

### Abstract

With the rapid improvement of wireless communication and semiconductor technologies, the body area sensor network (BASN) is fast developing. The BASN which is also referred to as the WBAN (Wireless Body Area Network), is widely used in medical applications and comprises of Body Sensors attached to human body. These body sensors will help to monitor the interior functions of the body. The data generated by the sensors is transmitted via the internet and collected in external servers which are then used for analysis. The sensors being flexible and compact consume less power and provide a perfect environment for wireless sensing research. The main area of application of the WBAN is the medical field although it can also be extended to other areas like gaming, entertainment, road safety etc. These sensors will help to increase sensitivity and specificity. These days body sensors are emerging as wearable computers such as Computer clothing, Google glass, Smart watches etc which paves the way for using it in many more real time applications. In this paper we have discussed in detail about the architecture, application areas, and characteristics of the WBAN and how they are attached with the human body. WBAN is a sure platform that will dominate all the future wireless applications.

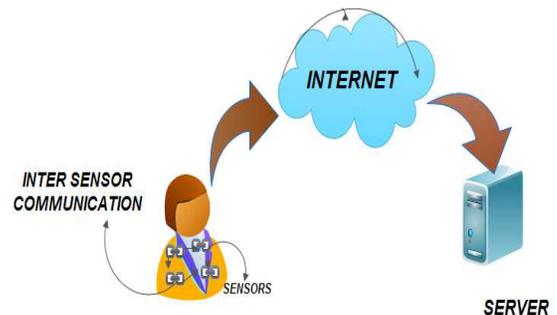
**Keywords:** Wireless Body Area Network (WBAN), Body Area Sensor Networks (BASN).

## I. Introduction

The term WBAN was first coined by Van Dam et al. in 2001 [11] which was followed by the interest of several researchers [5], [7], [8], [19]. The WBAN is a network formed by wireless sensors connected in the body. These sensors generate various data which are applied in different applications such as gaming, medical applications, remote health monitoring, emergency situations, etc. These sensory data can also be stored on external servers and later analysis could be performed. These low power sensor data are transmitted through high power gateway and generate control signals. The WBAN also maintains the security and privacy of sensor data.

## II. Architecture of WBAN

The architecture of the WBAN is represented in Fig 1.



**Fig 1: Architecture of WBAN**

WBAN is a network where the nodes are deployed on the surface of the human body. The number of nodes ranges from 1-20 on a person. The sensors communicate with the network through the following communication interfaces.

- IEEE 802.15.4

The IEEE 802.15.4 standard was devised to support low power, low data rate networks. This is average power consumption of sensors. It works as the star network where the co coordinating device is external to the body.

- ZIGBEE

Zigbee is an operational network having the function of security and encryption. It creates the semi-centralized network. It allows end device to reduce the power but it will maintain the main body sensor node for communication. The services which included are application services, star topology routing.

The attributes of these communication interfaces are listed in table 1.

|                            | Zigbee                                 | 802.15.4                          |
|----------------------------|--|-----------------------------------|
| <b>Physical medium</b>     | Narrow band                            | Narrow band, UWB, HBC             |
| <b>Bands</b>               | ~900MHz                                | ~900Mhz, 3-10Ghz, 16Mhz, 27MHz    |
| <b>Range</b>               | 10-100m                                | 10m                               |
| <b>Power consumption</b>   | Low                                    | Low                               |
| <b>Typical application</b> | Mostly industrial, building monitoring | Sensor nodes in WBAN applications |
| <b>Complexity</b>          | Low                                    | Very low (with HBC)               |

**Table 1: Attributes of the WBAN Communication Interfaces**

### III. Requirements for Body Sensors

- *Value:* Perceived value generated by the sensors has to be accurate. It can depend on many factors, such as assessment ability and user's quality.
- *Safety:* Wearable and implanted sensors will need to be biocompatible to prevent harm to the user. Applications must have fault-tolerant operation.
- *Security.* Security measures such as user authentication will prevent unauthorized access which is key in WBAN applications.
- *Privacy:* The WBAN often deals with sensitive information about people. Protecting user privacy will require both technical and nontechnical solutions
- *Compatibility:* BASN nodes need to interoperate with other nodes. This will require standardization of communication protocols and data storage formats.
- *Ease of use:* Wearable BASN nodes will need to be small, unobtrusive, ergonomic, easy to put on, few in number, and even stylish. The on-body and off-body user interfaces must be very user friendly in terms of information presentation.

### IV. Issues in WBAN

- **Data Confidentiality**  
The applications which are used in the WBAN should have secure data transfer. The eavesdropping [2] on the traffic of messages and snooping of data packets has to be controlled.
- **Data Authentication**  
Only legitimate nodes [15] in the WBAN should participate in the network. It should verify whether the received message from the sender is authenticated.
- **Data Integrity**  
The WBAN should check whether the transmitted message is authorized or not. Data may be corrupted due to physical conditions [2]. This is needed to transmit message without any corruption.
- **Data Freshness**  
Data which is continuously received must be constantly updated. This is very important in certain application such as healthcare. The new messages go through the medical diagnosis and treatments are accordingly updated. Losing of data will lead to wrong treatments.
- **Location privacy**  
The communications between the sensors in the human body will uniquely identifying a person. So the applications based on the WBAN should inherit the location based services to maintain the privacy of the person.
- **Contextual Accuracy**  
WBAN enables to relate the source and destination of the context sensitive information. This information is an important requirement in eHealth applications to relate the patients disease and treatment.
- **Access Control**  
Different users can send and receive information in the WBAN network. It is essential that the information which is transferred is authorized.
- **Non-repudiation**  
The WBAN applications will have the location independent services. It provides service providers for using the services. Repudiation happens when the sender and receiver deny the sending and receiving messages [6]. It is important that the messages are non- repudiated.

### V. Applications

WBAN is currently being used in the wide area of application is shown in the Fig 2.



Fig 2: Applications of WBAN

### 5.1 Medical

The body area sensors are used in following instruments [16]:

- ECG,
- EMG,
- Capsule endoscope,
- Cardiac defibrillators.

The WBAN are widely used in monitoring patient's health and disease penetration. Personal health information such as glucose monitoring, heart beat monitoring could also collected and stored on secured servers [1].

### 5.2 Entertainment

The body sensors are used in:

- Computer games
- Gesture detection

In entertainment sector, WBAN are used in the connecting headphones to the music streaming equipment with higher bandwidth. In gaming devices, they sense the different body postures which will be fed as input to the system.

### 5.3 Lifestyle

WBAN can facilitate the ability to identify a user, recognize their personal information and determine their exact location. In addition to these, they could help in:

- Emotion detection
- Ambient intelligence
- Posture detection.

### 5.4 Sports

The body sensors help in:

- Sport safety
- Blood pressure
- Heart rate monitor
- Activity monitor
- Pedometer
- Weight scale

They help to maintain the body condition and also closely monitor the activity of the sportsmen. Individual medical records are maintained for each member according to the sensed data.

### 5.5 Defence

- Soldiers vital sign monitor
- Blast dosimeter

The intra-communication between soldiers is done by the body sensors. These details can be securely maintained within the campaign. The body sensors are also used in fire fighters for the vital sign monitors.

### 5.6 Consumer Electronics

The sensors could be attached to the human body for the communication and transferring of information to the following instruments:

- Cell phone
- Music player
- Headphones
- Hearing aids

## VI. Types of Body Sensors

These are the some sensors which are widely used in Wireless Body Area Networks (WBAN) apart from medical applications.

- Location sensors
- Identity sensors
- Counting sensors
- Bio-metric sensors
- Photoelectric sensors
- Position sensors

### 6.1 Location Sensors

The location sensors help to find the latitude and longitude position of the individuals. These sensors are mostly used for the military and civilian purposes. This will monitor the personal locations in the potentially untrusted systems. The location information gathered by the sensors is maintained as personal sensitive information [9], [12], [13], [17].

### 6.2 Identity Sensors

Identity sensors communicate with the human bodies to determine the human's exact location and identity. This is adapted in the smart phones for finger

print technology. These sensors help to detect the unique finger print of the authorized user.

### 6.3 Counting Sensors

Counting sensors determine the number of objects or people within its sensing area. The counting sensor produces the *aggregate location information*, i.e., its sensing area along with the number of detected objects within its sensing area, to the appropriate server.

### 6.4 BIO-Metric Sensors

Bio-metric sensors are helpful in identifying the physical characteristics. These sensors will help to detect the physical characteristics of the eye or DNA. Signals contain analog to digital converters and store the digitalized image to authenticate the identity. This sensor which helps to maintain customer security and access control management. It is also helpful in the financial security applications. Private financial data is kept more secure. These sensors are used in the applications of USB devices, enrolment stations, MOC technologies and networking ID verification. Also used in the passwords, keys and PINs for the high reliability and security

### 6.5 Photoelectric Sensors

This sensor helps to detect the distance of object whether it is presence or absence by the using of light emitting diode and infra red. The sensor will have its own function such as modulation, demodulation, amplification and output switching. Some of the self contained sensors will have control timers and counters. Apart from these certain types of smoke detectors also use photoelectric sensors.

### 6.6 Position Sensors

These sensors are also known as speed sensors. They provide information about the position of the component, the speed of the component and the changes in it. It is mainly used to find the speed of object. It is used in vehicle engines and its diagnostic routines. This will measure the output speed and wheel speed.

These are the some sensors which help which helps to identify or transfer the collected information within the WBAN.

## VII. Emerging Technologies in WBAN

In WBAN, the body sensors are used in many real time applications as wearable computers. They are also referred to as wearable or body borne computers and include mini electronic devices or computers attached to the human body. These wearable computers [10] are small in size, close in proximity to the body and are

usable in almost all situations. These act as the intelligent agents performing a variety of tasks depending on the user context. This movement of development of wearable devices that is going on in the electronics and computer industries is called post pc era. Some of the latest inventions include:

- Google glass
- Computer clothing
- Smart watches

### 7.1 Google Glass

Google glasses are made up of optical head mounted display which is created by GOOGLE. It is also known as "Digital eye glass". This is produced by the market as ubiquitous computers [14]. It displays the information as a smart phone which can communicate with the internet through natural language using voice commands. [18], [4]. The services of the GOOGLE GLASSES access the android devices through Bluetooth connection.

### 7.2 Computer Clothing

In this portable android powered devices are integrated with wearable clothes. The conductor fibre in the musical jacket has been developed, which are smart shirts that can read our heart rate and breathing. The light emitting diode (LED) can also be integrated in the musical jackets for the display of text and images. These computerized clothes are ultimate in portable high-tech gadgetry.

### 7.3 Smart Watches

This is another type of wearable computer which is computerized with the functioning of time keeping. Smart watches help to run mobile apps, all mobile operating systems, portable media players which is offering the playback of FM radio, video, audio through Bluetooth. Like computers, smart watches will collect information from internal and external sensors. The main features included are GPS navigation, camera, and scheduler. It will connect with modem, insulin pump or other devices.

## VIII. Conclusion

We have seen how the body sensor network has developed over the years. We have explained in detail about the characteristics, requirements, architecture and the communication interfaces of the WBAN. Though the WBAN was initially developed for medical support, its scope has been widening over the years. The application areas of the WBAN have no boundaries and can surely be extended to other fields too. It can also be integrated with other networks to form hybrid networks. There have

been many real time inventions in this area like wearable computers. Many scientists have been working on this field to bring many more new improvements. WBAN is sure to dominate the world in the next few years and excellent area for new research.

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