HEALTH CARE USING WIRELESS BODY AREA NETWORKS

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ABSTRACT*—Wireless Body Area Networks (WBANs) are a subclass of wireless sensor networks. Wireless sensor networks composed of microsensors for the purpose of sensing, monitoring environment, and physiological pavements. WBANs use a different type of sensors which are attached to clothes and even embedded inside or outside human skin. These sensors sense different vital signs of humans, such as; blood pressure, oxygen level, ECG rate, etc. We can develop different types of applications by using different types of sensors in WBANs which are useful for improving healthcare and lifestyle. For example; we can use body area networks for patient monitoring in hospitals, old people monitoring in house, for tracking of army troops on the battlefield and for tracking players' health and so on. Our main interest in this paper is to help the Healthcare sector to reduce cost and save time by developing an application to monitor patients' vital signs such as measurement of heartbeat, body temperature, etc.*

Keywords- Healthcare, Wireless Body Area Networks, Resource Space Model

1. INTRODUCTION

The Healthcare sector is facing high costs by the rapid increase of the world population and the sector is struggling to meet the needs of increased patients with existing resources. Many patients around the world cannot afford to stay in hospitals for a long time due to economic problems, work restrictions, or any other personal reasons. A wireless monitoring system will be a good option for such patients that will help in monitoring human health in the future. Healthcare applications will prove a good contribution to patients' healthcare, diagnosing, and therapeutic monitoring. In this way, patients will be monitored remotely, and medical staff will be able to monitor many patients at the same time. The basic aim of work is to be identifying and select technologies and protocols which will require for developing healthcare applications regarding patients' mobility.

2. NON MEDICAL APPLICATIONS

WBAN applications[14] cover a large area, such as; safety, military and aerospace applications, preventing wire and conductor theft, lifestyles, and supports, networking, and communication, Heat-Warning-System[15], and also WBAN for animals.

A. Military Applications:

Wireless Body Area Networks are used in the military for many purposes, such as; hydration level, temperature, location, and health. Uniforms of armed forces may be a wearable electronic network that can be integrated with sensors, cameras, GPS for health and location monitoring, and also move data to and from soldiers' wearable electronic devices. WBAN can detect Chemicals and monitor the physiological condition of soldiers. The use of WBAN is a new way of battlefield survives ability.

B. Lifestyles and supports:

Wireless Body Area Networks make possible many new functions and services, such as; wearable music entertainment, routine navigation in vehicles or while walking, locate and navigate places for example petrol pumps, museums, and many others. In sports heart rate and performance is measured by WBANs. Another function is about wireless cash cards where one can check their balance and also view their recent transactions.

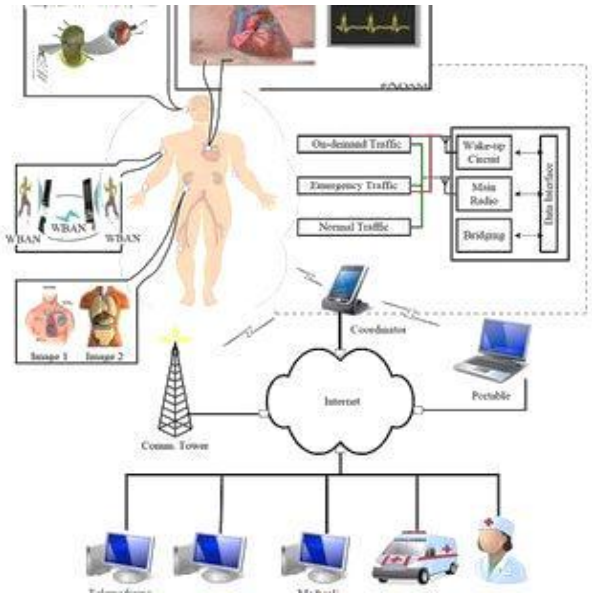

Fig. 1. WBAN actions in military operations [5]

C. WBANs for animals:

WBANs help us to diagnose diseases in animals. WBANs are very important tools to monitor different diseases in animals. Most tests are performed on animals prior to cure human beings from newly developed diseases. It is therefore important to improve testing methods in animals from infectious diseases that give food, milk, meat, eggs to humans. Humans and animals are depending on each other[10]. This symbiosis relationship now implemented and transfers in Cyber-Physical Symbiosis that co-exist today subsequently allows us to create a Cyber-Physical reality in which we implement our information systems to achieve a goal of being heterogeneous within the society.

3. HEALTHCARE USING WBAN

Wireless Body Area Networks in the medical field allows patients' physiological data such as body temperature, heartbeat, and blood pressure for monitoring and also make available drugs in hospital for treatment. Human body phantom model [13] is purposed for the effectiveness of the WBAN in healthcare while testing the measurement and

simulation of arm-swinging.When any unusual situation occurs then sensors collect data via BCU (Body Control Unit) gateway that is linked to sensors that are placed remotely [6]. Then this data is transferred to an isolated place like an emergency center where doctors take action through the Internet. It will be possible to examine the patient for necessary prescription whether the patient is at home or elsewhere.

A. Patient Monitoring:

According to the World Health Organization (WHO), there are an estimated 31 percent of deaths occurred globally in 2016 due to Cardiovascular Disease (CVD) which makes approximately 17.5 million deaths. 85% of the deaths occurred due to heart attacks or strokes. There are also an estimated 17 million people who suffered premature deaths, 37 percent of premature deaths occurred due to CVDs, and 82 percent of these deaths were reported in low to middle-income nations[7]. There are roughly 246 million people are suffering from diabetes and many other diseases like hypertension, Parkinson's disease, stress monitoring, asthma, etc. The death rate can be reduced by offering proper healthcare and monitoring

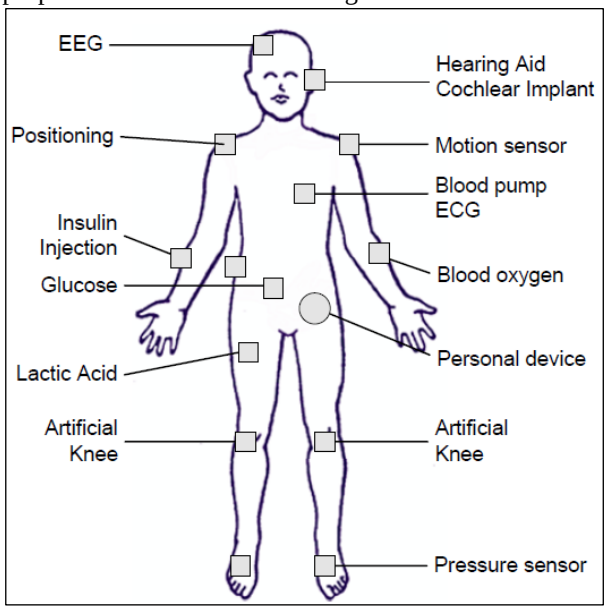

Fig. 2. Different types of sensors using in the human body [4].

By using BAN health care application patients will be monitored whether they are at the home, hospital, or during any other activities. The patient has no need to stay at the hospital. An example of a WBAN in healthcare used for patient monitoring is shown in Figure 1. Different sensors are placed in clothes, directly on the body or under the skin of a person and measure the temperature, blood pressure, heart rate, ECG, EEG, respiration rate, SpO2- levels, etc.

4. TAXONOMY AND REQUIREMENTS

Numerous diversified sensors are used in the application of WBAN. In this Chunk analysis of the various type of devices used in WBAN will be deliberate. In addition demands and objections will discuss in this section. These accommodate the wide volatility of data rate, bounded energy dispersion reliability, quality of service by a therapeutic specialist, and privacy problem[4].

A. Type of devices sensor node:

1) Wireless sensor node: Wireless sensors are also called wireless actuator networks. The wireless sensor node is partially scattered sovereign sensors which observe physical or uncertain condition like sound, pressure, temperature, etc. Also, simultaneously pass data to a certain location and process the data if it is important to report the information wirelessly. It has many components power unit, transmitter, sensor hardware, processor, etc. There are two types of medical applications one is called wearable and the other is implanted.

2) Wireless personal device (PD): It collects all the information which receives from the sensors actuator and it provides information to the user which may be patient, nurse or GP, etc. Through external gateway or display on the device or LED. It consists of a power unit memory and transceiver. It is also called the body control unit (BCU). Smartphones are used in some applications. Various types of sensors are used in the application of WBAN (healthcare). The main uses of all these sensors are in medical applications. The expected range of nodes is 20-50.

3) Implant node: In this type node is placed in the human body or instantaneously under the skin or inner the body tissue.

4) Body surface node: In this type node is a place on the surface of the human body or two centimeters away from the human body.

5) External node: Node is not contacted with the human body or implement few centimeters to five meters away from the human body.

B. Classification of nodes:

1) Coordinator node: Coordinator node like a gateway to the exterior world, an access coordinator, PDA is the coordinator of WBAN through all the nodes of communication.

2) End node: End nodes are enclosed applications and are not talented to broadcast of another, a message from another node.

3) Relay: Relay is intermediate nodes. Relay has a parent node, a child node, and a message. In reality, if the node is at an acuteness (e.g. foot) Relay node may be qualified for sensing data.

C. Date Rates:

Healthcare applications are well diversified and due to its diversity, data rate change firmly ranging from cinch data at a few Kbit/s to the video stream of several Mbit/s. During the bursts, data send at a higher rate. The data rate of various applications is given in table1. Using wireless body area network different types of allocations can be implemented like ECG, EMG, etc. In medical, devices built on data rates. The low data rate can encounter high BER. BER depends upon the criticalness of data.

Application	Data Rate	Bandwidth	Accuracy
ECG (12 leads)	288 kbps	100-1000 Hz	12 bits
ECG (6 leads)	71 kbps	100-500 Hz	12 bits
EMG	320 kbps	0-10,000 Hz	16 bits
EEG (12 leads)	43.2 kbps	0-150 Hz	12 bits
Blood saturation	16 bps	0-1 Hz	8 bits
Glucose monitoring	1600 bps	0-50 Hz	16 bits
Temperature	120 bps	0-1 Hz	8 bits
Motion sensor	35 kbps	0-500 Hz	12 bits
Cochlear implant	100 kbps	–	–
Artificial retina	50-700 kbps	–	–
Audio	1 Mbps	–	–
Voice	50-100 kbps	–	–

Fig. 3. Example of Medical WBAN Application [4]

D. Energy:

Energy expenditure can be branched into region 1. Sensing 2.Wireless communication 3.Data processing. Wireless communication is the most power expenditure. Often power restricted which is available in nodes. Batteries size used to store energy in most of the cases biggest grantor to sensor device in circumstances of both weight and dissensions in some WBANs applications. WBANs sensor or actuator node should proceed while supporting battery life-time even a year without interference. For example, a glucose monitor should require a few years to a lifetime. Specially implanted devices replacement and recharging of devices cause high cost which is obnoxious for only implanted devices but also costly for most of the devices. During operation of the system lifetime of a node can enhance for given battery by scavenging energy. Autonomous WBAN can achieve through the combination of low energy consumption and energy scavenging. Energy scavenging for WBAN is very suitable if derived from body resources like body vibration and body heat. The device produces heat during the communication which is captivated by neighboring tissue which increases the body temperature and to save resources of battery. The energy expenditure should be minimum. Reconciliation for transmitting near the human body similar to one for mobile phones with up-tight transmits requirements of power.

E. Security and privacy:

Communication between sensors in healthcare application WBAN and the internet is firmly secret and confidential should be unscripted to protect the privacy of the patient. Medical staff gathers data demand to destroy that data is not self-assured with an easy start from that patient. It cannot be habitual medical staff or the average person is skillful to setting up and authentication and supervising the process. Security and privacy assurance mechanisms use an important part of the usable energy and would therefore energy efficient.

5. POSITIONING WBANS

The domain of Wireless Body Area Networks is at an early stage of development and research. Protocols for WBANs can cover communication between sensors and body node which is connected to data networks to the Internet. For a clear understanding, we firstly use definitions of Intra-body Communication and extra-body communication. The information management between sensors on the body and personal devices are done formerly and later on, ensures communication between external networks and personal device. As a result data from the patient is consulted by a physician or stored in a medical server database. This task is done in three steps. Step 1 involves intra-body communication, step 2 extra-body communications of the personal device with the Internet, and step 3 shows extra-body communication between the Internet and medical server.

A Wireless Body Area Networks is closed to the human body so its range of communication is of few meters most probably 1-2 meters.

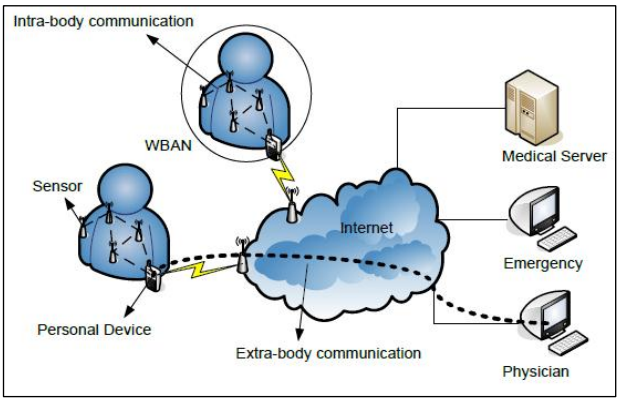

Fig. 4. Example of intra-body communication and extra-body communication in WBANs [4]

Wireless Personal Area Network (WPAN) is a network that exists around the person, whereas WBAN is the interconnection of one's wearable devices. The communication range may be changed according to the data rate which may be low or high. Wireless Body Area Networks are also called as a WSN (wireless sensor networks) or WSAN (wireless sensor actuator networks) with respect to requirements. The human body is made up of a complex environment that interacts with the external environment. The human body surrounding not simply has a smaller range other than requires different challenges to monitor frequency faced by wireless sensor networks (WSNs). The medical data which is monitored stresses for reliability. For energy efficiency, these sensors lead to battery and antenna.

The sensor nodes can move from one place to another within the human body as sensors node sited in the wrist moves towards sensor nodes placed on the hip. Wireless body area networks (WBANs) are similar to wireless sensor networks (WSNs). These have some intrinsic differences.

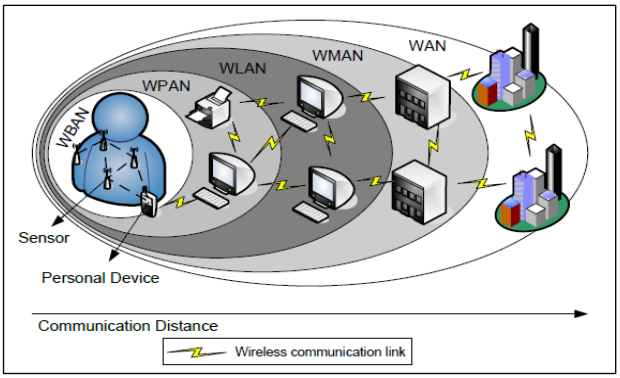

Fig. 5. The positioning of WBAN in the realm of wireless networks [4]

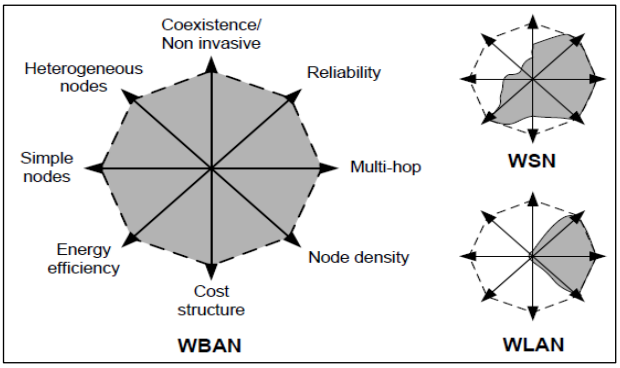

Fig. 6. Characteristics of WBAN compared with WSN and WLAN [4]

6. PHYSICAL LAYER

Due to the concurrence of the human body physical layer has different characteristics as compared to an ad-hoc network or regular sensor network. There is insufficiencies communication between the nodes placed on the back of the patient and node placed on the chest in Tests with TelosB motes. This was a highlight when the broadcast power was set to a minimum for energy storing reasons. Here we will briefly describe characteristics of the propagation of Radio waves in WBAN and other different types of communication.

A. RF communication:

Many researchers are investigating path loss inside of the human body. Using Ultra Wide Band (UWB) or narrowband radio signals. All of the researchers concluded that the signal has a great loss.

In the Body: In human body propagation of electromagnetic waves has been inspected from 1949 to 1950. Where the loss is mostly due to the saturation of power in tissue, which is destroyed as heat than the body act as a communication channel. As the tissue is lost and mostly abide by water. Before they grasp the receiver, EM-waves are constricting. Due to heat distraction to determine the amount of power loss specific absorption rate is a standard measure of how much power is absorbed by the used tissue. It results in that difference between the shape of the body (e.g. male, female, and a child) is at least as large as the encounter of patients' arm movement.

Along the Body: Several devices that are used in a body area network are attached to the human body. Propagation with the human body divided into two segments: line of sight and non-line of sight[4]. Model for a line of sight generation with the human body was studied, Both experimentally and similarly. There is no direct view between the sender and receiver with the no-line of sight[4].

B. Movement of the body:

The strength of receive signal moments of the body plays an important role. The front and side of body arm motion may have little impact in the received signal. The most important variation found when arms are moved so they block line sight between two antennas[4].

Challenges	Wireless Sensor Network	Wireless Body Area Network
Scale	Monitored environment (meters / kilometers)	Human body (centimeters / meters)
Node Number	Many redundant nodes for wide area coverage	Fewer, limited in space
Result accuracy	Through node redundancy	Through node accuracy and robustness
Node Tasks	Node performs a dedicated task	Node performs multiple tasks
Node Size	Small is preferred, but not important	Small is essential
Network Topology	Very likely to be fixed or static	More variable due to body movement
Data Rates	Most often homogeneous	Most often heterogeneous
Node Replacement	Performed easily, nodes even disposable	Replacement of implanted nodes difficult
Node Lifetime	Several years / months	Several years / months, smaller battery capacity
Power Supply	Accessible and likely to be replaced more easily and frequently	Inaccessible and difficult to replaced in an implantable setting
Power Demand	Likely to be large, energy supply easier	Likely to be lower, energy supply more difficult
Energy Scavenging Source	Most likely solar and wind power	Most likely motion (vibration) and thermal (body heat)
Biocompatibility	Not a consideration in most applications	A must for implants and some external sensors
Security Level	Lower	Higher, to protect patient information
Impact of Data Loss	Likely to be compensated by redundant nodes	More significant, may require additional measures to ensure QoS and real-time data delivery.
Wireless Technology	Bluetooth, ZigBee, GPRS, WLAN, ...	Low power technology required

Fig. 7. Schematic overview of differences between Wireless Sensor Networks and Wireless Body Area Networks [4]

7. NETWORK LAYER

It is an unusual assignment to develop proficient protocols in WBANs because of particular characteristics of the wireless environment. First of all control information on network protocols is limited because bandwidth is limited due to sharing and can differ as a result of fading, noise, and interference. Secondly, available energy and computing power on network nodes are heterogeneous. An overview of WBANs routing strategies is given which is based on two strategies one is temperature based and the other is cluster-based protocols.

A. Temperature Routing:

Wireless transmission around the human body has some issues of heat and radiation absorption in the body. A traffic control algorithm is used to reduce tissue healing transmission. Communication is balanced over the sensor nodes by protocols. Thermal Aware Routing Algorithm (TARA) allows data to route away from high-temperature areas which are shown in Figure 8. In the TARA algorithm Least Temperature Routing LTR and Adaptive Least Temperature Routing reduce the loops by maintaining the packets on a recent node that is visited. From this low temperature and better energy efficiency is obtained.

The main disadvantage is a protocol must know the temperature of all nodes in the network.

B. Cluster-Based Routing :

The clustering is used to decrease the number of direct transmissions to a remote station by data assembly protocol known as Anybody. In order to extend energy dissipation, LEACH selects a cluster head at standard time-space. Clustering is based on LEACH which assumes that all nodes of data sending are in the area of the base station. The routing protocols discussed in the research are only developed for WBANs.

8. CROSS-LAYER PROTOCOLS

The arrangement of two or more layers from the protocol stack improves the efficiency of protocols and interaction between protocols in the network of cross-layer protocols design. Research done for WBANs has gained a lot of attention in sensor networks. Roselle et al. purpose a cross-layer energy-efficient multi-hop protocol built on IEEE 802.15.4 [4].The network is distributed into time zones for taking turns in transmission for each one.

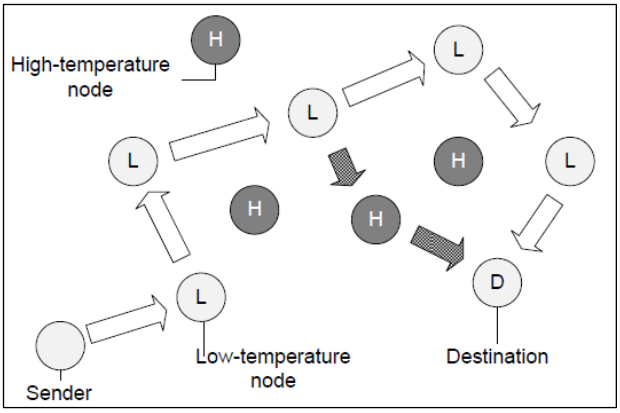

Fig. 8. An example of LTR and ALTR [4].

The transmission starts in distant nodes and data transmission takes place in distant nodes and so on until it is reached on the sink. The protocol which is useful for WBANs was developed for sensor networks.CICADA [4] practicing a data gathering tree which has low packet loss and high sleep ratios in-network elasticity that controls the communication using distributed slot task. It allows two-way communications. The lifetime of the network is improved by using the duty cycle and data aggregation. Another approach for this is completely different by distributing layered structure and all functionality is implemented in modules.

9. QUALITY OF SERVICE

Quality of service is measured by some features like reliability, delay, bandwidth, or reservation. Researchers have shown little effort for WBANs to provide a better quality of service solutions. In order to improve reliability additional method was proposed by CICADA reliability, such as; randomization and overhearing messages sent by the siblings. BSN applications brought three new challenges to BodyQoSaddresses[4]. The processing is done at the central device which uses an asymmetric architecture. Second, they use virtual MAC (V-MAC) that supports different MACs. Third, in WBANs to offer bandwidth and reliable data communication, it uses a resource scheduling approach. The preferred quality of service will influence the energy utilization. It is important to maintain a balance between the desired reliability of networks and energy consumption[4].

10. EXISTING PROJECTS

In this part, we give an overview of recent projects for WBANs. Many researchers and business vendors are ready to develop prototypes of WBANs. This research focuses on service platform and system architecture on developing network protocols. Otto et al[16]and Jovanovic et al [4, 17] present a system architecture in multi-tier telemedicine that handles communication within WBANs and between a medical server and WBANs. The communication is single-hop like in Bluetooth and ZigBee. To design a prototype WBANs they uses off-the-shelf sensors. The Tmote sky policy used in CodeBlue-projects wherever WBANs are important to diagnose disaster state. They developed a wireless ECG and a wireless EMG. Ayushmanis a sensor of monitoring infrastructure in medical to collect and analyze patient health information with a Mica2 wireless transceiver wireless ECG and surrounding monitoring was developed. The remote client was developed for consulting the data in software. The European E-health projects are a complete platform for patients to monitor and to diagnose problems like ECG, blood pressure, and heart speed. BANNET a French project provides technologies to design widest range WBANs applications in energy consumption, sports, and E-health. They focus on the propagation of WBANs channels, MAC protocols, and other wireless networks. The Flemish IBBT IM3-projects that focuses on the study of wearable sensors to monitor the health of the patient. By using WBANs data is collected and analyzed on the sensor worn by the patient. If the problem occurs then the signal sent to a medical physician who can see this and evaluate it remotely.

11. OPEN RESEARCH ISSUES

A number of researches are working on WBANs and a lot of issues exist[4]. Models for the physical layer are purposed and researchers are taking interest in electromagnetic waves in and on the body. Galvanic coupling and transformation of information via bones are emerging technologies and need to be explored in detail. Although, data link layer and networking have protocols to take data but still it have open issues for research. WBANs need to develop specific MAC protocols that take reports of body movement. Other interesting open issues are mobility maintenance in protocols, security, inter feasibility. In a cross-layer protocol, it is necessary to combine many of these mechanisms for a globally optimal system. For autonomous body area networks, the optimal solution is achieved by energy scavenging and a combination of lower energy protocols. The purpose is to generate a smart band-aid for all necessary sensors and communication with base networks.

12. Evolution

A.The Future of Human-Computer Symbiosis: Human-computer symbiosis has progressed tremendously since Licklider wrote his paper on man-computer symbiosis. He suggested a world where computers would complement humans and we can say we are living in that world where human-computer symbiosis is used on a daily basis [8]. This relationship is getting complex due to fast-paced technological advancement and the 4th industrial revolution, a new field of research is emerging – Cyber-Physical Society [9, 12]. It is a multi-dimensional space with physical, cyber, socio, and mental sub-subspaces. The WBANs devices and communication networks have enabled a basic relationship of the complex space which can be map while adopting the multi-dimensional Resource Space Model (RSM)[10].

Healthcare systems should re-evaluate their structure for the enhanced outcomes and consider using service-oriented architecture as it provides a suitable approach for integrating and mapping the real-time systems by adapting the Resource Space Model[11, 12].

13. CONCLUSION

In this survey, we have discussed current research on WBANs (Wireless Body Area Networks). This work presents a general idea of data communication in and on the human body, routing and MAC protocols, security, and Quality of service. A WBAN is a very useful technology that offers a wide area of benefits in E-health monitoring and diagnosing medical issues of a patient and also detects problems that occur in society. With the current growing technology sensors will be applied as skin patches and sensors will act like a drams integrated in WBANS. To improve the quality of life we are going closer to operational WBANs gradually. We believe that this survey can be measured as a source of motivation for other researchers.

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