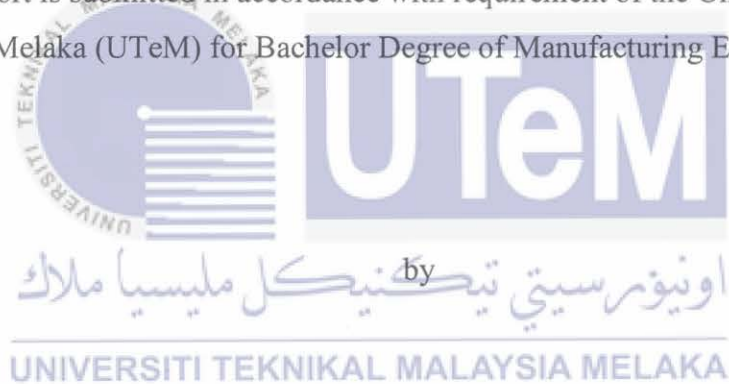




## **WAREHOUSE INVENTORY SYSTEM USING MESSAGE QUEUING TELEMETRY TRANSPORT**

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)



**GOH SHE HUI**

**B051820074**

**981130-05-5466**

**FACULTY OF MANUFACTURING ENGINEERING**

**2022**

**BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA**

Tajuk: **WAREHOUSE INVENTORY SYSTEM USING MESSAGE QUEUING  
TELEMETRY TRANSPORT**

Sesi Pengajian: **2021/2022 Semester 1**

Saya **GOH SHE HUI (981130-05-5466)**

mengaku membenarkan Laporan Projek Sarjana Muda (PSM) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. \*Sila tandakan (√)

**SULIT** (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA

**TERHAD** (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan)

**TIDAK TERHAD**

Disahkan oleh:



Alamat Tetap:

1763, Jalan SJ 9/12,  
Taman Seremban Jaya,  
Seremban, Negeri Sembilan  
Tarikh: 26<sup>TH</sup> JAN 2022

  
Cop Rasmi. **DR. MOHD NAZRIN BIN MUHAMMAD**  
Pensyarah Kanan  
Fakulti Kejuruteraan Pembuatan  
Universiti Teknikal Malaysia Melaka

Tarikh: 26 Jan 2022

\*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

## DECLARATION

I hereby, declared this report entitled “Warehouse Inventory System Using Message Queuing Telemetry Transport” is the result of my own research except as cited in references.

Signature



Author's Name : GOH SHE HUI

Date : 26<sup>TH</sup> JAN 2022



## APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:



## ABSTRAK

Kepintaran sistem inventori gudang merupakan salah satu penyelesaian untuk meningkatkan kecekapan penjejakan inventori kerana kebanyakan kesilapan manusia dalam menjejak inventori secara manual menyebabkan kesilapan salah ambil data dan kerugian syarikat. Oleh itu, kajian ini berkaitan dengan sistem IoT dalam inventori gudang menggunakan MQTT protokol dicadangkan sebagai sesuatu penyelesaian untuk menggantikan kerja menjejak inventori secara manual. *Message Queuing Telemetry Transport (MQTT)* protokol mempunyai sifat automatik dalam menghantar data terkini yang dapat dijejak melalui telefon bimbit. Keupayaan Seni bina MQTT protokol dikaji menggunakan aplikasi berlainan dalam mempapar mesej dari MATLAB ke Raspberry Pi dan MATLAB ke ThingSpeak. Kedua-dua seni bina MQTT mempunyai keupayaan kerana data mempapar adalah sama dengan data diterima. Selain itu, ThingSpeak juga boleh menghantar amaran kepada pengguna semasa terdapat kekurangan kuantiti inventori yang tetap. Amaran ini dapat mengelakkan kekurangan inventori dalam kilang. Kajian ini juga akan melaksanakan kecekapan analisis dan kos analisis dengan menggunakan MQTT protokol.

## ABSTRACT

Smart warehouse inventory management has become a solution to maximize the efficiency of keeping track of inventory as there is a lot of human error which is prone to the inefficiency of manual records and sharing of paper records which can lead to loss of a company. Hence, the IoT-based warehouse inventory will be presented using MQTT protocol to replace manual inventory tracking. The Message Queuing Telemetry Transport (MQTT) protocol offers automated features which can publish real-time data and can be tracked by using a mobile device. The MQTT Protocol architecture is study the capability in using different applications such as publishing data from MATLAB to Raspberry Pi and MATLAB to ThingSpeak. Both MQTT architecture are capable as the data publish is the same as the data received. Besides, the engineer will be notified of the low inventory of the stock through the E-mail from ThingSpeak will keep update to ensure the stock is top up. On the other hand, this paper will also present the efficiency analysis and cost analysis of implementing MQTT protocol.



## ACKNOWLEDGEMENT

I would like to express my gratitude to my supervisor, Dr. Mohd Nazrin bin Muhammad to provide me with valuable insights and encouragement on this project. I would also like to acknowledge my panels which are Ir. Dr.-Ing. Azrul Azwan Bin Abdul Rahman, En. Mahasan Bin Mat Ali and Ir. Dr. Lokman Bin Abdullah for the valuable suggestions and comments on my project. A special thanks to Ir. Dr. Lokman Bin Abdullah that willing to share the technique on the report writing skills. I would also like to thank the coordinators of *Projek Sarjana Muda* (PSM), Mr. Nor Akramin bin Mohamad and Dr. Chang Siang Yee to invite different speakers to provide us the guideline for the presented PSM report.

اونيورسيتي تيكنيكل مليسيا ملاك  
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

# TABLE OF CONTENTS

<b>ABSTRAK</b> .....	<b>i</b>
<b>ABSTRACT</b> .....	<b>ii</b>
<b>ACKNOWLEDGEMENT</b> .....	<b>iii</b>
<b>TABLE OF CONTENTS</b> .....	<b>iv</b>
<b>LIST OF FIGURES</b> .....	<b>viii</b>
<b>LIST OF TABLES</b> .....	<b>xi</b>
<b>LIST OF ABBREVIATIONS</b> .....	<b>xii</b>
<b>LIST OF SYMBOLS</b> .....	<b>xiv</b>
<b>CHAPTER 1</b> .....	<b>1</b>
<b>INTRODUCTION</b> .....	<b>1</b>
1.1 Research Background .....	1
1.2 Problem Statement.....	2
1.3 Objectives.....	3
1.4 Scopes of the Research .....	4
1.5 Rational of Research.....	4
1.6 Organization of the Study.....	5
1.7 Summary.....	5
<b>CHAPTER 2</b> .....	<b>6</b>
<b>LITERATURE REVIEW</b> .....	<b>6</b>
2.0 Warehouse Inventory System .....	6
2.1 Internet of Think (IoT).....	8
2.2 IoT based Inventory System .....	9
2.2.1 Sensor In Inventory Tracking Systems.....	9
2.2.1.1 Barcode.....	9
2.2.1.2 Computer Vision .....	11
2.2.1.3 Radio Frequency Identifier (RFID).....	12
2.2.1.4 Conclusion.....	14
2.2.2 IoT Gateway .....	15
2.2.2.1 NodeMCU .....	15



2.2.2.2	Arduino.....	16
2.2.2.3	Raspberry Pi.....	17
2.2.2.4	Conclusion.....	18
2.2.3	Network Communication .....	18
2.2.3.1	Bluetooth.....	19
2.2.3.2	Wi-Fi.....	19
2.2.3.3	Bluetooth vs Wi-Fi.....	20
2.2.3.4	Conclusion.....	21
2.2.3.5	Communication Protocol.....	21
2.2.3.6	HTTP.....	22
2.2.3.7	CoAP.....	22
2.2.3.8	MQTT.....	23
2.2.3.9	MQTT vs Other Communication Protocol.....	25
2.2.3.10	Conclusion.....	27
2.2.4	Cloud Service Application .....	27
2.2.4.1	MIT App Inventor.....	27
2.2.4.2	Blynk.....	28
2.2.4.3	ThingSpeak.....	29
2.2.4.4	Conclusion.....	30
2.3	Relevant Works.....	31
2.4	Summary.....	32
<b>CHAPTER 3</b>		<b>33</b>
<b>METHODOLOGY .....</b>		<b>33</b>
3.0	Project Development Model .....	33
3.1	Flow Chart of General Project development .....	34
3.2	Design of Proposed Inventory System Framework with MQTT.....	35
3.3	MQTT Protocol Architectural.....	35
3.4	Requirement Specification.....	36
3.5	Technologies in Implementation of MQTT protocol .....	37
3.6	Implementation of IoT-based Inventory System Simulation.....	38
3.7	Raspberry Pi Implemented with MATLAB using MQTT.....	40
3.7.1	MQTT Protocol Architectural .....	40
3.7.2	MQTT Publisher.....	41
3.7.3	MQTT Broker.....	42
3.7.4	MQTT Subscriber.....	42

3.8	ThingSpeak Implemented with MATLAB using MQTT .....	44
3.8.1	MQTT Protocol Architecture .....	44
3.8.2	MQTT Publisher.....	44
3.8.3	MQTT Subscriber.....	45
3.8.3.1	ThingSpeak.....	46
3.8.3.2	ThingView.....	48
3.9	Alert System in ThingSpeak .....	48
3.10	Efficiency Analysis.....	49
3.11	Cost Analysis .....	51
<b>CHAPTER 4.....</b>		<b>52</b>
<b>RESULT AND DISCUSSION .....</b>		<b>52</b>
4.0	Implementation of IoT-based Inventory System .....	52
4.1	MQTT Protocol Architecture with Raspberry Pi.....	56
4.1.1	Setup Raspberry Pi .....	56
4.1.2	Capability of MQTT Publisher.....	56
4.1.3	Capability of MQTT Subscriber.....	59
4.2	MQTT Protocol Architecture with ThingSpeak .....	63
4.2.1	Capability of MQTT Publisher.....	65
4.2.2	Capability of MQTT Subscriber.....	68
4.2.2.1	ThingSpeak.....	68
4.2.2.2	ThingView.....	69
4.3	Send E-mail Alerts from ThingSpeak.....	70
4.3.1	Implementation of Alert System .....	70
4.3.2	Performance of the Alert system .....	70
4.3.3	The Efficiency of the Alert System .....	72
4.4	Efficiency Analysis.....	73
4.5	Cost Analysis .....	74
<b>CHAPTER 5.....</b>		<b>76</b>
<b>CONCLUSION AND RECOMMENDATIONS .....</b>		<b>76</b>
5.0	Conclusion .....	76
5.1	Recommendation .....	77
5.2	Improvement of the System.....	78
5.3	Sustainability .....	78
<b>REFERENCES .....</b>		<b>79</b>
<b>APPENDIX .....</b>		<b>85</b>

Appendix A .....	85
Appendix B.....	86
Appendix C.....	87
Appendix D .....	89
Appendix E .....	91
Appendix F .....	91





## LIST OF FIGURES

Figure 2.1 Warehouse Management System (Vatumalae et al., 2020) .....	6
Figure 2.2 Technology roadmap for Internet of Things (IoT) (Tejesh & Neeraja, 2018).....	7
Figure 2.3 Barcode .....	9
Figure 2.4 The Case diagram of the operation of Barcode Inventory Control System (Muyumba & Phiri, 2017) .....	10
Figure 2.5 Automatically object and human detection and classification (Khan, A. I. and Al-Habsi, S. (2020)) .....	11
Figure 2.6 Detection process of the object or image (Robotics Tomorrow) .....	12
Figure 2.7 The components of RFID system (Tejesh & Neeraja, 2018).....	13
Figure 2.8 RFID tag (Adcbarcode,2017).....	13
Figure 2.9 General feature of IoT Gateway (Kang et al., 2017).....	15
Figure 2.10 NodeMCU (Paveesha et al., 2020).....	15
Figure 2.11 Arduino Uno Board and L293D Motor Driver Shield (Pololu Corporation, Open Circuit).....	16
Figure 2.12 Raspberry Pi (Seth Kenlon,2021) .....	17
Figure 2.13 ZF & Bluetooth® Low Energy (ZF Friedrichshafen AG) .....	19
Figure 2.14 Wi-Fi (Autodesk).....	19
Figure 2.15 Percentage of successful activity of the attacks (Susila et al., 2017).....	20
Figure 2.16 Communication Protocols in different layer (B. Mishra & Kertesz, 2020).....	21
Figure 2.17 Architectural of HTTP (Yokotani & Sasaki, 2017) .....	22
Figure 2.18 Comparison between architecture of CoAP and HTTP (Devopedia, 2019) ....	23
Figure 2.19 The MQTT development over time (B. Mishra & Kertesz, 2020) .....	23
Figure 2.20 Architecture of MQTT Protocol (Pham & Hoang, 2021).....	24
Figure 2.21 MQTT Protocol on tracking shipment .....	25
Figure 2.22 Request and Respond model used by HTTP and CoAP .....	26
Figure 2.23 Publish and Subscribe model used by MQTT .....	26
Figure 2.24 Graphical interface editor of MIT App Inventor (Mir & Llueca, 2020).....	27
Figure 2.25 Code editor of MIT App Inventor (Mir & Llueca, 2020) .....	28
Figure 2.26 Switch ON button in Blynk app.....	28
Figure 2.27 Schematic of the Blynk's component.....	29

Figure 2.28 Sensor output on ThingView Free APP (Tapakire & Patil, 2019).....	29
Figure 3.1 Waterfall Model .....	33
Figure 3.2 Flow Chart of the project overview .....	34
Figure 3.3 Hardware inventory system framework .....	35
Figure 3.4 MQTT Protocol architectural .....	35
Figure 3.5 Implementation of MATLAB in replacing the experimental in lab. ....	36
Figure 3.6 Machine Type-B (MTB) robot.....	38
Figure 3.7 Algorithm of the simulation in CoppeliaSim .....	39
Figure 3.8 MQTT Protocol between MATLAB and Raspberry Pi .....	40
Figure 3.9 Algorithm of the coding in MATLAB connected to Raspberry Pi.....	41
Figure 3.10 Set up Raspberry Pi connect to MQTT in Matlab.....	42
Figure 3.11 Scanning IP address of Raspberry Pi .....	43
Figure 3.12 PuTTY Configuration .....	43
Figure 3.13 Interface of the command-line of Raspberry Pi .....	43
Figure 3.14 MQTT Protocol between MATLAB and ThingSpeak.....	44
Figure 3.15 Algorithm of the coding in MATLAB connected to ThingSpeak .....	45
Figure 3.16 Creating channel in ThingSpeak .....	46
Figure 3.17 Get MQTT under 'Device' .....	46
Figure 3.18, Add a new device under MQTT Device .....	47
Figure 3.19 Fill up the details in the following column .....	47
Figure 3.20 Specific MQTT credentials for the channel. ....	47
Figure 3.21 Add channels to allow publish and subscribe .....	47
Figure 3.22 ThingView in subscribing channels .....	48
Figure 3.23 Algorithm of the alert system in ThingSpeak .....	49
Figure 3.24 'Run and Time' in Matlab (Editor) .....	50
Figure 4.1 IoT-based inventory system .....	52
Figure 4.2 Coding in MATLAB to calculate the angle $\theta_1$ and $\theta_2$ .....	53
Figure 4.3 Part of the MTB language .....	54
Figure 4.4 Initial environment of simulation (left) and end environment of simulation (right).....	54
Figure 4.5 Stock is scanned and loaded onto conveyor belt.....	55



Figure 4.6 The RFID active area for reading RFID .....	55
Figure 4.7 Wi-Fi set-up of Raspberry Pi .....	56
Figure 4.8 Properties of Raspberry Pi in Matlab .....	57
Figure 4.9 Connection between Raspberry Pi and Matlab using MQTT .....	57
Figure 4.10 The inventory quantities update in MATLAB .....	57
Figure 4.11 Real-time inventory update for four stock in Raspberry Pi .....	58
Figure 4.12 Data Received of Topic A in Raspberry Pi.....	60
Figure 4.13 Data Received of Topic B in Raspberry Pi.....	61
Figure 4.14 Data Received of Topic C in Raspberry Pi.....	62
Figure 4.15 Data Received of Topic D in Raspberry Pi.....	63
Figure 4.16 Interface of the ThingSpeak with 4 fields.....	64
Figure 4.17 MQTT credential.....	64
Figure 4.18 Successfully connected between MATLAB and ThingSpeak via MQTT.....	65
Figure 4.19 The inventory quantities update in MATLAB.....	65
Figure 4.20 Real-time Inventory Update for Four Stock in ThingSpeak.....	66
Figure 4.21 Time-Table generated by function call ThingspeakRead in Matlab.....	67
Figure 4.22 Graph generation by updating the data from MATLAB to ThingSpeak in different fields.....	68
Figure 4.23 Front page interface of ThingView .....	69
Figure 4.24 Screenshot from the phone.....	69
Figure 4.25 Profile of the ThingSpeak.....	70
Figure 4.26 MATLAB code successfully run .....	71
Figure 4.27 Notification sent to e-mail when low inventory.....	71
Figure 4.28 Last update of the Stock A's quantities.....	72
Figure 4.29 ThingSpeak Alerts in every 5 minutes.....	72
Figure 4.30 Total time taken of the MQTT protocol with Raspberry Pi.....	73
Figure 4.31 Total time taken of the MQTT protocol with Raspberry Pi.....	73
Figure 4.32 Comparison of 'Free version' and 'Standard version' of ThingSpeak (MathWorks, 2022b) .....	74
Figure 4.33 Features of the 'Standard Version' which cost USD 710.00/year .....	75
Figure 4.34 Features of the 'Standard Version' which cost USD 4,150.00/year .....	75

## LIST OF TABLES

Table 2.1 Comparison Between Manual, Semi-automated, and Fully-automated system (Abugabah et al., 2020; Tejesh & Neeraja, 2018).....	7
Table 2.2 Pros and Cons of Barcode Sensor .....	10
Table 2.3 Pros and Cons of Computer Vision.....	12
Table 2.4 Pros and Cons of RFID .....	14
Table 2.5 Different types of Raspberry Pi with either support or no support MATLAB ...	18
Table 2.6 Bluetooth vs Wi-Fi compare between (Autodesk) .....	21
Table 2.7 Type of QoS (B. Mishra & Kertesz, 2020; Pham & Hoang, 2021) .....	24
Table 2.8 Advantages of MQTT.....	25
Table 2.9 MQTT Compared With Others Communication Protocol (Jaloudi, 2019).....	26
Table 2.10 List of research that related with IoT Warehouse Inventory System .....	31
Table 3.1 Requirement specification of the project.....	36
Table 3.2 Technologies in implementation of MQTT protocol .....	37
Table 3.3 Initially quantities of stock in Raspberry Pi implementation .....	42
Table 3.4 Initially quantities of stock in ThingSpeak implementation .....	45
Table 3.5 Variables in comparison of the performance of Raspberry Pi and ThingSpeak .	49
Table 3.6 Result of the performance of Raspberry Pi and ThingSpeak.....	50
Table 3.7 Parameter of the efficiency.....	50
Table 3.8 Implementation Cost .....	51
Table 4.1 True coordinate on x-axis and y-axis. ....	53
Table 4.2 Stocks quantities updated of Raspberry Pi for 20 Times .....	58
Table 4.3 Stocks quantities updated of Thingspeak for 20 Times .....	66
Table 4.4 Result of the performance and efficiency of Raspberry Pi and ThingSpeak .....	73

## LIST OF ABBREVIATIONS

AC	-	Alternative Current
API	-	Application Programming Interface
APK	-	Android Package
APP	-	Application
ASRS	-	Automated Storage and Retrieval System
BLE	-	Bluetooth Low Energy
CoAP	-	Constrained Application Protocol
Covid-19	-	Coronavirus Disease 2019
CPU	-	Central Processing Unit
DC	-	Direct Current
DOF	-	Degree-Of-Freedom
DoS	-	Denial-Of-Service
GPIO	-	General-Purpose Input/Output
HTTP	-	Hypertext Transfer Protocol
ID	-	Identity Document
IoT	-	Internet Of Things
IP	-	Internal Protocol
JIT	-	Just-In-Time
JSON	-	JavaScript Object Notation
M2M	-	Machine To Machine
MAC	-	Media Access Control
MCU	-	Microcontroller
MITM	-	Man-In-The-Middle
MQTT	-	Message Queuing Telemetry Transport
MTB	-	Machine Type-B
NPO	-	Non-Profit Organization
OASIS	-	Organization For the Advancement of Structured Information Standards
PC	-	Personal Computer

QoS	-	Quality Of Service
QR	-	Quick Response
RF	-	Radio Frequency
RAM	-	Random Access Memory
RFID	-	Radio Frequency Identification
ROI	-	Return of Investment
ROM	-	Read-Only Memory
SBC	-	Single Board Computer
SCADA	-	Supervisory Control and Data Acquisition
SSL	-	Secure Sockets Layer
SSP	-	Secure Simple Pairing
TCP	-	Transmission Control Protocol
TLS	-	Transport Layer Security
TTL	-	Time-To-Live
UDP	-	User Datagram Protocol
UHF	-	Ultrahigh Frequency
USB	-	Universal Serial Bus
Wi-Fi	-	Wireless Fidelity
WIP	-	Work-In-Progress
WMS	-	Warehouse Management System



UNIVERSITI TEKNIKAL MALAYSIA MELAKA



## LIST OF SYMBOLS

cm	-	Centimeter
GHz	-	Giga Hertz
m	-	Meter
mm	-	Millimeter
Mbps	-	Megabits per second
RM	-	Ringgit Malaysia
s	-	Second
USD	-	United State Dollar
%	-	Percentage






# CHAPTER 1

## INTRODUCTION

Chapter 1 will establish the research background on the Radio Frequency Identification (RFID) and Message Queuing Telemetry Transport (MQTT) in this coming trend and identify the problems exist in the Warehouse Inventory Management. Then determine the objective, scope and structural of the project.

### 1.1 Research Background



In this age of globalism, the transfer of goods has expanded much more than ever before. As such, inventory management has become a crucial part of the industry. For example, small retailer or e-commerce shop rely heavily on inventory management for planning and decision making. The transparency in the warehouse inventory between the buyers or customers have to be maintained. (Laxmi & Mishra, 2018) Darya Plinere et al (2015) stated that production scheduling can be more effective through inventory management which helps in forecasting and purchasing of stock. Hence, efficient asset utilization is achieved and issues such as over stocking or out-of-stock can be avoided. A well-known inventory system is the Just-In-Time (JIT) inventory system by Toyota Motor Corporation which utilizes data of inventory to react quickly and efficiently on the trend of demand. Besides, Syed Mohamad et al. (2016) also mentioned that the inventory management is directly influence the company's performance so it plays an important role in financial performance of company. Hence, company must keep track on the amount of the inventory to maintain a proper inventory level to maximize profitability.

In conjunction to the mass availability of electronics such as sensors, Internet of Things (IoT) has become an emergent technology that would revolutionize inventory management in the industry. Radio Frequency Identification (RFID) technology offers effective inventory tracking by exposing the physical placement of inventory to digital systems (Aishwarya Raj Laxmi, 2018). For example, real time visualization of work-in-progress (WIP) or finished products can be achieved by attaching it with RFID tags which identifies its location.

Therefore, an inventory system is proposed in this research which utilizes Message Queuing Telemetry Transport (MQTT) protocol to facilitate the communication between PC and mobile devices through the cloud. The publishing devices will publish data through broker to subscribing devices. The overall architecture involves inventory data gathered from RFID sensors which is published to the cloud through a Wi-Fi gateway using MQTT protocol, and subsequently subscribed by PC or mobile phone for monitoring purposes. Cloud database is utilized as a scalable pay-per-use data storage solution.

The outbreak of Corona Virus Disease 2019 (COVID-19) has devastated economic sector especially supply chain. (Sube Singh et al, 2020). Thus, highlighting the importance of communication between companies and suppliers to coordinate the transfer of goods, which can be made more effective through a cloud-based inventory management system. Decisions on logistics can be made more efficiently by accessing data on the availability and demands of supplies and products with the tap of a mobile device through the cloud.

## 1.2 Problem Statement

The task of inventory management is to define the quantity of current inventories that will fulfill the demand (Darya Plinere et al, 2015). However, the impact of supply issues such as overstock or out-of-stock will be exacerbated by a small inventory. One of the solutions to alleviate the risks in a supply chain is by improving the inventory tracking system. Current widely used paper-based manual inventory counting system is inefficient and prone to human error, which sometimes results in improper inventory control and missing items. Besides, the paper records are shared between departments which may lead to further delays and errors.

Therefore, it is obvious that there is a need to revolutionize warehouse inventory tracking system by computerization of data and automation of inventory counting operations (Thomas Muyumba, 2017). Currently, web-based inventory tracking system using barcode is available on the market. Although it is simpler and cheaper to use it, but it is less durable and less secure compared to RFID-based system.

In addition, the mass availability of mobile phones presents an opportunity to expand the accessibility of inventory tracking system. Adopting mobile devices in asset monitoring eliminates the need for human operators to physically be present on site. This is important as human travel time significantly contributes to the loss of efficiency in a production line.

Furthermore, manual inventory counting brings about the risk of human error. This is especially apparent during the COVID-19 outbreak, where labour shortage lead to overworked workers which are prone to mistakes (Singh et al., 2021). Reduction of labour requirements in inventory tracking will improve efficiency as workers can then be tasked with more impactful duties.

### 1.3 Objectives

The objectives of the project are as below:

- (a) To investigate current IoT-based Warehouse Inventory Management System in using a suitable technology to track the inventory quantities.
- (b) To develop IoT-based Warehouse Inventory Management System with MQTT protocols that can track inventory quantities by various application and mobile devices.
- (c) To evaluate the efficiency and performance of the MQTT protocol architectural and notification system of ThingSpeak when the inventory is low.



## 1.4 Scopes of the Research

The project scopes of research are shown as below:

- (a) Research will be conducted on the IoT-based Warehouse Inventory Management with compared between 3 types of inventory system and how the IoT integrated to increase the efficiency of the Warehouse Inventory System.
- (b) The study on the IoT-based Warehouse Inventory Management system with MQTT protocol in the aspects of architectural and component. Comparison is made between different type of sensors, network connection and IoT protocols.
- (c) Appropriate method to develop MQTT protocol is studied and the comparison is made between different type of Cloud service provider.
- (d) Extend the existing warehouse management system by enhancing the system into Cloud Based service that can accessed by different users in a software-based.



## 1.5 Rational of Research

The rational of project research are shown as below:

- (a) There is different type of inventory system that need to be studied to define the different on the pro and cons of each system and the integration of the IoT to help in giving a bigger picture on the history.
- (b) Different type of IoT components have different system requirement. characteristic and working principle of each components have to be weighed

when deciding a suitable component in implementing an IoT system that can connect to the mobile phone with suitable Cloud Service provider.

- (c) To construct a reliability alert system of ThingSpeak to notify the user when low inventory occurred.

## 1.6 Organization of the Study

An IoT based RFID inventory tracking system using MQTT is proposed in this thesis. The findings in this report are divided into 5 Chapters. Chapter 1 is Introduction which establishes the background study of the title and giving an overall idea about the project objective, scope of research, and rational of research. Next, Literature Review is presented in Chapter 2 which comprises of previous studies to highlight the work done on automated inventory control system and its components. Research methodology is presented in Chapter 3 which includes the Software and hardware to be used and the detailed architecture of the proposed IoT system. Preliminary Results in Chapter 4 is analyzed to ensure the project developed is capable and efficient. Lastly, conclusion and recommendation on this research are summarized in Chapter 5.

اونيورسيتي تيكنيكل مليسيا ملاك

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## 1.7 Summary

In short, background on current inventory tracking and control system is presented in this chapter. The problem statement is also highlighted which revolves around the reliance of current systems on manual human labour. Then, the objectives of this research which emphasizes on automation of inventory tracking system are proposed and justified with the respective rationales. In addition, the scope of this research is staged to set limitations and expectations on the proposed project.



## CHAPTER 2

### LITERATURE REVIEW

This chapter is a compilation of work done by other researchers on topics related to the proposed project. Information that are relevant to inventory tracking and management, along with Internet of Things (IoT) using Message Queuing Telemetry Transport (MQTT) protocol is presented and discussed.

#### 2.0 Warehouse Inventory System

Warehouse Management System (WMS) is Software that is designed for optimizing inventory flow between warehouses and distribution centers. (Rana, 2020)



Figure 2.1 Warehouse Management System (Vatumalae et al., 2020)

The main goal of WMS is to manipulate the movement of products within the facility to minimize the loss of time. By integrating semi-automated and automated