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Wireless Body Area Networks for Healthcare

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ABSTRACT

Wireless Body Area Network is one of network technology that have revolutionized the world of technology and to explain the importance of the networking major in the different majors, in this project we choose one of the important major in the life is the healthcare major. In this research explain how can make system emergency to the elderly people and heart disease through collaborating between the WBAN technology and internet of things (IOT)devices to make the emergency system use the heart sensor and IOT devices to send Short Message Services (SMS) connected with Global Position System (GPS) to determine the location of patient by click the link with availability Wireless Fidelity (Wi-Fi) or Third Generation (3G) to easily arrive for saving patient's life in the short time and surest way. This technology is not used only in the healthcare major, it also used in different majors likes sports, entertainments, martially etc.

1. Introduction and background

Our world is facing a rapid growth of population accompanied with an increase in the average lifetime of individuals. According to a study presented by the World Health Organization (WHO), the population beyond 60 years of age would be around 2.1 billion by the year 2050 [28]. Ubiquitous healthcare is an emerging technology that promises increases in efficiency, accuracy and availability of medical treatment due to the recent advances in wireless communication and in electronics offering small and intelligent sensors able to be used on, around, in or implanted in the human body. Wireless Body Area Networks (WBANs) are an active area of research and development as they offer the potential for significant improvement in health care delivery and monitoring [29]. WBANs consist of a number of heterogeneous biosensors. These sensors are placed in different parts of the body and can be worn or implanted under the user's skin. Each of them has specific requirements and is used for different tasks. These devices are used to measure changes in a patient's vital sign and detect human emotions or states, such as fear, stress, happiness, etc. It communicates with a special coordinating node, which is generally power-constrained and has greater processing capabilities[9]. It is responsible for sending biological signals of the patient to the medical doctor in order to provide real time medical diagnostic and allow him to take the right decisions. As exposed in Figure1.1, the WBAN common architecture consists of three tiers communications: Intra-BAN communications, Inter-BAN communications and beyond-BAN communications. Intra-BAN communications denote communications among wireless body sensors and the master node of the WBAN. Inter-BAN communications involve communications between the master node and personal devices such as notebooks, home service robots, and so on. The beyond-BAN tier connects the personal device to the Internet. Communications between different parts is supported by several technologies, such as Bluetooth, IEEE802.15.4 [29]. IEEE802.15.6 was designed especially for WBAN applications while responding to the majority of their requirements[34]. However, it looks less performing in some cases in comparison with other technologies supporting WBAN. Wi-Fi, Bluetooth and mobile networks can be solutions for implementing WBAN applications, since each technology offers specific characteristics, allowing it to meet the constraints of some applications. In fact, WBAN applications cover numerous fields in order to improve the users quality of life.

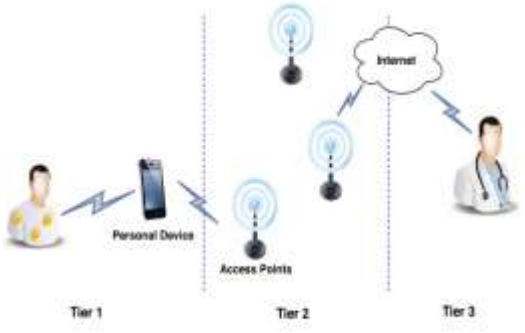

Figure1.1 Three-tiers WBAN architecture[28].

According to World Health Organization (WHO), Cardiovascular Disease (CVD) is the prime cause of the deaths in the world. In fact, it is estimated that the number of CVD related deaths, mainly from heart disease and heart stroke will reach up to 23.3 million by 2030 [28]. Besides this, more than 246 million people will suffer from diabetes and the rate of CVD patients or diabetics will increase, similarly, the percentage of individuals in the populace with age having more than 60 years will increase in the upcoming years [29]. In this study, we aim to design and implement a smart healthcare IS with an IoT-based architecture to measure and send heart rate, blood oxygen level, blood pressure, GPS and continuously monitored body temperature and thermal temperature information to the Internet. In addition, we design a interface for end user [28]. The developed System can overcome the limitations of fixed health measurement variables and existing health devices, which can be replaced with home-use sensors, commercial sensors by adding control and communication layers to the sensors without redesigning them or performing mass migration.

2. Literature Background.

Wireless Body Area Network (WBAN) is one of the technical is develop from Wireless Personal Area Network (WPAN) In this chapter, we will give more details about WBAN application, architectures, layer, technology and routing. As companies rely on applications like electronic mail and database management for core business operations, computer networking becomes increasingly more important [1]. Based on designs developed in the 1960s, the Advanced Research Projects Agency Network (ARPANET) was created in 1969 by the U.S. Department of Defense and was based on circuit switching – the idea that a single communication line, such as a two party telephone connection, deserves a dedicated circuit for the duration of the communication. This simple network evolved into the present day Internet [2].

2.1. Type of Network

The network divided to two types from the connect way:

2.1.1. Wired Networking

Wired networking (networking cable) are networking hardware used to connect one network device to other network devices or to connect two or more computers to share printers, scanners etc. Different types of network cables, such as coaxial cable, optical fiber cable, and twisted pair cables, are used depending on the network's physical layer, topology, and size. The devices can be separated by a few meters (e.g. via Ethernet) or nearly unlimited distances (e.g. via the interconnections of the Internet)[3].

2.1.2. Wireless Networking

Wireless networks are networks that use radio waves to connect devices, without the necessity of using cables of any kind. Devices commonly used for wireless networking include portable computers, desktop computers, hand-held computers, Personal Digital Assistants (PDAs), cellular phones, pen-based computers, and pagers. Wireless networks work similar to wired networks however, wireless networks must convert information signals into a form suitable for transmission through the air medium[4].

2.2. Wireless Sensor Networks (WSNs)

A WSN is a wireless network that contains distributed independent sensor devices that are meant to monitor physical or environmental conditions. A WSN consists of a set of connected tiny sensor nodes, which communicate with each other and exchange information and data [35]. These nodes obtain information on the environment such as temperature, pressure, humidity or pollutant, and send this information to a base station. The latter sends the info to a wired network or activates an alarm or an action, depending on the type and magnitude of data monitored [30]. Typical applications include weather and forest monitoring, battlefield surveillance, physical monitoring of environmental conditions such as pressure, temperature, vibration, pollutants, or tracing human and animal movement in forests and borders. They use the same transmission medium (which is air) for wireless transmission as Wireless Local Area Networks (WLANs). For nodes in a Local Area Network (LAN) to communicate properly, standard access protocols like Institute of Electrical and Electronic Engineering (IEEE) 802.11 are available [30]. The importance of WSN makes it suitable for application in health, military, education, firefighting and prevention, and psychology. The survival rate in cardiac arrest in the first 720 s (12 min) is 48%– 75% as reported by the American Heart Association (AHA). A detailed description of the WSN application shown in Figure 2.1.

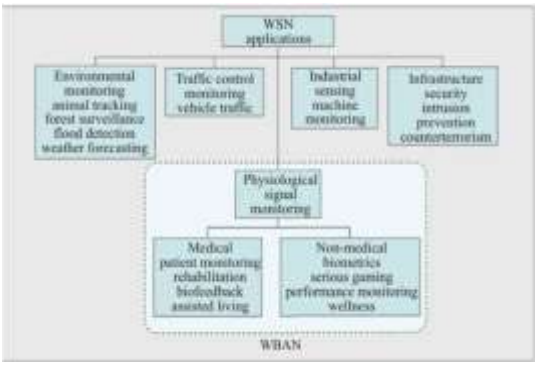

Figure 2.1 WSN applications

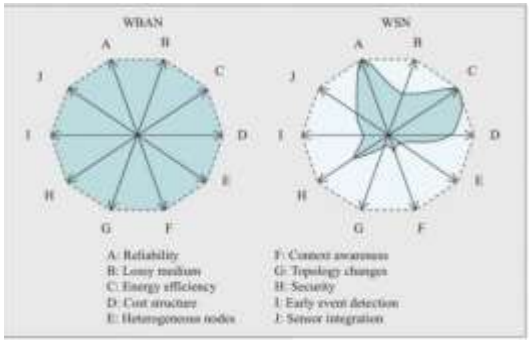

Figure 2.2 WBAN and WSN

There are several wireless sensor technologies, which are regarded as an offshoot of WSN, and the commonest is WBAN. WBANs, which are also referred to as Body Sensor Networks (BSNs) or Body Area Networks (BANs), are fashioned with thin, small lightweight sensors dispersed around, on, and in a human body to function as a monitoring device for the body and its immediate environment. WBAN functions as a monitoring, data detection and collection, and wireless data transfer system. Usually, PDA and smart mobile phones are used to transfer the data to the health professional through a main wireless system. The measured data are either processed or transferred in its raw state through a single gateway or multigateway. The sensor nodes are commonly made-up of sensing component, processing component, communicating component, and a power unit. Together they sense, collect, process, and transmit data wirelessly to a central receiver. The following features are important for the most reliable and efficient sensor nodes: low cost, power efficient, wireless capabilities, multi-hop data routing, and decentralized processing [30]. The lifespan of sensor nodes is mostly affected by the quality and duration of the power source, that is, the battery. Previous studies have tried to increase the lifespan of sensor nodes by balancing or duty cycling the load among the sensor node. However, recent studies seek to prolong the node's lifespan by integrating renewable energy.

Deployment of sensor nodes is done in multitudes because of their low and small size. Although WBAN is referred to as an offshoot of WSN, there are several differences between these two systems, and these parameters of differences are presented in Figure 2.2. Energy efficiency and reliability are very important parameters in both systems. The other parameters are more important in WBAN than in WSN, for instance, maximum security is required in WBAN because of the sensitive nature of the data being transmitted [5].

2.3. Wireless Body Area Network (WBAN)

WBAN was first presented in an article from 1996, but he named these body networks as the WPAN at the beginning. WBAN is seen as a valuable solution to monitor human body remotely and fluently. Many works have discussed WBAN definitions, architectures, applications, etc. because various current trends such as growing population have promoted the growth of WBAN. However, most of the existing works focus on theoretical performance enhancement. IEEE 802 has established a Task Group called IEEE 802.15.6 in November 2007 for the standardization of WBAN. The purpose of the group is to establish a communication standard optimized for low power high reliability application for BANS. We can find different annotations for WBAN like WBANS - Wireless Body Area Sensor Networks or WBSN Wearable Body Sensors Network.

2.5. WBAN Architectures

Sensors collect physiological data and send them to the concerned entities. Then, diagnosis based on the received information is performed and the right decisions are taken. A three - tier architecture for a WBAN communication system can be proposed show in figure 2.3 the WBAN architectures:

a) Intra - WBAN Communication

Communication around the body of sensors between each other's and communication between sensors and Sink node (PDA, phone, sensor, etc.).

b) Inter - WBAN Communication

it is the communication between the Sink node and an Access Point (AP). In inter – WBAN communication, a device coordinator Sink with specific features could be responsible to communicate with the adjacent WBANS. A coordinator is generally considered as a resource rich device, which can be a multi standard node to interface with other technologies such as static WSN, WIFI APs or broadband cellular networks (Fourth Generation (4G), Long-Term Evolution (LTE), etc.).

c) Beyond - WBAN Communication

Connects to the inter - BAN through a gateway. Its functionalities are database and data storage, remote access for medical stuff etc. The system performs a real time analysis of sensors data.

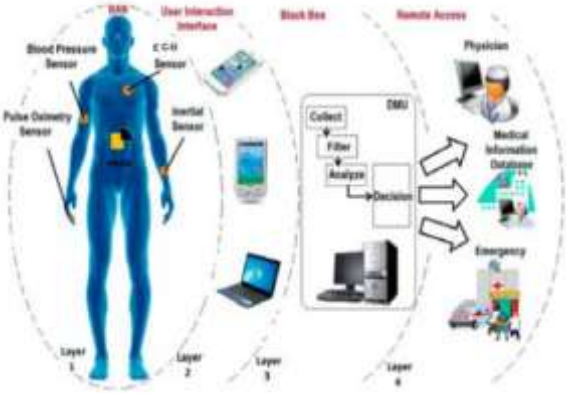

Figure 2.3.WBAN Architectures [32]

2.6. WBAN Communication Stack Layers

2.6.1. Physical Layer

Three factors: Body Path - Loss (BPL), Receive Noise Figure (RNF) and Signal - to – Noise Ratio (SNR) affect the sensor node's transmission power when sending any data wirelessly. SNR is subject to communication link's quality. RNF is a factor that is device dependent. BPL is influenced by antenna in use and radiation pattern. Some of the main responsibilities of the physical layer include frequency selection, signal detection, modulation, and encryption. For on - body sensors , frequency bands are :1.3-5 MHz , 5-50 MHz , 400 MHz , 600 MHz , 900 MHz , 2.4 GHz and 3.1 10.6 GHz [33].

2.6.2. Data link Layer

This layer is responsible for multiplexing, frame detection, channel access and reliability. At Media Access Control (MAC) layer, collision occurs when two or more nodes attempt to transmit at the same time. To ensure energy efficiency, MAC protocols propose to synchronize transmission schedule and listening periods to maximize throughput while reducing energy by turning off radios during sleep periods. There is a tradeoff between reliability, latency and energy consumption.

2.6.3. Network Layer

Commonly, nodes in WBAN are not required to route the packets to other nodes. However, new researches show that multi - hop routing in WBAN is more adequate and is required to guarantee low transmission power low energy consumption and efficient data routing by distributing the routing load over the entire network. In addition, routing is possible when multiple WBANS communicate with each other through their coordinators. WBANS coordinators exploit cooperative and multi hop body - to - body communication to extend the end - to - end network connectivity [6].

2.7. WBAN Technologies

WBAN may involve different technologies at different levels. In this section, we present a comprehensive study of the main proposed technologies for WBAN.

2.7.1. Bluetooth

Bluetooth technology was designed as a short-range wireless communication standard intended to maintain high levels of security. Thanks to this technology, each device can simultaneously communicate with up to seven other devices within a single picante, an ad hoc network including one device acting as a master and up to seven others as slaves for the lifetime of the picante. Slaves have to synchronize by the system clock of the master and follow the hopping pattern, determined by the master. Besides, each device can belong to several picots simultaneously, as they enter radio proximity of other master devices[31].

2.7.2. Bluetooth Low Energy

A derived option of the Bluetooth standard is the Bluetooth Low Energy (BLE) , which was introduced as a more suitable choice for WBAN applications where less power consumption is possible using low duty cycle operation. Bluetooth LE was designed to wirelessly connect small devices to mobile terminals. Those devices are often too tiny to bear the power consumption as well as cost associated with a standard Bluetooth radio, but are ideal choices for the health-monitoring applications [31]. Bluetooth Low Energy technology is expected to provide a data rate of up to one Mbps. Using fewer channels for pairing devices, synchronization can be done in a few milliseconds compared to Bluetooth seconds. This benefits latency-critical BAN applications, like alarm generation and emergency response and enhances power saving. Its nominal data rate, low latency and low energy consumption make BLE suitable for communication between the wearable sensor nodes and the AP [31].

2.7.3. Zigbee and 802.15.4

ZigBee defined by the ZigBee specification, is one of the wireless network technologies, which is widely used from the low power environment. ZigBee is targeted at radio-frequency applications that require a low data rate, long battery life and secure networking, thanks to its 128-bit security support to perform authentication and guarantee

integrity and privacy of messages. Through the sleep mode, ZigBee enabled devices are capable of being operational for several years before their batteries need to be replaced.

2.7.4. IEEE 802.15.6

IEEE 802.15.6 is the first WBAN standard that serves various medical and nonmedical applications and supports communications inside and around the human body. IEEE 802.15.6 standard uses different frequency bands for data transmission including: The Narrowband (NB) which includes the 400, 800, 900 MHz and the 2.3 and 2.4 GHz bands; the Ultra Wideband (UWB) 4, which uses the 3.1 to 11.2 GHz; and the Human Body Communication (HBC) which uses the frequencies within the range of 1050 MHz This standard is a step forward in wearable wireless sensor networks as it is designed specifically for use with a wide range of data rates, less energy consumption, low range, ample number of nodes (256) per body area network and different node priorities according to the application requirements.

2.7.5. IEEE 802.11

IEEE 802.11 is a set of standards for WLAN. Based on the IEEE 802.11 standards, WiFi allows users to surf the Internet at broadband speeds when connected to an AP or in ad hoc mode. It is ideally suited for large data transfers by providing high-speed wireless connectivity and allowing videoconferencing, voice calls and video streaming. An important advantage is that all smartphones, tablets and laptops have Wi-Fi integrated; however, high-energy consumption is an important drawback.

2.7.6. Other Radio Technologies

Advance Network Technology (ANT) protocol is another emerging standard for wellness and health monitoring applications. ANT is a low speed and low power protocol being supported by several sensor manufacturers. The Zarlink technology is ultra-low power, which makes it suitable for medical implant applications requiring low frequency and low data rates. Rubee active wireless protocol uses Long Wave magnetic signals to send and receive short (128 byte) data packets in a local network. Rubee does not require line of sight communication for its operation. Additionally, Rubee has the advantages of efficient transmission distance, high security level, ultra-low power consumption, stable operation providence and long battery lifetime, which make convenient for many WBANs applications such as patient monitoring and mobile healthcare [7].

Table 2.1.

2.8. Types of WBAN Devices

As the name indicates, WBAN comprises tiny devices with communication capabilities. Based on their functions and roles, these devices are divided into three classes. This section presents a brief taxonomy of WBAN devices according to their functionality.

2.8.1. Wireless Sensor Node

It comprises four components: transceiver, battery, microprocessor and the sensor component. WBAN sensor nodes provide wireless monitoring for anybody, anywhere and anytime. These nodes can be physiological sensors, ambient sensors or bio kinetic sensors.

a) Wearable Sensors

These devices are added to clothes or positioned on the body to gather vital signs, such as the Saturation of Peripheral Oxygen (SpO2) that measures the oxygen saturation level in the human blood, which coincides with the cardiac cycle. The Electrocardiogram (ECG) sensor that investigates the heart function by sampling the heart muscle propagation electric waveform with respect to time. The EEG sensor that detects brain electrical activity and the motion detection sensors that combine both accelerometer and a gyroscope to monitor and analyze a person's movements.

b) Implantable Sensors

These devices are injected under the skin or in the blood stream. In Parkinson's disease, for example, these sensors are used to send electrical impulses to the brain through neural simulators. Other applications for implantable sensors can be found.

2.8.2. Actuators

Actuators are used to administer medicine to a patient. The required drug is administered directly in a predefined manner when a sensor detects an abnormality or when it is triggered by an external source, according to the doctor's decision. Similar to a sensor node, an actuator consists of a transceiver, battery, memory and the actuator hardware that holds and manages the drug. The drugs could be used to control blood pressure, the body's temperature and to treat many other illnesses. The actuator is activated upon receiving data from the sensors.

2.8.3. Wireless Personal Device (PD)

It is responsible for establishing communication between sensors, actuators and a cellular phone in a wireless fashion. Its main components are a transceiver, a rich power source, a large processor and a large memory this taxonomy is summarized in

Table 2.1. WBAN devices

BAN devices	Functionality	Examples	
Sensor node	Samples and communicates physiological attributes and provides a response to the information through wireless communication for anybody, anywhere and anytime.	arable: added to clothes or placed on the body to collect vital signs.	Spo2, ECG, EEG
		Implantable: injected under the skin or in the blood stream.	In Parkinson's disease, sensors send electrical impulses to the brain through neural simulators

Table 2.1. WBAN devices

WBAN devices	Functionality	Examples
Actuators	Administer medicine to a patient when a sensor detect an abnormality according to the doctor's decision	control blood pressure, the body's temperature and to treat many other illnesses
Personal Device (PD)	Set up communication between a cellular phone sensors, actuators wirelessly.	Can be a specialized dedicated unit, PDA or a smart phone

2.9. Applications of WBAN

WBAN applications span from the health care and entertainment fields to sport and the military among others. WBAN applications are categorized as either medical or non-medical. This section classifies WBAN applications according to their target domain of application. Each application is further classified into medical, nonmedical, implanted, and wearable. They are further classified into medical and nonmedical applications. Table 1 also gives some examples for each WBAN field.

2.9.1. Healthcare

This continual monitoring allows a proactive fatal and anomalies detection which is vital for diagnosing heart and brain activities. Actuators help in automatic drug delivery. Some applications such as cochlear implants, hearing aids and artificial retinas help enhance the life style of human beings. Additionally, given that medical accidents can and do happen, WBAN applications help to reduce them and increase public safety by using profiles of previous medical accidents to alert medical personnel before similar accidents occur. Consequently, WBAN is expected to improve the management of illnesses and reaction to crisis, which will increase the efficiency of health care systems. WBAN health care applications can be further classified as follows.

2.9.1.1. Medical Applications

WBAN medical applications enable the continual monitoring of physiological parameters such as the heartbeat, the body temperature and blood pressure. The data collected can be sent through a cell phone, which acts as a gateway, to a remote location such as an emergency center so that the relevant action can be taken. WBAN is considered key to the early detection and treatment of patients with serious cases such as diabetes and hypertension.

Medical applications of WBAN can be further divided according to the position of the medical sensors as follows:

a) Wearable Applications

Medical wearable healthcare applications include temperature monitoring, blood pressure monitoring, glucose level monitoring, ECG, Electroencephalogram (EEG), Electromyogram (EMG), SpO2, drugs delivery.

b) Implant Applications

These applications comprise nodes implanted either under the skin or in the stream of the blood such as in diabetes control systems, cardiovascular diseases and cancer detection [29].

2.9.1.2. Non-Medical Applications

These applications are considered to fall within the wearable sensor class of applications and include two applications, which are:

a) Motion Detection

This application is used to detect, capture, recognize and identify body gestures and motions and send alerts to the owner of the application. For example, fear increases heartbeat, which leads to sweating and other symptoms. Thus, emotional status can be measured and monitored.

b) Secure Authentication

This is a very promising WBAN application as it is the core of both multimodal biometrics and electroencephalography. This application harnesses

physiological and behavioral human body biometrics such as fingerprints and facial patterns.

2.9.2. Sports

Sport activities and fitness can be improved by keeping a log of vital physiological data such as temperature, heartbeat and blood pressure. The data can be used to avoid sport accidents and injuries and to plan for future training .WBAN sport applications are considered medical wearable applications. Such applications enhance professional and amateur sport training especially for athletes.

2.9.3. Entertainment

Entertainment is also a very promising field for WBAN. The film industry for example benefits from motion capturing and postproduction mechanisms to produce movies in which actors perform the objects roles. Using the on body accelerometers and gyroscopes for capturing motions facilitates the possibility of tracking the different positions of body parts.

2.9.4. Military and Defense

WBAN provides new capabilities to improve performance of individual and teams of soldiers in military situations. To avoid threats at the individual tier, a group of sensors sample important information on the surrounding emerging actions and environment. At the team level, the taken information enables the commander to coordinate team tasks efficiently. Inter-WBAN communications and security play a key role in preventing critical data from being hacked by enemies. WBAN applications can be considered as either medical wearable or non-medical wearable as follows:

2.9.4.1. Medical Military WBAN Applications

These types of applications are used to assess soldier fatigue and battle readiness and for safeguarding uniformed personnel. For example, sensors surrounding soldiers, firefighters or police officers can foresee a life-threatening situation by monitoring the level of air toxins.

2.9.4.2. Non-Medical Military WBAN Applications

Such applications involve off-body sensors (on buildings) that are used for emergencies. Such sensors are capable of, for example, detecting a fire in the home or a poisonous gas and must directly send this information to on and in body devices to notify the wearer of the emergency situation. Table 2.2 gives some examples for each WBAN field [8].

Table 2.2. Fields and applications of WBAN

WBAN fields	Applications types		Examples of applications
Healthcare	Medical	Wearable	ECG, EEG, EMG, SPO2, temperature, blood pressure, drugs delivery
		Implant	Diabetes control
	Non-medical	Motion detection	
		Secure authentication	
Military and defense	Medical wearable	Asses solider fatigue, detect life threatening situations	
	Non-medical wearable	Fire detection, poisonous gas	
Sports	Medical wearable	heartbeat, temperature, blood pressure, motion sensor	
Entertainment	Non-medical wearable	Gaming purposes, virtual reality, ambient, intelligence areas, personal item tracking and social networking	

2.10. IOT with WBAN

The Internet of Things (IOT) is a platform that provides an enormous access to the network communication the world has emerged into an evolution that affected and enhanced the way human beings live. Throughout decades and centuries, these information technologies have continuously interchanged positively to ultimately benefit the world with endless solutions and improvement of technologies, which has also led to numerous employment opportunities. Furthermore, IOT has affected the human life in many ways, from the way a driver navigates a car to a person who easily can purchase and shop online within seconds, and the smart watches have a lot of services that life and health activities can be monitored and displayed; on the other hand, modern houses have remarkably collecting smart appliances such as smart room temperature adjusting along with air conditioners, smart washers and smart Televisions (TVs). In addition, the IOT is embedded in any item that consists of the important facts, which are electronic, software and sensors. Where IOT acts as data storage that data can be stored,

managed, remolded and shared in the benefits of the consumer and increasing data efficiency. The data can be collected from the sensors, and the work can be done afterward. A perfect example that can simplify the work of IOT is with the air conditioner, which contains an embedded sensor with health and temperature information that can be sent to the IOT platform, where feedback services alert the consumer in case of replacement or emergency. WBAN with IOT according connecting data or information from sensors embedded in electronic and other devices such as sensors, monitors, mobile phones, etc. to the Internet or exchange of information from one device or sensor to another. IOT supports more of facilitations for WBAN technology to connect to internet, storage and processing's data, collections the information, controls the sensors and node and connect to communication mobile to provide more of reliability and synchronized data too sure for arrive the information about health patient to save him life in opportune time so increase rate of deliverance figure2.4 shown WBANs for IOT [5].

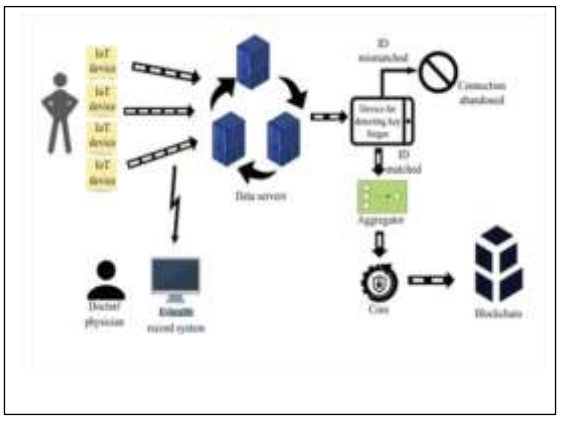

figure2.4 WBANs for IOT

2.11. WBAN Systems For Healthcare

Healthcare is one of the most important processes that define the economic and social growth of a country. All developed and developing countries are striving to increase the usage of technology in bringing excellent healthcare to their population. However, existing medical resources cannot satisfy the future healthcare demands of different types of patients (older or younger). The resources are quite limited, and it is impossible for most patients to stay a long time in the hospital because of economic restrictions work, and other personal reasons, even though their health status must be monitored in real time or frequently. As a result, wireless monitoring medical systems will become part of mobile healthcare centers with real-time monitoring in the future. WBANs supporting healthcare applications offer different contributions at monitoring, diagnosis, and therapeutic levels figure 2.4 show typical of WBAN. They cover real-time medical information obtained from different types of sensors with secure data communication and low power consumption. Due to the increasing interest in the applications of this type of networks, several articles dealing with different aspects of such systems have been published recently.

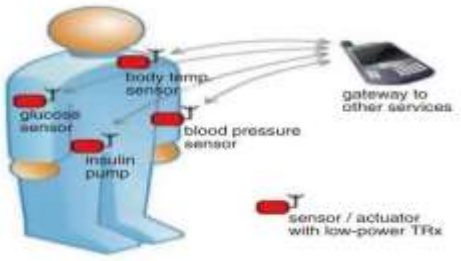

Figure 2.5. Wireless body area

Electronic Health (E-Health) and Telemedicine are two areas that are leveraging current wireless communication technologies to provide emergency medical services, enable outpatient monitoring and treatment, facilitate patient recovery, and directly connect doctors and nursing staff with patients. WBAN healthcare applications can offer valuable contributions to improve patient healthcare, including diagnosis and therapeutic monitoring. Patients, while performing their activities comfortably at home or outdoors, can be monitored by the medical staff. In this field, data reliability and energy consumption (considering 24/7 monitoring) are fundamental characteristics to consider when choosing appropriate WBAN sensor nodes. These nodes operate in close proximity to the human body collecting data for various medical and non-medical applications. Medical bands used in WBAN provide physiological data from sensor nodes. They are chosen in such a way that it reduces interference and thus increases the coexistence of sensor node devices with other network devices available at medical centers. The collected data is sent to stations using medical gateway wireless boards [9].

2.12. WBAN Scenarios for Healthcare System

Following are the scenarios where WBAN can be used for wireless health monitoring.

a) Telemonitoring of Patients With Cardiac Arrhythmia

Cardiac arrhythmia is very common and in many cases, is related to coronary heart disease. Around one million patients suffer from coronary heart

disease. In patients suffering from arrhythmia, ECG measurements have to be taken regularly to monitor the efficacy of drug therapy. To save time and reduce costs, the patient can transmit ECG and blood pressure via General Packet Radio Service (GPRS) from home or elsewhere to the health call center, where a cardiologist monitors the vital signs. The intention is that irregular patterns will be detected quickly and appropriate intervention canbe initiated. This scenario will evaluate how the patients and the cardiologist can gain time and reduce the related costs.

b) Integrated Homecare For Women With High-Risk Pregnancies

Women with high-risk pregnancies are often admitted to the hospital for longer periods because of possible pregnancy-related complications. Admission is necessary for the intensive monitoring of the patient and the unborn child. Homecare with continuous monitoring is desirable and can postpone hospitalization and reduce costs, as well as offering more security for the mother and unborn child. In this scenario, patients are monitored from home using the BAN and the (maternal and fetal) bio signals are transmitted to the hospital. An additional objective of the scenario is to evaluate if such a solution postpones hospitalization and reduces costs. The scenario will use both GPRS and Universal Mobile Telecommunication System (UMTS) networks.

c) Tele Trauma Team

The trauma patient BAN will measure vital signs, which will be transmitted from the scene to the members of the trauma team located at the hospital. The paramedics wear trauma team BANs that incorporate an audio system and a wireless communication link to the hospital. The purpose of this scenario is to evaluate whether use of mobile communications can improve quality of care and decrease lag-time between the accident and the intervention. When using telemetry technology, time can be saved and thus treatment and chances for patient recovery improved.

d) Support Of Home-Based Healthcare Services

This scenario involves use of GPRS for supporting remote assistance and home-based care for elderly and chronically ill patients suffering from co-morbidities. The wireless health monitoring nurse-BAN will be used to perform patient measurements during nurse home visits and the wireless health monitoring patient-BAN will be used for continuous monitoring during patient rehabilitation at home, or even outdoors. It is very important to facilitate patients' access to healthcare professionals without saturating the available resources, and this is one of main expected outcomes of the wireless health remote monitoring approach. Parameters to be measured are oxygen saturation, ECG, spirometer, temperature, glucose and blood pressure.

e) Outdoor Patient Rehabilitation

The patients involved in this scenario are chronic respiratory patients who are expected to benefit from rehabilitation programs to improve their functional status. The physiotherapist will receive online information on the patient's exercise performance and will provide feedback and advice. It is expected that by enabling patients to perform physical training in their own local settings, the benefits, in terms of cost and social acceptance, can be significant. Parameters to be measured are pulse Oximetry, ECG and mobility with audio communication between patient and remote supervising physiotherapist.

f) Physical Activity And Impediments To Activity For Women With Rheumatoid Arthritis (RA)

This scenario will subject women with Rheumatoid Arthritis. The use of the BAN together with the mobile communications will enable collection of a completely new kind of research data, which will enhance the understanding of the difficulties, and limitations, which these patients face. The objective is to offer solutions that will make their lives easier. By this collection of data, the scarce knowledge about what factors impede normal life will be supplemented and quality of life of RA patients may thereby be improved. By use of wireless health monitoring BANs, the activity of the patients will be continually monitored. Parameters measured include heart rate, activity level, and walking distance and stride length.

g) Monitoring Of Vital Parameters In Patients With Respiratory Insufficiency

The group of patients involved in this scenario suffers from respiratory insufficiency due to chronic pulmonary diseases. These people need to be under constant medical supervision in case they suffer an aggravation of their condition. Besides needing regular check-ups, they are also dependent on oxygen therapy at home, which means oxygen delivery and close supervision. The use of the wireless health monitoring BANs is designed to enable the early detection of this group of diseases but also to support homecare for diagnosed patients

by detecting situations where the patient requires intervention. The expected benefits are a reduction of the number of checkups and hospitalizations needed, thus saving both time and money. Parameters measured are pulse rate, oxygen saturation and signals from a motion sensor (accelerometer).

h) Home care services and the possibility of monitoring health conditions at a distance

Are changing the way of providing care to patient. If suitable, home-based services are provided and patients do not need to be in hospital, for example they are recovering from an intervention. By investing in home care, hospitals have been able to significantly reduce Pressure on beds and on staff time dedicated to the kind of patients named above. This scenario tests transmission of clinical patient data by means of portable GPRS/UMTS equipment to a physician or a Registered District Nurse (RDN) from patients living in a rural, low population density area. The expected benefit is that this solution will reduce the number of cases where the patient is supposed to visit a hospital for consultation unnecessarily.

i) Ambient Assisted Living

The aging population, the increasing cost of formal health care and the importance that the individuals place on living independently, all motivate the development of innovative-assisted living technologies for safe and independent aging. Applications in this field improve quality of life to maintain a more independent lifestyle using home automation. In fact, assisted living facilities have emerged as an alternative housing facility for people with disabilities and elderly who are not considered independent but do not need around-the-clock medical care, as in nursing or retirement homes.

An ambient sensor network can sense and control the parameters of the living environment and then delivers the body data to a central station, thanks to a continuous cognitive and physical monitoring. The health condition of these people can be estimated from their heart beat rate, blood pressure and accelerometer data. The system may be connected to a health care center for observation and emergency assistance, in case of strong changes in the observed parameters or deviations from the normal range [10].

3. HARDWARE

We will describe the pieces of the project and the hardware of each piece.

3.1. SIM800L GSM/GPRS module

SIM800L GSM/GPRS module is a miniature GSM modem, which can be integrated into a great number of IoT projects. Can use this module to accomplish almost anything a normal cell phone can; SMS text messages, Make or receive phone calls, connecting to internet through GPRS, TCP/IP.

3.1.1. Hardware of SIM800L GSM/GPRS module

At the heart of the module is a SIM800L GSM cellular chip from SimCom. The operating voltage of the chip is from 3.4V to 4.4V. All the necessary data pins of SIM800L GSM chip are broken out to a 0.1″ pitch headers. This includes pins required for communication with a microcontroller over UART. The module supports baud rate from 1200bps to 115200bps with Auto-Baud detection.

The module needs an external antenna to connect to a network. The module usually comes with a Helical Antenna and solders directly to NET pin on PCB. The board also has a U.FL connector facility in case keep the antenna away from the board figure 3.1. Shows SIM800L Module Hardware.

Figure 3.1 SIM800L Module

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There's a SIM socket on the back! Any activated, 2G micro SIM card would work perfectly. Correct direction for inserting SIM card is normally engraved on the surface of the SIM socket figure 3.2. Shows Micro SIM Socket.

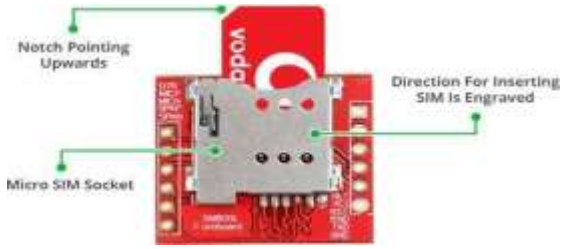

Figure 3.2 Micro SIM Socket

This module measures only 1 inch but packs a surprising amount of features into its little frame. An antenna is required to use the module for any kind of voice or data communications as well as some SIM commands. There are two ways can add an

antenna to SIM800L module. The first one is a Helical GSM antenna which usually comes with the module and solders directly to NET pin on PCB. This antenna is very useful for projects that need to save space but struggles in getting connectivity especially if your project is indoors figure 3.4. Shows SIM800L GSM Module with Helical Antenna.

Figure3.4 SIM800L GSM Module with Helical

The second one is any 3dBi GSM antenna along with a U.FL to SMA adapter which can be obtained online for less than $3. You can snap-fit this antenna to small u.fl connector located on the top-left corner of the module. This type of antenna has a better performance and allows putting your module inside a metal case – as long the antenna is outside figure 3.5. Shows SIM800L GSM Module with 2dBi Duck Antenna.

Figure 3.5 SIM800L GSM Module with 2dBi Duck

d. SIM800L GSM Module Pinout

The SIM800L module has total 12 pins that interface it to the outside world. The connections are as follows figure 3.6. Shows SIM800L GSM Module Pinout[11].

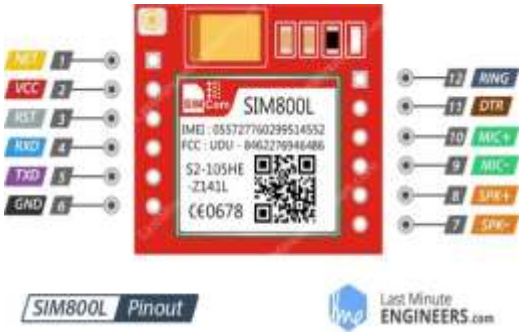

figure 3.6. Shows SIM800L GSM Module 3.6.

3.2. GPS module

3.2.1. How does GPS work

GPS is a system of 30+ navigation satellites orbiting the earth. We know where they are in space because they constantly transmit information about their position and current time to Earth in the form of radio signals. A GPS receiver listens to these signals. Once the receiver calculates its distance from at least three GPS satellites, it can figure out where you are. This process is known as Trilateration.

a. NEO-6M GPS Chip

At the heart of the module is a GPS chip from U-blox – NEO-6M. The chip measures less than a postage stamp but packs a surprising amount of features into its tiny frame figure 3.7. Shows NEO-6M GPS Module Chip .

Figure 3.7 NEO-6M GPS Module

It can track up to 22 satellites over 50 channels and achieve the industry's highest level of tracking sensitivity i.e. -161 dB, while consuming only 45 mA current. Unlike other GPS modules, it can perform 5 location updates in a second with 2.5m horizontal position accuracy. The U-blox 6 positioning engine also has a TimeTo-First-Fix (TTFF) of less than 1 second. One of the best features offered by the chip is Power Save Mode (PSM). This allows a reduction in system power consumption by selectively switching certain parts of the receiver on and off. Figure 3.11. Shows NEO-6M Patch Antenna .

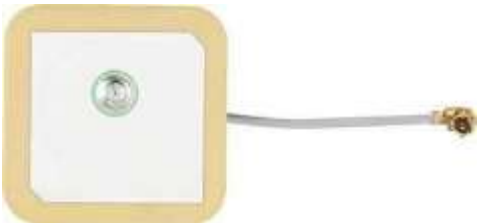

figure 3.11. NEO-6M Patch Antenna

Can snap-fit this antenna into the small U.FL connector located on the module figure 3.12. Shows NEO-6M GPS Module - u.fl Connector.

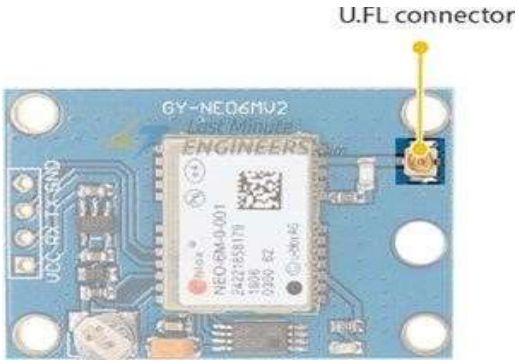

figure 3.12. NEO-6M GPS Module

g. NEO-6M GPS Module Pinout

The NEO-6M GPS module has a total of 4 pins that connect it to the outside world. The connections are as follows figure 3.13. Shows Ublox NEO-6M GPS Module Pinout [12].

Figure 3.13. Ublox NEO-6M GPS Module

3.3. MAX30100 Sensor

The MAX30100 pulse oximeter and heart rate sensor is an I2C-based low-power plugand-play biometric sensor.

3.3.1 MAX30100 Module Hardware

The module features the MAX30100 – a modern, integrated pulse oximeter and heart rate sensor IC, from Analog Devices. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry (SpO2) and heart rate (HR) signals figure 3.14. Shows max30100 module hardware overview IC and LED.

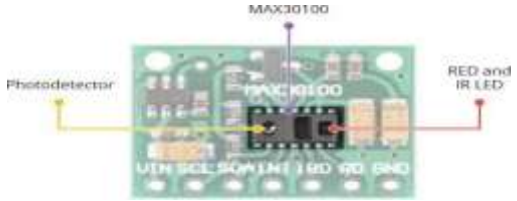

figure 3.14. max30100 module hardware

a. Power Requirement

The MAX30100 chip requires two different supply voltages: 1.8V for the IC and 3.3V for the RED and IR LEDs. So the module comes with 3.3V and 1.8V regulators. This allows you to connect the module to any microcontroller with 5V, 3.3V, even 1.8V level I/O figure 3.15. Shows max30100 module hardware overview two regulators.

figure 3.15. max30100 module hardware overview

One of the most important features of the MAX30100 is its low power consumption: the MAX30100 consumes less than 600µA during measurement. Also it is possible to put the MAX30100 in standby mode, where it consumes only 0.7µA. This low power consumption allows implementation in battery powered devices such as handsets, wearables or smart watches.

b. On-Chip Temperature Sensor

The MAX30100 has an on-chip temperature sensor that can be used to compensate for the changes in the environment and to calibrate the measurements. This is a reasonably precise temperature sensor that measures the 'die temperature' in the range of -40°C to +85°C with an accuracy of ±1°C.

c. I2C Interface

The module uses a simple two-wire I2C interface for communication with the microcontroller. It has a fixed I2C address: 0xAEHEX (for write operation) and 0xAFHEX (for read operation).

d. FIFO Buffer

The MAX30100 embeds a FIFO buffer for storing data samples. The FIFO has a 16sample memory bank, which means it can hold up to 16 SpO2 and heart rate samples. The FIFO buffer can offload the microcontroller from reading each new data sample from the sensor, thereby saving system power.

e. Interrupts

The MAX30100 can be programmed to generate an interrupt, allowing the host microcontroller to perform other tasks while the data is collected by the sensor. FIFO Almost Full : triggers when the FIFO becomes full and future data is about to lost figure 3.16. Shows max30100 module hardware overview interrupt pin.

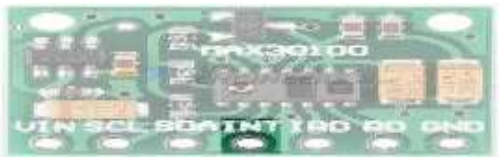

figure 3.16. max30100 module hardware

The INT line is an open-drain, so it is pulled HIGH by the onboard resistor. When an interrupt occurs the INT pin goes LOW and stays LOW until the interrupt is cleared.

3.3.2. How MAX30100 Pulse Oximeter and Heart Rate Sensor Works

The MAX30100, or any optical pulse oximeter and heart-rate sensor for that matter, consists of a pair of high-intensity LEDs (RED and IR, both of different wavelengths) and a photodetector. The wavelengths of these LEDs are 660nm and 880nm, respectively figure 3.17. Shows max30100 pulse detection Photoplethysmogram .

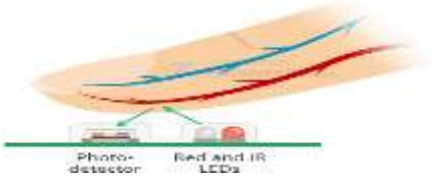

figure 3.17. max30100 pulse Photoplethysmogram

The MAX30100 works by shining both lights onto the finger or earlobe (or essentially anywhere where the skin isn't too thick, so both lights can easily penetrate the tissue) and measuring the amount of reflected light using a photodetector. This method of pulse detection through light is called Photoplethysmogram. The working of MAX30100 can be divided into two parts: Heart Rate Measurement and Pulse Oximetry (measuring the oxygen level of the blood).

a) Heart Rate Measurement

The oxygenated hemoglobin (HbO2) in the arterial blood has the characteristic of absorbing IR light. The redder the blood (the higher the hemoglobin), the more IR light is absorbed. As the blood is pumped through the finger with each heartbeat, the amount of reflected light changes, creating a changing waveform at the output of the photodetector. As you continue to shine light and take photodetector readings, you quickly start to get a heart-beat (HR) pulse reading figure 3.18. Shows pulse detection heart rate sensor working Photoplethysmogram .

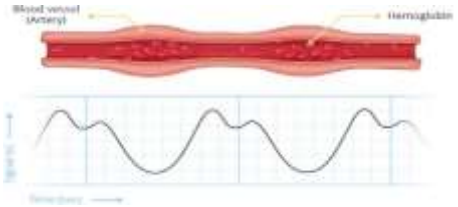

figure 3.18. pulse detection heart rate sensor working Photoplethysmogram

b) Pulse Oximetry

Pulse oximetry is based on the principle that the amount of RED and IR light absorbed varies depending on the amount of oxygen in your blood. The following graph is the absorption-spectrum of oxygenated hemoglobin (HbO2) and deoxygenated hemoglobin (Hb) figure 3.19. Shows absorption spectrum of hb and hbo2.

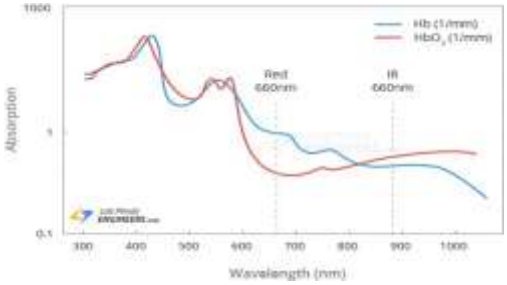

figure 3.19. Shows absorption spectrum of hb and hbo2

From the graph, deoxygenated blood absorbs more RED light (660nm), while oxygenated blood absorbs more IR light (880nm). By measuring the ratio of IR and RED light received by the photodetector, the oxygen level (SpO2) in the blood is calculated.

3.3.3. MAX30100 Module Pinout

The MAX30100 module brings out the following connections figure 3.20. Shows max30100 module pinout.

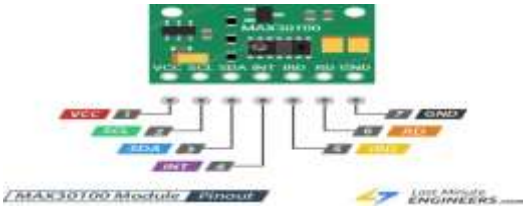

figure 3.20. Shows max30100 module pinout

3.4. Arduino Nano

3.4.1. Introduction To Arduino Nano

Arduino Nano is a small, complete, flexible and breadboard-friendly Microcontroller board, based on ATmega328p, developed by Arduino.cc in Italy in 2008 and contains male I/O headers, configured in a DIP30 style 30. Arduino Nano is simply a smaller version of Arduino UNO, thus both have

almost the same functionalities. It is programmed using Arduino IDE, which can be downloaded from Arduino Official site. Functions like pinMode() and digitalWrite() are used to control the operations of digital pins while analogRead() is used to control analog pins. Figure 3.27. and figure 3.28. Shows the specifications of the Arduino Nano board.

Figure 3.27. Specifications of the Arduino

Figure 3.28. Specifications of the Arduino Nano board

It is programmed using Arduino IDE which is an Integrated Development Environment that runs both offline and online. No prior arrangements are required to run the board. All you need is a board, mini USB cable and Arduino IDE software installed on the computer. USB cable is used to transfer the program from the computer to the board No separate burner is required to compile and burn the program as this board comes with a built-in boot-loader.

3.4.6. Arduino Nano Programming & Communication

- The Nano board comes with the ability to set up communication with other controllers and computers.
- The serial monitor is added to the Arduino IDE, which is used to transmit textual data to or from the board.
- The Arduino Nano is programmed by Arduino Software called IDE which is a common software used for almost all types of board available. Simply download the software and select the board you are using.
- Uploading code to Arduino Nano is quite simple, as there's no need to use any external burner to compile and burn the program into the controller and you can also upload code by using ICSP (In-circuit serial programming header).

Arduino board software is equally compatible with Windows, Linux or MAC, however Windows are preferred to use [14]. Figure 3.38. shows pieces the project.

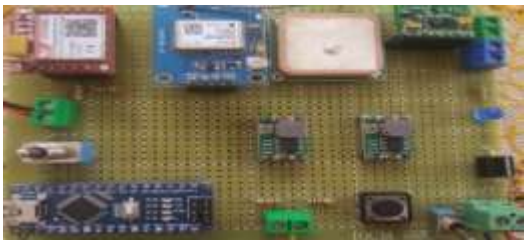

Figure 3.38. shows pieces the project.

4. Software

We will describe how can we apply the WBAN for healthcare , describe the codes and connection way.

4.1. Devices Connection

The Connection pins between GSM ,GPS, Max and Arduino nano. Table 4.1 describe receives and transfers pins.

Table 4.1. connection pins

Devices	Pins	Arduino Nano pins
GSM SIM800l	Pin TX	Pin RX 12
	Pin RX	Pin TX 11
GPS NEO-6m	Pin TX	Pin RX 8
	Pin RX	Pin TX 9
Max30100	SDA	4A
	SCL	5A
Button	Pin TX	Pin 6

6.3. Recommendations

These are some recommendations help the other researchers to develop this project:

- Doing database by name and phone of patients

  If you have a database by name of patients' easy to help the people arrive to them in short, time
- Availability of Wi-Fi access point
  Using the messages by the internet is lower cost than GSM messages
- Design a website with a map to detected nearest hospital to patients This will help to take the patient to hospital as soon as possible without wasting time.

- Availability of another small-sized source of power for the project In this project we use a large source of power so it will be hard to carry everywhere and the level of power will hurt the patient.

6.5. Conclusion

In this project we discussion one of the new sections of networking major it's Wireless Body Area Network. WBAN is the future of saving the human life, it's help to monitor the physiology signal to develop human life. In this project we explained one of the applications that used in it this technology. We implemented the project to the older people and heart disease patients from period 1/1/2022 to 30/5/2022 in constant study from five chapter explain in them this technology, developed from any technology and its devices ,application, layers ,relationship with IOT, how can it help in the healthcare system and the important applications healthcare the WBAN technology help in it. Explain how this technology help to rescued the patients as soon as possible so this will reduce the death rate and explain how the networking major has strong relationships with other majors and help to facilitate them. Also explain how we implement this technology by making system sends SMS and detected the location then talk about the difficult we faced, recommendations and suggestion to develop this project.

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