Independent University, Bangladesh

An undergraduate internship report submitted by

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In consideration of the partial fulfillment of the requirements for the degree of

BACHELOR OF SCIENCE

in

Computer Science and Engineering

Department of Computer Science and Engineering

Autumn 2020

Web application development and IOT integration of the Vital Sign Monitoring Software

at

Bioforge Health Systems Limited

An undergraduate internship report submitted by
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has been approved on --/--/--.
Sanzar Adnan Alam
Internship Supervisor & Lecturer

Department of Computer Science and Engineering
School of Engineering & Computer Science
Independent University, Bangladesh

Letter of Submission

21th January 2021
Sanzar Adnan Alam
Lecturer,
Department of Computer Science and Engineering,
Independent University, Bangladesh

Subject: Letter of Submission for Internship Report, Fall 2021

Dear Sir, This is to inform you that with due honor and respect, I, Abrar Shams Chowdhury (ID: 1511102) from Internship Course of Fall 2021 Semester, Section would like to submit my Internship report. This report is based on my internship program and the project I have worked on. My internship period started from the 1st of December 2020 and it is expected to end on the 28th of February 2020 at Bioforge Health Systems Limited.

This report is based on my experience and the work I did at Bioforge during my internship program. The primary goal for my internship was to gain experience from working in the software engineering industry and familiarize myself with all the different technology related fields of the company, including research and development, documentation, software development and to get acquainted with software development processes and practices.

Over the period of my internship at Bioforge, I had to learn and adapt to the evolving technologies being used in the healthcare sector and requirements and to be able to apply them in real life projects. I hope the following report can achieve your approval and is adequate.

Sincerely yours,
Abrar Shams Chowdhury
1511102

Acknowledgement

First and foremost, I must express my deepest sense of gratitude to Almighty Allah, it is because of His mercy and blessing that I have come this far with everything in life. It has been a great privilege to work for Bioforge Health Systems Limited. I have received a lot of support and encouragement from the individuals of Bioforge who have a tremendous and commendable passion for saving lives through improving the healthcare system of Bangladesh. I find myself extremely lucky that such experienced members have shared their time and knowledge with me and have guided me through this process. I would like to convey my special thanks to the founder of Bioforge, Dr Dewan for his continuous support and guidance.

I would like to express my gratitude to my internal supervisor, Sanzar Adnan Alam, Lecturer, Department of Computer Science and Engineering, Independent University, Bangladesh (IUB), for his invaluable instructions, continuous guidance, support and motivation during my internship period and preparation of this report.

I likewise, want to express my deepest gratitude to my external supervisors and my mentors Ms. Shama Hoque and Dr Nabil Haque for sharing their valuable knowledge and providing support in any places I got stuck. They were always there to help me out. And it is only for their help that I could have completed this smoothly. They were the driving force of this project.

My gratitude also extends to all other employees of Bioforge Health Systems Limited who helped me learn so much in my own skill development process and made me fit right in the environment. Namely, I would like to thank Afsana Afrin Esha, Hasib Ahmed Chowdhury, Shovon Sudan Saha, Muttakin Islam, Hasnain Hossain, Khondoker Sajid Mahmud, Promittee Kamaly and Zaki Ahmed.

Finally, I proudly acknowledge the great sacrifices, good wishes, moral support, fruitful advice, inspirations and encouragements from my family members, relatives and friends.

Abrar Shams Chowdhury
January, 2021

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Acronyms

AE	Adverse Event
BMRC	Bangladesh Medical Research Council
CPD	Continuous Physiological Data
ECG	Electrocardiogram
GCP	Good Clinical Practice
HR	Heart Rate
VSM	Vital Sign Monitor

Chapter 1: Introduction

Background of the Work

The vital signs monitor is essentially a real time device that displays certain received signals from the human body. It is widely used in medical institutes all over the world. Patient monitoring systems are used for measuring continuously or at regular intervals, automatically, the values of patient's important physiological parameters. There are several categories of patients who may need continuous monitoring or intensive care. Critically ill patients recovering from surgery, heart attack or serious illness, are often placed in special units, generally known as intensive care units, where they can be supervised constantly by the use of electronic instruments. And currently given the outbreak of coronavirus, real time monitoring emerges as a frontier of telemedicine. It comes with unique and comprehensive features that can serve the immediate covid-19 need.

Recent studies have shown that continuous monitoring in combination with other systems in case of deterioration improves patient outcomes. However, for continuous monitoring to be applicable for regular use, it should not lead to decreased mobility of the patient. Therefore, continuous monitoring devices should preferably be portable, wireless, and wearable on an easily accessible body part. In different parts of the world, wearable and wireless biosensors collecting continuous physiological data (CPD) in real time to generate information reflecting the patients' current state is being established. This has been proven to be highly effective both for the treatment of individual patients as well as for assessing the efficacy and safety of care given to these patients. In Bangladesh, it would severely decrease the risk of healthcare providers decreasing their exposure to coronavirus, help meet the supply of required workforce and improve healthcare delivery.

Scientists have perceived the importance of body vital signs monitoring as they have a significant influence on the body. One of the important vital signs is SpO_2 which stands for peripheral capillary oxygen saturation, which estimates the amount of oxygen in the blood. It is the percentage of oxygenated hemoglobin compared to the total amount of oxygenated and deoxygenated hemoglobin in the blood. In the neonatal intensive care unit (NICU) oxygen saturation is continuously monitored in infants, while blood pressure is often monitored continuously immediately after birth, or during critical illness (Kumar et al., 2020). Vital sign monitoring system plays an important role in ameliorating the care of ill or premature newborn infants (Tarassenko, 2014). The body temperature is a vital sign which denotes the efficacy of any treatment applied by the physician. Both the hypothermia (<95 F) and hyperthermia (>104 F) are medical conditions concerning the body temperature. These aberrations of temperature can cause brain damage (Minamisawa et al., 1990) , cardiac arrest (Callaway et al., 2016), strokes (Doshi & Giudici, 2015). Vital sign monitoring helps in detecting these anomalies earlier which would help avoiding such hazardous circumstances. Tachycardia is a heart rate disease which occurs when the heart rate is above 100 beats. Most of the time the patient remains unknown of this deterioration. Vital sign monitoring systems can help patients and relevant health care personnel be aware of this heart beat disease (Duus et al., 2018).

Current wearable sensors are capable of recording heart rate (HR), respiration rate, temperature, and movement. Although some wearable sensors have now obtained approval

for medical use internationally, uptake within health care has been minimal in Bangladesh. One reason could be that there is little research and development of such products in our country. The validity and reliability have not been studied in a relevant environment like ours. Therefore, this will be a revolutionary step to be fully originated in Bangladesh, decreasing costs but ensuring full efficacy of the medical device.

Technology and medicine, together, has rapidly evolved in the past 10 years, especially with the expansion of wireless broadband and expanded capabilities of computers. With the evolution of consumer electronics, the medicine endpoints are moving toward large scale hospitals and even individuals. There is no end to this evolutionary pressure with the meteoric rise of computers, bio peripherals, 5G networks, and next-generation medical platforms. The VSM is the right step towards technological advancement and has the potential to revolutionize Bangladesh's healthcare industry.

Objectives

- A system for monitoring vital signs of a live body, comprising an inquiring device which is portable
- A system should allow nurses and to monitor all the patients from a single screen
- A system that allows doctors to also monitoring patients from their own devices of all sizes which are connected to the internet
- A web-application with a very user friendly UI
- A system that records patient details on a cloud database
- A system that is completely secure

Scope of the Project

- View the dashboard for the doctors and nurses for monitoring all the connected patients
- View individual Patient patient page for more detailed information about the selected patient
- Add, Remove, Update, Replace Patients to the corresponding VSM devices

Chapter 2: Literature Review

Project relation to Undergraduate Courses

Almost all CSE courses that are offered have provided knowledge that made this project sail smoothly. While some courses were implicitly helpful others provide knowledge that was directly incorporated in this project

CSE 101 Introduction to Computer Programming:
This course was where the journey began. Every single thing that was taught in this course became the part & parcel of not just this project, but for any other software I have done or will be doing in the future. This course introduced variables, functions, objects and methods and so touched on simple algorithms. All in all everything learned from this was relevant for this project and will be relevant in all the foreseeable future projects.

CSE 203 Data Structure:
This course introduced advanced topics such as complex arrays, objects, classes, array of objects, objects of array, nested arrays, nested objects, etc. Moreover, we learned and practiced how to manipulate all those. Although, the vsm project doesn't involve too many complex algorithms, it does involve handling countless arrays and objects.All the skills gained from this course made handling them significantly easier.

CSE 213 Object-Oriented Programming:
It was for this course that I built my first somewhat useful application. This course taught me the importance of "not aiming for the best possible app with countless features" and aiming for more doable and manageable projects which can always be improved later.
It also taught how to write modular programs which made codes less repetitive and more reusable. This modularity concept later helped me work with and design the React.js client for the VSM. This allowed me to avoid writing repetitive code.

CSE 303: Database Management:
According to me, this was the course that turned me into a software engineer from just a programmer and again, it was for this course that I built my first ever full-stack web application that incorporated various different libraries.
It covered popular planning and strategy practices such as System Development Life Cycle, Rich Picture, Requirement Analysis, Entity Relationship Diagram, Business Process Model and Notation Diagram and many more. These techniques helped in the development planning and strategy of VSM project and also turned out very handy while writing this report.

CSE 309: Web Applications and Internet: While doing the Database Management course we had learned a lot of new web technologies in a very short time which left huge gaps in understanding all the other technologies other than MYSQL.
Web Applications and the Internet filled in those gaps and provided a solid foundation on web application development. It covered very important technologies that are highly in demand in the industry, such as HTML, CSS, JavaScript, Bootstrap, PHP and MySql. The tools and technologies learned from this course immensely contributed to the development of the VSM project as my line of work on it was on the web application.

Although I have used a different stack for the project, the underlying concepts remained the same.

CSE 445 Software Engineering:
Just like Web Applications and Internet it picked up right where CSE 303 left but focusing the software engineering aspects this time. It too filled in a lot of gaps in terms of project design planning and architecture. Covering everything CSE 303 covered plus more details. There this course too played a big role in the overall planning of the project and its lifecycle.

Related Work

Vital sign monitors began with Seymour B. London, an American physician and inventor from Florida who designed the first automatic blood pressure monitor. He created an automated blood pressure machine after finding constant manual blood pressure readings cumbersome. The physician designed his prototype using a blood pressure cuff, a column of mercury, a microphone and a fish tank pump. While his materials may have been unconventional, his research technique was anything but; he then tested the device on 400 doctors at a 1965 American Medical Association convention. He demonstrated there was no significant difference from vital sign monitoring versus hand-taken blood pressure readings.

Today, vital sign monitors are used everywhere from hospital operating rooms to emergency situations. Vital sign monitors have continued to evolve through the development of technologies including digital signal processing, and new sensors that more accurately read the measurements, blood pressure, electric heart signals, blood oxygen, and temperature.

Vital signs monitors enable healthcare workers to efficiently, accurately and quickly evaluate their patients, whether in a hospital or office setting. Whether vital sign monitors are used for a single purpose or to measure all of a patient's vital signs, today's technology renders these diagnostic tools compact and accurate. A basic vital signs monitor is also highly portable, and even available for in-home use. Utilizing vital signs monitors affords knowledge of important information about a patient's health. They are vital in assessing a patient's overall condition. The more unstable a vital sign monitor shows a patient's signs to be, the more seriously ill that patient is. Typically, vital signs monitors measure a patient's main bodily functions including temperature, pulse rate, respiration rate, blood pressure and lastly, blood oxygen levels.

Modern vital sign monitors are used everywhere, even outside of a standard medical setting. They can be utilized for in-home care, administered by team physicians for professional athletes on the playing fields, and they are in ever-increasing use in a doctor's office.

Still, for the most part, vital sign monitors are used either in operating rooms, by nurses in hospital recovery rooms, or for the consistent, long-term monitoring of patients under long

term care. They're also used frequently by paramedics and emergency room staff, when trauma victims of necessity need the closest monitoring.

A new monitoring system designed to indicate patient vital signs was recently invented. The Remote Physiology Monitoring (RPM) is a portable device that is extraordinarily mobile and can be operated remotely.

Compared to heavy equipment used at home and hospitals in decades past, modern devices are much faster, primarily digital, non-invasive and often combine several analytic features into a single small device.

Google Fit: Health and Activity Tracking - Apps on Google Play

Figure 2.1: UI screenshots of Google Fit application for smart watches

Chapter 3: Methodology

Software Development Life Cycle

In software engineering, a software development process is the process of dividing software development work into distinct phases to improve design, product management and project management. It is also known as a system development life cycle (SDLC). We can define SDLC as a framework that describes the activities performed at each stage of a System Development Project. So, it has some basic stages to be followed during the development phase. There many different SDLC to choose from like

- **Waterfall Model**
- Prototyping
- Agile
- Spiral Model
- Rapid Application Development
- V-Model
- Incremental
- Evolutionary Model

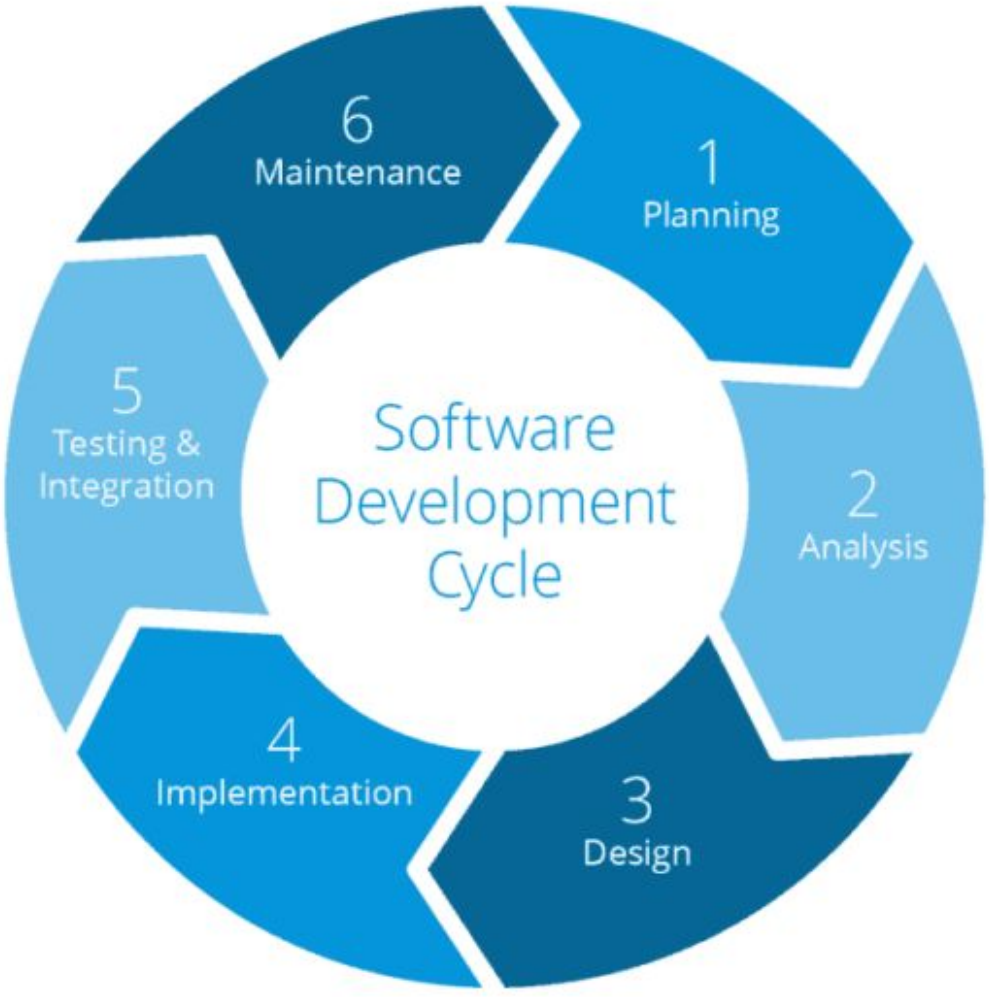

Figure 3.1: The software development life cycle

All methodologies have their own advantages and disadvantages. However, the one that worked great for us was the waterfall method. Because we needed an easy to manage and a rigid model. More importantly, we wanted to divide our work into phases with specific deliverable and a review process. Moreover, the fact that the requirements were set by ourselves instead of having them defined by the client meant that we had very well defined requirements which are not likely to change in the near future.

Waterfall Model

The waterfall model is a popular version of the systems development life cycle model for software engineering. Often considered the classic approach to the systems development life cycle, the waterfall model describes a development method that is linear and sequential. Waterfall development has distinct goals for each phase of development. Imagine a waterfall on the cliff of a steep mountain. Once the water has flowed over the edge of the cliff and has begun its journey down the side of the mountain, it cannot turn back. It is the same with waterfall development. Once a phase of development is completed, the development proceeds to the next phase and there is no turning back.

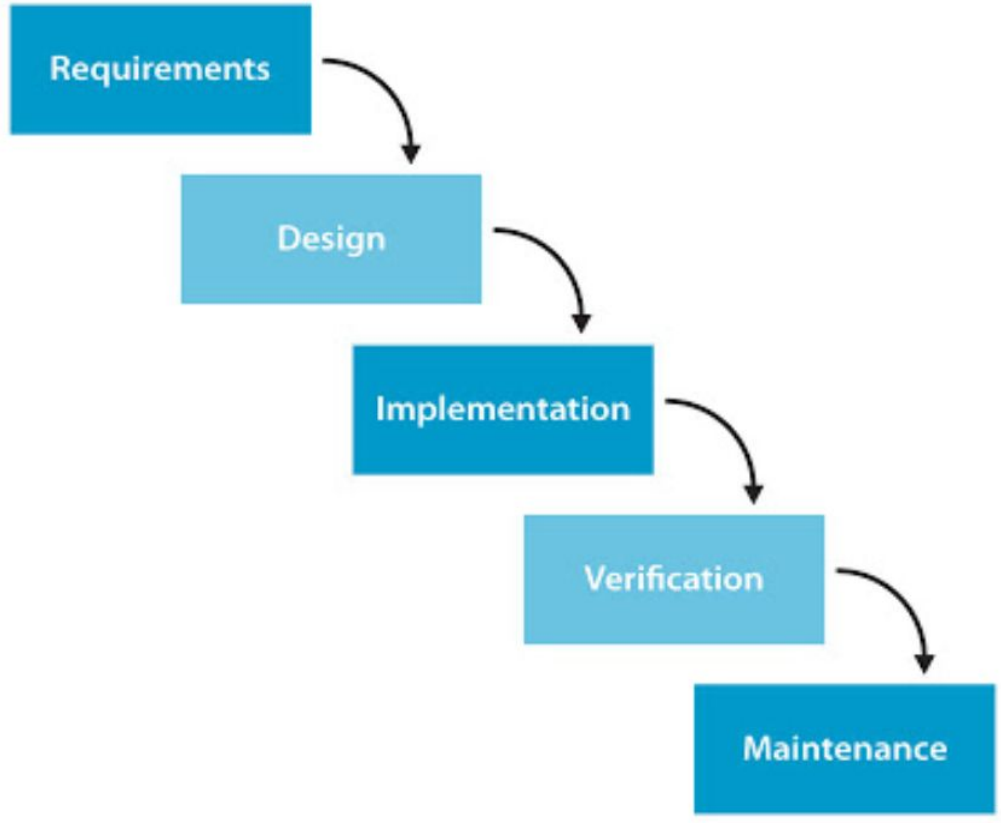

Figure 3.2: Waterfall Model

Advantages of Waterfall Model

- It allows for departmentalization and managerial control.
- Simple and easy to understand and use.
- Easy to manage due to the rigidity of the model – each phase has specific deliverables and a review process.
- Phases are processed and completed one at a time.
- Works well for smaller projects where requirements are very well understood.
- A schedule can be set with deadlines for each stage of development and a product can proceed through the development process like a car in a car-wash, and theoretically, be delivered on time.

Disadvantages of Waterfall Model

- It does not allow for much reflection or revision.
- Once an application is in the testing stage, it is very difficult to go back and change something that was not well-thought out in the concept stage.
- No working software is produced until late during the life cycle.
- High amounts of risk and uncertainty.
- Not a good model for complex and object-oriented projects.
- Poor model for long and ongoing projects.
- Not suitable for the projects where requirements are at a moderate to high risk of changing.

Chapter 4:

Project Management & Financing

Work Breakdown Structure

The WBS is a method for getting a complex, multi-step project done. It is a way to divide and conquer large projects, so things are done faster and more efficiently. Work breakdown structure (WBS) is a hierarchical tree structure that outlines a project and breaks it down into smaller portions. The goal of a WBS is to make a large project more manageable. Breaking it down into smaller chunks means work can be done simultaneously by different team members which leads to better team productivity. Below is the WBS of the VSM project.

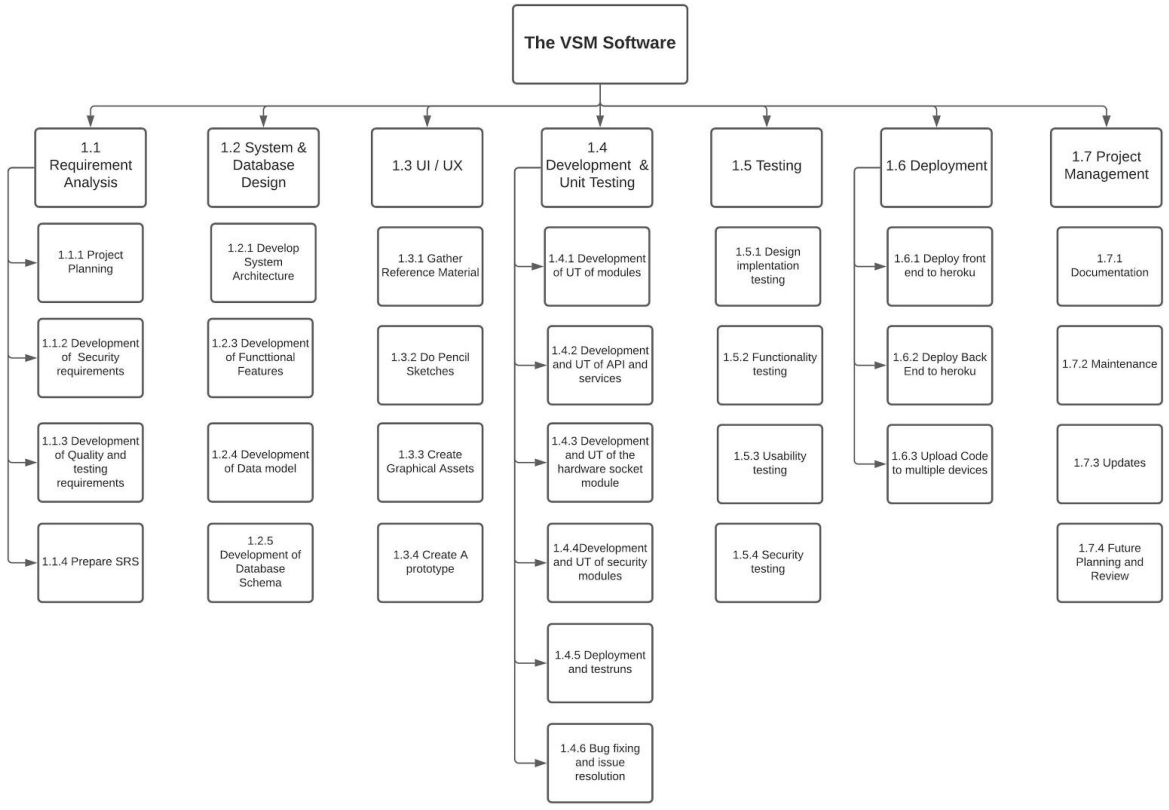

Figure 4.1: Work Breakdown Structure of the VSM software

Gantt Chart

A Gantt chart has been produced to help plan and schedule project tasks. It helped assess how long the project should take, determine the resources needed and plan the order in which tasks will be completed. It also helped in managing the dependencies between tasks.

The Gantt chart was also useful for monitoring the project's progress once it has started. It helped in having a clearer vision of what should have been achieved by a certain time frame and when the project fell behind schedule; appropriate actions were taken to bring it back to course.

The following Gantt chart was made for managing the VSM software project. Only the first nickname initials were used for decluttering the chart. The full names are as follows.

- R- Dr. Dewan Choudhury
- S - Ms. Shama Haque
- N - Dr. Nabil Haque
- A - Abrar Shams Chowhdury
- M - Muttakin Islam
- SSS - Shovon Shudan Shaha
- H - Hasib Ahmed Chowdhury
- Z - Zaki Ahmed

Figure 4.2: The VSM software project management GANTT CHART

Chapter 5: Project Body

Description of the Work

The VSM device is designed to transmit its data in real time to a server, such that it can be viewed through a web application by doctors and nurses. This would allow for ease of access to the vital signs conditions of any patient with their data being readily available through any mobile or computer device with internet connection. To achieve this, the measurements recorded by the VSM will be transmitted from within the device using an ESP32 chip, which has integrated WIFi and Bluetooth. The data transmission itself takes place via Socket.io, which is a JavaScript Library that allows for real-time, bi-directional communication with a server. The open source server used for the software integration of the VSM is Node.js. The server will simultaneously communicate, also via Socket.io, with a browser hosting the web application for all the VSM measured data. The doctors and nurses can then interact with this interface to search for and view details of vital signs conditions for any patient. The server will also upload and arrange the patient data into a cloud database, created using MongoDB Atlas. The end result allows for all VSM data to be continuously updated and stored in a cloud based system and allows any changes to be viewed real-time through a web application, thus providing full software integration of the device.

System Analysis

It is a process of collecting and interpreting facts, identifying the problems, and decomposition of a system into its components. System Analysis [13] is conducted for the purpose of studying a system or its parts in order to identify its objectives. It is a problem-solving technique that improves the system and ensures that all the components of the system work efficiently to accomplish their purpose. Analysis specifies what the system should do. This chapter contains parts of System Analysis that will help understand the project better.

Six Element Analysis

Process	System Roles				
	Human	**Computing hardware**	**Software**	**Database**	**Comm. & Network**
Monitor all patient	Nurse / Doctor	Desktop /Laptop/Phone/ etc	Web Browsers, Chrome, Firefox, etc	MongoDB	WAN
Monitor specific patient	Nurse/ Doctor/ The patient	Desktop /Laptop/Phone/ etc	Web Browsers, Chrome, Firefox, etc	MongoDB	WAN
Add new patient to the system	Nurse	Desktop /Laptop/Phone/ etc	Web Browsers, Chrome, Firefox, etc	MongoDB	WAN
Edit patient details	Nurse	Desktop /Laptop/Phone/ etc	Web Browsers, Chrome, Firefox, etc	MongoDB	WAN
Associate patient to a VSM device	Nurse	Desktop /Laptop/Phone/ etc	Web Browsers, Chrome, Firefox, etc	MongoDB	WAN
Dissociate patient from a VSM device	Nurse	Desktop /Laptop/Phone/ etc	Web Browsers, Chrome, Firefox, etc	MongoDB	WAN
	Nurse	Desktop /Laptop/Phone/ etc	Web Browsers, Chrome, Firefox, etc	MongoDB	WAN

Table 5.1: Six Elements Analysis of the VSM software

Feasibility Analysis

Feasibility Study [14] is a study to evaluate feasibility of a proposed project or system. Feasibility study is the feasibility analysis or it is a measure of the software product in terms of how much beneficial product development will be for the organization in a practical point of view. Feasibility study is carried out based on many purposes to analyze whether software products will be right in terms of development, implantation, contribution of project to the organization, etc.

Main parts of Feasibility Study :

- **Technical Feasibility:** In Technical Feasibility, current resources; both hardware and software along with required technology are analyzed/assessed to develop the project. This technical feasibility study gives a report whether there exists correct required resources and technologies which will be used for project development. Along with this, feasibility study also analyzes technical skills and capabilities of technical team, existing technology can be used or not, maintenance and up-gradation is easy or not for chosen technology, etc.

  The VSM software is built using React, Node.js, Express.js, MongoDB, Websockets. These are the technologies that are very popular in the modern industry and the two developers assigned for this project are well familiar with all the technologies except for websockets which too the team was very eager to learn. Hence, it can be concluded that the project is Technically Feasible.

- **Operational Feasibility:** Operational Feasibility: In Operational Feasibility degree of providing service to requirements is analyzed along with how easy the product will be to operate and maintain after deployment. Along with these, other operational scopes are determining usability of the product and determining whether a suggested solution by the software development team is acceptable or not etc.

  The VSM software is a web application made with complex logic and technology but for any end user it is quite self-explanatory. The UI of the project was designed with usability in mind. A lot of difficult choices were made to make it user-friendly even though they made the development complicated. Moreover, a short training will also be provided even though everything is very self-explanatory. Therefore, the project can be determined as Operationally Feasible.

- Economic Feasibility: In Economic Feasibility study cost and benefit of the project is analyzed; a detailed analysis of what will be the cost of the project for development which includes all required cost for final development like hardware and software resource required, design and development cost, operational cost, etc. After that it is analyzed whether the project will be beneficial in terms of finance for organization or not.
  The system that this software along the VSM device is designed to replace is very cumbersome and extremely expensive. The only cost in developing this software in

terms of other services is the payment for the domain. Everything else is going to be free for the first iteration. Lateron, the system will have to move towards a paid database service and maybe paid hosting service too. However, even when that happens the amount of money will be insignificant in front of the service it will be providing Thus, in conclusion, it can be said that the project is Economically Feasible.

Problem Solution Analysis

The existing system in hospitals today is very back-dated and extremely expensive to install. There has been advances in technology everywhere. However, for some reason hospitals are still holding on to their old ways. The problems that our system is solving are listed below:

- **Cannot be remotely monitored**
- **Devices are bulky and suffocating for the patient**
- **All patients cannot be looked after at same time**
- **The entire system requires huge number of hardware and human resources**
- **The Current System is expensive to install.**

System Design

Rich Picture

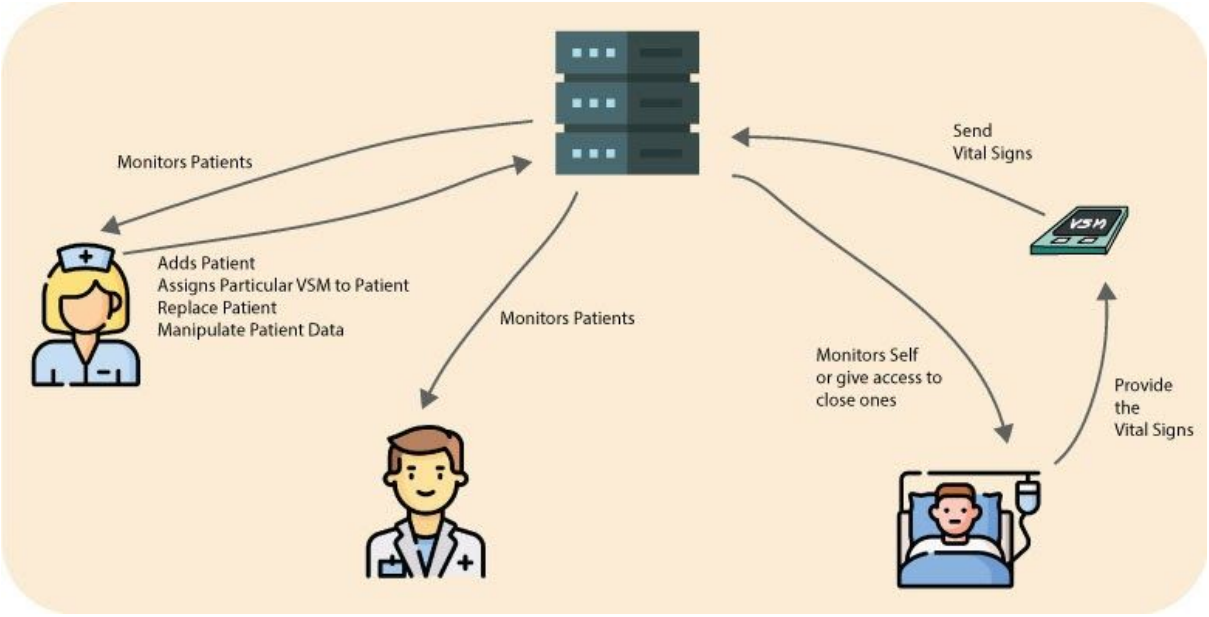

Figure 5.1: rich picture of the VSM project

The rich picture illustrates how the different stakeholders interact with the system. The Nurse has the option to add, update patients. They can then go on to associate/ disassociate a patient to/from the available devices. Moreover, the doctors and the nurses can monitor each all the patients realtime, as data is being collected from the patient real-time

Architecture of the System

Software architecture [16] is what defines and structures a solution that meets technical and operational requirements. Software architecture optimizes attributes involving a series of decisions, such as security, performance and manageability. It describes the organization and interaction of software components. There are many types of architectures that are used in different softwares. The Architecture that we went with comprises a websocket connection that allows real-time bidirectional data flow between client and server. Also have a RESTFUL API created for the all CRUD functionalities on the same server.

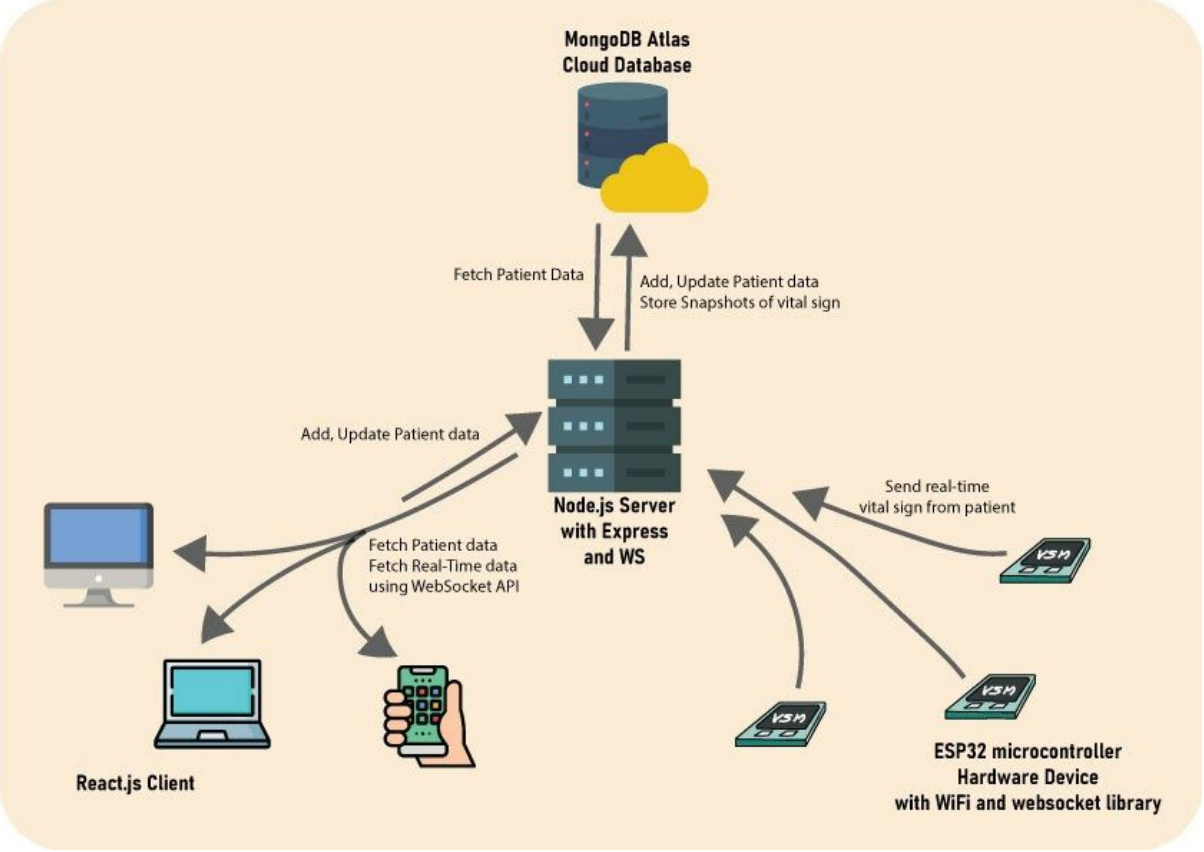

Fig 5.2: The architecture of the VSM software

Process flow diagram

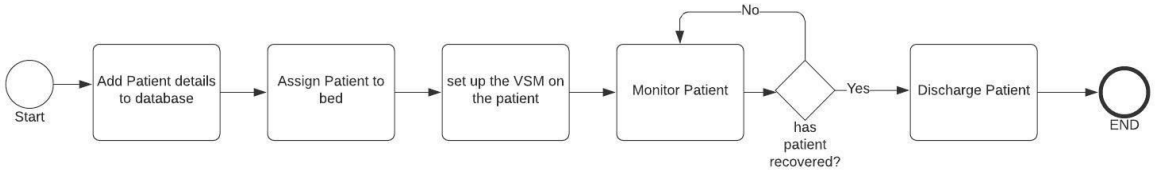

Fig 5.3: The process flow diagram

Requirements

The software requirements [18] are descriptions of features and functionalities of the target system. Requirements convey the expectations of users from the software product. The requirements can be obvious or hidden, known or unknown, expected or unexpected from the client's point of view. Requirements can be divided into two types; functional and non-functional requirements.

Functional Requirements

A functional requirement [19] is a function or feature that must be included in an information system in order to satisfy the business need and be acceptable to the users. A functional requirement defines what an application and its components are and what these components are supposed to accomplish. The following functional requirements were gathered with our decided requirements gathering methods. The inputs, processes and output are discussed below:

Non-Functional Requirements

Another type of requirement is non-functional requirements. A nonfunctional requirement is a description of the features, characteristics, and attributes of the system as well as any constraints that may limit the boundaries of the proposed solution. Non-functional requirements are briefly described below:

- **Performance:** represents the performance of the system which is required to exhibit and to meet the needs of users. Performance describes the acceptable throughput rate and acceptable response time. This application should provide a smooth experience for the Doctors and the Nurses and also should have no lag in displaying the real-time as long as the devices are connected to a stable internet.

- **Information:** represents the information that is pertinent to the users in terms of content, timeliness, accuracy and format. Information is about the necessary inputs and outputs and how it will be managed, types of the required data to be stored, how currently the information will be saved into the system, how the interfaces of external systems will work, etc

- **Security & Control:** Security and administrations are always a concern for any system but it is more sensitive in this project since this system will be dealing with medical data All information on the server side and client side is secured. Only the application administrators and developers have access to core code of the application to be able to directly manipulate any sort of information. Even the ESP32 clients require authentication before establishing the socket communication. In this project, node.js and express.js have been used for backend technology, which have various layers of security, where security requirements for this system have been taken care of. Control requirements represent the environment in which the system must operate, as well as the type and degree of security that must be provided. Access to the system or information must be controlled with the privacy requirements.

- **Efficiency:** represents the system's ability to produce outputs with minimal waste. We have tried to eliminate duplicate steps in the processes and to use the resources in an efficient way. Keeping our code non repetitive by using reusable code and components is how we achieved efficiency

- **Extensibility and Maintainability Requirements:** There is one standard User interface designed for the look and feel of the application. The application can be expanded to accommodate many further modules without making any changes to any existing modules. The application is created in such a way that the developers can easily maintain both the server and client sides.

The VSM Device

The device is a battery powered device The data collected can be displayed on the server online. Any device such as a laptop can access and view the data. The side interface is highly flexible.

Figure 5.4: VSM prototype

The figure represents the Vital Sign Monitoring prototype which will be used for the clinical trial and the vital signs like temperature, pulse rate, oxygen saturation and Electrocardiogram will be recorded by the prototype.

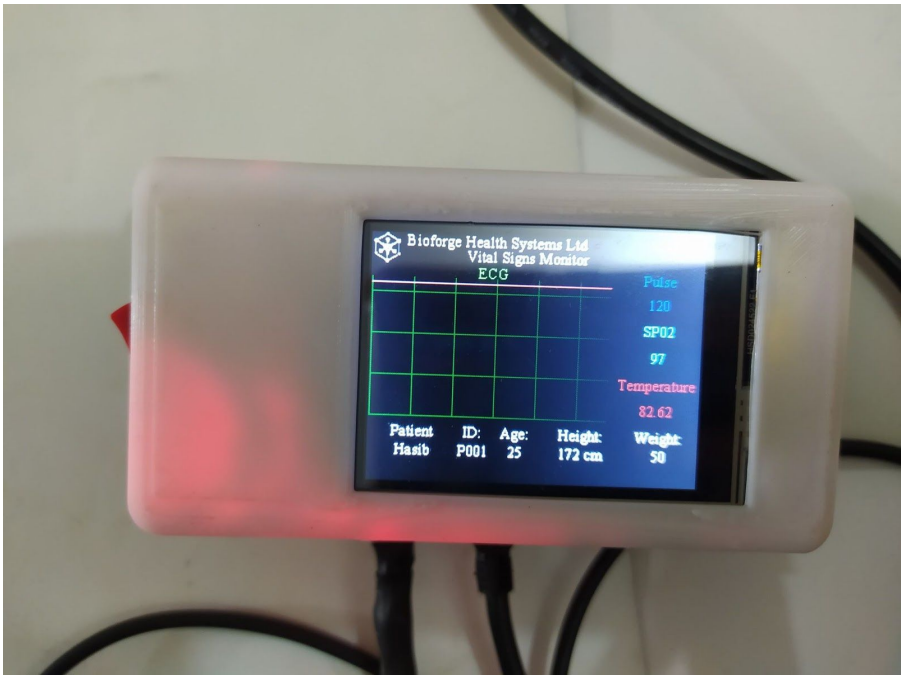

Figure 5.5: Displayed readings

In the figure above, a monitor is shown which displays the VSM data with the patient information like name, ID, age, height and weight.

The parameters this prototype collects

1. Temperature

Body temperature is an age-old method of measuring the health status of a human body. It is a measure of the body's ability to generate and get rid of heat. The human body reacts instantly to changes in surrounding temperature to regulate the body temperature within a very narrow spectrum of optimum body operation. Using a temperature sensor the body temperature is calculated. The collected signal is then modified appropriately for proper data reading. A real time display is expected to be shown to grasp the continuous changes in body temperature.

Mean temperature

Despite different variations, the human body has a mean temperature. The mean human body temperature was first calculated in the middle of the 19th century. The temperature of twenty thousand people was measured and documented and the mean temperature was found to be around 98.6° F or 37° C with a variation of 1° F or 0.6° C. This value is still taken as the mean human body temperature and the set point to measure variations.

Temperature sensor model

Temperature sensor (DS18B20): This is a waterproofed Temperature sensor. It is useful for measuring temperature far away, or in wet conditions. The sensor is good up to a temperature of 125℃ . Because they are digital, you don't get any signal degradation even over long distances! The DS18B20 provides 9 to 12-bit (configurable) temperature readings over a 1-Wire interface, so that only one wire (and ground) needs to be connected from a central microprocessor.Usable with 3.0-5.5V systems. Because each DS18B20 contains a unique silicon serial number, multiple DS18B20s can exist on the same 1-Wire bus. This allows for placing temperature sensors in many different places.

Figure 5.5: Temperature sensor

Internal circuit

The internal circuit uses operational amplifiers, diodes and transistors to get the output with accuracy.

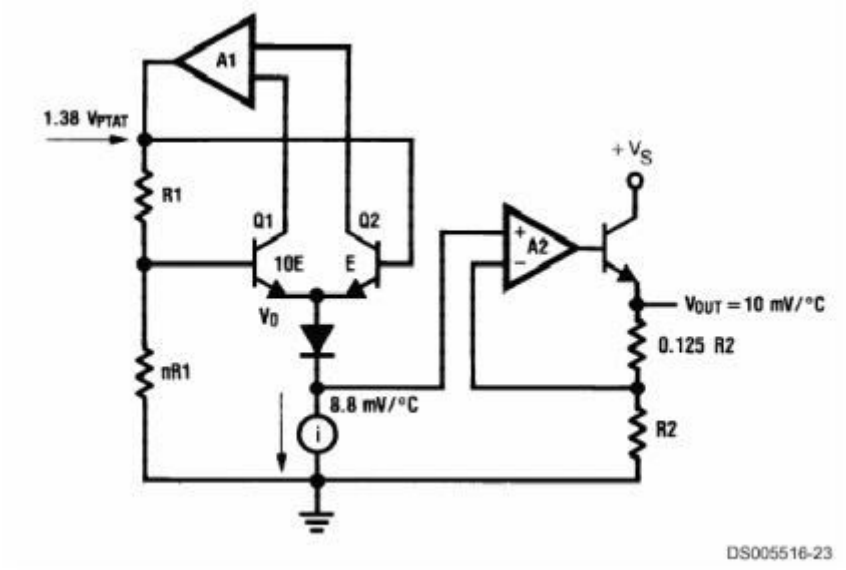

Figure 5.6: Internal circuit

2. Oxygen saturation

Oximeter is based on the concept that arterial oxygen saturation determinations can be made using two wavelengths. The two wavelengths assume that only two absorbers are present, oxyhemoglobin and reduced hemoglobin. Light passing through the finger will be absorbed by skin pigments, tissue, cartilage, bone, arterial blood, venous blood but this absorption is indifferent to the wavelength of the light being passed through it. Therefore the absorbance by all these helps us in the determination of oxygen saturation in the blood.

Sensor model

Pulse and SPO_2 sensor (MAX30100): The MAX30100 is an integrated pulse oximetry and heart rate monitor sensor. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals. The MAX30100 operates from 3.3V and 5V power supplies and can be powered down through software with negligible standby current, permitting the power supply to remain connected at all times. It follows the I2C protocol for communication.

3. Electrocardiogram (ECG)

The recording of electrical activity associated with the functioning of the heart is known as Electrocardiogram. ECG acts as a recorder of bioelectric events. The waveforms thus derived from ECG have been standardized in terms of amplitude and phase relationships

and any deviation from this would reflect the presence of abnormality. The monitor will provide continuous processing of 3-lead ECG, with standard lead selections, and filtering from electrocautery discharge. The ECG readings will be taken from the chest.

ECG sensor

ECG sensor(AD8232): The AD8232 Single Lead Heart Rate Monitor is a cost-effective board used to measure the electrical activity of the heart. This electrical activity can be charted as an ECG or Electrocardiogram and output as an analog reading. ECGs can be extremely noisy, the AD8232 Single Lead Heart Rate Monitor acts as an op amp to help obtain a clear signal from the PR and QT Intervals easily.The AD8232 is an integrated signal conditioning block for ECG and other bio-potential measurement applications. It is designed to extract, amplify, and filter small bio-potential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement.

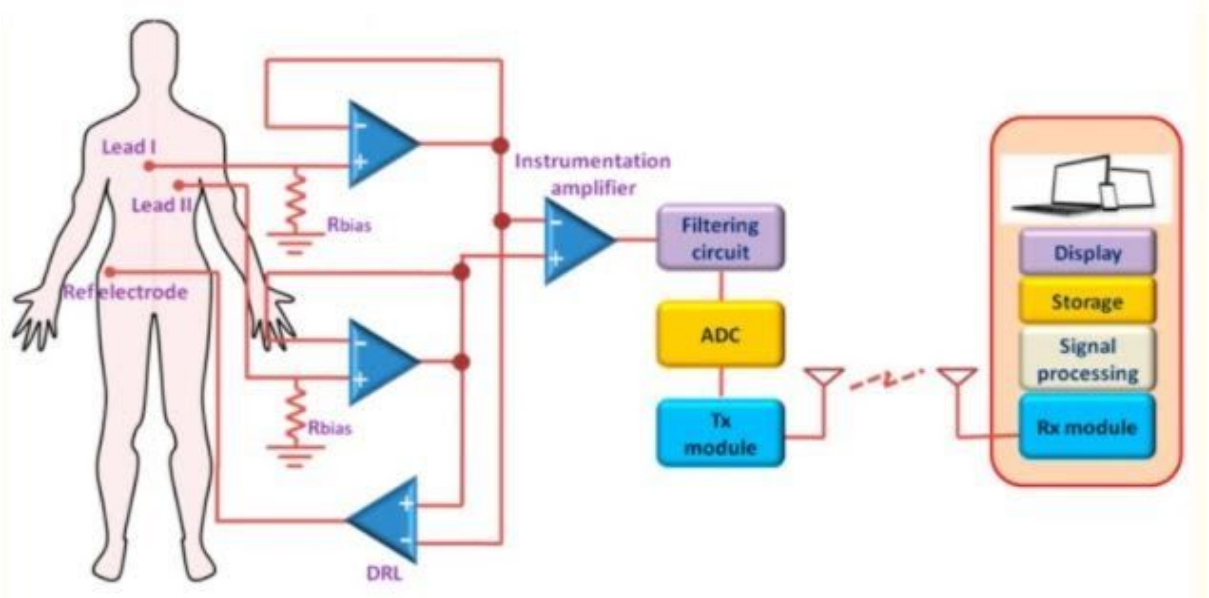

Figure 5.7: ECG procedure

Chapter 6: Results

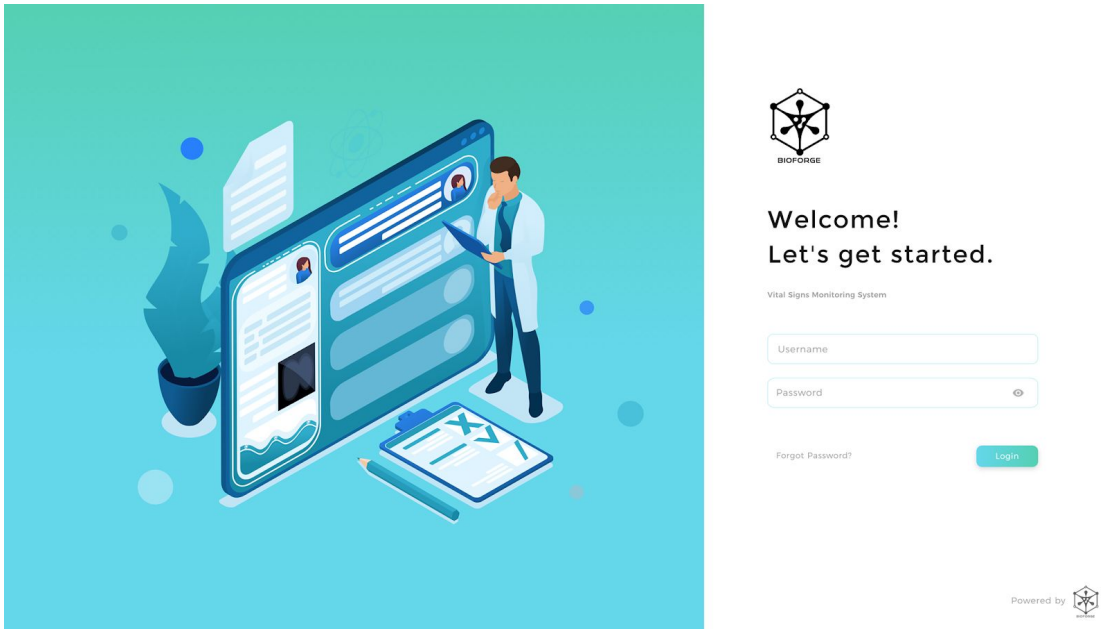

Figure 6.1: The VSM software login page

This page will allow user to login to the system, where the Doctors and Nurses will have full access to the website and the patients will have access to their own profile.

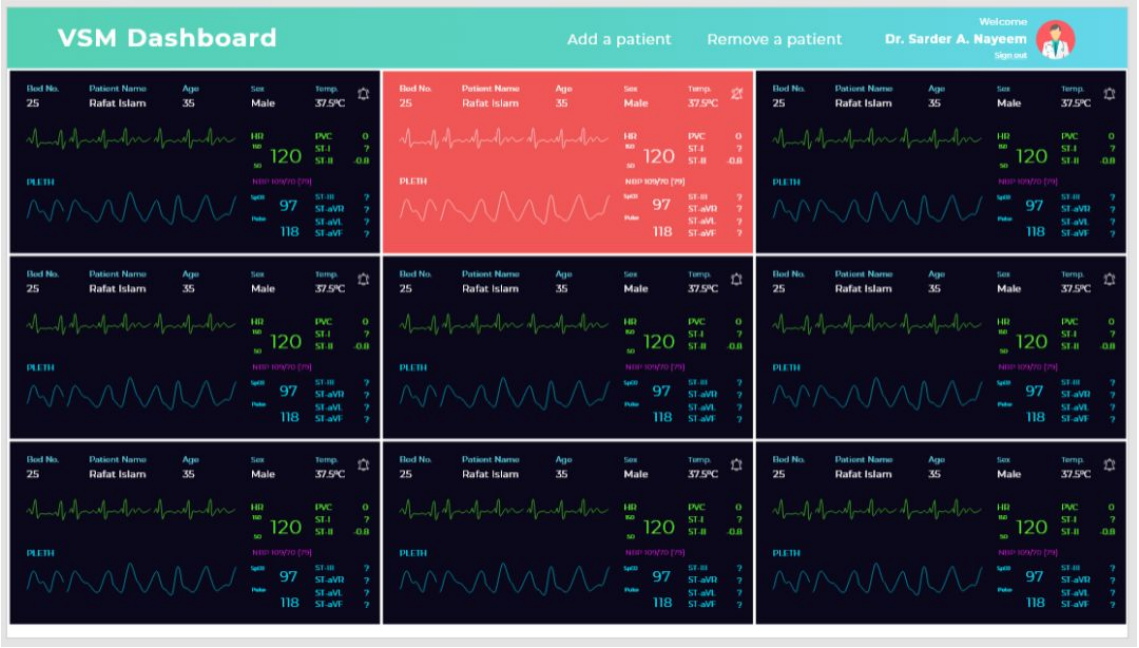

Figure 6.2: The VSM software dashboard

This page will display all the connected patients vital signs making it a very convenient place for the nurses to monitor all the patients from one place.

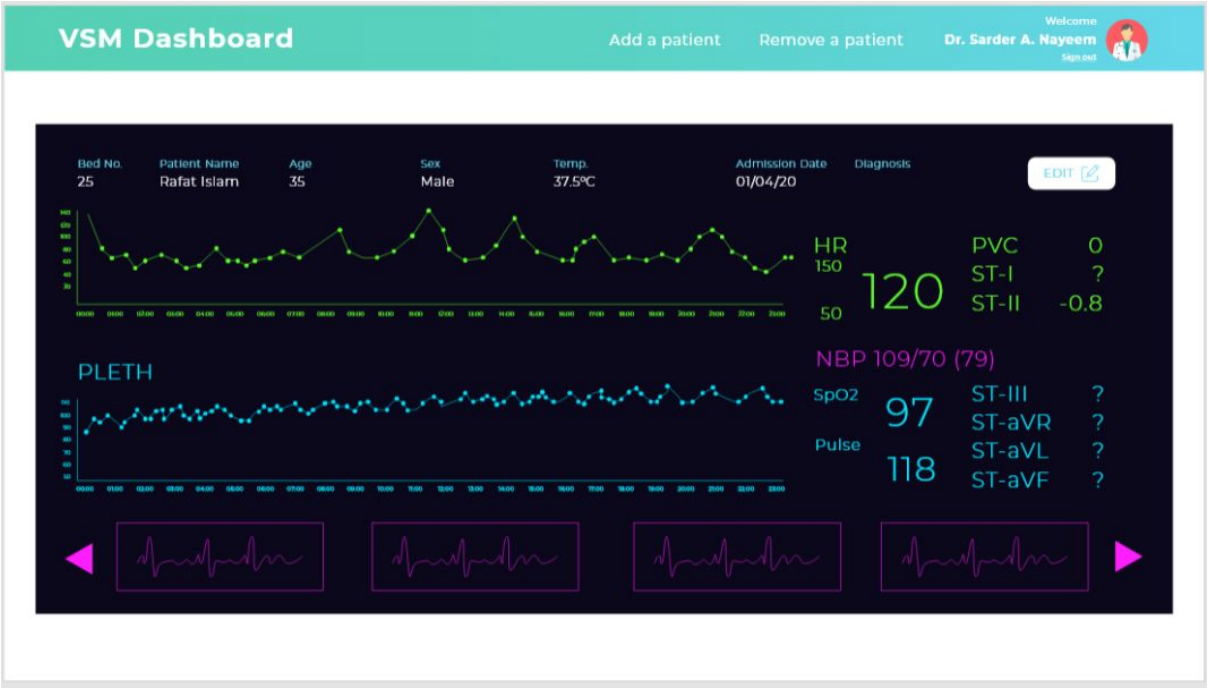

Figure 6.3: The VSM software specific patient page

This page will give a focused view on an individual patient and also allow editing their information from this page. All type of user will have access to this page

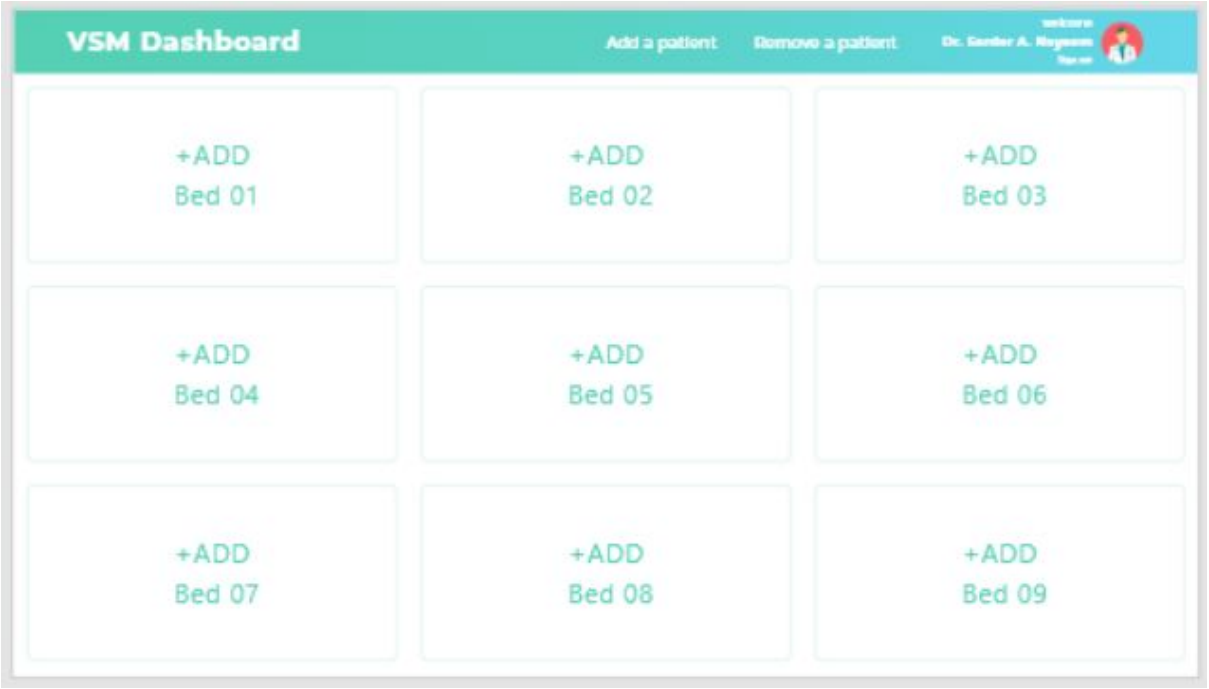

Figure 6.41: The VSM software add new patient page

This page will allow adding new patient and associating them to the VSM on a particular bed

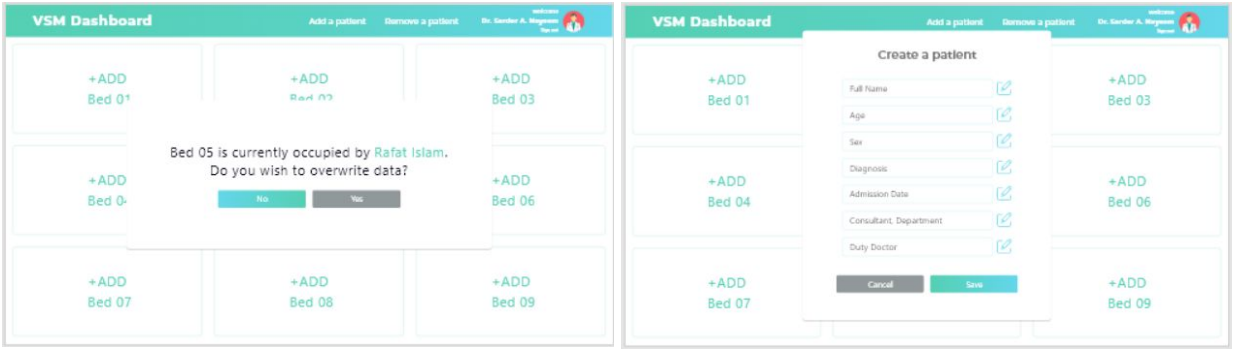

Figure 6.5: The VSM software add new patient modals

This popup will bring a form for adding patient details and a confirmation message if an user is already associated to the bed

Figure 5.6: The VSM software remove patient page

This page will allow removing a patient and disassociating them from the VSM on a particular bed

Chapter 7: Project as Engineering problem analysis

Sustainability of the product

Sustainability of the product refers to its ability to be maintained and updated. In the modern world, every application being released needs to be maintained and continuously updated for its user base.

A product can be sustainable in three main categories:

- **Community Sustainability:** This type of support comes in many forms such as downloading and installing the application, using the application, subscribing to paid services, feedback and referring to other people etc. After the deployment and official release of the VSM Software, it is believed that it will have a strong user base since the target audience for the application is specifically narrow and concise. We can expect the users to refer to other hospitals regarding the application and thus growing the user base. With a growing user base it will also grow a community and hence it can be said that it is Sustainable in terms of Community.

- **Financial Sustainability:** This refers to how the application's running cost will be maintained after it has been released and whether it will generate enough revenue as acceptable profit. An application's running cost includes - server cost, database storage cost, third party API cost, etc. The initial release of the VSM software will have a small development fee to use but as the user base grows there are plans to introduce new premium services which will eventually be used to generate revenue.

- **Organizational Sustainability:** It relates to how the organization will continue to operate after the release of the application. After the release of an application, usually the organization maintains the application via its current team, an extended team or by a fresh new team. Also, organizations update their project by adding newer features to it and organization may pivot to other projects, expand the teams, create new teams, etc. the VSM software has many more features planned for the future to be worked on and released. Since the application has further plans, the project will be maintained and updated after its release as well and release premium services to it. In conclusion, it can be said that the project is Organizationally Sustainable.

Social and Environmental effects and analysis

Social Effect:

the VSM software aims to get more hospitals interested in an efficient and data oriented admissions process which develops an ease to use virtual applications where they can speed up the paperwork process and focus more on the treatment side of things.

Environmental effect:

The hospitals here in Bangladesh still have a long way to go in regards to getting with the time and using technology for their advantage. As future iterations of the module start rolling out the company hopes to build an eco-system where all applications merge to create a one system which the hospital staff and doctors will be using without any hesitation thus furthering the growth inside the medical industry here in Bangladesh.

Addressing Ethics and ethical issues:

Ethics and Ethical issues

In the world of smartphones with so much data collection, hacking, cybercrime, etc. there are some unspoken rules and ethics guidelines that need to be followed when working on creating and releasing an application. The developers of the VSM software believe that the application does not breach any code of conduct of application release and development since they all have been taken into serious concern. Some of them are:

- Collecting only relevant User data: The app does collect user data, but those are strictly and only relevant for the app. The only data that is being collected are the user's pantry information and preferences information that the user will only provide on their own accord.
- Not Sharing or Selling any User data: Even though the data collected may not be of any privacy concern for most users, the app does not let any service, any application or any third party have access to the data collected.
- Data Storage Security: Only the lead developer and the owner of the VSM software has access to the server and the database. Since they are hosted in the cloud and can only be accessed via lead developer's and the owner's login credentials; the data stored can be deemed as safe and secure.
- Proper use of third-party services and API: the VSM software does not violate any rules of the third-party services or the APIs that have been used in its development.
- No Discrimination or Favoritism: the VSM software does not discriminate of any kind based on race, sexuality, gender, religious beliefs, color, language, political or other opinion, national or social origin, property, birth, or other status.

- Clear Promotion: the VSM software only intends to promote the company that created it, itself, and people's health. Other than what has been mentioned, the VSM software has no intention of promoting anything or anybody else.

Chapter 8: Future Work and Conclusion

Future Work & Conclusion of the Project

The rapid development, uptake of affordable wearables such as wearable devices that involve continuous measurement of vital measures may provide added information to the care of patients. To date, there have been limited studies on the use of wearables in hospitalized medical patients in Bangladesh. Overall, there are numerous benefits of using such technologies. Performing manual observations on patients can take between 5-10 minutes per patient and can be time consuming for staff. The use of automatic monitoring systems such as this can free up staff to perform other tasks. The way that observations are taken currently is open to user interpretation, whereas wearable sensors will help to reduce any bias in recording observations.

Future challenges of using sensor technology to measure vital signs is the need for sensors and data transmission to be reliable, accurate, as well as to ensure that the collected patient data is securely saved (Yilmaz, 2010). Once reliability and accuracy are proven more widespread sensor use can take place. There is the potential for use in the community by patients with chronic medical conditions or high risk patients at risk of deterioration such as the elderly. Wouldside, the vital signs monitoring devices market size is anticipated to reach USD 9.1 billion by 2026, according to the new report of Grand View Research. The key factors in wearable sensor growth are a combination of higher user demand, advancement in sensor technologies resulting in miniaturisation, reduced production costs, coupled with both wireless communication streams and a longer battery life.

There is a big market in Bangladesh with very few or no leaders in the field. This is a very lightly researched field and hence there is a huge potential for easy market entry. Such devices are mostly very expensive and can currently only be imported from other countries. This increases the costs. Therefore, making it locally not only provides national healthcare institutions an opportunity to improve their healthcare delivery with their own products but also get them at a very affordable price without any compromise in quality.

Challenges Faced During the Internship

During my internship program, I have faced lots of challenges while working on this Project. The main ones are:

- Adapting to New Technologies: since this was the first time, I have ever worked on a websocket connection and real-time bidirectional data transferring. I had to learn and adapt to this new technologie. Moreover, it was also my first time doing an IOT project as well. Because it was an IOT I also had program for the ESP32 as well while being unfamiliar with the syntax
- Choosing the right library: There were few options while choosing the libraries. Implementing them on the webapp was very straightforward but doing on the ESP32 was very difficult. I ended up switching between libraries after spending a lot of time on one. However, eventually everything worked out fine.
- **Staying on track with the Gantt Chart:** I took other courses along with the internship there during the later half of january it became quite a stretch
- Identifying and Fixing Bugs: often, there were bugs which were very hard to find, and even after they have been found it became a big problem to fix it. There were bugs that were so difficult to deal with that it would take a whole week to fix it.

Conclusion of the Internship

It was a wonderful experience working with the Bioforge family as an intern. During the internship period I have learnt and applied a great deal of knowledge from my university courses and experience here. I was introduced to new cutting-edge technologies like React.js, Node.js, Express.js, Websockets and so much more. I have learned a lot about developing different kinds of applications also about various development styles. I was pushed to adapt to changes rapidly and come up with logical solutions. During my project, I cooperated with my mentors and seniors to solve the challenges faced. Despite their workload, my supervisors were always there to answer any queries and help me settle nicely. This internship opportunity has paved the way to investigate the development environment and marketplace. I would like to appreciate once again everyone who has made my life as an intern such a great experience.

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14. Attribution: Icons made by srip, Freepik and Pixel Perfect from www.flaticon.com
15. What is Waterfall Model and the list of its advantage and disadvantage