IoT based Road accident controlling model using Wireless Body Area Network and GPS

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Declaration

It is hereby declared that

1. The thesis submitted is our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. We have acknowledged all main sources of help.

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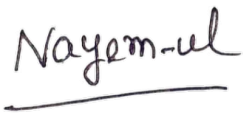

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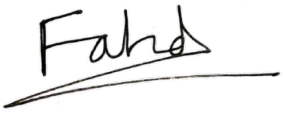

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Abstract

With the rapid growth of population and number of vehicle, traffic collision and volume of accident is increasing rapidly. The lack of awareness, road condition, driver's physical condition, car's states are main causes behind the accident. As individuals need to drive vehicles at a daily basis, a model can be implemented in a smart manner which can detect and prevent road accidents. One of the benefits of IoT is the capability to make things more consistent and productive. The architecture of IoT enables us to connect sensors together which then can perform certain task by sending and receiving data from one to another. This work will have a huge contribution on road safety by the help of WBAN(Wireless Body Area Network), IoT(Internet of Things) sensors and GPS(Global Positioning System). There have been many studies on road safety techniques which includes improper driving detection, accident prevention, distance sensing, negligent driving detection and weather related events. This study will offer a IoT based model that will reduce the road accident using WBAN.

Keywords: wireless body area network; Internet of Things; global positioning system; improper driving detection; negligent driving detection; accident avoidance

Dedication

We would like to dedicate this thesis to our ever supporting and loving parents.

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First of all, all praise to the Almighty Allah for whom our thesis has been completed without any major interruption.
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Chapter 1

Introduction

1.1 Causes of Road Accidents

Nowadays, road accidents are a familiar and common problem worldwide. Road accidents have become a regular incident in recent times in the world and are still increasing at a frightening rate. The developing countries face this problem to a greater extent. Reasons to include for road accidents are lack of traffic control management, carelessness of drivers, driver's physical condition, unawareness of the nation, lack of knowledge about safe driving, drunk state, distraction, over-speeding, red-light jumping, not wearing seat-belts and many more. Traffic control in the developing countries is not up the mark. In the developed countries there are no traffic police on the road. Because the drivers had to pass some test before getting the driver's license. As a result, they are quite aware about the rules of the road. On the contrary, in the developing countries, no such written tests are taken which in turn causes road accidents due to lack of proper knowledge. However, drivers are often found to be distracted as they talk over the phone while driving. Moreover, on the highway, drivers have a tendency to over-speed the vehicle which does devastating damages. The number of road accidents are worse in the developing countries.

Year	Fatal	Injury	Property damage only	Total crashes
2009	30,862	1,517,000	3,957,000	5,505,000
2010	30,296	1,542,000	3,847,000	5,419,000
2011	29,757	1,530,000	3,778,000	5,338,000
2012	31,006	1,634,000	3,950,000	5,615,000
2013	30,057	1,591,000	4,066,000	5,687,000
2014	30,056	1,648,000	4,387,000	6,064,000
2015	32,539	1,715,000	4,548,000	6,296,000
2016	34,748	2,116,000	4,670,000	6,821,000
2017	34,560	1,889,000	4,530,000	6,453,000
2018	33,654	1,894,000	4,807,000	6,743,000

Table 1.1: Motor Vehicle Crashes (2009-2018)

Because, they do not have proper implementation of safety driving laws. Furthermore, the drivers in those countries are not aware of the rules of safe driving. The rules and ways the developed countries follow to ensure safe driving still cannot prevent road accidents. Theoretical knowledge about road signs and safety is a must for any driver. Implementing better ways to take driving license tests is must for any country. However, statistics shows that even with better road safety rules, road accidents are not reducing as expected. One of the best data collection and analyzing publishers website, 'iii.org' published the above table which shows the motor vehicle crashes worldwide from 2009 to 2018 [1].

Moreover, statistics indicate that around 80% people die where road accidents are involved directly. Statistics also show something more dangerous. At least six people die in road accidents daily where around 25% of victims are below 16 years and another 25% are in between 25 to 35 years. After investigating, we have found around 60% road accidents occur because of over speed where 70% victims are male. Our technologies have been updated but still road accidents show us something alarming. Globally 1.2 million people die in road accidents every year where 20 to 50 million people are suffering in various injuries. Another thing is noticeable that 90% road accidents occur in low income and middle income countries like Bangladesh. From the above information we can easily predict that road accidents will become the fifth cause of death within 2030 if we cannot find any solution at this point.

1.2 Internet of Things (IoT)

When we state about the Internet of Things(IoT), we mainly focus on the sensors and servers. Without the sensors, the concept of IoT is nothing. The sensors combined form a vast network for the communication. It can capture tons of data within seconds. IoT mainly combines the use of AI and human observation. The very basic thing about IoT is that the sensors will transmit the information to a database and people will take actions based on the information received. Kevin Ashton first introduced the term "Internet of Things" in 1999 during his work at Procter & Gamble. IoT was invented to make our life easier. For example, a smart air conditioner will determine the owner's distance from home by tracking his/her smartphone and automatically switches on to make the room cool for the owner as soon as he/she arrives. For such self-automating smart capabilities, we can use IoT to predict probable road accidents and can stop them from happening.

Figure 1.1: IoT system overview

As a result, the importance of road accident detection is very prominent for our society. Imagine a vehicle containing a large number of foreign products which is very important. When a sensor senses data, it immediately sends it to the computational device inside the IoT system. This device can give a prediction or can pass it to the cloud network for storing the data and get further instructions. This means there are various layers of IoT. However, we do not need all layers of IoT. We can customize the system according to our needs. But, sensor networks must be present to form an IoT system. Sensors are one of the main pillars of IoT. In addition to sensors, internet connectivity is required most of the time in such kinds of systems. Because, if we want to control any smart device from a distant location, internet connectivity is a must. In this case, the cloud server is transmitting data from the sensor to the client and vice-versa. The most interesting part of IoT is that it is mainly focused

on 'human-less interactions'. In other words, IoT systems are generally built to conduct operations automatically without any help from humans. IoT is a flexible system. In other words, we can use IoT with varieties of layers modifying as per our needs. To elaborate more, we can add computational devices or not if we want. Internet connectivity is essential in many of the IoT systems. If a user wants to remotely access any device, internet connectivity is a must. However, if there is no need for a remote connection, the internet is not needed. With the help of an IoT system, a person can accomplish most of the work if needed. Because, nowadays we can already see that everything is becoming 'smart'. We have smartwatches, smartphones, smart heaters, smart fans, smart air conditioner and so on. However, all these smart capabilities of an IoT system makes it demanding to control road accidents.

1.3 Wireless Body Area Network (WBAN)

With the advancement of Science, people are using wireless devices nowadays. Sharing information to each other at any time and any place is possible due to the blessing of modern technology. Additionally, wireless communication bestowed a fortune in the field of data sharing. WiFi, WLAN and some other mobile communication networks are used in various sectors such as health care service, education, military and industry to provide people with a convenient way to communicate with each other. Van Dam first came up with the term "Wireless Body Area Network" in 2001. WBAN is implemented in healthcare, sports, multimedia sectors along with many other similar fields. For example, in terms of healthcare, WBAN is used to measure a patient's blood pressure, heart-rate, respiration and even electrocardiogram (ECG). The patient can move freely while measuring all these tests. In terms of sports, WBAN is used to monitor an athlete's body functions. However, the use

Figure 1.2: Smart Ring

of WBAN in road accident control is quite new till today. The WBAN concept is quite simple. It consists of several nodes or sensors, which can be controlled by the internet from anywhere using a control centre which can be a computer, mobile or similar device. It is to be noted that Wireless Body Area Network is the portrayal of the physical layer in a network. It includes path loss between two nodes and estimation of the delay spread. WBAN differs from any technology by mobility, energy consumption and cheap sensors. Also, one need not to stay at a place using WBAN. Generally, WBAN is of two types depending on the type of sensors used. These are on-body sensors and in-body sensors. The on-body sensors are placed over the human body. These sensors generally take their reading from outside a person's body. Readings like ECG, heart-rate, oxygen level (SpO2), body temperature and many more data are taken by the on-body sensors. On the contrary, in-body sensors are placed inside the human body which measures muscle contraction, cardiovascular functions, brain functions and many other important readings which can be monitored from anywhere. The interesting fact of these sensors is that the person does not need to stay in a place for monitoring of these functions. Once, the sensors are implemented in the human body or clothes, anyone can move freely anywhere. They can be monitored easily through the control center. The person can move freely as long as internet connectivity is available. Internet connectivity is needed for remote monitoring of health. This reduces the time and cost needed for the treatment as well as increases the probability of success in terms of healthcare. Not only in medical sectors but also in many other sectors such as in sports, WBAN sensors are used frequently. In sports, body functions of athletes are monitored to create a proper and better sports environment. This also helps the athletes to get

help in terms of emergencies if any accidents happen.

A lot of different wireless technologies are available such as Low Power WiFi, Bluetooth and Zigbee. WBAN is such a technology by which a lot of sensors can be connected and can work properly. Those sensors have to be set up inside or outside of the human body where one part holds nodes or sensors. This sensor is available everywhere because of it's low cost and easy install process. Other parts are known as coordination units as different sensors send signals here and this unit works as a Central Control Unit or CCU. Then CCU sends that information to the next section. WMTS or Wireless Medical Telemetry Service and Ultra-Wide Bare are the other two examples of modern technologies by which we can monitor one's body in low transmission power. Here WBAN is used as the gateway to transfer information to the destination. Last but not the least there have to be end devices for human readability such as mobile phone for text, laptop or PC for monitoring and email and server for saving information in the Database.

1.4 Global Positioning System (GPS)

The Global Positioning System (GPS) is a radio-navigation system which uses satellites to track the position of any device which has the GPS chip embedded in it. This technology is owned by the United States Space Force and was invented in 1973. Today, GPS has become a part and parcel of our life. All the smartphones nowadays, have the GPS chip embedded inside it. By using this technology, one can easily track their own position in the world. All the IoT systems can use this GPS system if needed. The GPS chip inside a device transmits radio signals to the satellite in space. There are many artificial satellites which are used for GPS tracking. These satellites emit signals which contain the pseudo-random codes (codes containing series of zeros and ones) known by the receiver. There are huge antennas in different parts of the world which makes the interaction between the receiver and the satellite in space possible. The whole GPS process operates by trilateration. Trilateration is the process which calculates the position of an unknown point by measuring the lengths of that unknown point and two or more known points imagining it as a triangle. The receiver collects four such signals from four different satellites. After that the receiver calculates the position in three dimensional Cartesian Coordinates

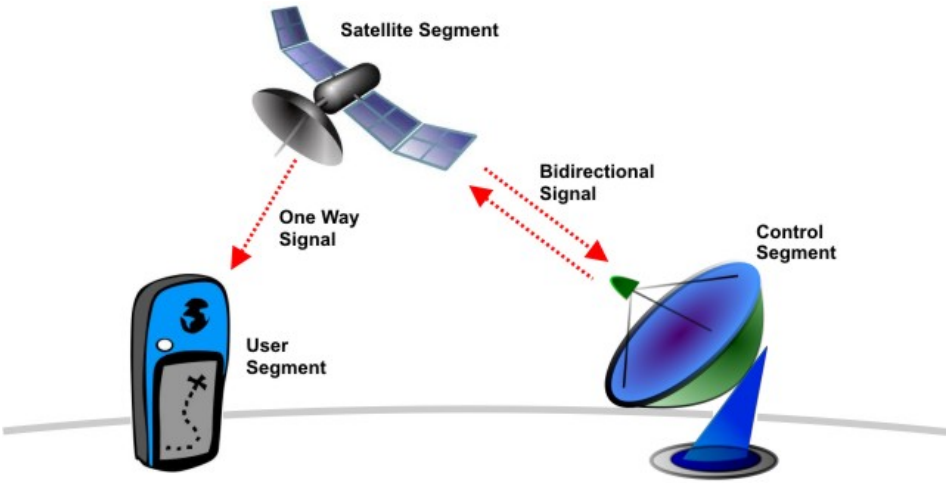

Figure 1.3: GPS system overview

using navigation equations. The satellites rotate Earth at an interval of 11 hours 58 minutes. This means they rotate the Earth twice during one solar day. These satellites have atomic clocks inside them which deviates only one second in a hundred million years. These precise clocks help the GPS receiver to determine its pin point location in the Earth. Furthermore, if a receiver wants to track the location continuously, the GPS system will continuously receive signals from different satellites again. Using the tracking algorithm (known as tracker), it will track its current location at each second. However, with the help of this GPS system, we can locate a driver's location and send help if needed. Additionally, we can also identify the exact location if any accident happens despite all the measures taken. Moreover, with these GPS data, we can figure out statistics and can identify which locations are accident prone zones. This data will also help us to take necessary actions in the future in those accident prone zones.

1.5 Aims and Objectives

The aim of this research is to obtain a road accident controlling system which will be able to detect the probability of an accident by using IoT and WBAN. Today, IoT is one of the very unique technological advancements that has blessed us with billions of physical devices connecting to the internet and all collecting and sharing data. Therefore, it is influencing our lifestyle by bringing up new solutions to our existing problems. Most of this is done using sensors which emit data from the devices. IoT provides a common platform to all the devices that are connected together and is platform independent which makes the devices communicate easily with each other. Another big advantage of IoT is it's security system which ensures the safety of data that passes through the system. This was undoubtedly one of the biggest inventions of the 20th century. With the help of IoT, road accident controlling models can be developed. There has been a lot of research where IoT has been used to prevent road accident controlling systems. One of our major research would be studying the concepts of IoT. Diversely, wireless body area network is another technological concept that has caught the eye of the researchers for a long time. In short wireless communication, physiological sensing provides a production of ultra low power devices, integrated circuits, a number of these devices can be integrated into a wireless body area network or WBAN. It has opened a new horizon in the medical sector. With the use of WBAN, it is easily possible to monitor health status of a patient without the patient not being physically present at the scenario. As a result, this is another technological area we are trying to explore to come up with a road accident controlling model which will not only emphasize on the detection of car crashes but also recognize the risk of the drivers bad health condition. Variously, we would also be focusing on Global Positioning System(GPS), Global System for Mobile Communications(GSM), Bluetooth Low Energy(BLE) technology which are important technologies in the field we are trying to do our research. However, our objective is to combine the information taken by the WBAN sensors and predict the possibilities of road accidents that might occur with the help of IoT systems in order to design a good predictive model. The model would not only predict any possibility of an unwanted accident but also take necessary steps to prevent it from occurring. Unfortunately, if the accident still occurs, the model would alert all emergency support for aid in order to reduce the loss of lives and damage of properties. Understanding different factors and attributes are also needed to get a precise outcome from this model.

Chapter 2

Literature Review

2.1 Previous Research

Road accidents are a major drawback in the progress of mankind which is hampering our development and causes unacceptable deaths and permanent injuries of our loved ones. In addition, in many road accident cases, drivers have had health issues which ultimately resulted in the accident. Researchers have tried to come up with effective solutions to prevent road accidents using advanced technology. To be more precise, many authors have tried to use IoT to make road accident controlling models and WBAN to improve the existing healthcare system. So, we have tried to review some of the research done in this domain.

Before deciding to work with the mechanisms of WBAN, we thoroughly studied about other mechanisms which are similar to WBAN. The authors of [2], [3] these papers have pointed out some differences between WBAN and another similar technology called Wireless Sensor Network (WSN). Firstly, one of the major advantages of WBAN over WSN is mobility [2]. WBAN structure has the superiority of moving the sensor nodes with the same mobility pattern. On the other hand, WSN is generally stationary. Secondly, energy consumption is less in WBAN than that is in WSN [2]. In the case of human body sensors, energy consumption is a key point to be noted. Thirdly, WSN structure was not built to tackle specific requirements associated with the interaction between the network and the human body [2]. The topic we are working with requires a technology that is capable of successfully interacting between the network and the human body like WBAN. In addition, WSN was created with the novel vision of making a technology which can cover the environment. Fourthly, WBAN structure has a better robust and accuracy rate than that of WSN structure [3] which is very essential in our case. Fifthly, WBANs contain bio-compatible sensors which are human wearable [3]. But most of the WSNs are not bio-compatible as the technology was not created to be used in human body interaction. Lastly, WBANs has the dominance over WSN due to its sensors having biodegradable standard [3]. Diversely, WSN technology has many advantages over WBAN technology which we have not mentioned here due to the fact that those advantages have no vital role in our research of interest. After analyzing both the technology we came to a decision that WBAN mechanism is preferable than WSN mechanism in our research.

The paper [4] focuses on a new approach to prevent road accident by using IoT. When two vehicles come too closer to each other and has a possibility of crashing, the system will itself brake the car and if unfortunately an accident occurs than the system will send an email to the authority with the car details for the rescue. Hardware components proposed in the paper are:

- Raspberry Pi
- Ultrasonic Sensor
- Servo Motor
- Buzzer
- LED

The system has four alerting options depending on some criteria. While the cars are driving safe, there will be a green LED signal showing the safety signal. When two vehicles come close to each other, the system will give a yellow LED alert to the driver for caution. If the cars get too close, it will give a red LED alert with the buzzer on. Lastly, if the cars are in a danger zone of crashing with each other then the system will automatically slow down the car or brake. In case the car crash or an accident occurs, the system will automatically send an email to the authoritative body for help with the car details. Furthermore, the servo motor proposed in the paper can be set up in both automatic transmission cars and manual transmission cars. For automatic transmission cars, the servo motor needs to be placed near the master cylinder, to the brake pedal. In case of manual transmission, it should be placed at the gearbox. The system proposed in the paper was very practical and implementable.

In paper [5], implementation of a system is being designed by an IoT based car. Some new sensors have been proposed and some existing sensors have been already mentioned there. Vibration sensor, heart rate sensor and accelerometer were the new sensors that were proposed in this paper. The following components were included in the model:

- Arduino
- Accelerometer Sensor
- Vibration Sensor
- Heart Rate Sensor
- Central Server
- Global System for Mobile (GSM)
- Global Positioning System (GPS)

An advanced algorithm has also been proposed in the paper. Furthermore, information of the accident location is supposed to be tracked by GPS. The system then would send an SMS to the services/family members if any accident is detected by it. GSM communication is being used to send the SMS. In addition, the heartbeat sensor is embedded in the seat belts. Moreover, the hardware setup proposed here consists of these sensors and the algorithm which is appropriate for road accident detection. The system was simulated by using an Arduino IDE and gave test results for each sensor. Later on the results were analyzed and keeping in mind the limitations in had, the system successfully gave accurate results.

The paper [6] presents the implementation of an autonomous WBAN with integrating the IoT which would produce healthcare applications. Consisting of 3 major parts, the first one is a flexible solar energy harvester with MPPT. The second part is a wearable sensor node with BLE transmission. The last part is a smart phone application acting as the IoT gateway for sensor data visualization and emergency notification. Though this paper[6] emphasizes more on the healthcare sector, the concepts used here are very much parallel in implementing a road accident controlling model. The sensors used here are:

- MCU
- Accelerometer Sensor
- Temperature Sensor
- Pulse Sensor

As wearable sensors are essential components in WBAN and the power consumption of these sensors needs to be very low for long-term use, so a hybrid solar power channel has been used. Furthermore, for connecting the sensors with the wearable device, wireless medium Bluetooth has been used which has a very low energy transmission rate. For 24 hour continuous operation of the wearable sensor node the energy storage component used is the 12.5F super-capacitor. Afterwards, the data from the sensor nodes will be transmitted to a web-based smartphone application through a commercial BLE module. The paper has brought to life a different approach of integrating IoT cloud with WBAN which is very cost efficient and effective and will be very practical in the field of healthcare.

The paper [7] aims to make a survey of WBAN and its application. Now a day's population is increasing rapidly and for that excessive population, health care costs are rising too. To reduce the health care rate, people are trying to use the latest technologies. In latest technologies, WBN (Wireless Body Area Network) is one of the promising systems which has been used worldwide. Mainly It works on the human body whether outside or inside of the body. A Body Sensor, A Body Control Unit and some long range remote gadgets are the main components of WBAN. Mainly WBAN is used for the health condition of the human body such as- Electrocardiogram, Electromyography, Body Temperature and Diabetes of the human body. On the health side, BAN (Body Area Network) monitors users' crucial signs and can give a suggestion regarding health issues. Although BAN and WBAN work kind of the same but WBAN uses some extra sensors which are set in human's various parts

of the body. Besides some sensors have to be implemented under the patient's skin. These sensors mainly measure human fear, stretch, bliss and so on. It creates an opportunity to get real time medical diagnoses and be able to give patients proper suggestions. In this paper, the author has divided WBAN architecture into four areas. Normally the first area indicates normal architecture of a body area network. It is mainly used for monitoring. In there they will use sensors for nonstop checking which is essential such as- heart rate, ECG, Blood weight and so on. This sensor gives proper information to the human body and sends that information to the next area. Second area mainly cooperates between the body and servers. These parts are called Body Control Unit or Central Node. They have some individual servers and they store information which they find from sensors. Third area is responsible for end user machines and by that they get help from doctors. The last area is a control center which connects to end devices. In this paper, the author divided the phase of communication into three phases. They are Inter-WBAN communication, Intra-WBAN communication and Beyond-WBAN communication. Mainly the first phase establishes communication between nodes of the same body. In the second phase personal server nodes send data to one or more Access Points which help WBAN to establish different network processes. Personal servers work like a gateway. Second phase has been divided into two parts. One is infrastructure based. Network is arranged in a dynamic arrangement in a restricted area. Second one is Ad-hoc based. This is mainly a mesh construction frame. In the third phase a gateway is used for a communication bridge between phase 2 and phase 3. To implement this, people have to face some serious issues like Data Security of remote gadgets. Besides gadget has to be low power expending and not get charged after a short time. Besides gadget has to be little in size. Besides medical application, this system can be used in sports applications to check if their position is okay or not.

In paper [8], the authors tried to point out the uses of WBAN. People from all over the world are trying to reduce the health cost with the help of modern technologies. WBAN is one of the parts of this modern technology. In WBAN, there are some sensors which are connected with the human body under human skin or above the skin. These sensors or devices are so intelligent that they monitor human health conditions in real time and prescribe proper guidelines for that particular body. Besides, data can be recorded for a long period of time to improve more physically. This WBAN system works by sensors and actuators. Sensors mainly measure important features such as Electrocardiogram, heartbeat, body temperature and so on. On the other hand, Actuators receive data from sensors and take initiative for the betterment of patients. To set up connections between these devices, Wireless Sensor Networks and Ad-hoc Network can be used. To build up these sensors, those devices have to have limited energy resources as it has to be small. But it is also difficult to change battery or recharge for long time uses. All devices are important for application. In this system, they use some protocol. As for example MAC-protocols, routing protocols. WBAN is a powerful technology which is used worldwide. In this technology they use some sensors and radios as skin patches. This sensor will give an integrated result in a WBAN. This system will bring a better result from day to time. But there may come security issues. As for example- data authenticity, data freshness, data confidentiality and data integrity. For this we have to be strict to protect data. Data is only accessible for authorized people. Beside this an overview

of MAC, network and physical layer are also available here. With that cross layer and quality of service is also described here. Overall the author discussed all types of protocol and then summed up the writing with security issues.

Harshal S Yeotkar, with his team has attempted to create a bridge between IoT and wireless sensor network and proposed a body parameters monitoring system in their paper. In this paper [9], the authors mainly discussed measuring human body parameter by using Wearable wireless sensor network. Those parameters are measured for using in medical science, sports science, rehabilitation, virtual reality and surveillance. In this system they use Galvanic Skin Response Sensor, Heart-Rate Sensor, Temperature Sensor, accelerometer and pulse oximeter. Person is monitored by his network. Author indicates a technology which is wireless sensor network or WSN. In this modern era, WSN come to the world as a blessing. This paper also reviews different type of system such as WLAN, WPAN, WIMAX and WBAN etc. To increase efficiency, these technologies are compared against energy consumption, security and routing protocols. IoT is interconnecting devices in sensing and monitoring processes. By this monitoring, old disease can be controlled comparatively. On human, Zigbee-Based Wearable Physiological parameters such as heart rate, temperature can be used. In this system they use sensor node. Then they communicate from sensor node to Coordinator through wireless communication. This data sends to end devices through internet. In block diagram they design several inputs from sensors to measure physiological parameters of human body such as temperature sensors for body temperature, heart rate and blood oxygen level. Accelerometer is used for detecting body movement, muscle movement motion and galvanic skin response sensor. In here signal come from sensor and they use micro-controller, then micro-controller sends it to IoT devices. Then it sends it to the end devices through internet. In here end device means mobile or personal Computer. The coordinator works as a router which is mobile or modem here. If a host computer can connect with a sensor node, data is automatically updated on IoT. In their system design they use Arduino nano, Accelerometer ADXL345 Module, NTC Thermistor 10K, mAX30100 Heart-Rate Sensor Module and Pulse Oximeter Sp02, Galvanic Skin Response (GSR), Node MCU ESP8266 ESP-12 wi-Fi board. In the software part they write their program in C language. This language is compiled by Arduino Integrated Development Environment. They show their software flowchart clearly. For the result part they use the Thinger.io platform which is open source for the Internet of Things or IoT. Mainly they tried to build a bridge between sensor and coordinator to get data. By using those data they track human physical condition.

This paper [10] presents a new WBAN technology named "ASE-BAN" which is developed by Aarhus University School of Engineering. Due to excessive growth of population, personal healthcare is increasing day by day. To solve this problem, technologies come with its blessing. Wireless Sensor Technologies are one of those blessings. It enables new sorts of software for controlling and monitoring people's physiological parameters. From generation to generation technologies have updated greatly. Specially in third generation actuators and sensors are connected without wire to a mobile body area network. These affordable devices are tiny and affordable. That's why these types of devices demand are increasing day by day. In WBAN, they use some different nodes or sensors in the human body. They also

use body gateway communication with a remote application or local application or remote central Server. Some nodes can achieve large quantities of medical information in real time. Data should be updated time to time on host for storage. As wireless data transmission is a costly process, the gateway should only transmit context relevant data when it is needed to reduce energy consumption. This is required in designed BANs. BAN is becoming popular day by day, so researchers are researching a lot on this. Mainly in this system, a lot of biomedical sensors are connected with each other and work as an integrated system compound. In this paper, the author shows hardware modules. They also describe wireless BAN. They also provide details about requirement design of a BAN architecture and design of ASE-BAN. Especially fluid balance and ECG sensors are described well here. In there they describe BAN sensor nodes, radio communication, Networks and Standards, MAC layer, 6LoWPAN, software frameworks, middle-ware and Operating System. Then they describe general requirement for wireless BAN which are Diverse User Group, User Communication, calling for Help, GPS Outdoor Positioning, Fall Detection, Mobility, Physical Constraints for BAN Components, Power consumption and Economic of BAN. After that they describe some general system requirement such as Security and Safety Issues, Healthcare Application Flexibility, monitoring Data Types, User identification, Node and Person Matching, Open Standards and Open Source, Network Topology and Communication. In System architecture, system allow component add, remove and modified. Mainly it describes its architecture and behavior of the system. In software and hardware platform, they describe software and hardware details. Besides they use some protocols as for example BLIP protocol, HTTP, IETF etc. They also describe gate and software components such as smartphones as a body gateway, System Software Components and communication. In sensors part, they use fluid balance sensor, ECG sensor, HRV sensor, Fall Sensor, Accelerometer sensor, proximity detector and Temperature sensor. They also describe how they will show their result in details. At last author describes their future target on this system and so on.

In the paper [11], authors have proposed a routing algorithm which is more efficient for wireless body area networks. The algorithm was suggested keeping in mind some issues like effective energy strategy, in body or on body sensors, different transmission rate and throughput for different data collections. The data from the sensor nodes will first be received by the central node which would be a hand device as it was described in the paper. The authors have named the algorithm "Dynamic Routing Algorithm". For finding the shortest path to the central node, Dijkstra's algorithm was suggested. In addition, a weight matrix has been included for the energy consumption matrix. 12 nodes have been used including 1 central node and 11 sensor nodes. While simulating the system, some compromises were seen. The DRA constructed the lifespan of the nodes appropriately. Still establishing the weight lengthen the lifespan of the complete network notably and some loss of the the lengthiest lifespan of some nodes were made.

The paper [12] emphasizes two major issues of wireless body area networks which are fault-tolerance and reliability-related issues. The survey was unique in itself and very descriptive. In short, the paper gave a long brief about the existing WBAN concepts, its applications, communication standards, types of WBAN devices, challenges of

WBAN and then the proposed solutions for fault-tolerance and reliability-related issues. Firstly, With the rapid increase of elderly patients due to the improvement of the healthcare system, people started to look for scopes to keep patients at their home and check the patients health condition from the hospital which ultimately resulted in the concept of WBAN. Secondly, there are quite some applications of WBAN such as in the sectors of healthcare, military, defense, sports and entertainment. Some are in body and some are on body wearable devices. Thirdly, IEEE802.15.6 is the WBAN communication standard. IEEE TG6 provides two categorizations for sensors according to their position in the human body which are implanted nodes, body surface nodes and external nodes. Types of WBAN devices are given below:

- Wireless Sensor Node
- Wearable Sensors
- Implantable Sensors
- Actuators
- Wireless Personal Device (PD)

Furthermore, some of the challenges of WBAN are power consumption, heterogeneity of devices, reliability etc. Some node level faults such as , hardware faults, software faults and data faults were also discussed in the paper. Centralized node fault detection using fusion center, distributed node fault detection, node self-detection, clustering detection, cloud-based node fault detection have been proposed to prevent fault tolerance approaches at node level. In addition, centralized context aware fault detection, centralized fault detection using middle-ware have been proposed for fault tolerance approaches at channel level.

The authors of the paper [13] performed an investigation on the WBAN's applications for motion detection based on android smartwatch. The biggest challenge the authors faced was the sensors attached to the human body sending data through Bluetooth, reading the motion and orientation of the body and displaying it in the graph form. The major contribution of this paper was to propose a method by using gyroscope sensors and accelerometer which are integrated with a smartwatch. Afterwards, the system will display results in the form of numeric values and then convert it in graph form. In addition, gyroscopes and accelerometers are used to monitor the acceleration of the user's orientation and movement separately. Firstly, the accelerometer and gyroscope sends the data to the smartphone using Bluetooth communication medium. Secondly, an application needs to be installed in the smartphone by which the numerical data can be read and displayed into a graph form. Lastly, this paper shows an implementable WBAN application for motion sensing.

The paper [14] broadly discussed the concept of WBAN and its real time applications. Firstly, it described some of the communication interfaces of WBAN such as ZIGBEE and IEEE802.15.4. Secondly, give a comparison of these two communication interfaces. Thirdly, it focused on the requirements of body sensors which were value, safety, security, privacy, compatibility, ease of use. Later on they discussed about the issues of WBAN which are stated below:

- Data Integrity
- Data Freshness
- Data Confidentiality
- Data Authentication
- Location privacy
- Contextual Accuracy
- Access Control
- Non-repudiation

Besides, the paper also described the application of WBAN. Some of them were in the sectors of medical, entertainment, lifestyle, sports, defense, consumer electronics. In addition, the authors also included the types of body sensors available currently which are given below:

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

Lastly, the authors wrote about the emerging technologies in WBAN. Here, they discussed google glass which is made up of optical head mounted display which is created by Google. It displays the information as a smartphone application which can communicate with the internet through natural language using voice commands. Also about computer clothing which are basically portable android powered devices integrated with wearable clothes and smart watches.

Paper [15] has a new approach for preventing accidents due to Drowsiness of drivers by using IoT. The motor of the Car will be automatically halted if the driver doesn't wear the seatbelt, if the driver closes his eyes for a certain time. Also, the system will keep ringing until the driver wakes up. They proposed a Drowsiness Identification and cautioning framework for such purposes. The hardware components used in this project are:

- Eye blink Scanner
- Seat Belt sensor
- MQ3 Alcohol sensor
- Motors

- Wifi Module
- Arduino
- GSM Sensor
- Buzzer

The Eye blink sensor scans the eye closing opening and if found faulty will notify via the Arduino which will transmit via WiFi Module. The seat belt sensor senses whether the seat belt is put on or not. If the situation goes negative it will activate the buzzer. MQ3 Alcohol Sensor is a liquor locator sensor which is used for identifying the liquor focus on the breath. The resistive property of this sensor mostly depends on liquid fixation. If any alcohol exists, the conductivity of it gets high. This will then activate the alarm. The sensors collect their respective data and activate alarm if something goes wrong. They want to implement such an accident prevention system based on a very common situation of the drivers. This project is quite practical to implement.

Paper [16] is quite compelling to mention as it is an unique approach in this field. They proposed a good system which is actually based on IoT. Their idea was to implement mobile traffic sensors on the vehicle directly. As a result, fast real-time processing of data is possible and it will help to reduce accidents on the road. They also used an IoT cloud system for monitoring the traffic which is based on OpenGTS and MongoDB. The hardware to mention for this project is the GPS tracker bdt 103 which is installed directly on the vehicle. They keep a track of the vehicle and monitor it. This project is directly not about monitoring the driver's condition and preventing accidents rather they collect all data of the vehicles and make an estimation of traffic in each road. Google maps can do the same but the difference is that this project is quite faster than that, if implemented. It will help to prevent more accidents and alert the drivers via an app that which roads contain traffic, speed of each of them etc. Although this project is an improvement or an extension to the existing system, it is an excellent idea to see the road in real-time and take decisions based on the data.

While studying Paper [17], we found that they tried to implement an idea which is based on Speed detection system. The idea they came up with is that an over-speeding sensor will automatically slow down the vehicle if it is in an accident prone zone. Also, this system has some law related areas to mention. If a vehicle is found over-speeding, the sensor will also send a report to the concerned authorities. The hardware to mention:

- GPS module
- Radar
- Google maps
- Speeding sensor

The GPS module collects real-time data using Google Maps and then estimates the traffic and vehicle speeds at each area. Also, it has the data of the speeding limit of each road which is collected via Google Maps. If a vehicle is over-speed, the sensor automatically slows it down based on over-speeding limits of each road. Also, if the machine detects an accident prone zone or accident area it will also slow down the vehicle. This proposed system is cost-effective and easier to implement.

Paper [18] focuses more on the drowsiness drivers and came up with an idea which is very simple but effective to implement. They used a simple IoT based system to prevent accidents. Here, they used:

- Accelerometer ADXL-330
- Arduino Uno R3
- Ultrasonic sensor
- Infrared sensor
- MQ-3 Sensor

The ultrasonic sensor is used to detect the road bumpers while the MQ-3 sensor detects the alcohol level of the driver. Moreover, the Infrared sensor uses IR rays to monitor the mouth. They implemented many yawn patterns to monitor the driver's yawning pattern to detect if the driver is really drunk or not. It used the OpenCV Library for mouth monitoring. All these are controlled by the Arduino. If anything goes out of hand, the sensors send a message to the Arduino to receive an output about what the sensors should do. The code is burned inside the Arduino and the system works accordingly. This is a simple but effective project.

Paper [19] aims to prevent accidents along with pollution detection. They use the idea of measuring the tire pressure and the amount of carbon monoxide is used to detect pollution. The hardware used for this project are:

- ADXL345
- Node MCU
- BMP180 Sensor
- MQ 7 for Pollution Detection
- Ultrasonic Sensor

They divided their project in 4 units. The Accident Detection Unit uses the ADXL345 embedded with Node MCU. By using the I2C communication system they sent the data to the servers. The 2nd unit is the Accident Prevention Unit which used the BMP180 sensor to detect the tire pressure and temperature. In normal situations, the tire pressure and temperature is set to a certain value. But during accidents, they change. So, they set a threshold value for that. The ultrasonic sensor keeps a safe distance from other vehicles and avoids accidents. The following unit is Pollution Monitoring Unit. The MQ 7 sensor measures the carbon

monoxide amount from the combustion unit and reports according to the threshold values of pollution detection and sent to the server. The last unit is the Communication Unit. The reason that this unit is the most important of all is because it connects all other units using the MQTT protocol. All other units use this unit for communicating with each other. This proposed system has a 67% accuracy in their practical result analysis. This system is one of the effective systems despite being costly.

In the paper [20], the authors proposed an IoT based model which is capable of detecting abnormal behavior of drivers while driving at night and using the sensors, the model can prevent unwanted accidents. The root cause of the paper was to come up with a model which was internet based and could help the drivers by alerting them during drowsiness while driving. The sensors that has been specified in the paper are:

- GSM & GPRS Module (Mobile phone)
- Power Supply(12V 2Amp. DC+ SMPS)
- Engine Speed Controller
- NXP RD25(8051 Microcontroller)
- Drowse Sensors(IR sensors)
- LM358 Comparator
- Gravity Sensors(3- axis accelerometer)
- Analog to Digital Converter(ADC)
- LCD Display
- Vibrator

Using the IR sensor, the measurement of eye blink is taken into record and head movement using the accelerometer. After taking the inputs, the outputs are provided to a logical circuit which would indicate the alarm. Afterwards, the results were shown on the LCD display. The placement of the accelerometer is on the driver's fore-head which measures tilt angle of the drivers in vertical either forward or backward direction and also the left or right direction from the driver knee. The proposed prototype provides some exclusive features such as a solution for drunkards when they are driving, night drivers when they are sleepy and driving, tracking and locating the location of accidents using GPS. There are advantages like User friendly interface which is helpful for vehicle drivers and disadvantages like active internet connection throughout the ride.

The paper [21] presents a car accident prevention mechanism by monitoring the vehicle from every direction and then the data holding the distance between the vehicles is stored. Afterwards, the information is shown to the driver for each second through LCD display. The LCD display is placed beside the steering of the vehicle. The sensors proposed in the paper are:

- GPRS
- Camera
- Buzzer
- Arduino
- UltraSonic sensor(US)
- Bump sensor(BS)
- LCD Display

Whenever there is a vehicle that gets too close to the car, the model gives a caution to the driver. Furthermore, it also invokes an automatic brake. The caution assist to alert the driver not to sleep while driving and the calculation of distance aid to forecast the probability of collision. In case any accident occurs, the touch sensor activates automatically which generates and sends a message to the closest located police station, ambulance, blood bank, relatives with vehicles current location. In addition, during an accident, an external camera is also activated automatically which takes images around 360 degree which could be helpful to identify the vehicle that causes the accident.

In this paper [22], the author tries to detect accident information through Arduino using IoT sensors and Ethernet adapters. Author at first installs Arduino and some software for proposed model which are given below-

- COM6 Drives
- CH341SER

Then the author builds such a cloud platform for incoming data which come from Sensor. By completing all components' connections, the author checks that it works properly or not. Here in sensors part, author uses some IoT sensors which are given-

- Smoke Sensor
- MEMS Sensor

Generally smoke sensors detect smoky things where MEMS or Micro-Electro Mechanical System measure an accelerometer. Basically in this model, the author tries to figure out the accident environment through some sensor and Arduino. Here the author uses Arduino 1.6.9 and Arduino Uno. Arduino will send all data to the Ethernet board and then it will transfer those data to its destination. This system can be an effective one because of its quick responses.

This paper [23] mainly focuses on detection of accidental environments and tries to help the victims as soon as possible through IoT sensors. Authors proposed components are given-

- Accelerometer

- GSM
- Microcontroller
- Crystal Oscillator
- GPS

Authors proposed such a system where it will detect accidents through accelerometers and GSM. It will send information to the microcontroller if the car loses its control through a vibrating frequency sensor. GPS will help to identify the location where an accident has occurred. Here GSM module will help to notify the emergency team and victim's relatives about their accidents. GSM module will work here as a mobile phone because of its calling and sending message functionality. Authors will use crystal oscillators for making electrical signals which can track accident time. Authors also mentioned Wi-fi Module and cloud storage to connect controllers with a network and store data information respectively. This proposed system can be implemented easily because of its simplicity.

In this paper [24], authors described such a system where vehicles will be controlled autonomously to avoid collision. Here authors have used some IoT sensors to control the speed of vehicles. Those sensors are given below-

- Eye Blink Sensor
- Ultrasonic Sensor
- Smoke Sensor

They proposed to use eye blink sensors and ultrasonic sensors to avoid accidents where eye blink sensors will check if eye blinks have done continuously or not. They will also use ultrasonic sensors for avoiding collision with obstacles or vehicles where sensors will send signal to the embedded board which will send the car motor a signal to reduce the speed instantly. They will also use smoke sensors to avoid motor damage detection. All of those sensors will send data to the microcontroller which will reduce speed along with buzzer beeping and error displaying. Here they will use microcontrollers such as at89s52, LCD display and DC motor. This is an efficient system to avoid collision.

This paper [25] is all about detection of alcohol and accident alerts. Here authors will use some sensors and components such as-

- MQ-135(Alcohol sensor)
- GSM Module (SIM 900 A)
- GPS Module
- Crash Sensor
- PIR Sensor

- Aluminum Wire Foil
- Panic Button
- ARM 7 Microcontroller
- LCD
- Relay
- Buzzer

Here Microcontroller is the main part of this system. If the driver becomes alcoholic, the MQ-135 sensor will detect it immediately. As a result, the sensor will send a signal to the controller so the relay remains stopped. If the driver doesn't become alcoholic, then only the relay will be on. In the mean if the driver drinks, then the sensor will use a buzzer and LED to alert the driver. Crash sensor, Aluminum foil and PIR sensor will detect the environmental condition of the car and human body. This system can be a good option to reduce road accidents.

In this paper [26], authors proposed a model where accidents have been detected and prevented by using IoT sensors. Authors have used so many sensors which are given-

- Ultrasonic Sensor
- Alcohol Sensor
- MEMS Sensor

Here they have used Raspberry-pi 3 for processing which is used for vehicle to vehicle communication. Beside this, they also have used-

- DC Motor
- DC Motor Driver
- RF Transmitter
- RF Receiver
- Buzzer
- GPS

All of those sensors will send data to Raspberry-pi 3 if something unusual occurs. Then Raspberry-pi 3 will send information to DC motor Driver which eventually sends information to DC Motor. Besides this buzzer alarm will be on and GPS will detect the exact location immediately and will send it to the authority. This system can be an easy and efficient system to reduce accidents.

Chapter 3

Proposed Model

3.1 Components

In the proposed model, we made an effort to combine IoT sensors and WBAN sensors in order to make a model which would not only determine the condition of the vehicle but also the health condition of the driver. After conducting our research we came up with the best possible components we found for implementing the model. Although, we discussed about the hardware components of our model in this section, we also need an smartphone application and a power supply which weren't discussed here. In addition, as the prototype is going to be set up in the vehicle so the power could be supplied from the vehicle itself.

Development Board [Arduino Uno Rev3]

For the proposed prototype we would require an Arduino Uno Rev3 as the development board for the IoT sensors and WBAN sensors. Arduino is a micro-controller assembled on a single-board for building digital devices. It can process data and control sensors. Arduino would assist as a bridge between the IoT sensors, WBAN

Figure 3.1: Arduino UNO Rev3

sensors and smartphone application. Furthermore, it will receive the data from the sensors and forward it to the smartphone application for further processing. It can be powered by an external power supply or via USB connection. In our case, the power supply we are going to use is the power supply of the vehicle which is the battery of the vehicle The operating voltage of Arduino Uno rev3 is 5.0V. It's input voltage recommended is 7-12V and the input voltage maximum and minimum limit is 6-20V.

Ultrasonic Sensor [HC-SR04]

Ultrasonic sensor(US) HC-SR04 will be used for detecting accidents. The sensor head emits an ultrasonic wave and receives the wave echoed from the target. The module has 4 pins naming Vcc, Trigger, Echo and Ground respectively. In addition,

Figure 3.2: HC-SR04

its operating voltage is +5V and operating frequency is 40Hz. The module will detect a speed breaker also known as speed bumper. While driving at night in an unfamiliar location, the driver misses speed breakers which causes serious damage to the car as well as to the passengers. It would also observe if any other vehicle is reaching a dangerous distance with the car.

Further information of the sensor is given below in the table[27] :

Features	Best Suitable Range
Operating Voltage	5VDC
Operating frequency	40KHz
Max Range	4m
Min Range	2cm
Operating Current	15mA
Dimension	43*20*15mm
Measuring Angle	15°
Trigger Input Signal	10µTTL pulse

Table 3.1: Ultrasonic Sensor [HC-SR04]

Infrared Sensor

An infrared (IR) sensor is a module that assists in measuring and detecting infrared radiation in its neighbouring surroundings. The infrared sensor will be used for detecting the drowsiness of the driver. The module contains IR LED and IR photo-diode which would count the eye blink rate. When the eye is closed, maximum amount of light will be reflected due to the fact that our skin part of the eye is opaque. On the other hand, when the eye is open, the minimum amount of light will be reflected due to the consumption of light as the human eye cornea is transparent. It's operating voltage is +5.0V.

Figure 3.3: Infrared Sensor

Further information of the sensor is given below in the table[28] :

Features	Best Suitable Range
Operating Voltage	5VDC
Range	<20cm
Supply Current	20mA
Sensing Range	Adjustable

Table 3.2: Infrared Sensor

Buzzer Sensor

We would use a buzzer sensor for notifying the driver about the upcoming dangers if proper actions are not taken. For example, if there is a speed breaker ahead, the buzzer would beep to alert the driver about the speed breaker or if the driver

Figure 3.4: Buzzer Sensor

falls asleep, the buzzer would beep to awake the driver from sleep. The module's operating voltage is around 3.3V-5V.

BLE Transmission Module [HM-10]

The HM-10 is a Bluetooth Low Energy(BLE) module which comes with Bluetooth 4.0 build-in. This module is used for establishing wireless data communication. We would use it to transfer data from Arduino to the smartphone without the need of a

Figure 3.5: HM-10

wire. Its working frequency is 2.4GHz ISM band and an operating voltage of 2.0V-3.6V. Moreover, it is easily connectable to Arduino. The module is used for wireless communications of less than 100 meters. As both the Arduino and the smartphone of the driver will be in the car, so we don't need to worry about the range. It is also cost efficient.

Pulse Oximeter and Heart-Rate Sensor [MAX30101]

The sensor we are going to use for detecting heartbeat and oxygen saturation in blood is High-Sensitivity Pulse Oximeter and Heart-Rate Sensor MAX30101. It is

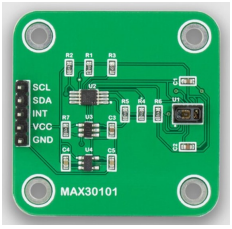

Figure 3.6: MAX30101

an integrated heart-rate and pulse oximeter monitor module. It has photo-detectors, LEDs, optical elements and low-noise electronics. The sensor can be used in Smartphones, Tablets, Fitness Assistant Devices and wearable devices. Its operating voltage is +1.8V to 2.0V (max) and +5.0V for the internal LEDs. We proposed two different sensors in Pre-Thesis-II, but after further research we came up with this efficient sensor which can conduct both the works of those two sensors.

Further information of the sensor is given below in the table[29] :

Features	Best Suitable Range
Max Voltage	2V
Min Voltage	1.7V
Operating Current	600µA
SNR(db)	89
Resolution (bits)	16
Operating Temperature	(-40-+85)°C

Table 3.3: Pulse Oximeter and Heart-Rate Sensor [MAX30101]

Temperature Sensor [MAX30205]

To measure the body temperature of the driver we proposed the MAX30205 sensor which is a temperature sensor. The sensor accurately measures temperature and

Figure 3.7: MAX30205 Sensor

provides an over-temperature alert output. It measures the body temperature when it is worn by the driver. It has various applications for example in the fitness and medical sector. The sensor's operating voltage range is 2.7V-3.3V.

Further information of the sensor is given below in the table[30] :

Features	Best Suitable Range
Operating Voltage Max	3.3V
Operating Voltage Min	2.7V
Operating Current	600µA
Temperature Resolution	0.00390624°C(16 bits)
Temperature Threshold	Programmable
Accuracy (±°C)	0.1

Table 3.4: Temperature Sensor [MAX30205]

Servo Motor [SG90]

For our research, we proposed the servo motor SG90 for the prototype system. The

Figure 3.8: Servo Motor SG90

definition of a servo motor can be written as a rotary actuator that permits exact control in terms of acceleration, velocity and angular position. Its operating voltage is +5.0V. The servo motor will slow down the car if the system needs it to in order to avoid any accident.

Resistor

In order to build the circuit we had to use some resistors. Some of the components used in the proposed model have lower operating voltage than the Arduino supplies. As a result, to reduce the voltage, we had to use some resistors.

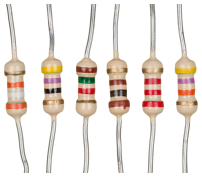

Figure 3.9: Resistors

The High-Sensitivity Pulse Oximeter and Heart-Rate sensor MAX30101 has an operating voltage of maximum 2.0V, Temperature sensor MAX30205 has an operating voltage of maximum 3.3V and BLE Transmission module HM-10 has an operating voltage of maximum 3.6V. The Arduino Uno rev3 outputs a regulated 5.0V from the regulator on the board. As a result to balance the voltage flow, we have used six resistors. We have used one 15.0k, three 10.0k, one 5.23k and one 3.92k resistors. The model proposed 10.0k and 15.0k resistor for the sensor MAX30101, 5.23k and 10.0k resistor for the sensor MAX30205, 3.92K and 10.0k resistor for the BLE module HM-10. For visual representation the whole circuit diagram has been attached in the workflow description.

3.2 Flowchart

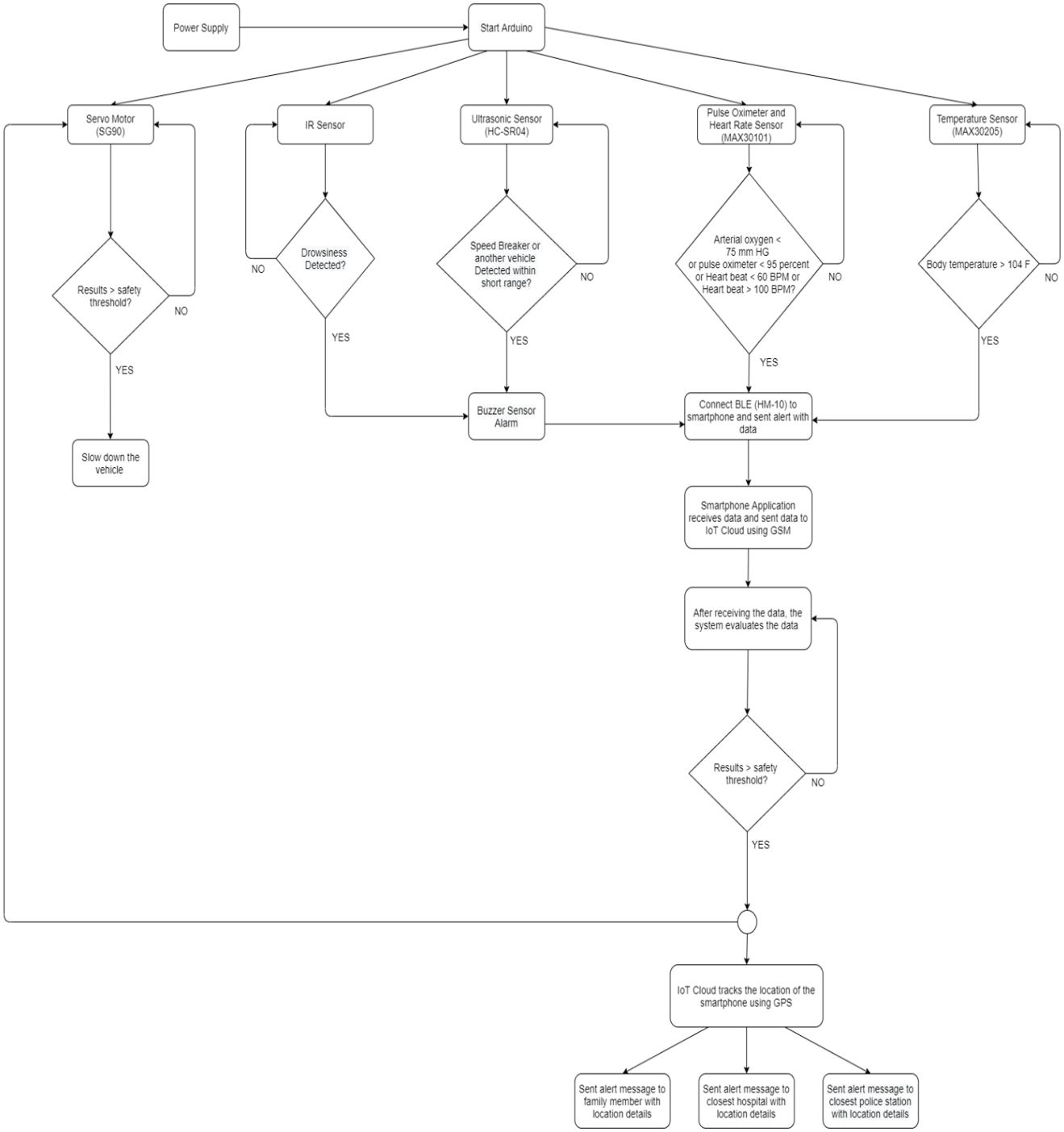

Figure 3.10: Flowchart of the Prototype

3.3 Workflow Description

The research fundamentally aims at integrating the sensors used by the Internet of Things(IoT) and Wireless Body Area Network(WBAN) together with a common development board which would act as the Central Control Unit(CCU) for both the advanced sensors. In addition, Bluetooth Low Energy(BLE) technology popularly known for very low energy consumption and fast data transferring was applied for transferring the data from the CCU to the smartphone application. Furthermore, another robust technology Global Positioning System(GPS) was used for detecting the location of the vehicle and the driver. Moreover, in order to store the data received from the sensors, thinger.io has been chosen as it is very user friendly and can be connected easily with both the CCU and smartphone application.

In order to illustrate the workflow description, the system can be divided into four phases.

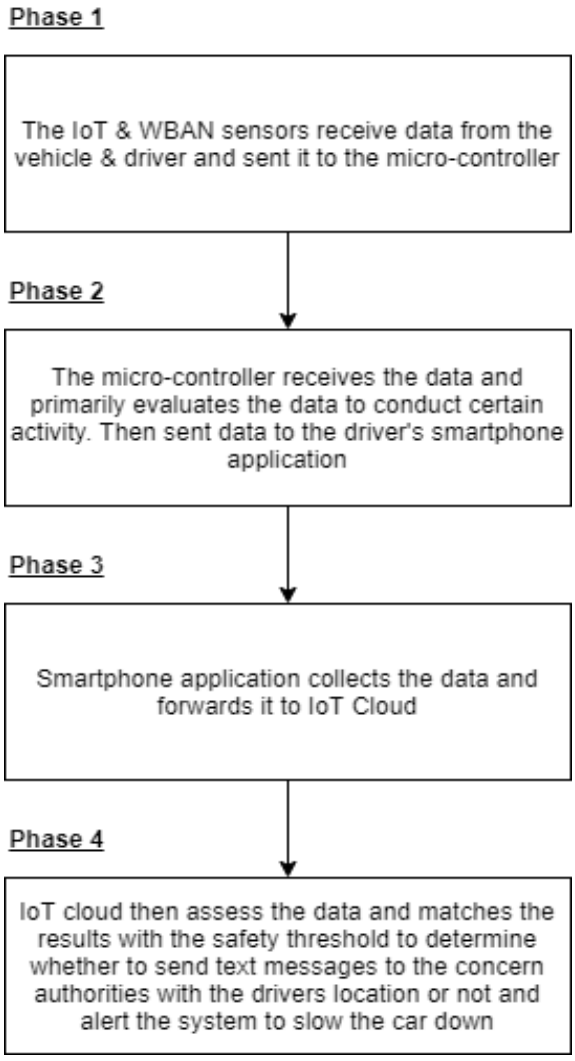

Figure 3.11: Description of separate phases of Proposed model

The first and foremost decision we had to take was to decide which microcontroller we should use in order to build the circuit. After conducting a lot of research, we

Features	ZigBee	BLE	IEEE 802.11ah	IEEE 802.11ac	LoRA WAN	LTE
Frequency Band (GHz)	2.4 GHz	(2.4-2.483) GHz	(863-868.6) MHz	5 GHz	(865-923) MHz	(1920-1980) MHz
Coverage Range	10-100 m	100 m	1 km	35-140 m	2-3 km	100 km
Data Rate	20 kb/s-250 kb/s	3 Mb/s	40 Mb/s	1.73 Gb/s	300 b/s-37.5 kb/s	1 Gb/s
Power Consumption	Less	Less	Less	Medium	Less	Less
Supported Device Number	65000	Unlimited	8000	2000	100000	Unlimited

Table 3.5: Comparison of data transmission protocols

came up with a suitable microcontroller which is the Arduino Uno Rev3. It the the development board which the research is using for building the circuit. After choosing the development board there was a issue of power supply as it needs a certain amount of electricity to run. The solution the research came up with is that the vehicle's battery which is the primary power supply of the vehicle can also act as the power supply of the development board. The Arduino Uno Rev3 would then be connected to all the other sensors and modules that the research fundamentally required and provide the necessary power supply from itself. The development board would take data inputs from the sensor and transfer it to the smartphone via the BLE module, also evaluate the data and if certain measure should be taken, then it would send signal to the authorized sensors or modules to complete the action. For example if the brake the vehicle before the estimated threshold, then the vehicle would automatically brake itself. Here, the ultrasonic sensor sends the data to the Arduino and the Arduino sends signal to the servo motor which afterwards helps to brake the car automatically. The sensors that would only send signal to the Arduino are the ultrasonic sensor, infrared sensor, pulse oximeter and heart-rate sensor and temperature sensor. In addition, the sensors that would only receive signal from the Arduino are the servo sensor and buzzer sensor. The BLE module would both send and receive data from the Arduino and the smartphone. In order to write the Arduino code C++ programming language has been proposed. The Arduino would evaluate the primary checking of the boundaries setup for instant action.

The research also includes a smartphone application which would receive the data from the Arduino via BLE module and send the data to the IoT cloud in order to store the data for further use. The smartphone application could be a website or an android, IOS application. The application would also show the daily condition of the driver. Other information such as the weather report about the location the vehicle is going, condition of the road etc. could be given in the application to make it easier for the driver to take decision. The smartphone application would use the Global System for Mobile Communications(GSM) to transfer the data to the IoT cloud. As the vehicle would be on the road and running, so GSM ought be the best

option available for transferring data. Another important technology the research proposes is the use of Global Positioning System(GPS) for locating the vehicle. As one of the feature of the system is that it can alert the driver's relatives, nearby hospital and police station about any unwanted situation with the current location of the vehicle, the system needs to track down the location of the driver. The GSM technology also has other use in the system like sending Short Message Service(SMS) to the relatives, nearby hospital and police station including the location of the vehicle for urgent help. The technologies working together can build a system which can prevent road accident and also decrease the loss of lives and properties.

Furthermore, for the cloud system the research has proposed an open-source IoT based cloud system called "Thinger.io". It is a free IoT platform. The infrastructure is hardware sceptic meaning that different devices from different manufacturers can be easily integrated. It is also very scalable. The advantage of using this infrastructure is that it can connect to any devices, store data, display real-time data, trigger events and data values. As a result, it is a complete package for a system the research proposes. Thinger.io would primarily receive data from the smartphone and store the data in its server. It would also trigger an event if needed. The server would also have the contact information of the driver's relative. It would also require having the emergency contact information of all the hospital and police stations. Although this process of storing all these emergency contacts is very laborious, in order to make the system fully capable, it is very important.

The next discussion would be about the sensors. Firstly, the ultrasonic sensor HC-SR04 proposed in the model which is connected with the development board Arduino Uno Rev3 would detect speed bumps on the road, other vehicles approaching the vehicle or any other object in a close distance. In case of both these scenarios, the sensor would alert the Arduino to bring the attention of the driver to the situation by using the buzzer sensor.

Figure 3.12: Auto Vehicle Brake

If the driver doesn't respond to the alert of the buzzer sensor and the speed bumper, other vehicle or object gets even close, then the Arduino would stop the vehicle automatically by the use of a servo motor. Multiple research has been conducted regarding the emergency autonomous brake assist. The vehicle needs to be at a limited speed in order to break it at a short distance. There are systems that can reduce the braking distances by up to 70 ft at 125 mph.

Another sensor which would play a vital role in preventing any accident according to the research conducted is the infrared sensor. It would detect the drowsiness of the

driver. Often, during long distance driving, drivers tend to fall asleep while driving which can cause serious consequences. In addition, during driving, if the driver faces any panic attack or any other attack which could make him/her unconscious could also bring serious damage. For the above mentioned plots, the infrared sensor would detect if the drivers eyes are open or closed.

Figure 3.13: Eye blink detection sensor

If the eyes are closed for a long period of time, then it would alert the Arduino to bring the attention of the driver back to the road. The sensor needs to be in a place where it can detect the eyes of the driver. The solution the research came up with is that the sensor would be attached to a wearable glass and connected to the development board. The perfect threshold for continuous eye closure would be around 6 seconds and the sensor would send continuous data for around 60 seconds with a 6 seconds interval. If the eye is closed for more than 6 seconds the Arduino would alert the driver by using the buzzer sensor. If in the next 6 second interval the driver doesn't respond then the Arduino would brake the vehicle automatically by using the servo motor.

One more sensor that is proposed in the model is the Pulse Oximeter and Heart-Rate Sensor MAX30101. In the prototype, the sensor monitors the heart beats of the driver as well as the oxygen saturation in blood. During research, it was found out that heart beats less than 60 beats per minute(BPM) or above 100 beats per minute is dangerous for a driver if he is not an athlete. It increases the chance of fainting during driving. In order for the drive to be safe, the sensor would monitor the heart beat of the driver. If the safety threshold mentioned above is surpassed, then the sensor would alert the Arduino. Furthermore, research also showed arterial oxygen level below 75 mm HG or pulse oximeter level above 95 percent is dangerous for drivers during driving. It can cause headaches or dizziness which loses consciousness. So, in order to prevent any accident, the sensor would aware the Arduino if the safety threshold brought up above is exceeded.

Moreover, the temperature sensor MAX30205 would measure the body temperature of the driver while driving. Advanced research shows that body temperature above 104 degree Fahrenheit(F) is threatening for drivers during driving. In such high temperatures, individuals can temporarily lose consciousness which could play a vital role in an accident. Also the driver loses his control over the vehicle due to severe weakness. So, to stop such an incident from happening, the sensor would measure the temperature of the driver and if it is beyond the safety threshold discussed above, it would send a signal to the Arduino. The Arduino would then take

Components	Threshold value
Pulse Oximeter and Heart-Rate Sensor [MAX30101]	Arterial Oxygen >75mm HG, SpO_2 <95% and Heart Beat <60 BPM or >100 BPM
Temperature Sensor [MAX30205]	>104°F
Infrared Sensor	>6 sec

Table 3.6: Threshold parameters of some components

necessary steps like braking the vehicle by using the servo motor to minimize the chance of any major accident.

The servo motor SG90 proposed in the model is for the prototype system. The motor would be placed in the gearbox or brake paddle which is the most effective way. It basically enables to change the gear and in cases of certain auto brakes, it can operate to control the speed of the vehicle. For the most part, this motor won't be used but in times when the driver is unable to drive the vehicle for example during unconsciousness, the motor would slow down the vehicle by receiving the signal from the Arduino. The feasibility of using such a motor in the prototype is immense.

Another important part of the research was to come up with a standard through which the data could be passed from the arduino to the smartphone application. For that, the proposed standard was Bluetooth Low Energy(BLE) which is the IEEE 802.15.1 standard. The wireless technology standard BLE was proposed due to the fact that it consumes very low power which makes it more feasible for the proposed prototype Table 3.5. For example, with BLE's power consumption, applications can run on a small battery for four to five years. However, BLE remains in sleep mode constantly except for when a connection is initiated. Another point to be mentioned is that, despite the low power consumption, BLE has a high data rate of 1 Mb/s. It is also very suitable for the model because in the model, data needs to be sent at a very short range as both the Arduino and the smartphone would be situated in the vehicle. One of the foremost fraction of the research was to come up with a development board in which the WBAN and IoT sensors both can be connected with. As the research is working with the on-body wearable sensors, so it was a dominant preference to use Arduino as the micro-controller board. Developed by Arduino.cc and manufactured by Arduino, it is one of the most prominent single-board microcontrollers. It is both efficient and reasonable as a result as the most realistic micro-controller for the prototype.

The sensors and modules the research used would be attached to the development board Arduino. The sensors Ultrasonic Sensor, Infrared Sensor, Pulse Oximeter and Heart-Rate Sensor and Temperature Sensor would only send signal to the development board and Buzzer Sensor and Servo Motor would only receive signal from the development board. The BLE module HM-10 would both send and receive signals from the board. The connection of the separate sensors and modules has been represented visually by showing a block diagram below:

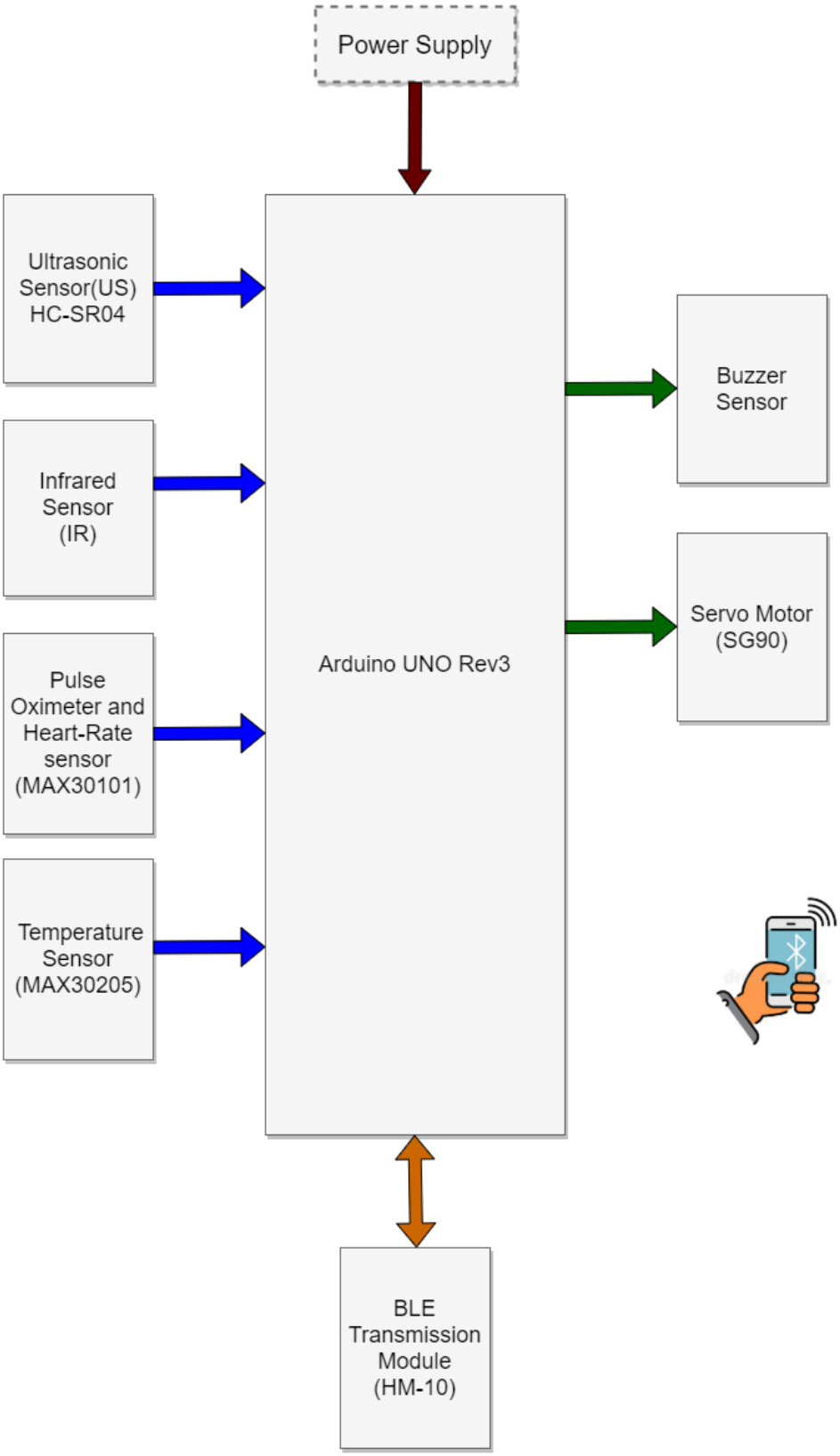

Figure 3.14: Block Diagram of the Prototype

To create the circuit diagram, we used a software named 'PROTEUS'. In this circuit diagram, the SCL and SDA pins of module MAX30101 and MAX30205 are connected with the A4 and A5 pins of the Arduino respectively. Moreover, the RX pin and TX pin of the BLE sensor (HM-10) are connected with the TX and RX pins of Arduino. Beside these connections, we also used some digital pins of Arduino for the servo motor (SG-90) and Ultrasonic sensor (HC-SR04) along with the IR sensor. We used digital pin 5 of the Arduino to control the servo motor with the pulse width modulation (PWM) signal. In addition, digital pin 6 of the Arduino is connected with the output pin of the IR sensor to get its readings. We used the resistors 10k Ohm and 3.92k Ohm to deliver 3.6 V from the Arduino to the BLE sensor. Similarly, we used resistors 10k Ohm and 5.23k Ohm to deliver 3.3V to the MAX30205 module and resistors 10k Ohm and 15k Ohm to deliver 2V to MAX30101 module. Finally, along with the buzzer, all modules are connected to the VCC (5V) and GND pin of the Arduino through their respective power pins. The circuit diagram of the proposed model is given below:

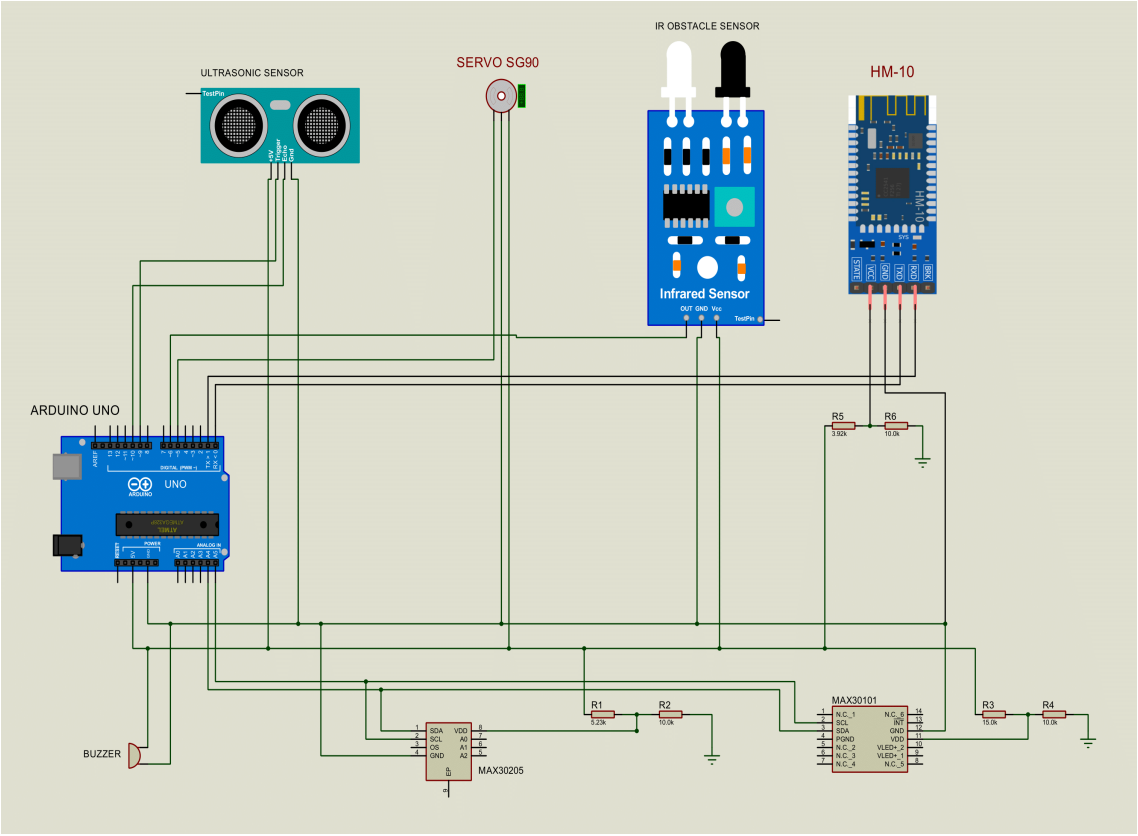

Figure 3.15: Circuit Diagram of the Prototype

3.4 Algorithm

In order to describe a system, an algorithm is one of the very most efficient ways to express it shortly. As a result, the research has been described in an algorithm. The algorithm for the proposed model can be divided into some major steps which are given below:

- After the driver gets into the vehicle and starts it, the module would automatically start.
- When the driver wears the module it would start taking the input of the driver's health condition through the WBAN sensors and the vehicle information through the IoT sensors.
- The Arduino would evaluate the values of the data received from the sensors and if the warned threshold is crossed then it would take necessary actions it is instructed to do by using the buzzer sensor and servo motor.
- The Arduino would also send the data to the smartphone application through BLE technology and if the informed threshold parameter of the sensors is crossed it would also send that.
- The smartphone application would show the data in the display and also send those data to the IoT cloud using GSM technology. It would also send the information about whether a certain threshold is crossed or not with the location of the vehicle by using GPS technology.
- The IoT cloud would then store the data in its server and if the threshold parameters are crossed and any major accident took place then it would send the contact numbers of the driver's relative, nearest hospital and police station number to the application.
- The application would then send the SMS to the relative, nearest hospital and police station with the location of the driver using GSM technology.

Chapter 4

Conclusion

4.1 Limitations

Due to the COVID-19 pandemic, the hardware components necessary for the prototype was not being able to be managed. As a result, the project development was hampered hugely. In addition, as the university curriculum went online and the university premises were closed during the pandemic, the communication between the thesis members were also badly impacted as the only communication medium is through online platform. As building the hardware project became next to impossible so the thesis group decided to build a simulator of the system with the guidance of our honorable supervisor and co-supervisor. The group tried to build the simulator by using tinkerCad, Cupcarbon, netsim and so on. But unfortunately all the components were not available to us. Specially all sensors were not available there which the proposed model had required to build the project simulator. Also, some of the components were paid modules. Furthermore, one of the rarest technologies in the field of computer science is WBAN and as a consequence our domain related research papers were very scarce to find.

4.2 Future Works

The foremost vision is to build the system physically. Our future vision is to enhance the model so that it can be more efficient as well as structured by integrating the concept of offline database so that the information regarding the closest emergency services could be accessed more quickly. It would be a milestone as then the system would be able to sent the information of the driver to the nearest police station and hospital without the need of any IoT cloud support. Furthermore, there are plans of developing the smartphone application in a very user friendly way.

4.3 Conclusion

Road accidents are very common incidents in our daily life. Many people die in road accidents everyday. Loss of valuable life and products are frequently occurring each minute due to road accidents. The proposed model is aimed to solve the road accident to some great extend by integrating intelligent features in the already existing field of IoT. The addition of WBAN sensors make the system more reliable and efficient. Moreover, the system can also determine some key accident scenarios by measuring the driver's health condition and the driving response in critical situation and triggering immediate action and help from emergency services in a short period of time which can practically save life. The health sensor to monitoring the heart rate is a great advantage in this case. But, if the nearby hospital is quite far from the accident location, there remains a risk of saving the victim's life. We are still working on that to reduce the risk factor. We also focused on informing the family members of the driver such that they can also take additional actions as necessary. All the hospitals and police station numbers are stored in the web-server such that the alert message can be sent quickly as soon as the nearby hospital and a police station is detected. If the working model is implemented with proper planning and resources, it could serve the society to a great extent. Thus, such working frameworks are needed to save valuable lives from road accidents.

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