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Wireless Body Area Networks – A Review

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***Abstract*: A network is basically formed when two or more computers connect with each other in order to perform certain tasks, it could be data transfer, file exchange etc. The connection could be either a wired or a wireless connection. Before the advent of wireless communication and technology, the devices in a network were physically connected with wires, example optical fibre cable/Ethernet etc. Needless to mention, there most certainly are quite a few limitations associated with wired communication especially in manually unreachable areas. Henceforth, this calls the need for wireless communication between devices. In a wireless medium, instead of using a wired physical media, we use air/RF signals as the communication link in the network. In this review paper, we specifically lay emphasis on Wireless Body Area Networks or (WBAN); its architecture, types, applications, drawbacks etc.**

***Keywords*: Body Area Networks, Sensors, Wireless communication.**

1. Introduction

In modern technology and current times, wireless communication provides a lot of possibilities to be able to share information to each other anytime/anywhere. A plethora of sectors such as education, health care service & industry utilise intelligent mobile communication networks in order to provide people a convenient way to communicate with each other.[1] The demand of ubiquitous network is ever accelerating as always, and this calls for the indispensable need for information devices that communicate wirelessly. The advent & development of ubiquitous network has put itself into the world market.[5] WBAN or Wireless Body Area Network has now become an application of such technique.

2. Analysis

A. Wireless Body Area Networks

Wireless Body Area Networks or (WBAN's) as abbreviated; consist of independent sensor nodes & actuators that are attached intricately in or on the human body or on the clothes etc. which connect independent nodes. [3] The term being coined in 2001, by Van Dam, this network encompasses over the whole human body and the nodes are adjoined wirelessly via a wireless communication channel.[8] It assists in the accurate measurement of the bio-signals such as heart rate, brain waves, electrocardiogram, blood pressure etc. This technology has a wide variety of significant applications in the medical sector, especially as it permits unrestricted mobility and information share.[3] In addition, it also has a multitude of applications in multimedia, home, health care, remote monitoring, industry, education etc. due to the unconstrained freedom offered in the aspect of movement. The technology is primarily devised and based on Wireless Personal Area Network (WPAN), which assist in limited range communication.

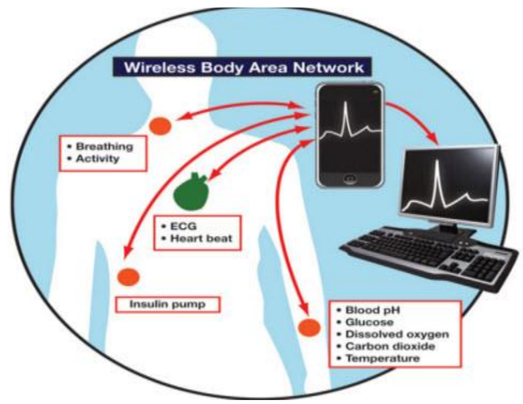

Fig. 1. Wireless Body Area Network

The wireless communication integrated in this technology is primarily of two major classifications,

- In-body communication
- On-body communication

The communication between sensor nodes that are implanted inside human body is called in body communication. For example, the Medical Implantation Communication System (MICS) is specifically used in this type of communication. [9] The communication between wearable devices which consists of sensor nodes primarily is termed on body communication. The Industrial Scientific and Medical band (ISM) and Ultra-wide band communication (UWB) are utilised only for on-body communication. [13]

1) Requirements of WBAN Network

- Low Power Consumption
- Self-Healing
- Quality of Service
- Interoperability
- Deployment
- Data Aggregation
- Security
- Low Complexity MAC and Network Layer
- Fewer false alarms

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- Low Latency
- Maximum required communication bandwidth
- Maximum Power Supply Current
- Communication Setup

The WBAN fundamentally consists of two crucial things, Sensor Nodes & Gateway Nodes – they accumulate data from the human body via sensors. These sensor nodes are connected to the external server and the additional telecommunication networks via the intermediate gateway node.[11] It can either be a WLAN network/ mobile network/ hospital network etc. The collected data is transmitted via 3G/4G network.[7]

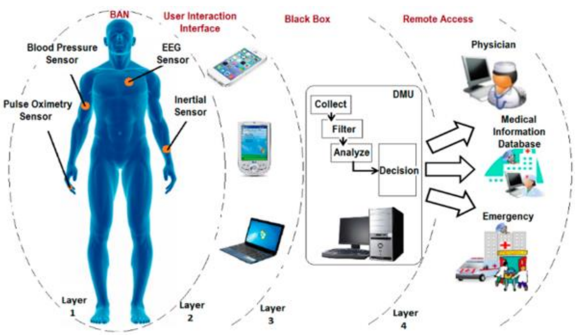

Fig. 2. WBAN Layers

2) Some WBAN standards

The IEEE 802 has established a Task Group called IEEE 802.15.6 for the standardization of WBAN. The IEEE 802.15.6 standard defines a Medium Access Control layer, such as Narrowband, UWB, Human Body Communication layers. The modulation schemes used are DQPSK, DBPSK & GMSK etc. The proper selection of PHYs or frequency bands remains as one of the important issues in the development of WBANS.[7] The available frequencies for WBANs are monitored and sanctioned by communication authorities in various countries. The medical implant communications service band is a licensed band used for implant communications and has the same frequency range of 402 - 405 MHz in most countries. The given last frequency range is 2400 - 2483.5 MHz. [8]

B. WBAN Architecture

The WBAN consists of WBAN part/CCU/WBAN communication/control centre.

The network architecture can be segregated into 4 sections.

1. *WBAN Part:*
   It contains numerous inexpensive and low-power sensor nodes which are utilised for continuous monitoring biometric parameters etc of a person. This does not restrict the mobility of the person for uninterrupted evaluation. Due to its wireless nature.[9] Henceforth, WBAN is extensively used in healthcare systems for persistent physical monitoring. The sensor nodes are relatively inexpensive and consume low power with the appropriate inertial and physiological sensors very strategically placed on the human body.
2. *CCU (Central Control Unit)*
   All the peripheral sensor nodes provide their respective inputs to a central coordination node present in the CCU or the Central Control Unit. [17] The received signals from nodes are processed additionally and transmitted to the consecutive unit for monitoring the human body. There is no predefined wireless technology affixed particularly to target WBAN. Some of the popular wireless technologies used are WLAN/Wi-Fi/GSM/3G/4G/WPAN etc.
3. *WBAN communication:*
   It accepts the data incoming from CCU & is an intermediate gateway to transfer information to the final destination.[15] For example, mobile node is an intermediate gateway to remote station to transmit message to a cellular network via GSM/3G/4G.
4. *Control centre*
   It is primarily responsible for storing user information which can be used in the future or for monitoring purposes. It consists of end devices like mobile phone, computer systems and server etc. [12]

C. Working of WBAN

The WBAN is predominantly designed for its intensive applications in the medical sector. The minute sensor nodes in the network accumulate data and other vital biometric parameters and transmit it to the server via intermediate sub modules. [12] The WBAN communication is secure as the network utilised personal human data, i.e, physiological values. WBAN further utilises cryptographic keys to ensure encrypted, secure information. WSN or Wireless Sensor Networks are different from WBAN in the aspect that the sensors used in WBAN are immensely limited in memory and power. Additionally, the encryption protocols used in WBAN entirely differ from that used in WSN. [11] Plug and play scheme is primarily used in WBAN. The scheme also happens to be compatible and is in congruence with respect to the network topology change. One of the issues faced in this scheme is the menace of security and information leak due to more than ample information being intermittently exchanged. [10]

WBAN uses Medical Implant Communication Service (MICS) band for data acquisition via the sensors that are location intra/inter human body. Remote wireless monitoring uses Wireless Medical Telemetry System (WMTS) band. The local networks transfer data to the remote locations. Should there be multi patient monitoring, Media Access Layer (MAC) layer is implemented on a system-based level. The sensor node captures raw data and serves three main functions –

- Signal Detection
- Digitising and Coding
- Wireless Transmission via a transceiver.

The signal acquired via the human body is amplified in order to intensify signal quality and strength. Subsequently, the signal is digitised via the ADC (Analogue to Digital) conversion module. Post digitisation, the signal is retained in the microprocessor which further is transmitted via a transceiver. [19]

D. *Applications of WBAN*

WBAN is a promising technology which is anticipated to have a rather significant impact on our society as well as in the field of medical/non-medical sector. [11] The particular technology aims at offering secured, deployable wireless transmission of data. Sustainability factors such as affordability, legal, regulatory and ethical issues and user friendliness etc. would also play a paramount role in the effective implementation of the WBAN technology development. [20]

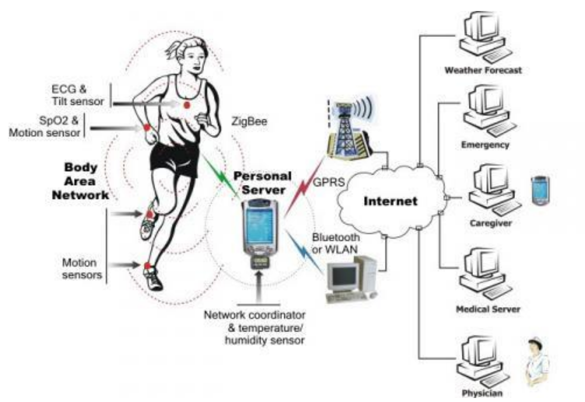

Fig. 3. WBAN architecture

1) Remote health care monitoring

WBAN offers a range of automatic medical services via remote monitoring of a patient's vital organs. Sensors are affixed on the body of patient that are capable of transmitting a variety of biometric signals. [19] These sensors are predominantly of two types - on-body and in-body implants. On body implants are wearable sensors affixed outside or on the body. In body sensors are implanted inside the body in order to measure crucial parameters. [9]

2) Life style & entertainment

WBAN plays an essential role in our daily life as well. Basic services like navigation support while walking/driving, infant monitoring, wireless wearable music system, video call using big screen TV, playback of audio and videos from portable devices etc. are supported by WBAN technologies.[4]

3) Assisted living

WBAN is additionally used in the domain of assisted living in the medical sector. [10] Wearable medical sensors are used at home to measure physiological data from patient's body & retain them into medical centre servers/ control unit intermittently. It enables the consistent monitoring of a patient at home and should there be an emergency, an alarm is raised notifying the nearby medical centre.[14]

4) Telemedicine

Telemedicine offers adequate health care services remotely via information and communication technology. WBAN technology is additionally integrated in the sectors like online medical consultation, medical imagery transmission, medical diagnosis etc. This enables remote monitoring and the doctors can provide e-prescription by monitoring patient's vital parameters.[18]

5) Military

WBANs have immense applications in the military sector. They can be used to communicate between soldiers and send their activities like attacking, running, retreating and digging etc. to the base commander in a battlefield.[14] WBAN sensors assist to monitor health conditions, location, and temperature and hydration levels of soldiers in the battlefield. WBAN can provide more accuracy, survivability and connectivity in implementing clandestine military operation(s)

E. *WBAN Technologies*

Several technologies have been inculcated in WBAN hierarchically.

1) Bluetooth

It is a short-range wireless communication which connects up to eight devices in network. The central network is also known as a pico-net wherein one device is the master whilst the other devices are slaves.[16] The devices integrated in a pico-net mutually exchange roles as per requirements. Henceforth, the assigned roles are only but temporary and variable. A collaboration of two or more pico-nets is called a scatter-net & it is widely utilised in mobile communication etc. [19]

2) ZigBee

It is a power efficient wireless technology utilised mainly in remote areas etc. It can be simulated and initiated via open-source simulators, most of which are additionally integrated with C/C++ libraries.[4] ZigBee predominantly operates on the MAC & Physical layers and can be of three types.

- ZigBee Coordinator
- ZigBee Router
- ZigBee End Device

3) IEEE 802

Set of standards primarily designated for Wireless Local Area Network (WLAN). Media Access Layer (MAC) uses the specification IEEE 802.11 which provides high speed, large scale wireless data transfer. IEEE 802.15.6 happens to be the first WBAN standard & is utilised in several medical/non-medical applications. This standard supports a variety of frequency bands like Ultra-Wide Band (UWB), Narrow Band (NB), Human Body Communication (HBC) etc. for data transfer. [6]

4) Miscellaneous Technologies

Apart from the above-mentioned technologies, there are a variety of additional technologies used for WBAN development. [7] Short range communications primarily use UWB technology which enables a higher bandwidth provision. Another protocol utilised is the ANT protocol; main feature being low power consumption and speed. Another technology is the Zarlink, primarily used for medical applications which work on low data rate and frequency.

F. *Shortcomings in WBAN Technology*

Although WBAN is an immensely profound proposed technology and has a plethora of applications in the medical and the non-medical sector; It also has a variety of drawbacks and challenges to be addressed.[7]

- *Security* **–** This is the main bottleneck for WBAN and ample efforts are being taken and implemented in order to address the security issues and prevent unauthorised access. Intermixing of patient data should be thoroughly prevented. The main security requirements of WBAN include authentication, confidentiality and integrity.

- *Interoperability* – Uninterrupted and flawless data transfer has to be ensured across various technology standards like Bluetooth, ZigBee. Scalability has to be implemented in order to enable uninterrupted network connectivity upon large scale network coverage.
- *Privacy* – WBAN must ensure the privacy and security of the network in order to ensure confidentiality, data encryption & restrict unauthorised data access.
- *System Devices* – The devices implemented in the system must have low complexity, lightweight, efficient power & energy consumption.
- *Sensor Validation* – The data accumulated via the sensors must be validated. This ensures identifying issues in the hardware & software designs. Inaccurate readings may lead to errant data transfer.
- *Data Consistency* – Data consistency must be thoroughly maintained. The data is fragmented and transferred at various nodes in a WBAN network which might more often times than not lead to errors and inconsistencies.
- *Interference* – Wide-scale implementation of WBAN system demands lowered interference which consequentially ensures congruence & coexistence amongst sensor nodes and other devices in the network.
- *Data Management* – An immense amount of data is generated in this type of system; and this calls for the excruciating need of effective data management.

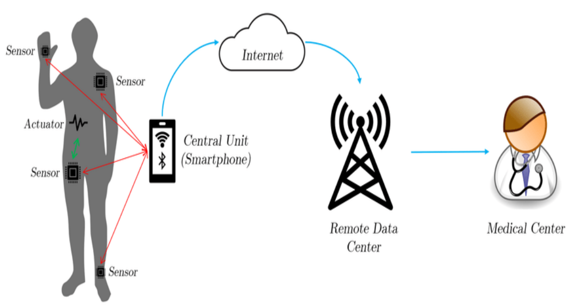

Fig. 4. WBAN modules in health care

3. Conclusion

WBAN technology is exceedingly being incorporated in applications wherein people and their well-being are involved, increasing the involvement of technologies in patients' health. WBAN devices not only provide constant monitoring information about patients but also assist in the effective diagnosis of diseases & espouse appropriate treatments. [1] It is rather crucial to continue advancing in the continuous reliability improvement of the information acquired using the WBAN as well as the device autonomy. [9] This permits the devise of new robust and immune models through techniques such as artificial intelligence and machine learning that can provide monitoring for diseases affecting abundance of the population, whilst taking the assistance of tactile internet and personal gadgets. [6]

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