Development of UTAR Hospital RFID Linen Monitoring through Gantry using JAVA

By

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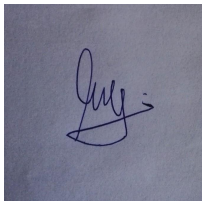

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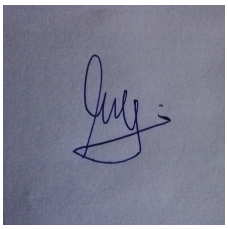
Signature : 

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ABSTRACT

In this project, I will propose and develop a Radio-Frequency Identification (RFID) based Hospital Linen Monitoring System through gantry using JAVA to UTAR hospital, in order to provide low power consumption, low operating costs, and improved monitoring. This project will provide the student with embedded, programming, networking, and database analysis skill and knowledge. The proposed system consists of RFID tag, and RFID Reader, Antenna. The hospital Linen Management System is designed to detect, count, record, and report on the hospital linen incoming and outgoing process. The outgoing process is usually sending linen from the hospital to the laundry plant for washing. RFID reader and data processing system are using software developed by a combination of programme. The user or staff in the UTAR hospital will be able to track or monitor the hospital's linen, which includes bed sheets, towels, pillowcases, and other medical linens. The benefit of implementing RFID for linen management is that it reduces human mistakes in counting things and ensures a smooth laundry item cleaning procedure is carried out. The database tracking application allows the user to keep track of the number of linens that come in and go out of the hospital. As the objects pass through the RFID scanner, their unique IDs will be immediately identified. The database will record and display the number of RFID tags that have been detected at the moment and record it in the database. As a result, the hospital staff or back-end management will be able to track the status of certain linen. Users will also be able to check the database record system for any missing linen.

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LIST OF ABBREVIATIONS

UTAR	Universiti Tunku Abdul Rahman
RFID	Radio-Frequency Identification
LMS	Linen Monitoring System
ID	Unique Identification
SDLC	Software Development Life Cycle
DB	Database
IDE	Integrated Development Environment

Chapter 1: Introduction

RFID (radio frequency identification) is increasingly being employed in hospital administration. RFID technology implemented in hospitals can improve patient safety and operational efficiency. RFID is an auto-ID technology that allows for the wireless transmission and reading of data contained on a microchip. This means that data is sent without eye contact using magnetic and electromagnetic fields, and particular items or components become readily identifiable as a result. Until today, the technology has been widely employed in hospital linen management, and it also offers a clear additional value to hospitals [1].

RFID readers acquire information about items and their environment by communicating with a tag antenna. Mobile Readers and tags can communicate wirelessly without the need for any wires or cables. RFID can also recognize fast-moving objects and a limited number of tags at the same time because it has an anti-collision function. The RFID system has three essential components which include tags, mobile readers, and host computers, RFID tags are made up of tiny microchips and miniature antennas enclosed in some kind of packaging [2].

Moreover, each tag contains a unique identification (ID) that provides mobile tracking of the object to which the tag is attached. For example, data can be stored inside the chips such as registration numbers, dates and times, configuration instructions, and technical information [3]. This is due to the fact that the chip used in RFID tags can store a vast quantity of data. However, this developed technology is not new and it has been used in a variety of applications around the world. Since Universiti Tunku Abdul Rahman (UTAR) has been building a hospital for students and people to provide quality healthcare service. In this project, I will be developing an RFID Linen Monitoring through Gantry using JAVA language, to track and monitor UTAR hospital linen and perform data analysis collected from both the hospital and from laundry.

1.1 Problem Statement and Motivation

According to findings in the general hospital, I found that many healthcare facilities will have to manually keep track of each valued asset. For example, the current issue faced by the hospital is that the linen management, people rely significantly on physical counting, either for verification of clean linens obtained or filthy linens which will pose hygiene risks to humans and not working efficiently as by counting one by one [4]. A report shows that in the hospital overall linen has a loss of 15% per year, with the following stock resulting in the hospital that they have to overstock linens or sheets every year in order to satisfy fulfillment and compensate for losses.

For the new coming UTAR hospital, due to the conventional of management and to prevent such methods this project is to propose the solution which is to use RFID in hospital linen management for tracking and monitoring. This solution can reduce nurse or staff workload in the hospital and potentially increase efficiency on time taken. Not only that, when it was sent to the laundry for cleaning, the linen location is tracked for 24 hours which can significantly reduce loss.

The motivation for taking this project is affected by several advantages of RFID technology, the recent Covid-19 cases, and also personal education. Nevertheless, RFID has been widely employed in many industries, particularly management, RFID enabled the hospital supply chain to track data more quickly, efficiently, and precisely, resulting in enhanced data accuracy, less time spent on administrative tasks, and stock savings. For the recent cases of Covid-19, many people were infected by the virus and number of people were sent to hospital, this will significantly increase the workload for staff in the hospital, and there would be large linen sent out for clean purposes, in consideration I realized that for some hospital does not apply technology such RFID, hospital staff will be tough and having non-stop work to manage and process the clean and dirty linen, in order to immediately and effectively isolate that linen, I was intended to develop using RFID for linen management. On the other hand, for personal education purposes it will be a good experience in developing the system and for passionate about building the things

related to the Internet of Things and also to improve knowledge in the RFID field and enhancing embedded skills.

1.2 Objective

The objective of this project is to develop a RFID linen monitoring system through Gantry using JAVA programming language that will be able to track and monitor the linen for UTAR hospital. The aim of using RFID will also bring some solutions which is:

1. To provide linens visibility easy and quickly

In this project to develop an RFID linen monitoring can provide visibility to the hospital management as they can get the real-time data of the linen incoming and outgoing once the linens is scanned through the RFID. Hospital that lacks linens or asset visibility find it difficult to correctly manage for events because they cannot perform operations effectively or avoid stolen or lost linens. Items that have been stolen imply a failure to execute the daily amount of inventory. This may cause delay in day-to-day operation due to erroneous inventories. RFID tags on linen can help the hospital take inventory more quickly, effectively, and on an regular basis. In order to provide visibility of the linens this project will going to develop an dashboard to show the details of each tag.

2. To improve data accuracy and availability

It can improve the data of linens become more accuracy using RFID to do monitoring and scanning, than human manually record. This is because RFID eliminates transcription mistakes, redundant data, and "missing items" when used to gather data on a large number of items at the same time since data is captured and updated electronically. The usage of cloud-based solutions allows everyone within the hospital to access the most up-to-date information on the location or status of linens. To develop an RFID monitoring that remove duplication data, in this project I will develop on the software side and programming function needed to solve the duplication problem and get details of the data such as timestamp, antenna port, specific linen with unique tag and linen types to become more accuracy.

3. To provide tracking accuracy for check-in and check-out

Nowadays most healthcare industry struggle to keep track of their assets especially in the hospital usually will have large amount of linens incoming and outgoing for laundry wash, with RFID technology embedded tag into each of the linen RFID systems provide a quick and dependable method of tracking items without needing to count every linen manually. The RFID monitoring system allow hospital staff to see instantly the number of each linens that they have and how many are in the laundry for washing. Each linens will being tracked through check-in and check-out door and hospital user will receive the information of the linen in real-time. This is because RFID system can captures data in real-time at various phases of the linen, it gives improved status reports for planning and operating purposes. Hence hospital linen management can manage the linen and distribute necessary amount of linen to other department.

1.3 Project Scope and Direction

The scope of this project is to develop a system using RFID to do monitoring or track of UTAR hospital linen process. The propose software is the Linen Management System (LMS). This system will be use in UTAR hospital to get the information from the linens and then store the data into a database and send it to the cloud which the database is stored inside an application, user can download it from an android phone because the RFID mobile reader is an android-based. The current general hospital linen management work procedures rely significantly on physical counting, whether to identify clean linens received or soiled linens that pose hygienic risks. Hence, the intention of using RFID monitoring and tracking is to improve management of linen loss, reduce hospital staff workload in the hospital and potentially increase efficiency on time taken and also visibility of the linen incoming and outgoing process for cleaning from the hospital to the laundry plant.

Moreover, this project will need both hardware and software, whereby the hardware is sponsored by MDT Innovation Company which is RFID mobile reader, RFID tag, and RFID Gantry, for the software side is required student to complete the programming skill. Furthermore, to develop the RFID system this project has scheduled the process to go through each phase which includes planning, design, research, identifying the use of programming language, prototyping, integrating, and testing. To ensure the RFID system is functional and working properly, it will be tested out for various scenario in order to make sure the collected data is correct and function properly.

In addition, for my direction to develop the RFID linen monitoring system I will be using RFID Gantry and to choose programming language, I will be using JAVA language in my project. The software that I had chosen to develop my RFID monitoring project is Eclipse which is and integrated development environment (IDE) for developing applications and used for doing my JAVA programming, and MongoDB which is an NoSQL database that is document-oriented and utilized for high-volume data storage while it is using JSON format to store complex data. MongoDB will be using as database to store RFID tag record and also show chart and display all the information or data in dashboard for hospital staff to visualize.

However, the hardware will be using in this project is RFID Gantry, RFID Tag and RFID Reader for doing my JAVA program and testing using RFID Tag.

To conclude, this project required the knowledge of using the Eclipse and MongoDB software, on the software side need understanding the flow and JAVA programming language. On the hardware side need to understand the hardware setup and plug in with the correct port to make sure it is working fine.

1.4 Contributions

In this project, I was developing an linen monitoring system using RFID through gantry to monitor all types of linen in UTAR hospital. For the contribution of developing the RFID linen monitoring system I am using JAVA programming language to developed this project. With the coding application I am using Eclipse IDE. In order to provide linens visibility easy and quickly, in JAVA program I will use plug in external library of MongoDB which is an NoSQL database to update all the RFID tag information to the database and from there MongoDB also provided feature that enable creator to create charts using the database information, hence I also developed a dashboard by using the collected data for hospital staff easy to visualize all the linen information.

Moreover, to achieve the objective of improve data accuracy and availability, in the JAVA program I had created several function firstly hospital staff can print out all the tag and see total how many tag that they currently have. During the scanning process for incoming or outgoing linen in the hospital to laundry, RFID will scan every two second, so it will have many duplicate tag scanned. In order to remove the duplication tag, I had created a function that used to remove the tag with the same tag ID.

Lastly, the objective of provide tracking accuracy for check-in and check-out , in order to achieve this the hospital staff can see how many tag they have scanned during the scanning process. All of this information such as tag ID, timestamp, total tag, and total scan will be send and store in the database which I will be using MongoDB, and from the database will capture the real-time data during the scanning process and update every 1 minutes.

1.5 Background Information

Radio-frequency Identification (RFID) is a viable technology and one of the most rapidly increasing sectors of today's technology, its use can use to automatically identify, collect, and gathering data in the industry. However, this developed technology is not new and it has been used in a variety of applications around the world. Since Universiti Tunku Abdul Rahman (UTAR) has been building a hospital for students and people to provide quality healthcare service. In this project, I will be developing an RFID tracking system used to track and monitor UTAR hospital linen and perform data analysis collected from both the hospital and from laundry. When the hospital is open it is expected to have a large amount of linen incoming and outgoing from the hospital

1.6 Report Organization

In this section, I will list the details of this development project in the following thesis outline of the chapter. Chapter 1 is introduction and overview of this proposed project, in this chapter contains problem statement and motivation, objective for developing this project, project scope and directions which include all the software used and a brief introduce the used of application and platform and also design, contribution and project report thesis outline. Next, the project's scope and significance are outlined, as well as the project's schedule and expected outcome.

In chapter 2 is literature review, this chapter will discuss about the existing project using RFID monitoring which are similar to our project. The sources will be find online and such reliable sources are journal, websites, and articles. After review about the existing similar project, will do a comparison such as strength and weaknesses, limitation of our project, compare between difference system and solution will be discuss in this chapter.

Next, in chapter 3 is proposed method and approach, this chapter will discuss about the system requirement such as hardware and software that needed in order to develop this project and also discuss about the process of collecting requirements, analyzing information, and designing the system architecture, functionalities, database, and interfaces.

In chapter 4 will be the preliminary work which will discuss about the system implementation such as hardware RFID setup, database plugin, programming flow and software used. In this chapter there also discuss about the testing, different testing of the system will be taken such as system functionality, usability, database and network performance.

Lastly, chapter 5,6 and 7 include of the system evaluation and performance testing and also finalize the whole project. The conclusion will be in chpater 7 which will conclude the whole project, to review the objective of this project and check whether our objective have met, conclude the system performance and outcome and future work to improve the system.

Chapter 2: Literature Review

RFID has been widely developed and used by other industries. In this chapter, I will be researching the similar existing system in the sector. A company ProLinenCare (M) Sdn Bhd is one of Malaysia's rapidly growing linen and laundry companies which specialized in healthcare linen and laundry services since its founding in 2004. ProLinenCare delivers end-to-end linen and laundry support to enable healthcare providers in optimizing the usage of their linen while allowing them to concentrate their full dedication to the primary function of patients' medicine and healthcare activities.

Studied the linen management process of ProLinenCare, at present, they are using the conventional management for their linen which they have staff to manage and manually count and do the linen manage in daily. As time goes on, several issues have been raised about healthcare linen management. However, inventory inconsistencies and linen losses are two of ProLinenCare's key important business concerns, which both have significant ramifications for healthcare linen management. Inventory shrinkage was discovered to be one of the main sources of inventory inconsistencies in the instance of ProLinenCare. Additionally, ProLinenCare also facing the improper linen location made linen tracking more difficult because the organization has over 120 types of linens that may be classified based on color, size, type, and materials. Furthermore, for linen loss based on the data reviewed that the company has an amount of linen loss every year the reason is either sent for clean wash or soiled linen was thrown.

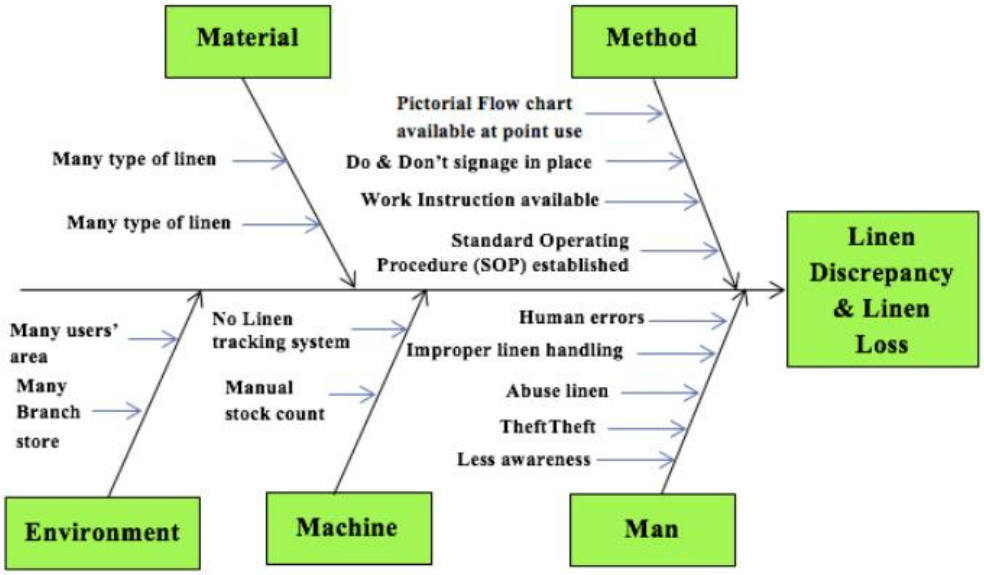

Figure 2.1 ProLinenCare Fish-bone Diagram

After the company has studied the benefits of RFID, they started to implement an RFID technology tracking system for doing the linen and laundry management. In general, RFID technology improved productivity, enhanced data capture accuracy, and reduced expenses by offering better stock or asset control. RFID appears to be a superior alternative for ProLinenCare in order to reduce linen discrepancy and linen loss. There is some adoption of using RFID technology that solves their business challenges effectively which is quickly and simply provides inventory visibility. RFID tags sewed through each linens item allow the company to conduct inventory more quickly, efficiently, and on a daily basis. RFID scanners installed in each storage space take a constant assessment to help identify where linens are lost or stolen. RFID technology is also able to assist ProLinenCare in tracking when its linens are filthy and transferred to an outside laundry service, as well as when they return, allowing it to determine when any inventory is missing [5].

2.1 Limitation of using RFID

Despite RFID technology having a great potential for hospital management but there are various concerns or barriers that prevent its application, including economic and technological concerns. The cost of the system and the system's return on investment are two of the most challenges in RFID technology. According to the research, depend on the capabilities, the price of an RFID tag could range from 4 cents to 50 dollars per tag. Taking consideration into the hospital, the adoption of RFID technology for the linen management will also have some possible challenges and difficulties as hospitals usually have a large amount of linen, and each the linen needs to install on the tag which can be very costly and also because most RFID tags are tiny and light, they can easily transported away from the hospital, resulting in a loss of tag inventory and, as a result it will be an unwanted expense for the hospital. Another limitation is that in order to function in real-time, an active RFID system required the installation of antennas and readers throughout the hospital [6] . These RFID's technological constraints can limit its implementation, particularly in healthcare. First, RFID can cause interference with hospital equipment, such as medical equipment. Moreover, RFID reader and scanner accuracy is affected by a number of elements, including the tagged object, tag location, angle of rotation, and read range result in term of the collected data are not always reliable.

2.2 Barcode System

Barcodes are a technique of encrypting numbers and characters by using varied length bars and spaces. Lines and spaces are both read. These could be considered a different type of writing since they replace key data entry as a technique of data acquisition. In business, proper barcode utilization may minimize inefficiencies and increase production, ultimately increasing a company's bottom line. Simply mentioned, barcodes are a quick, simple, and accurate method of entering information. Monitoring, asset tracking, and validation are the three basic uses of barcode technology. Whether a business employs one function or a combination of functions, overall cost savings, increased productivity, and enhanced quality can be significant [7].

2.3 Comparison of RFID and Barcode

Barcode use for managing inventory or tracking is another important element of total inventory control and management. At the present, barcode technology is widely utilized on items whereby those items may be scanned by bar code scanners, which send the information to the central control unit pertaining to the product information and update different details about the product. RFID and barcode are two different technology with distinct uses that occasionally overlap. RFID's benefits have made it increasingly popular in recent years, particularly among inventory managers who have been operating with barcodes for a certain time and have experienced irritation owing to its inherent limits. The primary difference between the two is that barcodes are line-of-sight technology. Such that, a scanner must "see" the barcode in order to process it, which means people must usually discover the barcode toward a scanner in order for it to be read. The advantage of RFID is that it does not require line of sight. RFID tags may be detected as long as they are close to a scanner. In this situation, RFID is a much better choice for the hospital to do linen management as considered hygienic.

Table 2.3.1 Comparison of RFID and Barcode

Items	RFID	Barcode
Read rate	High throughput. Tag can be read simultaneously.	Low throughput. Tag only can be read manually.
Line of sight	Not required	Required
Durability	High	Low
Read/write capability	Able to modify, read, write and update	Able to read only
Human capital	System automated	Need people to do manually

2.4 Different between RFID Passive, Semi-passive and Active tag

RFID tags are classified as either active or passive. Conventional passive tags are normally "asleep" until they are activated by the reader's transmitted field. The reader's field charges the capacitor that powers the credential in passive tags. Because of the required signal intensity, passive tags are often utilized for short read-range applications usually 1.5m, and need a high-powered reader with an antenna capable of receiving the information. Passive tags are generally very light and tiny, with infinite life lengths.

Furthermore, card payments, which are plastic cards the size of a card that may be accessible through a reader device, are sometimes mistaken for passive RFID. Although the transmission technology is the same, smart cards feature on-chip processing and memory capabilities that RFID does not. RFID just stores an identifier, but the smart card may store personal information, advanced encryption mechanisms, or application-specific algorithms.

Active tags are often powered by an internal battery which can last several years but is completely dependent on the application and used for extended read-range applications up to 100m. Active tags can continually generate the detection signal and have a larger overall memory since they are read or written. Active tags are typically heavier, more costly, and have shorter life spans as a result of these increased capabilities.

Semi-passive tags also known as semi-active or battery-assisted RFID are another type of tag. These tags interact with the reader in the same way that passive tags do, but they also include a power onboard to perform certain purposes, such as storing regular temperature data from an integrated temperature sensor[8].

2.5 Proposed Solutions

The limitation of implementation RFID in the healthcare industry has been discuss in the previous sub-chapter. In this project is aim to proposed the solutions that solve the limitation of using RFID in healthcare. There are many possible solutions to this problem but looking specifically in the hospital area, in this project I proposed a solution that is proving successful in many other hospital used in order to be able hospital install RFID system and collect the accurate data or information of the incoming and outgoing linens and also provide visibility on the linens items and being able to do analysis.

The first problem is the economic concern which the RFID will costly for hospital to implement as there are huge amount of linen items. Hence, the proposed method will be using is passive RFID tag. After discuss about the comparison between active and passive tag, active can be more costly, although it is powerful but life span is short so it is not suitable to implement in hospital as it need to renew and cost money for hospital, compare to passive tag, it is more suitable to implement in the linens items. During checking it does not required a long range reader instead, short range reading tag is enough for checking and also passive tag do not required their own power source. In terms of solving the economic concern for hospital to implement the RFID linen monitoring system, RFID passive tag is the better choice.

Moreover, the second problem is technological concern which is related to the places of RFID installation that will cause interference with hospital equipment and also the information accuracy. The proposed solution to this problem is that the installation of the RFID Gantry hardware will be place in the hospital outgoing door to ensure that there will no equipment close to the RFID hardware that will cause device interference. In order to ensure all the linens are properly scanned, there are four antennas place surrounded a bag of linens. For the information accuracy problem, although the antennas is set to scan the tag every two second, inevitably there will be many duplicate record. In order to solve this problem, this project is proposing a method on the software programming side, which will check the scanned result and eliminate the tag duplication record and provide a clear result with record table.

Chapter 3: Proposed Method/Approach

In this chapter will discuss about the hardware and software that is require in order to develop in this project, the method or approach used in this project, system design and architecture and lastly discuss about the project schedule timeline.

3.1 System Requirement

3.1.1 Hardware

The hardware involved in this project is RFID Gantry, RFID tag and a computer. On the software side involved Eclipse IDE, MongoDB. For the software side, a computer is needed to do processing for the data, monitoring linen status, and programming.

Laptop:

Figure 3.1.1.1 Laptop

Table 3.1.1.1 Specifications of Laptop

Description	Specifications
Model	ASUS TUF FX504
Processor	2.3GHz Intel Core i5-8300H
Operating System	Windows 10
Graphic	2GB Nvidia GeForce GTX 1050
Memory	8GB DDR4 SDRAM 2,660MHz
Storage	1TB hybrid SSHD FireCuda

RFID Gantry:

The RFID Gantry has two, first type of Gantry is integrated with a weighing scale another is without a weighing scale. The Gantry with the weighing scale will have two sizes which are big and small, the big scale which is also called a platform usually will place the incoming clean linen for the hospital, it will weigh the clean linen with the trolley and record the weight of the clean linen and the system will do some calculation. The trolley will have a tag, so the user can know the weight of the trolley. The small weighing scale is used by the soiled linen. In front of the Gantry has an industrial panel used as a monitor, at the middle of the Pole Gantry there is an antenna used to scan and detect RFID. The bottom of the Pole Gantry has a junction box that inside has a reader to read all data and use to send it to the cloud. Below is the figure showing the Gantry with and without a weighing scale.

Figure 3.1.1.2 RFID Gantry with and without weighing scale

RFID Lintag

RFID Lintage is will be embedded with the linen and each of the tags will have a unique ID to identify the linen, this tag is waterproof which means there is no problem sending it to the laundry plant for washing.

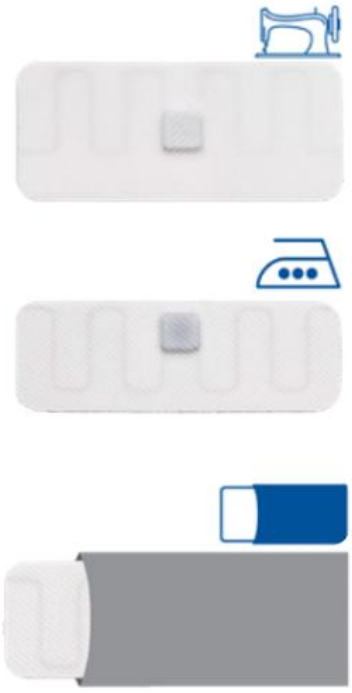

Figure 3.1.1.3 RFID Lintag

Table 3.1.1.3 Specifications of RFID Lintag

Description	Specifications
Model	LinTag™ 200
Operating Frequency	860-960 MHz
Chip Type	MONZA M5
Reading distance	7 meter
Memory	128bits EPC
Anti-Collision	Yes
Material	Cotton and polyester

3.1.2 Software

Eclipse 2022 IDE

Figure 3.1.2.1 Eclipse IDE 2022

Table 3.1.2.1 System requirement of Eclipse

Requirement	Minimum	Recommended
Java version	1.4.0	5.0 or greater
Memory	512 MB	1 GB or more
Free disk space	300 MB	1 GB or more
Processor speed	800 Mhz	1.5 Ghz or faster

Eclipse is an Integrated Development Environment (IDE) use to develop software with various of programming language. It has a base workspace as well as an extendable plug-in framework for configuring the environment. It is the second most widely used Java programming IDE. Nevertheless, this application is needed to do programming such as printing tag information, linens type, counted linen record and remove data duplication in order to complete this project. On the other side, the reason that I choose Eclipse is that, the Impinj which is the hardware RFID brand that use in this project provided the JAVA library that needed in order to setup with

Eclipse and also guideline is provided. With that Eclipse also allow for external library to be plug in and dependencies.

MongoDB

Figure 3.1.2.2 MongoDB

MongoDB is an open source a non-relational document database that can store data in JSON format. The MongoDB database includes a dynamic data format that allows user to store unstructured data or complex data, as well as comprehensive indexing and replication support via rich and straightforward APIs. With Ad-hoc queries, MongoDB allows for field, range, and regular-expression searches that can return supporting information, specific fields of records, or random sampling of results. Main and secondary indices can be used to index fields in a MongoDB document. MongoDB provides a variety of index formats, including number of fields array, hash, and text. Lastly for replication, MongoDB offers high availability using replica sets that have two maybe more copies of the information. The main replica handles writes, while any replica can provide read requests. If the main replica fails, a backup replica is promoted to take its place [10] . MongoDB used mainly in this project is the database to store RFID tag with the linens information, total tag in the hospital, incoming and outgoing tag scanned. The feature provided by MongoDB is that MongoDB allow user to create own dashboard which will be use in this project in order to create a overview of the hospital linens information for hospital staff who do not have any programming knowledge that provided an easy to read and visibility of the data.

3.2 System Methodology

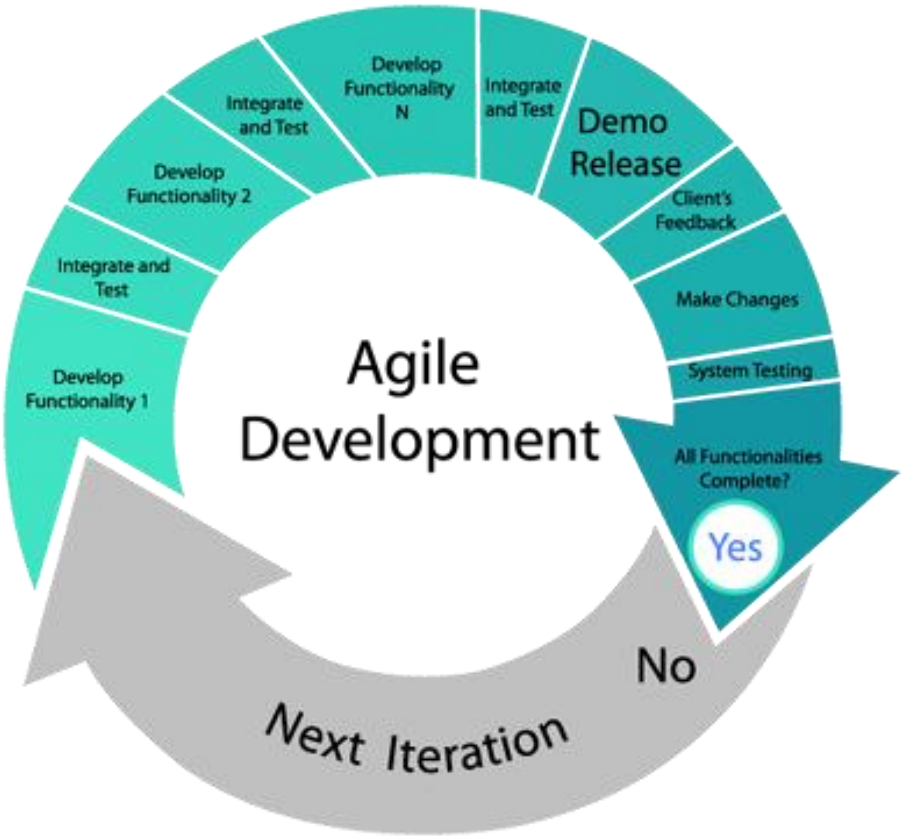

Figure 3.2.1 Agile Software Development(SDLC)

The methodology that will implemented in this project is Agile Software Development Methodology (SDLC). This methodology used to create a rigorous software management process that also allows for some frequent change in the development project Agile development is designed to reduce risk by building software in short time periods known as iterations [9] . The advantage of this methodology is that it provide iteration loop for the process of design, developing and testing phase which is suitable for this project because it allow me to check on previous phase or function, if any problem occur I can rebuild and do testing again. By using this technique each functionality can be divided in to a smaller part and each part including the iteration of designing, developing and testing, in which this can continuously deliver some useful function in a short-time period in order to complete the whole system.

There will be total of five stage include in this process which is planning stage, design stage, implementation stage, testing and maintenance stage. In planning stage, I will prepared all the hardware that is required in this project such as RFID reader, antennas and RFID tag, for the software I will used is Eclipse and MongoDB and make sure these software is already installed. In second stage, first will make sure all the RFID hardware plug in correctly, then start to design the flow such as RFID tag is scanned and define the problem such as network duplication, then design the flow in order to solve the problem. In implementation stage, which I will be start to do JAVA coding on the software and implement several function such as remove tag duplication, list out tag information, RFID antenna port, linen types and total count. After that, will come to the testing phase which all the coding function will then be tested, if there is any error on coding I will go back to design phase check the flow and implement again if necessary. Lastly, after checking all the function is completely working, the whole RFID linen monitoring will then developed then I will create dashboard for hospital staff to monitor.

3.2.1 Planning phase

In the first phase, I will prepare those RFID hardware that is needed in this project and start to setup the hardware and connect the hardware to my computer. Firstly, there will need to do some important setup on the software side and also prepared installed for the software needed such as Eclipse IDE in order to completely connected to the hardware so that when the tag is scanned, my computer will came out the tag. After setting up I will do testing of all the tag and check if it is working fine. Then, I look and define the problem and review my objective of this project to ensure what I need to achieve in this project.

3.2.2 Design phase

In this design phase, I start to plan out on the programming side I will be using JAVA to do coding. After scanning all the tag, the problem comes with there are too many duplication which the antennas will scanned the RFID tag every two second. Then the design flow for the system I will planing is firstly I will collect all the RFID tag information which included duplication, then filter out the duplication tag, print out

all the tag and see total RFID tag, specify the tag with specific linen types. Lastly, when all data is collected, then will update to database and create a dashboard.

3.2.3 Implementation phase

In the following stage, after planning and also designing the overall flow of the whole system. I will start to do JAVA programming using Eclipse, here I will start to implement the function one by one. Each function will be implement in a way that following the designing flow done in the previous stage.There several function to be implement in this stage such as remove duplication tag, for instance I will create a new list and do comparison with the scanned tag and store it into the new created list, then list out all the RFID tag to ensure there will be in total of 50 tag and others function such as list out the tag information, RFID antenna port, linen types and total count.

3.2.4 Testing and Maintenance phase

In this last stage is the testing and maintenance stage, after I had implemented the all the function, each function will be tested out for several situation such as scanned result and information of each tag to check whether it is correct. If the result is not correct error code occur then will be back to the step designing the flow, implement again to ensure it is working. Lastly, if all the function is working correctly then the system will be deploy as setting up the database and upload all data to the database. Then, in order to let hospital staff for easy visualize data, I will create a dashboard and maintain the system. In the future work, I will continue improve the system as many information is needed to show on dashboard.

3.3 System Design Diagram

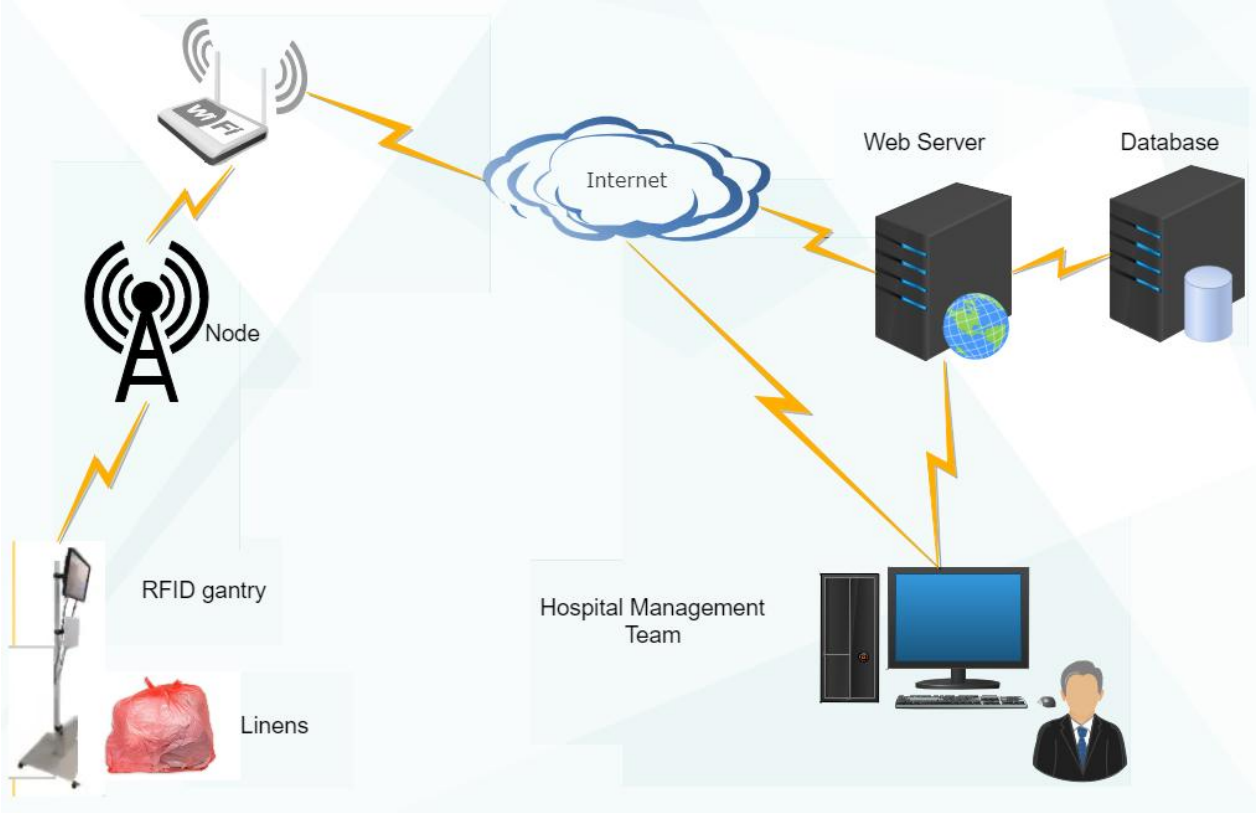

Figure 3.3.1 Design Diagram

Above is the system architecture diagram of the overall flow of the RFID linen monitoring system the lines is to represent the communication. Firstly, a plastic of incoming or outgoing linens will be scan in front of the RFID Gantry, through out the antennas will send the tag information to the internet which it must connected to a WIFI. Then, web server will receive all the information and update to the database that has been setup for the RFID. From there after received the data, the created dashboard will then display charts and details about the RFID tag on the computer for the hospital management team to check and record.

3.4 Project Timeline

Below is the project timeline that I scheduled by the given total of Week 12 to complete this project. By scheduling each task, it provides an overview of all the necessary tasks, as well as respective assignments, priority levels, and step by step achieving the milestones by given separate time in a period. This also ensure me working toward a goal and achieve my objective when the deadline are met. It also allow myself to tracks my progress.

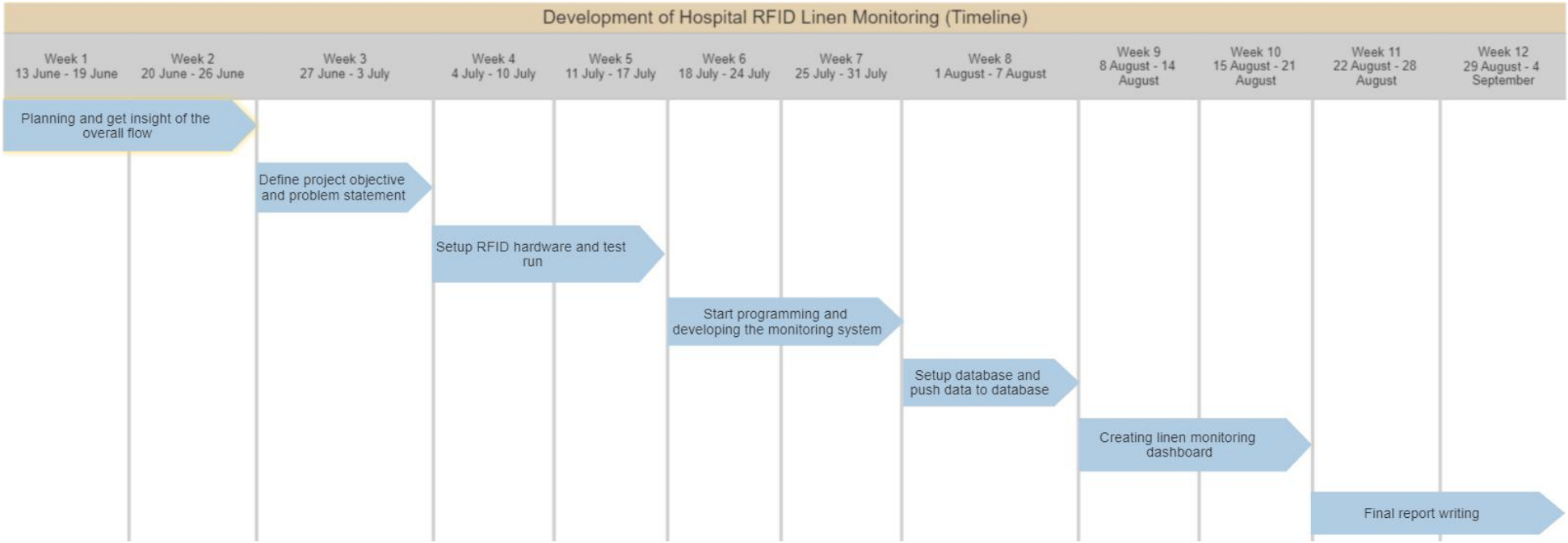

Figure 3.4.1 Timeline Diagram

Chapter 4: Preliminary Work

In this section, I will going to discuss about the work that needed to prepared and be done such as software installed, any configuration need for setup and RFID hardware setup in order to develop this project. After discuss about the preliminary work that is required to be done before starting to develop project, then in the sub-chapter will discuss about the function implementation and flow of the system.

4.1 Setting up

4.1.1 Software Setup

Before start to develop the RFID hospital linen monitoring project, there are two software that is required to be installed and setup for an account on my laptop which is:

1. Eclipse IDE 2022
2. MongoDB

Following are the setup by step for Eclipse IDE 2022, which on the website of RFID called Impinj need to download an Octane SDK java library and need to do some setup with Eclipse:

1. Launch Eclipse and create a new Java project
2. Name a new project folder and select correct JRE which is JavaSE-1.8
3. From the downloaded Octane SDK java file open to com folder and copy
4. Paste the com folder into Eclipse under src folder
5. In Package Explorer, create a new folder and name Lib
6. Then from the downloaded Octane SDK java file open to lib folder and copy
7. Paste it to lib folder on Eclipse
8. On Eclipse, expand lib folder, right click on the "OctaneSDKJava-X.XX.X.XX-jar-with-dependencies.jar", go to Build Path and Add Build Path.
9. Click Run and Run Configuration, on the menu tab
10. Double click Java Application and click Arguments tab
11. On the VM arguments box, enter -Dhostname=impinj-14-2f-d9, apply and run

Below are the picture show that after completing the setup of Octane SDK library with Eclipse. All the necessary java file included under src folder, dependencies under lib folder and added host name on VM arguments. After all the setup on software is done, I can start to test and scan the RFID tag to check the result. For the MongoDB setup which is the database, user just required to create a new account and create a new database query.

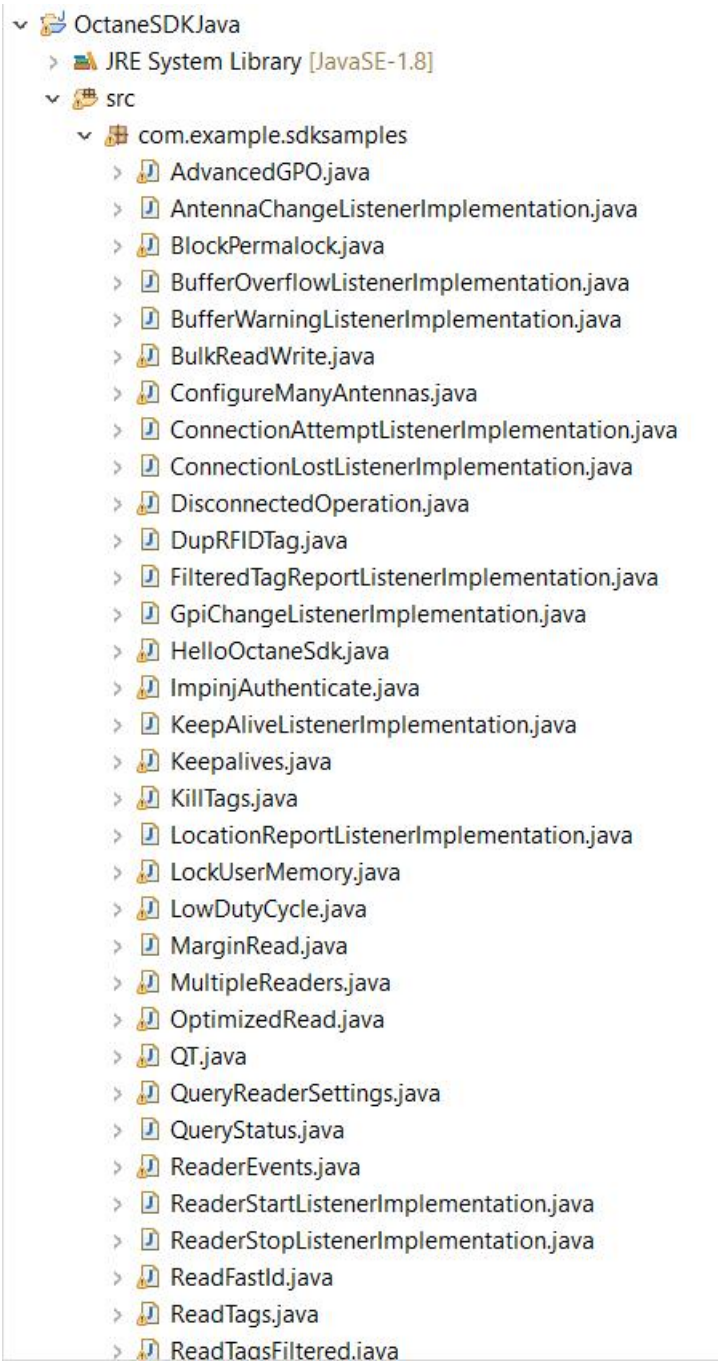

Figure 4.1.1.1 Java file

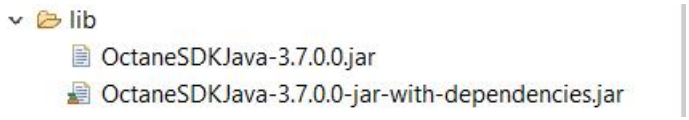

Figure 4.1.1.2 lib folder

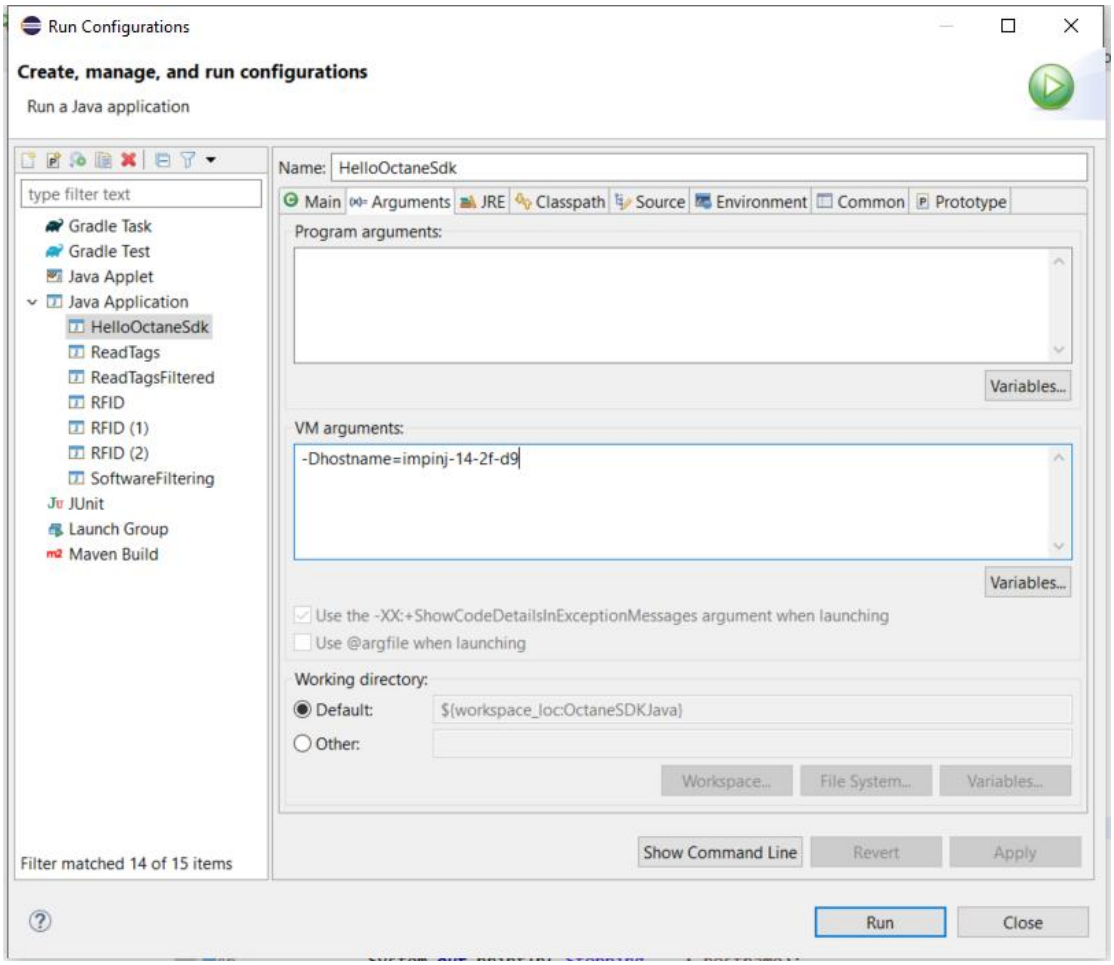

Figure 4.1.1.3 add reader host name

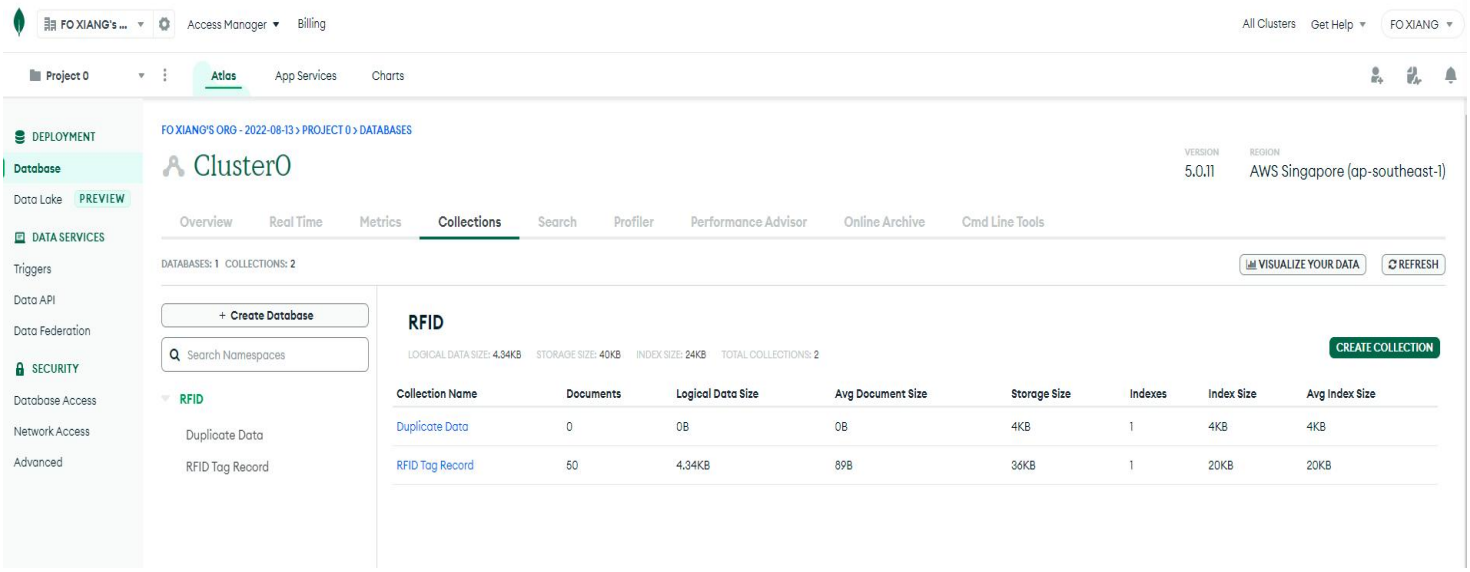

Figure 4.1.1.4 MongoDB environment

4.1.2 Hardware Setup

After done all the setup on the software side, on the RFID hardware are included RFID Reader, Antenna, and RFID Tag. Below is the picture show that how I wire up each of the hardware with following the proper guideline. To make sure the Reader is working fine, I must check on the antenna port 1 light, it must show a blue light. The battery shown green light. For the IN port is connected to my laptop, and for the OUT port is connect to Reader. Then, Reader antenna port 1 is connected to antenna and tag is ready to be scan.

Figure 4.1.2.1 RFID Reader Port 1 to Antenna

Figure 4.1.2.2 Battery

Figure 4.1.2.3 OUT port connect to reader

Figure 4.1.2.4 IN port connect to PC

Figure 4.1.2.5 RFID Tag ready to scan

After setting up all the hardware and ensure the RFID reader is working the first thing to on computer is to go to the impinj website with the host name which is impinj-14-2f-d9. Then, if this website is logged in I will do some setting to the interface which the available region I will change to Hong Kong. Below is the picture showing the website after logged in. After that tag is scanned, then I can start to do programming on the software side.

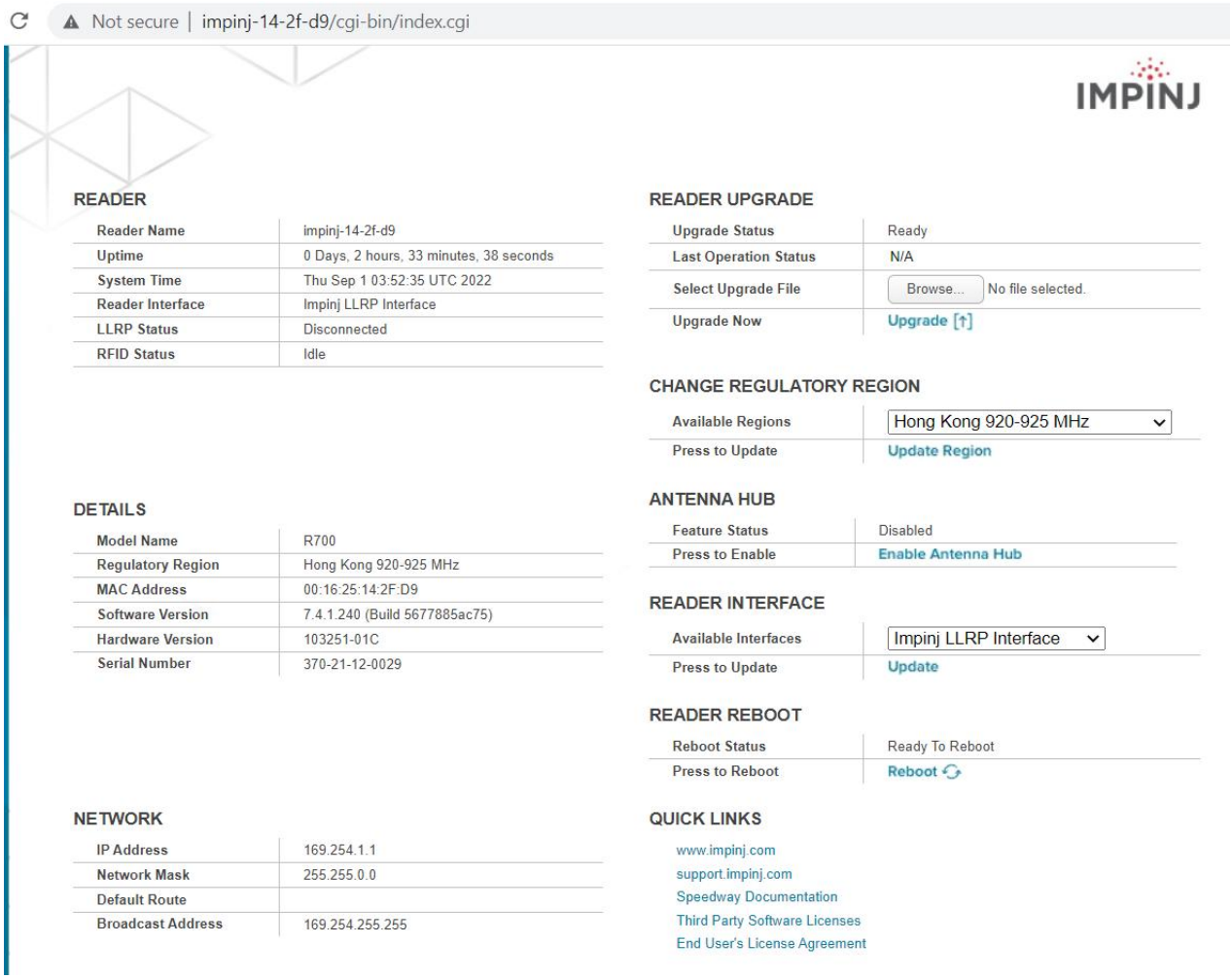

Figure 4.1.2.6 Impinj Website

4.2 Function Implementation

4.2.1 Getting original data

Firstly, this is the original scan result from the reader. As we can see the result scanned shown below, there are many duplication tag scanned. By default, there are only EPC information which is the tag ID. Then, I do some programming to add more data such as timestamp, number for count, and antenna port. The first method created is that during the scanning process, I will add all the tag into an array list included the information I mentioned above and this array list is named "DuptagID" which including original duplication tag. Below figure 4.3.1.2 shows the function that I implemented.

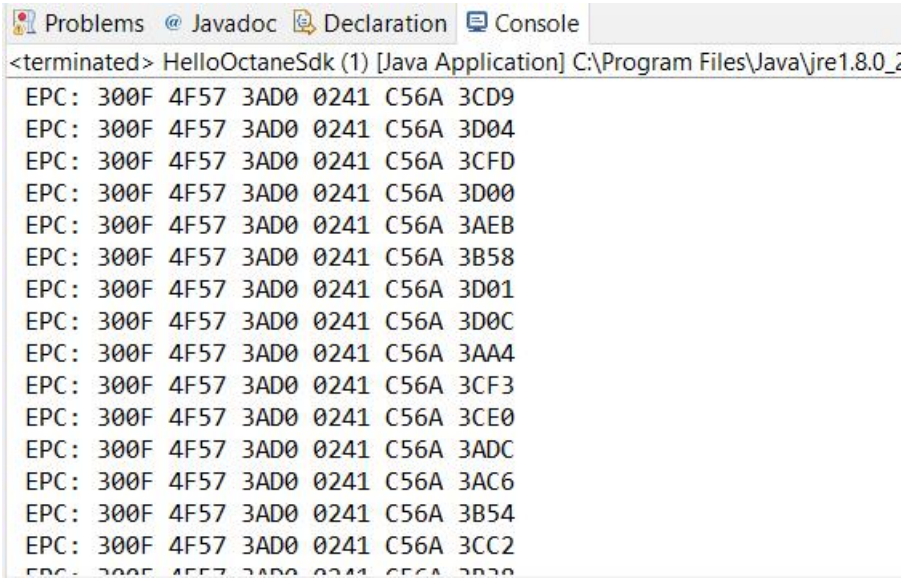

Figure 4.2.1.1 Original data

```
List<Tag> tags = report.getTags();

for (Tag t : tags) {
    System.out.print(" EPC: " + t.getEpc().toString());

    Timestamp timestamp = new Timestamp(System.currentTimeMillis());
    String epc = t.getEpc().toString();
    String dateTime = timestamp.toString();
    int antenna = t.getAntennaPortNumber();


    DuptagID.add(new DupRFIDTag(epc, dateTime, antenna));
```

Figure 4.2.1.2 duplication array list

4.2.2 Filter out duplication data to list

Second, after collecting all the scanned result of RFID tag and store it into an array list, then I will create another array list which will filter out all the duplication tag ID. First I will take the duplication array list and compare to the newly create array list named “aList”. If the “aList” contains the same tag ID in the duplication array list then will continue to compare the next, else will add the RFID tag into the newly created array list. In this case will make sure the newly created array list will only store each of the unique tag ID without any duplication. This function will loop the size of array list of duplication tag until finish.

```
//duplicate list
DrfidList = new TagReportListenerImplementation();
List<DupRFIDTag> dupli = DrfidList.getList1();
System.out.println(dupli.size());

//filter list
List aList = new ArrayList();


for(int j = 0; j < dupli.size(); j++) {
    if(aList.contains(dupli.get(j).getTagID())) {
        continue;
    }
    else {
        aList.add(dupli.get(j).getTagID());
    }
}
```

Figure 4.2.2.1 filter out duplication

4.2.3 Add information to RFID tag

After filtering out all the duplication, I get the clean list with only unique tag which is called “aList”, then I created another new one array list name “tagID”, in this array list I will add the tag from “aList” with some information included such as timestamp get from the time it scanned, antenna port, linen types and linens label which is making an assumption using ASCII alphabet and number for each tag. First, I will compare the duplication list with the “aList”, then after compared is the same tag ID it will assign the timestamp and antenna port with the latest information and add in to the “tagID” array list.

```
//filter list with information
  rfidList = new TagReportListenerImplementation();
  ArrayList<RFIDTag> tagID = rfidList.getList();

  String timestamp = "";
  int antenna = 0;
  for(int k = 0; k < aList.size(); k++) {
      for(int i = 0; i < dupli.size(); i++) {
          if(aList.get(k) == dupli.get(i).getTagID()) {
              timestamp = dupli.get(i).getDatetime();
              antenna = dupli.get(i).getAntenna();
          }
      }

      String label = "Linen ";
      int min2 = 65;
      int max2 = 90;
      int asciiAlpha = (int)Math.floor(Math.random()*(max2 - min2 + 1) + min2);

      label += (k + 1);
      label += (char)(asciiAlpha);

      String[] type = {"bed sheet", "towel", "blanket", "cloth", "pillow cases", "patient garments"};
      Random r = new Random();
      int linenType = r.nextInt(type.length);
      String linen = type[linenType];

      tagID.add(new RFIDTag((k + 1), aList.get(k).toString(), timestamp, label, linen, antenna));
  }
```

Figure 4.2.3.1 Added information

4.2.4 Push data to Database

Lastly, after removing all the duplication tag and get the clean data in an array list. Here, I will push the clean data to database which is using MongoDB, from MongoDB website I will choose connect to application and get the link and paste it into my Eclipse for database function. This will make my Eclipse connected to the MongoDB, then I start to do some coding. Firstly, I will need to get the database name and collection from my MongoDB. After that, I created a loop method for and take the size of the clean data which is "tagID" and find the No. If the No. is found means previously data already existed in the database and user want to update with new data or if the there is no No. found means this is new data that user want to upload to the database. This function will upload the information of tag number, tag ID, timestamp, linen label, linen types and antenna port.

```
MongoClient client = MongoClients.create("mongodb+srv://"
        + "foxiang:foxiang1127@cluster0.u3nkcth.mongodb.net/?retryWrites=true&w=majority");
MongoDatabase db = client.getDatabase("RFID");
MongoCollection col = db.getCollection("RFID Tag Record");

for(int k = 0; k < tagID.size(); k++){
    Document found = (Document) col.find(new Document("No", k + 1)).first();

    if(found != null){
        Bson updateValue = new Document();
        ((Document) updateValue).append("No", tagID.get(k).getTagNum());
        ((Document) updateValue).append("EPC", tagID.get(k).getTagID());
        ((Document) updateValue).append("Date & Time", tagID.get(k).getDatetime());
        ((Document) updateValue).append("Label", tagID.get(k).getLabel());
        ((Document) updateValue).append("Linen Type", tagID.get(k).getLinen());
        ((Document) updateValue).append("Antenna Port", tagID.get(k).getAntenna());

        Bson operate = new Document("$set", updateValue);
        col.updateOne(found, operate);
    }
    else{
        Document tagDoc = new Document();
        tagDoc.append("No", tagID.get(k).getTagNum()).append("EPC", tagID.get(k).getTagID())
        .append("Date & Time", tagID.get(k).getDatetime()).append("Label", tagID.get(k).getLabel())
        .append("Linen Type", tagID.get(k).getLinen()).append("Antenna Port", tagID.get(k).getAntenna());
        col.insertOne(tagDoc);
    }
}
System.out.println("Successfully Updated!");
```

Figure 4.2.4.1 push data to MongoDB

4.3 Preliminary Work Results

In this topic, after completing implementation of the function here I will show the work results of the function that I created and display how it works. Below is the picture showing the output after filtering the data compare to the original data. As the result we can see the output after filtered and added information, it contains information of the linens with unique tag, which antenna port scanned, timestamp, linen type and total count number. After successfully store inside, then it will upload these tag information to the database called RFID Tag Record in the MongoDB, all this information will store as a document as figure 4.3.2 shown below. As a result the dashboard will display all the information about each linen embedded with the tag. The dashboard was shown in figure 4.3.3.

```
1   300F 4F57 3AD0 0241 C56A 3CFD   2022-09-01 17:27:08.114   Linen 1H   cloth   1
2   300F 4F57 3AD0 0241 C56A 3AEB   2022-09-01 17:27:08.352   Linen 2L   blanket   1
3   300F 4F57 3AD0 0241 C56A 3B57   2022-09-01 17:27:08.354   Linen 3Z   cloth   1
4   300F 4F57 3AD0 0241 C56A 3B5E   2022-09-01 17:27:08.356   Linen 4J   towel   1
5   E280 1170 0000 0213 F680 E4C2   2022-09-01 17:27:08.603   Linen 5Z   pillow cases   1
6   300F 4F57 3AD0 0241 C56A 3D04   2022-09-01 17:27:08.603   Linen 6I   bed sheet   1
7   300F 4F57 3AD0 0241 C56A 3ACC   2022-09-01 17:27:08.604   Linen 7L   cloth   1
8   E280 1170 0000 0213 F680 EDC7   2022-09-01 17:27:08.605   Linen 8R   patient garments   1
9   300F 4F57 3AD0 0241 C56A 3B2B   2022-09-01 17:27:08.605   Linen 9G   patient garments   1
10   300F 4F57 3AD0 0241 C56A 3D03   2022-09-01 17:27:08.606   Linen 10G   blanket   1
11   300F 4F57 3AD0 0241 C56A 3B79   2022-09-01 17:27:08.607   Linen 11O   blanket   1
12   E280 1170 0000 0213 F680 E4C0   2022-09-01 17:27:08.608   Linen 12Q   patient garments   1
13   300F 4F57 3AD0 0241 C56A 3AC6   2022-09-01 17:27:08.608   Linen 13Y   cloth   1
14   300F 4F57 3AD0 0241 C56A 3CD9   2022-09-01 17:27:08.609   Linen 14G   cloth   1
15   300F 4F57 3AD0 0241 C56A 3DF7   2022-09-01 17:27:08.61   Linen 15Y   bed sheet   1
16   300F 4F57 3AD0 0241 C56A 3AAC   2022-09-01 17:27:08.61   Linen 16J   pillow cases   1
17   300F 4F57 3AD0 0241 C56A 3A9F   2022-09-01 17:27:08.611   Linen 17F   patient garments   1
18   300F 4F57 3AD0 0241 C520 4DC1   2022-09-01 17:27:08.611   Linen 18F   blanket   1
19   300F 4F57 3AD0 0241 C520 4B57   2022-09-01 17:27:08.612   Linen 19F   blanket   1
```

Figure 4.3.1 Information data

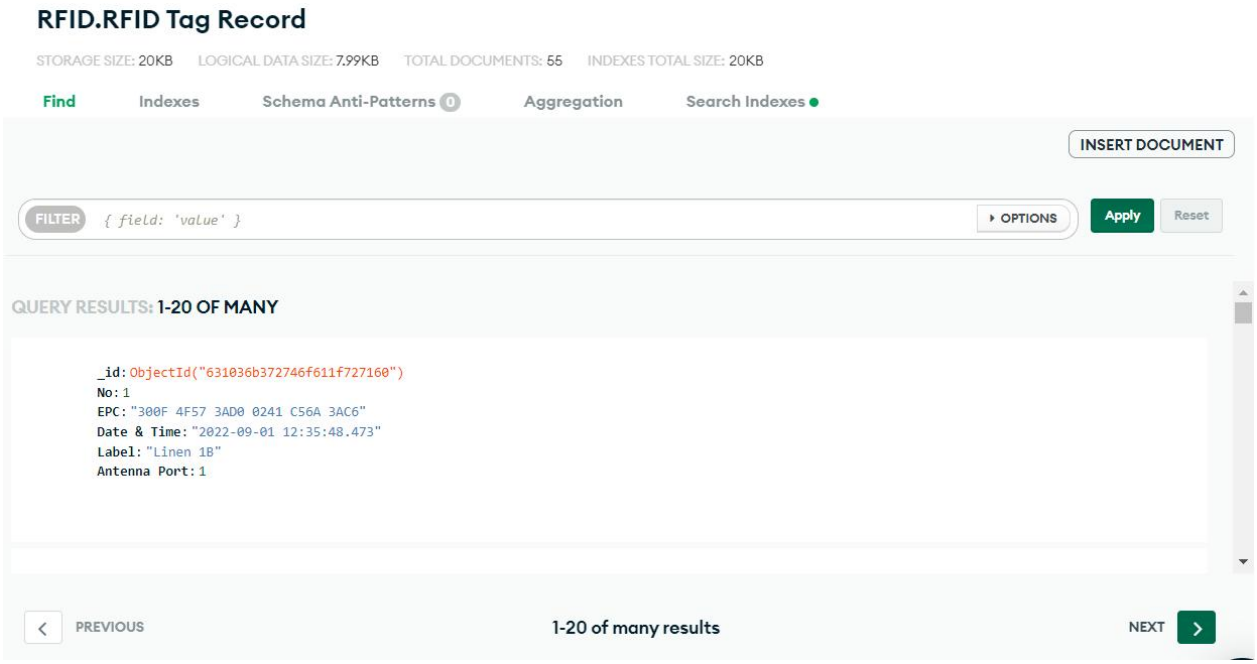

Figure 4.3.2 Data inserted

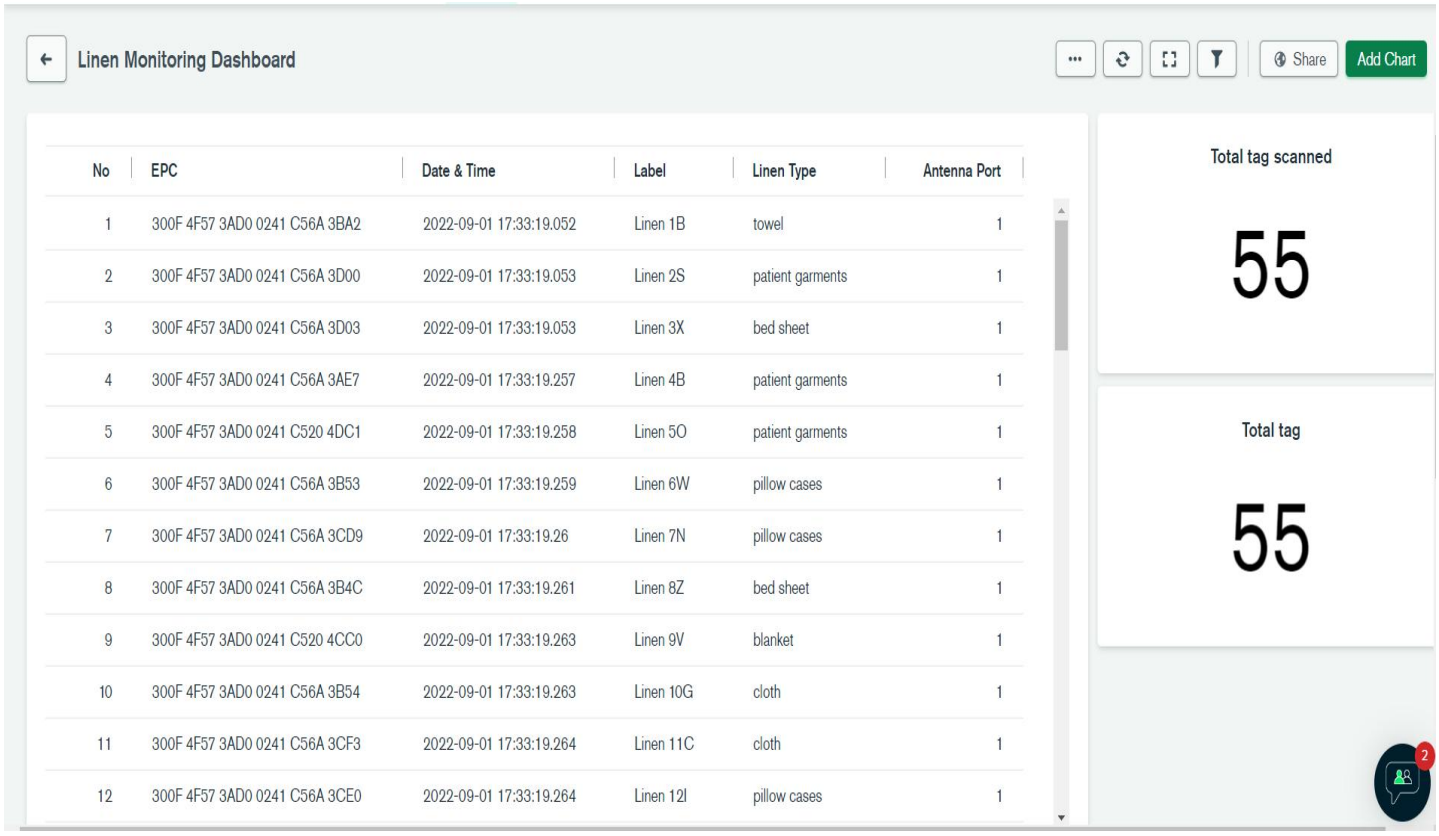

Figure 4.3.3 Chart 1

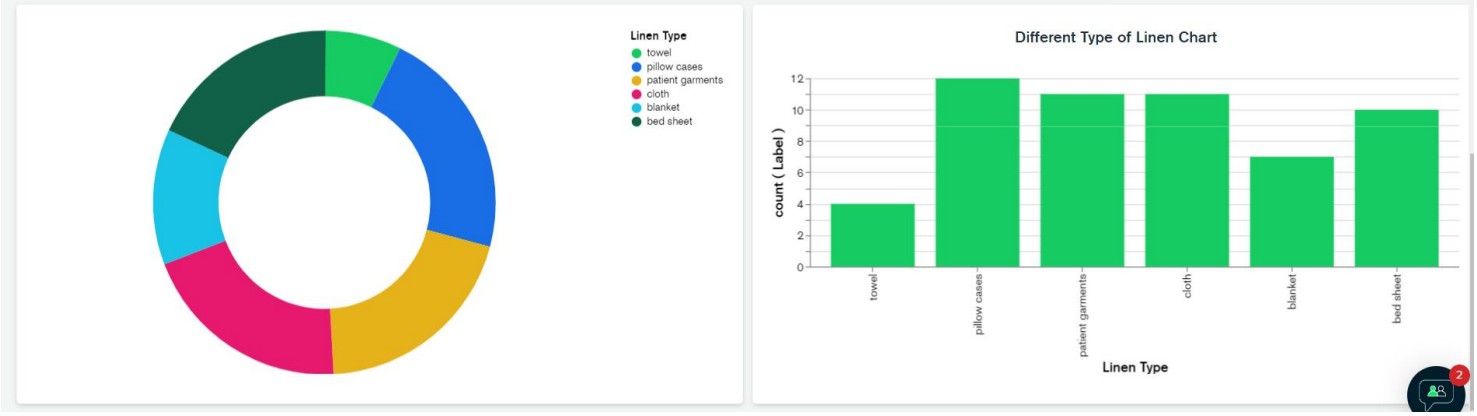

Figure 4.3.4 Chart 2

Chapter 5: System Implementation

In this chapter, I will explain about how where the proposed system or solution is put into action or performed. This section will also explain how the deployment work, installation of the system based on the design and the actual development. The issue that faced during the implementation will also be clearly explain.

5.1 Setting and Configuration

Below is an overview of the hardware which is RFID setup and configuration with wiring. The RFID tag will embed into the linen such as sheet, towel, pillow and others. After all setup is ready, the antenna place will get ready to scan for the coming linen then transfer the data to RFID reader, reader will read the scanned tag ID and show up on the laptop or PC for the tag information. The IN port is connected to the laptop Ethernet port, to make sure the connection is successfully on the laptop it will show the Ethernet has been connected and can try to launch the impinj website to login, from the reader and battery IN port it will show yellow light. For my scenario, I had only tested to connect with the Antenna Port 1 for the whole operation.

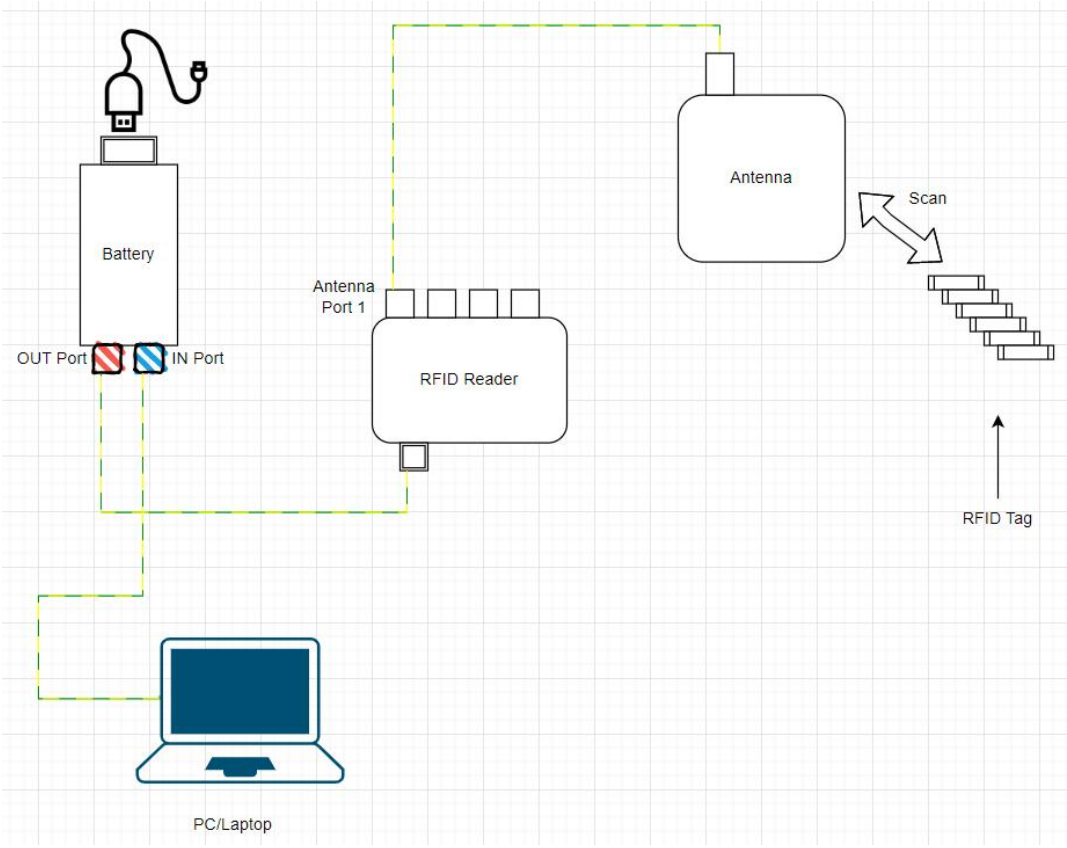

Figure 5.1.1 RFID Configuration

5.2 System Operation

This system operation chapter I will be giving an brief explain about how the context of RFID linen monitoring for hospital activities that will be involved such as using RFID technology to manage and monitoring linens. This might involve operations like linen check-in and check-out, linen monitoring, managing the inventory, and data analysis. The fundamental system activities may include scanning RFID tags on linens using RFID readers, gathering data such as linen type, location, and status, updating the system database with real-time information, and creating reports or alerts depending on specified rules or parameters.

After setting up the hardware side as shown in the figure 5.1.1 and also the software side has been developed it can be operate in a real-time to track and manage the linens. In the hospital environment, the antenna will be placing at the door in which the linen going out and in. In the software side after scanned the tag it will start to process the data as the tag belongs to which linen and timestamp that being scanned. All of the data will then store in the database. The database will be access by the hospital staff which is from the PC or laptop to check the dashboard and record the linen going. To scan the linen, hospital staff will need to press the button on Eclipse of the program. The scanning time is set to 5 second, after 5 second of scanning it will stop and start data processing from the software side and update the real-time data on dashboard. There are two dashboard, one is for scanning the outgoing linen and another is for the incoming linen.

5.2.1 Monitoring outgoing linen dashboard

Below is the figure for the outgoing dashboard which the table will shows overall scanned linen and display it is information, the information contains number of tag being scanned, tag ID, timestamp, label, linen type, scanned from which antenna port, hospital and floor. It will also showed the total tag that being scanned and available tag.

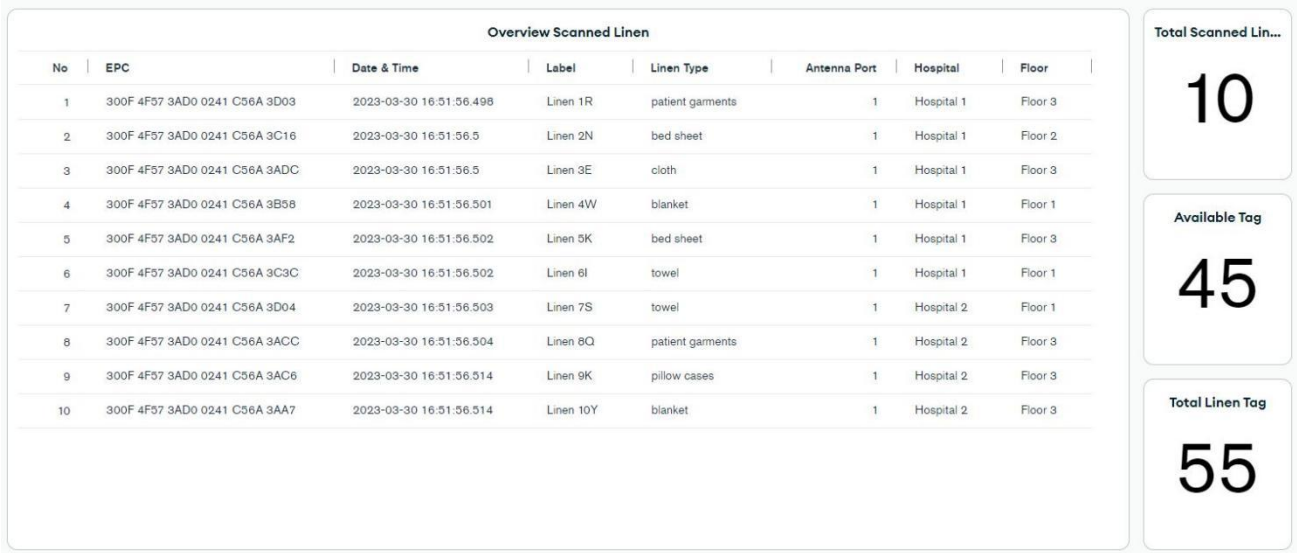

Figure 5.2.1.1 Dashboard Outgoing Linen Overview

This figure below is show about the chart for the linen type information, it show the overall linen type that is scanned for outgoing and a histogram to show the type, this dashboard is designed for a better view for hospital staff, if they want to record for the amount of linen.

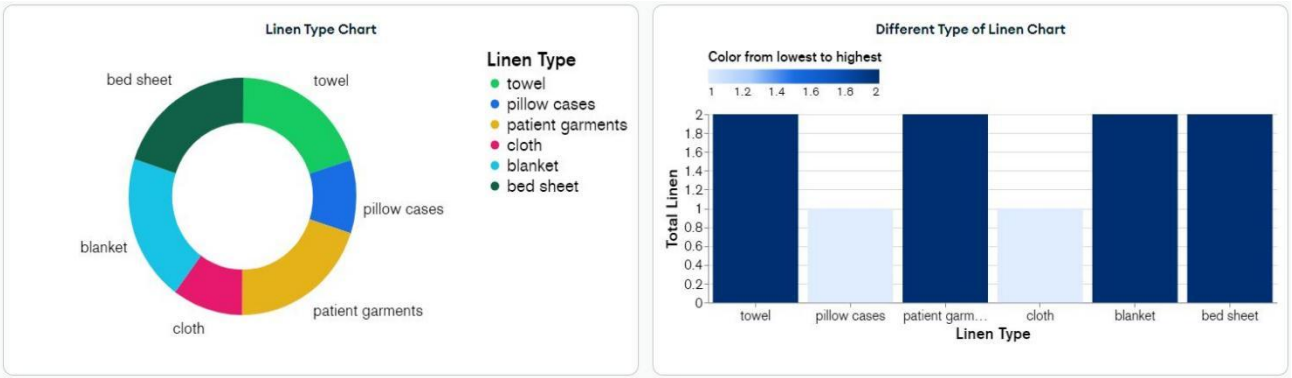

Figure 5.2.1.2 Linen Type Chart

In the dashboard this is the part for overall hospital view for the linen that is going out and in. In UTAR we had two hospital which is Traditional Chinese Medicine and Western Medicine. In developing the dashboard I also include two hospital that had scanned the tag and separate it into two details.

Figure 5.2.1.3 Hospital Overview Table

Below is the figure that show two different hospital with the tag information. In each hospital we had different floor, this assumption I also included in developing the dashboard which the staff can record and check from which floor and how many linen is going out. Here, I made 3 floor for each hospital and show the important tag information included from which hospital, floor, tag ID, timestamp and linen type

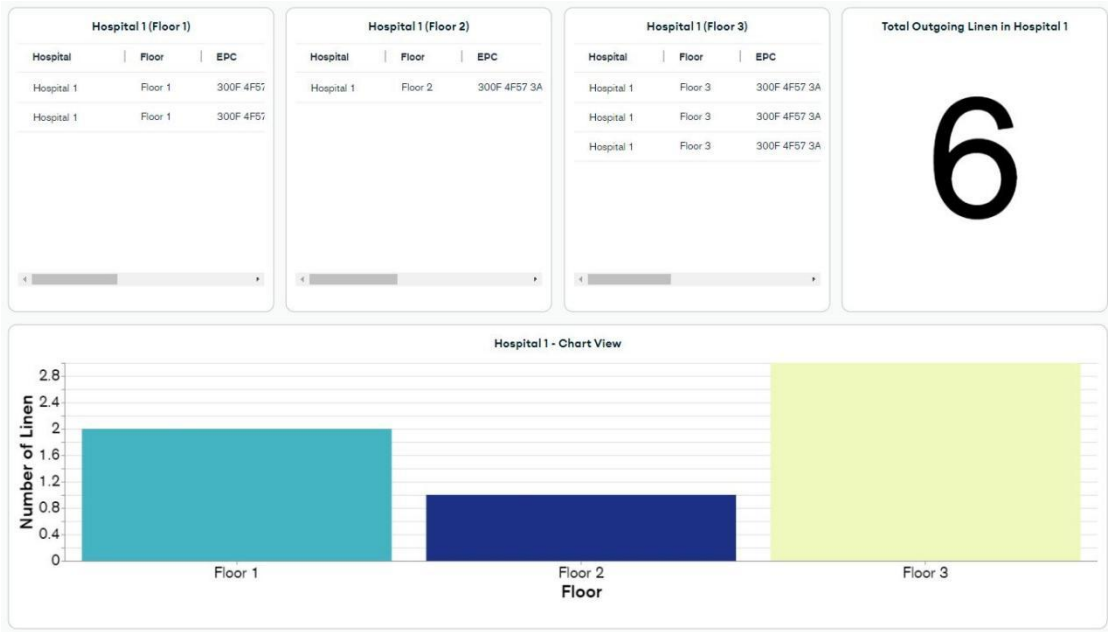

Figure 5.2.1.4 Hospital 1

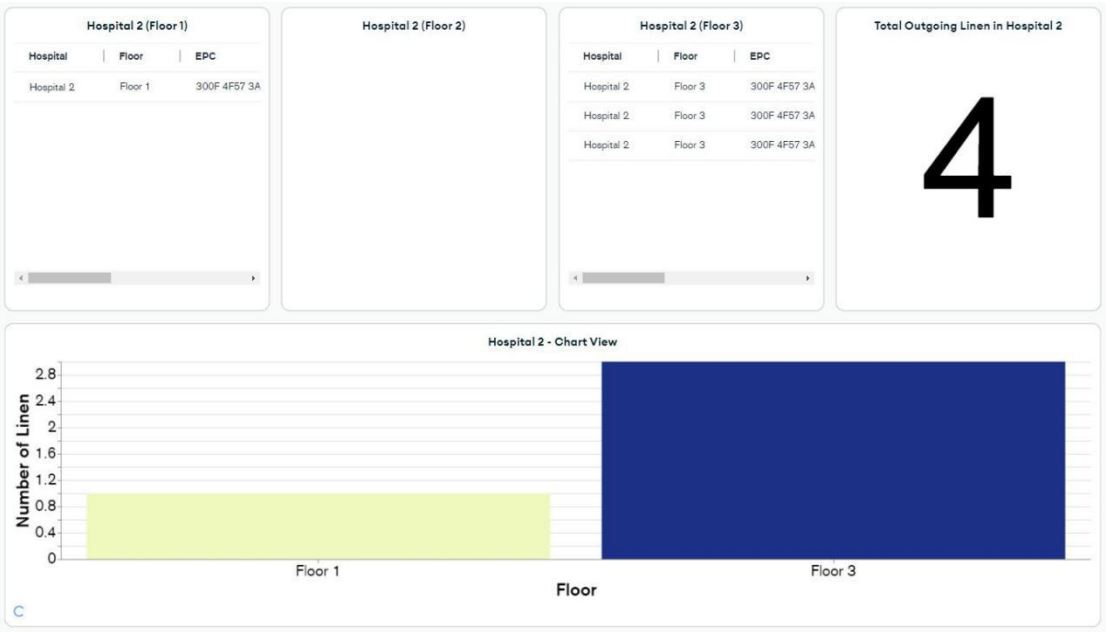

Figure 5.2.1.5 Hospital 2

5.2.2 Monitoring incoming linen dashboard

This part will showing the developed incoming dashboard and what has included in the incoming linen dashboard. For the dashboard, if the hospital staff want to scan for incoming or outgoing it need to switch the dashboard in order to receive the information. First, below is the figure showing that the overview of the linen scanned, and displayed the incoming linen that has scanned for outgoing previously. It included all the information as mentioned in the part of outgoing dashboard. The incoming dashboard has also included the separate of each hospital and floor linen information for better data record.

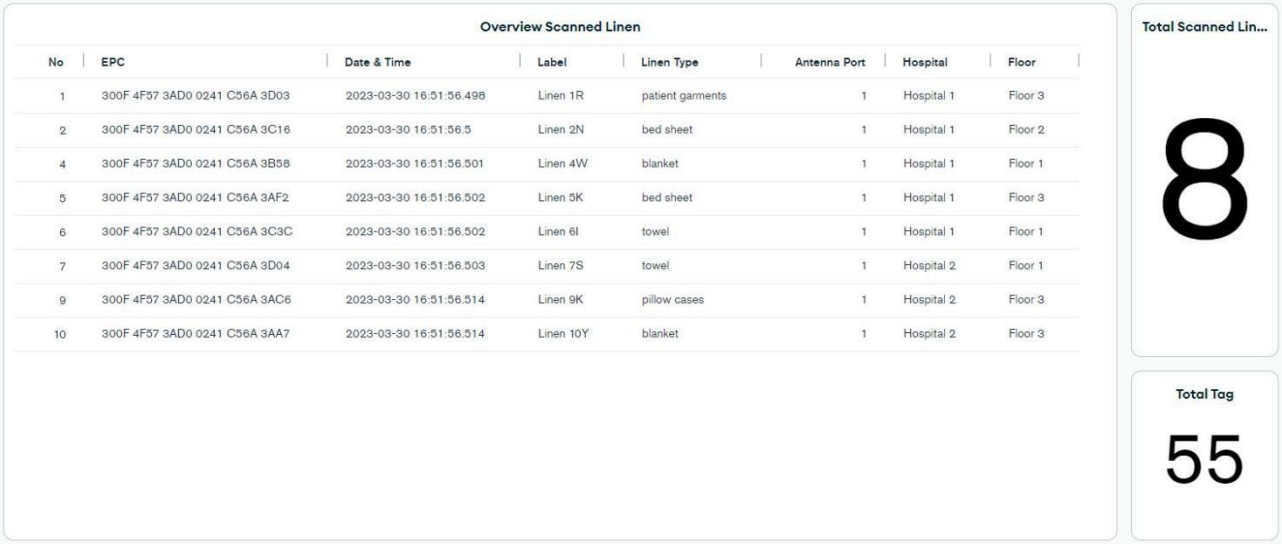

Figure 5.2.2.1 Dashboard Incoming Linen Overview

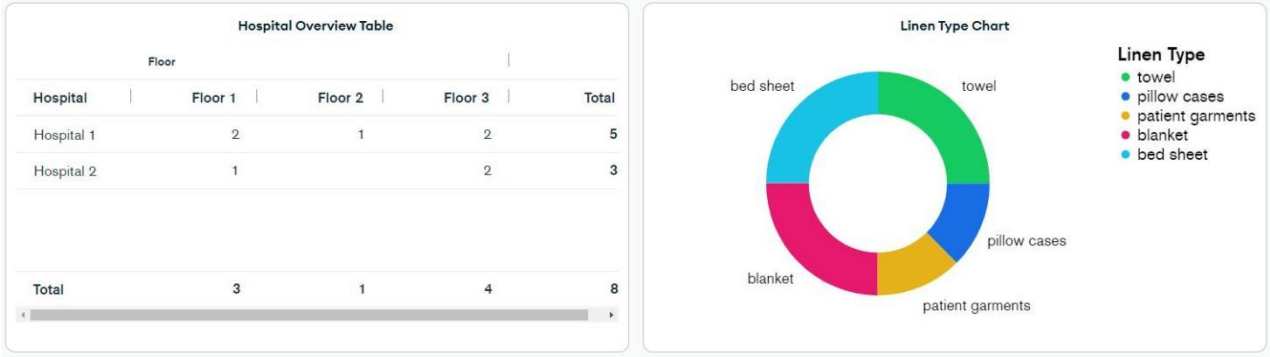

Figure 5.2.2.2 Incoming Linen Overview Table

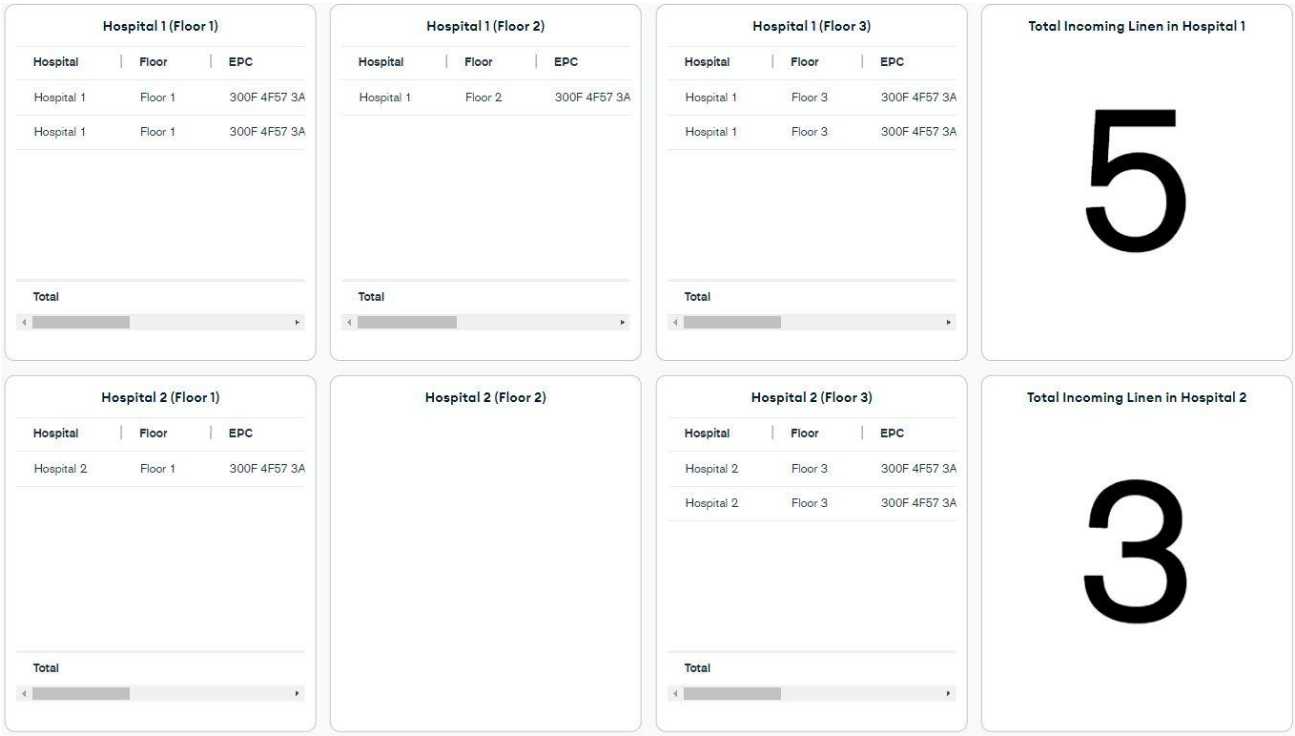

Figure 5.2.2.3 Hospital 1 and 2 Information

5.3 Expanding System Functionality

This sub-chapter I will explain about the new function that I had implemented in this project. The intention was to add more assumption for the hospital use case and make the system has more features and functionality in order to fulfill the hospital requirement. There are several function added to this system including scanning time, separation information for two hospital and each floor, collect incoming linen information and newly added collection of database.

5.3.1 Scanning time function

This scanning time function has been added into the system, when hospital staff started to scan the linen they just need to click on the run button to run program after process all the information it will automatically stopped which reduce hospital manually click. This scanning function was added in front of the program and it is set to 5 second. After scanning for 5 second and collected all the linen tag information it automatically proceed with next function.

```
// connect a listener
reader.setTagReportListener(new TagReportListenerImplementation());

// Start the reader
reader.start();

//scan for 5 second
TimeUnit.SECONDS.sleep(5);

System.out.println("Stopping  " + hostname);
reader.stop();

System.out.println("Disconnecting from " + hostname);
reader.disconnect();

System.out.println("Done");
```

Figure 5.3.1.1 Scanning Function

5.3.2 Added hospital and floor information

From the previous programmed function in chapter 4 function implementation, that linen information contains tag ID, tag number, timestamp, linen label, antenna port, and linen type. Here is the improved version of the previous which I had added two information and it is hospital and floor. For the hospital, expected that UTAR has two hospital which is tradition chinese medicine and western medicine, then I created for the linen after scanned it will separate half for each hospital. For the floor information, I assuming that each hospital has 3 floor, the linen will be randomly assign to the floor. This is the preset considering for hospital use case.

```
half = tagID.size()/2;

for(int i = 0; i < tagID.size(); i++) {
    NtagNum = tagID.get(i).getTagNum();
    NtagID = tagID.get(i).getTagID();
    Ndatetime = tagID.get(i).getDatetime();
    Nlabel = tagID.get(i).getLabel();
    Nlinen = tagID.get(i).getLinen();
    Nantenna = tagID.get(i).getAntenna();

    String hospital1 = "Hospital 1";
    String hospital2 = "Hospital 2";

    String[] floorNum = {"Floor 1", "Floor 2", "Floor 3"};
    Random r = new Random();
    int randFloor = r.nextInt(floorNum.length);
    String floor = floorNum[randFloor];

    if(i <= half) {
        newTag.add(new PresetCleanTag(NtagNum, NtagID, Ndatetime, Nlabel, Nlinen, Nantenna, hospital1, floor));
    }
    else {
        newTag.add(new PresetCleanTag(NtagNum, NtagID, Ndatetime, Nlabel, Nlinen, Nantenna, hospital2, floor));
    }

}

//show tag info
for(int i = 0; i < newTag.size(); i++) {
    System.out.println(newTag.get(i).getTagNum() + "  " + newTag.get(i).getTagID() + "  "
+ newTag.get(i).getDatetime() + "  " + newTag.get(i).getLabel() + "  " + newTag.get(i).getLinen() + "  " + newTag.get(i).getAntenna()
+ "  " + newTag.get(i).getHospital() + "  " + newTag.get(i).getFloor());
}
```

Figure 5.3.2.1 Hospital and Floor Information

5.3.3 Incoming linen database

This is the newly created function for collection database. This function will mainly store the incoming linen information. This function will perform checking for the incoming linen ID and compare the outgoing data, after found the same linen it store the information into the database, to compare the data from outgoing it loop through all the information in outgoing database and compare with the array, if items found same with the array then store it as for linen incoming information. Firstly, the scenario assuming that the first scan is for outgoing, then the record will store into the RFID Record database, and there is nothing to compare because the RFID Record database is empty. The second scan is assuming to be incoming linen, since the database RFID Record had the data that scanned before then it will find iterate and compare with the array list, and finally found the same linen ID and store it into the incoming linen database.

```
MongoClient client = MongoClients.create("mongodb+srv://foxiang:foxiang1127@cluster0.u3nkcth.mongodb.net/?retryWrites=true&w=majority");
MongoDatabase db = client.getDatabase("RFID");
MongoCollection col1 = db.getCollection("RFID Tag Record");
MongoCollection col2 = db.getCollection("IncomingTag");

col2.drop();
MongoCollection colComp = db.getCollection("RFID Tag Record");
//Incoming
MongoCollection incoming = db.getCollection("IncomingTag");


Document found0 = (Document) colComp.find(new Document("No", 1)).first();
long countDoc;
```

Figure 5.3.3.1 Collection For Incoming Database

```
Document found0 = (Document) colComp.find(new Document("No", 1)).first();
long countDoc;

if(found0 != null) {
    countDoc = colComp.countDocuments();
    int numCountDoc = (int)countDoc;
    FindIterable iterDoc = colComp.find();
    Iterator it = iterDoc.iterator();
    ArrayList<String> checklist = new ArrayList<String>(); //rfid list

    while (it.hasNext()) {
         Document docEPC = (Document) it.next();
         String EPC = docEPC.get("EPC").toString();
         checklist.add(EPC);
    }

    for(int g = 0; g < newTag.size(); g++) {
        if(checklist.contains(newTag.get(g).getTagID())) {
            Document foundInsert = (Document) incoming.find(new Document("No", g + 1)).first();

            if(foundInsert != null){
                Bson updateValue = new Document();
                ((Document) updateValue).append("No", newTag.get(g).getTagNum());
                ((Document) updateValue).append("EPC", newTag.get(g).getTagID());
                ((Document) updateValue).append("Date & Time", newTag.get(g).getDatetime());
                ((Document) updateValue).append("Label", newTag.get(g).getLabel());
                ((Document) updateValue).append("Linen Type", newTag.get(g).getLinen());
                ((Document) updateValue).append("Antenna Port", newTag.get(g).getAntenna());
                ((Document) updateValue).append("Hospital", newTag.get(g).getHospital());
                ((Document) updateValue).append("Floor", newTag.get(g).getFloor());

                Bson operate = new Document("$set", updateValue);
                incoming.updateOne(foundInsert, operate);
            }
            else{
                Document tagDoc = new Document();
                tagDoc.append("No", newTag.get(g).getTagNum()).append("EPC", newTag.get(g).getTagID()).append("Date & Time",
                        newTag.get(g).getDatetime()).append("Label", newTag.get(g).getLabel()).append("Linen Type", newTag.get(g).getLinen()).append("Antenna Port", newTag.get(g).getAntenna())
                .append("Hospital", newTag.get(g).getHospital()).append("Floor", newTag.get(g).getFloor());
                incoming.insertOne(tagDoc);
            }
        }
    }
```

Figure 5.3.3.2 Compare and Add Function

5.3.4 Show available linen

This is the function that created to store the available linen inside the database and display on monitoring dashboard. The calculated method shown as figure below is taken out the total tag in another database and minus the number of linen that has been scanned which is from the RFID Record database and show the available tag on dashboard. This function is just showing the number of linen that left inside the hospital, but not contains all the linen information. The number of available linen is display on the outgoing monitoring dashboard.

```
long countTotal1, countTotal2;
MongoCollection total = db.getCollection("RFID Total Tag Collection");
MongoCollection record = db.getCollection("RFID Tag Record");
MongoCollection ava1 = db.getCollection("Available Tag");
ava1.drop();
MongoCollection ava = db.getCollection("Available Tag");

countTotal1 = total.countDocuments();
int num1 = (int)countTotal1;
countTotal2 = record.countDocuments();
int num2 = (int)countTotal2;

int available = num1 - num2;
Document avaTag = new Document();
avaTag.append("Total", available);
ava.insertOne(avaTag);
System.out.println("Successfully Updated!"); //first database store assume scan for outgoing..
```

Figure 5.3.4.1 Show Available Tag

5.4 Implementation Issues and Challenges

This sub-chapter I will be listing out the implementation issue and challenges that I faced during this period of developing the system. First from the project 1, I had faced the implementation issue with RFID Reader that is not working or stable. The problem is that when I plugged the Ethernet port to my laptop I saw that the light from RFID Reader was not stable and I cannot login to the impinj website for further work and development. This cause the antenna after scanned the tag it was not read by the reader as the signal was not stable and keep connect and disconnect. After I had consulted to my supervisor, he has to send the reader back to the company for maintenance and due to this issue, during this period I have to continue with the software side development with creating an assumption for the tag scanned scenario and also further work with implement the function. This issue happened around week 10 during my project 1.

Besides, the second issue that I faced is on my own laptop problem with the Ethernet port that is not functioning when I plugged. After the RFID Reader has been repaired and return back with good condition, I started to test out scanning the tag and try to observe the information, during the configuration I realize that my Ethernet port was not working the possible reason was since it was not using for a long time. Then, to continue with the progress I have decided to buy a USB-Ethernet Converter to replace the Ethernet port issue.

In my project 2, I do not faced any issue on the hardware technical side, but from the software side I face some challenges during implementing the code or program. As mentioned the RFID Reader was not working in previously I was continue my progress with making assumption, after the hardware is returned I had to understand all the documentation provided by the impinj into the Java code and then from there to modified my code to make all the function connected and worked. I take quite some time to understand some of the important program and then connect it with my own coding.

Moreover, another part of the challenges is coding the program that tracking record with the incoming and outgoing linen. For example, I had to record of the outgoing linen and when scanning the incoming linen I had to compare with the previous data, which I had acquired some time of thinking the solution and make this work. Because of using the free version of database which is called MongoDB, all the data that has been uploaded will be refresh with the new data. After thinking the solution for some day I found the solution and that is finally working fine. At the end I managed to create those function that fulfilled my objective and the basic requirement.

Chapter 6: System Evaluation And Discussion

This Chapter will present about the system evaluation and discussion of this project. This chapter discusses system performance evaluation, testing findings, project barriers, and objective evaluation. The performance of the system is evaluated by examining its efficiency, accuracy, and reliability. System testing was performed in order to verify the overall functionality and guarantee that it fits the criteria. The system testing findings are provided together with any difficulties identified throughout the testing procedure and their resolution. With also dicuss about the project challenge including privacy and security challenges, cost and resource constraints.

6.1 System Testing and Performance Metrics

This section I will measure the used of system performance and evaluate the performance in terms of accuracy, efficiency and reliability. These metrics give information about the system's performance and assist in identifying areas for improvement. Among the most frequent performance measures used in system testing including the program response time, time taken for linen data to store in the database, resource utilization, the throughput of the linen data accuracy.

System response time:

This measure is about the response time for the program in Eclipse after scanned all the linen and gathered information and performed all the function then stop running to conclude the overall of time taken. I had tested for 20 time of scanning and record the time.

Table 6.1.1 System Response Time Record

No.	Scanning Time (in second)	Number of tag	System response time (in second)
1	5	23	6
2	5	42	7
3	5	12	6
4	5	34	6
5	5	2	6

6	5	12	7
7	5	4	6
8	5	10	7
9	5	28	6
10	5	37	6
11	5	38	7
12	5	12	7
13	5	23	7
14	5	45	7
15	5	50	7
16	5	38	6
17	5	24	7
18	5	48	6
19	5	38	7
20	5	30	6

Time taken for storing database:

This measure is about the data after program has ran and scanned through all the data with assigned it is line information and store it to the database. Measure about the latency on the MongoDB that the time taken to update the new data. The measurement will be how many time forcing refresh on the MongoDB database dashboard to update the new data. I had tested for 20 time with different data to observed and record the outcome.

Table 6.1.2 Database Refresh Time

No.	Number of tag	Force refresh	Dashboard data
1	25	1	Data Updated
2	28	1	Data Updated
3	48	2	Data Updated
4	23	1	Data Updated
5	47	1	Data Updated
6	38	1	Data Updated

7	34	1	Data Updated
8	43	1	Data Updated
9	48	2	Data Updated
10	29	2	Data Updated
11	39	1	Data Updated
12	50	1	Data Updated
13	34	1	Data Updated
14	23	1	Data Updated
15	39	2	Data Updated
16	49	1	Data Updated
17	28	1	Data Updated
18	23	1	Data Updated
19	10	1	Data Updated
20	2	1	Data Updated

Resource utilization on MongoDB database:

The resource utilization is about the overall data usage from the MongoDB database. This resources include utilizing by the dashboard and the collection of database. There is two dashboard created which is for outgoing and incoming. The usage for creating the two dashboard consume 260MB. For the collection of database which I had created 4 collection such as storing the outgoing data, available tag, total of tag data and the incoming tag data. The figure below show the total usage of 94KB for these collection.

Figure 6.1.1 Dashboard Usage

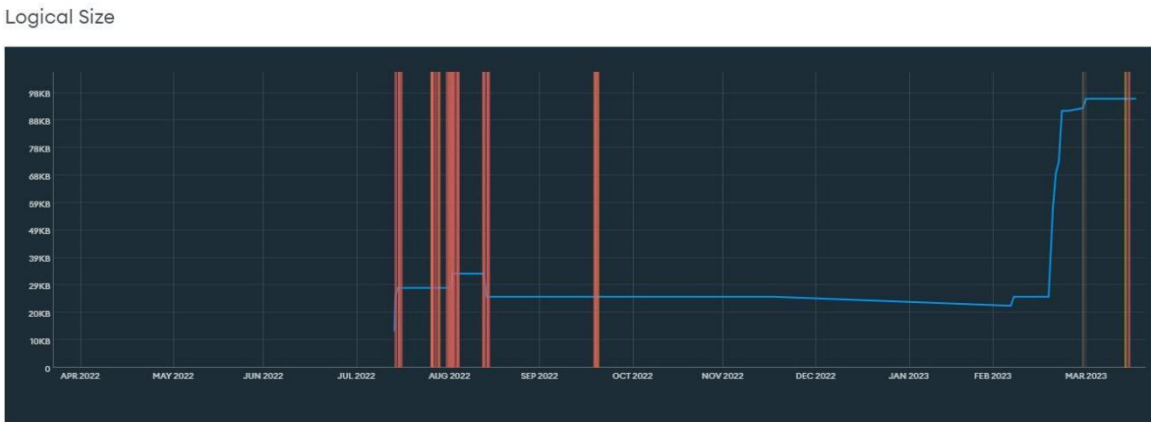

Figure 6.1.2 Total Database Collection Usage

Compare linen data accuracy:

To evaluate the system I had to ensure that the outcome has higher accuracy. I compare the linen data accuracy that display on the dashboard which will comparing the data for outgoing and incoming data and also the available tag display accuracy. To ensure the system function well I had tested 20 times for different data and record the outcome of this system performance.

Table 6.1.3 Compare Incoming and Outgoing Data

No.	Number of tag	Outgoing	Incoming	Available tag
1	28	28	28	27
2	12	11	11	44
3	23	23	23	32
4	43	43	43	12
5	21	20	20	35
6	37	37	33	22
7	24	22	22	33
8	50	50	50	5
9	24	24	24	31
10	19	19	19	36
11	53	53	53	2
12	16	16	16	39
13	18	18	18	37
14	3	3	3	52
15	48	48	48	7

16	37	37	37	18
17	26	26	23	32
18	22	22	22	33
19	40	40	40	15
20	37	35	35	20

6.2 Performance Testing Result

The performance testing was carried out to assess the system capacity to manage heavy user loads and to discover any performance issues that needed to be rectified. The testing environment consist of my own laptop with an Intel Core i5, 8GB of RAM, and a MongoDB database. The hardware setup which include the antenna, RFID Reader, RFID Tag and battery are testing in the environment of FYP Lab. The testing objective was to assess the system's performance under different load circumstances and to establish the maximum load that it could tolerate. Besides, the test scenario was included simulating the user activity such as logging in to the Impinj browser confirm the region setting, open Eclipse as for the program that run the function and tested out with different number of tag, with a maximum of 55 RFID tag. This performance testing was to measured the system response time, throughput of the linen data and latency of the data store on database.

I had tested for several condition including the response time, time taken for storing database, resource utilization on MongoDB database and compare linen data accuracy. Each of the testing will be tested for 20 times and the performance testing results showed that the system response took overall 6 to 7 second then minus out for the 5 second scanning it averagely took 1 to 2 second to run through all the function and update the linen data. After that, I also tested for the latency of the data to update in the database, this will be measured by how many times forcing the refresh on the dashboard to look for data update. With different number of tag being scanned, I refresh the dashboard to observed the data and it took averagely 1 to 2 times to refresh and data was successfully updated on dashboard.

Furthermore, the last testing which is important in overall system is to compare the linen data for outgoing and incoming whether the data is accuracy and reliable. For scanning the RFID tag on the RFID Reader, I tested with different number of tag but I observed that not all the tag are being scanned, from the result showed that in 20 times of testing there was an 4 times missed scanned which had error rate ins canning between the hardware Reader and tag, on the software side comparing with outgoing data and incoming data on the dashboard the result was shown are all correct and accurate data.

In conclusion, the overall system performance was at a good rate, as from the system response time to conclude that it will take 1-2 second to run all the function and update data to the database. For the data on the dashboard to be update I took mostly 1 times force refresh then all the data was being updated and it was not a big concern, because the timer refresh setting was set to 1 minute routinely refresh each time so the data will usually be updated. For the resource utilization on the data was small, which consume of only 94KB so all the data being updated on the database is expected to be fastest. The accuracy and reliability linen data tested for outgoing and incoming data on the software side the accuracy is 100%, however on the hardware side scanning tag data was not accurate as it sometime will have some error rate, an suggestion can made is to scan 2 times to ensure all the linen data being scanned or the scanning time can be improve longer. Overall the performance testing results demonstrated that the system was capable of achieving the performance criteria and providing hospital staff with a satisfactory user experience.

6.3 Project Challenges

The creation and deployment of the RFID Linen Monitoring System for hospitals involves a number of challenges and barriers that must be overcome in order for the system to be effective. These difficulties originate from technical concerns like hardware and software integration to operational ones like employee training and operational integration. It is essential to recognize as well as understand these problems in order to design effective solutions and assure that the system has successful adopted and deployment. I will describe the project obstacles that were encountered throughout the development and implementation of the RFID Linen Monitoring System for hospitals, as well as how these challenges were solved, in this chapter.

The main challenge in developing the RFID Linen Monitoring System for hospitals is the privacy and security challenges. For these project the dashboard was created for user admin to view the data, but it does not have any security on it means that the hospital staff can view data via network to login the MongoDB and all of the data can be downloaded in excel file. The linen information that being is still considered as potential privacy issue it could be considered sensitive data that need to be protected. For example, the system may indicate the amount and frequency of linen consumption in various regions of the hospital, providing information about hospital operations that should not be shared to the public or rivals. Furthermore, the system may contain private data about the individual, such as the owner or user that might be used for illegal reasons or exposed to identity theft.

Besides, another challenge in this project is the cost and resource constraints. There are several consideration of this challenge which include the hardware cost, installation and integration cost and maintenance cost. The cost to purchase the hardware such as reader, tag and antenna are especially expensive if the system need to cover a large hospital, in this project there are two UTAR hospital. In addition, the deployment and integration of the RFID system with existing hospital facilities might potentially be expensive, especially if there are technical difficulties or system compatibility concerns. RFID reader and antenna installation at several places across the hospital can be heavy on resources and time-consuming.

Chapter 7: Conclusion and Recommendation

7.1 Conclusion

In conclusion, this was a report about Final Year Project 1 that developed an RFID linen monitoring through Gantry using JAVA programming language. The problem highlighted in previous chapter state that in the hospital industry the current issue faced by the hospital is that the linen management, people rely significantly on physical counting, either for verification of clean linens obtained or filthy linens which will pose hygiene risks to humans and not working efficiently as by counting one by one. Hence this project was to proposed a solution by developed an RAID-based monitoring and tracking system for UTAR hospital. The motivation of developed this project mentioned before was that there are several advantage of using RFID technology such as track data more quickly, efficiently, and precisely, resulting in enhanced data accuracy, less time spent on administrative tasks. The Covid-19 case which many people were infected by the virus and number of people were sent to hospital linen, this will significantly increase the workload for staff in the hospital that hospital staff need to do linen counting manually in order to immediately and effectively isolate soil linen. Lastly, it was related to my personal education, throughout the project I learn more about RFID and have a deep knowledge of knowing how the entire process work and the procedure. It was a good experience in developing the system and for passionate about building the things related to the Internet of Things and also to improve knowledge in the RFID field. This project also aim to provide linens visibility easy and quickly by developing an dashboard for hospital management team easy to visualize and quickly received data, to improve data accuracy and availability by providing the tag information with specific linen, timestamp, linens count, linen types and antenna used port. Last is to provide tracking accuracy for check-in and check-out for hospital staff to perform linen distribution to other department. In order to achieve the objective, I will check my work progress every week to make sure I met the milestone and the goals of my project. In week 12, I can conclude that I met all the objective and this developed system will be support in UTAR hospital for real-time linen monitoring.

7.2 Recommendation

Based on the findings in this whole project, there are several recommendations for future work to improve the system's efficiency and effectiveness. Firstly, this RFID gantry based can be further improve in future to integrate with existing hospital system, such as inventory management and patient tracking. This would give a more complete picture of hospital operations and perhaps enhance efficiency. Secondly, an prospective future effort that may be explored is expanding the created RFID-based monitoring and tracking system for UTAR hospital to other hospitals or healthcare institutions. The system might be used to manage linen inventory in other hospitals or healthcare institutions with some tweaks and adjustments. The system might be tailored to the individual needs of any hospital or healthcare facility. This would necessitate an in-depth knowledge of the linen management process as well as the unique requirements of each healthcare facility. Furthermore, coordination with hospital personnel, linen suppliers, and RFID technology specialists is critical to the success of this growth.

Besides, in the future as the system is being used and more data will be collected, it may have some opportunities to optimize the performance,. There are several actions can be performed in the future to improve system performance. The RFID gantry's hardware configuration, which might be adjusted or enhanced to increase read accuracy and speed, could be one of the primary areas for development. Furthermore, the system might be further refined by exploring new data processing methods and techniques, which could assist to minimize processing time and increase overall system efficiency. As a whole, system performance optimization is a continual process that necessitates continuing examination and improvement. The system may be modified and improved with the right approach to deliver even more value to hospitals management.

Lastly, the ongoing maintenance process and support. The RFID linen monitoring system comprised of any other technical system, will require regular maintenance and assistance to guarantee that it continues to perform efficiently. It is recommended that a plan for continuing support and maintenance, including frequent updates and bug patches, be implemented. To provide successful maintenance and support, a dedicated team of skilled technicians and IT experts familiar with the system's hardware and software components should be established. Regular system inspections and maintenance tasks, such as cleaning the RFID readers and antennae, repairing problematic hardware components, and upgrading the software system, should be performed by the team. This will guarantee that the system continues to function properly and effectively in controlling the hospital's linen inventory.

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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimester 3 Year 3	**Study week no.: 2**
Student Name & ID: Lim Fo Xiang 19ACB04947	
Supervisor: Ts Dr. Goh Hock Guan	
Project Title: Development of UTAR Hospital RFID Linen Monitoring through Gantry using JAVA	

1. WORK DONE

Review back previous project 1 worked and get back to used the hardware and test run

2. WORK TO BE DONE

Ensure all the function that run previously is working fine and function

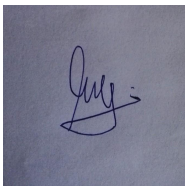
3. PROBLEMS ENCOUNTERED

No problem encounter

4. SELF EVALUATION OF THE PROGRESS

Getting started to the project 2 and planning the work for project 2

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimester 3 Year 3	**Study week no.: 4**
Student Name & ID: Lim Fo Xiang 19ACB04947	
Supervisor: Ts Dr. Goh Hock Guan	
Project Title: Development of UTAR Hospital RFID Linen Monitoring through Gantry using JAVA	

1. WORK DONE

Check on the previous FYP 1 report and look for my objective for this project, what need to be done

2. WORK TO BE DONE

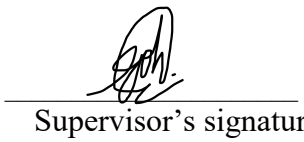
Planned out on the chapter that need to be included into FYP 2 report

3. PROBLEMS ENCOUNTERED

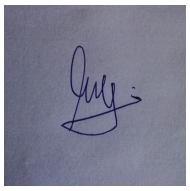
No problem encounter

4. SELF EVALUATION OF THE PROGRESS

Working effectively as the previous project did not face any problem, can continue with the progress of developing the system



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimester 3 Year 3	**Study week no.: 6**
Student Name & ID: Lim Fo Xiang 19ACB04947	
Supervisor: Ts Dr. Goh Hock Guan	
Project Title: Development of UTAR Hospital RFID Linen Monitoring through Gantry using JAVA	

1. WORK DONE

Meeting with supervisor and discuss about the project

2. WORK TO BE DONE

Need started with implementing the function and programming

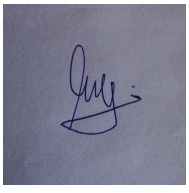
3. PROBLEMS ENCOUNTERED

No problem encounter

4. SELF EVALUATION OF THE PROGRESS

After I had meet supervisor discuss about the next process, I spent sometime thinking on the coding side and solution, which need to make of use case for hospital.

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimester 3 Year 3	**Study week no.: 8**
Student Name & ID: Lim Fo Xiang 19ACB04947	
Supervisor: Ts Dr. Goh Hock Guan	
Project Title: Development of UTAR Hospital RFID Linen Monitoring through Gantry using JAVA	

1. WORK DONE

Had slowly implemented the function discussed with supervisor before and all is function at the end is working fine

2. WORK TO BE DONE

Need to test and build new database in order to build an dashboard for incoming

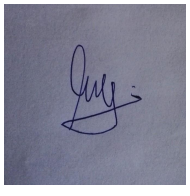
3. PROBLEMS ENCOUNTERED

No problem encounter

4. SELF EVALUATION OF THE PROGRESS

Spending more time in thinking of the solution of how to record outgoing data and compare with incoming. As the MongoDB has limited function with free tier

Supervisor's signature



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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimester 3 Year 3	**Study week no.: 10**
Student Name & ID: Lim Fo Xiang 19ACB04947	
Supervisor: Dr. Goh Hock Guan	
Project Title: Development of UTAR Hospital RFID Linen Monitoring through Gantry using JAVA	

1. WORK DONE

All the function has been implemented with necessary database such as outgoing and incoming linen record, tested the function in FYP Lab

2. WORK TO BE DONE

Need to start writing the report

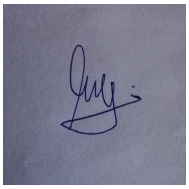
3. PROBLEMS ENCOUNTERED

No problem encounter

4. SELF EVALUATION OF THE PROGRESS

Creating intuitive dashboard for both outgoing and incoming with hospital and floor information

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Trimester 3 Year 3	**Study week no.: 12**
Student Name & ID: Lim Fo Xiang 19ACB04947	
Supervisor: Dr. Goh Hock Guan	
Project Title: Development of UTAR Hospital RFID Linen Monitoring through Gantry using JAVA	

1. WORK DONE

Performance test on the system such as linen data accuracy and reliability

2. WORK TO BE DONE

Continue to writing and finalize report

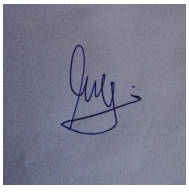
3. PROBLEMS ENCOUNTERED

No problem encounter

4. SELF EVALUATION OF THE PROGRESS

Overall progress of this project meet the goals, after done developing the whole project, I evaluate my objective and make sure I achieve all of the objective

Supervisor's signature



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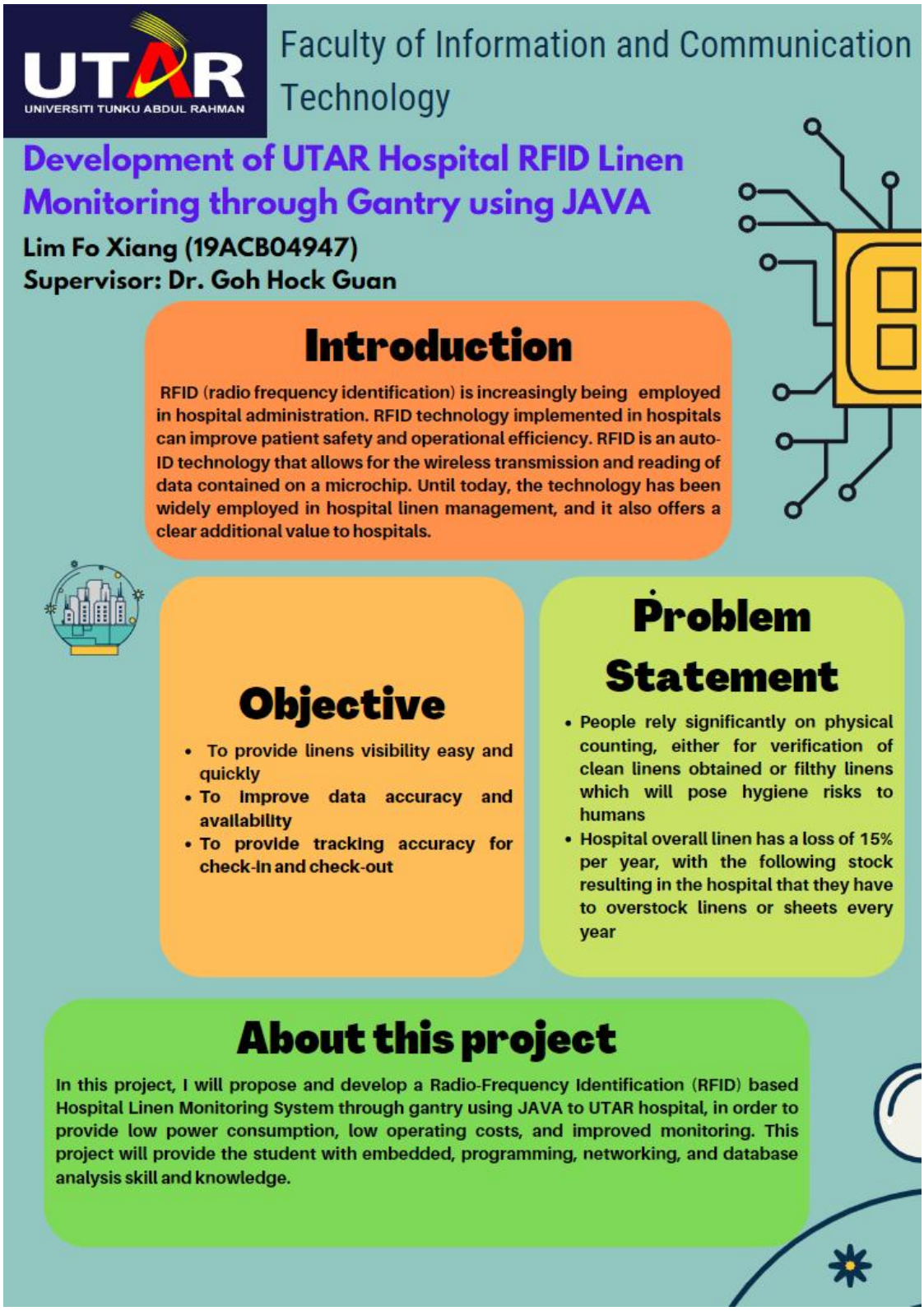
POSTER


UTAR
UNIVERSITI TUNKU ABDUL RAHMAN
Faculty of Information and Communication Technology
Development of UTAR Hospital RFID Linen Monitoring through Gantry using JAVA
Lim Fo Xiang (19ACB04947)
Supervisor: Dr. Goh Hock Guan
Introduction
RFID (radio frequency identification) is increasingly being employed in hospital administration. RFID technology implemented in hospitals can improve patient safety and operational efficiency. RFID is an auto-ID technology that allows for the wireless transmission and reading of data contained on a microchip. Until today, the technology has been widely employed in hospital linen management, and it also offers a clear additional value to hospitals.
Objective
To provide linens visibility easy and quickly
To improve data accuracy and availability
To provide tracking accuracy for check-in and check-out
Problem Statement
People rely significantly on physical counting, either for verification of clean linens obtained or filthy linens which will pose hygiene risks to humans
Hospital overall linen has a loss of 15% per year, with the following stock resulting in the hospital that they have to overstock linens or sheets every year
About this project
In this project, I will propose and develop a Radio-Frequency Identification (RFID) based Hospital Linen Monitoring System through gantry using JAVA to UTAR hospital, in order to provide low power consumption, low operating costs, and improved monitoring. This project will provide the student with embedded, programming, networking, and database analysis skill and knowledge.

PLAGIARISM CHECK RESULT

Development of UTAR Hospital RFID Linen Monitoring through Gantry using JAVA

ORIGINALITY REPORT

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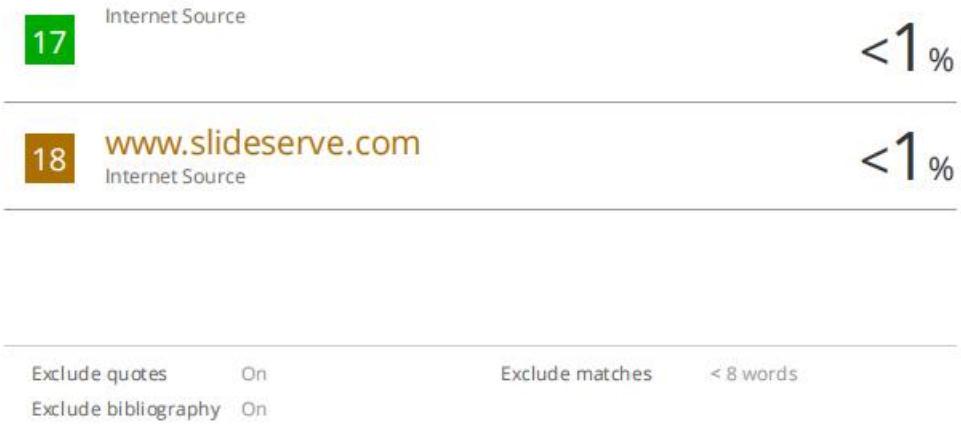
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FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	LIM FO XIANG
ID Number(s)	1904947
Programme / Course	Communication and Networking (CN)
Title of Final Year Project	Development of UTAR Hospital RFID Linen Monitoring through Gantry using JAVA

Similarity	**Supervisor's Comments (Compulsory if parameters of originality exceed the limits approved by UTAR)**
Overall similarity index: 5% Similarity by source Internet Sources: 3% Publications: 0% Student Papers: 2%	
Number of individual sources listed of more than 3% similarity: 0	
Parameters of originality required, and limits approved by UTAR are as Follows: **(i) Overall similarity index is 20% and below, and** **(ii) Matching of individual sources listed must be less than 3% each, and** **(iii) Matching texts in continuous block must not exceed 8 words** ***Note: Parameters (i) – (ii) shall exclude quotes, bibliography and text matches which are less than 8 words.***	

Note: Supervisor/Candidate(s) is/are required to provide softcopy of full set of the originality report to Faculty/Institute

Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.

Signature of Supervisor _____

Name: Goh Hock Guan

Date: 27/4/2023

Signature of Co-Supervisor _____

Name: _____

Date: _____

FYP 2 CHECKLIST

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY (KAMPAR CAMPUS)

CHECKLIST FOR FYP2 THESIS SUBMISSION

Student ID	19ACB04947
Student Name	LIM FO XIANG
Supervisor Name	Ts Dr. Goh Hock Guan

TICK (√)	DOCUMENT ITEMS Your report must include all the items below. Put a tick on the left column after you have checked your report with respect to the corresponding item.
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√	Signed Report Status Declaration Form
√	Signed FYP Thesis Submission Form
√	Signed form of the Declaration of Originality
√	Acknowledgement
√	Abstract
√	Table of Contents
√	List of Figures (if applicable)
√	List of Tables (if applicable)
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√	List of Abbreviations (if applicable)
√	Chapters / Content
√	Bibliography (or References)
√	All references in bibliography are cited in the thesis, especially in the chapter of literature review
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√	Signed Turnitin Report (Plagiarism Check Result - Form Number: FM-IAD-005)
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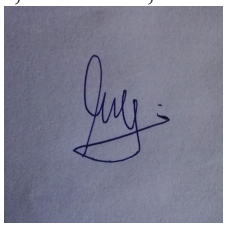
I, the author, have checked and confirmed all the items listed in the table are included in my report.



(Signature of Student)
Date: 23/4/2023