

School of Computing

PRCO303SL

Final Stage Computing Project

Smart Health Monitoring and Alerting System

Final Report

BSc (Hons) in Software Engineering

K. C. A. A. Iroshan

2019/2020

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Acknowledgments

The completion of this project would not have been possible without the help of numerous parties that have helped and guided me throughout the course of the project.

First and foremost, I would thank and express my gratitude towards my supervisor, Ms Manoja Weerasekara, for the guidance I received in accomplishing the tasks of the project. The meetings and the guidance was quite helpful in making certain decisions with regards to how I should progress with the project and what I should add and what I should remove. Her suggestions were wise and stimulation and encouraged me to achieve the best I could with every challenge that I faced and everything that was going on.

Secondly, I want to thank NSBM Green University and University of Plymouth. The final year project is the outcome of everything I have learned throughout my degree program and the knowledge and experience that I gained at the university and the skills I managed to gain and enhance played a big role in getting the final project done. I would like to thank all the lecturers at the NSBM Green University and the University of Plymouth flying faculty for teaching me the concepts in Computer Science and Software Engineering and giving me the knowledge that was essential all of my endeavors. I would also like to forward my sincere gratitude towards the instructors and the guest lecturers and professionals from the industry for spending their valuable time in providing us the industrial skills and practical technical knowledge which I have utilized in the final year project.

Last but not least, I have to thank my closest friends and the team members with whom I worked for the rest of the group assignments. Final year project is an individual coursework but that does not mean that one would be able to do it all by themselves. My closest friends provided me with suggestions and guidance when it comes to the technologies I used in this project and their pros and cons and those information helped me in making decisions with regards to what technologies I should use for the project.

I want to forward special thanks for my family for providing me the opportunity of studying at the NSBM Green University without which none of these would have taken place.

Report Abstract

The report ventures in to explanations with regards to numerous aspects of the project and its course of development. The project objectives and scope has been explained in detail and the background of the project has been stated. Diagrams have been used to explain the system architecture, data flows, communication and database structure. Screenshots of parts of codes, API as well as the web application are included.

The report is consisted of a technology review that reviews the technologies that have been used in the development of the system and the reasoning behind those. It describes the path that were taken in selecting the technologies and the technologies that were tried, dropped and adopted.

The report is consisted of a literature review with regards to the research that has been done on the effect of computerization towards saving lives of patients. The feedback that has been collected from many people are included in the report with the relevant graphs and diagrams.

The challenges faced throughout the project and how that affected the final outcome has been explained in detail and the cloud drive link to the project and the API documentation has been included in the report.

Finally, the document specifications of the report are as follows.

Software - Libre Office

Platform - Linux

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1. Introduction

1.1. Background

Patients who are admitted to hospitals need to be monitored constantly in order to maintain a stable health condition or to effectively provide treatments to cure the patients as soon as possible. In most of the hospitals in Sri Lanka, medical staff go to the patient and monitor them in person. The most important vitals that are monitored are the heart rate and the body temperature. These monitoring happens periodically and is not constant because of the number of staff members being significantly less than the number of patients admitted. But, if there is a way for the staff to constantly monitor all the patients, it could help the staff to manage their treatments efficiently and precisely which would help the patients to get better quicker.

Once a patient has been cured, for the betterment of the patient, prolonged monitoring can be carried out at home. Currently, most of the hospitals in Sri Lanka does not provide any form of a remote monitoring service. For a highly effective and efficient patient management system, remote monitoring can be integrated with the patient management system of the hospital which maintains profiles for each and every patient maintaining their medical history which is readily available to the doctors which can be helpful when treating a patient or responding to an emergency situation.

1.2. Business Case

The existing patient monitoring mechanisms used which involves the constant attendance of medical staff can be inefficient when monitoring a large number of admitted patients and for remote monitoring which requires the presence of a nurse at the location. Medical staff does not get immediately notified of medical emergencies and does not have ready access to the medical history of the patient undergoing the medical emergency. This results in long response times.

With the Smart Health Monitoring and Alerting System, not only real time monitoring of patients can be done by the staff via a dashboard, but also the staff gets access to the medical details of the patient allowing them to plan the treatments efficiently at the right time. This system also allows a hospital to offer remote monitoring services to the patients. The system gives the ability for effective and quick responding to emergencies with the alert functionality allowing the hospital to provide better health care driving up the trust and satisfaction of the patients.

The system is consisted of an electronic device that is worn by the patients on their arms, and a web application that is used by the medical staff to access the patient data. The electronic device measures the pulse rate and the temperature of the patient and sends the data to the cloud based database. The web application obtains the data from the cloud database and represents under the patient's profile in a dash board where the medical staff can access it. The web application stores all the data of a patient including their medical history which the medical staff can access when needed. The system provides alerts when the vitals of a patients exceed the specified parameters. The device is rechargeable and communicates with the cloud using GPRS due to its longer range and low power consumption. It has a single toggle switch to turn it on and off for the simplicity of operation. The existing systems for patient management in Sri Lanka do not involve the real time monitoring of the patient vitals, which is available in our system. The feedback from the participants of the testing program has been positive on the concept with suggestions for improvements.

1.3. Objectives

- Monitor a number of patients at the same time using a dashboard.
- Monitor patients remotely.
- Maintaining profiles for patients that contains patient details and medical history.
- Enable the staff to reduce the response time in a medical emergency or a patient undergoing unstable health conditions.
- Enable the medical staff to get ready for a patient before the patient arrives at the hospital.
- Enable the medical staff to send ambulances to pick up the patients undergoing a medical emergency by letting the staff know about the emergency situation with alerts.

1.4. Scope

This project is for the development of a patient management system for medical institutions. The system will be consisted of an IOT device and a web application. The Web application will facilitate the management of patient data, their medical records and the profiles. The Web application will allow doctors to maintain their own profiles and associate patients and doctors with a certain medical record. The purpose of the IOT device would be to measure the heart rate and the temperature of the patients who are undergoing remote monitoring. The statistics of the patients who are undergoing remote monitoring would be shown to the doctors in a dashboard. The system will allow the staff in the medical institution to register or un-register doctors and patients. Doctors will have the ability to add and edit medical details of the patients.

2. The effect of computerization towards saving the lives of patients

2.1. Abstract

Computerization in the health care industry has lead to the reduction of mortality rates globally. However, most of the systems used in Sri Lankan hospitals are incomplete and some are not computerized.

The primary objective of this study is to describe how computerization can improve the efficiency of patient management in Sri Lankan hospitals and improve the chances of survivability of patients in critical conditions. The study ventures in to explaining how the effective remote and continuous monitoring of patients and automated medication where applicable enables quicker recovery than conventional treatment methods. Furthermore, the impact of comprehensive medical history of a patient being available to the medical staff in the emergency setting is evaluated.

The study make use of data obtained from research articles and books for the purpose of understanding the scope of computerization that is taking place in health care industry. Studies that have been conducted with regards to technologies have been analyzed for the purpose of understanding the optimal data storage mechanisms for health records and the applicable technologies in the context of a Sri Lankan hospital.

2.2. Literature review

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3.

4. PID – Project Initiation Document

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Project Initiation Document

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Smart Health Monitoring and Alerting System

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1. Introduction

When the patients are admitted to a hospital, they are treated and their health conditions are monitored. The most important vitals that need to be monitored are the blood pressure and the body temperature as the stability of a persons health depends on these two. Currently, on patient basis, these vitals are not recorded and profiled, and in order to monitor a patient, the medical staff have to check on the patient time to time. Sometimes, some patients will be needed for prolonged monitoring even after they're released to their homes. But other than with a dedicated medical personal, an effective remote monitoring system is yet to be implemented. It's also necessary to store a brief medical history of patients to be used in case of an emergency situation for better preparation to handle the patient on the hospital's side.

It's more efficient to have a centralized computer based patient monitoring system where the medical staff of a hospital can monitor vitals of the admitted patients (who needs to be constantly monitored) and the released patients who also may need to be monitored, using remote monitoring, all in the same centralized system. If the medical staff gets alerted of a medical emergency of a patient with the access to that patient's medical history, it'd help them immensely to get ready for the patient (if the patient is in remote monitoring, sending an ambulance to collect the patient), by arranging the hospital before the patient arrives at the hospital. This system would also be beneficial even when monitoring the already admitted patients, for quick attendance to the need.

2. Business Case

2.1. Business need

The existing patient monitoring mechanisms used which involves the constant attendance of medical staff can be inefficient when monitoring a large number of admitted patients and in remote monitoring. Medical staff does not get immediately notified of medical emergencies and does not have ready access to the medical history of the patient undergoing the medical emergency. This results in long response times.

2.2. Business objectives

Automating parts of the patient monitoring scenario which enables the medical staff to

- Constantly monitor a large number of patients at the same time removing the need to manually attend to the patient whenever the staff wants to know about the patient vitals.
- Effectively monitor the released patients remotely (when it's necessary).
- Keep records of the medical history of patients under their profiles to be accessed in a medical emergency.
- Enables the staff to reduce the response time in a medical emergency or a patient undergoing unstable health conditions.
- Enables the staff to get ready for a patient before the patient arrives at the hospital (in an ambulance in a medical emergency).
- Enables the medical staff to send ambulances to pick up the patient undergoing a medical emergency. (Notifying the ambulance is done by the medical staff the regular way and not through the system. The system provides the information for the medical staff that are necessary to make their decisions.

2.3. Background

This project does not have a funding client. But it's possible to offer this system to a client once it's completed. The client most likely would be a medical institution. This project is being done as I believe there is a need for a system like this in hospitals.

3. Project Objectives

1. Analyze the existing patient monitoring procedures.
2. Analyze the existing patient data recording procedures.
3. Analyze the existing technologies applicable to the proposed solution.
4. Implementation of the system as a prototype.
5. Documentation of the system.

4. Initial scope

1. The processes of the system are identified through observation and interviews.
2. The processes of the system are documented with UML diagrams.
3. The databases of the system are identified through observation and interviews.
4. The databases of the system are documented using EER diagrams.
5. The proposed system will allow
 - a) The medical staff to view the vitals (blood pressure and body temperature) of each and every patient.

- b) The medical staff to view the medical details of each and every patient.
- c) The medical staff to register patients in the system.
- d) The medical staff to remove patients in the system.
- e) The medical staff to receive alerts regarding emergency health conditions of the patients.

5. Method of Approach

Agile software development life cycle will be used in developing the system. Possible technologies are Arduino equipment and Arduino programming language, Java native application or a web application using appropriate technologies. SQL for databases. Proper evaluation of the technologies will be done during the project in order to select the best and the most suitable technologies for implementing the system.

6. Project Plan

Stage	Deadline	Products/Deliverable/ Outcomes
1. Products/Deliverable/ Outcomes	19 th October 2019	Project Proposal
2. Initiation	5 th November 2019	Project Initiation Document
3. Investigation and Requirements	15 th November 2019	Analyzing the existing system. Identification of the suitable technologies for the development of the system.
4. High-Level design	1 st December 2019	Designing the system. (UML, EER, Interface designs)
5. Increment 1	18 th December 2019	Progress Video Working Health Monitoring Device
6. Increment 2	13 th January 2020	Interim Report 1 Dashboard of the system with patient registration, patient profiles and patient health data storing and displaying capability.

7. Increment 3	18 th February 2020	Interim Report 2 Displaying real time patient vitals (blood pressure, temperature) under the patient profile
8. System and User acceptance testing	3 rd March 2020	Testing of the completed system. Testing the emergency alert functionality.
9. Assemble and Complete the final report	3 rd April 2020	Final Report Completed System

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6.1. Control Plan

End stage reports and reviews, risk management, communication plan and quality plan are employed.

6.2. Communication Plan

Multiple supervisor meetings will be held regularly per week basis and feedback meetings will be held as necessary.

7. Initial Risk List

Risk	Management Strategy
Schedule overrun	Contingency has been introduced into the project plan. The project will be conducted under a project plan approved by the supervisor under the supervision of the supervisor.
Difficulty using/learning the development technologies	Multiple technologies will be tested by developing simple prototypes before finalizing a main technology to be used for the entire process. Online tutorial usage.
Technology Failure	Regular backups of the working systems are kept so that in case of a failure of code, there's a working version to resort back to. Video proof of

	the working system are taken.
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8. Initial Quality Plan

Quality Check	Strategy
Requirements	Requirements will be checked to make sure that they are relevant, useful, correct and achievable.
Design Validation	Databases will be normalized. Interface designs will be checked against HCI guidelines.
Hardware Validation	Hardware will be tested for reliable operation. Output will be tested against expected output and the reliability of the output is checked. Individual components are tested.

5. Interim Report I

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Final Stage Computing Project

Smart Health Monitoring and Alerting System

Interim Report I

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1. Introduction

When the patients are admitted to a hospital, they are treated and their health conditions are monitored. The most important vitals that need to be monitored are the blood pressure and the body temperature as the stability of a persons health depends on these two. Currently, on patient basis, these vitals are not recorded and profiled, and in order to monitor a patient, the medical staff have to check on the patient time to time. Sometimes, some patients will be needed for prolonged monitoring even after they're released to their homes. But other than with a dedicated medical personal, an effective remote monitoring system is yet to be implemented. It's also necessary to store a brief medical history of patients to be used in case of an emergency situation for better preparation to handle the patient on the hospital's side. It's more efficient to have a centralized computer based patient monitoring system where the medical staff of a hospital can monitor vitals of the admitted patients (who needs to be constantly monitored) and the released patients who also may need to be monitored, using remote monitoring, all in the same centralized system. If the medical staff gets alerted of a medical emergency of a patient with the access to that patient's medical history, it'd help them immensely to get ready for the patient (if the patient is in remote monitoring, sending an ambulance to collect the patient), by arranging the hospital before the

patient arrives at the hospital. This system would also be beneficial even when monitoring the already admitted patients, for quick attendance to the need.

2. Tasks undertaken and outcomes

The IOT device that is used to obtain the vitals of the patients has been developed.

The software that is used to manage the patient details has undergone the designing phase.

The designing of the database is completed and the implementation will happen shortly.

The login and registration of the patients have been developed.

The IOT device once turned on takes inputs from the sensors and send the data to the cloud.

3. Products produced and product quality

1. Products

The system is consisted of an IOT device, a software application that displays the out puts of the IOT devices connected in a dashboard that also manages the details of the patients, and a database system that's used to store all the data associated with the system. The development of the software is ongoing whereas the IOT device is completed as a product and is undergoing testing.

2. Quality

The parts of the device are placed under a quality housing to avoid the damage that could occur to the sensitive devices and the connections. Each and every part of the device has undergone rigorous to make sure that they function properly. Exception handling has been utilized in the parts of the software that have been developed to make sure that any error that exist is captured and taken care of and the object oriented concepts have been utilized for the program to work effectively.

4. Risks that have materialized and your response

The battery of the IOT device died and was replaced.

Some of the wires inside the device stopped supplying the power to the sensors. They were replaced with new wires.

The heart rate sensor was burnt. New heart rate sensor was bought and will be replacing the old one.

The device does not send both the heart rate and the temperature data to the cloud at the same time. Only one data stream can be sent at a time. Currently working on a solution for this matter.

The database implementation resulted in issues regarding the relationships between the tables. The database was redesigned.

The tools that were initially planned on using needed to be changed. Selected a more familiar set of tools to develop the software application.

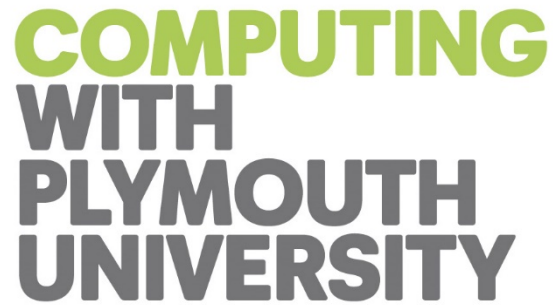
5. Schedule

Project Schedule 1 st January 2020 to 6 th April 2020															
Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Interim Report 1			Green												
Software Design Completion			Red	Red											
Supervisor Meeting				Yellow											
Representation of IOT data on the software				Blue	Blue	Blue									
Testing the application dashboard						Light Green	Light Green								
Research abstract							Orange	Orange							
Interim Report 2								Orange							
Development of the software								Purple	Purple	Purple					
Testing the system											Red	Red	Red	Red	
Poster Design													Green	Green	Green
Final Project Report													Green	Green	Green

6. Student learning undertaken and required

Learning of the arduino libraries was needed.

Learning of the arduino electronics was needed.



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Final Stage Computing Project

Smart Health Monitoring and Alerting System

Interim Report II

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1. Introduction

When the patients are admitted to a hospital, they are treated and their health conditions are monitored. The most important vitals that need to be monitored are the blood pressure and the body temperature as the stability of a person's health depends on these two. Currently, on patient basis, these vitals are not recorded and profiled, and in order to monitor a patient, the medical staff have to check on the patient time to time. Sometimes, some patients will be needed for prolonged monitoring even after they're released to their homes.

But other than with a dedicated medical personal, an effective remote monitoring system is yet to be implemented. It's also necessary to store a brief medical history of patients to be used in case of an emergency situation for better preparation to handle the patient on the hospital's side.

It's more efficient to have a centralized computer based patient monitoring system where the medical staff of a hospital can monitor vitals of the admitted patients (who needs to be constantly monitored) and the released patients who also may need to be monitored, using remote monitoring, all in the same centralized system. If the medical staff gets alerted of a medical emergency of a patient with the access to that patient's medical history, it'd help them immensely to get ready for the patient (if the patient is in remote monitoring, sending an ambulance to collect the patient), by arranging the hospital before the patient arrives at the hospital. This system would also be beneficial even when monitoring the already admitted patients, for quick attendance to the need.

2. Tasks undertaken and outcomes

The IOT device that is used to obtain the vitals of the patients has been developed.

The IOT device once turned on takes inputs from the sensors and send the data to the cloud.

Development of the back end of the system is underway.

The API is being developed.

The database system has been developed.

3. Products produced and product quality

1. Products

The system is consisted of an IOT device, a software application that displays the out puts of the IOT devices connected in a dashboard that also manages the details of the patients, and a database system that's used to store all the data associated with the system.

The development of the software is ongoing whereas the IOT device is completed as a product and is undergoing testing.

The back end of the system is under development and the database system has been developed.

2. Quality

The parts of the device are placed under a quality housing to avoid the damage that could occur to the sensitive devices and the connections.

Each and every part of the device has undergone rigorous to make sure that they function properly.

Exception handling has been utilized in the parts of the software that have been developed to make sure that any error that exist is captured and taken care of and the object oriented concepts have been utilized for the program to work effectively.

4. Use Case Diagram

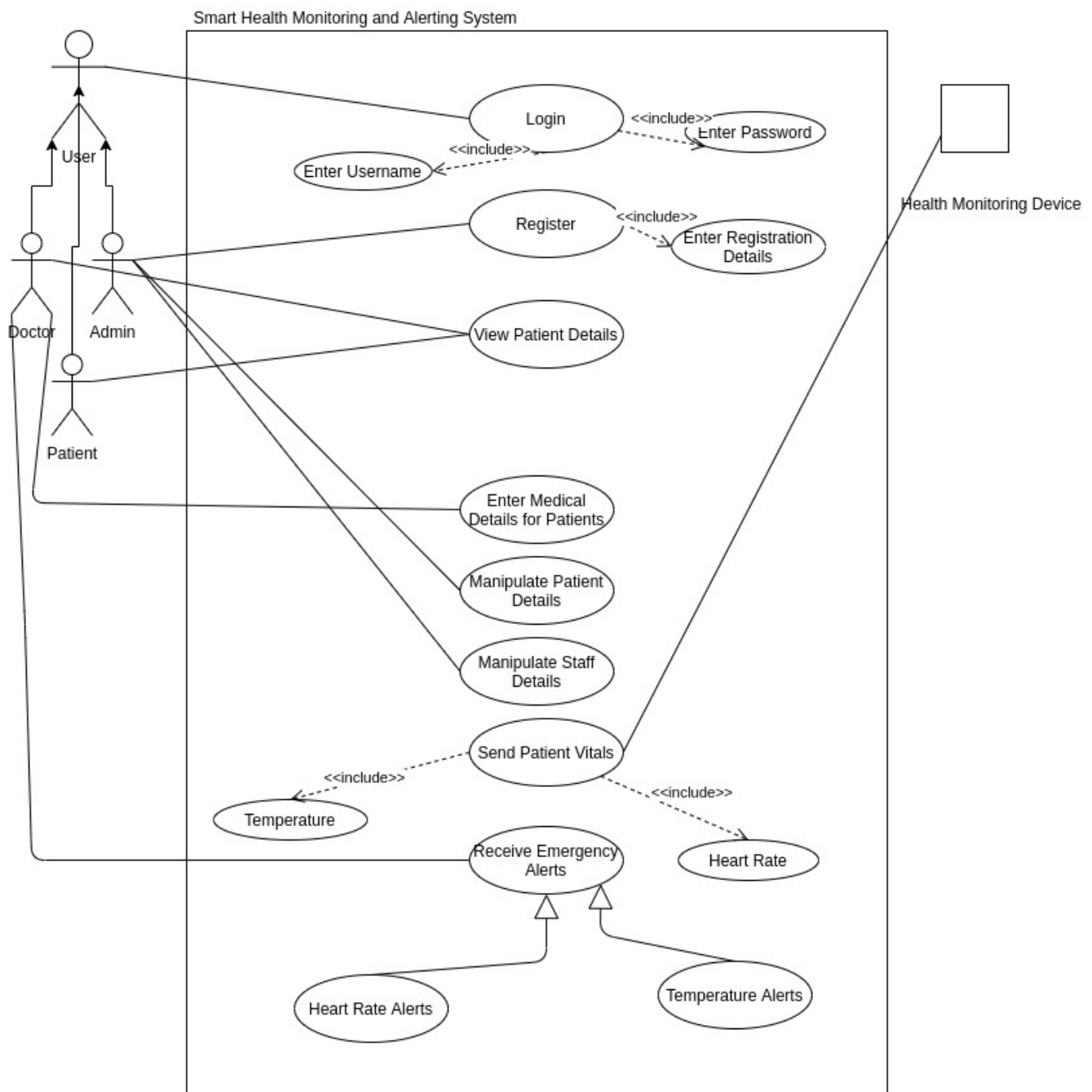


Figure 1: Use Case Diagram

5. EER Diagram

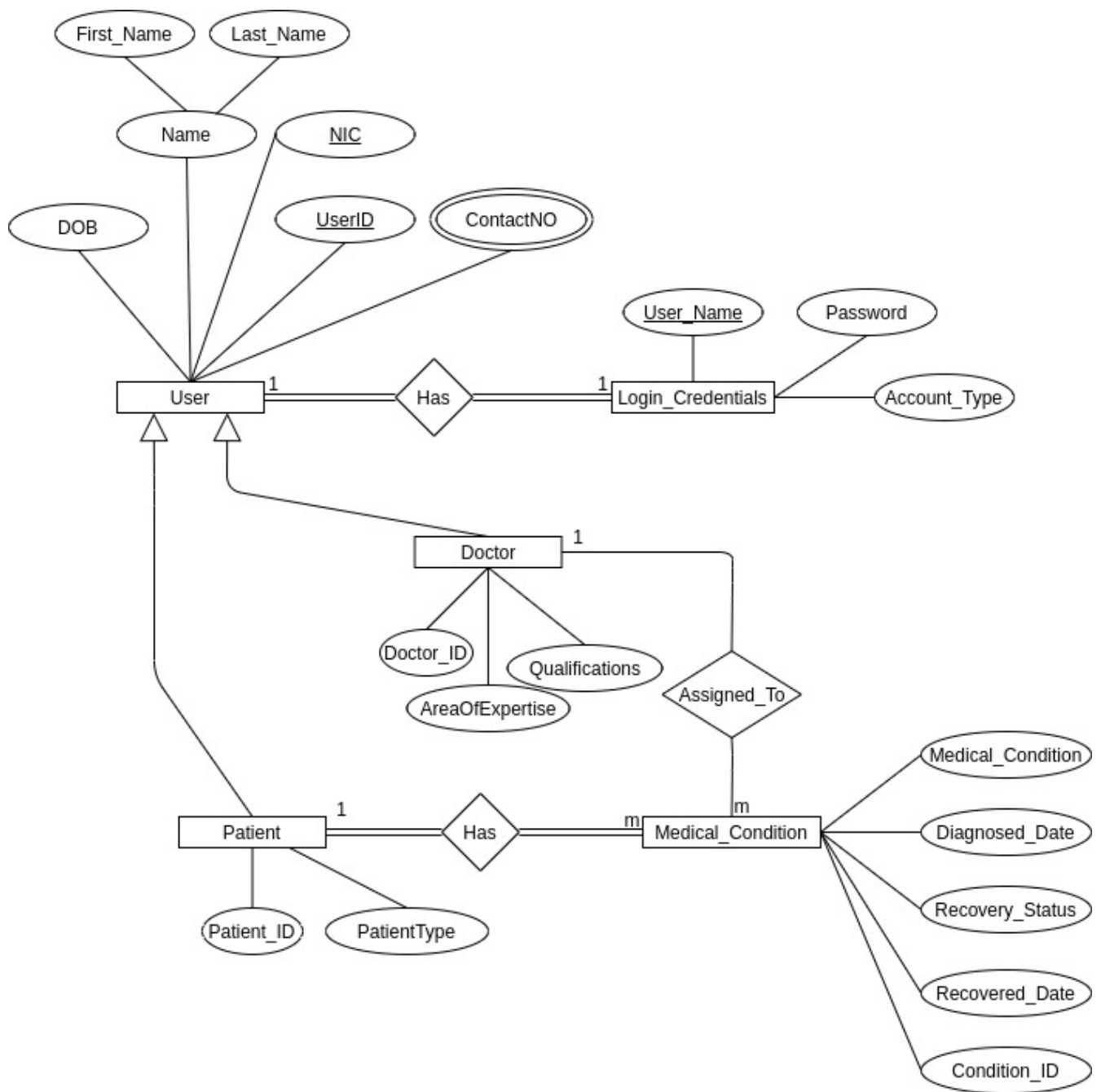


Figure 2: Extended Entity Relationship Diagram

6. Draft of the contents of the final project report

Acknowledgments

Abstract

- 1. Introduction**
 - 1. Background**
 - 2. Business Case**
 - 3. Objectives**
 - 4. Scope**
- 2. Legal Social and Ethical Issues**
 - 1. Licenses**
 - 2. Data Protection**
 - 3. Privacy**
 - 4. Confidentiality**
- 3. System Analysis and Design**
 - 1. Requirement Development**
 - 1. Functional Requirements**
 - 2. Non functional requirements**
 - 2. Design**
 - 1. Architecture diagram**
 - 2. Extended Entity Relation Diagram**
 - 3. Use case diagram**
 - 4. Class diagram**
 - 5. Database Design**
- 4. Project Management**
- 5. Methods of approach**
- 6. Development technologies**
 - 1. IOT Device**
 - 2. Web application**
- 7. Learning requirements**
- 8. Testing**
 - 1. Unit testing**
 - 2. Functionality testing**
 - 3. Usability testing**
- 9. End-Project report**
- 10. Project Postmortem**
 - 1. Challenges faced**
 - 2. Future enhancements and implementations**
 - 1. Enhancements**
 - 2. Implementations**
- 11. Conclusion**
- 12. Bibliography**
- 13. Appendices**
 - 1. Technical documentation**
 - 2. User Manual**
 - 3. PID**
 - 4. Interim report 1**
 - 5. Interim report 2**
 - 6. User interface designs**

7. *User stories*
8. *Third party resources used*
9. *Additional studies undertaken*
10. *User test results*

7. A draft of a chapter from the final project report

1. Introduction

When the patients are admitted to a hospital, they are treated and their health conditions are monitored. The most important vitals that need to be monitored are the blood pressure and the body temperature as the stability of a person's health depends on these two. Currently, on patient basis, these vitals are not recorded and profiled, and in order to monitor a patient, the medical staff have to check on the patient time to time. Sometimes, some patients will be needed for prolonged monitoring even after they're released to their homes.

But other than with a dedicated medical personal, an effective remote monitoring system is yet to be implemented. It's also necessary to store a brief medical history of patients to be used in case of an emergency situation for better preparation to handle the patient on the hospital's side.

It's more efficient to have a centralized computer based patient monitoring system where the medical staff of a hospital can monitor vitals of the admitted patients (who needs to be constantly monitored) and the released patients who also may need to be monitored, using remote monitoring, all in the same centralized system. If the medical staff gets alerted of a medical emergency of a patient with the access to that patient's medical history, it'd help them immensely to get ready for the patient (if the patient is in remote monitoring, sending an ambulance to collect the patient), by arranging the hospital before the patient arrives at the hospital. This system would also be beneficial even when monitoring the already admitted patients, for quick attendance to the need.

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Development of the software								Purple	Purple	Purple						
Testing the system											Red	Red	Red	Red		
Poster Design													Green	Green	Green	
Final Project Report													Green	Green	Green	

9. Student learning undertaken and required

Learning of the arduino libraries was needed.

Learning of the arduino electronics was needed.

Learning of API development was done on linked in learning and using you tube tutorials

Learning of javascript frameworks was done

6.