Assessment Cover Sheet

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ASSESSMENT DETAILS

Unit title	IOT LAUNCHER PROJECT	Tutorial /Lab Group	2	Office use only
Unit code	SWE30012	Due date	24/9/2021	
Name of lecturer/tutor	Dr Mark Tee Kit Tsun			
Assignment title	An IoT Based supply chain management for warehouse owner utilizing inventory tracking and delivery to increasing efficiency in warehouse			Faculty or school date stamp

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An IoT Based supply chain management for warehouse owner utilizing inventory tracking and delivery to increasing efficiency in warehouse

1 TABLE OF CONTENTS

Project Proposal[1] : An IoT based Supply Chain Management for warehouse owner utilizing inventory tracking and delivery to increase efficiency in warehouse

2 BACKGROUND / PROBLEM DESCRIPTION

In this supply chain industry, warehouse owner might face lots of problem if they could not handle the items stored in their warehouse efficiently. Problems such as could not find where the item is located, loss of item, waste too much time finding an item will occur. Especially today, in digital era where most purchase are done online, warehouse owner not only need to manage stocks for online sales but also face to face sales. IoT supply chain system can be a solution to these problems with the help of sensors such as RFID and barcode to help with the inventory tracking of the warehouse. According to Yanamandra (2019), usage of IoT in supply chain firms does not only reduce cost of business processes but can also help the firms gain competitive advantage of having a 'Smart Supply Chain'.

3 PROJECT SCOPE

3.1 OBJECTIVE

The objective of this project is to propose a cheaper IoT Based supply chain management solution for warehouse owner to easily handle the items stored in a warehouse with the lesser manpower.

3.1.1 Capability

The followings are what the system is capable of:

1) Locate items inside warehouse
    - With the help of IoT devices, it will be much easier to locate the items in a large warehouse as sensors can provide useful information such as the location of a particular item. This can prevent time being wasted by an employee to find a particular item, misplaced of items, and also lost of items.

2) Reduce employee workload by automating their daily task
    - Employees does not have to take note of all the item in the warehouse manually one by one. The items will be scanned, and the information will be noted down into the database. According to Kumar et al. (2019), the usage of IoT system has improved the performance of supply chain management by reducing the need of manual paperwork for order placement such as order delivery receipt, invoices and payment bills. This can ease the employee's job and reduces human error. Therefore, employees will be able to focus on other important task running the business.

3.1.2 List of constraint

1. Business owners have difficulties in keeping track of inventory due to large volume of inventory
2. Difficulties in adopting effective IoT supply chain system due to their high cost
3. Inconsistent Network coverage
4. Difficulties in visualisation of supply chain management
5. Status or information of supply chain inventory must be updated manually and frequently
6. Customers have no information about the status of their order

3.1.3 Stakeholders

The following are the user of the system: --

1) Administrator
   - The administrator will be the one who maintaining the IoT system.

2) Employee that are in charge with customer order
   - Employee will be the one who is in charge with the customer order.

3) Storekeeper
   - The storekeeper will be the one who manage the items stored in the warehouse.
4) Delivery staff
   - The delivery staff will be the one who scans and update the status of product before delivery

5) Business owner
   - The business owner is the one who own the warehouse and the client of this IoT project.

6) IoT system developer
   - The IoT system developer will be the one who will be building this IoT system.

7) Customer
   - The customer will be using the mobile application developed to track the status of their order

3.1.4 Usage Scenarios

RFID and barcode system will be used to track the item in the warehouse. When the product arrived at the warehouse, RFID and barcode will store the information of each item such as which shelf is it stored at and the status of order. The employee or storekeeper can search for the item using the web application or mobile application. When the item is searched for, the item will be flagged on the shelf by using LED. When a product is purchased and prepared for delivery, the storekeeper or delivery staff can scan the product to update the status of product. The customer can then receive a notification regarding the status of their order. Deadstock that has been stored at the warehouse for too long will also be notified to the warehouse owner.

3.1.5 Deliverables and schedule

3.1.5.1 Deliverables

	Item
1.	Website for IoT supply chain management
2.	Mobile application for IoT supply chain management
3.	IoT RFID scanner made with Raspberry Pi and RFID sensor and LCD monitor
4.	IoT Barcode scanner made with Raspberry Pi and Camera and LCD monitor

5.	Barcode system for Item tracking
6.	RFID system for Item tracking
7.	Database for supply chain management
8.	IoT devices/LED on shelf for item flagging

3.1.5.2 Schedule

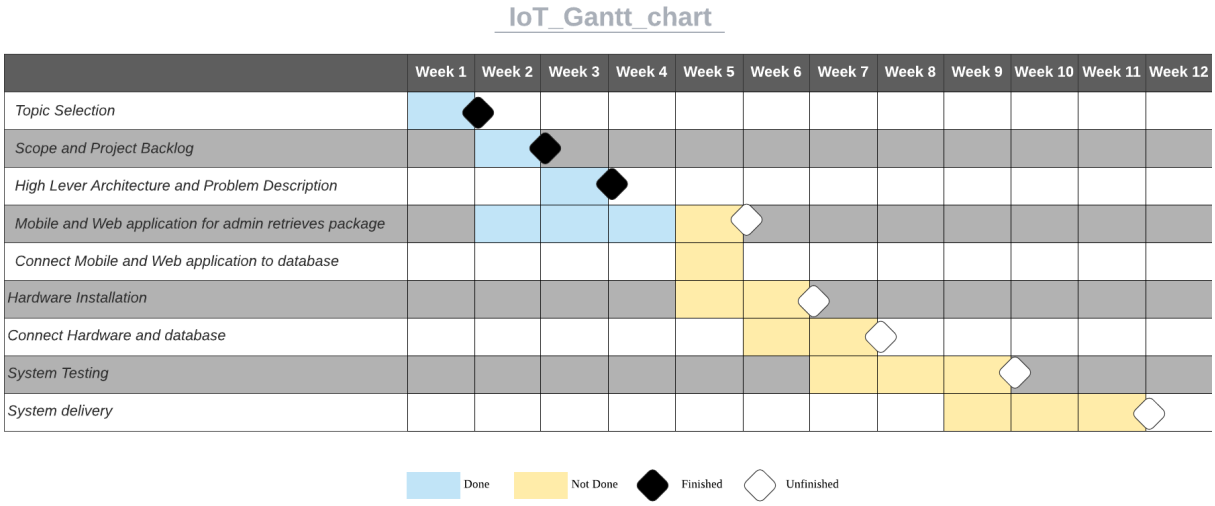


Figure 1 Gantt Chart for Schedule

4 PROJECT BACKLOG

No.	Item	Dependencies	Value (1-20)	Date needed
1.	Connect to local area network	-	20	Sprint 1
2.	Databases for package content	6	20	Sprint 1
3.	Mobile application for admin retrieves package information	2	15	Sprint 1
4.	Develop a node platform for packages	-	18	Sprint 1
5.	Barcode generator function on web application	6	14	Sprint 1
6.	Web application for admin to manage the monitoring of package	2	15	Sprint 1
7.	Developing and setting cloud platform	-	17	Sprint 1
8.	Update the details an item by scanning the barcode when is purchased by customer	2 and 5	10	Sprint 2

9.	Notification system to notify warehouse owner on product that is stored for too long	2	8	Sprint 2
10.	LED to flag item that are being searched for	12 and 4	13	Sprint 2
11.	Develop a Portable RFID scanner that will be used to scan the crate of item	-	18	Sprint 2
12.	Develop a Portable barcode scanner that will be used to scan the barcode of an item	-	18	Sprint 2

Table 1 Project backlog table

5 SOLUTION DIRECTION

5.1 PROJECT FORCES

	Ideas	Scope	Time	Cost
1.	Barcode and RFID inventory management	The scope of the solution covers the inventory tracking of the warehouse via the use of RFID and also the barcode system. The status and the location of an item will be displayed to the storekeeper to assist them in managing the warehouse. The scope also covers the delivery of the item to the customers, where the customers can check the status of their orders via web application.	The time expected to deliver this project is approximately 4 months. Although the solutions or idea might seem simple, the self-made barcode and RFID scanner using raspberry pi might take longer than usual.	The cost of the project will be low, as the objective of this idea is to develop an affordable supply chain system for small to medium businesses using the combination of RFID and barcode to track the item. The total cost of the project depends on the size and capacity of the warehouse
2.	RFID inventory management	The scope of the solution covers the inventory tracking of the warehouse via the use of RFID.	The time expected to deliver the project is approximately 3 months. The time needed is relatively shorter than the other solution because it	The cost of the project will be moderate, as all the item in the warehouse will be tracked using RFID. The total cost depends on the size and capacity of the warehouse, and it might be costly if there are thousands

			mainly focuses on RFID only.	of items to be tracked.
3.	Automated RFID inventory	The scope of the solution covers the automation of inventory tracking using RFID machine and conveyor belt. The management of the item in the warehouse will be done with automated forklift.	The time expected to deliver the project is unknown, due to the technology gap.	The cost of the project will be unknown; however, it is expected to be quite expensive due to expensive equipment such as the RFID machine and conveyor belt.

Table 2 Project Forces table

5.2 PROJECT SOURCING

For the project sourcing, **Digikey Electronics** and **Cytron Technologies** has been selected. Although Cytron Technologies is our main choices, some of the products is limited to only 2 or 1 per customer, such as the Raspberry Pi. Therefore, **Digikey Electronics** will be used purchase hardware which is limited on **Cytron Technologies.**

5.3 IDEAS FOR SOLUTION SYSTEM

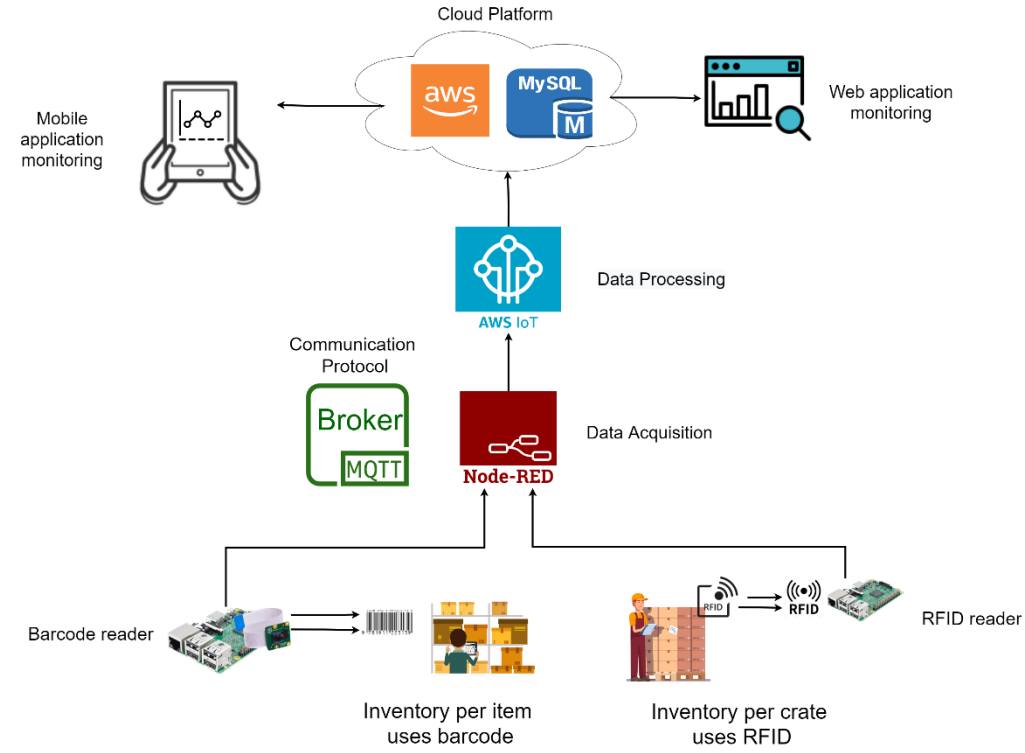
5.3.1 First idea

- Use barcode and RFID tag to locate the item
- Barcode is use for single item while RFID tag is used for box of item
- The light at the rack will light up to let the user know the item is located there
- Barcode and RFID tag will store the information of the item
- Update status of product for delivery by scanning barcode

The first idea for the supply chain management is the combination of RFID and barcode to track the inventory management. Li et al. (2017) has noted that supply chain owners have difficulties in adopting Smart Supply Chain due to the cost and the combination of RFID and QR Code to reduce the cost. The idea is proposed as such is to lower the cost of IoT supply chain management system by using barcode for individual item and RFID only for a crate of item. When the item is received by the warehouse owner, the information is registered such as this item belongs to shelf X. When the storekeeper search for the item, the light at the rack will light up to help ease the storekeeper in finding for the item. The item management can also be monitored via web application and mobile application.

When the customer purchases a product, the storekeeper can update the status of the product such as "*OUT FOR DELIVERY*" or "*READY FOR DELIVERY*". This is so that the customer can know the status of the product that they ordered.

5.3.1.1 High level architecture



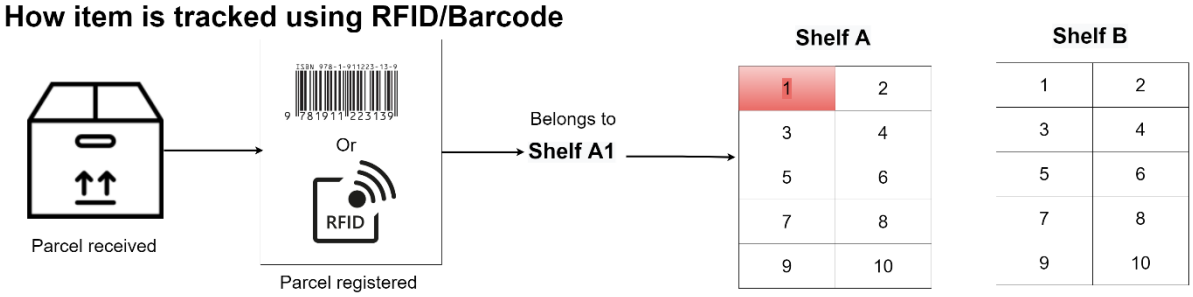


Figure 2 High-level architecture- First Solution (Warehouse)

5.3.1.2 *Delivery status*

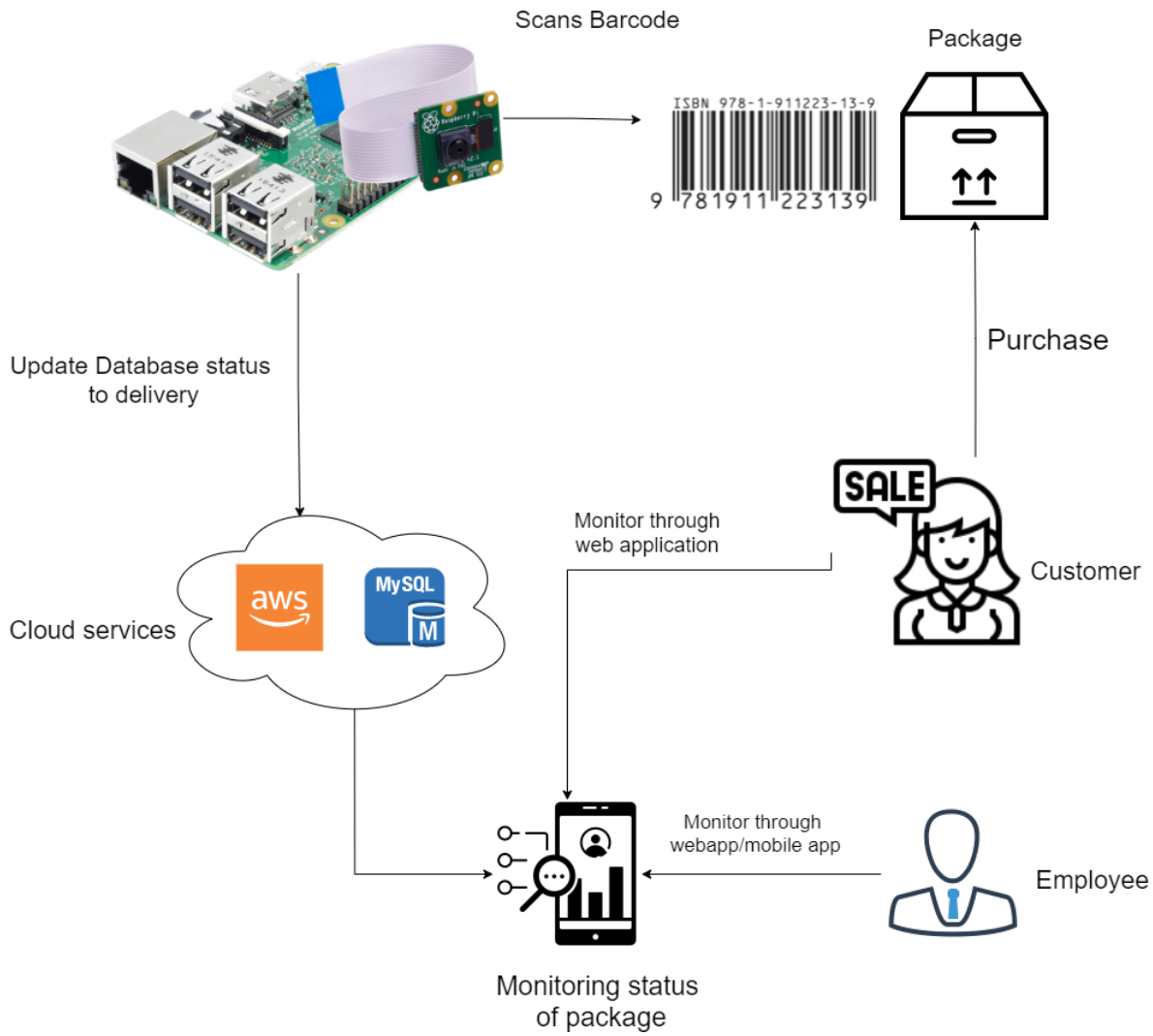


Figure 3 High-level architecture- First solution (Delivery)

5.3.1.3 KoST

Knowledge (problems)	Skills		Technology Gap
	Weak	Strong	
• How large is the volume of the inventory? • How is the item of the inventory packed? Whether the item is pack in one box or in packages. • Does not know the process such as how they gain profit, how they receive and store inventory and types of products and so on.	• **Integrate IoT solutions into mobile application** • **Integrate RFID tag and barcode to item in order to locate them** • **Integrate a lighting system to easily locate the item location**	• **Communication of IoT devices through AWS cloud services.** • **Connect to a database hosted on Aws cloud services.** • **Setting up basic IoT system such as connection between Raspberry Pi, Arduino and IoT sensor.** • **Develop a web application to monitor the IoT devices.**	• RFID Reader and barcode reader which is made with Raspberry Pi

Table 3 KoST table – First Solution

5.3.1.4 Cost

5.3.1.4.1 Component

	Item	Price (RM)
1.	Raspberry Pi 2gb ram	174
2.	Raspberry Pi	115
3.	Barcode Sticker (1 roll/2000 pcs)	6.50
4.	LED	0.10
5.	LCD monitor	7.00
6.	RFID Reader	8.00
7.	RFID tag	1.00

Table 4 Component Cost- First solution

5.3.1.4.2 Component usage

Cost per crate (RFID) = RM 1
Cost per 2000 package (Barcode)= RM6.50

5.3.1.4.3 Usage scenario item

Cost per barcode scanner = Raspberry Pi (RM 174) + Raspberry Pi camera (RM 115)
= RM 289
Cost per RFID scanner = Raspberry Pi (RM 174) + RFID reader (RM 8)

5.3.2 Second idea

- Use RFID tag to locate the item
- The light at the rack will light up to let the user know the item is located there
- Use GPS module to track the item out for delivery
- RFID tag will store the information of the item

The second idea for the solution is similar with the first idea, and the major differences between these ideas is that instead of using the combination of barcode and RFID to track the packages, the second idea focuses on the usage of RFID only. By using RFID for all the packages, the storekeeper does not have to target the barcode scanner accurately to the barcode. Instead, they can easily scan the packages by bringing the RFID scanner close to the packages.

The delivery of the product is supported by GPS to let the customer know the current live location of their product. When the customer purchases a product, the product is assigned to *Lorry A* and this information will be stored in database. This *Lorry A* has a GPS system integrated and customer can know their live location of the product during delivery. This can help them to estimate when will their product will arrive so they can plan their time better.

5.3.2.1 High level architecture

5.3.2.1.1 Inventory management

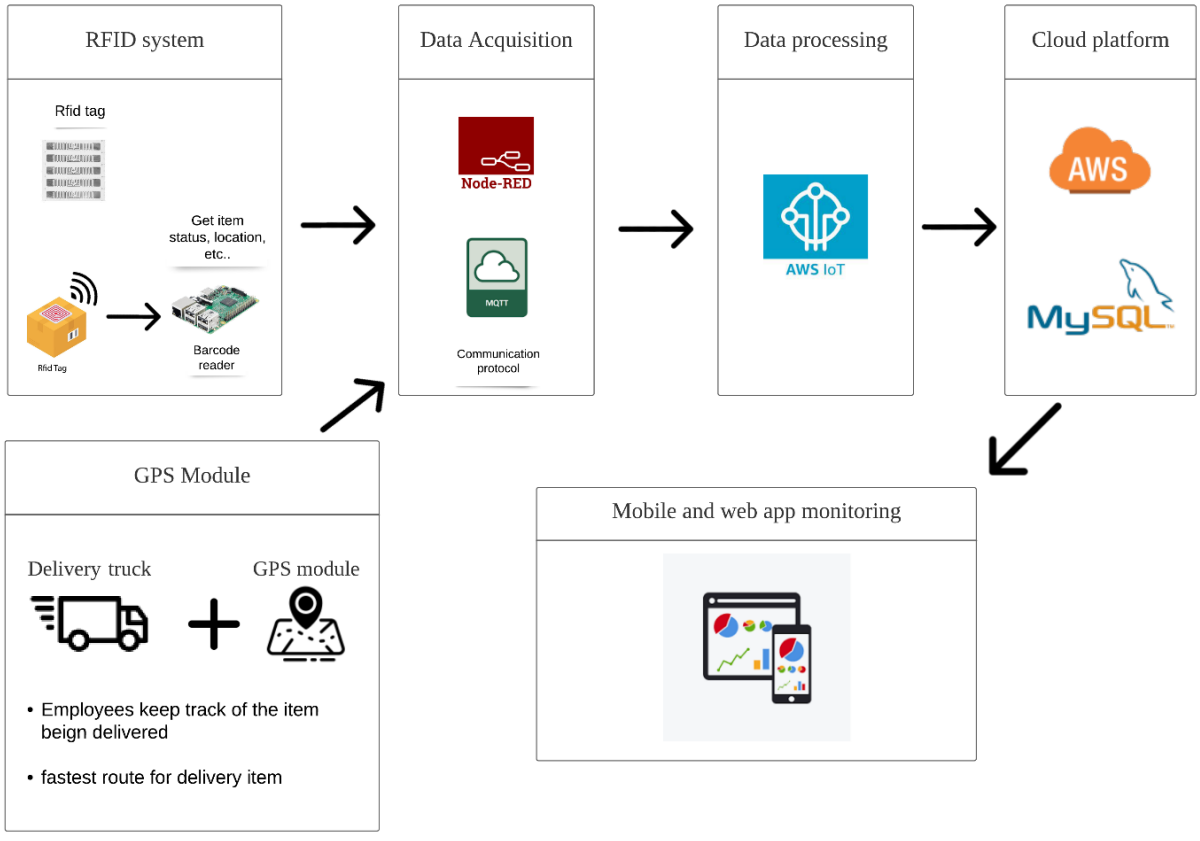


Figure 4 High-Level architecture- Second Solution (Warehouse)

5.3.2.1.2 Delivery

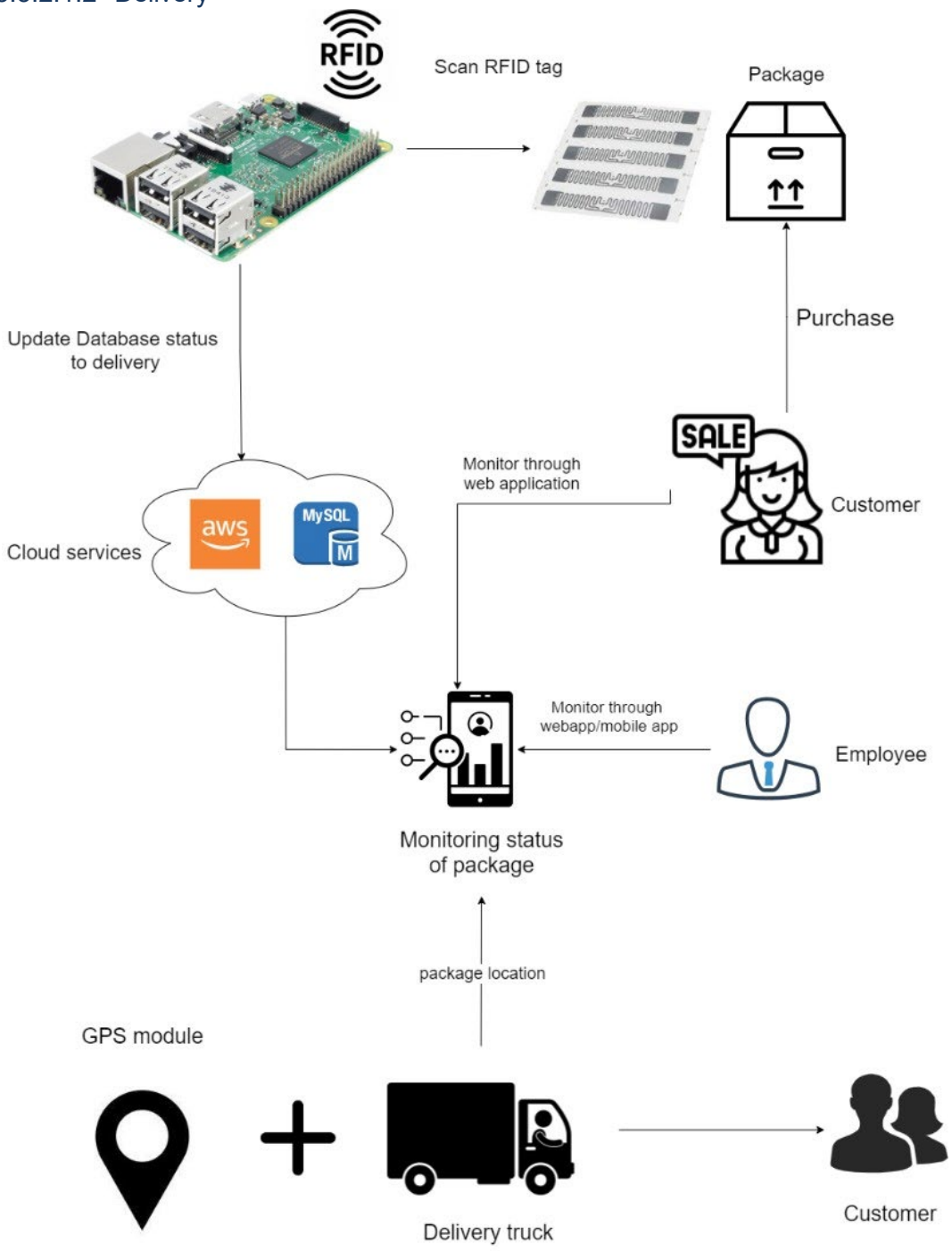


Figure 5 : High-level architecture- Second Solution (Delivery)

5.3.2.2 KoST

Knowledge (problems)	Skills		Technology Gap
	Weak	Strong	
• How large is the volume of the inventory? • How is the item of the inventory packed? Whether the item is pack in one box or in packages. • Does not know the process such as how they gain profit, how they receive and store inventory and types of product and so on.	• **Integrate IoT solutions into mobile application** • **Integrate GPS module to the delivery system to track the item outside the warehouse** • **Integrate RFID tag to item in order to locate them**	• **Communication of IoT devices through AWS cloud services.** • **Connect to a database hosted on Aws cloud services.** • **Setting up basic IoT system such as connection between Raspberry Pi, Arduino and IoT sensor.** • **Develop a web application to monitor the IoT devices.**	• Affordable real-time location GPS • RFID Reader which is made with Raspberry Pi

Table 5 KoST table- Second Solution

5.3.2.3 Cost

5.3.2.3.1 Component

	Item	Price (RM)
1.	Raspberry Pi 2gb ram	174
2.	Raspberry Pi camera	115
3.	LED	0.10
4.	LCD monitor	7.00
5.	RFID Reader	8.00
6.	RFID tag	1.00
7.	GPS	38.50

Table 6 Component Cost- Second Solution

5.3.2.3.2 Component usage

Cost per item (RFID) = RM 1
Cost per fleet = RM 38.50

5.3.2.3.3 Usage scenario item

Cost per RFID scanner = Raspberry Pi (RM 174) + RFID reader (RM 8)

5.3.3 Third Idea

- Everything is automated such as using conveyor belt and RFID machine to register each package
- Robot that replaces storekeeper to manage the warehouse.
- Use machine learning to decide the most suitable place to store the item
- Delivery system has GPS module that can give fastest route for delivery of item

The solution for the third idea is a fully automated IoT supply chain system. Instead of having to scan or register each item one by one. This solution uses the combination of conveyor belt and RFID machine to register each package automatically. After the product is registered into the database, the automated forklift will manage or store the item to their respective location without the need of a storekeeper. According to Mishra and Mohapatro (2020), IoT system in supply chain system itself does not have a holistic intelligence on the inventory of the warehouse and instead, only knows the movement of item in and out of warehouse. Therefore, the third solution also has a machine learning integrated to help the store owner to decide where the best placement of the product is based on their size, quantity and how frequent is the product sold.

For delivery, it is like the second idea, which is supported by a GPS system. In addition, it will also be integrated with machine learning to help the driver to decide which is the fastest route to deliver the product to the customer.

5.3.3.1 High-level architecture- Third solution (Warehouse)

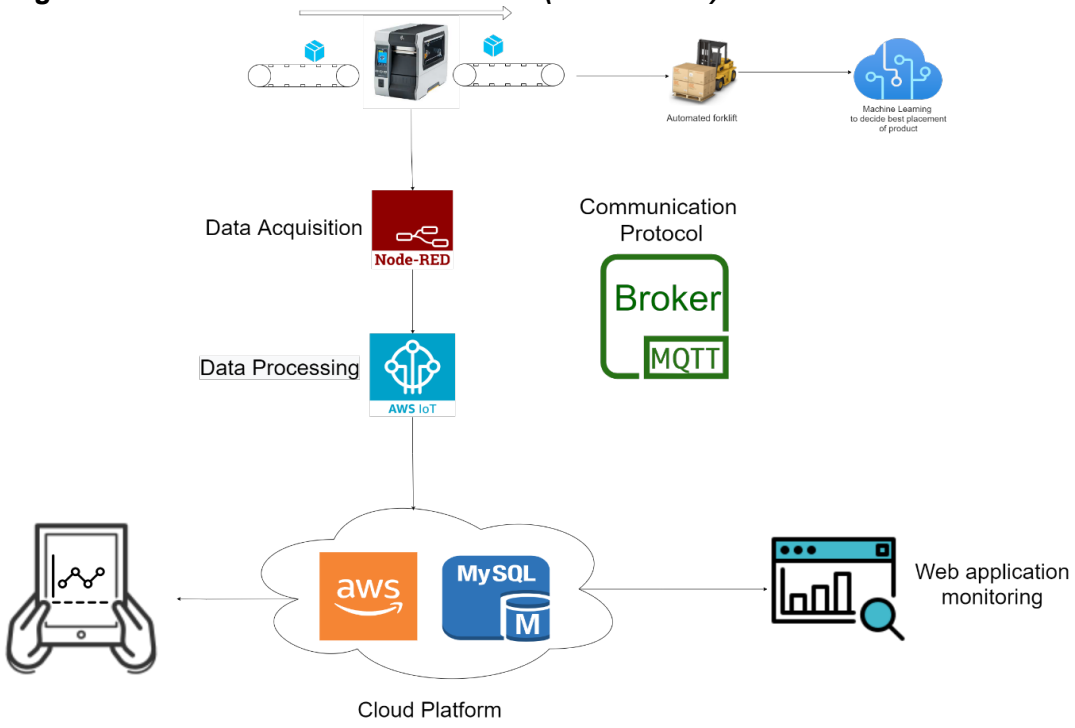


Figure 6 High-Level Architecture-Third Solution

5.3.3.2 High-level architecture-Third Solution (Delivery)

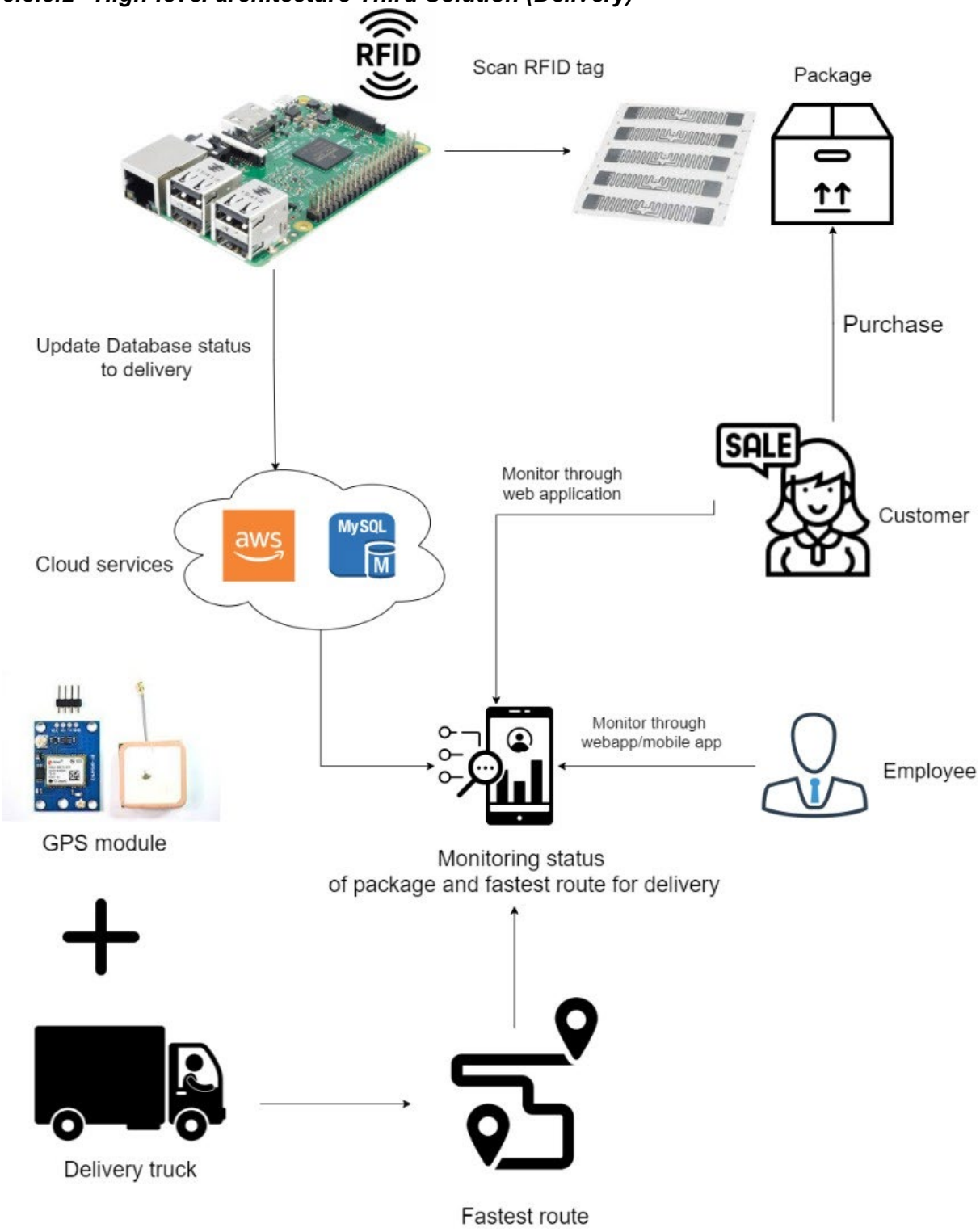


Figure 7 : High level architecture- Third solution (Delivery)

5.3.3.3 KoST

Knowledge (problems)	Skills		Technology Gap
	Weak	Strong	
• How large is the volume of the inventory? • How is the item of the inventory packed? Whether the item is pack in one box or in packages. • Does not know the process such as how they gain profit, how they receive and store inventory and types of products and so on. • Does not know how to operate the conveyor belt and RFID machine due to its complexity • Does not know in depth whether the machine learning are capable enough to have an automated forklift to manage the warehouse	• **Integrate IoT solutions into mobile application** • **Integrate RFID tag to item in order to locate them** • **Integrate GPS module for delivery truck to use fastest route for delivery**	• **Communication of IoT devices through AWS cloud services.** • **Connect to a database hosted on AWS cloud services.** • **Setting up basic IoT system such as connection between Raspberry Pi, Arduino and IoT sensor.** • **Develop a web application to monitor the IoT devices.**	• Affordable real-time location GPS • Use robot/automated forklift to replace store keeper to manage the item • Machine learning to select best place to store the item • Affordable real-time location GPS • Portable RFID Reader which is made with Raspberry Pi

Table 7- KoST table - Third solution

5.3.3.4 Cost

5.3.3.4.1 Component

	Item	Price (RM)
1.	RFID scanner machine	Unknown
2.	RFID tag	1.00
3.	GPS	38.50
4.	Automated forklift	Unknown
5.	Conveyor belt	Unknown

Table 8 Component Cost - Third Solution

5.3.3.4.2 Component usage

Cost per item (RFID) = RM 1

5.3.3.4.3 Usage scenario item

Conveyor belt to RFID scanner machine= RM?

5.4 CHOSEN IDEA

The chosen solution is the **First Idea, the Barcode and RFID for supply chain inventory management.**

The idea is chosen based on the KoST analysis and also the cost feasibility of the solution. The chosen solution, when compared to second idea which is the **RFID for supply chain inventory management** is quite similar. The knowledge and the time taken for the chosen project will be slightly more than the second idea. However, the first idea is chosen because it aligns with the project objective which is to have an affordable supply chain management system for small and medium businesses. As the second idea might be costly due to the use of thousands of RFID, it might push away the warehouse owner from adopting the IoT system.

The third idea is rejected because it is deemed close to impossible to be done due to the high lack of knowledge, unknown time needed to deliver the project and also unknown cost needed to build the project.

5.4.1 Hardware

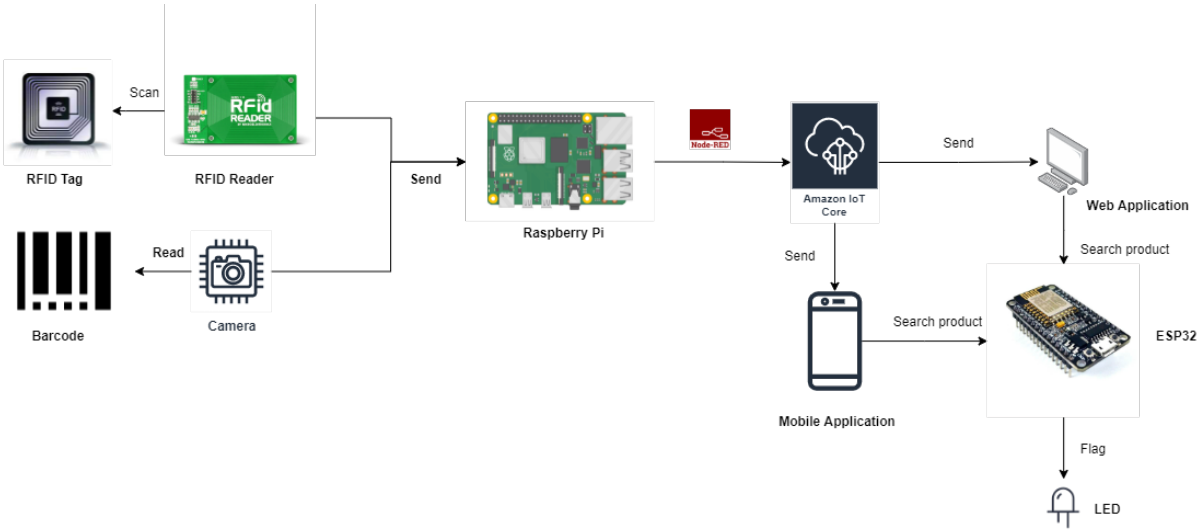


Figure 8 Hardware architecture for solution

5.4.2 Software

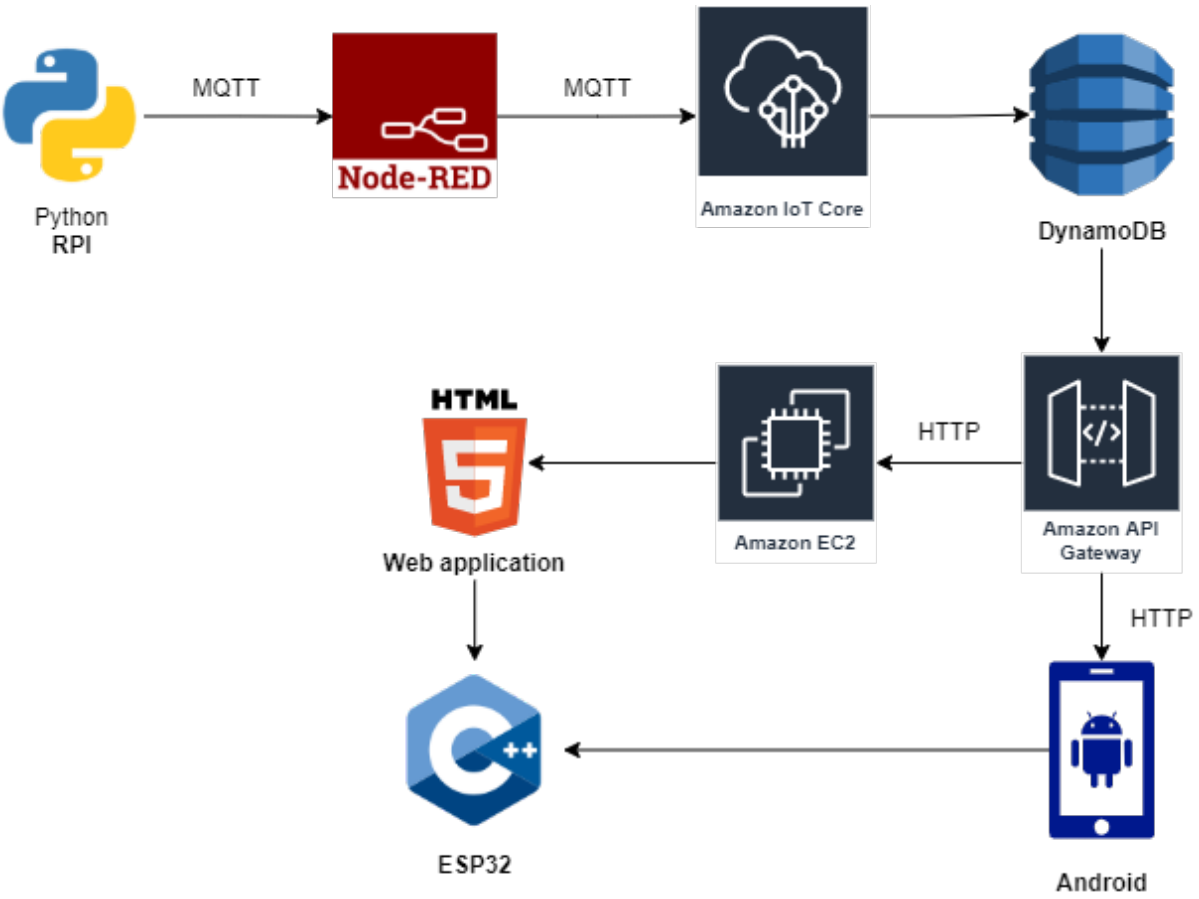


Figure 9 Software architecture for solution

5.2.3 Network

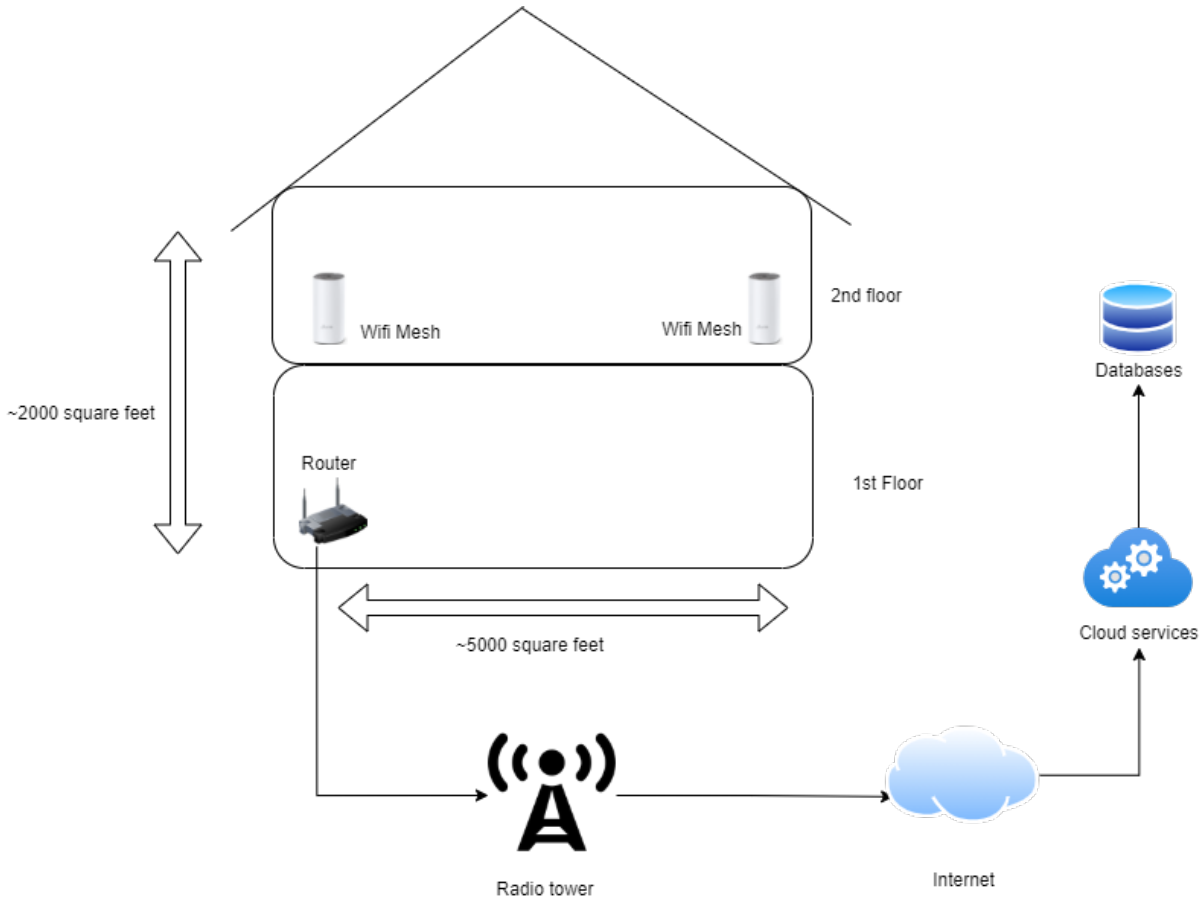


Figure 10 Network architecture for solution

5.2.4 Use Case

Use case view

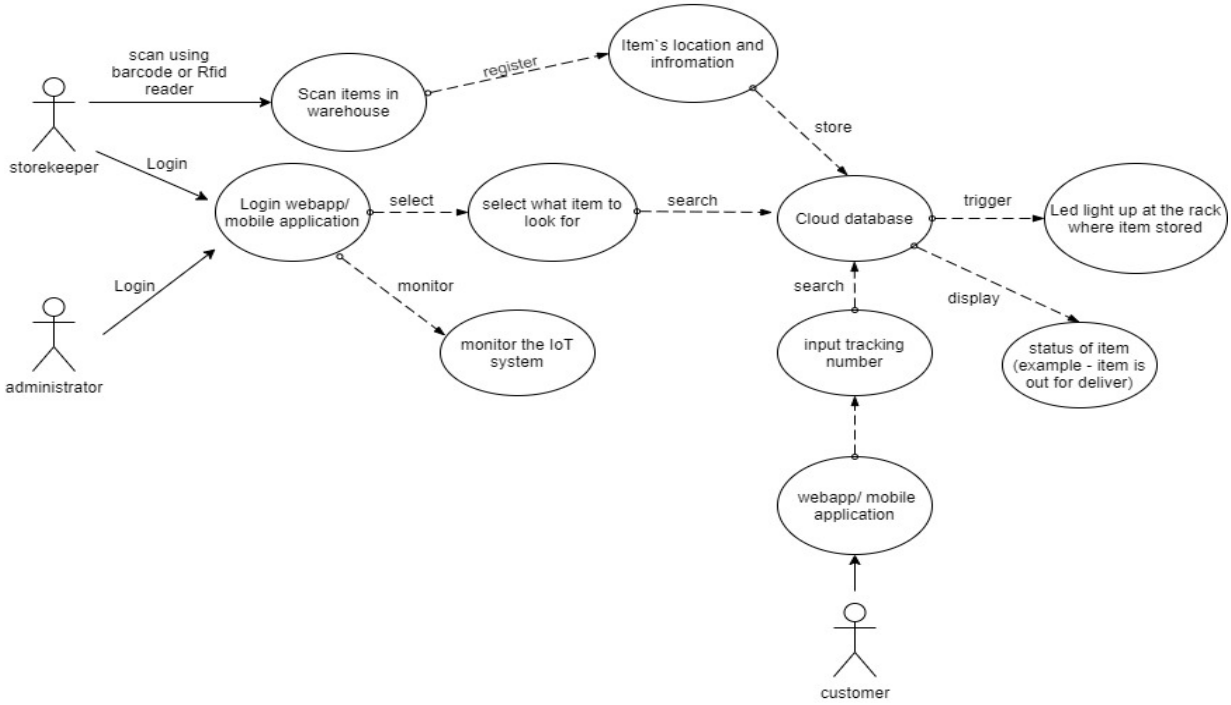


Figure 11 Use case for solution

5.4.3 Data flow

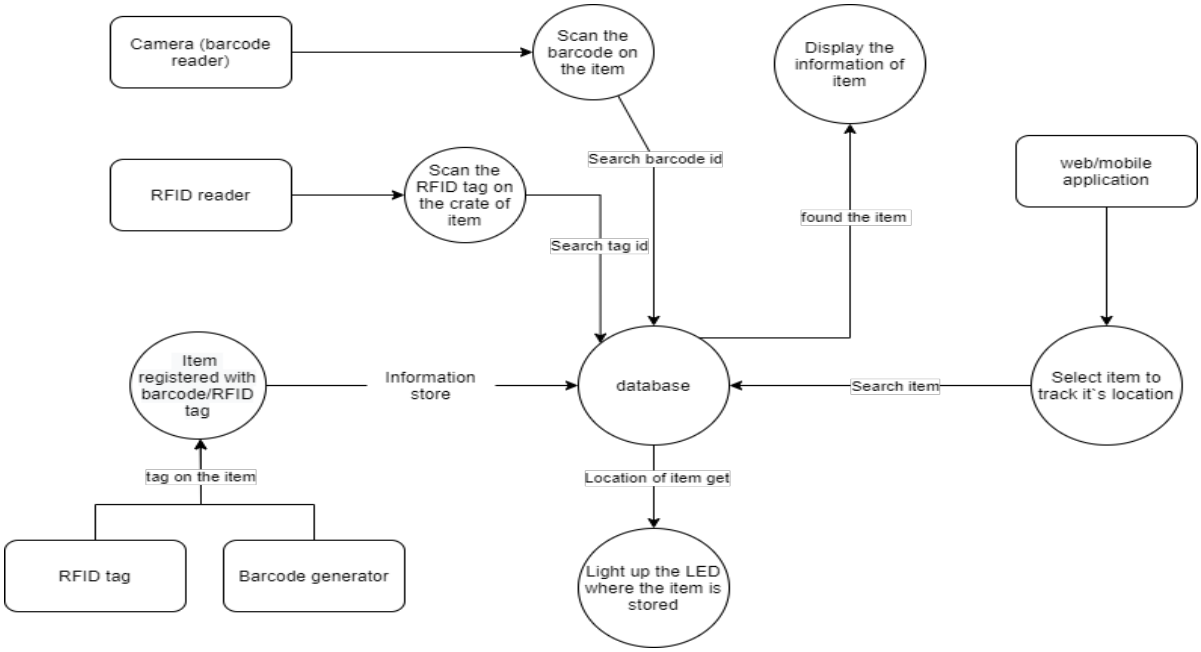


Figure 12 Dataflow for solution

6 QUALITY MANAGEMENT

No	Product Backlog Item	Quality Attribute	Definition of Done	Justification
1	Connect to local area network	**Availability**	It can connect to the internet and maintain the connection continuously for 24 hours throughout the warehouse (~2000sq.ft x~5000 sq. Ft)	Unstable internet connection might cause disconnection of RFID/ barcode scanner.
2	Databases for package content	**Integrity**	Users without authorization or high-level privilege will not be able to access the database	Insufficient security can cause data to be accessed by unauthorized people
3.	Databases for package content	**Functional completeness**	Can store data of the package content in the database and data can be retrieved.	Difficulties in managing the information of package and data storage of item in warehouse will be inefficient
4.	Mobile application for admin retrieves package information	**User interface aesthetics**	Information that is displayed on mobile application is neat and user can understand package information	Incorrect or messy information displayed will cause confusion to the admin/user
5.	Web application for admin to manage and monitor the warehouse	**Functional completeness**	The admin can add, delete, and edit the information of item in the database and monitor the warehouse using the website	Difficulties in making changes to the item information and monitor the warehouse
6	LED to flag item that are being searched for	**Functional completeness**	The LED will be able to light up and flag the item that is searched by the storekeeper	The storekeeper will have difficulties in finding the exact location of the item that is being searched for
7	Update the details of an item by scanning the barcode when is purchased by customer	**Modifiability**	Make sure that the status of an item can be updated without causing any impact to the IoT system	Without the ability of updating the status of items, customer will have problems of being uninformed of their purchases.
8	Notification system to notify warehouse owner on product that is	**Functional completeness**	The system can send notification to the warehouse owner whenever the product	The warehouse will be filled with dead stock without the warehouse owner

	stored for too long		is stored more than a year	notice.
9	Barcode generator function on web application	**Functional correctness**	Can create barcode anytime when needed	Can't store information of item in barcode
10	Develop a node platform for packages	**Functional completeness**	Can receive data from all the nodes	Difficulties in collecting all the nodes data to be processed
11	Self-made portable RFID scanner that will be used to scan the crate of item.	**Functional completeness**	Able to scan RFID tag and retrieve information from the RFID tag	Item management will be difficult because there is no information on a crate of item.
12	Self-made portable barcode scanner that will be used to scan the barcode of an item.	**Functional completeness**	Able to scan the barcode and retrieve information to the barcode	Item management will be difficult because there is no information on the item
13.	Cloud setup and connectivity	**Interoperability**	Cloud services can receive data from the IoT system without any issue	Risk of losing all the data due to having a local database if any natural disaster or accidents happen to the warehouse

Table 9 Quality management table

Resources

Provide a summary of the team members and their roles.

	Name of student	Roles
1	Dennis Lim Chia Yin	**IoT system developer-** Develop the hardware for IoT system such as nodes, sensors, and actuator for the system. Nodes platforms are also included as the job of IoT system developer. **Cloud Developer –** Develop the cloud architecture to be integrated int o the IoT system. Manages Cloud Databases and AWS IoT Core.
2	Darrell Lai Vui Kiat	**Cloud Developer –** Develop the cloud architecture to be integrated int o the IoT system. Will develop the backend for the admin webpages and APIs on the cloud. **Web Developer –** Develop the webpages for the IoT system. The webpages develop will be able to manage and monitor the IoT system. Separate web pages such as customer website will also be developed to allow them to search for the status of their orders.
3	Gabriel Kong Qi Hao	**Scrum Master –** Manages and facilitates the team to ensure that the team follow the processes that has been planned. Taking down minute meetings and task of each team members. Ensure that all the team members complete their task in time. **Mobile Application Developer –** Develop the mobile app for the IoT system. The Mobile Application developed will be able to monitor and scan the barcode on the item to update the status of the product. The Mobile app can be used by storekeeper to search for items, or customer to search for the status or their orders.

Table 10 Roles and responsibilities

Approval Signatures:

Project Team

	Name of student	Student Id	Signature
1	Dennis Lim Chia Yin	101209934	LIM
2	Darrell Lai Vui Kiat	101209714	LAI
3	Gabriel Kong Qi Hao	100078751	KONG
4			

Project Sponsor [Mark Tee Kit Tsun]

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