Low-Cost Asset Tracking and Inventory Management System (ATIM)

Vivek Vadi¹, Ayush Kotadiya², Rajdipsinh Solanki³, Mohan M. Khambalkar⁴

¹,²,³Student, Department of Electronics Engineering, Birla Vishvakarma Mahavidyalaya Engineering College, Vallabh Vidyanagar, Gujarat, India
⁴Assistant Professor, Department of Electronics Engineering, Birla Vishvakarma Mahavidyalaya Engineering College, Vallabh Vidyanagar, Gujarat, India

e-mail: ¹Vivpatel11@gmail.com, ²Ayushpatel8249@gmail.com, ³rajdipsolanki5@gmail.com, ⁴mmkambhalkar@bvmengineering.ac.in

Abstract. In any supply chain, the warehouse is the main component in linking the chain partners and nowadays it acts as a competitive factor. Current Inventory Management Systems are slow, inefficient concerning managing and tracking the huge demand for large inventory traffic and hence make a poor customer experience while managing large, urgent and important inventories. Internet of Things (IoT) is a promising technology that can be used in the context of Industry 4.0. This paper aims to improve inventory management efficiency multi-folds and enhance stock SCM (supply chain management) analysis for market planning. This solution strengthens store operations & inventory management smartly, safely and efficiently. Also, the blocks and layers of IoT are illustrated. Finally, the benefits and challenges of implementing IoT in the SCM and the warehouse are discussed.

Index Terms: Internet of Things, Supply chain Management, Wireless Sensor Network, Inventory management system

1. INTRODUCTION

Supply chain management is the management of the flow of goods and services and includes all processes that transform raw materials into final products (Adams Hayes, 2019). By managing the supply chain, companies can minimize excess costs and deliver products to the consumer quicker. This is done by keeping tighter control of internal inventories, internal production, distribution, sales, and the inventories of company vendors. It aims to achieve coordination between customer and supplier also proper supply chain methodologies help an organization to reduce buffers of inventory by sharing demand and present inventory level thus, predict demand and supply of product in the market.

Wireless Sensor Network (WSN) is used to lower the cost as well as increase their production in addition, increase scrutiny of their functional system. One of the most challenging tasks in inventory management is a shortage of inventory items, higher holding costs and unavailability of products need. The
Second challenge was to ensure security and theft resistance and damage control. By atomizing inventory management system will be a solution for the above challenges and monitors security and communicating with the server to save the cost of manual data entry.

In the proposed system low cost sensor-based network (WSN) is used which constantly monitors the product stock and it sends data to the server with the help of an esp8266 microcontroller for statistical calculation and demand analyzer using the Wi-Fi network. Auto encryption of data in google sheets to track record of every day sell and purchase to calculate profit and loss of the organization and provides data to make decisions about sales and purchase.

2. INVENTORY MANAGEMENT SYSTEM

Wireless sensor network (WSN) works mainly on two patterns: Tracking and Monitoring. It was used formerly in animal and human tracking etc. Then it was introduced in security systems, detection and inventory monitoring systems.

This paper focusing on the inventory management system with deploying sensors, collecting the data from sensor nodes using WIFI technology with the help of the IEEE 802.11 protocol. This system works on the open-source device (ESP8266) and Arduino IDE for a flexible programming environment. The star topology is appropriate with the proposed system as it works on indoor principles. The system is designed with open server IO (Adafruit IO) and IFTTT to transmit server data to google sheets. Google-sheets convert text into column format, also it calculates total sales, total purchase profit and gain. It also provides data about the highest consumption of a particular product to predict its demand.

When product count found below-set cut-off value owner will get an alert email as well as a message along with a google- spreadsheet link to ensure the authenticity of received alert. So it can help the owner to order new stock before it gets over and business goes on.

Statistical analysis and purchase history in a spreadsheet will be useful in maintaining the annual budget report.

3. SYSTEM REQUIREMENTS AND DESIGN

Many hardware, software and processing techniques are required in designing the proposed system as shown in the block diagram given below.

![Block Diagram of Inventory Management System](image)

**Figure 1. Block Diagram of Inventory Management System**
3.1 Hardware requirement

3.1.1 ESP8266:
An integrated WIFI SoC by Espressifs with efficient power usage, compact design and well-founded performance in IoT application. With stand-alone WIFI networking capabilities it can perform either as self-contained applications or slave to a host microcontroller.

Besides the Wi-Fi functionalities, ESP8266 also integrates an enhanced version of Tensilica’s L106 Diamond series 32-bit processor and on-chip SRAM. It can be interfaced with external sensors and other devices through the GPIOs makes it suitable for our proposed system.

Data fetched with the help of Ultrasonic Sensor will be processed in ESP8266 SoC for calculation of products. After processing final data will be sent to open server IO (Adafruit IO) to store on the server.

3.1.2 Ultrasonic Sensor:
An Ultrasonic sensor emits frequency generated in its crystal with its trigger and waits for a signal to reflect and receive it though its echo. With the difference in send and receive signals timing it calculates the distance between an object and ultrasonic sensor given by the formula.

\[ \text{Distance} = \frac{1}{2} \times C \times T \]

\(C=\) the speed of light, \(T=\)the speed of sound

At 22°C (70°F), the speed of sound is 342 m/s (1122 feet/second), but this may vary with temperature and humidity.

In our system Ultrasonic sensors will detect an object and measure the distance between an object and itself and sends that data to ESP8266 for processing.

3.1.3 WI-FI Router:
WIFI Router is a device responsible for the function of a Wireless Access point. It also provides access to the Internet or access to a private network. The different manufacturer adds different functionalities either used for Local Area Network (LAN) or Wireless only LAN or mixed functionalities.

Wi-Fi router works on IEEE802.11 standards and provides a bandwidth of 2.4GHz to 5GHz. It provides access to ESP8266 SoC to connect to the internet and transmit processed data to open server Adafruit IO with help of Message Queuing Telemetry Transport (MQTT) protocol.

3.2 Software requirement

3.2.1 Arduino IDE:
Arduino integrated development environment (IDE) is a platform used to program our proposed system. Arduino group has developed this platform with an inbuilt compiler and a tendency to convert byte code into machine code which can be transfer to Arduino based microcontroller.

The newer generation has added some new interaction with we can program our SoC also. Arduino IDE creates a sketch with programming language like C++, it can be written with the help of programming language C also.

In the sketch we define input and output parameter as set logic for our microcontroller or SoC so that it can process data received from Ultrasonic Sensor and use the MQTT library to work with MQTT protocol.

3.2.2 Message Queuing Telemetry Transport Protocol (MQTT):
MQTT is the machine to machine (M2M) Internet of Things protocol. It was designed as extremely lightweight messaging transport. It works on publish/subscribe command. MQTT is useful for connections with a remote location where small footprint code and network bandwidth at a premium. It is ideal for mobile applications due to its small size, low power requirement, minimum data packets and efficient distribution to one or many receivers.
3.2.3 Adafruit IO:
Adafruit IO makes the Internet of Things for everyone. It is an open-source IO platform that provides server support free of cost. It is a system that makes data useful. It focuses on ease of use and allowing simple data connections with little programming.
IO includes client libraries that wrap MQTT APIs and display and store received data from it. It also can send switching information to microcontroller/SoC using a subscribe command. To fetch data it needs to execute publish command which constantly retrieves data received and processed on microcontroller/SoC.
The feeds on hold metadata about the data we push. This includes setting weather data that is public or private. It also provides a graphical interpretation of data received.

3.2.4 IFTTT
If This Then That (IFTTT) is an open-source
Online service that creates a chain of a conditional declaration known as applets. An applet triggers under a change in web services such as email, twitter, Blynk IoT, etc. As specified if condition statement it monitors feeds and triggers concerning conditional input provided by the user.
Here we have specified feed of Adafruit which observe regarding state change in if conditional statement and accordingly data will be fetched from Adafruit and will be organized in google sheets as suggested in that conditional statement.

3.2.5 Google sheets
Google sheets is an online spreadsheet application included as a free web-based office suite offered by Google with its google drive services.
It offers an online spreadsheet platform with no charge and connectivity with IFTTT service. As new data arrives on Adafruit it is monitored with IFTTT and sent for wrapping in google sheets. With the help of hyperlinking and few mathematical formulation our spreadsheet gives us real-time sales information, real-time stock availability and statistical analysis to predict future expectations and purchase suggestions to avoid loss.

4. SYSTEM IMPLEMENTATION

![Schematic Diagram]
System implementation starts with hardware design after proper testing on a breadboard. PCB designing process will be done with the help of Eagle Autodesk. With help proper component selection and appropriate libraries the above mention schematic diagram (Figure 2.) is designed then it will be converted into “.brd” file and with the proper place and route printed circuit board (PCB) layout is prepared. This PCB will be soldered with pre-identified components.

Afterward software programming part comes. Programming will be done in Arduino IDE with the c programming language. MQTT library is added in the program to assure timely delivery of information monitoring stock in a storeroom, or malls, or any small scale shop to Adafruit IO server.

To guarantee accurate count with a simple ultrasonic sensor tending to detect an object and measure the distance it needs to develop logic with some constraints. An ultrasonic sensor needs to place at the entry point of the rack, also we need the length of the rack and width of the object that needs to be placed in the rack as shown in the given figure below.

Here given the picture depicts some acronyms as suggest:

- o-Object Width
- d-Distance between object and ultrasonic sensor
- D-Total length of the rack
- c=d-Clearance distance

The calculation of product count will be done with the formula

\[ \text{Product Count} = \frac{(D+c-d)}{o} \]

For example, rack length is 10, clearance is 2, product width is 2 and distance d=4. Putting values in the above formula.

\[ \text{Product count} = \frac{(10+2-4)}{2} \text{ Product count}=4 \]

This applies to any value any size, the user just needs to define required rack length and object width rest is adjusted in the above formula automatically and data processed involuntarily.

Post-processing the data generated will be sent to Adafruit secure account with the help of the MQTT broker every 10sec and Adafruit will graphically represent data received.

![Figure 3. Rack section overview](image)

![Figure 4. Data flow model](image)
As shown in the data flow model (figure 4.) data processed and transferred through various steps. Data received in Adafruit will be lodged to spreadsheets with the help of IFTTT service which will constantly monitor the feeds for Adafruit for fetching and wrapping of data in spreadsheets.

IFTTT provides facility to set cutoff state, if value below cutoff is received it will send instant mail and text message to the user for less availability and warn him to replenish the stock before it gets over.

With the help of mathematical formulation and hyperlinking of spreadsheets the monetary calculation proceeds which relate gross sale with gross profit or loss, also with some special formulas it suggests the highest consumed product details as well as at least consumed goods to insure future purchase benefits and avoid loss.

5. FINAL RESULT

We have tried to implement this project to generate necessary results to analyze the working application and find fruitful solutions for the generated faults. As of testing, we have tried to work out with three sensor network capable of real-time monitoring of stock of three (3) products at present and it worked well.

It has successfully monitored the real-time stock count and also updated it in the provided Google spreadsheet on the server so that one can access the data to do the needful. Whenever the stock count happens to be less than the set cutoff value, it has also sent alerts to the system owner (in this case us) with the help of Gmail service and also with the SMS so that we could not miss out in case of internet issues or Gmail failure. One access link of Google spreadsheet comes with the mail so that owner can confirm reality check (means email or SMS is not sent with error). We have attached Snapshots of emails and SMS regarding the system check and cutoff alerts.

![Figure 5. Stock cutoff alert](image)

The provided Google spreadsheet comes with the power of Google analytical tools with help from them we have added features like real-time monitoring data, total present and sold stock, total revenue generated, the total profit gained demand percentage, and also a graphical representation of the demand curve as shown in sheet.

With the help of the demand curve graph, one can judge the demand for a product and place orders accordingly. It can help owners gaining more sales hence more profit. On the contrary if the demand for a particular product continuously decreasing cam also emerges out and that will help lowering losses.

An additional feature is available for the user to auto-order on cutoff stock implementing the ATIM (Asset Tracking & Inventory Management) system in the warehouse in order to fulfill market greed and also smoothening of supply chain management.
6. CONCLUSION

Low-Cost Asset Tracking and Inventory Management System (ATIM) by deploying low-cost sensors creating a wireless sensor-based network to monitor and track record of inventory gives a more comprehensive vision to help to get the accurate vision, this system is built with open-source SoC so does the programming environment free. To build our system server requirement will be full filled by Adafruit at no cost and data lodging help will be availed by IFTTT to wrap data in meaningful manner at google drive offered google sheets a free online spreadsheet application.

With almost minimal cost this system can be implemented and practically best results can be achieved.

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