IOT BASED SUPPLY CHAIN MANAGEMENT

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Declaration

We, hereby declare that this thesis is based on results we have found ourselves. Materials of work from researchers conducted by others are mentioned in references.

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ABSTRACT

Beginning from the evolution of industrialization, planning, production and distribution has always been the significant process. For manufacturing and distribution of the products from company or suppliers to the customers involves many things e.g. people, information, materialistic resources etc. This vital process, known as Supply Chain Management (SCM) when collaborated with Internet of Things (IoT) can result into greater possibilities in different aspects of supply. In this paper, we focused on the integration of IoT with core features of supply chain management, which are production, packaging and delivery of the product. In this system, clients can place order online, and for packaging and tagging, we have used RFID tags, which can be read for keeping information about the product in different warehouses. For ensuring a user friendly delivery experience, we have used Ai-Thinker A7 module, which is a combination of GPS, GSM and GPRS system that continuously updates the vehicle information in cloud server through which clients can easily track their products' location. The main purpose of this research is to make automated SCM and increasing efficiency using IoT.

Acknowledgement

First of all, we would like to express our gratitude to Almighty Allah for keeping us safe and sound to initiate the research work and to put our best efforts and successfully complete it. Secondly, we would like to thank and show our immense respect to our honorable Supervisor Dr. Amitabha Chakrabarty, for his enormous contributions, incomparable guidance and tireless support in conducting the research work and preparing this report. His constant involvement and supervision ensured our gradual progress towards the completion of this thesis work. We are really grateful and humbled to have him as our supervisor. We also thank our parents as well as our beloved friends for the patronage, moral support and aids. They helped us a lot with their valuable suggestions and direct or indirect participation which helped us maintaining a better workflow and achieving our goal. Our heartiest gratitude to Tasnia Ashrafi Heya, Research Assistant of Department of Computer Science and Engineering, BRAC University for her excellent support and guidance regarding the research and preparation of this report. Last but not the least, we would like to thank specially our very own BRAC University for providing us the opportunity to conduct this research.

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CHAPTER 1

Introduction

This chapter gives a general review of the purpose of this research work and an overview of the entire research. It also includes the basic idea of Internet of Things (IoT) and supply chain management. Supply chain is the sequence of steps required to deliver the service or product to the customers beginning from the storage and movement of raw materials for production. With constant advancement of the industrialization, supply chain has become an important aspect. For any business that has the demand-supply factors, supply chain management is an important matter to consider. It provides information about manufacturing status, locations, product conditions etc. Supply chain management (SCM) follows 5 fundamental phases to maintain an effective outcome. These are: planning, source, execution, deliver and return [1], each of which are comprised of many small but crucial tasks. Hence, each and every task of SCM needs more supervision and caring.

Internet of things (IoT) refers to the system of devices that are wirelessly interconnected among themselves over the internet and can communicate with each other without the human interaction [2]. IoT is now the emerging idea in the sector of research and development that has already been active in many research fields. It is one of the most promising innovation for preparing any automated system. It provides authorized access to its information and there is hardly any technical error. Henceforth, considering the capability of IoT and the significance of supply chain process in the business sector as well as the industrial development, this research work has been conducted in order to propose a simpler and efficient way of management through integration of IoT with SCM.

1.1 Motivation

The process of supply chain involves almost everything from sourcing to production, even maintaining the operational information that need constant supervision [3]. The management of supply chain process cannot be much easier with IoT. One of the grievous reasons is people have so many limitations of time, speed, perfection and memory. Our core inspiration for doing this project is to make collaboration between IoT and Supply Chain Management and help the world of logistics, providing a smarter way to conduct their tasks.

1.2 Objective

The main objectives of this research are following:

- Ensure perfection, more efficiency and faster processing
- Precise data over the whole chain anytime and at any area
- Transparency to all the concerned organizations
- Traceability of every activities during the process
- Ease of maintenance with consistent automated supervision
- Minimize the entire efforts and struggles of supply chain process

1.3 Methodology

In this research, we have tried to incorporate IoT with SCM. For this, we have used online website or android application to take orders from the clients with online payment gateway system. After sourcing of the raw materials and production, while packaging the products, we tagged those using RFID tags and information about each package has been stored in the database. As the products have gone out from or entered in the warehouses, the tags are read and status have been updated. During the transportation, vehicles are tracked using GPS module, which consistently updated its location into the cloud server through GPRS communication.

1.4 Thesis Overview

In this report, chapter 1 is the introduction of our research work. We also have mentioned our motivation and objective to do this research as well as short overview of the methodology we followed.

Chapter 2 consists the literature review where we have demonstrated the background study that we have done for this thesis.

Chapter 3 is the section where we have presented our planning and workflow of the overall research, along with the short descriptions of the devices we have used.

In chapter 4, we have described about our implementation of the idea and results to strengthen our claim and the outcomes.

Chapter 5 contains the conclusion and future possibilities and planning of this research.

CHAPTER 2

Literature Review

In this chapter, the concept and background study required for this research work has been stated. The study includes understanding the process of supply chain, its various aspects and also the concept of IoT and other functionalities that have been implemented in this project. Supply chain management is represented as a set of associations which are connected by the exchange of services, information and product in between customer and company [4]. Supply chain management (SCM) is a best possible field to such provision. SCM is the approach that deals with the development of crude material into and association and it is conveyed in both indoor and open air condition and the data refreshes about the merchandise are transferred in the server with the assistance of IoT [5].

Supply chain management was first introduced by Keith Oliver in an interview for the "Financial Times" in 1982 [6]. According to the definition of supply chain management, it is the maintenance of a system and business proceedings that consists processing of production ingredients, production and the distribution of the produced goods. It can also be called the technique of delivering the correct product at the due place, within the due time period and must be within the fairly cost [7].

Figure 2 Phases of supply chain management[1]

[1] Source: Phases of supply chain management [Digital image]. Retrieved March 01, 2018, from http://holisollogistics.com/supply-chain-management-process-five-steps-for-building-excellence/

As supply chain depends on five basic phases [1], it needs various calculation operations and immense analysis needs to be done for a better outcome. Some of the measurement factors are- product flow, inventory turnover, cash flow etc. Based on Internet of Things, manufacturers, wholesalers, transporters, retailers can analysis the product flow, cash flow, information flow which they generated. So the supply chain can be optimized and enterprise can make quickly optimal decision with the information on supply chain [8]. SCM provides information about manufacturing status, locations, product conditions etc. To track these product inside the industry, RFID is used for information and outside the industry, GPS is used for location tracking [9].

With better visibility provided by RFID, the supply chain performance can be analyzed in finer granularity and improve its performance accordingly. With the real-time full visibility provided by IoT, supply chains are evolving to become more and more cost-effective, information-shared and environmental-aware [10]. Supply chain monitored using RFID and IoT should result in better and faster outcome.

2.1 Supply Chain Management (SCM)

Supply chain management is mainly managing the demand and supply by maintaining the legal business policy and client satisfaction. It starts with the Material Requirement Planning. The key parts of Material Requirement Planning (MRP) are gross requirements, schedule receipt, inventory on hand, planned receipt and planned order release [11]. As soon as the process of MRP is done successfully, the production starts. Organizations progressively are getting to be plainly mindful that their chance to having a focused edge in business can come through inventory network. On account of organizations working on worldwide scale, inventory network systems drive operational efficiencies and influence all that really matters.

On completion of the production, the product is ready for packaging and delivery to the customers. The process of packaging and delivery also needs several steps i.e. request choice speed, correctness and effectiveness are impacted by bundle identification, configuration, and taking care of simplicity. After this, the product can be either delivered to the customer directly or via wholesaler, retailer, distributor etc. All these steps need much more efforts and human power to manage the whole process of supply chain properly. Supply chain is a crucial strategical backbone to any business organization. Therefore it is considered very carefully. Lots of other economic and global as well as

international aspects depend on its success. Thus a proper and perfect planning and system to run the whole process of supply chain is noteworthy.

2.1.1 Importance of SCM to organizations

Let us consider one simple real life example. Whenever a new product is introduced in the market, every sales point or retailers or stores need to have that product available. A little problem in the delivery of that newly launched product or service might make the customer lose their interest or demand, which is surely a hazardous event for that product and economy of the company [7]. Hence, companies and business organizations make thorough analysis before launching any product and as soon as the product is delivered to almost all the outlets or stores, it is announced. Inventory monitoring and control is a key function for SCM since is any loss in the inventory placed anywhere, might cause huge loss in the business value.

2.1.2 Key functions of SCM

Supply chain management is definitely a broad sector that consists of almost all organizational and operational activities, not only confined within manufacturing and delivering. Some of the areas that play important role for success of the supply chain are sourcing strategy, inventory management, inventory monitoring and controlling, logistics management, warehouse planning, product information processing, financial analysis, delivery issues etc. For all these operations, information technology plays a vital role. Other aspects such as freight management, contract and paperwork, international logistics etc. are also crucial for overall strategy of supply chain success.

2.1.3 Problems and Constraints

The person who leads a supply chain process, faces many problems. One basic problem is the scale of the project. Since supply chain is a dynamic and large scale process, therefore controlling it is a difficult job that requires monitoring and supervision. Another issue is the right choice technology and its implementation. Various sensitive issues are also responsible for failure of the process or delayed delivery. Such as – damaged products, shipment to wrong address, careless driving, product lost etc. are reasons for the delay in delivery [12]. Reducing these types of problems and issues is the best way to provide customer and clients complete satisfaction.

2.2 Internet of Things (IoT)

Internet of Things is just as it sounds. The only thing to understand is, by the term 'Things' everything can be meant including the animals, sensors, devices, even the natural ingredients [13]. To simply put, IoT connects all the things through internet and creates an automated system. For the consistently developing technological era, IoT can be used to collect data, and by processing those data, any task can be done automatically as per requirement [14]. Since IoT is a broad sector which encompasses several other processes [15], thus to simplify, it has been illustrated as follows:

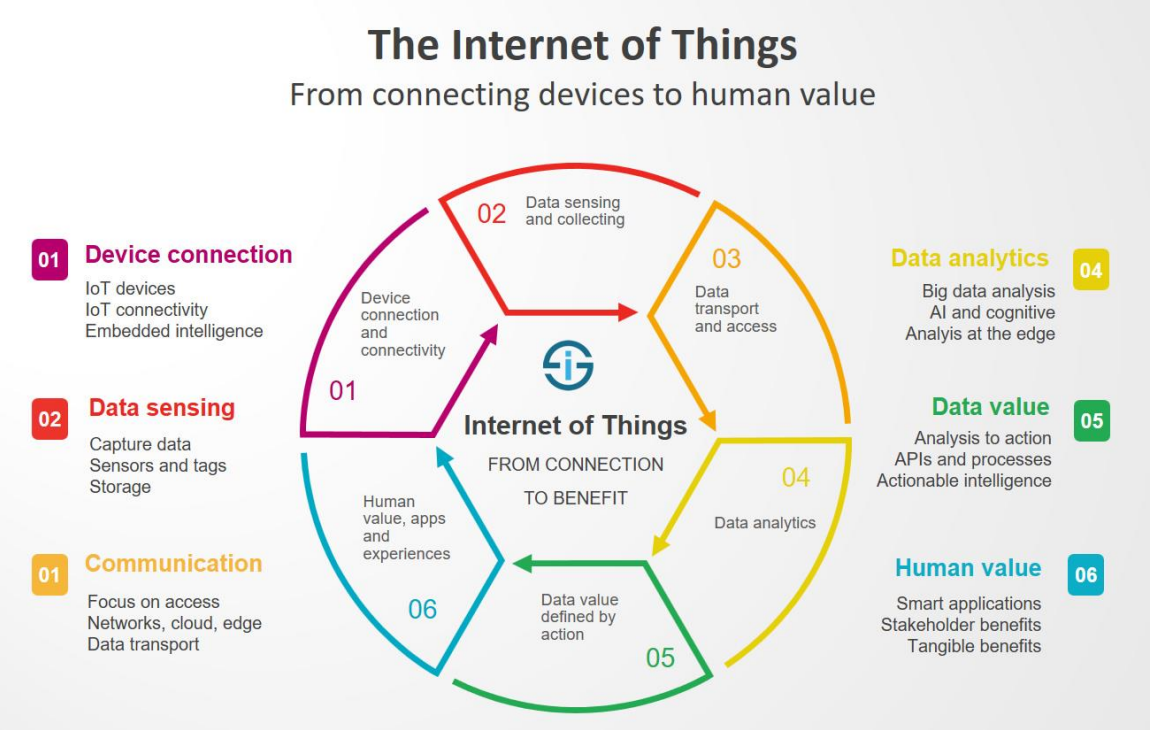

Figure 2.2 Internet of Things[2]

2.3 IoT and Supply Chain Management

Internet has revolutionized our way and standard of living. With the advancement of technology, business and other sectors are also developing faster. Supply chain has also been impacted by the internet in various ways which enabled many possibilities. Internet of Things should be integrated with supply chain in order to enhance transparency and maturity of the business, reduce the transaction time, precise tracking of product location, reduce the logistics expenses, increase efficiency, make data analysis

[2] Source: The Internet of Things redefined – from connecting devices to creating value [Digital image]. Retrieved March 09, 2018, from https://www.i-scoop.eu/internet-of-things/

easier and receive real time notifications [16], [17]. These features are very noteworthy and important for a successful management of supply chain process. As a result, IoT and supply chain management, when combined, generates greater opportunities delivering more customer satisfaction.

2.3.1 Transparency and Visibility

By using IoT with supply chain, it can be ensured that there would be full credibility and transparency to all the parties involved in the process such as, manufacturer, wholesaler, retailer, most importantly clients. Transactions via verified payment gateway system and respective product information access to the clients ensure the success of supply chain process as well as business.

2.3.2 Data analysis and improved efficiency

Without implementing IoT, data storing and analysis in supply chain sector would be a lot responsibility. IoT makes it simpler, as the devices connected through internet automatically exchange data and stores them online. Similarly, when needed, those information can be accessed at any time and after analysis, valuable business decisions can be adopted [16]. This also increases the productivity and efficiency of the business. Automated system does everything quickly and almost perfectly that better efficiency can be obtained and proper planning also results in more productivity.

2.4 Payment Verification

2.4.1 Importance of payment system in SCM

Previously, the payment in businesses was done by hand written documents or paper work. Moreover, clients had to run from bank to bank for payment and the company or business organization also had to do the same. However, in the present age, the scenario has changed. Now, the whole system is leaning towards e-banking or online payment methods. Most of the companies now use EIPP solution in a wider basis [18]. It is secured and faster. The importance of payment system in SCM is thereby inseparable.

2.4.2 Advantages of BrainTree

We have used BrainTree for following reasons:

- Very good integration system with websites.
- Provide excellent customer service.
- Multi-currency option is available

- No extra fee is needed.

Braintree offers vendor accounts and an installment entryway, with a high level of adaptability and various administrations accessible at no charge past handling expenses [19]. This organization forms in excess of one billion exchanges for each quarter — that is in excess of 4 billion exchanges for each year [19]. Braintree has a simple occupation with regards to straightforwardness. It uncovers all rates, expenses, and imperative legally binding stipulations on display, with positively no curve balls.

2.5 Chat bot

A chat bot is a software which is made or intended to copy discussion with humans [20]. Chat bots address advising organization that empower customers to arrange quires towards a “bot” that responds as requirements be [21]. The first chat bot Eliza, was built by MIT researchers in 1964 [20]. The chat bot utilizes NLP (Natural Language Processing) to endeavor to comprehend what you are saying to it and after that it answers in like manner. Instead of going through website, one can use chat bot to look things for them and it will do its work.

2.5.1 Importance of chat bot

According to recent reports, 40% of consumers prefer to deal with chat bots to human interactions [22]. So, why do we need chat bots? Why we cannot just use man power? The reasons are:

- Now-a-days client invests more time approximately 90% of their time [21] in messaging system apps on cell phones than they do on web based networking websites or media.
- From updates and arrangements to item dispatches, chat bots can keep clients on top of it without spamming them.
- Chat bots can serve multiple clients in a row more preciously and quickly than human being.
- According to tech analysts, the machine learning bot is able to project any data required [22].
- The ultimate functionality of chat bot is to give another layer of client benefit that makes the clients' life less demanding.

In corporate world, chat bots are becoming more popular and gaining a place in various fields including bank and supply chain management. According to Hot Trends in

Supply Chain report, in 2017, 51 percent of businesses are engaging with chat bots [23]. This report also suggests that we are one step closer to the year of chat bot [23].

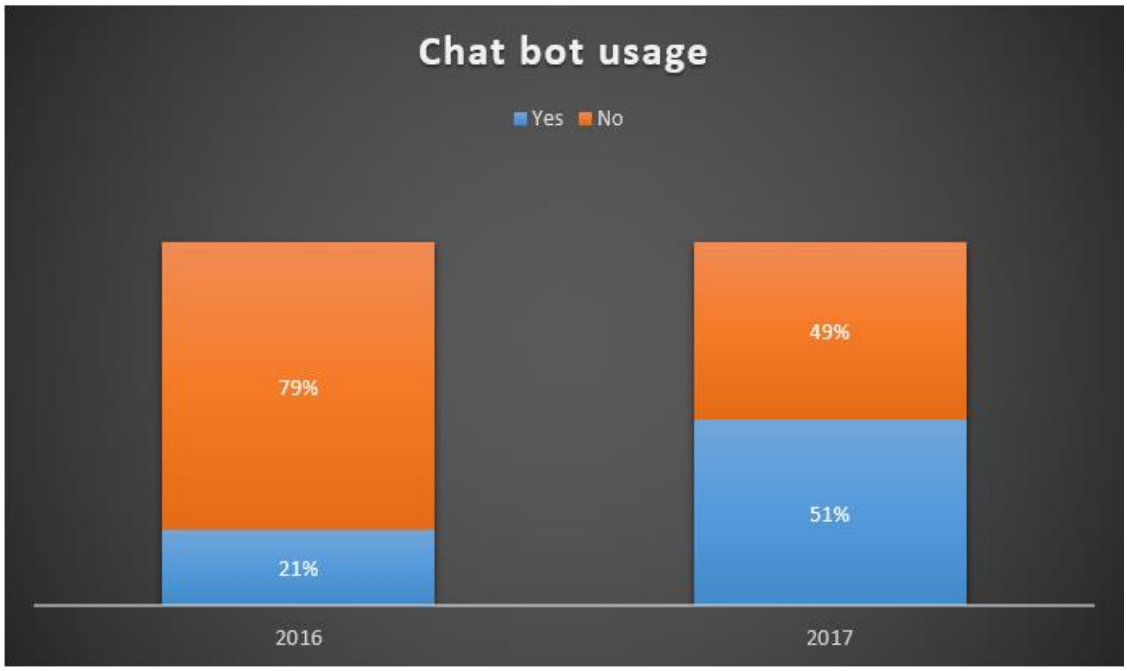

Figure 2.5.1 Impact of chat bot in supply chain management

Here are some reasons why chat bot is important for supply chain management:

- By using chat bot in SCM system, it will help companies for better B2B and B2C communication. Due to its quick action, it helps to get better results.
- Chat bot can also work with all the paperwork, selling orders, updating orders, canceling them with additional charges.
- Chat bot can also build to check out all the suppliers from market. This helps companies to get to know more about their supplier.

2.6 Vehicle tracking system

Whether a company is start up or well-known national or international, it is very important to know every one of company's vehicles location. Without the tracking system, delivery service may fall in great danger.

Vehicle tracking system means putting a GPS device in vehicle which continuously updates the location of vehicle and send it to main server. By using this service, company's authority will be able to know the exact vehicle location. According to Frost & Sullivan, GPS based vehicle tracking system saves up to 20-25% fuel, 20-30% idle time, 5-10% miles driven [24].

Figure 2.6 Impact of vehicle tracking system on supply chain management[3]

2.6.1 Importance of vehicle tracking

GPS vehicle tracking system is easily scalable. This gives companies option to locate the vehicle as well as the speed of the vehicle. This system helps companies to improve vehicle routing, customer relationship and other aspects. Besides, there are other reasons why vehicle tracking system is important for supply chain management:

- It also allows to check past data and plan routes based on that data.
- This system increases visibility among stake holders.
- Vehicle tracking system also deals with theft problem. This system gives continuous data of its location so that companies can track their materials and equipment and recover even if they are stolen.
- Because of this system, the customer can know the exact time of the delivery and drivers can also be able to know where the location of client is.

2.7 Email validation

Email validation means after sign up or registration on a website, the authority or administrator or the system will send a validation link to check whether a valid person is trying to create an account or not. There are some importance of this process:

- A verified email refers that it is a valid person. It prevents bot to create random account.
- It saves time for both client and authority. If client just click that link, his/her account will be created. S/he does not have to wait for authority's permission and authority does not need to check repeatedly for new request.

[3] Source: How GPS Vehicle Tracking Can Transform Fleet Management [Digital image]. Retrieved March 10, 2018, from http://www.supplychain247.com/paper/how_gps_vehicle_tracking_can_transform_fleet_management

2.8 Sales Prediction

Multiple linear regression is about modeling a data set with more than 1 independent and 1 dependent variable. In multiple regression we possibly work with a number of X variable with one dependent variable Y. It creates a best-fit line through the data. The data is multi-dimensional so when we actually use the least square method where we find the smallest sum of the squares of all the residuals means differences between the data points and the predicted line but for the multi-dimensional is more complicated. The multiple linear regression will identify Beta values (B_1,B_2,B_3,B_4,…,B_{n-1},B_n) where we have 'n' number of independent variables (X_1,X_2,X_3,X_4,X_5,..,X_{n-1}, X_n). These Beta values will be used to predict the dependent variable, y as follows

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + E \quad (1)$$

In equation (1), *E* is the error term.

Decision tree builds regression or classification models in the forms of a tree structure. It separates a dataset into many sub portions, during that time a related choice tree is gradually created [25].

Naive Bayes is used for strings and numbers (categorically) and can be used for classification so it can be either 1 or 0, nothing in between like 0.5 (regression). Naive Bayes does not provide a good result, even after modifying it.

Support vector regression is used to maintain all the main features that characterize the algorithm (maximal margin).the main idea is to minimize error, individualizing the hyper line which maximizes the margin.

2.9 Android Application

As we know, a website helps industry to reach more users, but it is effective to use android app for the services too. The benefits of these Android apps are self-evident. It is much more convenient, faster to access, and keep users up to date with notifications.

CHAPTER 3

Workflow and Devices

This chapter focuses on the workflow of this research, methodology and device description of system.

3.1 Workflow

First of all, as soon as any order is placed, we get the raw materials from the supplier and preserve it in the factory. After that we check the order and make the product. Then we put RFID tag on the product and read with RFID module and raspberry pi.

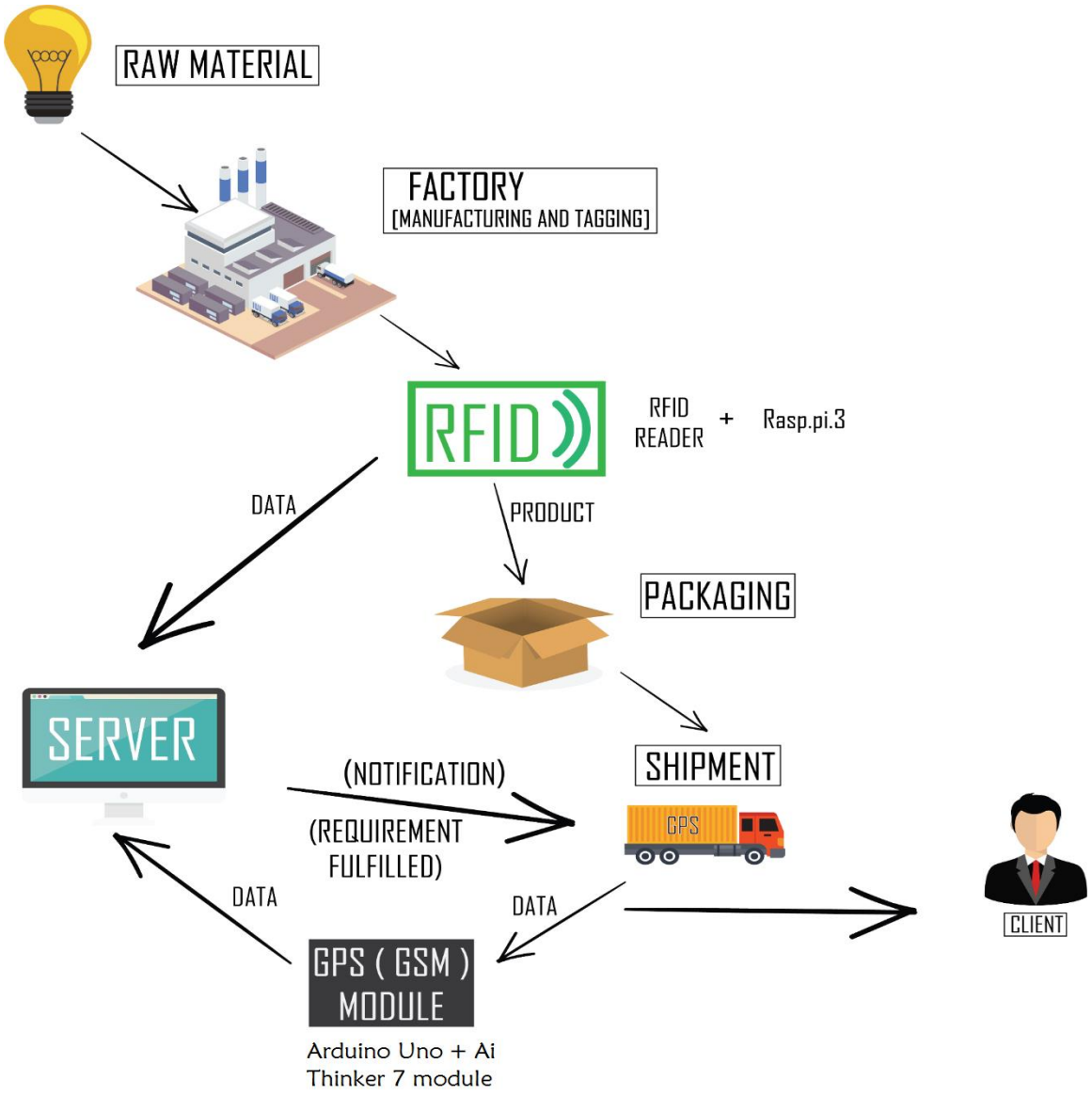

Figure 3.1 Workflow of the proposed system

Then we save the product information in the server and send it for packaging. After that if the order is complete, server send a notification to the packaging department. After getting the notification packaging team will have that order ready for shipment and send it using vehicle. Then we can track the product using GPS and send the data to server using GSM+GPRS module.

3.1.1 GPS system

This is flowchart of our GPS system:

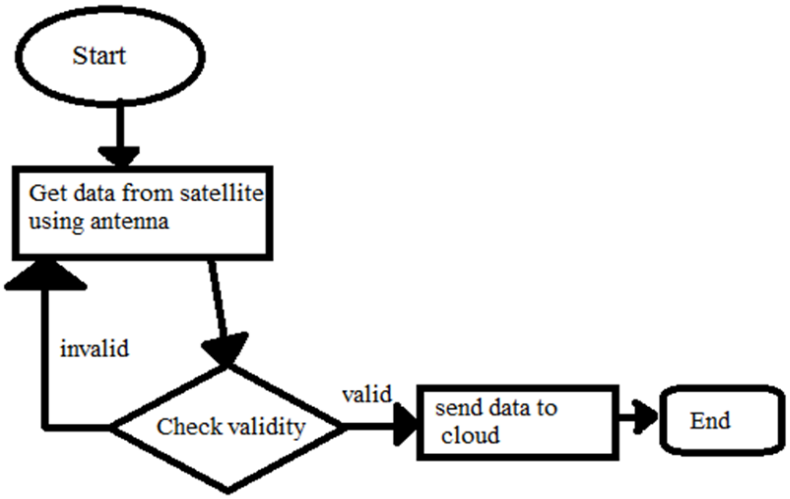

Figure 3.1.1 GPS system flowchart

3.2 Devices' description

To ensure that our system can be affordable and easy to implement, we have used all the common and available components and devices. Since, IoT means the connection of devices, we tried to minimize the human work as much as possible and to make an automated system. The devices and components we have used, are connected to the internet, and therefore required data are always updated in the database server and cloud. Below is the short demonstration of the devices we have used in our system.

3.2.1 RC522 13.56 MHz RFID Reader

This is MFRC522 chip based low cost RFID module. It operates on 13.56 MHz frequency and 3.3V supply voltage. Its reading range is approximately 3cm with supplied RFID card that is also of 13.56 MHz and fob and maximum data transfer rate is 10 Mbit/s. We have used this with Raspberry Pi Model 3B which is connected to the internet.

Figure 3.2.1 MFRC522 RFID Reader and cards

3.2.2 Ai Thinker GSM + GPRS + GPS Module

A7 module is a GSM/GPRS/GPS function module manufactured by Ai-Thinker. It is the latest of its series. It supports GSM and GPRS Quad-Band (850/900/1800/1900 network. Also, it has support for performing voice calls, SMS messages, GPRS communication and GPS functionality. The module is controlled by AT command via UART and supports 3.3V and 4.2V logical level for operation.

Figure 3.2.2 Ai Thinker GSM + GPRS + GPS Module

3.2.3 GPS Antenna

It is a Coaxial Magnetic Antenna with 15.7542GHz frequency. It has halt wave of maximum 1.8 and bandwidth is 10MHz. The operating voltage is 3V to 5V. It is an external antenna that have been used with Ai-Thinker GPS module to obtain better accuracy in the location information.

Figure 3.2.3 GPS Antenna

3.2.4 Raspberry Pi 3

This is called Raspberry Pi 3 Model B. It has an ARMv8 processor, at a rate of 1.2 GHz as opposed to 900 MHz with 1GB RAM and 40 GPIO (General Purpose Input/Output) pins. In addition, it includes Wi-Fi and Bluetooth chip. The Raspberry Pi 3 Model B can be used for both development and more common applications, such as the media center. We have used it to connect RFID reader and send the product information after reading the tag.

Figure 3.2.4 Raspberry Pi 3

3.2.5 Arduino Uno R3

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. This can be powered using 9V alkaline battery or any other power source ranged within 12V. Because of its ease of mobility and size, we have used this to connect with GPS module and receive and update the location status to cloud server.

Figure 3.2.5 Arduino Uno R3

CHAPTER 4

Implementation and Results

This chapter demonstrates the implementation of the whole thesis work followed by the results of those implementation.

4.1 Implementation

The whole concept of our system is to minimize the hassles and make the process of supply chain faster and efficient. This includes a lot of work starting from managing raw materials' storage and inventory management. In order to implement the system we chose to start from production. The website is a basic medium of communication between customers and the producers. We have implemented a website for our research purpose, and integrated various facilities in it such as – chat bot, verified payment system, android application of our website etc.

4.1.1 Front-end view of website

First of all, we build our web page where clients can register their company and place their orders. Here is the registration form for client. All fields are required to fill up. We are making sure that every username is unique. So we check through database if username exists in any table while user is typing username.

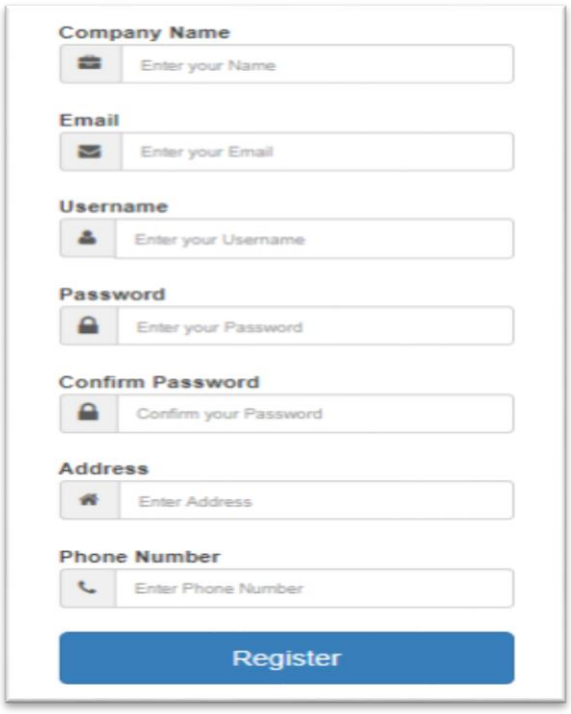

Figure 4.1.1.1 Registration Page

After successful login, admin can do following works:

- Admin can see the employee list and search through the list and delete certain employee while sending a confirmation mail.
- Admin can also see the new and approved order list where he can approve new order by sending a confirmation mail and also assign a manager for that order. Admin can also delete a new order but he have to send a mail why he is deleting the order. Besides, admin can also contact with client for a new order. Admin can see approved order list whether that order is complete or not.
- Admin can see also requested and current client list where he can delete old client and new client request sending a mail.
- Admin can also update their profile by changing password.

Manager has the authority to add, edit and delete driver info. Manager will fill up the form to add new driver. Following is the form for adding driver information:

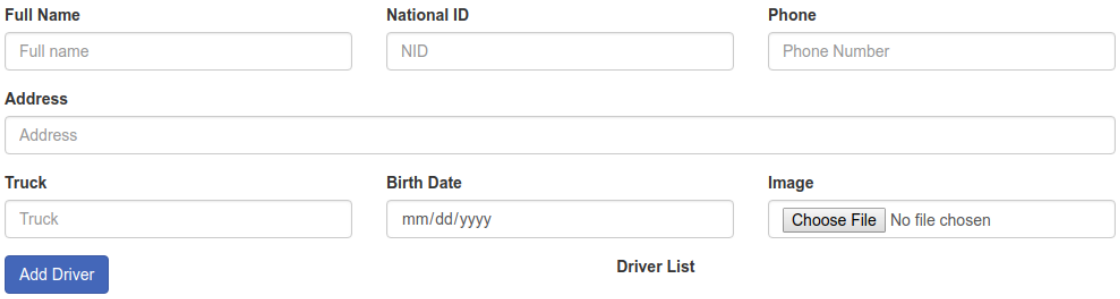

Figure 4.1.1.2 Form of adding new driver

Manager can also see the current driver list. He/she can edit information about the driver and delete driver profile if required. Following is the view of how the driver list is shown to manager:

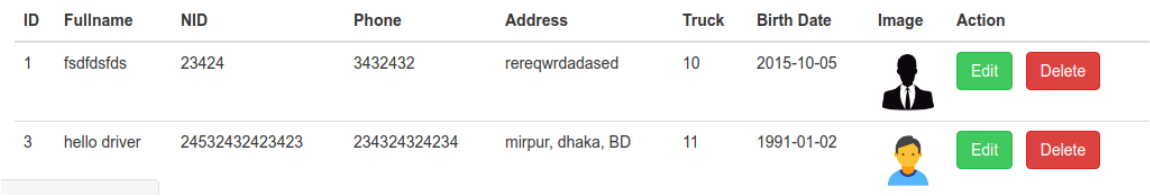

Figure 4.1.1.3 Driver list

Manager can also edit driver's information as stated earlier. If manager wants to edit driver data, a pop up message will come with necessary information to edit which include contact number, address and assigned truck number.

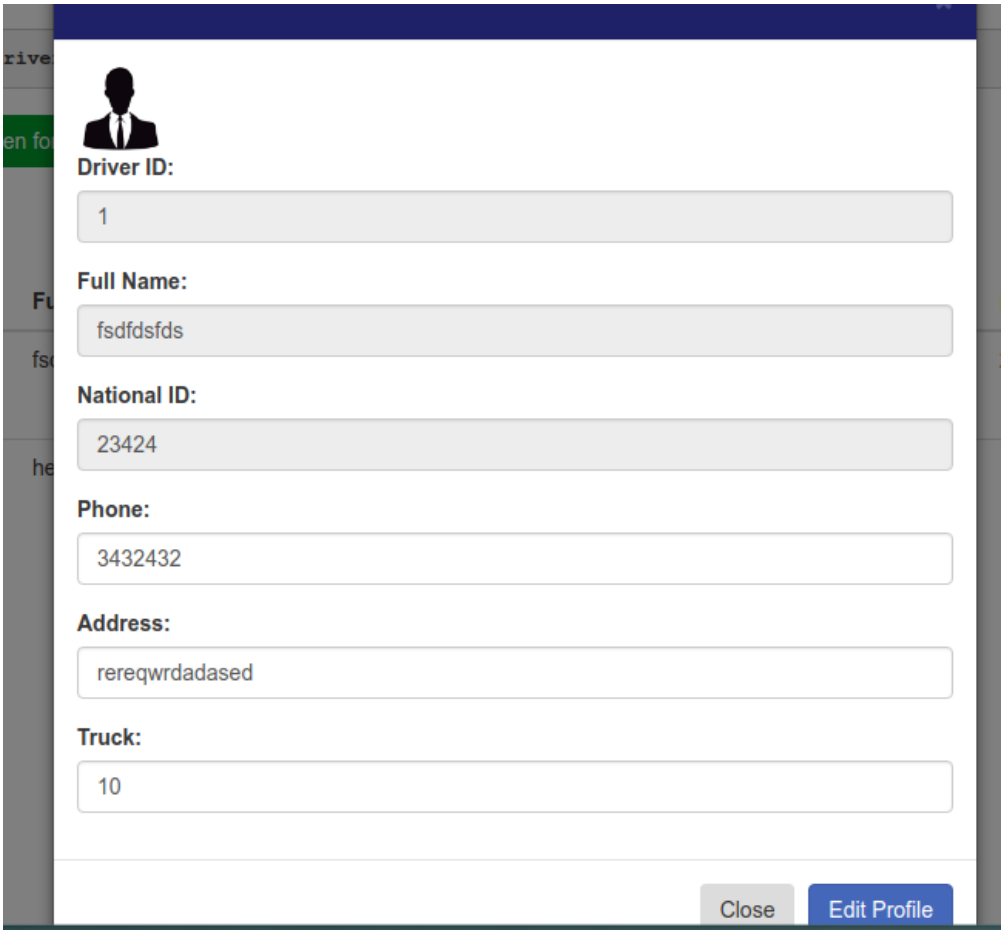

Figure 4.1.1.4 Driver information

4.1.2 Email Validation

We have integrated an email validation process in our website. After client sign up in our website, a validation link will go to client's provided email address with username and password. If client clicks on that link, the account will be created successfully. This has been implemented so that no fake accounts can be created. This also reduce the hassle of checking through each individual accounts and approving them. The outcome of the integration of this feature has been shown later in the result part of this chapter.

4.1.3 Payment System

For payment, we have used BrainTree for our payment process shown in Figure 4.1.3. In our system, client will go to ordering page to make an order. In that page will attached BrainTree payment service. It will ask for card number and expiration date. It can take any type of card for example, VISA, MasterCard etc. After filling all the information properly BrainTree will check if client provides correct information or not.

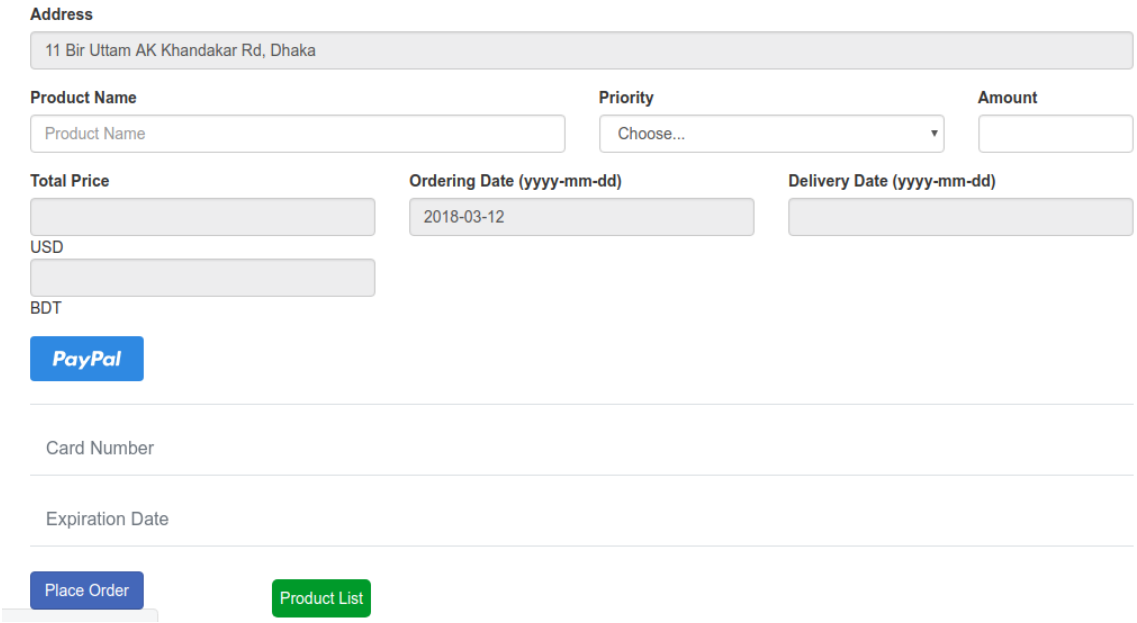

Figure 4.1.3 Payment System using BrainTree

4.1.4 Android application

Our android application for the website is available on android mobile phones, which is designed for the client to help them stay on track, avoid troubles, managing the order process, keeping update of shipping process, getting all the notification. It can also be accessed by admin or manager or concerned office staffs. It works on real time and hence the customer gets all the update about the order, the status of the product, where the product is staying, temperature of warehouse, location, how much time it will take to receive the product. It can be used for registration, ordering product, payment system. It's mainly website oriented and the interface is same as our website.

Features:

These are the following features of our android application:

- Registration system for the client
- Place order with payment verification
- Check the order status
- Track accessibility for product delivery

4.1.5 Packaging and tagging

Upon receiving order and successfully completing a part of the order we package the product by tagging RFID, information of which is stored in the database as well as cloud. We tag the product using RC522 RFID module and send the data to server and

cloud using raspberry pi. We are using raspberry pi as our master microprocessor. This is for the main factory and warehouses, where product tags are read from the packaging to store the check in time, check out time and other relevant information about the product.

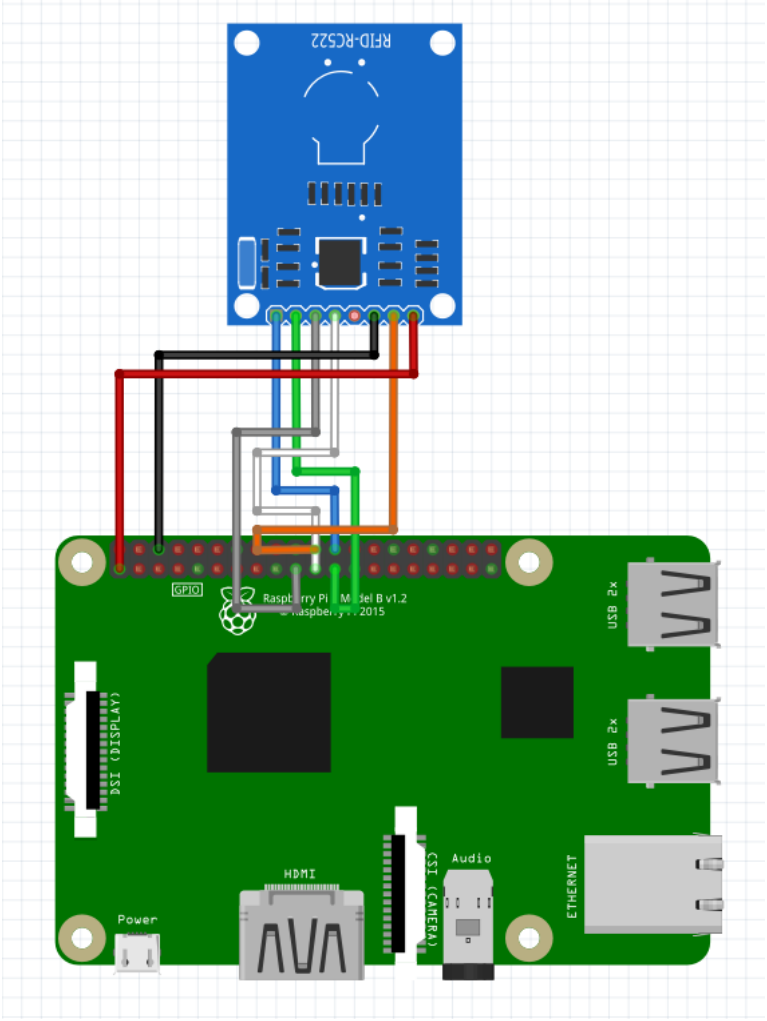

Figure 4.1.5.1 RC522 RFID module with Raspberry Pi schematic

For IoT cloud service, we are using ThingSpeak. In ThingSpeak we have created two public channels to send our feed to cloud. To save tagging info we have created a channel named RFID data tagging. In RFID data tagging channel, we are saving the RFID tag data, Order id and tagging time. We can access this channel using the API key of that channel. If the customer wants the product that have been produced, the product is shipped and the information about shipment like date, time, location etc. is stored in the database and also uploaded in the cloud. We have saved that information in RFID data Shipment channel. The date and time is recorded as soon as the product's RFID tag is read using MFRC522 RFID Reader while getting it out of the factory or warehouse.

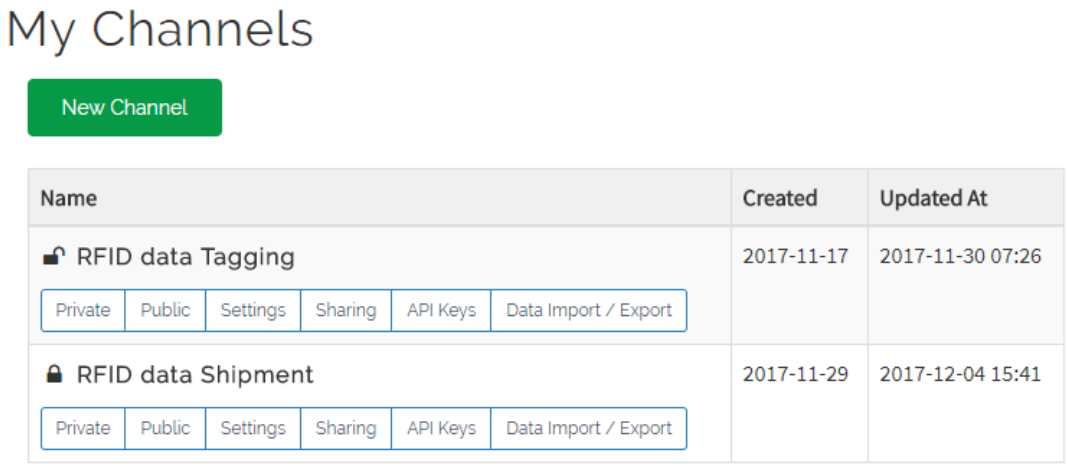

Figure 4.1.5.2 IoT channels in ThingSpeak server

4.1.6 Shipment and tracking

After getting out for shipment, the GPS data is obtained using Ai Thinker 7 GSM/GPRS/GPS Module with Arduino Uno. To save our data in cloud, we are using ThingSpeak.

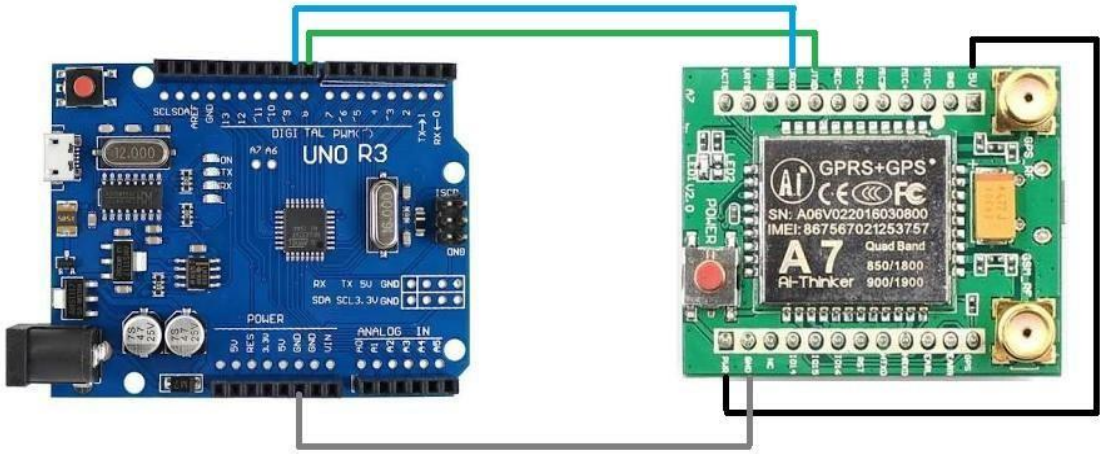

Figure 4.1.6.1 Circuit schematics for tracking system

In ThingSpeak we have created channel to send our location feed to cloud named “GPS”. We are getting data from satellite using antenna. Then if data is valid, we are sending that data to cloud. If data is invalid, then we will wait for valid data. We fetch that data from cloud and show it to website. The used GPS antenna is attached with the GPS module and it is giving location in GPGGA format. Time, position and fix related data for a GPS receiver.

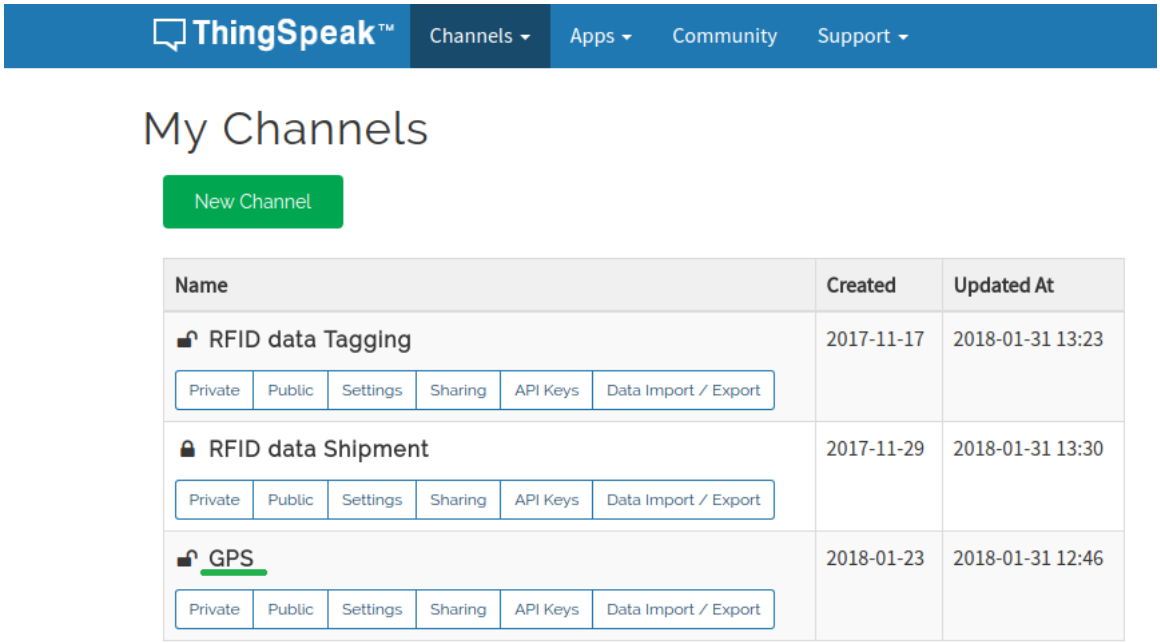

Figure 4.1.6.2 GPS Channel in cloud server

It gives us output in following way:

$GPGGA,hhmmss.ss,llll.ll,a,yyyyy.yy,a,x,xx,x.x,x.x,M,x.x,M,x.x,xxxx

hhmmss.ss = UTC of position

llll.ll = latitude of position

a = N or S

yyyyy.yy = Longitude of position

a = E or W

x = GPS Quality indicator (0=no fix, 1=GPS fix, 2=Dif. GPS fix)

xx = number of satellites in use

x.x = horizontal dilution of precision

x.x = Antenna altitude above mean-sea-level

M = units of antenna altitude, meters

x.x = Geoidal separation

M = units of geoidal separation, meters

x.x = Age of Differential GPS data (seconds)

xxxx = Differential reference station ID

We are using Google Map to show vehicle location. There are some reasons for choosing google map:

- It offers direction for walking, driving, biking and public transports.

- Provides notification and direction for every turn.
- It has an open platform and easy to use.
- It is free.
- It also shows estimated time with traffic status.
- Selects the shortest path from source to destination.

We are using two UI for showing vehicle location.

a) The manager has the option to search for location of a vehicle by giving the truck number. Then, we go to cloud and find that vehicle's updated latitude and longitude. After that, we are looking for its next client location and shows it on map. The manager can also see the estimated time of each destination delivery time. The page will auto reload after every 46 sec to show updated data.

b) A client can only see the vehicle location in which its product is loaded. A client can also see the delivery points before reaching to the client. Client can see the estimated time before reaching to the user. We are showing the earlier delivery points so that client can pick up its product from those points.

4.1.7 Prediction

In our project, we want to know the relationship between times, Product with the total revenue of the company; specifically we wanted to know whether the occasion does any effect to our total revenue system or not based on some previous data. In addition, we wanted to figure out the variation of revenue due to the variety of products. Here, The Key predictor variable is occasion and Dependent variable is revenue. If we want to get relationship that is more accurate then we need to factor in some additional variable in order to control for their effects. For example, we have included Laptop, mobile etc. Throughout the year, let us assume laptop has more sales revenue than mobile. People tend to buy more laptop compared to mobiles. Therefore, if we do not factor for laptop, mobile selling through the year, and our result of predictive power of revenue in terms of occasion might look a little bit strange.

The dataset that we have used in our model is manual input set. We could not found any relevant dataset for our model so we tried to build this data model with the help of our database. However, the database contains certain textual value, which is not relevant for making any relationship between them. Therefore, we have listed only that numerical value for our model that makes difference for the output.

Our main motive was to train the model into the machine at first, then predict the future outcome .In the dataset, we estimated the total revenue depending on the occasion and variety of product. Before training the model, we need to use data frame for reading values. After that, we train the data and fit into a certain model. Then we predict outcome for some test value. Looking at the data set we can see that the row where “occasion =1” has comparatively better sales outcome than the other way. Apart from that, the revenue is better when laptop is being sold more than mobile.

We observe that the data model contains continuous values. Therefore, this is a regression problem and we have to use regression model for prediction. In this model, we have used multiple regression, Regression tree, Support vector regression, Naive Bayes, logistic regression.

4.1.8 Chat bot : CarryOnJeeves

In our system, we have integrated a chat bot on our website to assist the client with basic help. We have used DialogFlow API to build our chat bot. The name of our chat bot is CarryOnJeeves.

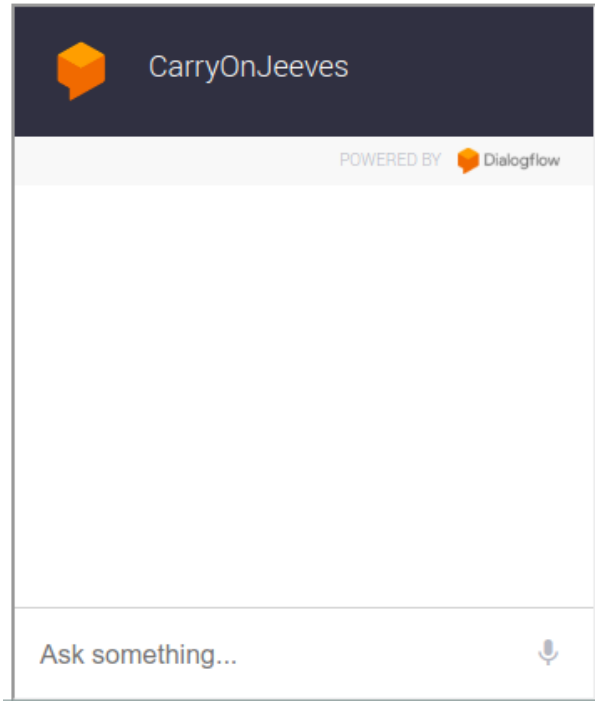

Figure 4.1.8 CarryOnJeeves (chat bot)

In our chat bot system, we use rule based intelligence systems. We fix some answer based on some keyword. We are taking input as text format and also from microphone. Client can message us or use their microphone to communicate.

4.2 Results

Upon successful completion of our research work, we have come up with the following results and outcomes.

4.2.1 Email validation result

After client fills up the registration form, a validation email id sends to the client's email id from website mail service. This email contains client's username and password. This mail also contains a validation link. By clicking on that link, client will be redirected to website and client id will be created. If user does not click on the link, the account will not be opened. One user can only use one email address to open. In here Figure 4.2.1, it has shown that, a client or user opens an account in website, a validation mail address is sent from our website. That mail contains, username which is ajmain02 and password is 123. There is also a validation link named "Click here". By clicking on that link, user can create his/her account. This user can only use this mail address for one time.

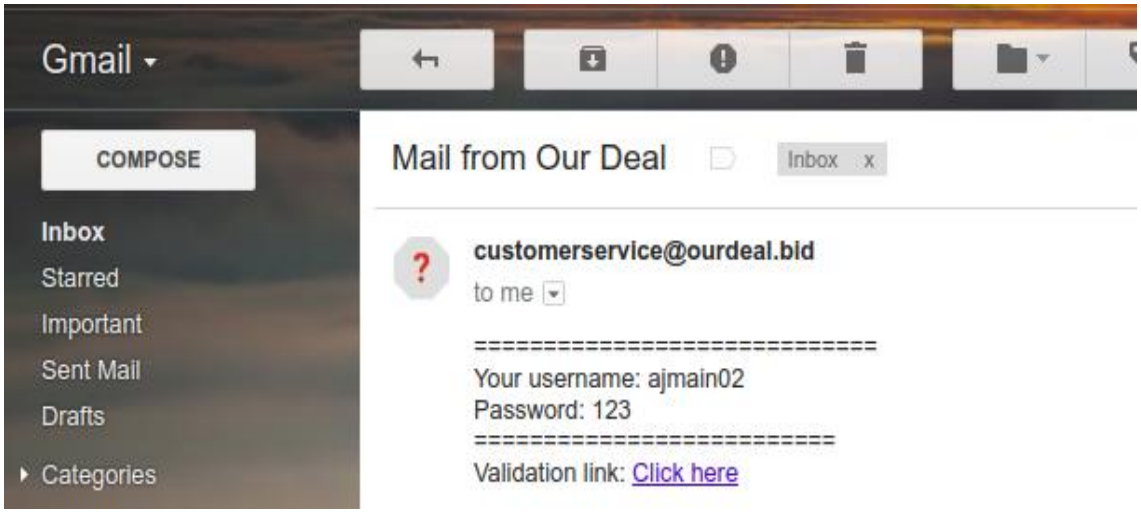

Figure 4.2.1 Client getting an email validation link after registration

4.2.2 Conversation with our chat bot

Client can use chat bot to get information about company and other things. For our system, we have used ruled based. In this Figure 4.2.2, a client wants to make an order. Then, chat bot will analyze the message from its system. To give an order client can say something like that:

- I want to make an order
- I want to give an order
- Where should I go to order a product

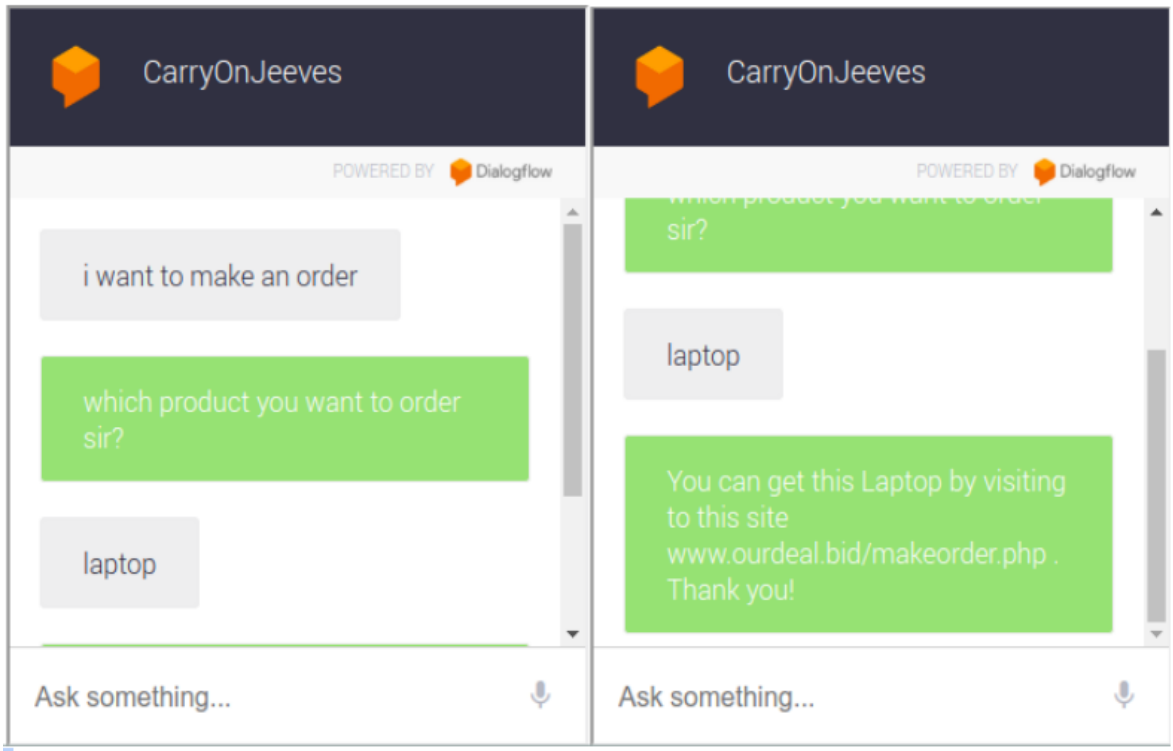

Figure 4.2.2 Conversation with client

As we are using rule based chat bot system, we are marking some keyword like "make order", "want order" or "where order product" to distinguish what user is trying to tell. Here client first asks chat bot to make an order and chat bot replies with product type. Then client replies that he/she wants to order laptop and chat bot redirects her to that location. Using keyword references we are determining what client is trying to tell to give them a better working experience.

4.2.3 Tracking result

By integrating vehicle tracking system in this system, we have received the following results. From Figure 4.2.3.1, for manager, system is getting that, vehicle is at 24, Tajmahal road, Dhaka, Bangladesh. It has 2 deliveries; those are at: (a) IDB Bhaban, E/8-A, Begum Rokeya Sarani, Dhaka, Bangladesh and (b) 11, Bir Uttam AK Khandakar Road, Dhaka, Bangladesh. Hence, system sorts these delivery points based on destination distance and estimated reaching time. Here truck number indicates that which vehicle information is shown in google map. Here, the information for truck number 10 is shown. Each destination point is divided as route. Route Segment 1 means that start point to immediate next destination.

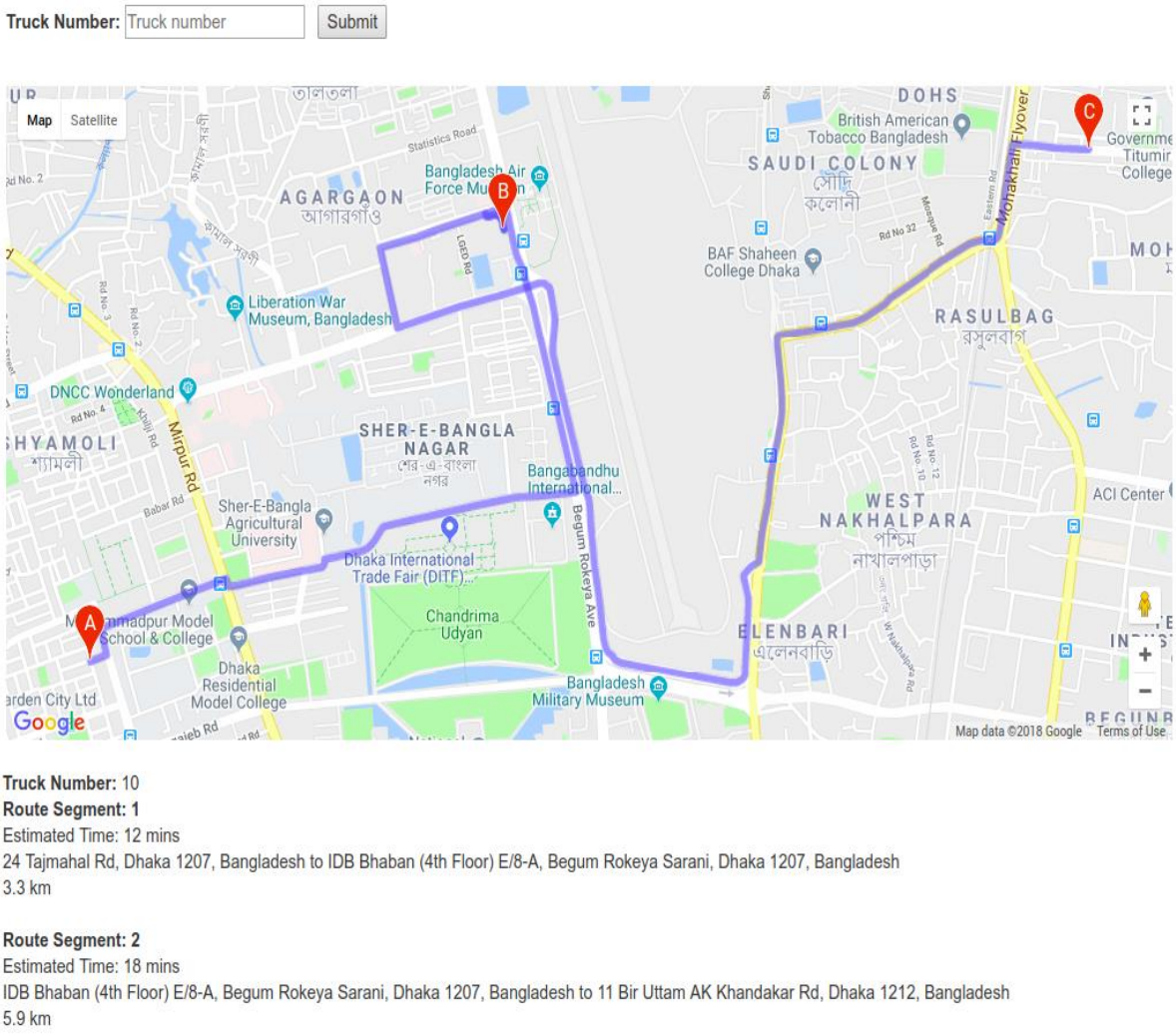

Figure 4.2.3.1 Manager's UI for tracking

In this Figure 4.2.3.1, for Route Segment 1, start point is 24, Tajmahal road, Dhaka, Bangladesh and end point is IDB Bhaban, E/8-A, Begum Rokeya Sarani, Dhaka. So, total distance is 3.3km. The estimated arrival time (ETA) is about 12 minutes. If we calculate the distance from 24, Tajmahal road, Dhaka, Bangladesh to 11, Bir Uttam AK Khandakar Road, Dhaka, Bangladesh, then we get 5.5km. As we can see, distance from 24, Tajmahal road, Dhaka to IDB Bhaban, E/8-A, Begum Rokeya Sarani, Dhaka, Bangladesh is closer than 11, Bir Uttam AK Khandakar Road, Dhaka, Bangladesh. That is why IDB Bhaban, E/8-A, Begum Rokeya Sarani, Dhaka, Bangladesh is our next destination point. Then Route Segment 2 means IDB Bhaban, E/8-A, Begum Rokeya Sarani, Dhaka, Bangladesh to 11, Bir Uttam AK Khandakar Road, Dhaka, Bangladesh and distance is about 5.9 km. It will need almost 18 minutes to come from IDB Bhaban, E/8-A, Begum Rokeya Sarani, Dhaka, Bangladesh to client's point.

The manager can see every delivery point's estimated reaching time with remaining distance. If a delivery is completed, that point will be removed from map and remaining delivery points will be sorted again and map will be updated. This map will automatically reload after every 46 secs to get updated location data.

For client, a client is at 11, Bir Uttam AK Khandakar Road, Dhaka, Bangladesh and vehicle is at 24, Tajmahal road, Dhaka, Bangladesh. The client can see that before coming to its location, the vehicle will go to 1 more place which is IDB Bhaban, E/8-A, Begum Rokeya Sarani, Dhaka, Bangladesh which is shown in the map. This will help the customer to pick up its delivery from those points. Client can also see the estimated time of arrival to location so that client don't have to panic and worried if he is going to miss that delivery. In here it is 30 minutes from 24, Tajmahal road, Dhaka, Bangladesh to 11, Bir Uttam AK Khandakar Road, Dhaka, Bangladesh. If client's product is not in any vehicle, then this page will be blank.

This will help the customer to pick up its delivery from those points. Client can also see the estimated time of arrival to location so that client don't have to panic and worried if it is going to miss that delivery. Client can do other work and time will be updated based on vehicle recent location.

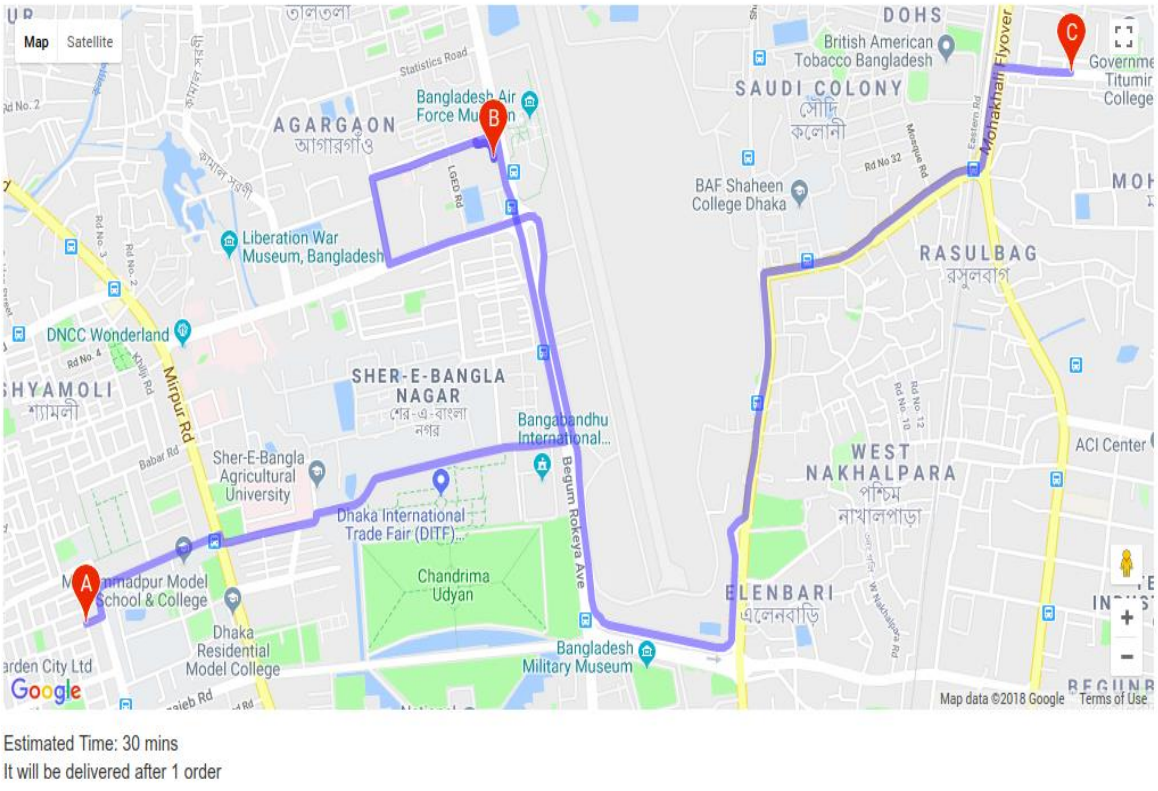

Figure 4.2.3.2 Client's UI for location

4.2.4 Payment

If all information is filled up properly in order page, then BrainTree will analyze the card number and expiration date. If everything is correct, then it gives a Transaction ID so that client can check if everything is correct and that amount of money has been cut from that account. This is a randomly generated transaction ID from PayPal. It will save in client's account and system's server. It shows that total amount is paid successfully.

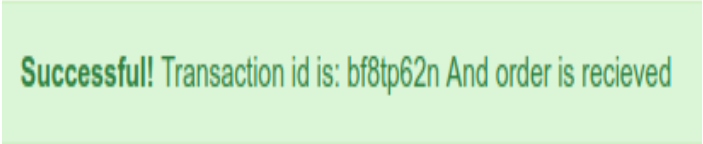

Figure 4.2.4 Transaction ID of order

In this Figure 4.2.4, a client orders a product and BrainTree returns a transaction ID which is "bf8tp62n". If any card information is failed for example, card number or expiration date, then the transaction will be failed and order will be cancelled.

4.2.5 Prediction outcome

1	month	year	mobile_discount	laptop_discount	city	occasion	laptop	mobile	revenue
2	1	2014	0	0	Dhaka	0	1	1	1200
3	2	2014	0	0	Dhaka	0	1	2	1500
4	3	2014	0	1	Dhaka	1	5	3	5500
5	4	2014	0	0	Dhaka	0	3	0	2000
6	5	2014	1	0	Dhaka	1	1	6	4612
7	6	2014	0	0	Dhaka	0	2	2	2500
8	7	2014	0	0	Dhaka	0	3	2	3300
9	8	2014	0	0	Dhaka	0	4	0	3200
10	9	2014	1	1	Dhaka	1	7	5	10000
11	10	2014	0	0	Dhaka	0	4	0	3520
12	11	2014	0	0	Dhaka	0	3	2	3500
13	12	2014	1	1	Dhaka	1	10	5	15000
14	1	2015	0	0	Dhaka	0	2	2	2700
15	2	2015	0	0	Dhaka	0	2	1	1800
16	3	2015	0	0	Dhaka	0	3	1	3300
17	4	2015	0	1	Dhaka	1	5	2	5300
18	5	2015	0	0	Dhaka	0	2	1	2500

Figure 4.2.5.1 Portion of the dataset

Figure 4.2.5.1 is our dataset. In this Figure 4.2.5.1, we are having total 8 columns which are: month, year, mobile_discount, laptop_discount, city, occasion, laptop, mobile, revenue.

Here, in month column, we are having the month number of each year and in year column, we are having the year. In mobile_discount column, we are having whether we are giving any discount for mobile. In laptop_discount column, we are having whether we are giving any discount for laptop. In both the columns, 0 (zero) means no discount/false and 1 means there is discount/true. In occasion column, we are checking whether that month has any occasion or not. 0 (zero) means no occasion/false and 1 means there is occasion/true. In laptop and mobile columns, we are getting respectively how many boxes of laptop and how many boxes of mobile, we have sold on that month. In revenue column, total amount of sales on that month in USD. Among those columns, revenue is dependent and month, year, mobile_discount, laptop_discount, city, occasion, laptop, mobile are independent column. So we have put month, year, mobile_discount, laptop_discount, city, occasion, laptop, mobile as our input column and revenue as our output column.

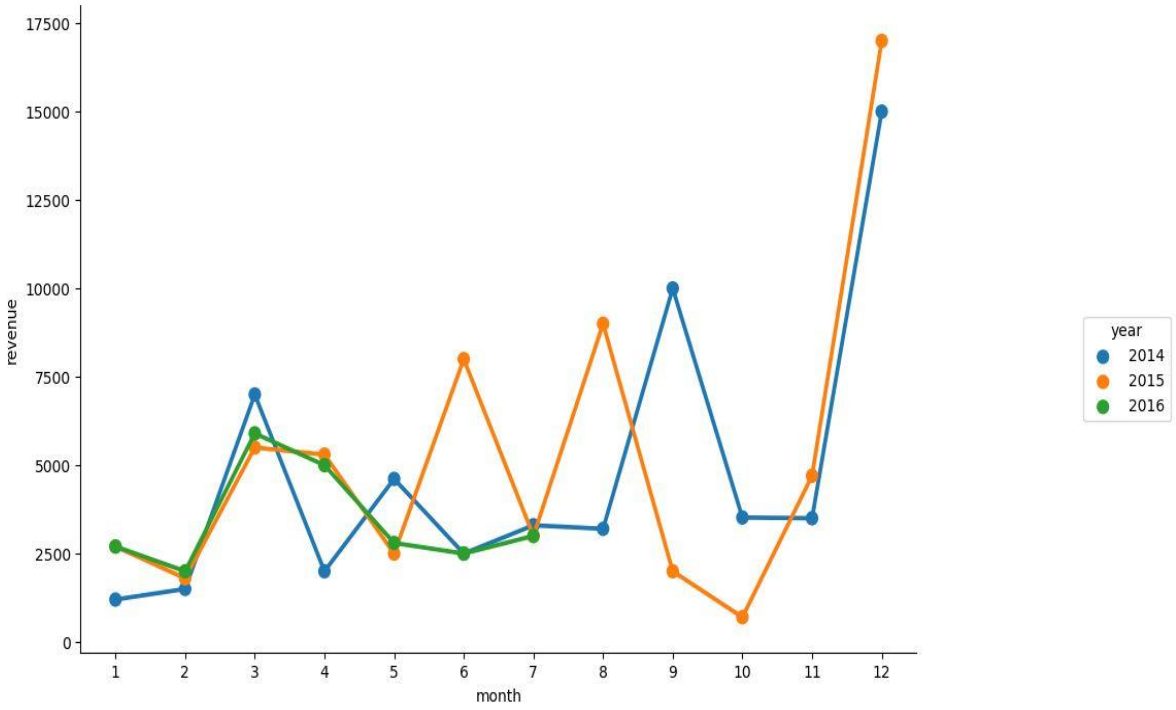

Figure 4.2.5.2 Graphical representation of trained data

In Figure 4.2.5.2, we are displaying graph of train data of three years 2014, 2015 and 2016. From given dataset in Figure 4.2.5.1, we are taking just month as our x axis to show graph in number. We are taking year as hue and in y axis, we are taking revenue in USD. We have implemented different algorithms in given dataset. Among those algorithms, multiple regression is better compared to the other regression method for our model.

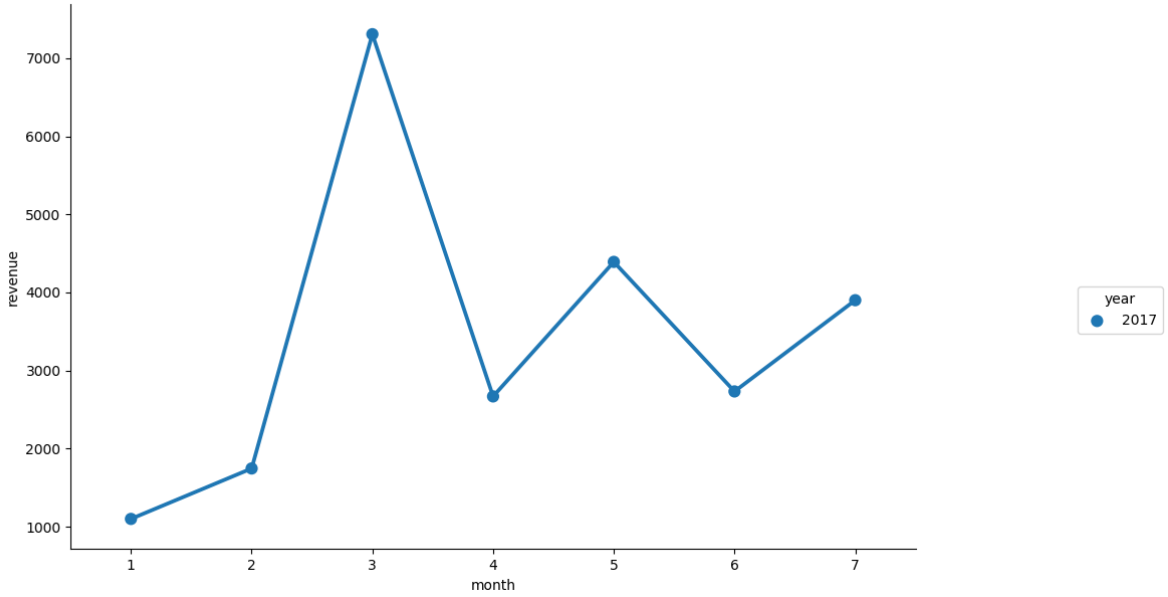

Figure 4.2.5.3 Graphical representation of test data

Given the particular dataset in Figure 4.2.5.3, multiple regression algorithm produce best and only relevant output. Here is the features of test dataset, we have used 'month', 'year', 'occasion', 'laptop', 'mobile' as input variable and ‘revenue’ as output variable.

x_check = df1[['month','year', 'occasion', 'laptop', 'mobile']]

y_check = df1[['revenue']]

Based on that we predict the sales revenue. So we put revenue as a dependent variable. And using linear. Score() function we put parameter of x_check & y_check to get the result in percentage It shows accuracy of 87%. In Figure 4.2.5.3, we are displaying graph of test data. We are taking just month as our x axis to show graph in number and in y axis, we are taking revenue. In Figure 4.2.5.3, 1 indicates the month January, 2 indicates February, 3 indicates March, 4 indicates April and so on. We are displaying first 4 month prediction. After end of January, we can cross check for accuracy.

4.2.6 Graphical representation of total clients

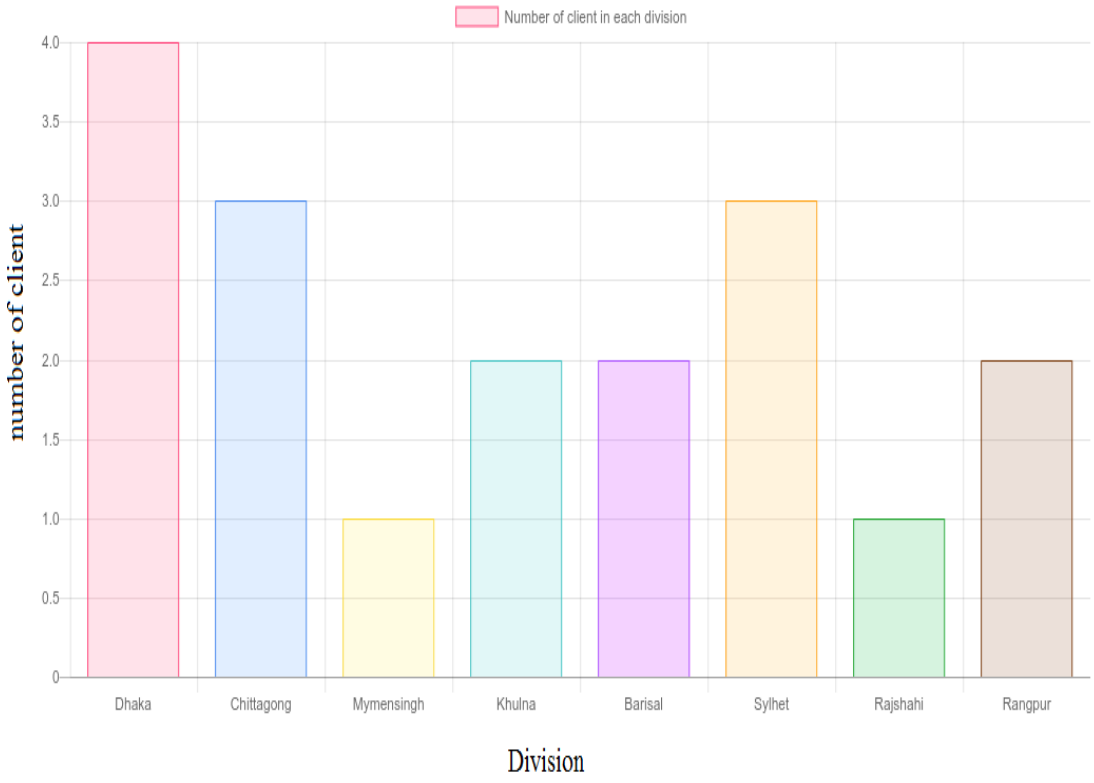

Figure 4.2.6 Division based client graph

We have shown a graphical representation of total client in each division. It will help company to know which from which division most of client from and where we need to provide better service. We are searching client table to get the division information from database and counting the number of client in that division. In Figure 4.2.6, we are putting division name in x axis and in y axis we are putting number of client. It will create a bar which indicates, which division has more client. We can see in Figure 4.2.6, in Dhaka division we have 4 clients, in Chittagong and Sylhet, we have 3 clients, in Mymensingh and Rajshahi, total number of client is 1 and in Khulna, Rangpur and Barisal, client number is 2. From Figure 4.2.6, we can understand most of our client is from Dhaka division and most of the orders are coming from this division.

CHAPTER 5

Conclusions

This chapter consists of a brief summary of this research and demonstrates the future aspects and possibilities. Traditional supply chain management process deals with hand to hand work and person to person communication in order to maintain the working process. However, in this proposed system, supply chain depends on the supervision of human, not needing any constant work or in person communication which saves a lot of precious time and money. This system supports automated product information storage, monitoring of the vehicle as well as provide the customers a better experience.

Since, this system has chat bot assistance, customers can always get the basic help. Because of the verified payment system, transaction has been secured, risk-free and faster. With the help of RFID tags, product information can easily be stored and maintained. Through GPS+GPRS+GSM module, vehicle can be easily tracked and customer also can know about their product location. For the future statistical analysis of the company's sales and for preparing any new business plan, this system also propose sales prediction. Finally, by the use of android application, this infrastructure also ensure better and faster communication and business experience for both the company and client. Therefore, this research where IoT incorporated with SCM, provides better solution for supply chain issues and develops an automated process.

5.1 Future Possibilities

Supply chain incorporated with IoT has innumerous scopes in the future. The world is rapidly changing and advancing toward a technological era. To keep pace with the challenging global market, supply chain process must be much more prepared. To maintain all the factors of the supply chain, IoT offers unimaginable results and this will certainly change the supply chain process and push to the next level [26]. Some of the possibilities where IoT can be of great use are mentioned below [27].

- **For protection:** IoT can be used for the protection of product delivery vehicles and also product. Anti-theft system or automated tracking can prevent any unfair means.
- **Quality assurance:** IoT can be implemented in supply chain to fortify the quality of the goods. There are many goods or products that need preferred temperature or environment for preserving the quality. IoT can be collaborated to ensure that.

Appendix

Material Requirement Planning: The planning for storage and movement of raw materials for production is known as the Material Requirement Planning.

Inventory management: The management of the inventory and stock is called the inventory management. This also includes monitoring the inventory for ordering and managing the sale amount [28].

ThingSpeak: It is an open source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP protocol over the Internet.

DialogFlow: It is an open source platform where one can build a chat bot using rule based intelligence system and integrate it in website or merge it with Facebook and other social site network using their API service.

GPGGA: It is data sentence format of the GPS defined by the National Marine Electronics Association (NMEA). It means Global Positioning Fix Data.

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