no. of bits increases with time; channel gain also increases. The advantage of MIMO scheme is that there is more no. of signals to pick up on; although it leads to fading which can be removed by fading mitigation techniques presented in the later part of the paper.

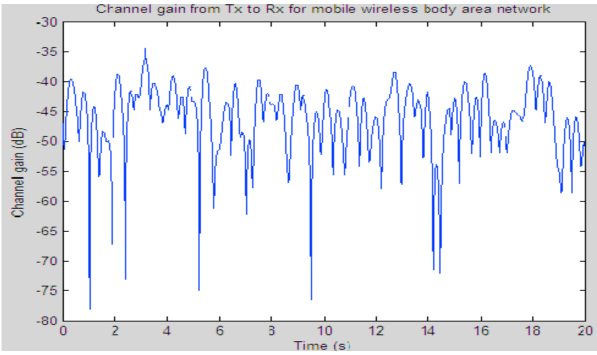

Fig.4. Analysis of Channel gain Vs Time using MISO

Hence figure 4 shows that as the no. of bits increases channel gain increases but is less as compared to multiple inputs multiple output antenna techniques. As path loss is inversely proportional to channel gain; so with an increase in no. of bits, channel gain simultaneously increases.

Fig.5. Analysis of Channel gain Vs Time using SISO

If path loss in SISO is calculated at a particular bit; it is less amongst all techniques, which is discussed in table 2 (refer appendix A).

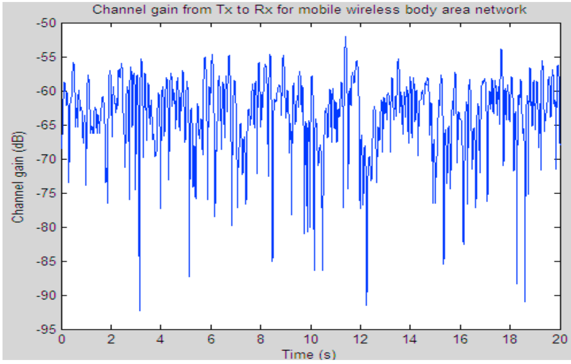

Fig.6. Analysis of Channel gain Vs Time using SIMO

The figure 6 show heavy fading in the signal which is meant for path loss. Table 2 was formed by taking channel gain at a particular time and with particular no. of bits.This shows that in MIMO technology as the no. of bits increases; channel gain increases with time, path loss decreases as the channel gain is inversely proportional to the path loss. With the help of the table above it can be observed that the SISO technique has maximum path loss and has minimum channel gain. So according to this MIMO should be preferred over all technologies. Hence, this section discusses evaluation results in detail. Now, next section will conclude this work in brief with some future scope/ enhancements.

6 Conclusion and Future Scope

Being a deterministic model; jakes model has defined a sum of sinusoids. It is used for simulating time correlated Rayleigh fading waveforms. This work presented a new approach of WBAN (Smart Antenna Technology: SISO, SIMO, MISO, MIMO) using Jakes model. The Jakes model was designed using Weibull parameters and implemented on every smart antenna technology explained in the introduction part. On the basis of which the channel gain was calculated. It was observed that as the channel gain increases, fading decreases; resulting a loss in path loss. This shows that MIMO technology is best amongst the entire above smart antenna technologies. To combat fading either equalization techniques or diversity techniques can be used as remedial measures. The table below presents some of the mitigation techniques to remove path loss mentioned below in the table 3 in appendix A. As present work concerns with the Weibull parameters, future work can be done with lognormal distribution and gamma distribution. Gaussian and uniform random variables can be used for the same purpose.

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Appendix A.

Table 1: NICTA specifications for WBAN

Parameters	NICTA specification	Permissible Range
Carrier frequency (fc)	820MHz	420-2500MHZ
Sample Rate	1Khz	0.75-15KHz
Velocity	1.5-5.5 Km/h	1.5-5.5 Km/h

Table 2. Channel Gain of Various MIMO Techniques

Technique Name / Channel Gain	Channel gain at bit no 12037	Channel gain at bit no 12041	Channel Gain at the bit no 12045	Channel Gain at bit no 12049	Channel Gain at bit no 12054	Channel Gain at bit no 12059	Channel Gain at bit no 12061
SISO	2.16E-06	2.02E-16	1.97E-16	1.93E-16	1.88E-16	1.84E-16	1.80E-16
SIMO	4.34E-04	4.34E-04	4.33E-04	4.32E-04	4.31E-04	4.30E-04	4.28E-04
MISO	2.69E-06	2.68E-06	2.67E-06	2.66E-06	2.65E-06	2.63E-06	2.62E-06
MIMO	6.37E-07	6.34E-07	6.24E-07	6.18E-07	6.14E-07	6.08E-07	6.04E-07

Table 3: Methods to mitigate distortion

To mitigate distortion	To mitigate loss in Signal to noise Ratio
Frequency Selective Distortion • Adaptive Equalization • Spread Spectrum • Orthogonal FDM • Pilot Signal	Fast and Slow fading • Error Correcting Code • Any diversity technique
Fast Fading Distortion • Vigorous Modulation • Signal repetition to extend the signalling rate • Using Code and interleaving	Types of Diversity • Time Diversity • Frequency Diversity • Polarization • Spatial (e.g. Spaced Received antennas)