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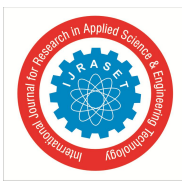
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# Smart Logistics and Supply Chain with Machine Learning and IoT

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**Abstract**— Logistics is an important part of the Supply Chain. The management of logistics and supply chain is a complex process of planning and management of services, goods from the origin to the point of consumption. Logistics is defined as the process of managing movement of goods in and out of an organization. Supply Chain is defined as the process of managing movement and coordination of goods in between multiple organizations. Together Logistics and Supply Chain includes planning the transport, warehousing, inventory and sales an example of logistics could be the military stockpiling ammo whereas an example of Supply Chain management is making sure the right amount of goods reaches the destination, supplying more could lead to increased storage costs and supplying less could lead to inefficiencies. So, the main objective of Logistics is customer satisfaction and the main objective of Supply Chain is to have a competitive advantage by being more efficient. This project aims to have both customer satisfaction and efficiency and will achieved by implementing Internet of Things and Machine Learning to Logistics and Supply Chain. Large Corporations invest a lot of money to improve supply chains. This paper aims to help small businesses and rural businesses to improve their Supply Chain. This project aims at providing customer satisfaction and efficiency. Implementation using IoT and machine learning provides better efficiency.

**Keywords**— Smart Logistics, Smart Supply Chain, Industry 4.0, Internet of Things, Machine Learning.

## I. INTRODUCTION

Logistics is a part of Supply Chain today since to make a product, goods are sourced from various companies and factories. Supply Chain runs the world today. An efficient supply chain can save a company a lot of money. So, there is a need to make the supply chain as efficient as possible. By using IoT and Machine Learning. It can digitize to automate various parts of the supply chain. The concept of Industry 4.0 is fascinating. The automation and digitization of factories using the Internet of Things. It is about using data generated at various points to make automation work better in various ways. Since more data is generated with time the Machine Learning algorithms get better with time to and gradually the supply chain becomes more and more efficient.

The Covid-19 pandemic has prevented people from travelling and forced people to work from home. The people working on the supply chain like drivers, factory managers, warehouse supervisors can't exactly work from home. Digitizing this can help these people to stay safe and make the supply chain a lot more efficient. During the lockdown there was a huge demand for packaged foods and people were hoarding food and other necessary medicines and condiments. The companies can't handle sudden disruptions like this. Here not only the goods are scarce, the supply is also reduced. The only way to fix this is to use digital services to make sure goods reach places that require them the most. In times like this more fabrics will be in demand by mask making and PPE companies than clothing brands. Active Pharmaceutical Ingredients and medicines are a priority to the pharma industry and hospitals. A smart supply chain will be able to make sure the goods reach their destinations on time.

The goods and containers transported are tracked using RFID inside factories and warehouses and GPS outside the factories and warehouses. This makes sure that the right containers are transported via the right mode to the right location. This GPS tracking of containers makes sure that the goods are on schedule and safe.

This much of digitalization can help in moving a step closer to automating the entire supply chain. Data Analytics can be used to analyze customer behavior and quantity of goods in the stores to automatically order low quantity goods from the warehouses. The most important part of the supply chain is efficiency. It doesn't make sense to transport 10 units of a particular item every 1 hour just because money can be saved in storage costs at stores. So, the Machine Learning Algorithm must be smart enough to keep storage costs, transport costs minimum.

## II. LITERATURE SURVEY

A. Torben Schütz and Zoe Stanley-Lockman, [1]

This paper concentrates on logistics required in the military, it also brings to light those emerging technologies have the ability to impact the production of goods, the means of transportation and the volume of transported goods and the importance of better logistics. It also mentions few important points such as Green Technologies and the importance of having a very less carbon

footprint in today's world. It also mentions Additive Manufacturing as a very important aspect of reducing delivery time and keeping equipment functional. This paper also talks about the role of Artificial Intelligence and Nervous Systems and the role that AI, big data and deep learning are going to play in minimizing manual effort. To conclude this paper also talks about the role of robotics and unmanned systems and also risks associated with completely automated logistics.

*B. Abhirup Khanna, Rohit Goyal [2]*

The work presented in this paper talks about an Intelligent Traffic Management System that has its foundation on Cloud computing, Internet of Things and Data Analytics. Their proposed system claims to help to resolve various challenges that are being faced by traffic management authorities in terms of predicting an efficient route, reducing average waiting time, traffic congestion, travel costs and also the extent of air pollution. Their system aims to use machine learning algorithms for analyzing and predicting the best possible routes based on the traffic mobilization patterns and vehicle categorization. This paper also gives a layered architecture plan on the implementation of an Intelligent Traffic Management System. This paper also gives a detailed Mathematical Model and an Algorithm along with a real-life example and implementation of this model. The paper also discusses the ways such that an optimum route is suggested to the end user and how the optimum route is actually more beneficial than the shortest available route in most cases in terms of fuel cost and total travel time.

*C. Aishwarya Raj Laxmi Ayaskanta Mishra [3]*

This paper provides information about how IoT based technologies like RFID and wireless sensor networks are the key technologies used for monitoring and tracking the live condition of the goods, the present location of the goods, and the concern delivery point. The papers tell about how to build the algorithm for the RFID shipment tracking by using RC5222 passive RFID reader, raspberry pi, and implemented by using python. The logistics and supply chain network is a complex amalgam of actors that need coordination, collaboration, and information exchange to increase productivity and efficiency.

*D. S. Yuvaraj, M. Sangeetha[4]*

The paper talks about how the supply chain management (SCM) works in designing, planning, execution, control, and monitoring of goods. These methods are heavily followed by areas such as operations management, logistics, and information technology. The proposed system in paper talks about the database, GPS tracking, and RFID tags that make the transportation of goods easy. RFID is the wireless use of electromagnetic fields to transfer data, to automatically identify and track tags attached to the objects so it will reduce average time and increase efficiency in the tracking of goods. For indoor and outdoor tracking, different tracking methods like RFID and GPS can be used.

*E. Marcin Hajdul, Arkadiusz Kawa [5]*

The paper mainly focuses on a concept like GPS, GPRS, these will tell exact position, speed, time anywhere in the globe, so it would easier to track goods transportation. It also talks about the T-Traco system developed by ILIM in collaboration with Call Freedom. T-Traco is a global system of intelligent cargo monitoring without roaming, and This is possible through the use of the USSD (Unstructured Supplementary Service Data) communication channel.

**III.METHODOLOGY**

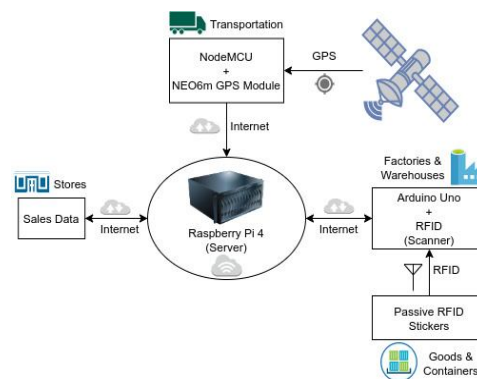


Fig 1. Block Diagram of Smart logistics and supply chain.

Fig 1 explains the different aspects of this proposed method, it also showcases the different tools that would be needed.

- A. A Raspberry Pi 4 is used as a server to host the Supply Chain Dashboard.
- B. The dashboard is built using HTML & JavaScript. Arduino Uno is used to tracking goods or containers using RFID Scanner.
- C. NodeMCU is interfaced with the NEO-6m GPS module to track the goods during transportation. NEO-6m GPS module outputs NMEA data frames and it is decoded using a library called TinyGPS+.
- D. Since the GPS modules are on transport, the data should be sent over a network. It is done using MQTT. MQTT is a subscriber-publisher protocol on TCP/IP.
- E. It is implemented on the NodeMCU using a library called PubSubClient. Latitude and Longitude data is pushed to topics called 'GPS/Latitude' and 'GPS/Longitude' respectively.
- F. Using JavaScript the MQTT data can be retrieved from the MQTT broker and be used to display live data on a web dashboard.
- G. The RFID module is used to save the contents and data of goods and containers digitally. This helps save the data securely and since the RFID tags have to be scanned before transportation.
- H. The containers and transport are linked, this makes tracking easier and digitized.

The machine learning algorithm focuses mainly on Demand Forecast.

*ML algorithm for Demand forecast:*

For a machine learning algorithm to learn how to make predictions, both the inputs and the desired respective outputs need to be shown. It will then automatically understand the relationships between these inputs and outputs. An ML algorithm will learn patterns from all the dataset and will apply what works best to each product. With machine learning, it is possible to increase the accuracy of the model by providing more products. Multiple Linear Regression model is a very good fit for this prospect, it takes in multiple parameters and finds correlation in the data and gives out accurate results.

#### IV. OBJECTIVES

- A. Use RFID tracking to make goods tracking simpler in factories and warehouses.
- B. Use GPS to track goods being transported.
- C. GPS data should be transferred over a network.
- D. Build an effective Machine Learning algorithm to predict demand.

#### V. RESULTS

```
Received ASCII | Received HEX
Scan RFID:
Card UID: A9 40 34 B2
Shipment ID: BLRG0I210420-001
Priority: HIGH
Route (IATA): BLR -> GOI
Delivery by: 2021-04-20
```

Fig 2: RFID Tags with some information relevant to Logistics

```

pi@raspberrypi:~$ node MQTT_Sub_JavaScript.js
Latitude_Subscribed
12.87
12.87
12.87
12.87
12.87
12.87
pi@raspberrypi:~$ node MQTT_Longitude.js
Longitude_Subscribed
77.57
77.57
77.57
77.57
77.57
77.57

```

Fig 3: GPS Data retrieved from MQTT broker using JavaScript

Fig 2 and Fig 3 shows the data being retrieved to a computer. This data can be fed into a Supply Chain Dashboard and by digitizing such data helps Supply Chain Managers to accurately take right decisions. The RFID tags can be programmed to hold more data if required.

In Fig 3, the live GPS data retrieved from a MQTT broker using JavaScript can be observed. The use of JavaScript makes it easy to integrate it with other softwares or websites. A more accurate GPS data can be received from the GPS module (upto 6 decimal places). For the purposes of demonstrating it is shortened.

To simulate the Multiple Linear Regression model, a dataset with medicines sold, date, ratings and weather was used. The linear regression model assumes that for any subject/individual with response  $Y_i$  and predictor

$X_{i1}, X_{i2}$  satisfies

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \epsilon_i$$

where  $E\epsilon_i = 0$ , or equivalently

$$E(Y_i) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2}$$

Sometimes, it is also written as,

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \epsilon$$

where  $E\epsilon = 0$ . or equivalently

$$E(Y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2$$

where  $\beta_0, \beta_1, \beta_2$  are called regression coefficient.

$\beta_0$  is called intercept.

$\beta_1$  is called coefficient of  $X_1$ .

$\beta_2$  is called coefficient of  $X_2$ .

For the multiple linear regression model to predict demand based on the ratings of the medicine and the weather conditions on a given day, the coefficients derived for ratings and weather conditions was 2.43918564 and 0.04609484 respectively and the intercept 10.88741526.

The mean absolute error was 22.43 and the mean sum of squares 945.77.

### VI.FUTURE SCOPE

- A. With the anticipated arrival of Self-driving vehicles in the forceable future, smart systems can be installed in vehicles in order to eliminate most of the human interaction with goods and to ensure better transit times.
- B. Using predictive models for transport of goods allows the respective authorities to control the flow of traffic, maybe even have different routes for passenger traffic and goods traffic.



- C. As in recent times more and more companies have been opting for ML based or AI based solutions for the problems faced, a Smart Logistics and Supply Chain will prove to be useful and also be viable as it will be future proof as it keeps evolving to market conditions.
- D. The hardware can be optimized, with the arrival of 5G in the coming years lower latency network connections can be used. With 5G more data can be collected as it allows higher bandwidth. Route optimization can play an important role in Supply Chain Management.
- E. Currently MQTT is hosted locally it can be moved to cloud and encrypted MQTT connections can be used. The use of Cloud can reduce latency between devices significantly.

## VII. CONCLUSION

In reference to smart logistics, the use of AI and ML are in very early stages. Presently there is increasing insistence in fields such as manufacturing, energy, and transportation to adopt AI and Machine Learning to help improve efficiency in operations and to enable better business decisions through futuristic systems. None of it is easy, but the trend is definitely pointing towards AI, Machine Learning and Deep Learning.

Supply chain and Logistics are a very important aspect of industries, as they encompass the whole process of raw materials being converted to finished goods. Therefore, having better supply chains and logistics systems is a very important aspect of industry.

The available systems of logistics and supply chain cannot be used in the future and therefore there is a requirement for better alternatives. Having a connected supply chain which can understand data and make better decisions on its own without human involvement is needed.

When new information is supplied, a connected supply chain may modify and accommodate. If a shipment is delayed due to weather, a networked system can anticipate the situation and adapt manufacturing priorities accordingly.

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