IoT in Logistics

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

This is to certify that the project report entitled **IOT IN LOGISTICS** submitted by NAMBOODIRI AKASH PRASAD (BL.EN.U4ECE12089) in partial fulfillment of the requirements for the award of the **Degree Bachelor of Technology** in ELECTRONICS AND COMMUNICATION Engineering is a bonafide record of the work carried out under our guidance and supervision at Amrita School of Engineering, Bangalore and Robert Bosch Engineering and Business Solutions Limited..

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This project report was evaluated by us on ………

EXAMINER 1	EXAMINER 2

ACKNOWLEDGEMENT

The development and technology that we see today is a result of engineering endeavour and perseverance. I take extreme pride in the fact that we are engineers and feel privileged to make any contribution to technology.

I would like to begin with offering our sincere regards **to Amrita Vishwa Vidyapeetham**.

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ABSTRACT

The idea for a less cumbersome and more efficient product tracking methodology struck when we observed that the factory officials had no access to real time information about their product. Most of the details were updated manually. It would be more efficient to design a system which automates the whole process by eliminating the need for manual intervention. It would be imperative to shift from a desktop to an app based ecosystem. Therefore, this project was undertaken to analyze and come up with a mechanism to smoothen the end-to-end logistics of a B2B scenario. A Proof of Concept (PoC) was designed and implemented using a Raspberry Pi as a central hub for giving live updates, RFIDs and IR sensors were used for product identification, tagging and giving location updates respectively. An Android app was created for the smooth ordering process and live tracking the product using Google Map in the app. ZigBee network was also designed as a parking solution for incoming and outgoing trucks and other vehicles. This is a project undertaken by the interns at Robert Bosch Engineering India Ltd. The app, nicknamed "iLogi" stands for IoT in Logistics.

ROBERT BOSCH ENGINEERING AND BUSINESS SOLUTION LTD.

Robert Bosch)), or Bosch, is a German multinational engineering and electronics company headquartered in Gerlingen, near Stuttgart, Germany. It is the world's largest supplier of automotive components measured by 2011 revenues. The company was founded by Robert Bosch in Stuttgart in 1886. Bosch is 92% owned by Robert Bosch Stiftung.

Bosch's core products are automotive components (including brakes, controls, electrical drives, electronics, fuel systems, generators, starter motors and steering systems), industrial products (including drives and controls, packaging technology and consumer goods) and building products (including household appliances, power tools, security systems and thermo technology)

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Bosch entered India in 1922, when Illies & Company set up a sales office in Calcutta. For three decades, the company operated in the Indian market only through imports. In 1951, Bosch set up its first manufacturing plant in India.

Currently, Bosch India has a turnover of over $2 billion and over 26000 employees spread across 10 locations and 7 application development centers. 84% of Bosch India revenues come from its automotive business, with the remaining 16% split between its non-automotive businesses that include packaging, energy and building solutions, power tools and consumer retail. Bosch also has an R&D facility in Bangalore, India. This is Bosch's largest R&D facility outside its home market of Germany

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Bosch has always been a value-driven company. Our values reflect the manner in which we run our business: Our professional ethics in dealing with our business partners, investors, employees and society.

- **Future and result focus**

Our actions are result-focused. This allows us to secure our future. It also creates a sound basis for the social initiatives of the company and the foundation.

- **Responsibility and sustainability**

We act responsibly in the interest of our company, also taking the social and ecological impact of our actions into consideration.

- **Initiative and determination**

We act on our own initiative, take entrepreneurial responsibility, and pursue our goals with determination.

- **Openness and trust**

We communicate important company matters in a timely and open fashion. This is the best foundation for a relationship built on trust.

- **Fairness**

We deal fairly with our colleagues and business partners, and view this fairness as a cornerstone of our corporate success.

- **Reliability, credibility, legality**

We promise only what we can deliver, accept agreements as binding, and respect and observe the law in all our business transactions.

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CHAPTER 1

1. INTRODUCTION

1.1 LOGISTICS

Logistics is generally the detailed organization and implementation of a complex operation. In a general business sense, logistics is the management of the flow of things between the point of origin and the point of consumption in order to meet requirements of customers or corporations. The resources managed in logistics can include physical items such as food, materials, animals, equipment, and liquids; as well as abstract items, such as time and information. The logistics of physical items usually involves the integration of information flow, material handling, production, packaging, inventory, transportation, warehousing, and often security.

Logistics management is the part of supply chain management that plans, implements, and controls the efficient, effective forward, and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customer's requirements. The complexity of logistics can be modeled, analyzed, visualized, and optimized by dedicated simulation software. The minimization of the use of resources is a common motivation in all logistics fields. A professional working in the field of logistics management is called a logistician.

1.1.1 BUSINESS LOGISTICS

One definition of business logistics speaks of "having the right item in the right quantity at the right time at the right place for the right price in the right condition to the right customer". Business logistics incorporates all industry sectors and aims to manage the fruition of project life cycles, supply chains, and resultant efficiencies.

In business, logistics may have either an internal focus (inbound logistics) or an external focus (outbound logistics), covering the flow and storage of materials from point of origin to point of consumption (see supply-chain management). The main functions of a qualified logistician include inventory management, purchasing, transportation, warehousing, consultation, and the organizing and planning of these activities. Logisticians combine a professional knowledge of each of these functions to coordinate resources in an organization.

There are two fundamentally different forms of logistics: one optimizes a steady flow of material through a network of transport links and storage nodes, while the other coordinates a sequence of resources to carry out some project (e.g., restructuring a warehouse).

1.1.2 LOGISTICS AUTOMATION

Logistics automation is the application of computer software and/or automated machinery to improve the efficiency of logistics operations. Typically this refers to operations within a warehouse or distribution center, with broader tasks undertaken by supply chain management systems and enterprise resource planning systems.

Industrial machinery can typically identify products through either Bar Code or RFID technologies. Information in traditional bar codes is stored as a sequence of black and white bars varying in width, which when read by laser is translated into a digital sequence, which according to fixed rules can be converted into a decimal number or other data. Sometimes information in a bar code can be transmitted through radio frequency, more typically radio transmission is used in RFID tags. An RFID tag is card containing a memory chip and an antenna which transmits signals to a reader.

1.2 INDUSTRY 4.0

Industry 4.0, Industrie 4.0 or the fourth industrial revolution, is a collective term embracing a number of contemporary automation, data exchange and manufacturing technologies. It had been defined as 'a collective term for technologies and concepts of value chain organization' which draws together Cyber-Physical Systems, the Internet of Things and the Internet of Services.

Industry 4.0 facilitates the vision and execution of a "Smart Factory". Within the modular structured Smart Factories of Industry 4.0, cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions. Over the Internet of Things, cyber-physical systems communicate and cooperate with each other and with humans in real time, and via the Internet of Services, both internal and cross-organizational services are offered and utilized by participants of the value chain.

1.2.1 DESIGN PRINCIPLE

There are four design principles in Industry 4.0. These principles support companies in identifying and implementing Industry 4.0 scenarios.

- **Interoperability:** The ability of machines, devices, sensors, and people to connect and communicate with each other via the Internet of Things (IoT) or the Internet of People (IoP).
- **Information transparency:** The ability of information systems to create a virtual copy of the physical world by enriching digital plant models with sensor data. This requires the aggregation of raw sensor data to higher-value context information.
- **Technical assistance:** First, the ability of assistance systems to support humans by aggregating and visualizing information comprehensibly for making informed decisions and solving urgent problems on short notice. Second, the ability of cyber physical systems to physically support humans by conducting a range of tasks that are unpleasant, too exhausting, or unsafe for their human co-workers.
- **Decentralized decisions:** The ability of cyber physical systems to make decisions on their own and to perform their tasks as autonomous as possible.

Only in case of exceptions, interferences, or conflicting goals, tasks are delegated to a higher level.

1.3 PROBLEM STATEMENT

The forgoing supply chain process involves monitoring manually at the ends, being prone to a lot of human errors, does not assist the customer in tracking, thereby causing considerable delay, which can be invested to enhance productivity.

1.4 OBJECTIVE

To automate the end to end supply chain process by tracking by RFID, upload the data to the cloud using Raspberry Pi and manage the logistics with an intent to optimize both resources and energy.

Improve Overall Supply chain Efficiency

1.5 MOTIVATION

- Need for real-time tracking of products
- Need for automation in logistics
- Need for better co-ordination between suppliers and the factory officials
- Need for increase in security and safety of the products
- Reduce the wastage of resources

1.6 EXISTING SYSTEM

- Almost every activity in the logistics is manual.
- There is no efficient real-time tracking of products.
- Barcodes are still most prevalent form of product tagging.
- Barcodes are prone to error due to less line of sight.

1.7 DRAWBACKS

- Human errors are common and may lead to drastic losses.
- Cumbersome to track the products.
- Items often get misplaced or go missing.

1.8 METHODOLOGY

The design consists of both the hardware and software. We integrated the modules of selected sensors and readers to Raspberry Pi.

Table 1.1 Components Specification

Component	Specification	Description
RaspberryPi 2B+	Hardware	2nd generation. 5V supply. 1GB RAM. 16GB external SD
EM18 RFID reader	Hardware	Operational frequency: 125 KHz Read Distance: 10cm
RFID Tags	Hardware	Operational frequency: 125 KHz
XBee modules	Hardware	Range: 100m
IR Sensors	Hardware	Range: 10cm
Idle	Software	Text editor for Python
X-CTU	Software	Configure XBees
Phant	Cloud Service	Data logging live updates
FireBase	Cloud Service	Updating live data and interfacing with the app.

1.9 THESIS ORGANIZATION

Rest of the contents of the thesis is as follows:

- Chapter 2 describes the components of the system and the modules used in it.
- Chapter 3 describes the architecture of our concept and the process flow.
- Chapter 4 describes implementation of the prototype and showcases the results.
- Chapter 5 discusses the future scope and conclusion of this concept.

CHAPTER 2

2. COMPONENTS & APPLICATION

2.1 RASPBERRY PI 2 B+

The Raspberry Pi is a credit card–sized single-board computers developed by the Raspberry Pi Foundation with the intent to promote the teaching of basic computer science in schools and developing countries. The original Raspberry Pi and Raspberry Pi 2 , as shown in the Fig 2.1, are manufactured in several board configurations through licensed manufacturing. The hardware is the same across all manufacturers.

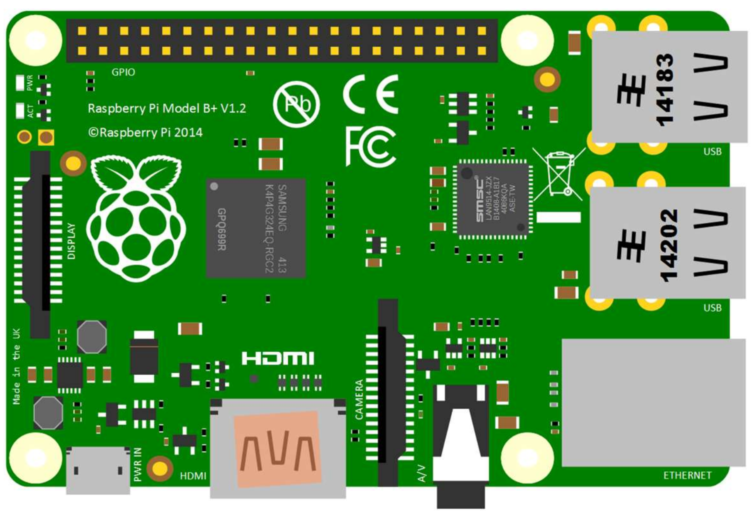

Fig 2.1 Raspberry Pi 2B+

All models feature a Broadcom system on a chip (SOC) BCM2836 which include an ARM compatible CPU and an on chip graphics processing unit GPU (a VideoCore IV). CPU speed is 900 MHz for the Pi 3 and board memory of 1 GB RAM. Secure Digital SD cards are used to store the operating system and program memory in MicroSD sizes. The board have four USB slots, HDMI and composite video output, and a 3.5 mm phone jack for audio. Lower level output is provided by a number of GPIO pins which support common protocols like I2C

The Foundation provides Debian and Arch Linux ARM distributions for download and promotes Python as the main programming language, with support for BBC BASIC (via the RISC OS).

2.1.1 HARDWARE

The Raspberry Pi hardware has evolved through several versions that feature variations in memory capacity and peripheral-device support, as shown in Fig 2.2.

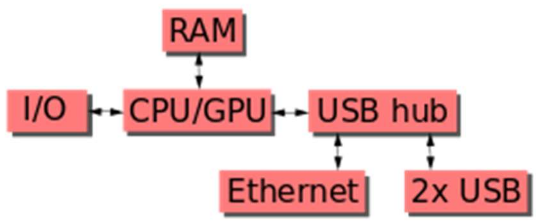

Fig 2.2 Hardware architecture

On model *B+* and later models the USB/Ethernet chip contains a five-point USB hub, of which four ports are available.

2.1.1.1 PROCESSOR

The Raspberry Pi 2 uses a Broadcom BCM2836 SoC with a 900 MHz 32-bit quad-core ARM Cortex-A7 processor, with 256 KB shared L2 cache.

2.1.1.2 RAM

The Raspberry Pi 2 and the Raspberry Pi 3 have 1 GB of RAM.

2.1.1.3 NETWORKING

On the model B and B+ the Ethernet port is provided by a built-in USB Ethernet adapter using the SMSC LAN9514 chip.[30] The Raspberry Pi 3 is equipped with 2.4 GHz

WiFi 802.11n (600 Mbit/s) and Bluetooth 4.1 (24 Mbit/s) in addition to the 10/100 Ethernet port.

2.1.1.4 PERIPHERALS

The Raspberry Pi may be operated with any generic USB computer keyboard and mouse.

2.1.2 SOFTWARE (OPERATING SYSTEM)

The Raspberry Pi primarily uses Linux-kernel-based operating systems.

The ARM11 chip at the heart of the Pi (first generation models) is based on version 6 of the ARM. The primary supported operating system is Raspbian, although it is compatible with many others. The current release of Ubuntu supports the Raspberry Pi 2, while Ubuntu, and several popular versions of Linux, and do not support the older Raspberry Pi 1 that runs on the ARM11. Raspberry Pi 2 can also run the Windows 10 IoT Core operating system, while no version of the Pi can run traditional Windows. The Raspberry Pi 2 currently also supports OpenELEC and RISC OS.

2.1.3 GPIO

The Pi has 40 GPIO (General Purpose Input Output). See Fig 2.3.

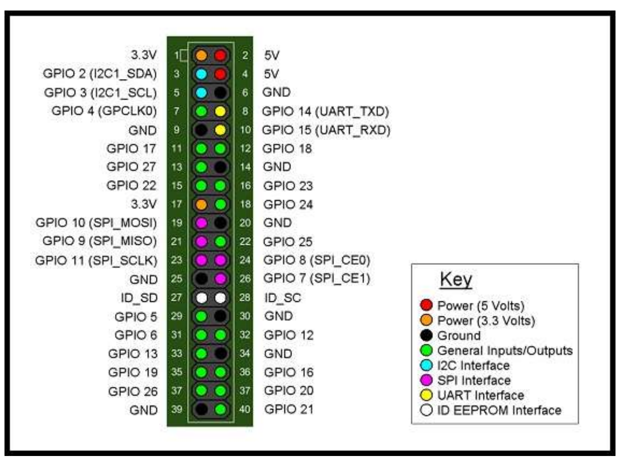

Fig 2.3 GPIO of Raspberry Pi 2 B+

2.2 EM-18 RFID READER MODULE

This module directly connects to any microcontroller UART or through a RS232 converter to PC. It gives UART/Wiegand26 output. This RFID Reader Module, as shown in Fig. 2.4, works with any 125 KHz RFID tags

Fig 2.4 EM-18 RFID reader module

2.2.1 SPECIFICATIONS:

Basal Specifications:

1	VCC	5V
2	GND	GND
3	BEEP	BEEP AND LED
4	ANT	NO USE
5	ANT	NO USE
6	SEL	HIGH IS RS232,LOW IS WEIGAND
7	RS232	RS232
8	D1	WEIGAND DATA 1
9	D0	WEIGAND DATA 0

- 5V DC through USB (External 5V supply will boost range of the module)
- Current: <50mA
- Operating Frequency: 125Khz
- Read Distance: 10cm
- Size of RFID reader module: 32mm(length) * 32mm(width) * 8mm(height)

2.3 ZIGBEE

ZigBee is an IEEE 802.15.4-based specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios.

The technology defined by the ZigBee specification is intended to be simpler and less expensive than other wireless personal area networks (WPANs), such as Bluetooth or Wi-Fi. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that requires short-range low-rate wireless data transfer.

Fig 2.5 ZigBee module

Its low power consumption limits transmission distances to 10–100 meters line-of-sight, depending on power output and environmental characteristics. ZigBee devices, as seen in Fig 2.5, can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. ZigBee is typically used in low data rate applications that require long battery life and secure networking (ZigBee networks are secured by 128 bit symmetric encryption keys.) ZigBee has a defined rate of 250 kbit/s, best suited for intermittent data transmissions from a sensor or input device.

The ZigBee network layer natively supports both star and tree networks, and generic mesh networking, as shown in Fig. 2.6. Every network must have one coordinator device, tasked with its creation, the control of its parameters and basic maintenance. Within star networks, the coordinator must be the central node. Both trees and meshes allow the use of ZigBee routers to extend communication at the network level.

ZigBee builds on the physical layer and media access control defined in IEEE standard 802.15.4 for low-rate WPANs. The specification includes four additional key components: network layer, application layer, ZigBee device objects (ZDOs) and manufacturer-defined application objects which allow for customization and favor total integration. ZDOs are responsible for some tasks, including keeping track of device roles, managing requests to join a network, as well as device discovery and security.

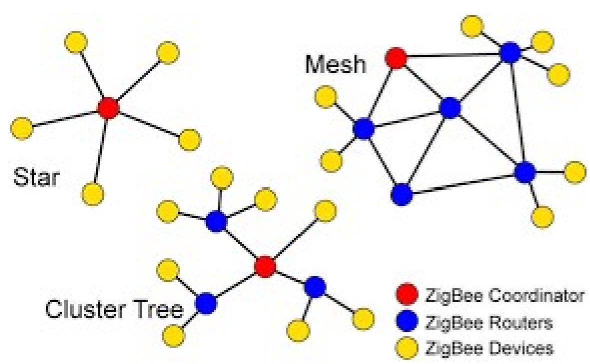

Fig 2.6 ZigBee topologies

2.3.1 DEVICE TYPES AND OPERATION MODES

ZigBee devices are of three kinds:

ZigBee Coordinator (ZC): The most capable device, the Coordinator forms the root of the network tree and might bridge to other networks. There is precisely one ZigBee Coordinator in each network since it is the device that started the network originally (the ZigBee LightLink specification also allows operation without a ZigBee Coordinator, making it more usable for over-the-shelf home products). It stores information about the network, including acting as the Trust Center & repository for security keys.

ZigBee Router (ZR): As well as running an application function, a Router can act as an intermediate router, passing on data from other devices.

ZigBee End Device (ZED): Contains just enough functionality to talk to the parent node (either the Coordinator or a Router); it cannot relay data from other devices. This relationship allows the node to be asleep a significant amount of the time thereby giving long battery life. A ZED requires the least amount of memory, and, therefore, can be less expensive to manufacture than a ZR or ZC.

2.4 PYTHON

Python is a widely used high-level, general-purpose, interpreted, dynamic programming language. Its design philosophy emphasizes code readability, and its syntax allows programmers to express concepts in fewer lines of code than would be possible in languages such as C++ or Java. The language provides constructs intended to enable clear programs on both a small and large scale.

Python supports multiple programming paradigms, including object-oriented, imperative and functional programming or procedural styles. It features a dynamic type system and automatic memory management and has a large and comprehensive standard library.

2.4.1 FEATURES

Python is a multi-paradigm programming language: object-oriented programming and structured programming are fully supported, and many language features support functional programming and aspect-oriented programming (including by metaprogramming and metaobjects (magic methods). Many other paradigms are supported via extensions, including design by contract and logic programming.

Python uses dynamic typing and a mix of reference counting and a cycle-detecting garbage collector for memory management. An important feature of Python is dynamic name resolution (late binding), which binds method and variable names during program execution.

The design of Python offers some support for functional programming in the Lisp tradition. The language has map(), reduce() and filter() functions; list comprehensions, dictionaries, and sets; and generator expressions. The standard library has two modules (itertools and functools) that implement functional tools borrowed from Haskell and Standard ML.

2.4.2 USE

Organizations that make use of Python include Google, Yahoo!, CERN, NASA.

Python can serve as a scripting language for web applications, e.g., via mod_wsgi for the Apache web server. With Web Server Gateway Interface, a standard API has evolved to facilitate these applications. Web frameworks like Django, Pylons, Pyramid, TurboGears, web2py, Tornado, Flask, Bottle and Zope support developers in the design and maintenance of complex applications. Pyjamas and IronPython can be used to develop the client-side of Ajax-based applications. SQLAlchemy can be used as data mapper to a relational database. Twisted is a framework to program communications between computers, and is used (for example) by Dropbox.

Python has been used in artificial intelligence tasks. As a scripting language with module architecture, simple syntax and rich text processing tools, Python is often used for natural language processing tasks.

The Raspberry Pi single-board computer project has adopted Python as its main user-programming language.

2.5 CLOUD COMPUTING

Cloud computing, also on-demand computing, is a kind of Internet-based computing that provides shared processing resources and data to computers and other devices on demand. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services), which can be rapidly provisioned and released with minimal management effort. Cloud computing and storage solutions provide users and enterprises with various capabilities to store and process their data in third-party data centers. It relies on sharing of resources to achieve coherence and economy of scale, similar to a utility (like the electricity grid) over a network.

Cloud computing has become a highly demanded service or utility due to the advantages of high computing power, cheap cost of services, high performance, scalability, accessibility as well as availability. Some cloud vendors are experiencing growth rates of 50% per year, but being still in a stage of infancy, it has pitfalls that need to be addressed to make cloud computing services more reliable and user friendly.

2.5.1 CHARACTERISTICS

Cloud computing exhibits the following key characteristics:

- Agility improves with users' ability to re-provision technological infrastructure resources.
- Cost reductions claimed by cloud providers. A public-cloud delivery model converts capital expenditure to operational expenditure. This purportedly lowers barriers to entry, as infrastructure is typically provided by a third party and need not be purchased for one-time or infrequent intensive computing tasks.
- Device and location independence enable users to access systems using a web browser regardless of their location or what device they use (e.g., PC, mobile

phone). As infrastructure is off-site (typically provided by a third-party) and accessed via the Internet, users can connect from anywhere.

- Maintenance of cloud computing applications is easier, because they do not need to be installed on each user's computer and can be accessed from different places.
- Performance is monitored, and consistent and loosely coupled architectures are constructed using web services as the system interface.
- Productivity may be increased when multiple users can work on the same data simultaneously, rather than waiting for it to be saved and emailed. Time may be saved as information does not need to be re-entered when fields are matched, nor do users need to install application software upgrades to their computer.
- Reliability improves with the use of multiple redundant sites, which makes well-designed cloud computing suitable for business continuity and disaster recovery.
- Scalability and elasticity via dynamic ("on-demand") provisioning of resources on a fine-grained, self-service basis in near real-time, without users having to engineer for peak loads. This gives the ability to scale up when the usage need increases or down if resources are not being used.
- Security can improve due to centralization of data, increased security-focused resources, etc., but concerns can persist about loss of control over certain sensitive data, and the lack of security for stored kernels.

2.6 FIREBASE CLOUD

Firebase is a cloud services provider and backend as a service company based in San Francisco, California. The company makes a number of products for software developers building mobile or web applications. Firebase's primary product is a realtime database which provides an API that allows developers to store and sync data across multiple clients.

2.6.1 SERVICES

2.6.1.1 REALTIME DATABASE

Firebase provides a realtime database and backend as a service. The service provides application developers an API that allows application data to be synchronized across clients and stored on Firebase's cloud. The company provides client libraries that enable integration with Android, iOS, JavaScript, Java, Objective-C and Node.js applications. The database is also accessible through a REST API and bindings for several JavaScript frameworks such as AngularJS, React, Ember.js and Backbone.js. The REST API uses the Server-Sent Events protocol, which is an API for creating HTTP connections for receiving push notifications from a server. Developers using the realtime database can secure their data by using the company's server-side-enforced security rules.

2.6.1.2 HOSTING

Firebase Hosting is a static asset web hosting service that launched on May 13, 2014. It supports hosting static files such as CSS, HTML, JavaScript and other files that do not change dynamically. The service delivers files over a content delivery network (CDN) through HTTP Secure (HTTPS) and Secure Sockets Layer encryption (SSL). Firebase partners with Fastly, a CDN, to provide the CDN backing Firebase Hosting. The company states that Firebase Hosting grew out of customer requests, developers were using Firebase for its real-time database but needed a place to host their content.

2.7 DATA.SPARKFUN.COM

Data.sparkfun.com is a cloud service where we can push our data from a hardware into the cloud.

2.7.1 PHANT CLOUD

Phant is a modular logging tool developed by SparkFun Electronics for collecting data from the Internet of Things. Phant is the open source software that powers data.sparkfun.com.

Each Phant data stream gets two unique keys – one public and another private. The public key is visible to everyone who visits your data stream because it's part of the URL.

The private key is required to post any data to your stream. This unique hash isn't publicly visible, and it should only be known by you or anyone else allowed to post to your stream.

Finally, each stream contains one or more field names – the "labels" for your data values. In our example, we have three fields named "light", "switch", and "name." Data of nearly any form can be stored in those fields – integers, strings, floats, you name it.

Once you have all three of those ingredients, plus data to assign to each field, you can construct either an HTTP GET or POST, and send it to data server.

CHAPTER 3

3. PROTOTYPE

3.1 ARCHITECTURE OF THE SOLUTION

The architecture consists of 3 layers: Physical Layer (Raspberry Pi, RFID etc.), Cloud and the app respectively.

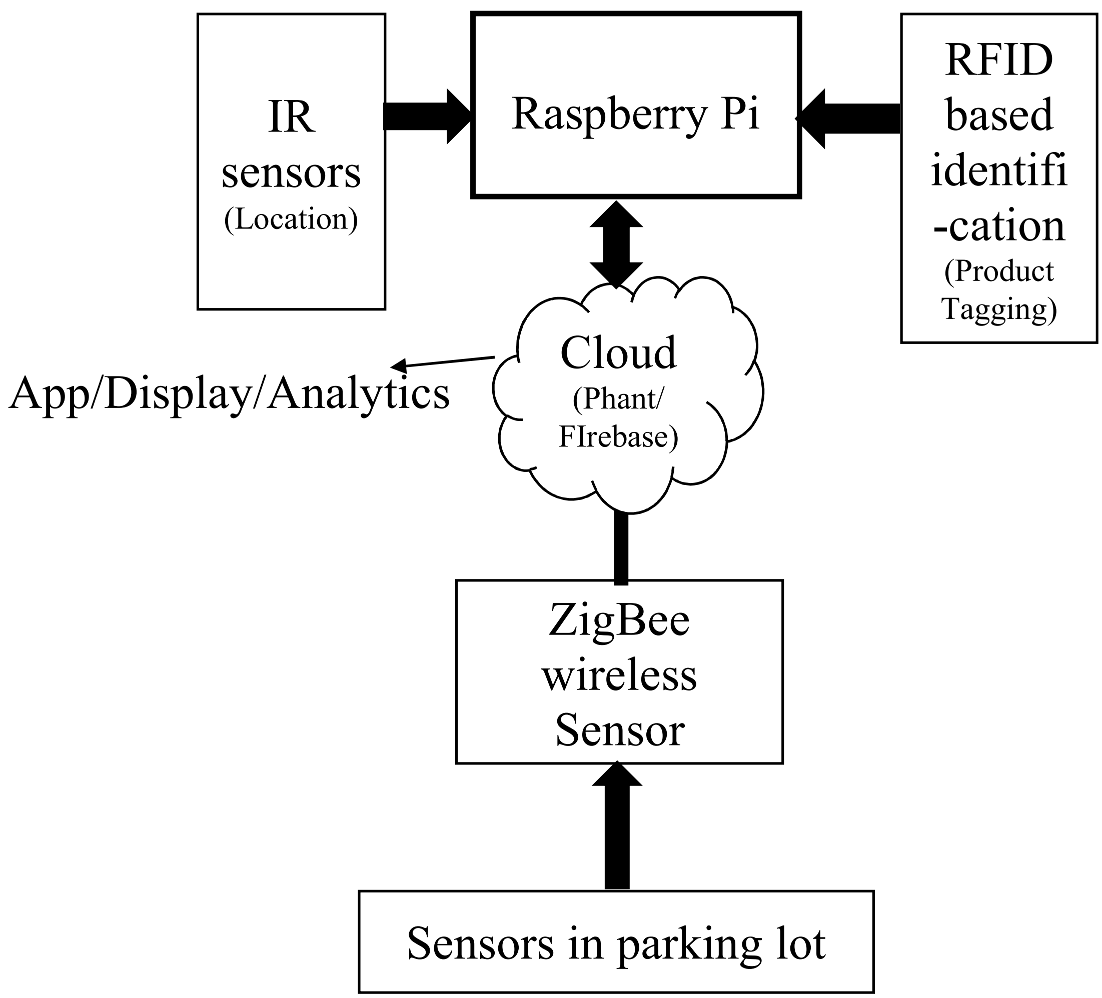

Fig 3.1 System architecture

3.2 PROCESS FLOW

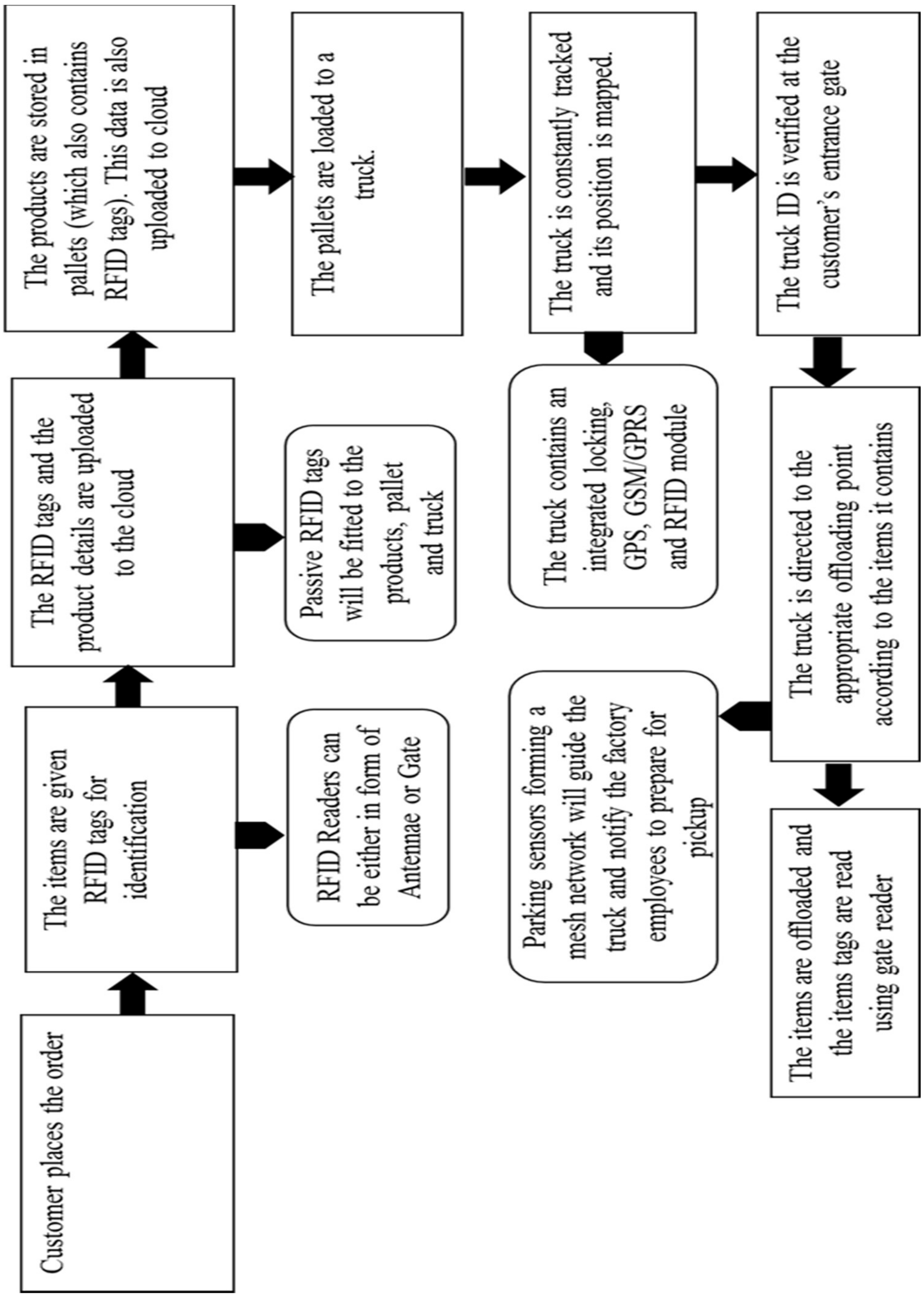

Fig. 3.2 Process Flow

3.3 THE PROCESS FLOW OF THE PROOF OF CONCEPT

- The customer, first, logs in the app. The customer can place order of products and the quantity.
- Once the customer finalizes his cart, he can proceed to checkout.
- Once, the customer places the order, the admin can approve/reject the order.
- Once the order is accepted, the algorithm finds out the best truck/vehicle for transporting the products according to the size, shape and quantity.
- The products are given RFID tags. The tags are read at the gates of the factories and updated periodically. The products are now loaded into the truck (RC truck).
- The truck is tracked by IR sensors. If the truck passes through a sensor, it will detect it, and the Pi will update the FireBase cloud. The app will fetch the data from the cloud and update the location accordingly in the map.
- The admin can always know the status of the product through phant server.
- The customer is always updated via SMS regarding the status of their order.
- The RFID readers are located at each factories and it will read the tags which products are going in and out.
- Every time the vehicle reaches a factory gate, it is assisted in parking by a ZigBee mesh, which will guide the driver to vacant parking spaces in order to save time and ensure quick delivery.
- Once, the product is received, the admin and the customer are both alerted by SMS.

3.4 PHYSICAL DESCRIPTION

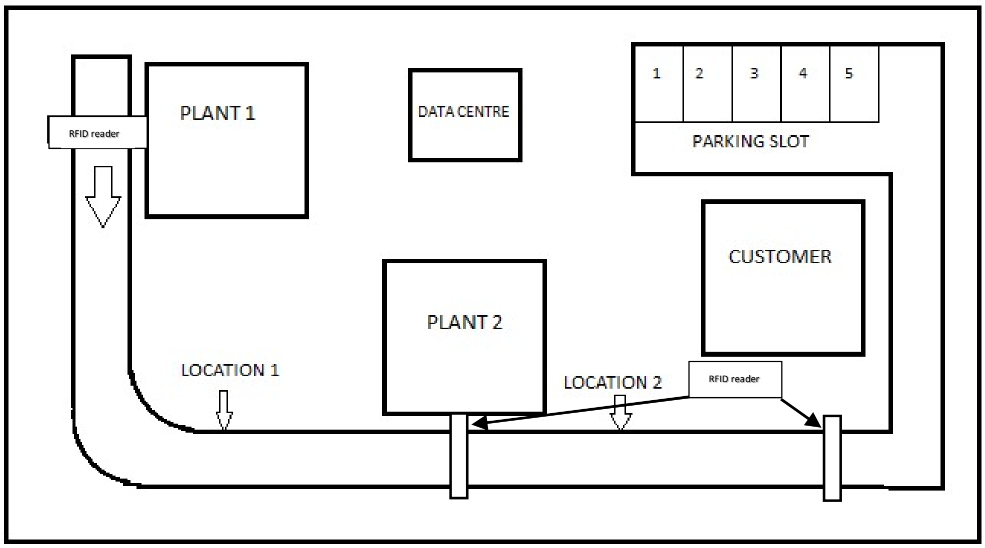

Fig 3.3 Physical outline of the PoC

Once the ordering has been done and the products have been dispatched, the following process takes places:

1. The truck (RC truck) collects the products from Plant 1. The products' RFID are read using the RFID reader installed at the Plant's gate. The IDs are stored in the cloud.
2. After collecting the items, the truck proceeds further the road.
3. At location 1, embedded IR sensors detect the vehicle and update is sent to the cloud server
4. The truck reaches Plant 2. The products are unloaded and reloaded according to the demand. It follows the same procedure as in Plant 1.
5. Similarly, a location update is triggered at location 2.

6. Finally, the truck reaches the customer location. At the customer location, the vehicle is guided to appropriate parking slot, which functions using a ZigBee mesh network.
7. Once the product reaches the customer, the customer is notified through SMS.

3.5 UNIQUE SELLING POINT

- **Reduction in manual labor:**
  As the whole supply chain mechanism is being automated, human intervention will be minimal.
- **Fastens supply chain and logistics:**
  Lesser manual labor leads to faster decision making, thereby, leading to faster logistics.
- **Easier monitoring:**
  The products can be tracked live anytime and anywhere, using mobile app.
- **Better accountability and transparency:**
  All the data is available online, with proper details. The admins can access it anytime. If required, the data can be shared with clients too. This transparency is good for the business perspective.

CHAPTER 4

4. IMPLEMENTATION & RESULTS

The whole Proof of Concept was built in about 2 months. It was well received by the Bosch mangement.

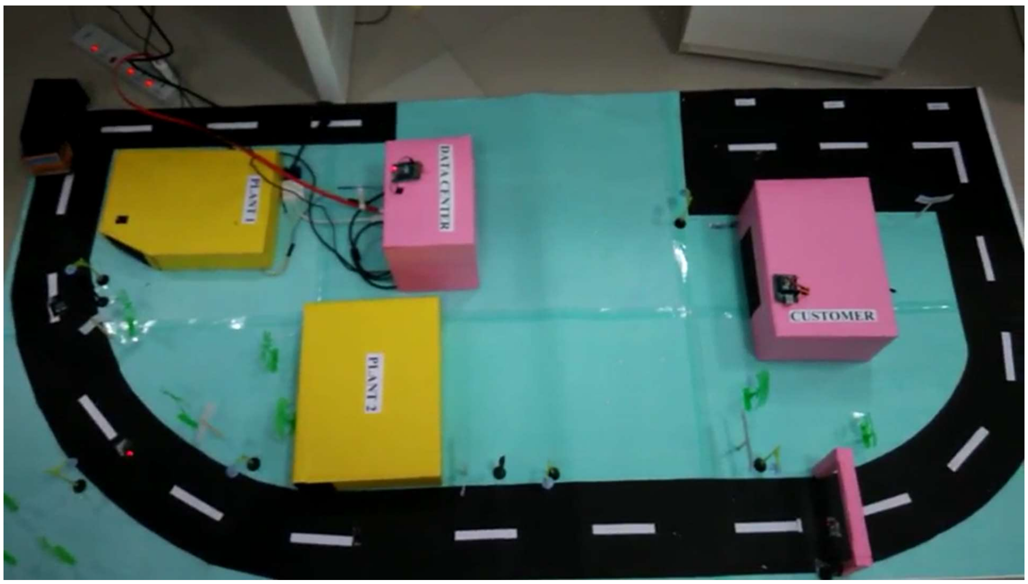

Fig 4.1 Bird's eye view of the prototype

Fig 4.2 Customer login

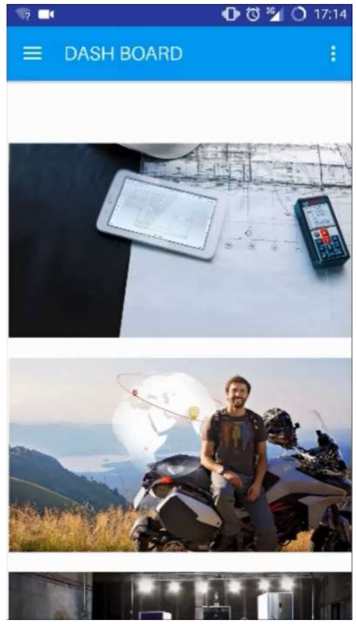

Fig 4.3 Customer's Dashboard

Fig 4.4 Products available in the warehouse

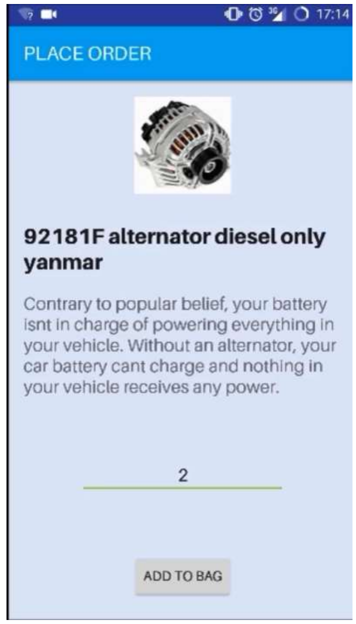

Fig 4.5 Customer placing the order

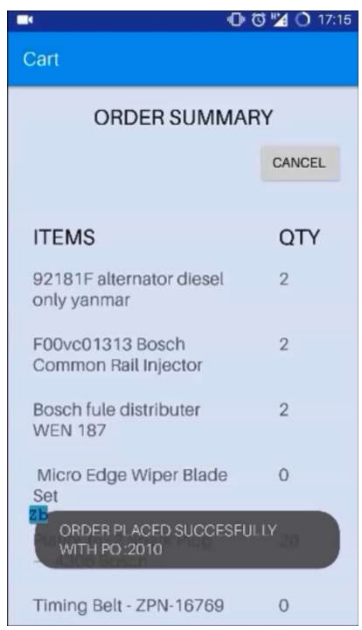

Fig 4.6 Order succesfully placed

Fig 4.7 Supplier's login

Fig 4.8 Truck/Container size required for delivery of order

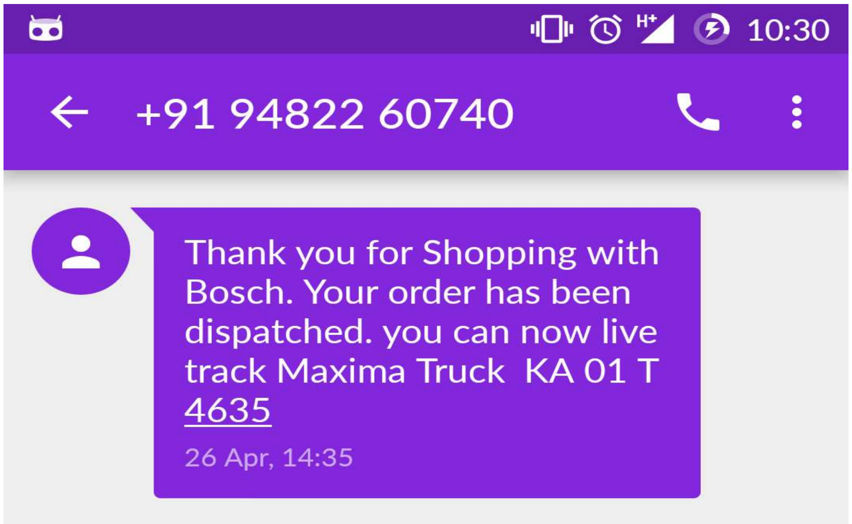

Fig 4.9 SMS received when the order is ready for dispatch.

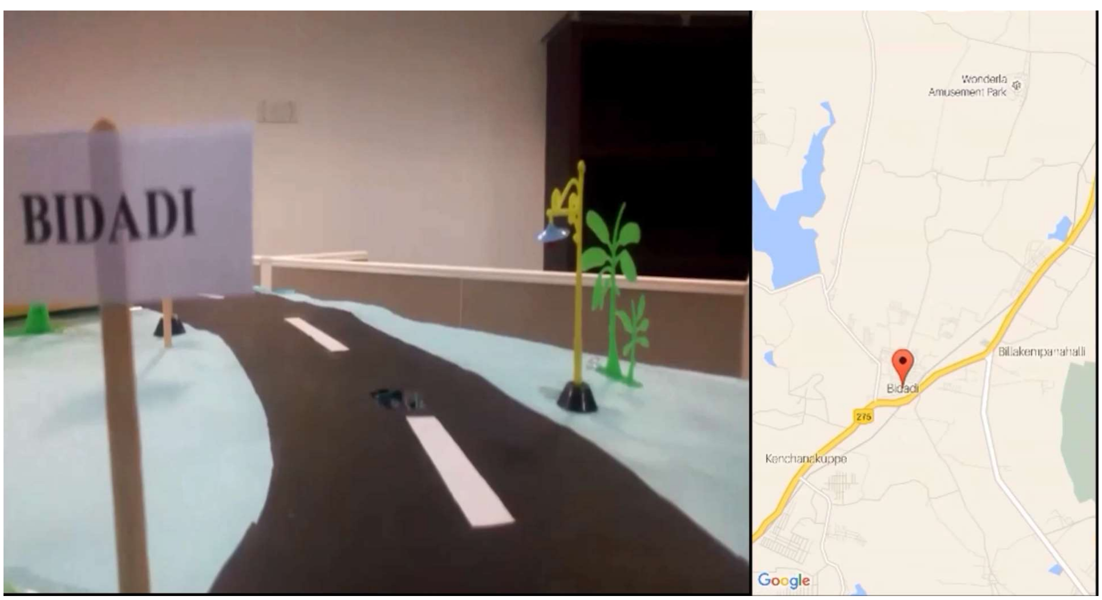

Fig 4.10 Truck picking up order from Plant 1 along with Live Tracking

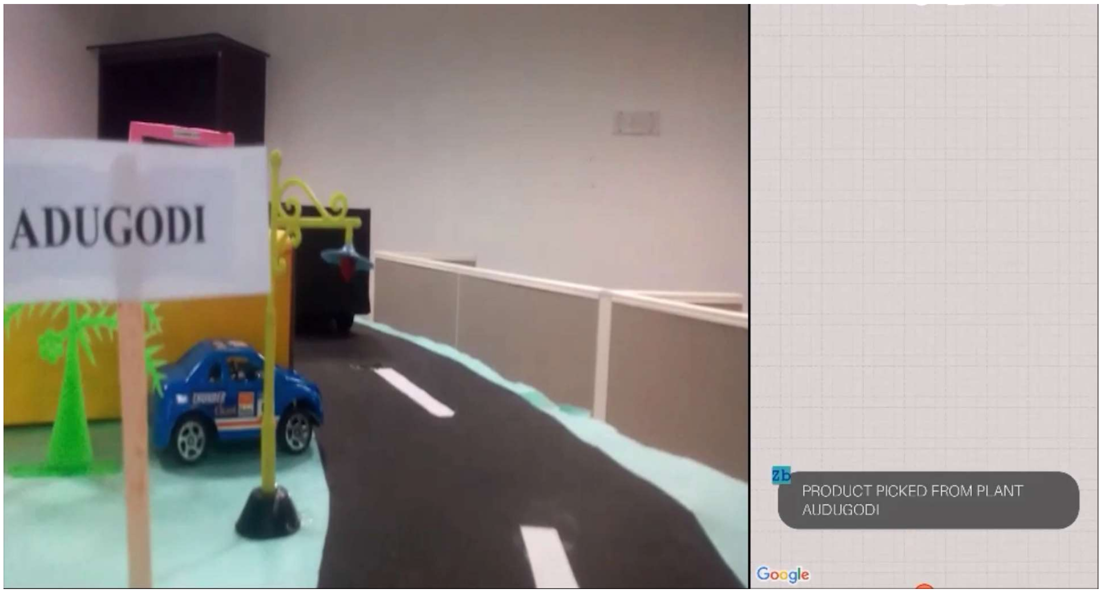

Fig 4.11 Truck picking up/ dropping product at Plant 2 along with Live Tracking

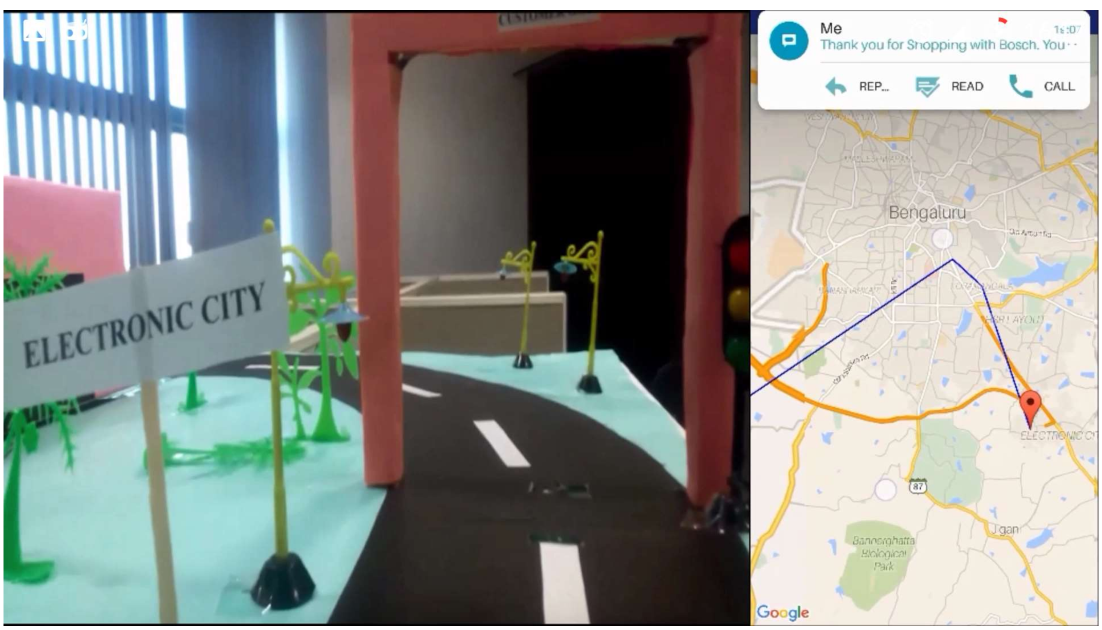

Fig 4.12 Product finally delivered at customer location along with live tracking

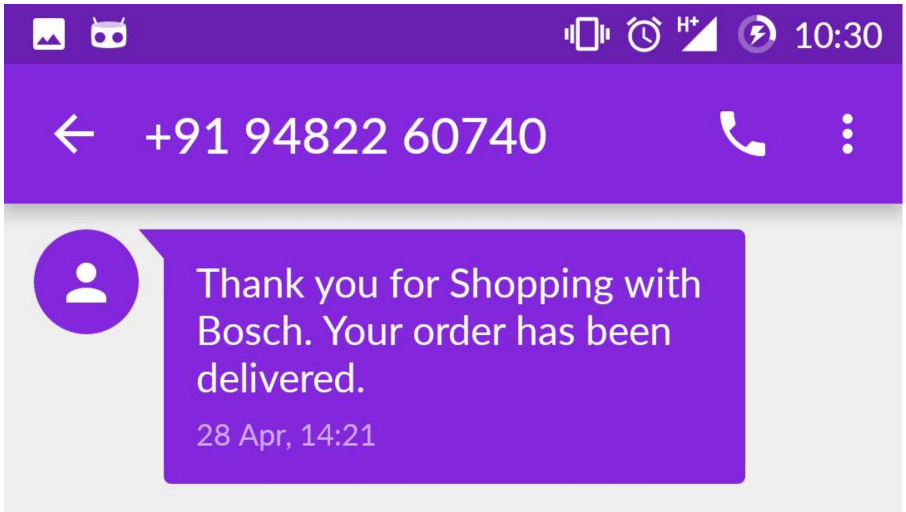

Fig 4.13 SMS received when the order has been delivered to the customer

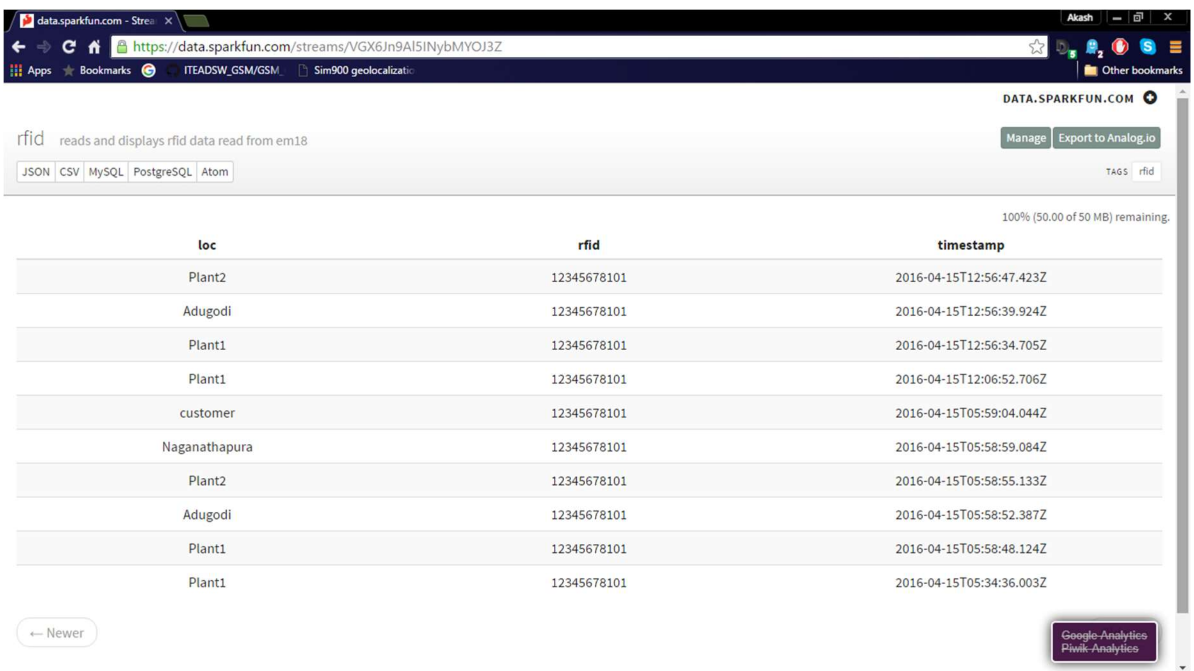

Fig 4.14 Data logged in the Phant Server with time stamp and RFID numbers. (Admin view)

CHAPTER 5

5. CONCLUSION & FUTURE SCOPE

5.1 CONCLUSION

The main problem faced in the existing system is that almost every activity in the supply chain management and logistics is manual. The technology has not been able to make any significant changes. The main reason behind this is probably the cost of these solutions. There is no real-time tracking of products. Inefficient barcodes are still being used for product tagging in majority of the places. Barcodes, due to their Line of Sight issues are quite cumbersome to work with. Nobody in the supply chain has a clear picture as to where their order is. Our solution hopes to address these issues by reducing the cost drastically, at the same time, making the whole process easier to work for the user.

The main challenges faced during the implementation were:

- Choosing the appropriate server, which is accessible for both Rasberry Pi and the mobile application.
- Pushing data to the cloud was a major challenge. It took around 2 weeks to get the code right and implement it successfully.
- Raspberry Pi was highly unstable. Slight voltage fluctuations would cause the memory to get corrupted. The memory had to be backed up frequently.

In the end, my team showcased this projects to potential customer- Mann Hummel. The company's CFO (Chief Financial Officer) was impressed and they are planning pilot projects on this prototype. My team received special appreciation from Robert Bosch India Vice President and the Robert Bosch India Business Unit Head.

5.2 FUTURE SCOPE

- The project has to be expanded and pilot has to be conducted on real vehicles and products. We plan to contact manufacturing plants/ warehouses which will allow us to conduct demo in real-life scenario.
- For locating the vehicles, GPS modules shall be used.
- Replace ZigBee with better networking solution like ANT+. ANT+ provides faster data transmission and lesser latency. As they are proprietary, not open source, we will need funds to acquire the modules and implement them.