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RESEARCH ARTICLE

The WBANs: Steps towards a comprehensive analysis of wireless body area networks

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Abstract

The wireless sensor network (WSN) has been an active research topic for years, extensively used in the military, healthcare, automation and various other applications. Inspired by the WSN, the wireless body area network (WBAN) is a crucial infrastructure for remote health monitoring and treatment, with sensors installed in the human body to detect medical indicators and gather data. These sensor nodes function even in harsh conditions where human communication is difficult, all while operating on a minimal power budget. In this paper, we cover various aspects of wireless body area networks, such as on-body and in-body sensor communication, MEMS and NEMS technology, WBAN architecture, MAC protocols, security threats and applications.

Keywords: Wireless sensor network, Wireless body area network, Sensor, Security, Routing protocols, Energy efficiency.

Introduction

A wireless sensor network (WSN) is a self-organizing network of microscopic sensor nodes that interact with one another through radio frequency signals. It is used on a wide scale to sense, remotely monitor, and comprehend a particular occurrence in order to regulate and comprehend the physical environment. WSN acts as a link between the physical and virtual worlds, enabling the observation of previously unnoticed occurrences at higher resolution on broad spatiotemporal scales. It has several potential uses in industry, research, medicine, transportation, civil engineering, and security. The sound surveillance system (SOSUS) was the first wireless network sound monitoring system with actual parallels to the current WSN, designed by the US Navy in the 1950s to identify and monitor Soviet submarines. Various applications in WSNs are either mature or in the early phases of development, and they are divided into eleven major categories based on the nature of their applications Keerthika M, (2021); Dionisis Kandris, (2020); S. Dharshini, (2022).

Moving on to wireless body area networks (WBANs), are rapidly expanding networks that draw researchers due to the manufacturing of sensors and wireless communication technologies. They are used to gather the main biological constraints of the body's biosensors carried by users and work on the human body. WBANs are made up of indoor and wearable biosensor units or devices that are installed inside and outside the human body, with a focus on compact size and low-power wireless communication. With wireless energy harvesting, these sensor nodes can gather important physiological signals such as electrocardiogram (ECG) data, hypertension, blood glucose, and external environmental information about the human body, as well as perform basic data processing and transferring Xiao Tan., (2021), Qian Yu Xu.,(2019), Jiasong Mu., (2019), Osama Amjad., (2019) Vigyanshu Mishra., (2020) Azeddine Attir., (2023).

Wireless Body Area Network (WBAN)

We use a range of technologies to create WBANs, which are wireless body area networks that employ many sensor nodes implanted in or near the human body to detect and transmit data through wireless channels.

Radio frequency

The introduction of a small-scale biomedical sensor system that utilizes open-source communications has brought

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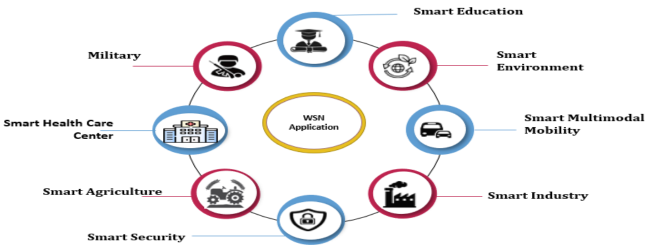

Figure 1: Application of wireless sensor network

about various types of wireless sensors. To be useful in the real world, a WBAN must have small and flawless sensors, controlled hardware, accessible memory, computer resources, and energy efficiency. The United States Industrial Science Medicine recognizes the importance of medical WBANs in the 2360-2400 MHz range, and IEEE 802.15.6 is allocated in collaboration with the Federal Communications Commission to address service disparities in short-distance communications in the human body Ruslan Dautov., (2017).

The IEEE 802.15.6 standard, based on radio frequency technology (RF), includes ZigBee, Bluetooth, BLE, and BAN and has a low specific absorption rate (SAR) requirement. The SD-WBAN nodes have a restricted power supply and are situated in the human body, which means they can be charged but not replaced. The IEEE 802.15.6 standard creates a one-hop or two-hop star topology, establishing the physical and data connection levels, and uses a single coordinator terminal as the HUB, which connects to multiple sensor nodes Vigyanshu Mishra., (2020), Oussama Haddad., (2020), Ghufran Ahmed.,(2018).

The IEEE 802.15.4 MAC standard enables low data rate protocols with up to 250 kbps packet data rates, and the network architecture consists of a fully functional device (FFD) and a reduced functional device (RFD) that combines all of the network's components. The primary goal of the WBAN MAC protocol is to minimize power consumption, collisions, delays, idle time, and retransmission while also ensuring that all data relating to critical events in the human body reaches the sensor with the shortest possible delay Murtaza Cicioglu (2020), Kefa G.Mkongwa (2021), Ananda Kumar Subramanian (2021).

There are three types of hop networks: single-hop, multi-hop, and both single-hop and multi-hop networks. Single-hop networks are made up of n nodes, and packets are transmitted directly from sources to destinations. Multi-hop networks transmit a wake-up signal to the next node before the wake-up receiver returns to "sleep" mode, while protocols using both single-hop and multi-hop schemes transport data from cluster heads to base stations Elie Zaraket (2021), Ikram Daanoune (2021).

WSNs versus WBANs

A WSN is a wireless network consisting of small, low-cost, and low-power devices that communicate with each other through wireless channels. WSN is primarily used to collect

Table 1: Comparability between wireless sensor network and wireless body area network

Problems	*Wireless sensor network*	*Wireless body area network*
Tracking	Environmental monitoring	Human Body
Range	Meters to kilometers	Centimeters to meters
Bio-compatibility	Not-important	Very important
Channel	ISM	Medical channel, ISM, body surface fewer.
No. of. nodes	Many nodes are required but the widest path is covered.	Fewer (or) Limited nodes
Node size	No requirement	The smaller the better
Node life	Week/Months	The Longer the better
Node energy	Replaceable	Irreplaceable
Task of node	Dedicated task	Multiple task
Node placement	Replaceable	Irreplaceable (Difficult to replace)
Accuracy of result	Through node redundancy	By node accuracy and strength
Network topology	Very likely to be fixed or static	More variable due to body movement
Data loss	Tolerable (ability)	Intolerable
Power needed	Large	Low
Power supply	Easy and frequent	Compatible system
Energy scavenging sources	Wind energy and solar energy	Motion, Thermal heat
Safety	Low	High
Impact of data loss	Compensated by unwanted node	Very remarkable
Technology	Compensated by excess nodes like Bluetooth, GPRS, WLAN.	Low-power technology required.
Standard	IEEE 802.11.4.	IEEE 802.15.6.

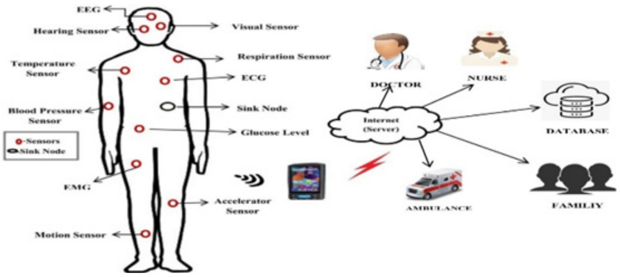

Figure 2: Wireless body area network in healthcare

environmental data, such as temperature, humidity, and air quality, and transmit it to a base station. In contrast, a WBAN is a specialized application branch of WSN that consists of several sensor nodes installed in or around the human body to perceive data and transmit it over wireless channels (Figure 1).

While there are many similarities between WSN and WBAN, there are also significant differences. For example, WSN devices are often stationary and placed in a fixed location, whereas WBAN devices are mobile and move with the human body. Moreover, WSN devices are generally not required to adhere to strict safety regulations, whereas WBAN devices must adhere to specific safety regulations to ensure the safety of the human body Rahat Ali Khan., (2018). Bendjehich Romaissa., (2017); A. M. Vinu Mohan (2020), Jianxiong Zhu (2020), Yating Qu (2019).

ON-Body and IN-Body Sensor Communication

In the 1990s, the Massachusetts Institute of Technology established the WBAN based on the idea of connecting electrical devices to the human body. The WBAN sector was pioneered in 2001 by Van Dam *et al*. However, as early as 1996, when mobile devices gained popularity, Zimmerman was focused on how these devices interacted with the human body. Initially, the network was called a "personal area network" (PAN), and then later renamed the body area network (BAN). Today, WBAN is integrated with various networks and devices to provide remote monitoring services, with health monitoring being one of its most significant applications. Figure 2 illustrates this A. Tavera (2020), Swati G. Mavinkattimath (2019).

WBAN, or wireless body area network, is a technology that has many benefits in the healthcare sector. It focuses on disease prevention and cost reduction while also aiding patients in monitoring and managing chronic diseases. Comparability between wireless sensor network and wireless body area network as shown in Table 1. One of the benefits of this technology is its ability to create personalized medication for patients. Sensors play a critical role in WBAN, with three primary functions: perception, processing, and communication with medical services for further analysis. During the realization process, sensors monitor or sense the parameters they are capable of comparing and saving the data they acquire before transmitting it to the sink for additional communication or processing before being delivered to the sink. In-body sensors are known as invasive sensors, while on-body sensors are non-invasive and wearable sensors. Some of the ongoing and completed initiatives for the benefit of WBAN patients include CodeBlue, Mobi Health, iSIM, and UbiMon. WBAN is used to monitor patients continuously with various disorders such as hypertension, Parkinson's disease, renal failure, postoperative depression, and sudden infant death syndrome. Table 2 displays the differences between in-body and on-body sensors. Advances in digital health are also expected to assist healthcare providers Ananda Kumar Subramanian (2021), Rahat Ali Khan (2018).

Table 2: Implantable and wearable sensor

ON-body/wearable sensor	*IN-body/implantable sensor*
Intraocular pressure sensor	Cerebral pressure Sensor
Microneedle drug delivery system	Pacemaker
Wearable UV exposure	Implantable blood analyzer chip
Glucose sensor	Implantable brain activity sensor
Wearable skin sensor	Wireless capsule endoscope (Electronic pill)
Smart contact lens	Implantable pressure sensor
Temperature sensor	Middle ear MEMS microphone
Pressure sensor for damaged nerves	Electronic pill for drug delivery
Non-invasive blood monitor	Retina implants
Concussion sensor	Nanoparticle-based cancer bio-marker sensor
Dietary spectrometer sensor	
PH-value, and oxygen-value	

MEMS and NEMS Technology

A WBAN is a network of intelligent wireless devices that monitor a specific parameter based on user requirements or around the body. These devices, also known as sensors and actuators, are designed to be autonomous and have processing and storage capabilities, allowing them to collect, analyze, and transmit data to a sink. The ultimate goal of WBAN is to simplify people's lives by simplifying their everyday routines Bendjehich Romaissa (2017).

There is a significant amount of research being conducted in the field of e-healthcare, with many sophisticated systems relying heavily on sensors, particularly WBAN. Therefore, the size and ease of use of sensor nodes are critical in this setting. Advances in electronics, such as micro-electro-mechanical systems (MEMS) and nano-electro-mechanical systems (NEMS), have made all of this possible. MEMS and NEMS are categorized into two types: flexible and interface Rahat Ali Khan (2018).

In recent years, flexible sensors have been extensively studied due to their versatility and enormous potential in health and other intermediary applications. The flexible sensor is typically combined with a wearable sensor due to its specific features. It can be used as a wearable device for tracking purposes and as a human-machine interface to detect high demands. Wearable electronics can be easily integrated into the human body to extend our senses, displaying pressure, strain, electrophysiology, temperature, blood oximetry, and other sensitive functions of wearable (Tech Tats) electronics.

Sensor interfaces have also been widely researched to create high-efficiency energy harvesters, sensors, and actuators with high output efficiency, easy manufacture, no material limit, flexibility, excellent adaption, and cost-effectiveness compared to other approaches A. M. Vinu Mohan (2020), Jianxiong Zhu (2020).

Poor posture and continuous work cause various physical discomforts such as back pain, headaches, neck pain, tight knots, poor blood circulation, poor digestion, and lack of focus. Go-pose gadgets are quite beneficial for tracking posture and delivering performance data on our devices. Air control of all the snow on smart devices with the AI mouse is another example of wearable gadget technology.

The rest of the text is organized as follows: WBAN Architecture, WBAN and MAC Protocols, WBAN Security Threats, WBAN Applications, and Current WBAN Technology, as well as the Conclusion.

WBAN Architecture

The WBAN communication structure consists of three tiers: Tier 1 is intra-BAN communication, Tier 2 is inter-BAN communication, and Tier 3 is beyond-BAN communication. In humans, various sensors are placed on the body, including EEG, ECG, EMG, glucose level, blood pressure, heart rate, and motion sensors. These sensors send data to the sink node, which is then transferred to the base station and eventually to the medical database or outside world, as depicted in Figure 3 - Architecture of WBAN Communication. The purpose of Tier 3 communication is to enable communication between physicians and patients Tallat Jabeen (2021), Indrajit Pandey (2019), Muhammad Shadi Hajar (2021).

The WBAN communication structure is divided into three layers.

Tier-1: Intra-BAN Communication

The first tier is Intra-BAN communication, which includes the interaction between the sensors. The nodes themselves and the sensor nodes communicate through wired or wireless connections, and the data rate depends on the properties of the sensor nodes and the physical layer and frequency used Indrajit Pandey (2019), Muhammad Shadi Hajar (2021).

Tier -2: Inter-BAN Communication

The second tier is Inter-BAN communication, which involves communication between two different BANs and communication between the central hub and access points. APs can be strategically placed in the environment to handle emergencies. This layer connects different types of networks to each other, using wireless technologies such as ZigBee, cellular, 4/5G, and Bluetooth Muhammad Shadi Hajar (2021), Rahat Ali Khan (2018).

Tier -3: Beyond-BAN Communication

The third tier is Beyond-BAN communication, designed for use in the metropolitan area network (MAN). It transmits data to remote parties, connecting the BAN network with the Internet to distribute data collected over long distances. IEEE has provided a special standard communication protocol for 802.15.6 to deal with channel gain and path loss, and the TCP/IP layer defines all protocols for this series of interactions Rahat Ali Khan.,(2018), Muhammad Shadi Hajar.,(2021), Hishan N. Almajed.,(2019), Arti Gupta.,(2019).

WBANs and MAC Protocol

To ensure energy efficiency in WBAN, the design of the PHY and MAC layers can be upgraded to an efficient hop system or adaptive duty cycle. This is particularly important as battery replacement for implanted sensors is costly and requires major surgery. A multi-layer architecture using the Time Division Multiple Access (TDMA) based MAC protocol has been proposed for WBAN. It consists of sensor nodes in the first tier, primary nodes in the second tier, and a monitoring station in the third tier. However, this proposal

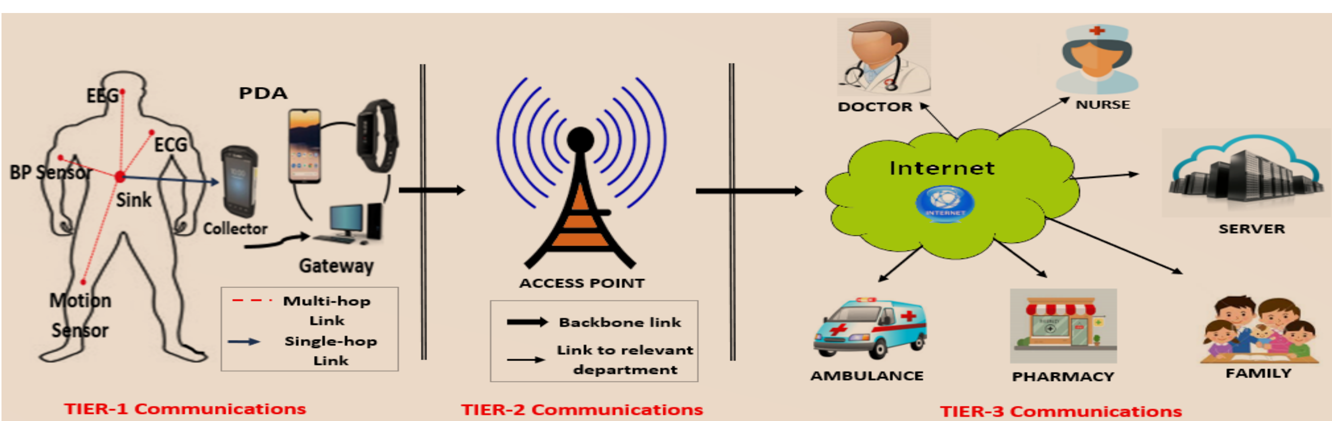

Figure 3: Architecture of WBAN communication

requires a secure channel, and adjusting transfer power may compromise energy efficiency. A path loss model can be used to improve energy efficiency. Single-hop communication has been found to be inefficient due to distance and line of sight issues. In these cases, multi-hop WBAN is more advantageous than single-hop, especially when the transmitter is on the back and the receiver is on the front Khalid Hasan.,(2019).

MAC Protocols

Adaptive MAC protocols are an essential requirement for Wireless Body Area Networks (WBANs) to support traffic effectively [18]. In this regard, traffic adaptive MAC protocols have been categorized into three types by experts: MAC protocols based on traffic load assessment (TLE), MAC protocols based on Adaptive Wake-up Interval (AWI), and MAC protocols based on adaptive time slot assignment (ATSA). Once categorized, the performance of these protocols is evaluated based on three criteria: delay, pocket distribution rate (PDR), and energy consumption Dalal Abdulmohsin Hammood., (2020).

In this text, we can find a discussion about the different types of MAC protocols that can be used in wireless body area networks (WBANs). The first type mentioned is the collision-free MAC protocols, which are divided into scheduling-based and polling-based protocols. Scheduling-based protocols use TDMA to avoid collisions between nodes, and each slot is allocated to transmit signals to a node. However, classical TDMA has some downsides, such as the need for node synchronization and energy consumption, and the difficulty of agreeing on slotting duties. On the other hand, polling-based protocols are based on the polling station access method and avoid collisions by using the polling mechanism. The primary issue with these protocols is the vote delay and the risk of the whole channel collapsing if the primary hub fails Abdul Saboor.,(2018).

The second type of MAC protocols mentioned is the condition-based MAC protocols, which are not reliant on set time intervals. These protocols are based on Carrier-Sense Multiple Access with Collision Avoidance (CSMA/CA) and allow nodes containing data for transmission to compete for medium access. These protocols are simple, versatile, and long-lasting, and they can more readily detect changes in traffic/density and distribute resources as appropriate. However, the waste of energy resources due to collisions and contentions is a key weakness of contentious protocols Abdul Saboor.,(2018).

Finally, the text talks about hybrid MAC protocols, which combine both contention-based and schedule-based protocols. These protocols use active-sleep duty cycles to split time into frames, reducing energy waste caused by passive listening. While many solutions have high energy economy and delay performance, real-time service support still has several hurdles. Hybrid MAC protocols provide the best and most efficient characteristics for real-time applications, but there are many more issues to be discovered in sensor networks and the hunt for an adequate solution for real-time communication and energy efficiency (Figure 4).

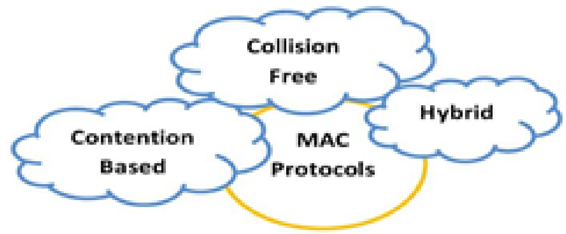

Figure 4: Classification of MAC Protocols

WBANs Existing Algorithm

Wireless body area networks (WBANs) use sensors placed on or near the body to monitor and send data, which can be utilized to track health, detect medical issues, and offer feedback for medical treatments. There are various algorithms and kinds of WBANs that exist to gather and send data, including Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), Code Division Multiple Access (CDMA), Orthogonal Frequency Division Several Access (OFDMA), Adaptive Modulation and Coding (AMC), Multiple Input, Multiple Output (MIMO), and Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). These protocols allow for more efficient use of available bandwidth, lower inter-node interference, and faster data rates with greater dependability.

Wireless body area networks (WBANs) use sensors placed on or near the body to monitor and transmit data. To achieve this, numerous algorithms and types of WBANs are available. These include:

Time Division Multiple Access (TDMA)

It divides available bandwidth into time intervals, and each node is assigned a specific time slot to transmit data, which results in more effective bandwidth utilization and lower inter-node interference.

Frequency Division Multiple Access (FDMA)

This approach divides available bandwidth into frequency bands, and each node is allocated a specific frequency range for data transmission, leading to better bandwidth utilization and lower inter-node interference.

Code Division Multiple Access (CDMA)

CDMA employs spread spectrum technology and assigns unique codes to nodes, allowing multiple nodes to use the same frequency band without interfering, leading to better bandwidth utilization and lower inter-node interference.

Orthogonal Frequency Division Several Access (OFDMA)

OFDMA divides available bandwidth into multiple sub-channels, and each node is assigned a unique sub-channel for data broadcasting, resulting in more effective use of available bandwidth and lower inter-node interference.

Adaptive Modulation and Coding (AMC)

This multiple access protocol uses adaptive modulation and coding techniques to assign unique modulation and coding schemes to nodes, allowing them to use the same frequency band without interfering, which results in better bandwidth utilization and lower inter-node interference.

Multiple Input, Multiple Output (MIMO)

This technique uses multiple antennas at both the transmitter and receiver ends to allow multiple nodes to use the same channel, which results in faster data rates and greater dependability.

Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)

In WBANs, CSMA/CA is a multiple access approach that uses carrier sensing to detect if the channel is free before attempting to broadcast, reducing collisions and improving efficiency.

Overall, the availability of various protocols and techniques for WBANs ensures better bandwidth utilization and lower inter-node interference, making them an effective tool for monitoring and transmitting health data.

WBAN Security threats

Communication data is critical in every network, especially in the case of Wireless Body Area Networks (WBAN), which are connected to the human body. If communication routes are not sufficiently secure, attacks such as traffic damage, message injection, message replay, or cheating can occur, which can lead to disastrous consequences. This could include not only infringement on privacy, but also serious physical harm.

One real-life example of this was the cyber-attack that Banner Health, an Arizona-based healthcare company, experienced in mid-2016. The attack exposed the personal information of 3.62 million patients, including names, credit card numbers, dates of birth, social security numbers, physicians' names, and health care information. This was one of the most severe HIPAA security breaches in history. Additionally, it was discovered that even compatible heart-monitoring devices were vulnerable to wireless compromises.

To safeguard users from such threats, it is crucial to implement effective security measures. However, the security structure of WBAN is more challenging to implement than that of other networks. The security architecture of the WBAN must meet performance criteria such as speed, scalability, and usability. Communication inside the WBAN may be separated into internal and external communication.

The internal communication within WBAN necessitates security measures to ensure data and resource dependability, confidentiality, integrity, and availability. Public-key encryption techniques are employed to ensure data dependability, while encryption is used to protect data confidentiality. Message Authorization Codes (MACs) or hashed MACs are used to ensure data integrity. Due to the vulnerability of the physical system in WBAN, the availability of data and resources is critical. Hackers often target denial of service (DoS) assaults, which can cause other sensor services to become unavailable. Therefore, it is essential to implement measures to prevent such attacks.

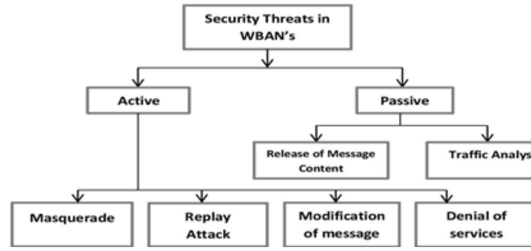

Figure 5: Security threats

The Communications Act categorizes attacks into two types: passive and active. Figure 5 illustrates that passive attacks are divided into two categories, while active attacks are subdivided into four types.

Release of Message Content

Passive assault, attacker reads message and releases it, recipient may experience delay.

Traffic Analysis

Intruders examine message content, note form or origin to determine location, difficult to detect as data is not altered.

Masquerade

Attacker creates a mask to disguise as a legitimate user, may steal data or gain access to computer.

Replay Attack

Passive collection of data unit and re-transfer to achieve illegal effect, attacker feeds legal data repeatedly to jam or delay data delivery.

Modification of the Message

Message content altered or recorded resulting in delayed or unrecognized impact.

Denial of Services

Attack renders network inaccessible, high load, flood server with traffic until it shuts down.

WBAN communication processing layer is vulnerable to tampering and jamming attacks due to reliance on radio frequencies. Jamming technique emits radio signal at random frequency, while cryptographic keys and computer code can be corrupted in tampering attacks.

MAC layer handles frame detection, multiplexing, and channel access, vulnerable to collision attacks that result in a fast rise in the back-off pocket. DoS can occur due to the

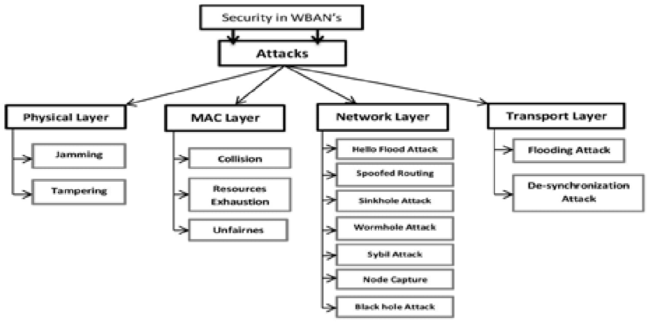

Figure 6: The classification of attacks

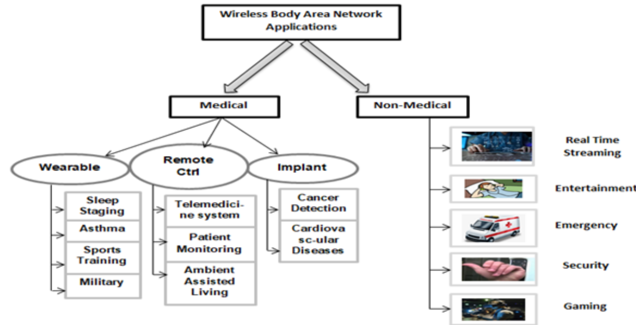

Figure 7: Wireless body area network applications

continual exchange of corrupted packets. The classification of attacks as shown in Figure 6.

Rogue nodes may impress themselves as the greatest coordinator and make adjustments to collected data, while a Sibyl attack can occur if a node has numerous network IDs. De-synchronization attacks involve transmitting a pseudo control flag or serial number to both ends of the active connection Muhammad Asam.,(2019), Pangkaj Chandra Paul.,(2019), Sagarika Karchowdhury.,(2019), Ismail Butun.,(2019).

Applications of WBAN

Because of its numerous advantages, WBAN is now used in a variety of applications. W-Healthcare BAN allows for remote data monitoring, diagnostic interfaces, and healthcare in hospitals. Patients can be continuously monitored and receive necessary medications without being tethered to large-scale equipment. Popular applications that employ WBAN are listed in Figure 7 (Body Area Network Application).

In medical situations, sensor nodes connected to the human body can be used with WBAN. These nodes wirelessly transmit biological information over short distances to a control device that is either worn or has access to one. Sensor nodes must be electronically miniaturized, low-power, and include medical signals. Patients with chronic conditions such as cancer, obesity, heart disease, and diabetes require continuous monitoring. WBAN is used to continually monitor such patients, with a focus on the health of the elderly. Real-time physical health monitoring and monitoring of the elderly's living environment are particularly necessary to improve health services. Table 3 discusses medical uses Bhawna Narwal.,(2020).

Medical Applications

Sensor nodes must be electronically miniaturized, low-power, and include medical signals. They are wirelessly competent and can send biological information from the human body over short distances to a control device that is worn or has access to a control device. Patients with chronic conditions such as cancer, obesity, heart disease, and diabetes require continuous monitoring. WBAN is used to continually monitor such patients, with a focus on the health of the elderly. Real-time physical health monitoring and monitoring of the elderly's living environment are particularly necessary to improve health services Swati G. Mavinkattimath.,(2019).

• *Military*

In military operations, WBAN may improve accuracy, survivability, and connection. WBAN sensors may be used to monitor troops' health, location, temperature, and hydration level. Cameras, GPS, monitoring sensors, and RF may all be implanted into military uniforms. The sensors in the surroundings assist controllers in tracking faraway places and making the best selections. WBAN may be used on the battlefield to communicate amongst troops and relay their operations, such as assaulting, running, retreating, and excavating, to the base commander.

• *Sports Players*

WBAN-enabled devices may be worn during training to monitor physical activities, such as heart rate, temperature, respiration rate, blood pressure, activity, and posture. WBAN sensors may be used to measure navigation, timing, and distance. Observed values will be saved as feedback for

Table 3: WBAN Medical Application

Wearable	*Implantable*	*Others*
1. Asthma 2. Sleep Staging 3. Evaluation of soldier exhaustion and battle readiness 4. Assistance to professional and Non-professional sport training 5. Fall detection.	1. Diabetes 2. Cancer Detection 3.Cardiovascular diseases. 4. Artificial retina 5. Neurostimulator for brain 6. Pacemaker 7. Bionic ears.	1. Rehabilitation and Therapy 2. Remote Monitoring 3. Ambient Assisted Living 4. Bio-Feedback 5. Telemedicine 6. Virtual Doctor and 7. CodeBlue, Mobi Health, iSIM and UbiMon.

future usage, making the player more efficient enough to provide a satisfactory response, and they will be used to compare the two players Rahat Ali Khan.,(2018).

- *Asthma Monitoring*

The asthma monitoring system assists asthma patients in identifying risk factors for asthma exacerbation. Adolescents suffer from severe asthma. Asthmatics should start taking albuterol as soon as possible. Agents or factors that cause allergies can also be tracked using WBAN sensors, which are useful for people who suffer from allergies or asthma. Asthma is more common in adolescents, and half of all adolescent asthmatics do not take their medication correctly. Understanding why this is occurring is critical to improving their outlook and quality of life. Asthma is thought to be linked to air pollution and climate change S. Dharshini.,(2022), Alan Kaplan.,(2020).

- *Fall Detection*

Fall detection is important not only in senior communities but also in workplaces and daily activities. The most deadly falls occur to those over the age of 65. There are two kinds of fall detection systems: (1) self-aware systems and (2) wearable systems Patients who utilize this solution are carefully watched, and their compliance is strictly enforced. Furthermore, the environmental orientation renders this technique inefficient in many application contexts. It is also driven by WBAN. A fall diagnosis can be devastating for people, resulting in limitations in movement or, in the worst-case scenario, traumatic death. The World Health Organization (WHO) estimates that the risk of accidental or unintentional fatalities is the second greatest cause of mortality globally each year Luigi La Blunda.,(2020).

- *Sleep Monitoring*

Sleep disorders affect a substantial part of the population, with sleep apnea thought to affect more than 100 million people worldwide. Sleeping is a necessary activity as well as a rhythmic physiological function. Sleep breathing, for example, affects 4% of men and 2% of women in European nations and has a direct influence on a patient's quality of life. The socioeconomic consequences include drowsy driving, workplace sleeplessness, and heart disease. WBAN technology can be used for wireless sleep mode to improve patient comfort. WBAN sleep monitoring makes it extremely simple to keep track of a specific individual or patient Mahammad Firose Shaik.,(2019).

Skin-Cancer Detection

Skin health monitoring is critical since the skin is the body's largest organ that is exposed to the environment. Unfortunately, people with skin issues are often subjected to societal shame and estrangement. WBAN is extremely effective in both diagnosing and treating specific skin cancers. Skin problems may vary in severity, from a little rash to a life-threatening injury. The CDC estimates that over 13 million workers are at risk of skin exposure to harmful chemical agents, which can lead to a variety of serious health problems.

- *Cancer Detection*

Cancer is a major cause of mortality worldwide and a significant obstacle to increasing life expectancy. According to WHO, cancer is the primary or second major cause of death before the age of 70 in 112 out of 183 nations studied. It is also the third or fourth leading cause of death in 23 countries. The large decline in mortality rates from stroke and heart disease in many countries highlights the importance of cancer as a leading cause of death. Clinicians can detect tumors by combining WBAN with miniaturized sensors capable of monitoring cancer cells Hyuna Sung.,(2021).

- *Heart Disease*

Heart disease is often seen as a concern for others, but it is the leading cause of death in the United States and a major contributor to disability. There are several types of cardiac disease, with coronary artery disease being the most common cause. This disease, which develops over time, is caused by constriction or blockage of the coronary arteries, which supply the heart with oxygen and nutrients. It is one of the primary causes of heart attacks.

- *Diabetes Control*

Diabetes is one of the most prevalent chronic diseases in the world. It is measured by glucose levels, which can be measured using several methods, including the IR glucose measurement method. This method is fast, accurate, and painless for patients Mahammad Firose Shaik.,(2019).

- *Telemedicine System*

WBAN technology has the potential to be used in telemedicine, which uses information and communication technologies to deliver remote healthcare. Telemedicine can be implemented anywhere and at any time, and WBAN can be a useful tool in this area.

Non-Medical Uses of WBAN

WBAN technology has numerous applications beyond medical purposes. The following are some examples of non-medical uses of WBAN, as shown in Table 4.

- *Emergency Response*

In the event of a fire, smoke detectors can sound an alarm. However, for the elderly who are deaf, the fire may be silent. WBAN sensors located outside the body can detect the severity of the situation and help people stay safe. These sensors are crucial in preserving workplaces and saving lives, not only in homes but also in industries that may be impacted by fire or toxic gas Khalid Hasan, (2019).

- *Fitness Monitoring, Real-time Streaming, Lifestyle, and Relaxation*

Many devices are now used for physical fitness and health. For example, a smartwatch can track the number of calories

Table 4: Medical and Non-Medical gadget applications

S. No.	*Medical and Non-Medical Application*	*Gadget's*	*The Gadget's Applications*
1	Asthma Monitoring (Medical Application)	Aluna.	Now anyone suffering from asthma or cystic fibrosis may evaluate their lung status at any time and from any location.
2	Sleep Monitoring (Medical Application)	NightWatch, URGO night.	Sleep trackers, worn on the wrist, are devices that monitor one or more characteristics of your sleeping habits, patterns, phases, quality, and/or duration, by sensing your body movements as you sleep, in order to compute how much time you spend awake vs sleeping, and some sensors use heart rate changes during sleep to calculate how much time you spend in each sleep cycle. The majority of sleep trackers work this way.
3	Cancer Detection (Medical Application)	Rede ye.	Biosensors, devices that detect biological analytes in the environment or the human body, have the potential to be particularly useful in monitoring cancer development, including cancer cell movement, metastasis, and the efficacy of pharmacological therapies, and may be employed in cancer monitoring. Smaller sensors offer easier access to cancer detection, as well as reduced costs, high throughput detection, and more potent and specific signal improvements.
4	Heart Disease (Medical Application)	Flow-Ez, ScanWatch, AngelMed Guardian.	Using electrical activity in the heart, the gadget detects variations in blood flow and sends an alert to a wireless device, such as a mobile phone issued to patients, when a problem is detected. It also causes individuals to feel vibrations in their chest. The technology has also enhanced diagnostics by assisting in determining whether or not a patient is experiencing a heart attack.
5	Diabetes Control (Medical Application)	Google Smart Contact Lens, AerBetic, Glutrac, Grapheal patch, OmniPod.	Glucose sensors, an important part of managing diabetes mellitus, are used to measure the blood glucose concentration of a patient. The sensor measures your interstitial glucose level, which is the glucose found in the fluid between the cells, and tests glucose every few minutes. A transmitter wirelessly sends the information to a particular user. Type 1 and type 2 diabetes are the most common forms of diabetes for which these sensors are used.
6	Telemedicine System (Medical Application)	mHealth.	Patients can use Mobile Health Technologies, such as GoogleFit, Fitbit, and AliveCor's KardiaMobile, to exchange secure messages, schedule appointments to consult with a doctor, and connect with a practitioner who is available for telemedicine visits 24 hours a day, seven days a week.
7	Fitness Monitoring, Real-time streaming, Lifestyle and Relaxation. (Non-Medical Application)	Alpha-Stim, Relief Heat, Quell.	The wearable device is useful for pain management, anxiety, insomnia, and depression therapy, as it allows people with chronic conditions to live longer, healthier lives. It uses electrical nerve stimulation to relieve pain, monitor its function and sleep patterns, and has no long-term negative effects, no danger of addiction, and no risk of drug interactions.

burned after a certain distance of jogging. Similarly, trainers at the gym can track the fitness levels of trainees and monitor their progress. WBAN sensors can also communicate with people and analyze sensitive data. In corporate workplaces, they can monitor employee performance and keep them happy, active, and productive. This data can be used by management to improve the work environment, resulting in improved levels of enjoyment and productivity Khalid Hasan, (2019).

- *Entertainment*

WBAN technology can be used in gaming applications and social media. Virtual reality gaming, where players are immersed in a three-dimensional environment, can be created using WBAN sensors and virtual reality software. This provides the user with a more realistic experience and allows them to fully enjoy the VR world Khalid Hasan, (2019).

- *Security*

WBAN technology can be used to enhance security, although it should be used with caution to protect privacy. It was established in 2013 to provide optimal security measures.

Conclusion

The prevalence of ailments such as heart attacks, diabetes, cancer, and asthma is a major concern in our world today. According to the World Health Organization, heart attacks are responsible for 31% of all deaths worldwide, with 17.9 million people dying each year. The majority of these deaths (85%) are caused by heart attacks or strokes. In 2020, there will be an estimated 19.3 million new cancer patients globally, with around 10 million cancer patients dying. Diabetes affects 463 million people aged 20-79 and claims the lives of 1.6 million individuals every year Benny Levenson.,(2020), Hyuna Sung.,(2021).

One of the most significant tools available to modern medicine for monitoring and addressing these health issues is the Wireless Body Area Network (WBAN). These networks consist of various sensors that can monitor our entire body in any location and at any time. WBAN sensors include heart rate monitors, sleep monitors, asthma monitors, fall detectors, cancer detectors, and diabetes management systems for both on-body and in-body communication.

WBAN technology can be extremely useful in quickly diagnosing any new illnesses, providing a cheap and early treatment for chronic diseases. WBAN technology also promotes the growth of a wide range of medical and non-medical applications. It has the potential to revolutionize healthcare in the future.

In this paper, we have highlighted some of the features and challenges associated with WBAN. By taking advantage of the vast range of sensors available through WBAN technology, healthcare professionals can develop novel medical and non-medical applications that improve the quality of life for millions of people worldwide.

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