Conceptual Study of Wireless BAN using Bluetooth/IEEE 802.11n

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Abstract: Enormous development in embedded computing devices, wearable and implantable bio-sensors have led to Body Area Network (BAN). BAN or Wireless BAN (WBAN) is a network of sensors/devices placed over the body. Remote patient monitoring is one of the needs in today's medical field. Apart from this, BAN has a wide range of applications like gaming, personal information exchange, etc. In this paper we present an overview of Body Area Network (BAN) analogous to the human circulatory system. We propose a BAN in which each and every component is analogous to the anatomy of the human circulatory system which includes the heart, veins and arteries and end points of the circulatory system such as finger tips, toe tips, ear lobes, etc. The human heart is considered as a central and the most powerful router or switch and is responsible for pumping blood in and out, which is analogous to a central router in star topology, routing data in a network. The veins and the arteries carry the deoxygenated blood from other parts of the body to the heart and vice versa respectively. Here the wireless connection between central router and other nodes or I/O devices acts as veins and arteries. Finger tips, toes and ear lobes, where the veins and arteries end are analogous to the end points (end devices or I/O devices). Places where branching of veins and arteries take place are considered or assumed to be nodes or network nodes or I/O devices. The frequency of heartbeat or number of beats per minute is analogous to the frequency of wireless transmission connecting the network. This communication is called intra-body communication. Inter-body communication or handshaking can also take place between two different entities or human beings. It is so fascinating to see how artificial body area network can be built based on the anatomy of the human circulatory system.

Keywords: Body Area Network (BAN), Wireless BAN (WBAN), human circulatory system, Intra-body communication, inter-body communication, handshaking

I. INTRODUCTION

A Body Area Network (BAN), also referred to as a wireless body area network (WBAN) or a body sensor network (BSN), is a network of wearable computing devices. BAN devices may be embedded inside the body, implants, may be surface mounted on the body in a fixed position wearable technology or may be accompanied devices which humans can carry in different positions, in pockets, in hand or in clothing.

The raging growth in physiological sensors, low-power ICs and wireless communication has enabled a new generation of wireless sensor networks, used for purposes such as gaming, sports, health, monitoring traffic and custom built WPAN. It is strange to see how a BAN system can be analogous with the anatomy of the human circulatory system. Below are the parts of the human circulatory system and their analogous artificial counterparts:

- Heart ||| Central switch/router
- Veins ||| Wireless data from nodes or devices to the heart
- Arteries ||| Wireless data from heart to nodes or end points
- Regions where veins and arteries end (finger tips/toe tips) ||| end points/stub/end I/O devices
- Regions where branching of circulatory system takes place ||| nodes/ network nodes

The wireless technology used to interconnect these sensors/nodes/end points in star topology, we make use of Bluetooth of 2.4 GHz [1] and IEEE 802.11n standard, having capability to switch between 2.4GHz and 5 GHz [2] according to the bandwidth requirement. This frequency range is preferred due to the following reasons:

- Low power consumption
- Well suited for short range communication
- These frequencies do not cause any harm to the human body
- Less eavesdropping.

II. BLUETOOTH AND IEEE 802.11N

Bluetooth is a wireless technology standard for exchanging data over short distances from fixed and mobile devices, and building personal area networks. Bluetooth is managed by Bluetooth special interest group (SIG) which has more than 25,000 member companies in the areas of telecommunication, computing, networking and consumer electronics. [3]

Bluetooth operates at frequencies between 2402 MHz and 2480 MHz, or 2400 MHz and 2483.5 MHz including guard bands of 2 MHz wide at the bottom end and 3.5 MHz wide at the top end. [4] It operates in the ISM band. [5] Bluetooth uses a radio technology called frequency hopping spread spectrum. Bluetooth is a standard wire replacement communications protocol primarily designed for low power consumption, with a short range based on low cost transceiver microchips in each device. Because the devices use radio (broadcast) communication system, they do not have to be in visual line of sight of each other; however a quasi optical wireless path must be viable. However the Bluetooth operates in a very narrow frequency band and has a very low bandwidth. These days the 2.4 GHz bandwidth is getting crowded [6], and to address the digital noise the 802.11n is chosen which can switch between 2.4 GHz and 5 GHz. When 802.11n was introduced in 2009, it brought with it the ability to communicate with speeds up to 600 Mbps. It has the ability to work either in 2.4 GHz or 5 GHz spectra. The 5 GHz spectrum has the following advantages: [7]

- Users can take advantage of the reduced noise available in the 5 GHz spectrum.
- Faster data rates and, fewer disconnects and more enjoyable experience.
- With a stronger signal and faster throughput, less power is required to get the signal above the noise floor, which will result in better battery life.
- Better network performance
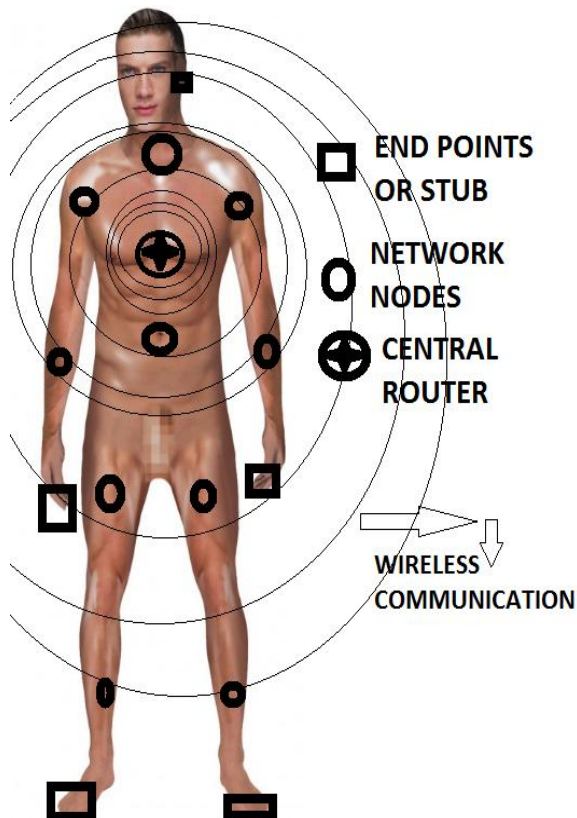- Uses MIMO technology.

III.METHODOLOGY AND SYSTEM DESIGN

Compared with the existing technologies such as WLANs, BANs enable wireless communication in or around a human body by means of sophisticated pervasive wireless computing devices. Figure 1 illustrates a typical BAN developed in this paper. It consists of three major components and a wireless connection/communication between them. They are:

- Central Router

A router is a networking device that forwards data packets between computer networks. A router is connected to two or more data lines from different networks. When there is an incoming data packet on one of the lines, the router reads the address information in the packet to determine the ultimate destination. Then, using the information in the routing table or routing policy, it directs the data packet to the next network on its journey. Static or dynamic routing can be established according to the application. A central router has the following features when compared to a normal router, they are:

1. It is placed centrally, so that all the nodes or end points are approximately equidistant from it (for better performance)
2. It is the most powerful router
3. High memory and computing capability
4. Always placed in the centre of a star topology (or always connected in a star topology)

It is the heart of the BAN and is responsible for forwarding/routing the data packets between nodes or I/O devices or end devices or stub. Figure 2 shows the anatomy of the human circulatory system and its analogous relationship with the system proposed in Figure 1.
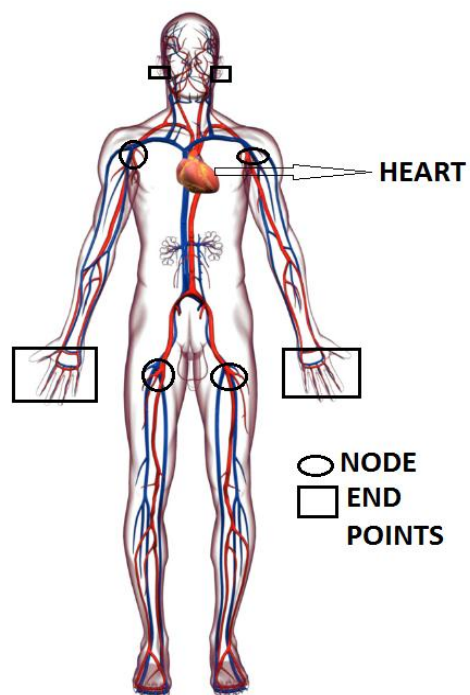

Figure 1 Proposed Body Area Network

Figure 2 Anatomy of the Human Circulatory System

• Network Node

In communication network, a node is either a connection point, redistribution point or a communication end point. Figure 2 shows various nodes in the body where branching takes place. Many I/O devices can be connected to a node. All the nodes are connected to the central router as shown in Figure 2 in star topology. Also comparing Figure 1 and Figure 2, one can observe the analogous nature of the network nodes and the points in the human body where the branching or redistribution of arteries and veins takes place. Nodes can be I/O devices, intermediate devices, repeaters, redistributors or sensors.
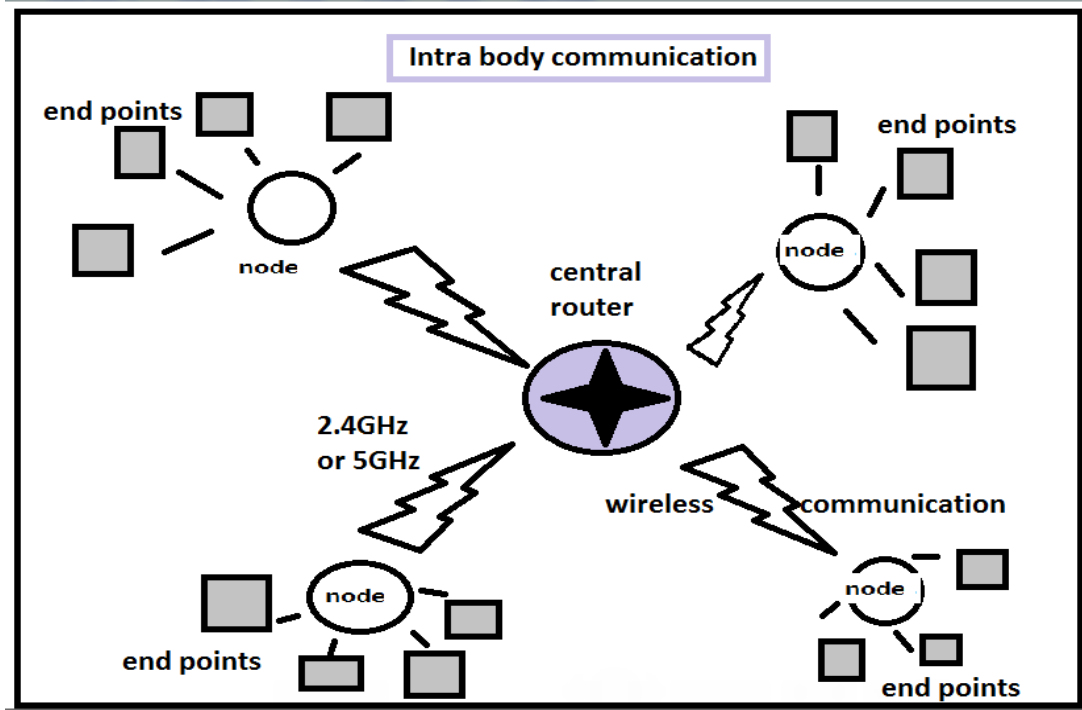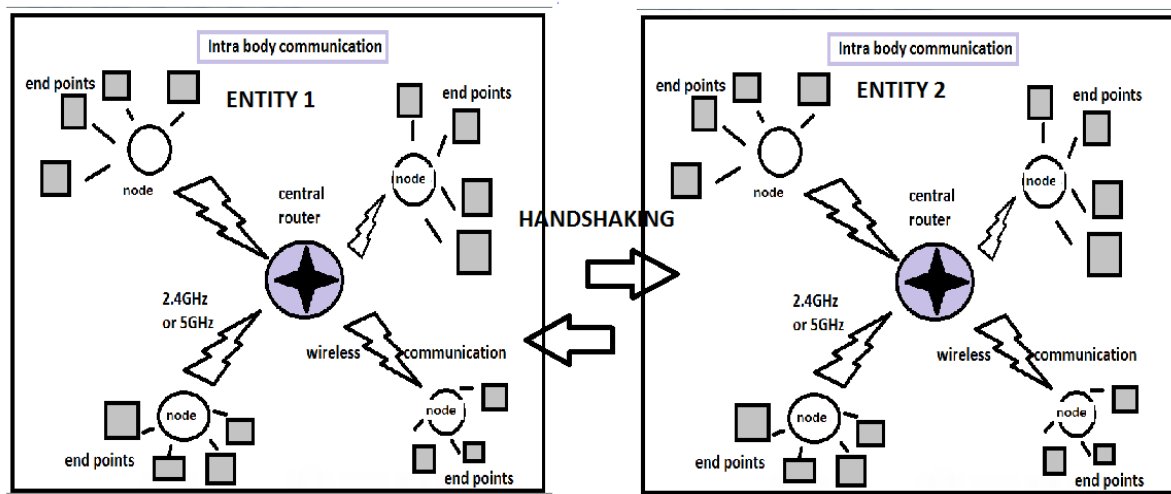

Figure 3 Intra-body Communication

Figure 4 Inter-body Communication

• End Points

Figure 2 shows end points or stub represented by square/rectangle. These are the points at which no further branching or redistribution takes place. These are end points or stub. Finger tips, toe tips and ear lobes are potential end points and usually inter-body communication takes place through these regions. A human being can communicate with another human being by handshaking through these regions.

In this paper we propose two kinds of body area communications

• Intra-body Communication

Figure 3 shows the block diagram of intra-body communication system. IEEE 802.11n is used or simple Bluetooth connection of 2.4 GHz is used according to the requirement of the application. A Bluetooth operates at 2.4 GHz and contains 79 channels of width 1 MHz each. [8] In such a case the bandwidth of the system comes under the scanner and the interference or noise is common.

But it is suitable for places that are not crowded or with minimum number of users. IEEE 802.11n which is a wireless standard, having the capability to switch between 2.4 GHz and 5 GHz can replace the Bluetooth device, to increase the bandwidth and suppress the noise. Also these frequencies dissipate lower power thereby, causing no harm to the human tissue.

- Inter-body communication

Figure 4 shows the block diagram of inter-body communication system. Here handshaking takes place between two intra-body communication units as shown in figure 4. Infrared sensors can be employed for this purpose when the receiver bulb of the second entity comes in contact with the transmitting bulb of the first entity; handshaking takes place between the two entities.

The vice-versa is also possible. After verification or pairing, a connection is established between the two entities constituting an inter-body communication network.

IV. SECURITY

Bluetooth implements confidentiality, authentication and key derivation with custom algorithms based on the SAFER+ block cipher. Bluetooth key generation is generally based on a Bluetooth PIN, which must be entered into both devices. This procedure might be modified if one of the devices has a fixed PIN (e.g., for headsets or similar devices with a restricted user interface).

During pairing, an initialization key or master key is generated, using the E22 algorithm. The E0 stream cipher is used for encrypting packets, granting confidentiality, and is based on a shared cryptographic secret, namely a previously generated link key or master key.

Those keys, used for subsequent encryption of data sent via the air interface, rely on the Bluetooth PIN, which has been entered into one or both devices. In September 2008, the National Institute of Standards and Technology (NIST) published a Guide to Bluetooth Security as a reference for organizations. It describes Bluetooth security capabilities and how to secure Bluetooth technologies effectively.

While Bluetooth has its benefits, it is susceptible to denial of service attacks, eavesdropping, man in the middle attacks, message modification and resource misappropriation.

Users and organizations must evaluate their acceptable level of risk and incorporate security into the lifecycle of Bluetooth devices. To help mitigate risks, included in the NIST document are security checklists with guidelines and recommendations for creating and maintaining secure Bluetooth piconets, headsets, and smart card readers. Bluetooth v2.1 [9] – finalized in 2007 with consumer devices first appearing in 2009 – makes significant changes to Bluetooth's security, including pairing.

V. CONCLUSION

BAN is a promising field in today's medical field [10] and entertainment media. We have proposed a BAN using IEEE 802.11n/Bluetooth technology which can dissipate low power without causing any damage to human tissue which is the most important concern with medical applications.

This proposal will provide a tool to collect all the vital physiological information about the patient and finally transmit to remote sensing area (Hospital). [11] These sensors are embedded on the body or the attire and can be easily replaced when required without actually changing the electronics. The wireless communication ensures the elimination of connecting wires throughout the body, eliminating tangling connections.

ACKNOWLEDGMENT

REFERENCES

[1] "Basic rate/enhanced data rate (br/edr)". Bluetooth.com. Retrieved 3 June 2016.
[2] http://standards.ieee.org/getieee802/download/802.11n-2009.pdf
[3] Newton, Harold. (2007). Newton's telecom dictionary. New York: Flatiron Publishing.
[4] "Bluetooth Radio Interface, Modulation & Channels". RadioElectronics.com.
[5] https://en.wikipedia.org/wiki/ISM_band
[6] https://www.techopedia.com/definition/27785/industrial-scientific-and-medical-radio-band-ism-band
[7] Gomez, C; Oller, J; Paradells, J. "Overview and Evaluation of Bluetooth Low Energy: An Emerging Low Power Wireless Technology" (PDF). Sensors (12(9) 1173411753). doi: 10.3390/s120911734. "A master can manage multiple simultaneous connections with different slaves, whereas each slave can only be connected to one master"
[8] "Basics | Bluetooth Technology Website". Bluetooth.com. 23 May 2010.
[9] "HTC TyTN Specification" (PDF). HTC. Retrieved 4 February 2008.
[10] "Innovative Foot Pressure Mapping Technology On-The-Go Using AndroidApplication" http://www.ijarcce.com/upload/2016/october-16/IJARCCE%20101.pdf
[11] "Tele-Medical Aid System: A Virtual Bridge between Remote VillagesandDistrict/TalukHospitals"http://www.ijarcce.com/upload/2016/november-16/IJARCCE%2026.pdf

BIOGRAPHIES

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