A Centralized and Real-Time Monitoring System for COVID-19 Quarantine Subject

by

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Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Information Systems
(Hons)

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Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Information Systems Programme
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Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS

SERI ISKANDAR, PERAK

September 2021

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Danial

DANIAL FITRI BIN ISMAIL

ABSTRACT

As we all know, COVID-19 has experienced a major incline in the number of positive cases not just in our country, but throughout the whole world. The factors that linked to this situation may be varies, but the violation of self-isolation or quarantine has been one of the big factors that has led to some unwanted circumstances. This violation has caused the widespread of the virus to be worsened. In some countries that have acknowledged this ongoing problem, there has been numerous systems that being built in a centralized and real-time format. Regarding that, the countries like New Zealand and Australia has succeeded in tackling the widespread of the virus hence getting a better control of the situation.

For this final year project, a wristband-look device will be developed and being applied to the subjects for testing. The device can detect and monitor the data needed from the subjects such as temperature, heart rate, and location. A centralized network architecture is built around a single server that handles all the main processing. The purpose of this proposed project is to create a better monitoring system that allows the authorities to control the situation remotely. A survey has been carried out to study and support the aim of this project. The results from the survey conducted shows that most of the respondents agree on the idea of a new system that is centralized and real-time should be created and notified in the country for a better monitoring system towards the subjects that are being in quarantined or self-isolated. This project might be a great solution on this problem and acknowledge others on how vital a centralized and real-time system can be in the effort of reducing the widespread of the virus itself.

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LIST OF ABBREVIATIONS

COVID-19	Coronavirus Disease 2019
FYP	Final Year Project
SDA	Serial Data
SCL	Serial Clock
VCC	Voltage Collector Collector
GND	Ground

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

1.1 BACKGROUND OF STUDY

COVID-19 has been a major problem to the whole world for almost 2 years now. While there are countries that have been managed to tackle the problems that the virus has brought, but it is fewer than the countries that are still struggling to find ways and solution to stop the widespread of the virus. Based on numerous articles regarding on how to tackle the virus transmission, apart from pharmaceutical factors and ways, non-pharmaceutical ways also play a huge part in this matter. One of the non-pharmaceutical ways that can be easily and realistically conducted is by having a proper quarantine and self-isolation system. Introducing quarantine measures early in a disease outbreak delay the disease outbreak and delay the peak of an epidemic in a country (WHO, 2020). A few examples from other countries that can be gathered are such in Slovakia, a mobile application that enable the system to give random facial recognition checks alongside providing tracking information has been built and applied to everyone in the country. The system then has made them to stay alert and cautious with their surroundings whenever and wherever they are. While in countries like Singapore and South Korea, a digital surveillance has been continuously carried out for the subjects that are in self-isolation or quarantine to ensure the subjects are not violating the respective rules. To mitigate the growth of infections, quarantine along with the isolation and social distancing plays a pivotal role (Wilder-Smith, A., and Freedman, 2020).

In Malaysia, the current situation of COVID-19 has been continuously worsening these past few months. The number of positive cases keeps rising by days, not in a small margin, but a margin that involves a big amount. This situation is the main evident of the exposure of the virus in the country keeps getting bigger by times.

Ministry of Health (MOH) has declared this situation as critical and as a state of emergency as the current situation has not shown any particular or big improvement. But, as days went by, we have kept receiving the news on the violation of quarantine and self-isolation rules that made the subjects to be closer to others hence transmit the virus to another person.

As there is still no advanced or better system that has been created particularly for monitoring the subjects, the authorities might face the difficulties in having a close control towards this violation problems due to their own lacking on some essential factors. As we are living a digitalized era where technology has been one of the most important aspect, we cannot deny how beneficial technology can be in this matter. By maximizing the usage of the existing technology in creating a centralized and real-time system, this will definitely help to improve and fix the deficiencies regarding this matter. There are few benefits that a centralized system can bring. Firstly is about data integrity. Data redundancy has been a major problem in maintaining data integrity. A centralized database can give access on any changes that want to be made to be taken place at one place only.

Apart from that, with all information being centralized, it is much easier to develop or construct reports that show the complete and broad activities of the subjects that have been engaged. On the other hand, for a real-time system, it will allow for a faster transmission of data hence enabling a faster response towards any issues arise. By combining these two characteristics into a single system, it can be a long-term solution towards any problem especially on the violation of quarantine and self-isolation rules that are happening vigorously in the current time. This is because as it is centralized, the major processing can be handled by a single server and with a real-time system, any data can be received timely hence enabling a faster action to be taken.

1.2 PROBLEM STATEMENT

There are a few problem statements that have been identified prior to this project. Firstly, the current quarantine and self-isolation might not being truly centralized or in a real time. This is because most of the violation cases have not being noticed earlier in the first place as the subjects that have violated the rules only to be noticed when they are already with the public. From this, there might be some difficulties in finding and analysing each subject's related data, hence involving more time. By centralizing all the related data into a place, issues that affect the integrity of the data such as data redundancy can be avoided.

In relation to that, data collection on the subject is not being displayed or monitored remotely. The current procedure related to this matter is solely just based on the pink band that indicated the representation of the subjects. They are just being told to stay isolate at home and have to be self-disciplined all by themselves. This is where for some irresponsible subjects, they tend to neglect the rules as they are not feeling that they are being truly monitored. Unlike social distancing measures, such as stay at home orders and business closures, quarantine is substantially more restrictive in that individuals or groups are totally confined except in cases of emergency (Hills K., 2016). Although strategies centred around strict monitoring and penalties for violations have not been thoroughly evaluated, they may even be counter-productive, compromising testing uptake and honest reporting during contact tracing and eroding public trust (Reicher S, Drury J., 2021).

So, any changes regarding the subject's condition or related data such as temperature, heart rate, and location cannot be identified quicker. This situation can be the obstacles for the authorities to have a good and timely monitoring on the subjects. With the presence of a real time system that can enable an accurate display or visualization on these data, the subjects can be monitored better and closer wherever and whenever it is. Given the material threat that covid-19 poses to individuals' health, social support with a firm belief in collective responsibility is more likely to achieve constructive actions across communities (Jetten J., Reicher SD, Haslam A, Cruwys T., 2020)

1.3 OBJECTIVES

1.3.1 PROJECT'S OBJECTIVES

There are a few objectives that this project brings alongside which are: -

- To investigate the requirements of a system for centralized monitoring or tracking system for COVID-19 quarantine and self-isolation subject.
- To design and develop a centralized monitoring or tracking system for quarantine and self-isolation.
- To evaluate and the user acceptance on the proposed system.

1.3.2 SYSTEM'S OBJECTIVES

The identified requirements of a centralized and real-time system related to the project are such: -

- To maximize the functions and facilities of the system from a single location.
- To have a better and closer monitor on the subjects that are being quarantined or self-isolated.
- To enable a faster response towards any issues that have raised.
- To provide the system with a better productivity.

1.4 SCOPE OF STUDY

Based on the previous objectives that have been outlined, the project aims to develop a system using IoT Hub and a few other related components that can play part in the completion of the project itself. The study of this project is mainly emphasizing on the importance of quarantine and self-isolation to minimize the exposure of COVID-19 virus. Lastly, this study also covers on how an effective and remote system can be built in the effort of making enhancements from the current existed system. The estimated time frame of this project will be probably taking up to 6 months to be completed.

i. FOCUS

The focus of this project is to analyse and study on the implementation of a centralized and real-time system for a better monitoring and control of the subjects that are being self-isolated or quarantined due to COVID-19. There will be some obstacles or limitations during the completion of the project.

ii. TARGET USER

The main target user for my project are the subjects that are being quarantined or self-isolated together with the authorities that are responsible to monitor them. The main user of this system is the authorities who's responsible to monitor the quarantine subject while having the main control of the system.

iii. LIMITATIONS

- The study is now only focusing on quarantine or self-isolation part only, not on every aspect related to COVID-19.
- The system may take a longer time and the tools and requirements might incurred a big cost.
- The actual implementation of the system might take times and face a few challenges along the way.

CHAPTER 2

LITERATURE REVIEW

2. LITERATURE REVIEW

2.1 INTRODUCTION

As the actual scope regarding COVID-19 is very wide and various, I know that I must have a deeper understanding into every aspect that is related to this project. To meet the requirements on that matter, I have conducted some research on three main different aspects related to COVID-19 which are on the general view of quarantine and self-isolation, importance of quarantine and self-isolation, and on the existing systems that are being used for quarantine and self-isolation throughout the whole world. I attempt to differentiate my understanding into these three different aspects for a larger number of insights and opinions that can be the essential knowledge which will be applied later throughout the progress of the project. Moreover, this monitoring project must provide an accurate set of information to the target users for it to be truly beneficial and applicable. Furthermore, as the developer of this project, most of my understanding and knowledge is being collected from the literature review research that have been gathered initially. All in all, all knowledge that being put into this project are from an effective research and study on the existing articles and anything related to that.

2.2 GENERAL VIEW OF QUARANTINE AND SELF-ISOLATION

2.2.1 How can we improve self-isolation and quarantine for COVID-19?

(Jung Won Sonn, 2020), says that there are two different mechanisms that have been used broadly for monitoring isolation. There are few ways of constructing a regular check whether by using telephone, and digital surveillance technologies. Local authorities such as police and public health sectors can play their part in coordinating the check together.

In Slovakia, for self-isolation at home, a mobile app has to be installed which has been invented earlier that will allow to carry random facial recognition alongside provide tracking information on the subject. Apart from that, in countries like Australia, Singapore, and South Korea have also taken the initiative on conducting digital surveillance on the subjects that are being quarantined. This has been done through mobile apps, drones, video call, location, and the close circuit television. In the meantime, local health authorities will continuously make contact through telephones for daily monitoring. Any violation will face heavy fines and even prosecution in some of these countries.

Other countries might face some difficulties and feels hard in implementing digital surveillance. The countries located around the Asia-Pacific region usually have a strong culture on the surveillance together with the public trust towards the government, but countries in the European region might have to take some privacy laws into consideration alongside the public attitude and responses to the governance might make the implementation of surveillance as a complete failure.

Self-isolation's current policies have to look strong and determined in recognizing the main obstacles that individuals confront. Although procedures and reminders on a strict monitoring and a heavy punishment have not being completely assessed, they may indeed be innovative in constructing all the reporting duties in completing the tracing assessment while improving public trust. Self-isolation usually comes out with standard reporting that is additionally required to determine the effectiveness of the tracing systems onto the desired subjects.

The perceptions among public usually shifted and impact individual choices. (SPI-B., 2020). One might feel have to self-isolate for them to assess the importance in deciding whether they completely follow the given set of rules. A direct and clear flow of information on health, and accessible towards any languages and communities is hence very critical and important.

2.2.2 Quarantine, isolation, and lockdown: in context of COVID-19

Quarantine is referring to the separation or restriction on certain aspects towards the people that have been infected with an infectious disease. This step being done for them to see whether they become sick. In the meanwhile, this step is to give protection to the public by preventing the exposed people transmit the disease to others.

Isolation is the action that being taken to make separation of people that have been infected with those who are healthy. A disease can be labelled as contagious if any possible transmission of the virus from into another could be happening within contact such as touch and a few more (Jay N Shah, 2020)

An aggregation of the cases being put and grouped into one place or so called as a cluster. On the other hand, an outbreak referred to the sudden inclination on the initial cases which have been suspected to be widen into another areas. In this situation, the term that is referred to it is called as Epidemic, and it will be called as Pandemic if the disease has been spread over several countries in different continents that have many people that have been affected. (Jay N Shah, 2020)

By having to self-isolate and quarantine within ourselves, it can offer a very challenging time to be managed smoothly as we are not in a good term, but we must admit that it is one of the major undertakings that can be done to limit the exposure of the virus. We must admit that there are a few non-pharmaceutical initiatives such are closure of places, social distancing and a few more can minimize the outbreak of COVID-19.

2.2.3 COVID-19: The ethics of clinical research in quarantine

To align with the situation of the continuous inclination on the number of positive cases, there should be an approach taken to control and minimize this outbreak. One of the approaches is by practising quarantine. By setting up a proper quarantine system, it can help to make the separation between the people that have been infected with others. Quarantine can be looked as more restrictive as it involves a certain of individuals or group at one period of a time. (Evans N. G., 2020)

Quarantine can play its part in controlling the widespread of the virus. For instance, a family has to put into quarantine if one of the family members has already tested positive. There have been numerous arguments that specifies the rights and needs of the individuals that are being quarantined. To address this situation, the quarantine system has to be enhanced to increase the productivity and effectiveness at the same time

A specific line of knowledge can be regularly gained by implementing quarantine which it may be hard to find in some other ways. There has been an issue saying that people have been the victim of injustice set by quarantine. Truthfully, they have taken the initiative in the wrong away and being delusional. In the context of COVID-19, they might be experienced because of some initiatives in tackling this problem and the pandemic.

Research inside quarantine and self-isolation must have a specific social and scientific value. Quarantine can offer the authorities to have a specific record on the behaviour of the disease and acknowledge on how the virus can be easily spread between one to another. Since quarantine and self-isolation within the community can also being looked like the placement of person that has been affected especially when in groups, this study will hope to enlighten the exact reality that is happening on how the transmission of the virus really works.

One of the main causes of the ineffectiveness of quarantine system is because of the government's lack of desire to react and make a quick response onto the problems related to the disease. There is no specific and firm solution or innovation that has been invented or discussed to really address the situation. All in all, COVID-19 will always be a part of global health black history. We should realize that role that the subjects that are being quarantined or self-isolated play a huge role in solving this emergency. (Centre for Disease Control and Prevention, 2019)

2.3 IMPORTANCE OF QUARANTINE AND SELF-ISOLATION

2.3.1 Effects of Social Distancing, Self-Quarantine and Self-Isolation, during the COVID-19 Pandemic on Peoples' Well-Being, and How to Cope with It

Coronavirus disease or so called as COVID-19 is a dangerous and infectious disease caused by the latest variance of virus which has been identified in 2019. Coronavirus has attacked animals first before the virus being transmitted to humans (Rothan & Byrareddt, 2020). The virus is originated from a place in China called Wuhan where the illegal trade of wild and exotic animals like bats and snakes have taken place vigorously. The first patient that has been tested positive to this virus was found in Wuhan on 8th December 2019 (Wu, 2020).

The virus has been widespread across other countries and continents within a short period of time only. The widespread has started in the location that is nearer to China. Bangkok, Tokyo, Taipei, and Hong Kong have experienced the highest potential of getting the virus due to the factors such as commercial air travels that frequently came from Wuhan. The first case that has been confirmed in Europe and Africa was on 24th January 2020 (Spiteri et al., 2020) and 14th February 2020 (Gilbert et al., 2020) respectively.

Up until 16th April 2020, there has been approximately 1,991,562 positive cases that have been identified. From this number, there are 130,855 deaths have been reported globally (World Health Organization, 2020). This situation has received many concerned and worries among all countries in the world as the virus has been transmitted faster and worse than what has been initially expected. Due to frequent contact among people that has been infected to others, the widespread of the virus has caused a fatal outbreak and shocking number of people that has been infected (Sohrabi et al., 2020). On 11th March 2020, World Health Organization (WHO) has been classified this situation as a global pandemic (World Health Organization, 2020).

In the effort of maintaining social distancing between one to another, any travel to a highly populated area is prohibited to reduce the risk of the virus being transmitted (Desai & Patel, 2020). On the other hand, as people still can do activities around their housing area, it is a compulsory to maintain their hygiene for personal issues and protection. It is important for everyone to stay hygienic and do precautions such as washing hands regularly, use alcohol to clean substances that have been touched, and maximize the usage of face masks especially in the areas that being labelled as high risk (Feng et al., 2020).

To ensure the effectiveness of self-quarantine during the period that has been assigned, a regular monitoring must take place to check whether the symptoms are worsening or not. Any consultation and advices given by the health officer is very important and has to be followed regularly. The regular checks being taken place because this virus can affect both physically and mentally on the overall health. So, it is a must to maintain a low level of stress and good health in this challenging period (World Health Organization, 2020). Any profession whether it is students or working adults have to take the initiative to pursue their focus online. An overall discussion has been taken place among the related authorities to make this step as an essential and applicable to everyone.

It is a complete mandatory to do self-isolation from the public if being tested positive to avoid the transmission of the virus to be worsened. While in isolation, they have been counselled and seek for medical assistance and keep in touch with the doctors. This step being done because the consequences that the virus serves can be fatal and severe. A fast support and help are required to be asked if there are any breathing difficulties or any worse symptoms being identified (CDC, 2020).

All in all, it is important to acknowledge that any actions of selfishness that lead to the violation of isolation rules should be punished and receive a heavy punishment in doing so. The virus has to be controlled with the cooperation with everyone to ensure the spread of diseases to be worsened by times. So, everyone should show their contribution to the society by putting honesty and truthfulness as their main characters towards the healthcare providers for us to get more security during this challenging time.

2.3.2 The actual implementation status of self-isolation among Japanese workers during the COVID-19 outbreak

As of May in 2020, the pandemic of COVID-19 is still going on actively. It is important to always do personal protective measures as one way to demolish of the infectious virus or disease such as COVID-19, especially before everyone has been totally vaccinated globally (Qualls N, Levitt A, Kanade N, Wright-Jegede N, Dopson S, Biggerstaff M, et al., 2017). Self-isolation is one of the preferred ways that has been recommended by World Health Organization (WHO).

Self-isolation can be referred as the voluntary action that separate or restrict the movement of the person that has been infected for the transmission of the virus to be prevented (European Centre for Disease Prevention and Control, 2020). It has been classified as a good and effective way in keeping away the subjects that are in isolation to make the widespread of the virus to be worsened. Japanese Ministry of Health, Labour and Welfare has continuously recommended every citizen to prioritise the practise of self-isolation during this pandemic era for them to recognise whether they have experienced or developed the earlier symptoms that has been listed initially.

Numerous researches related to self-isolation practices done by the required subjects have shown on the evaluation on the self-need of practising isolation and there has been approximately about 70-90% on the total prevalence of self-isolation. On the other hand, a few deeper studies that actually evaluate on the actual condition and status of subjects while being isolated (GOV.UK., 2020). There are also studies that show on the causes of people not doing isolation in the right way such as not being able to work from home, no paid leave that has been guaranteed, and low income have been involved for the person to violate or inhibit self-isolation rules and regulations. Self-isolation among the citizens is a very important aspect to maximize the protective measure for public health personally as the daily activities have been resumed. Plus, self-isolation among workers also brings a great importance since they might be out of controlled due to the huge number of workers and lack in number of authorities that can fully control them.

Besides the working factor, people also have commonly had the desired to go out during the quarantine and self-isolation period to address their essentials like groceries, medicines and more. In this challenging time, the European Centre for Disease Prevention and Control has recommended to the people that are being isolated to seek help from their friend, neighbour, or any other person that might lend their help just to make sure they are breaking the exact regulations as being received earlier. This step is likely to help improving the practices of self-isolation and ensure a safer circumstance at the same time.

With a strict and proper self-isolation, the subjects that have been identified having the symptoms related to COVID-19 was extremely low. There is 62.2% of the subjects have continued to go and do respective works after just 7 days after the onset symptoms has been detected. Initiative of letting workers to work from home is one of the effective ways to increase the effectiveness of self-isolation. The study has continuously emphasized on the necessities for an increased number in public awareness mainly focusing on self-isolation and quarantine to be taken place continuously. This is essential to keep sending the reminder on the importance of self-isolation in controlling and preventing the transmission of the virus from one to another.

2.3.3 Quantifying the impact of quarantine duration on COVID-19 transmission

The relation between quarantine and it proposed duration are still being debated in the public sphere. There are two ways that quarantine can reduce the transmission of the virus which are by avoiding transmission before symptoms onset, and second, by reducing the total transmission from chronically infected people. The length of the quarantine has to always align with the current condition and severity that the subjects faced. Theoretically, another huge step that can be taken is by implementing broad and consistent test on the virus, but maybe received some difficulties in the initial stages which can make this situation more difficult (Kucirka et al., 2020).

The approach is not feasible to most nations due to testing capacity limits. Quarantine comes at a tremendous price in terms of money, society, and mental health (Nicola et al., 2020; Brooks et al., 2020). It inhibits the freedom of individuals (Parmet and Sinha, 2020), but the limitation and restrictions given still at a high degree as the current COVID-19 situation is still in a bad condition (Parmet and Sinha, 2020).

Quarantine can be done either in both ways: the subjects have been identified as a close contact with person that has been infected, or they have returned from an area that being labelled as a high risk (WHO, 2020). The travellers might have their limitation in knowing their exact position or condition as they might not be given an enough set of information prior to the virus exposure.

Due to the huge proportion of pre-symptomatic and asymptomatic transmission, quarantine is one of the most critical methods in controlling the ongoing virus outbreak. A 10-day quarantine period, as applied in Switzerland, is sufficient enough prevent the transmission of virus from infected person with a positive test with the virus. The isolation period beyond 10 days provides no further effectiveness. By reducing the time taken for subjects to be quarantined, it can decrease the percentage of transmission that could be happened. Travellers have to take into their account to do their own self-isolation within the given proposed period to prevent the widespread of the virus to be worsened upon their arrival from a specific area.

The efficiency of the quarantine has to be analysed for further enhancements that can be done. The success of quarantine can be judged in terms of overall transmission decrease, but the time period of quarantine is likely a function of any other affected factors such as societal and economic. There has been numerous statistics based on the ratio of transmission that shows the relation between the exact period of time needed, in addition to epidemiological outcome, which simply analyses the reduction in transmission.

2.4 EXISTING SYSTEMS

2.4.1 Smart healthcare support for remote patient monitoring during COVID-19 quarantine

Quarantine and social distancing have been practised regularly now globally since the outbreak COVID-19 pandemic in that has started in 2019. To have better control in this matter, a frequent hospital visits have been blocked and discouraged. But there are still people feel that they are really in need to go to hospital to received checks and prescription from the doctors physically to enhance their confidence on their current health status.

Accessing to this situation, a remote smart home healthcare support system (ShHeS) has been proposed. The purpose of this invention is to monitor the health status of the subjects while receiving the prescriptions from doctors remotely while staying at home. With this invention, doctors can make their diagnosis remotely by using all information that has been successfully gathered from the system.

An Android based mobile application that has its own interfaces with a web-based application is being proposed to enhance the efficiency of communication between patients and doctors and in a real time mode. There will be sensors that have been located in the system to capture the physiological health parameters of the patients automatically. In addition from that, a hyperspace analogue to context (HAC) has been included to maximize functionalities of the system as a whole.

A remote monitoring system can be done within the proposed method. With the usage of various functions of automation equipment on their phones, will be feeling that the invention to be pleasant to them. As a result, one important finding that has been identified is the subjects can use the proposed platform and invention to give report on their current health condition or status. Nevertheless, even in such a situation, increased health and a comfortable lifestyle can be obtained. The 2019 COVID-19 pandemic is in a difficult phase, with 20,026,186 reported that have been recorded. Globally, 734,020 people have died.

2.4.2 IoT Q-Band: A low cost internet of things based wearable band to detect and track absconding COVID-19 quarantine subjects

Various researches related to healthcare studies are suggesting the usage of a wearable device that can increase the patients' productivity in getting to their medical routines and restrictions. In the effort of making one, a wearable band would be the definite solution to address this issue. A wearable band has been designed together with a mobile application that can do detection and tracking onto the subjects that are being quarantined in a real-time mode. This wearable band could only be detached when the quarantine period has been completed.

By inserting the usage of global positioning satellites (GPS), the system allows tracking activities to be in a real-time. It will also alert and allows the authorities to have an accurate detection towards the quarantine subjects. The mobile app associated with the band will then give reports on any tampering of the wearable band is happening during the supposed quarantine period.

The subjects that are being quarantined will be put on with the band on the logical part of body such as hand and leg which will be connected to the mobile application wireless with the usage of Bluetooth. The processing unit of the band (ESP32) (ESP32 Series Datasheet, 2020) detects whether the band has been detached within a specific period of time. By maximizing the usage of sensors, the band will then send the current status to the mobile application within every 2 minutes of time interval. Only responsible medical authorities will register the subject to the IoT-Q-Band system, and they will be authorised in determining the quarantine period and authenticating related information. Authority's supervisory role eliminates the risk of harmful data entering the tracking system while also protecting the privacy of quarantine subjects.

Along with the personal information, the GPS coordinates of the quarantine location are also saved throughout the registration process. Mobile application will provide visual feedbacks such: -

1. If the band is working fine or has been tampered.
2. If the subject is still in the supposed 50 meter radius from the initial and registered quarantine location.
3. Actual time left for the quarantine period.

In relation to the subject's initial registration, the mobile application will associate with the cloud server at regular intervals of 2 minutes, showing the current state of the band (tampered or working), timestamp, and GPS coordinates (longitude and latitude).

A designated individual can keep track of each quarantine case via a web of each quarantine case via a web interface that pulls up all active cases and displays them in a legible format. The data flow starts with the wearable band and ends with the monitoring web interface.

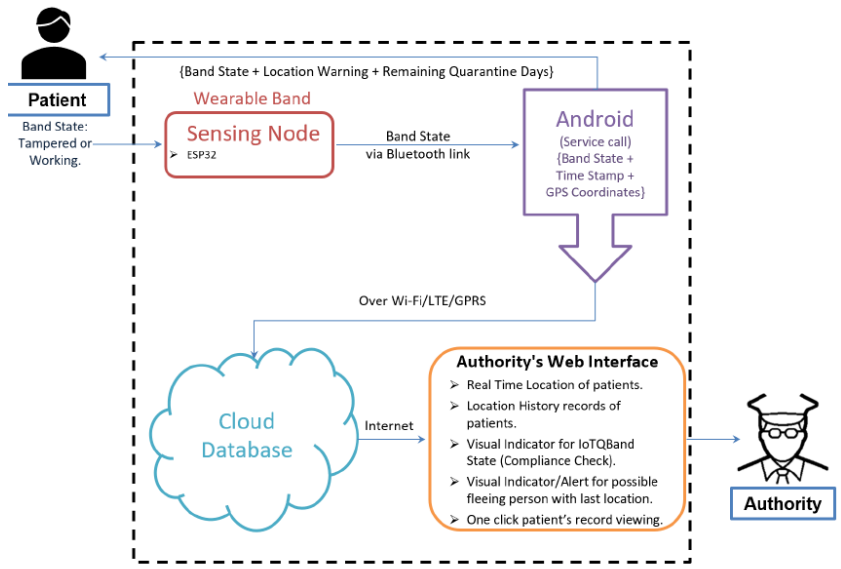

Figure 1 : IoT Q-Band System Architecture

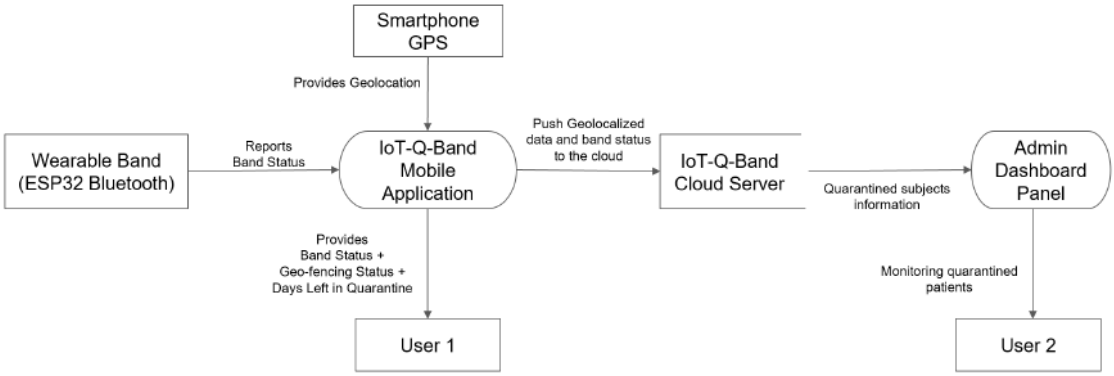

Figure 2 : IoT Q-Band Dataflow

2.4.3 "Smart" quarantine and "blanket" quarantine: the Czech response to the COVID-19 pandemic

In comparison with some of the most severely hit countries, the pandemic has given Czech a lesser effect. This is especially true in terms of the number of confirmed positive cases and deaths linked to the virus, as well as the result on lack of the current healthcare system has experienced. In some bordering countries, particularly Slovakia, there has been a similar observation regarding this matter. Several pundits have hailed this initiative as proof of success in the effort of tackling the widespread of the virus by times.

In Czechia, the "blanket quarantine," as it is known, has been proven to be very efficient in stopping the spread of infection. There have been some sayings told on the significance and unclear approaches or tactics socially and economically, as other countries or regions that have used during this lockdown. They have addressed the issue whether the invention will have some other limitations and complications which has sometimes resulted in a misunderstanding of what rules were in existence at the time. In Czechia, a similar conversation began in the early lockdown time period in establishing other distinctive method, dubbed a "smart quarantine," which will be dependent on the usage of ICT and big data, as well giving the available information consistently to people. Discussion has rapidly shifted to finalize the approach as a way of getting out from the lockdown.

A system called Smart Quarantine (SQ) have been deeply discussed among the related authorities with any related local agencies. It is a fascinating way in attempting a rapid and external prompted innovation in government, which has agreed to make the innovation as an official implementation in the country. It also demonstrates on how the new system works posed a challenge to conventional epidemiologic data collection, evaluation, and application methodologies.

A company called Czech SQ has been continuously operated with three main sources of data to each individual that has been infected or considered as a close contact which are: -

1. Location data gained from mobile phone operators.
2. The data of card payment.
3. Information gathered from a mobile tracing application called eRouska.

The usage of Bluetooth is essential in maximizing the functionalities of the app. Another source has been occasionally inserted: Mapy.cz, a well-known mobile app that allows users to publish their whereabouts and hence enabling the contact tracing. The SQ system unites a different type of sources, allowing epidemiologists from each region in the country to have their main access to the data gained. Authorities will then reconstruct and analyse the data of confirmed infection and the person who could have been infected via telephone.

2.5 COMPARATIVE STUDY

Country	Slovakia	Taiwan	South Korea
Types of Systems	Mobile App	Digital Fence	Mobile App
How It Works	• Carry out random facial recognition checks and provides tracking information	• Anyone that is required to do home quarantine, their location is being monitored via cellular signals • If any violation happens, it will trigger the alert system • Calls and messages will be received to update the whereabouts	• Those who have to undergo home quarantine, GPS will be used to keep track of their location • Those in quarantine can update and report their health status to the officials • An alert will be sent to both subject and officials if any violation occurs
Centralized	**Yes**	**Yes**	**Yes**
Real-Time	**Yes**	**Yes**	**Yes**

Table 1: Comparative Study

As refer to the table above, those are some examples on the systems that are being implemented in other countries like Slovakia, Taiwan, and South Korea. All of these systems have two main characteristics in common which are centralized and real-time. Both of these features have increased the productivity and the overall effectiveness of the systems that are being implemented. Align with this situation, this project will implement both of these features and set them into the local context which still cannot be find up until now.

Functions	Check
Heart Rate	Normal or Worsening
Temperature	Normal or Worsening
Location	Within or Out Of Radius

Table 2: Functions and Checks of the System

2.6 CONCLUSION

A continuous research and study on anything related to the aim of this project is essential for a better understanding due to a high number of insights and opinions. The study on how other countries have proposed their ideas and innovations on creating a better quarantine and self-isolation system has helped in analysing what could possibly being done and what seems to be hard to be deployed.

A good and enhanced quarantine and self-isolation system is essential in tackling the outbreak of the virus effectively. Moving forward, studies will be continued on how to implement such systems in the context of Malaysia. Factors such as demographic, personal preferences and many more will be taken into places for a feasible and acceptable system. As these factors have been determined and implemented into the system, the productivity of the system will be better by times.

CHAPTER 3

METHODOLOGY

3. METHODOLOGY

3.1 PROJECT METHODOLOGY

Software Development Life Cycle (SDLC) can be classified as a standard business practice that has been applied especially in building applications related to software. Basically, there are about six to eight stages that need to be done accordingly. Those steps are planning, requirements, design, build, document, test, deploy, and lastly in maintain. There might be times where several steps being combined into one following the preferences of respective project managers. All of these are truly important and essential in building a stable development of all software projects.

SDLC is an effective way in measuring and improving the overall development process. It offers from the slightest analysis up until the biggest steps in the project. This situation has become the necessities for companies and project managers to ensure a maximum efficiency and effort being put on every stage before proceeding to others. In the meantime, in this tough and challenging times, companies know that they have to reduce costs as possible as it could be and develop a faster and better software to meet the actual demands served by the customers. Nevertheless, SDLC helps to identify every inefficiency and provides the exact needed solution for a better and smoother workflow of the project.

Software Development Life Cycle can help to simplify the outlines of each task in each stage to be implemented in the software application. With this, it can ensure a reduction of waste and an increase in the efficiency of the overall process related to the development. Project managers have to always do their responsibilities in monitoring and ensuring the project is on track and within the initial timeline that has been set by the company.

For a better understanding and details, most companies now have decided to look these steps into a smaller unit that can be divided. For instance, planning is usually being divided into technology and marketing research, and also involves an analysis on the cost-benefits.

On the other hand, for a faster development, few stages have been merged into one. As example, testing can run together with development which can help the related person such as developers to detect and fix any issues straight away during the testing phase.

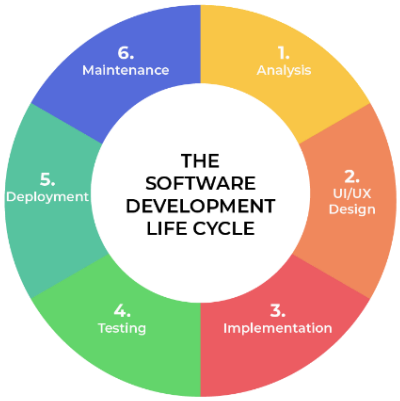

Figure 3: SDLC Life Cycle

System Development Life Cycle (SDLC) has seven main stages that needed to be completed prior to one another. Those stages start from planning then follows by design, development, testing, implementation, and ends with maintenance. All of these phases would not be stopped but will keep on looping if there are any changes have been occurred.

1. **Planning/Analysis**: In this phase, the initial objectives have been listed based on the problem statements that have been identified earlier. This phase requires to analyse the requirements needed, make evaluation on the scope of the project, check on available resources and acknowledge all opportunities and risks served for the current time and in the future.

2. **Design**: This phase requires to identify the specific system architecture, any configuration, and the data structure. In addition from that, this phase also helps to outline the desired outputs and details needed for the project.
3. **Implementation**: This is the phase where the development of the project starts. From this phase, we can actually look on how the project is actually works or moves.
4. **Testing**: In this phase, a test plan is being carried out. From this, we can identify what kind of resources needed and available for the tests. Tests are not restricted to a certain type; it can be done in various ways.
5. **Deployment**: When the project has been finally deployed in this phase, any lack or issues that could be existed can be identified clearly. So, this is the time that enable and acknowledge how the issues can be fixed or enhanced in the next phase.
6. **Maintenance**: As the real issues have been acknowledged earlier in the previous phase, this phase is the platform for any amendments to be taken place. From the issues that have risen, any future advancements or enhancements could be determined for the system to be better in the future.

By having a methodology, a right structure, plan, control, and maintain can be implemented in the development process. Thus, choosing the right methodology for a specific project is crucial is ensuring the workflow of the project goes within the time that has been discussed earlier. A right methodology can help an organization to save time and cost in the overall development of the project.

3.1.1 ARDUINO DEVELOPMENT PROCESS

Arduino is an open-source platform that is widely used in the development of electronic projects. Arduino has both circuit board to execute the program and Integrated Development Environment (IDE) as the software part that will execute the program after writing and uploading specific codes into the Arduino board.

To run the program, Arduino board is connected to a computer using USB cable, which then connects the board to the Integrated Development Environment (IDE). User will then write the code in the IDE first before uploading it to the board for the code to be executed, which then delivers the outputs needed from this project.

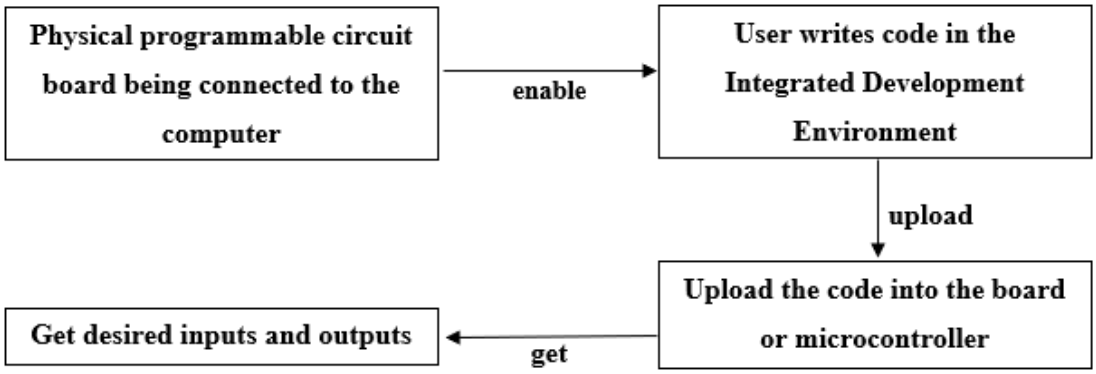

Figure 4: Arduino Development Process

3.1.2 IoT DEVELOPMENT PROCESS

The development of Internet of Things (IoT) will require mechanical, electrical, and software design teams that have to work together to get the products to be done on time. There are four components or factors that are crucial in this development to make the system works as what has been planned initially. The four components are sensors or devices, connectivity, data processing, and user interface.

First, the devices or sensors will gather the data collection gained from the environment. This data does not require to be huge or complex, it could also be as simple as the reading of temperature or heart rate. Multiple sensors can be added at one time to enable more actions or outputs gain at one time.

Next, the data will be sent to the cloud through various methods. Bluetooth, cellular, and Wi-Fi are among the methods that can enable a direct connection to the internet. A different IoT application might needed a different connection, but all of them are going for the same goal which is transferring data consistently and accurately to the cloud.

Once every data needed being stored successfully in the cloud, selected software will perform data processing. The process can be simple, such as checking the accuracy of temperature reading, or can be complex as identifying objects using computer vision. Any data will then come to the user to be interpreted. User can create an interface for the system to look more appealing and understand the system even more. As the system in the IoT application can be performed and influenced by the user, however, the system can also conduct some tasks automatically.

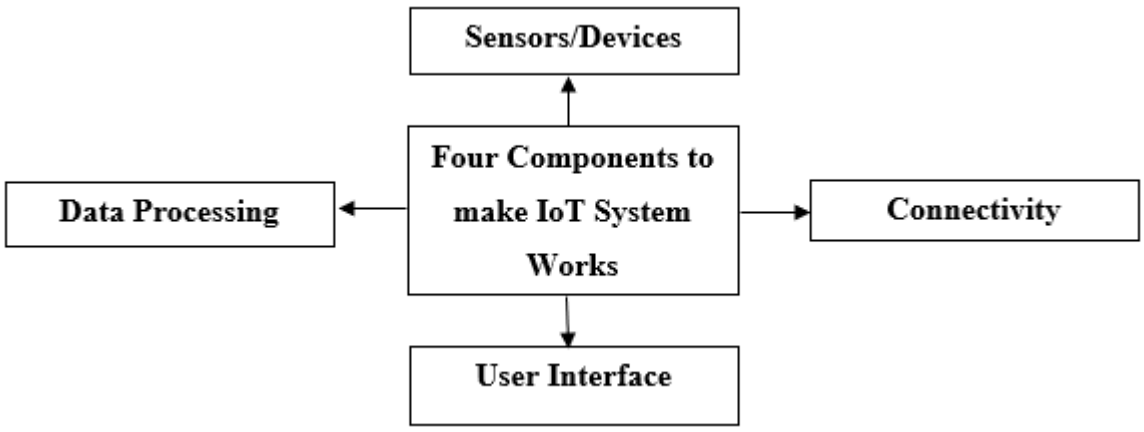

Figure 5: IoT Development Process

3.2 TOOLS AND EQUIPMENT

The development of this system requires a set of hardware and software tools that will be used accordingly during the development phase. All of the tools and equipment are essential to make the project to be done as what has been expected. Below are some hardware and software tools that being used in this project: -

i. Arduino MKR GSM 1400

Arduino MKR GSM 1400 is a development board that includes microcontroller of ATMEL SAMD21, which designs to give a lower consumption of power together with a good performance. The board has GSM connectivity whether its 2G and 3G which has increased the functionality of the board itself.

ii. Hologram Global IoT Sim Card

This sim card has a secure and futuristic characteristic that has supported eUICC. With fast activation, straightforward pricing, and developer-friendly tools, connection to a global network can be done. For this project, the device is being deployed in the hologram network with suitable local carriers such as Digi and Celcom.

iii. DFRobot Heartrate Sensor

DFRobot company has produced a sensor that helps to detect heart rate after specific and correct connection to the Arduino board has been executed. This sensor is a pulse sensor that uses PPG techniques to produce. This is a simple and inexpensive optical approach for detecting changes in the volume of blood. According to this view, detecting the pulsation of the cardiac cycle is relatively simple. In this project, this component is being utilizing to detect the subject's heart rate while being quarantined.

iv. DFRobot Temperature Sensor

This component helps to do detection on the wavelength and energy of infrared radiation that will help to determine the temperature. In the making of this infrared temperature sensor, components such as photoelectric detector, signal processing, output modules and a few more are being utilized. Alongside the heart rate, this component helps to give the data on the temperature reading at the same time.

v. Arduino IDE

Arduino IDE is a platform that enable the program to be written in C++ or C functions. This platform will be used to upload and execute specific program that are correct and compatible to the board. This is the platform for all codes required for this project to be executed.

vi. Microsoft Azure

Azure is a platform that enabled a public cloud computing to be done. Alongside networking, it gives the possibility of computing, storage, and analytics. Microsoft Azure helps to store the data gained from the device before visualizing it in Microsoft Power BI.

vii. Microsoft Power BI

Microsoft Power BI is built from a set of applications, software services, and few more components that helps to transform and visualize data in a more logical and interactive insights. The visualization of each data gained has been visualized interactively to provide an easier and clearer read that will enhance the understanding of the reader as well.

3.3 DATA COLLECTION

Before proceeding any further with the development, a set of data has been collected to make sure the project will be able to meet its objective. Observation and conducting public surveys are the two main strategies used to collect as much data as feasible.

3.3.1 OBSERVATION

For this project, a set of consistent objectives on the current situation of subjects that have to be quarantined at home because of COVID-19. However, it has been a frequent case where the subjects are violation the quarantine or self-isolation that have violated the rules and exposed themselves in the public whilst in a quarantine or self-isolation period. This situation shows that there is no proper and solid monitoring on these subjects as they have only been able to be traced as they have already violated the rules. This is the point where technology or a better system has to be utilized on the subjects for them to not be able to be exposed and brings the possibility to spread the virus even more together.

3.3.2 SURVEYS

In addition from observation, survey also has been conducted through online to gather data from the public regarding their opinions on the existing quarantine system that this country implements. The reason for this survey is to collect their justification and opinions on how efficient the current quarantine or self-isolation process is and whether a better system has to be invented or not. A total of 61 respondents have participated in the survey and answer all five questions that have been included. As a result of the study, the majority of respondents believe that a more effective approach is required, such as the creation of a centralised system that can track quarantine subjects' whereabouts and well-being such as the subjects’ location, heart rate, and temperature.

3.4 GANTT CHART AND MILESTONES

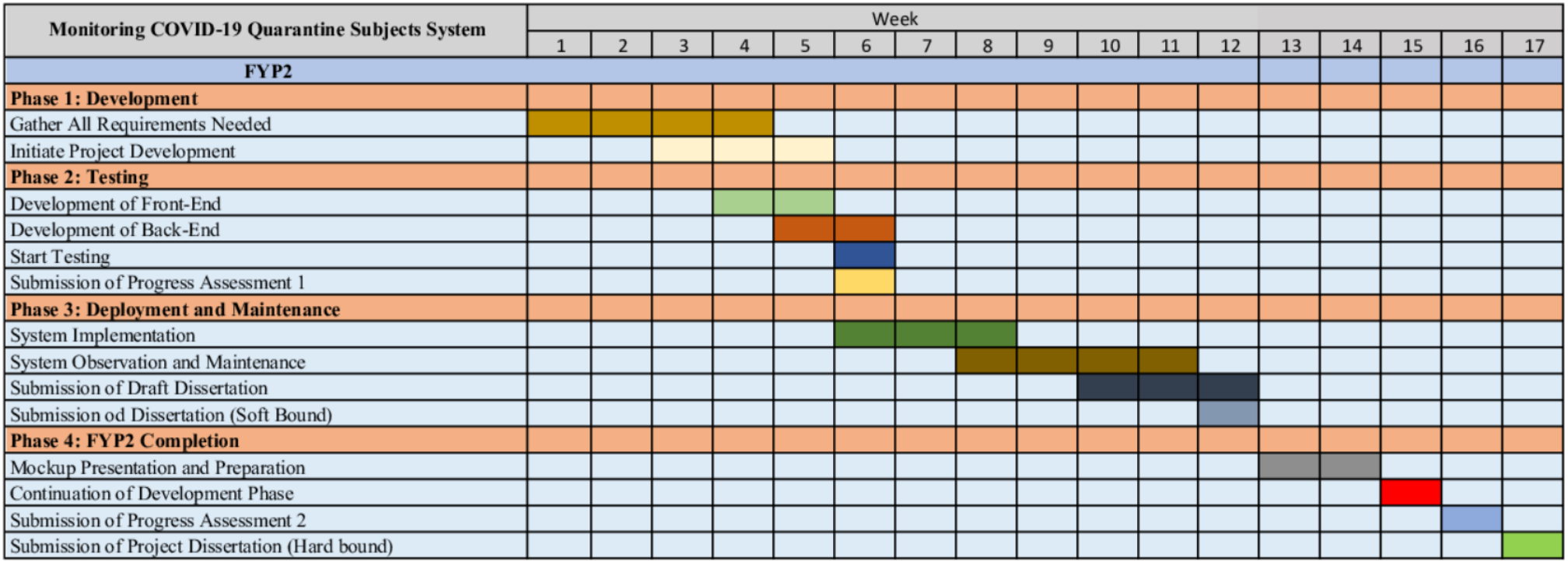

Figure 6: Gantt Chart and Milestones

The first project proposal is prepared and submitted over the first two weeks. During this phase, preliminary ideas are gathered to support the proposed project's goals. Following that, all resources and requirements are defined and gathered, and various research is conducted to obtain a better knowledge and collect any relevant ideas that can be incorporated into the project. For this project, hardware components such as Arduino MKR GSM 1400, DFRobot Heartrate Sensor, DFRobot IR Temperature Sensor, and a few more have been gathered prior to the development.

The initial design of the system is conceptualized and sketched during the design planning process. A large number of examples of similar systems or projects have been gathered in order to strengthen how the project can be viewed as viable and practicable. This phase, which is linked to the detail design phase, necessitates a more detailed design. This phase ensures that all needed functions may be added to and accessed on the project. The functions that have been initially chosen to be implemented in the system is the heartrate reading, temperature reading, and location.

On to software development, where all of the data is centralized and stored in a single, central database for future analysis. Following that, a test strategy was established to test the system while also looking for any potential issues that may have arisen. Regular testing and questionnaires are addressed at the end of the development phase before executing the final paperwork before the final submission. The centralization and storage of data is being done with the utilization of Microsoft Azure IoT Hub. The data stored will then be visualized in the form of dashboard from Power BI.

CHAPTER 4

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

4.1 SURVEYS RESULTS AND DISCUSSION

To understand the problem statement raised from this project alongside the objectives that have been underlined, an online survey has been conducted as this current pandemic still make physical activities restricted. The survey was created using Google Form platform and being spread and shared across various channels, which are mainly from social medias such as Instagram, WhatsApp, and Twitter. The survey was mainly asking on the public opinions on the current monitoring system for quarantine or self-isolation subject is in this country. As a result, the survey was able to receive a total of 62 respondents.

Question 1:-

Question: State your age

39 respondents that covered up to 62.9% of the total are at the age of 22. This is mainly because the survey tends to circulate among the author's circle only as the main platform used to spread the survey is from the author's social media itself. But, even in a small percentage compared in total, the survey also has attracted an older age of respondents which were between 30 to 47 years old.

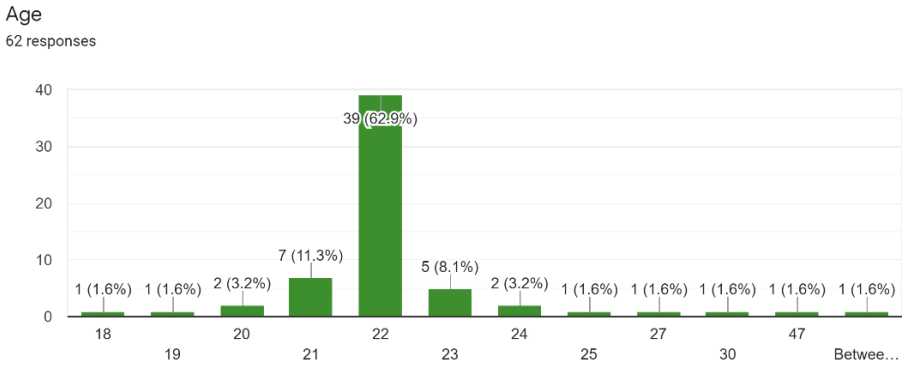

Figure 7: Question 1

Question 2:-

Question: Do you think the current system or ways of handling person who are being quarantined due to COVID-19 in Malaysia is effective?

Among all 62 respondents, 46 respondents considered that the system that are currently being implemented for quarantine or self-isolation subjects is only at moderate level. Only 4 persons felt that the current system is good and enough as the rest of it have chosen 'Bad' as their option which has covered 19.4% in total. This is probably because most of the respondents recognised and alert with the news of quarantine subjects were easily violated the quarantine rules and expose themselves to the public.

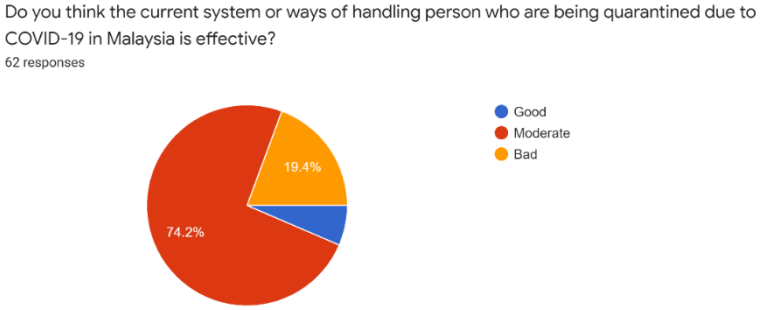

Figure 8: Question 2

Question 3:-

Question: Do you realized that there are still numerous of cases which the person who are being quarantined violate the quarantine rules?

To support assumption that has been stated in the previous question, there are 61 respondents that covered up to 98.4% have chosen 'Yes' as their option. This shows that they are acknowledging the fact the current quarantine system is not really effective as they might be bumping into news or witness the situation with their own eyes.

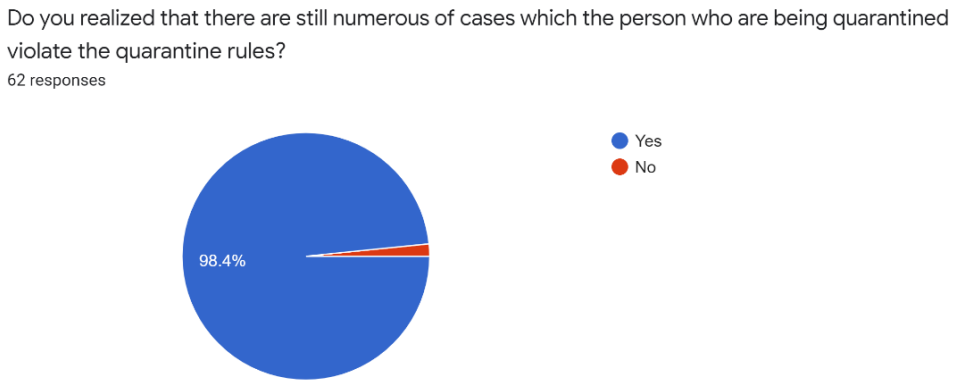

Figure 9: Question 3

Question 4:-

Question: Do you think that Malaysia should have a more effective system in making sure there are no violations against the quarantine rules?

For this question, all respondents have the same responses as they are completely agree if Malaysia implements a better and more effective quarantine or self-isolation system to prevent the subjects from violating the rules over and over again. This has shown that they are concerned about the ongoing situations and want changes to be made.

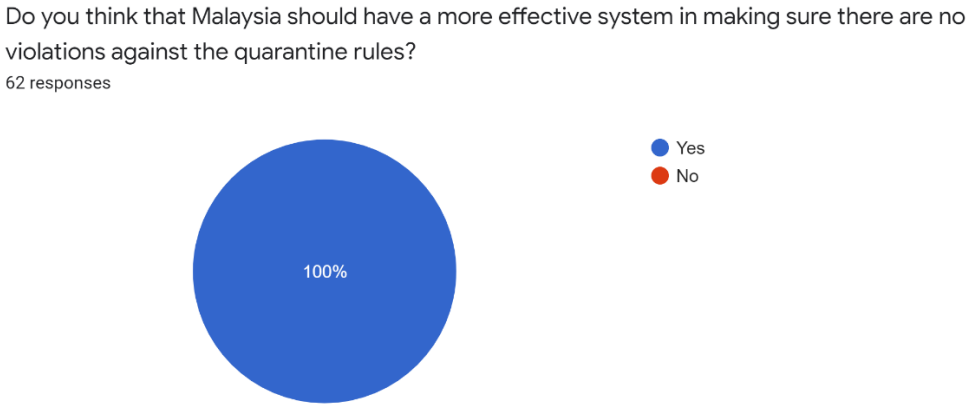

Figure 10: Question 4

Question 5:-

Question: If the data of the person who are being quarantined being centralized and monitored in a single system, do you think it will increase the effectiveness of quarantine or self-isolation? (e.g. location, temperature, heart rate)

77.4% of the respondents are insisting that the effectiveness of quarantine or self-isolation system will be enhanced if the required data such as location, temperature, and heart rate being monitored and centralized remotely. With this, every activity that the quarantine or self-isolation subjects can be traced and acknowledged faster by the authorities.

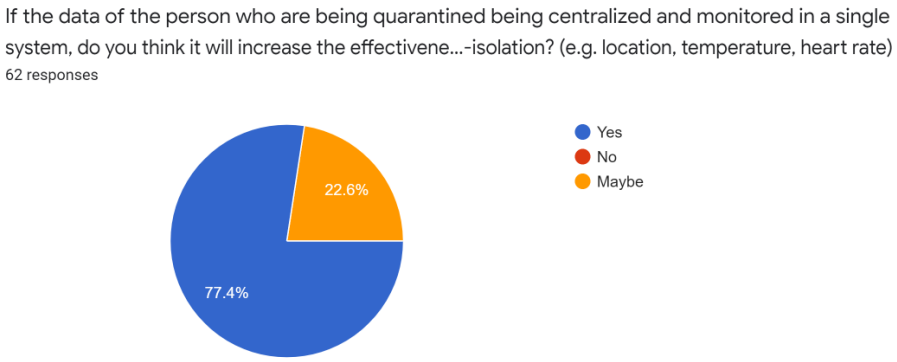

Figure 11: Question 5

Question 6:-

Question: In your opinion, what is the cause of the quarantine system in Malaysia being not really effective?

For the last question, this is the only question that enable respondents to choose more than one answer. As a result, 53 respondents have chosen 'Lack of concern' as the main factor of the ineffectiveness of the current quarantine or self-isolation system in Malaysia. 'Lack of expertise' came in second with 30 respondents and lastly is 'Lack of money' which is not being the main factor for most of the respondents.

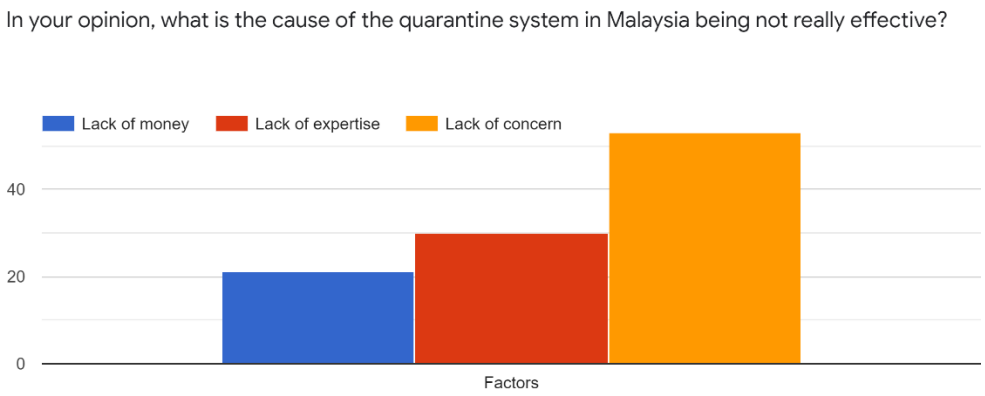

Figure 12: Question 6

4.2 SWOT ANALYSIS

SWOT Analysis consists of four main pillars which are the strengths, weaknesses, opportunities, and also threats. This is a great approach to understand the internal and external environment of the project hence analysing the suitability for the project to be conducted. SWOT Analysis for this project is mainly referring to the results from the data gathering process, observations, surveys, and comparative study that have been conducted earlier.

STRENGTHS	**WEAKNESSES**
• Streamline data in a timely and centralized manner. • Enable monitoring to be conducted remotely. • Any action can be acknowledged and taken faster.	• Might requires a lot of development and maintenance cost. • Not getting enough trust as the whole system is new. • Subjects might feel annoyed as being closely monitored.
OPPORTUNITIES	**THREATS**
• Increasing the effectiveness of the monitoring system for quarantine and self-isolation subjects. • Might be able to make breakthrough in the market as the system can be applied anytime and anywhere. • Increasing the security of the public as the quarantine subjects cannot expose themselves.	• Might require a lot of time to be well-developed. • Subjects might break and violate the system. • Data security might be threatened.

Table 3: SWOT Analysis

4.3 SYSTEM ARCHITECTURE

System architecture is a model that helps to describe the view, behaviour, and structure of the overall system. It is important because it will help to define the understanding of the whole system better hence providing a clearer objective or output. Furthermore, system architecture also enable any decision-making situations to be conducted faster as the understanding of the system overview has been secured.

With this, it can be a reference or guidance throughout the whole development and implementation of the project. In this project, there are three main components that will involve in the implementation phase which are the quarantine subjects, the system, and the authorities that will do the monitoring part. This system architecture will show the overall process flow on how the system will be done from start to the end.

i. Quarantine or self-isolation subjects

The subjects will be applied with the device during their quarantine period. The device will detect the data such as the temperature, heart rate, location, and whether the device is being worn or not. All of the data will then being compiled and transmitted to the IoT hub.

ii. IoT hub system

The data of subjects gained from the device will then being stored and streamlined in the IoT hub. With Azure, alongside the hub, the database, and stream analytics job also can be conducted. A live presentation of the data can be examined and gathered to ensure that the subjects well beings and whereabouts.

iii. Authorities

From the data that have been collected in the IoT hub, a presentation of data can be visualized timely and accurately. With this, authorities can acknowledge the situation better and act accordingly based on the live data that are being closely monitored.

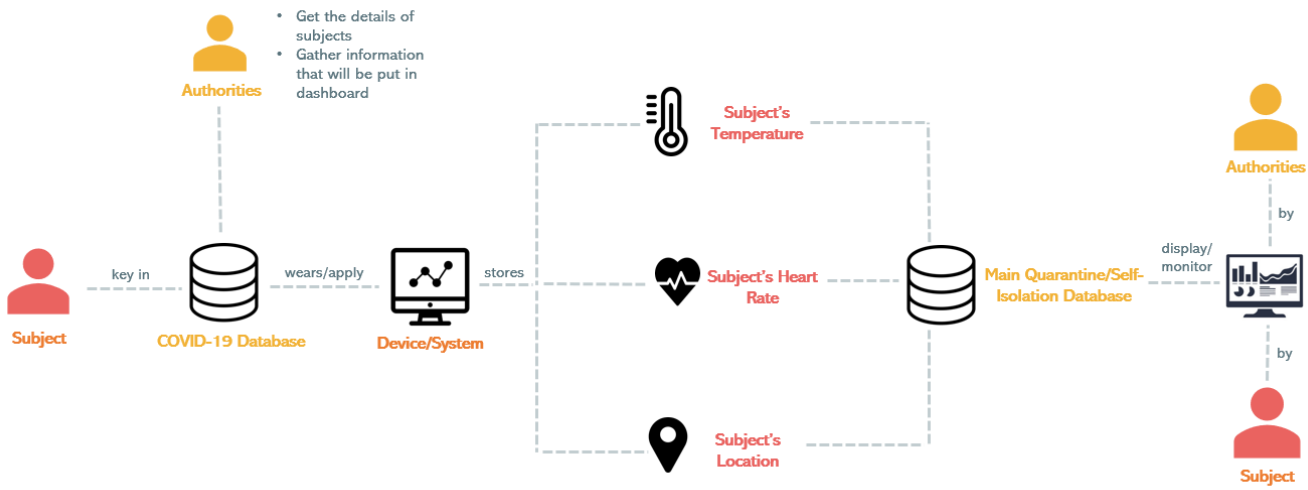

Figure 13: System Architecture

4.4 USE CASE DIAGRAM OF THE SYSTEM

In the use case diagram below, the author has identified the actors of the system and invented the relationship between them. The aim that this diagram brings along is to show and demonstrate the different set of actions or ways that user use to interact with the system. Each use case describes the actions done from the start to the end of the system. For this project, the main actors are the quarantine or self-isolation subjects, and the authorities that will do the monitoring. Each actor has performed a different type of use cases accordingly.

In addition from that, the use case diagram also demonstrates the relationship between the use cases with the label of 'extend'. For 'extend', it is used as an adding step to another first class of the use case. For instance, the "Visualize the data" is a use case of "Data being collected into the system".

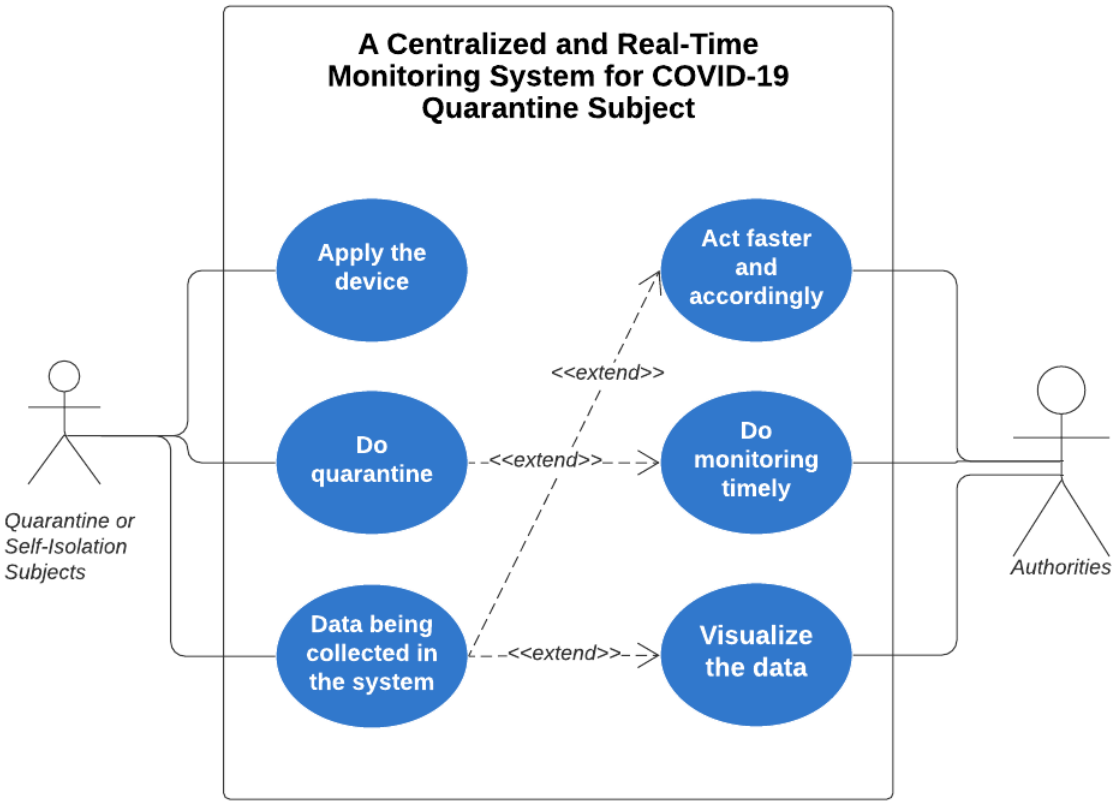

Figure 14: Use Case Diagram

4.5 FLOW OF SYSTEM

4.5.1 FRONT END OF THE APPLICATION

For the actual and desired system, the application will be running on the device in every 5 minutes. From the device, the data such as heart rate, and temperature can be collected. Apart from that, the device also checks if it is being worn by the subjects before compiling all the messages that will be sent to the backend.

Figure 15: Front-End System Flow

4.5.2 BACK END OF THE APPLICATION

The data that has been collected will then be received and stored in Azure IoT Hub. The, a stream analytics job will help to extract the data before sending it to Cosmos DB database. From the database, the data will then be visualized in Power BI which will give an interactive and clearer representation of the data.

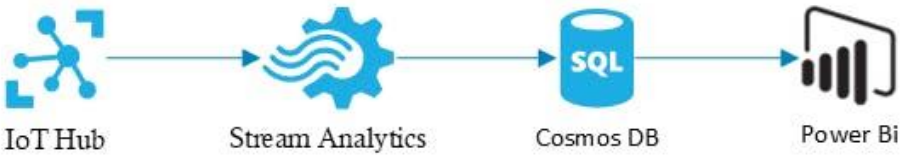

Figure 16: Back-End System Flow

4.6 DEVELOPMENT OF THE SYSTEM

The project is being developed following the steps that need to be done accordingly. This section will give guidance on how the project being constructed from the start to the end.

i. Step 1: Get all the tools and components needed

There are a few components that need to be gathered first for the front end of the project to be smoothly conducted. The components that have been gathered are Arduino MKR GSM 1400 which is the development board, GSM antenna that comes together in the development board, DFRobot Heartrate sensor, DFRobot temperature sensor, and Hologram sim card.

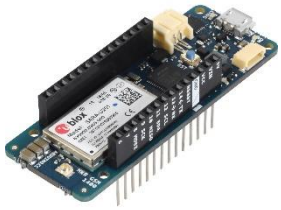

Figure 17: Arduino MKR GSM 1400

Figure 18: DFRobot Temperature Sensor

Figure 19: DFRobot Heartrate Sensor

Figure 20: Hologram IoT Global Sim Card

ii. Step 2: Work with MKR GSM

In this step, a certificate is being generated and stored on the device that will enable the connection with the backend of the project. From this step also, SHA1 string for the project has been successfully identified and will be used further in the development of the project.

```
COM7

ECCX08 Serial Number = 012350BE338B4B15EE

The ECCX08 on your board is not locked, would you like to PERMANENTLY configure and lock it now? (y/N) [N]: y
ECCX08 locked successfully

Hi there, in order to generate a new self signed cert for your board, we'll need the following information ...

Please enter the issue year of the certificate? (2000 - 2031) [2019]: 2019
Please enter the issue month of the certificate? (1 - 12) [1]: 2
Please enter the issue day of the certificate? (1 - 31) [1]: 6
Please enter the issue hour of the certificate? (0 - 23) [0]: 0
Please enter how many years the certificate is valid for? (1 - 31) [31]: 31
What slot would you like to use for the private key? (0 - 4) [0]: 0
What slot would you like to use for storage? (8 - 15) [8]: 8
Would you like to generate a new private key? (Y/n) [Y]: Y

Here's your self signed cert, enjoy!

-----BEGIN CERTIFICATE-----
MIIBLDCB06ADAgECAgEBMAoGCCqGSM49BAMCMB0xGzAZBgNVBAMTEjAxMjM1MEJFMzM4QjRCMTVF
RTAgFw0xOTAyMDYwMDAwMDBaGA8yMDUwMDIwNjAwMDAwMFowHTEbMBkGA1UEAxMSMDEyMzUwQkUz
MzhCNEIxNUVFMFkwEwYHKoZIzj0CAQYIKoZIzj0DAQcDQgAEln0r9VK543aFSyb94O1lwcsRdWOV
WV2dr1q+DndfXQts2ZKCJjfMzswQ2qQLtojwQ6slufm7fb4OcDIYT5gRxaMCMAAwCgYIKoZIzj0E
AwIDSAAwRQIhAN4KvtfWKc64DfgBmm9ZgmOV/W0B71f+q2B4V70sWTNMAiAao8Jgf7kRM+KziFi2
v1AN2XTnSVo5sdgiy89UENkT7A==
-----END CERTIFICATE-----


SHA1: 9b2fea40fa05202878587b0f6a7cc0f6e6c8b07c
```

Figure 21: SHA1 Certificate

iii. Step 3: Connect every component together

Onto the third step, this is where all components being wired up. The heart rate sensor is being connected to VCC, GND, and A1 of the Arduino board. While for the temperature sensor, it is being connected to the SCL, SDA, GND, and VCC of the board. The Hologram sim card also needs to insert first during this step.

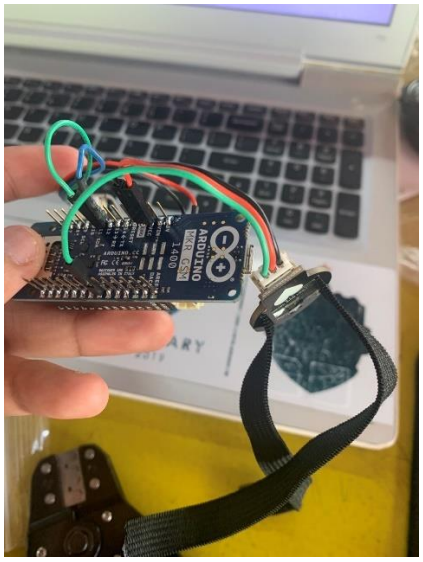

Figure 22: Connection of Heartrate Sensor

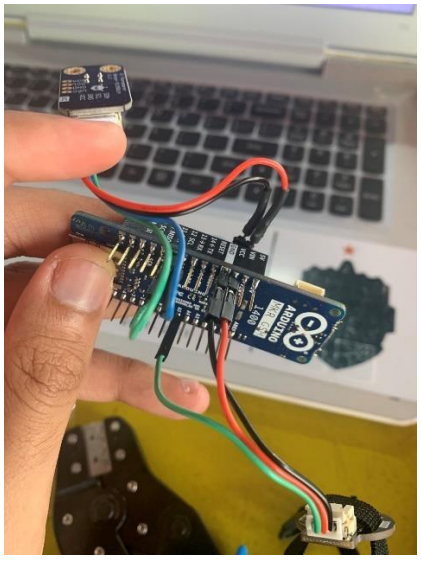

Figure 23: Connection of Temperature Sensor

iv. Step 4: Getting into IoT Hub

This step is about creating an IoT Hub that will be used to generate and store data that has been collected. In this step, a new resource group and name of IoT Hub have been assigned. Furthermore, the device that needs to be attached to the hub also has been created following the details that have been collected in the previous step such as the SHA1 string that being used as the primary and secondary thumbprint.

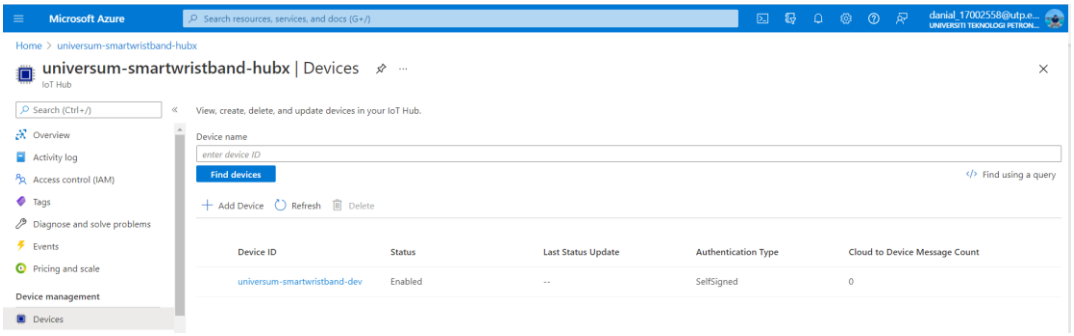

Figure 24: Azure IoT Hub

v. Step 5: Create database using Cosmos DB

The existing resource group that has been created in the previous step is being selected and the settings also remain the same. The region is still the same on both IoT Hub and database as a precaution from a transfer between region costs.

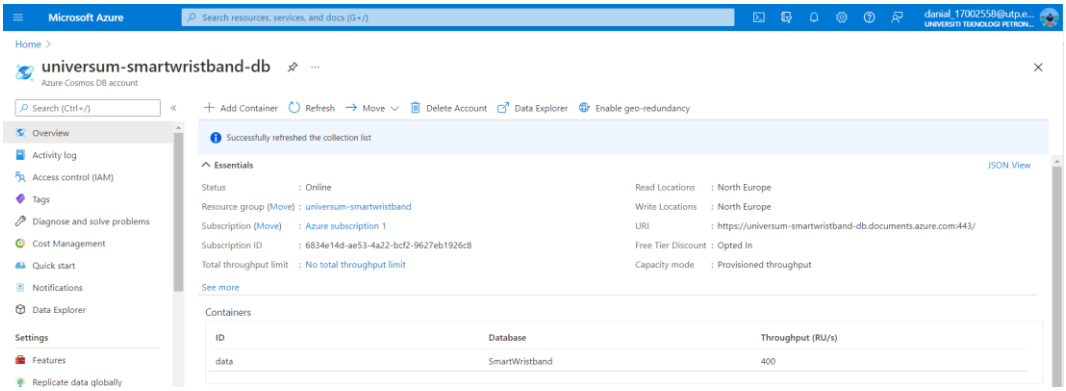

Figure 25: Cosmos DB Database

vi. Step 6: Create stream analytics job

In this step, both IoT Hub and database need to be connected so that the streaming can be done into the database. Same with the database, all details in setting up this stream analytics job remain the same except for the inputs and outputs details that need to be configurated. After that, a query that will supply the code to route the data from IoT Hub into the database. The stream will start after the 'Start' button being pressed.

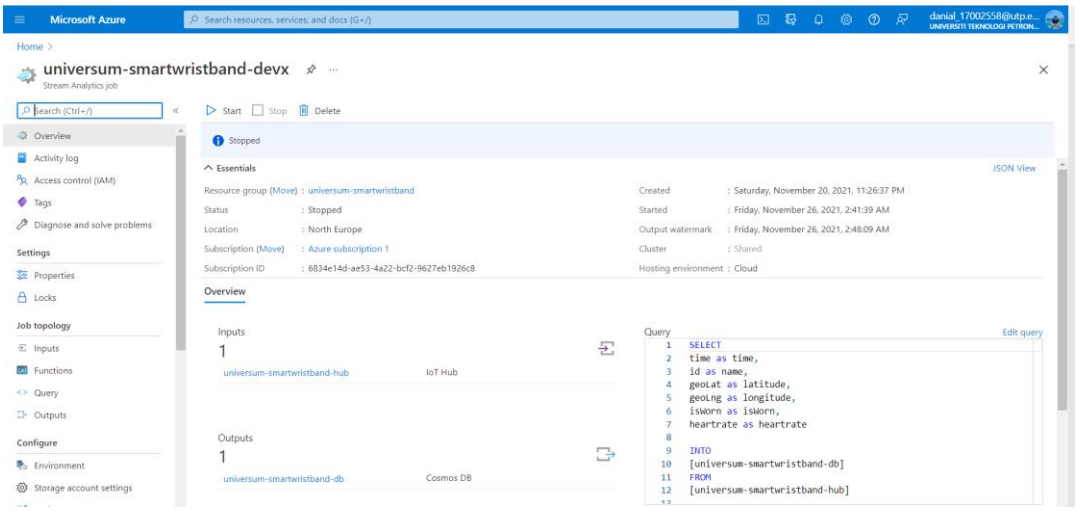

Figure 26: Stream Analytics Job

vii. Step 7: Required Libraries

To go further, few libraries need to be installed and stored first in the computer. The libraries are such: -

- MKRGRSM Library
- RTCZero Library
- Arduino Bear SSL Library
- Arduino ECCX08 Library
- Arduino MQTT Client Library
- Arduino Low Power Library
- DFRobot Heartrate Library
- DFRobot MLX90614 Library

viii. Step 8: Prepare the variables

Onto the frontend of the project, this is where variables being determined, and all required codes needed to be executed. Firstly, the hostname has been inputted into the *SECRET_BROKER* field in the *SECRETS.h* file from the project. In this step also, the device name and id being assigned. The application is on the *DEVELOP_MODE* which requires the device to be connected to the computer or any suitable power source.

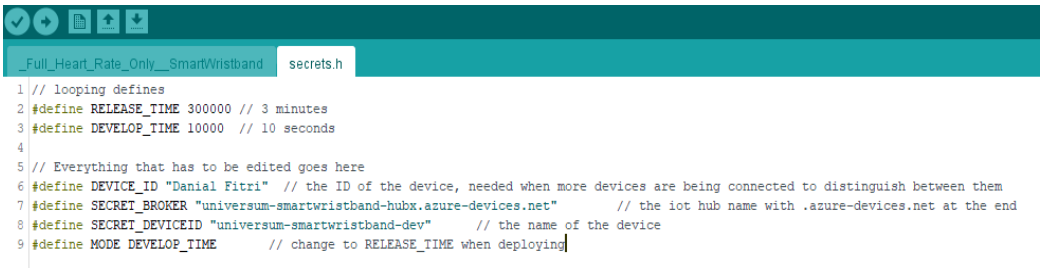

Figure 27: SECRETS.h file

ix. Step 9: Flash developer version

In this final step, the code has been tested out by uploading it into the sketch. While doing this, the device has to be connected to the computer via USB cable. The serial monitor will then show the verbose, but it might take some times to be configurated. The full code being tested using the heartrate sensor only in the first place to test whether the data can be compiled to the IoT Hub or not. It will then repeat using the temperature sensor.

```
_Full_Heart_Rate_Only__SmartWristband § | secrets.h

// Basic Includes
#include <MKRGSM.h>
#include <RTCZero.h>
#include "secrets.h"

// SSL and Azure Includes
#include <ArduinoBearSSL.h>
#include <ArduinoECCX08.h>
#include <utility/ECCX08SelfSignedCert.h>
#include <ArduinoMqttClient.h>

// sensors includes
#define heartratePin A5
#include "DFRobot_Heartrate.h"

// time Includes
#include "ArduinoLowPower.h"

// SSL globals
GSMClient      gsmClient;           // Used for the TCP socket connection
BearSSLClient sslClient(gsmClient); // Used for SSL/TLS connection, integrates with ECC508
MqttClient    mqttClient(sslClient);

// iot hub globals
const char broker[] = SECRET_BROKER;
String deviceId = SECRET_DEVICEID;

char payload[] = "{ \"%s\": \"%s\", \"%s\": %f, \"%s\": %f, \"%s\": %d, \"%s\": %d, \"%s\": %f, \"%s\": \"%s\", \"%s\": %f }"; // deviceID, geoLat, geoLng, isWorn, heartrate, temperature, time

// time globals
unsigned int localPort = 2390;      // local port to listen for UDP packets
IPAddress timeServer(129, 6, 15, 28); // time.nist.gov NTP server

const int NTP_PACKET_SIZE = 48; // NTP time stamp is in the first 48 bytes of the message
byte packetBuffer[ NTP_PACKET_SIZE]; //buffer to hold incoming and outgoing packets
GSMUDP Udp;

// temp globals
DFRobot_Heartrate heartrate(DIGITAL_MODE);

// GSM globals
GSMClient client;
GPRS gprs;
GSM gsmAccess;
RTCZero rtc;

// Location globals
GSMLocation location;
```

Figure 28: Snippets of Full Code

```
[loop / Time / synchRTC]
[setup] Initialising RTC with Time
[setup] Initialising RTC
[setup] Setting Current Time
[setup] RTC Setup Complete

[loop / Setup / iothub]
[setup] Setting up Security Chip
[setup] Signing certificates on time
[loop / Time / processTime]
[loop] Time is 2021-11-25T18:13:25.0
[setup] Setting up variables
[setup] Preparing callbacks

[loop / Setup / led]
[loop / Location / getLocation]
[loop / Location / lockLocation]
[loop] Attempting to lock
....
[loop] Location is 2.50, 112.50
[loop / Looping / prepareWakeUp]
[loop / Iothub / connectMQTT]
[loop] Attempting to connect to MQTT broker universum-smartwristband-hubx.azure-devices.net
[loop] Connected to the MQTT broker


[loop / Time / processTime]
[loop] Time is 2021-11-25T18:13:39.0
[loop / Looping / sendTwo]
[loop / Location / getLocation]
[loop / Location / lockLocation]
[loop] Attempting to lock
....
[loop] Location is 2.50, 112.50
[loop / Get / checkIfOn]
[loop] Checking if the device is being worn
--------------------------------------------------
[loop] Device is worn
[loop / Get / batteryLevel]
[loop / Get / processHr]
[loop] Getting Heart Rate
[loop] Ensure device is worn accordingly
[loop] Heart rate is 0
[loop / Iothub / compileMessage]
```

Figure 29: Details Received

From the figure above, every setting with respective details that needed for this project has been successfully configurated. The last section of the code has shown the detail whether the device is worn or not and process the current heartrate to the IoT hub which will be compiled later. The same kind of outputs sequence also will be shown if the temperature sensor being connected.

4.7 RESULTS FROM EACH COMPONENT

This section will show every result that each component has been given throughout the development of this project. All components being tested first with respective codes to ensure that each of them is running as what have been expected. Examples of components that have been tested accordingly are DFRobot IR Temperature Sensor, DFRobot Heartrate Sensor, and the outputs of both after being assembled together in the development board and process with the respective codes in the Arduino IDE. Few results from IoT Hub also will be represented in here.

4.7.1 RESULTS OF TEMPERATURE

The temperature sensor will first being connected using USB cable to the computer. The green light indicates that the sensor is compatible with the development board and considered as good to go. After that, a set of code or sketch is being written onto the Arduino IDE platform. For the code to be verified, it is a must to ensure that the code is free from any error. After being verified, then only the code will be uploaded into the system and the outputs can be seen by opening the serial monitor.

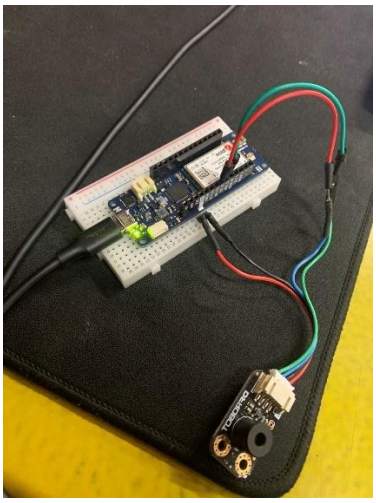

Figure 30: Temperature Sensor Connected

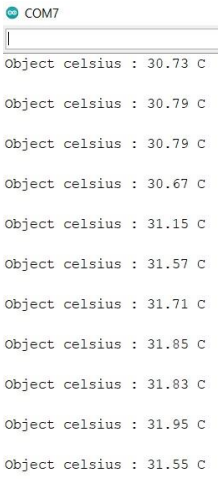

Figure 31: Temperature Outputs

dfrobot_temp

```
#include <DFRobot_MLX90614.h>

DFRobot_MLX90614_IIC sensor;   // instantiate an object to drive our sensor

void setup()
{
  Serial.begin(115200);

  // initialize the sensor
  while( NO_ERR != sensor.begin() ){
    Serial.println("Communication with device failed, please check connection");
    delay(3000);
  }
  Serial.println("Begin ok!");


  sensor.enterSleepMode();
  delay(50);
  sensor.enterSleepMode(false);
  delay(200);
}

void loop()
{
  /**
   * get ambient temperature, unit is Celsius
   * return value range:  -40 C ~ 85 C
   */
  //float ambientTemp = sensor.getAmbientTempCelsius();

  /**
   * get temperature of object 1, unit is Celsius
   * return value range:  -40 C ~ 85 C
   */
  float objectTemp = sensor.getObjectTempCelsius();

  // print measured data in Celsius
  //Serial.print("Ambient celsius : "); Serial.print(ambientTemp); Serial.println(" C");
  Serial.print("Object celsius : ");  Serial.print(objectTemp);  Serial.println(" C");

  // print measured data in Fahrenheit
  //Serial.print("Ambient fahrenheit : "); Serial.print(ambientTemp*9/5 + 32); Serial.println(" F");
  //Serial.print("Object fahrenheit : ");  Serial.print(objectTemp*9/5 + 32);  Serial.println(" F");

  Serial.println();
```

Figure 32: Sample Code for Temperature

4.7.2 RESULTS OF HEARTRATE

Same with the temperature sensor, the heartrate sensor needs to be connected first to the power source which is the computer. A green light is a sign that the sensor is not having any internal problem and the development board has detected it. The sketch then being uploaded to the Arduino IDE platform and going through the verification process first before being uploaded into the system. The outputs from this can be seen through the serial monitor.

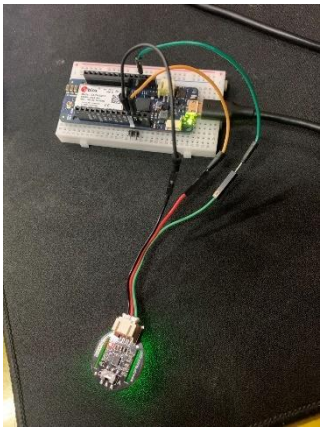

Figure 33: Heartrate Sensor Connected

```
Heart rate: 92.56 bpm
Heart rate: 95.32 bpm
Heart rate: 94.17 bpm
Heart rate: 94.69 bpm
Heart rate: 95.48 bpm
Heart rate: 93.30 bpm
Heart rate: 93.12 bpm
Heart rate: 92.56 bpm
Heart rate: 92.56 bpm
Heart rate: 93.36 bpm
Heart rate: 93.15 bpm
Heart rate: 92.01 bpm
Heart rate: 92.34 bpm
Heart rate: 0.00 bpm
Heart rate: 0.00 bpm
Heart rate: 92.56 bpm
Heart rate: 95.32 bpm
```

Figure 34: Heartrate Outputs

DFRobot_Heartrate_Digital_Mode

```
#define heartratePin A1
#include "DFRobot_Heartrate.h"

DFRobot_Heartrate heartrate(DIGITAL_MODE); ///< ANALOG_MODE or DIGITAL_MODE

void setup() {
  Serial.begin(115200);
}

void loop() {
  uint8_t rateValue;
  heartrate.getValue(heartratePin); ///< A1 foot sampled values
  rateValue = heartrate.getRate(); ///< Get heart rate value
  if(rateValue)  {
    Serial.println(rateValue);
  }
  delay(20);
}
```

Figure 35: Sample Code for Heartrate

4.7.3 RESULTS OF HEARTRATE AND TEMPERATURE

As both temperature sensor and heartrate sensor has been configurated successfully, then only both of the components being tested together at the same time using the same development board. A specific set of codes has been uploaded into the IDE platform and being verified successfully. The serial monitor will then show the outputs gained from this program.

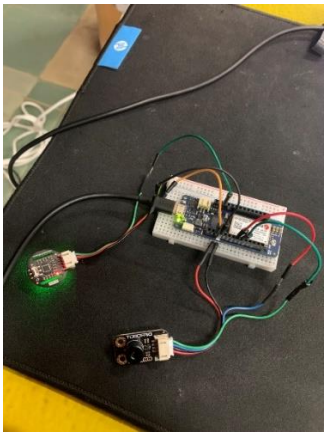

Figure 36: Both Sensors Connected

```
Object celsius : 30.90°C
Heart rate: 92.34 bpm
Object celsius : 33.25°C
Heart rate: 92.01 bpm
Object celsius : 35.78°C
Heart rate: 93.15 bpm
Object celsius : 36.56°C
Heart rate: 93.36 bpm
Object celsius : 36.55°C
Heart rate: 92.56 bpm
Object celsius : 36.23°C
Heart rate: 92.56 bpm
Object celsius : 36.25°C
Heart rate: 92.56 bpm
Object celsius : 36.38°C
Heart rate: 93.12 bpm
Object celsius : 36.55°C
Heart rate: 93.30 bpm
Object celsius : 36.40°C
Heart rate: 95.48 bpm
Object celsius : 36.42°C
Heart rate: 94.17 bpm
Object celsius : 36.41°C
Heart rate: 95.32 bpm
Object celsius : 36.45°C
Heart rate: 0.00 bpm
Object celsius : 30.90°C
Heart rate: 92.34 bpm
```

Figure 37: Outputs for Both Sensors

Heartrate_Temperature

```
#include <DFRobot_MLX90614.h>
DFRobot_MLX90614_IIC sensor;   // instantiate an object to drive our sensor
#define heartratePin A0
#include "DFRobot_Heartrate.h"

DFRobot_Heartrate heartrate(DIGITAL_MODE); ///< ANALOG_MODE or DIGITAL_MODE

void setup() {
  Serial.begin(115200);

  while( NO_ERR != sensor.begin() ){
    Serial.println("Communication with device failed, please check connection");
    delay(3000);
    }

  sensor.enterSleepMode();
  delay(50);
  sensor.enterSleepMode(false);
  delay(200);
}

void loop() {

  uint8_t rateValue;
  heartrate.getValue(heartratePin); ///< A1 get value
  rateValue = heartrate.getRate(); ///< Get heart rate value
  float objectTemp = sensor.getObjectTempCelsius();

  Serial.println(rateValue);
  Serial.print("Object celsius : ");
  Serial.print(objectTemp);  Serial.println(" C");
  Serial.println();
  delay(500);
}
```

Figure 38: Sample Code for Both Sensors

4.7.4 RESULTS FROM IOT HUB

Moving on to the IoT Hub, a few indicators that shows the device has been detected and streamlined with the hub have been identified. The indicators are such the ‘Devices Connected’, and ‘Total Requests’ in the database. The transfer of data can be seen through the ‘Metrics’ from Azure IoT Hub. From the data, it can be seen that a total of 1 device has been successfully connected to the hub. In the meanwhile, there are about 36 total requests that the hub has received from the frontend of the system.

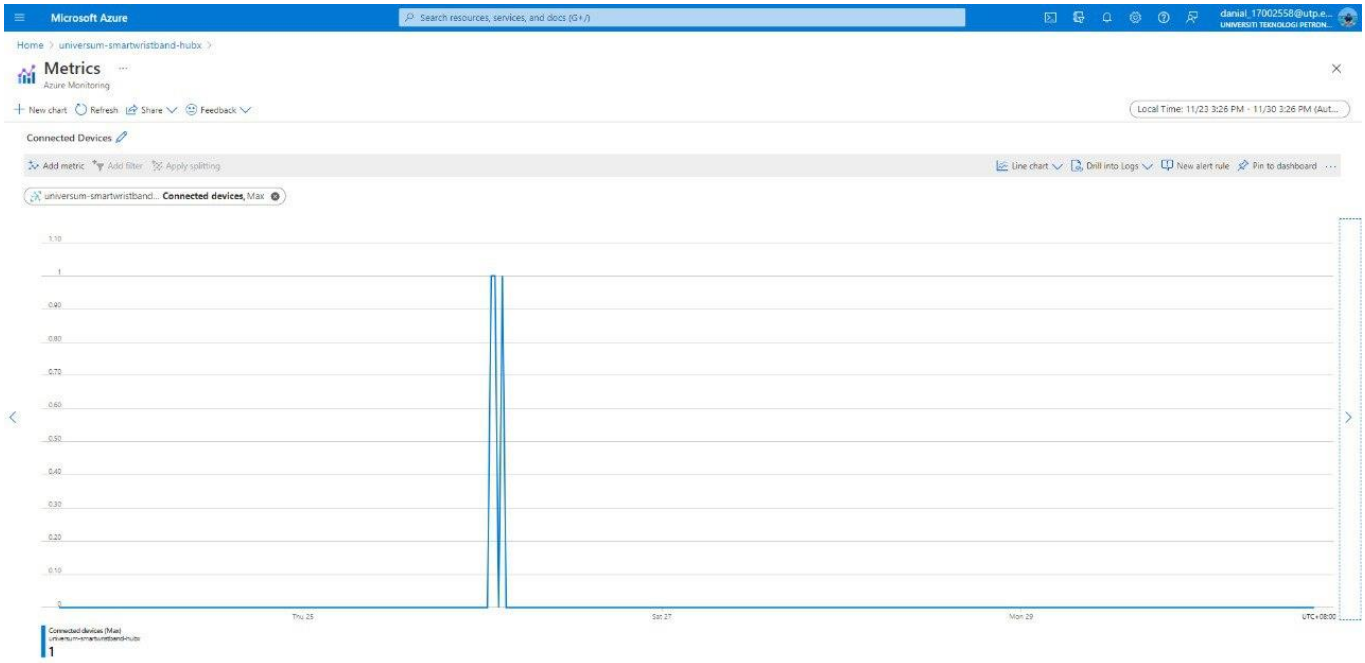

Figure 39: Connected Devices to IoT Hub

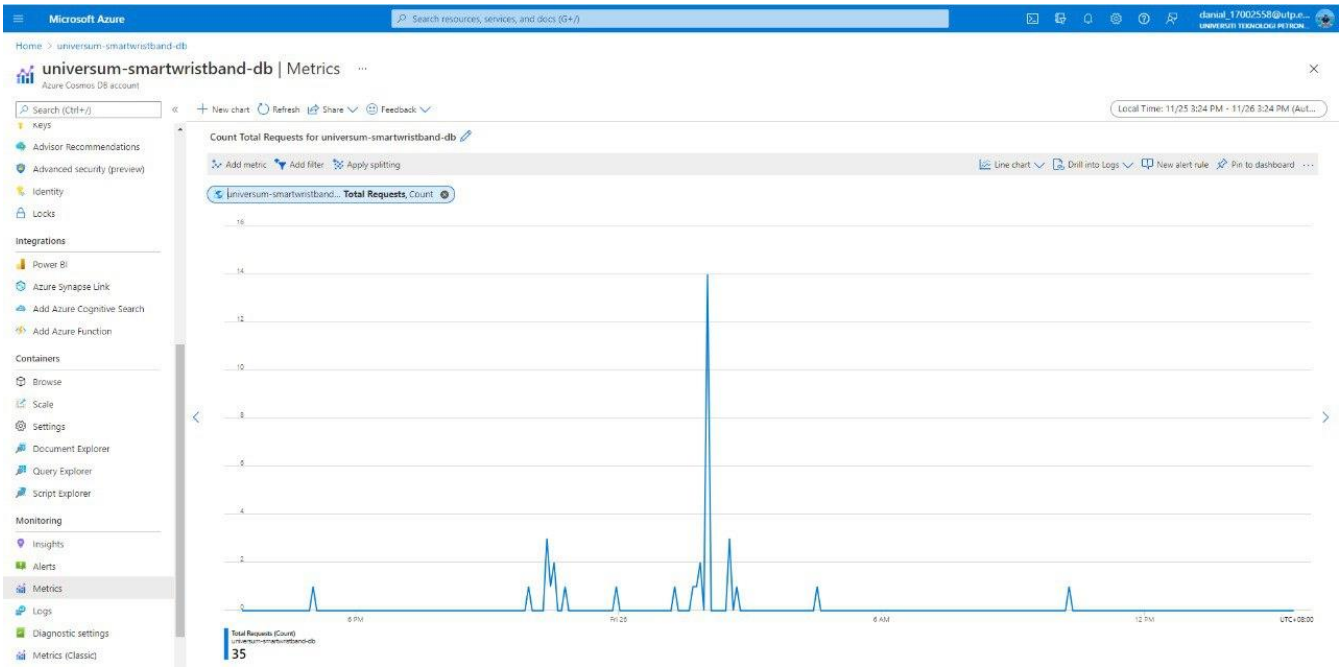

Figure 40: Total Requests in the IoT Hub

4.7.5 POWER BI INTEGRATION

As the outputs have been successfully streamlined from the device onto the IoT Hub, visualization through Power BI can be taken place later on. Through visualization, the outputs can be understand and acknowledged clearer as it provides an interactive approach to the reader. Below are the sample of visualization that can be done on the Power BI dashboard. The visualization is following on the creativity and not being restricted. Other functions such as the temperature and heartrate indicator can be added through Power BI platform. The data will be visualized in a live and timely manner.

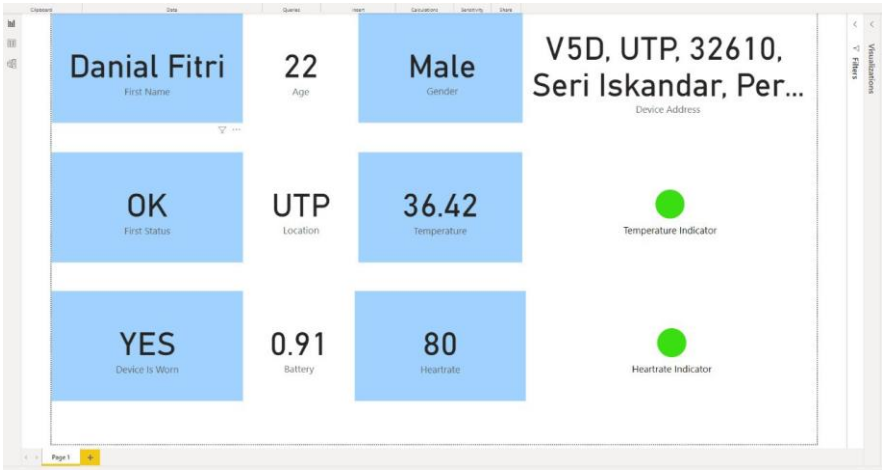

Figure 41: First Dashboard

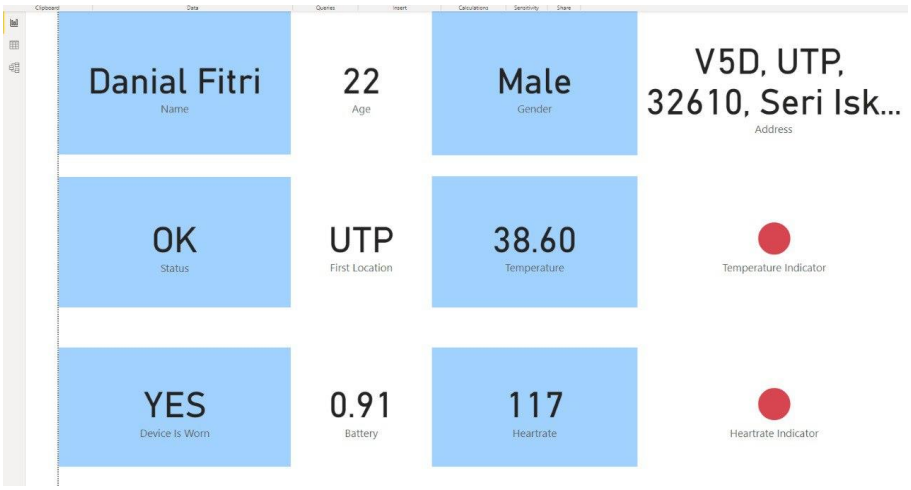

Figure 42: Second Dashboard

4.8 FUTURE ENHANCEMENT

The overall system of this project can be continuously developed and going through future enhancements. This will help the overall system starting from the frontend until the backend being consistently upgraded to ensure it can reach the full potential of tackling the problem regarding the violation of quarantine or self-isolation rules.

One of the enhancements than can be done in the nearest time is by applying battery as the main power source as an upgrade from the usual computer source that needs USB cable for every connection to be taken place. A 3.7V LiPo battery is sufficient for the device to perform up to 8 days with a single charge based on a rigorous testing that has been conducted. As the quarantine or self-isolation period lasts up to 10 or 14 days, the battery needs to be recharged and the recharging session can be taken place even if the device is still being worn. But, onto the sketch for the overall system, the *DEVELOP_MODE* has to change to *RELEASE_TIME* in the *SECRETS.H* file. This will enable the device to work without the connection from the computer or any cable as the battery has taken the position as the main power source.

Another enhancement that can be done is the enclosure of the device. After a sufficient amount of data and positive insights that can be gained from time to time, and if the frontend and backend of the application have shown an excellent accuracy, the device can be enclosed to make it look more proper and secure to be worn. The figure below is the example on how the enclosure can be done on the device of the overall system.

Figure 43: Sample of Enclosure

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5. CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

As a conclusion, three main objectives that have been stated earlier for the project were successfully achieved. The explanation on this is as below: -

Objective 1: To investigate the requirements of a system for centralized monitoring or tracking system for COVID-19 quarantine and self-isolation subject.

Explanation: This project has successfully identified what are the components and requirements needed for the overall system to be working. All functionalities and approaches that have proposed were able to meet the expectations based on the outcomes produced. The components needed also have a high-availability in the market and can be purchase anytime and anywhere.

Objective 2: To design and develop a centralized monitoring or tracking system for quarantine and self-isolation.

Explanation: The overall system has been built following a specific design and procedures that needs to follow accordingly. From the frontend part, this project has been able to show the correct ways to assemble each component into one specific device that is in a form of wristband. Onto the backend part, the project has specified the usage of IoT Hub and how beneficial it can be to make the overall implementation as good as it can be.

Objective 3: To evaluate and the user acceptance on the proposed system.

Explanation: For the time being, only one user has tested the functionality of the system, and everything seems to be right on track. The data such as the location and heart rate has been consistently gained and transferred to the IoT Hub as being proposed. The same set of procedures will be implemented on the temperature sensor also later on. In addition from that, the overall system can be tested on few people soon to gain their justification and acceptance on the system.

In summary, the main elements that are required from this project have been successfully identified and implemented. The development from the frontend up until the backend can be considered as a success as the projects are able to meet every objective that has been underlined within the project. The features like streaming and storing data are essential in making the monitoring system that being implemented on the quarantine and self-isolation subjects to be more effective and accurate. This project can be a guidance in solving the ongoing problem regarding the violation of quarantine or self-isolation rules and gives a numerous benefit mainly for the authorities that have to do the monitoring, and the community as a whole as they will feel safer and secured.

5.2 RECOMMENDATION

Upon the completion of this project, despite having to reach all objectives that have been initiated, there are still further recommendations that can done in the future to enhance the system from time to time. The first recommendation is that more functions can be included within the overall system. Oxygen level is one of the functions that can increase the productivity of the system and completely related to the COVID-19 virus. As the subjects are having their quarantine or isolation, the authorities such as doctors can get a more detailed set of data involving the rate of oxygen level during the monitoring process.

Onto the second recommendation, if the overall system wants to be implemented in a larger scale, it is better to have two separate teams which consists of the frontend team and backend team. This can ensure that a better communication will be received and given in each department hence making the development process to be faster and easier. If both frontend and backend of the system being consistently done in a more proper way, the system will only get better by times. This recommendation is being raised because the difficulties and confusion during the development of this project are mainly coming from the part where the streamlining the data between two platforms taken place.

Last but not least, another recommendation for this project is that more testing can be conducted first before the system is being deployed. Data testing can help to give details on the accuracy and consistency of each data that comes from each component or from the overall system. A high number of testings can acknowledge the flaws from the system which soon will be fixed for the system to be more solid and logical at the same time.

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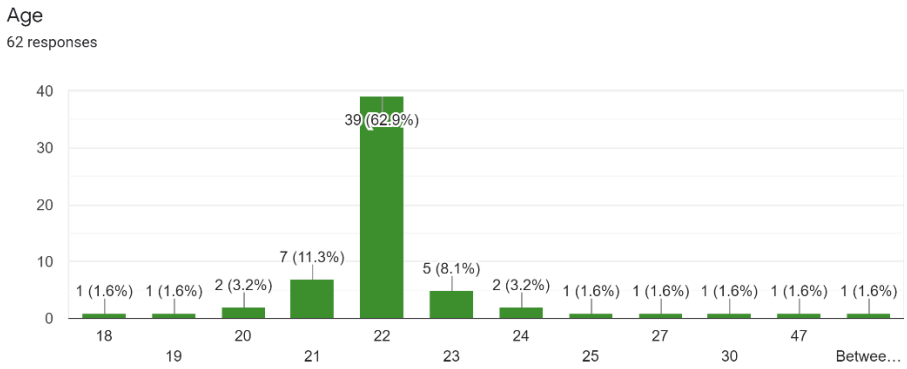
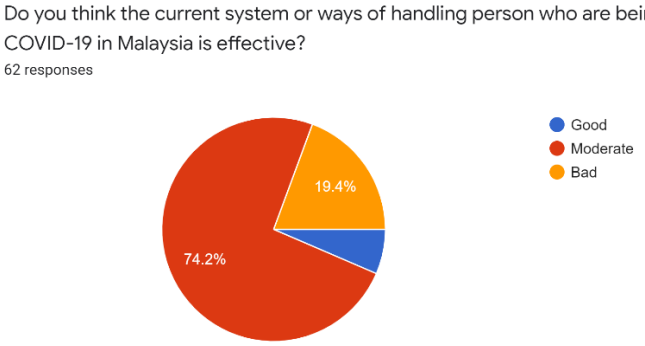
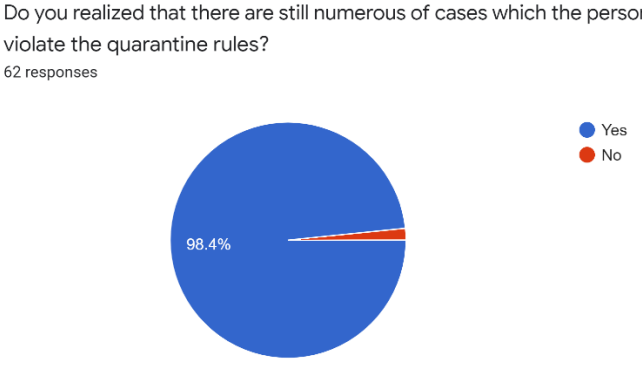
APPENDICES

APPENDIX A

ONLINE SURVEY QUESTIONS AND RESPONSES

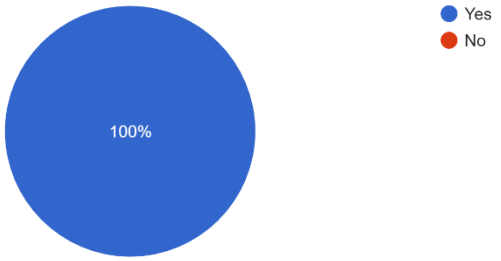






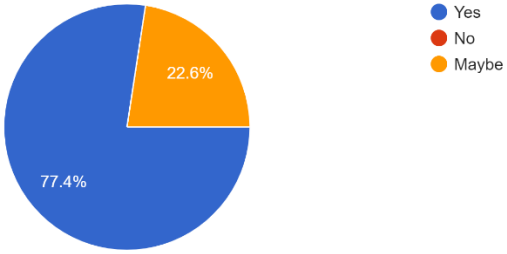
Do you think that Malaysia should have a more effective system in making sure there are no violations against the quarantine rules?

62 responses

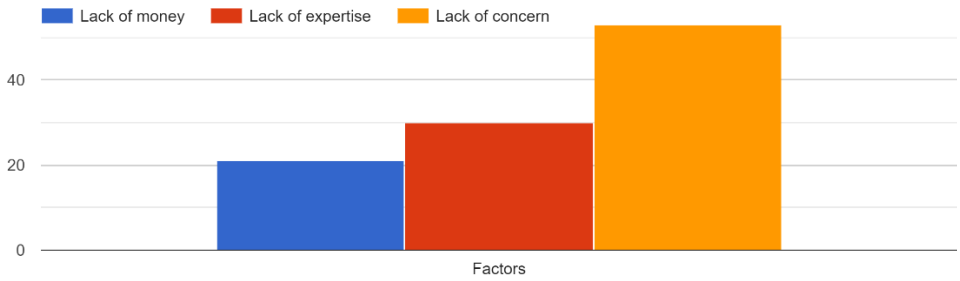


If the data of the person who are being quarantined being centralized and monitored in a single system, do you think it will increase the effectivene...-isolation? (e.g. location, temperature, heart rate)

62 responses



In your opinion, what is the cause of the quarantine system in Malaysia being not really effective?



APPENDIX B

SUMMARY OF SURVEY RESULTS

Do you think the current system or ways of handling person who are being quarantined due to COVID-19 in Malaysia is effective?	Do you realized that there are still numerous of cases which the person who are being quarantined violate the quarantine rules?	Do you think that Malaysia should have a more effective system in making sure there are no violations against the quarantine rules?	If the data of the person who are being quarantined being centralized and monitored in a single system, do you think it will increase the effectiveness of quarantine or self-isolation? (e.g., location, temperature, heart rate)	In your opinion, what is the cause of the quarantine system in Malaysia being not effective?
Good 4 votes (6.6%)	Yes 60 votes (98.4%)	Yes 61 votes (100%)	Yes 47 votes (77%)	Lack of money 20 votes (19.6%)
Moderate 45 votes (73.8%)	No 1 vote (1.6%)	No 0 vote (0%)	Maybe 14 votes (23%)	Lack of expertise 30 votes (29.4%)
Bad 12 votes (19.7%)			No 0 vote (0%)	Lack of concern 52 votes (50.9%)

APPENDIX C

COMPARATIVE STUDY

Country	Slovakia	Taiwan	South Korea
Types of Systems	Mobile App	Digital Fence	Mobile App
How It Works	• Carry out random facial recognition checks and provides tracking information	• Anyone that is required to do home quarantine, their location is being monitored via cellular signals • If any violation happens, it will trigger the alert system • Calls and messages will be received to update the whereabouts	• Those who have to undergo home quarantine, GPS will be used to keep track of their location • Those in quarantine can update and report their health status to the officials • An alert will be sent to both subject and officials if any violation occurs
Centralized	**Yes**	**Yes**	**Yes**
Real-Time	**Yes**	**Yes**	**Yes**