Advancements using IOT in Supply Chain Management of Pharmaceutical Industry

Arun Krishnan R
Symbiosis Institute of Business Management (SIBM), Symbiosis International (Deemed University) (SIU), Electronic City, Hosur Road, Bengaluru, Karnataka, India
Email: arun.krishnan21@sibm.edu.in

ABSTRACT

Keywords

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Introduction

Background and Context

This paper focuses on supply chain management for pharmaceutical industry by employing advanced technologies such as Internet of Things. Regarding the pharmaceutical industry, function of the supply chain is to transport medicines from manufacturer end to user end with maintained accurate temperature with monitor system to minimise the risk factors during its transportation. The customer cares for the product which they order or purchase, that it meets the specified quality standard and is safe to use. The cold supply chain system is employed in pharmaceutical industry. This cold supply chain refers to the distribution of products, through a temperature-controlled supply chain using transportation planning and logistics, along with refrigerated packaging to protect these products. The cold supply chain products system involves preparation, storage, transportation and tracking of goods that are very sensitive to temperature changes, from the supplier to consumer. Since pharmaceutical goods are sensitive to temperature, they require low temperatures to avoid chemical reactions. The components of this temperature-controlled supply chain with essential set of refrigerated storage and subsequent activities related to logistics, along with the required equipment, maintain the required low-temperature range used to preserve, extend and guarantee the durability of products.
This paper studies about IOT that helps in Supply chain of pharmaceutical with safety guide lines and potentially change the traditional approach, also by using data analytics tools as a third layer in this model to help collect present data which can help in making rapid decisions futuristically.

Problem Statement

Monitoring the temperature and humidity of the environment during transportation in real time for pharmaceuticals is a big problem in pharmaceutical industry, temperature in logistics planning functions necessary to ensure the maintenance of the necessary quality and standards of goods and product in the supply chains. The cold chain system consists of specific stages, such as preparation for shipment, storage, transportation, and monitoring products that are sensitive to temperature, from the moment the product is sent from suppliers to the moment of arrival to consumers. Previously, in the model used in SCM there are 2 layers, and the layers of model are independent to each other and the knowledge transferred is not related to each other and the information is baseless and control is not effective. To overcome this problem, the latest development in technology, IoT is proposed to be used in the future models.
Pharmaceutical organizations are not just constrained to help distinguish and make accessible medicines and safety kit for patients, doctors and staff; however, they additionally have a commitment to keep up flexibly and safe chains for existing medicines and administrations. In spite of ordinarily high safety stock levels and support stock over the biopharma supply chain, there are signs that the entirety and greatness of supply chain disturbances could affect the business' capacity to get medicines to patients even in transpiration is a big problem. Over the most recent two months since the pandemic started, 15 new medications have been added to the FDA sedate deficiency list. India's enormous import depend on China (about 70% by esteem) has become a danger to India's medicinal services industry and worldwide supply chain.

Research Questions

In the pharmaceutical industry, maintaining the low temperature of the sensitive and perishable drugs is of prime importance. Since pharmaceutical goods are sensitive to temperature, they require low temperatures to prevent chemical reactions from taking place. In pandemic situations, chances of transports medical kits and medicines getting infected is very high.
As per WHO (world health organization), about 25% of all vaccines come to the consumer in a spoiled form due to non-compliance with temperature regimes. At the same time, failure at any part of the logistics chain leads to futility of efforts at other stages. The world health organization has

developed the concept of a cold chain for the pharmaceutical industry – a set of sequential measures aimed at ensuring the proper temperature when moving a pharmaceutical or vaccine through the supply chain from production to direct use So, Transport or export from manufacturer to end consumer safely with accurate time and without damage is the main question in this paper in this Corona pandemic and normal days.

Relevance and Importance of the Research

The cold chain deals with the organized movement of products which are sensitive to temperature through the supply chain, employing functions that allow maintaining the necessary temperature using logistics planning functions to ensure the maintenance of the required quality of goods in the supply chains. Identifying the underlying aspects that make such a supply chain system is essential. Pharmaceutical products are temperature – sensitive products that require lower temperatures and a certain humidity to be maintained during transportation and storage in order to neutralize chemical reactions occurring in them. According to WHO, about 25% of all vaccines come to the consumer in a spoiled form due to non-compliance with temperature regimes. At the same time, failure at any part of the logistics chain leads to futility of efforts at other stages. The world health organization has developed the concept of a cold chain for the pharmaceutical industry – a set of sequential measures aimed at ensuring the proper temperature when moving a pharmaceutical or vaccine through the supply chain from production to direct use. Special attention is paid to maintaining the temperature regime during transportation. Violation of the temperature regime storage of drugs is not only accompanied by a decrease in their effectiveness, but also can lead to an increase in their reactogenicity, that is, it can harm human health. The storage temperature of a preparation or vaccine is usually indicated on its packaging. IOT is a network that smartly connects multiple objects and devices. The essence of the principle: all resources for solving a specific task must be in the same information network and objects must constantly exchange data. In fact, these ideas have become prototypes of the Internet of things. Researchers developed two main areas: radio frequency identification and sensor technologies. The development of pharmaceutical item from makers to its shopper includes various parties. These incorporate providers, producers, wholesalers, pharmaceutical advantage administrators, medical coverage organizations, clinics, and drug stores/retailers.
Coordination includes the combination of stock, warehousing, material dealing with, bundling and transportation of items alongside security. Pharmaceutical items used in transport used in supply chain are to follow guidelines by government and hospital conditions unfavourably affecting strength and bundling trustworthiness. Fruitful appropriation of SCM rehearses permits the organizations to increase a bargaining power and lessen costs by five to 10%. So As per this theme the major focus is to check factors affecting and influencing pharmaceutical SCM, and find the better technology using IOT to control and monitor the overall system in cheap way. The essential job of the pharmaceutical business is to make sure of the adequate temperature and screen the hazard factors during transportation. As indicated by the client point of view, the care for the products what they bought should fulfil the quality guidelines and wellbeing for utilization. These technologies are independent of each other and constitute a kind of decentralized system. The information which is collected and transferred is not interconnected and the data control is therefore ineffective. Consequently, as a solution to this problem, a new technology called Internet of Things (IoT) is introduced. Here a logistic system that uses IoT for the pharmaceutical industry is designed. The design introduces a system consisting of three different layers, the first being RFID, followed by a wireless layer (WSN) which feeds a data analytics layer(Scikit).The RFID layer works as an asymmetric tag-reader link, WSN layer works as ad-hoc network between reader nodes and Scikit Learn layer helps in taking decisions and can analyse where and what the problem is. This smart logistic system helps to achieve a lower cost of investment through live monitoring of goods from shipment to customer. The sensor devices, having access to the internet, provides live data transfer which gives an opportunity to the pharmaceutical organization to react immediately and take decisions at once if required in the logistic process.

Literature review

Key Concepts, Theories and Studies

1- Employing IOT in pharmaceutical industry

The logistics is an important part of supply chain management and plays a significant role for any company. Recently, the logistic systems are connected with high-tech technologies like radio frequency identifications (RFID)(scanning ids, wireless devices, GPS etc.)
This technology tries to reduce the risks related to the supply chain of pharmaceutical networks. The data and information transferred is not connected to each other and the information control is therefore ineffective. To overcome this issue, an internet-based technology called Internet of Things (IoT) has been used in the recent past. In this paper, a smart logistic system that uses IoT is designed for the pharmaceutical industry. The design introduces a two-layer network architecture of IoT used platforms. The first layer constituting RFID layer act as an asymmetric tag-reader link and WSN layer is an ad-hoc network between readers/master nodes. Adjusting this savvy strategic framework accomplishes live checking of products from shipment to the client at a lower cost of speculation. The sensor gadgets are associated through the web and continuous information move will give a chance to the pharmaceutical association to respond right away on the off chance that any progressions required in the strategic procedure.

2-Pharmaceutical Supply Chain Risk

This investigation will discuss about the appraisal of provider chances inside a buy division of pharmaceutical industry of Karachi, Pakistan with the intent to concentrate

how it is conceivable to productively deal with these gracefully chain dangers and to present a proper technique for the buy offices. No any past examinations survey dangers and issues in pharmaceutical organizations during breaking down the pharmaceutical supply chain chance extraordinarily provider side hazard. Any dangers influencing the pharmaceutical organizations could upset flexibly of prescriptions and social insurance framework viability. These acquirement dangers upset the gracefully of medication from various perspectives like their amount and quality and their conveyance to the opportune spot and clients and at the ideal time. Along these lines hazard ID in the flexibly procedure of pharmaceutical organizations and oversee them is enthusiastically suggested. The objective of this examination was the hazard distinguishing proof of gracefully chain in pharmaceutical industry in Karachi, Pakistan thinking about procedure's priority, hazard and odds of dangers.

3-Improving the pharmaceutical supply chain

This paper intends to inspect the job of online business in medical clinic drug stores regarding obtainment of medicines and determining how the pharmaceutical chain has been improved. While web-based business is in its outset here it is as yet viewed as a significant aspect of gracefully chain the executives. E-exchanging inside NHS drug stores is led by means of electronic information trade (EDI) offering demonstrated advantages and guaranteeing the proficient and powerful transmission of information between remote gatherings. This conversation offers a knowledge into how a drug store drew closer EDI, and this is additionally bolstered by late research directed into inspecting the drug store frameworks in activity in England and going with EDI frameworks and an examination of EDI take-up what's more, use in an example of drug stores in a similar district, the last being bolstered by episodic proof of upsides and downsides to utilizing EDI and potential boundaries to its presentation.

4-Uncertain Supply Chain Management

This paper studies a strategy to seamlessly interconnect the supply chain processes downstream. It fills in as an apparatus to dissect coordinated effort between elements in the gracefully chain procedure. The information assortment is cultivated through semi-organized talk with utilizing snowball inspecting and perception. Most of enterprises downstream choose created finished results with the intention of getting more noteworthy edges. Besides, elements that have high conditions will in general follow the system of the prevailing substances thus system of business process driven by the solid elements It very well may be applied to any industry that choose the successful coordinated effort with their provider, wholesaler and purchaser.

Key Debates and Controversies

Practice in pandemic case helping in drug and safety kit supply

Practice 1: Employee management in supply chain management

In the global fight against the pandemic, countries are facing with the following management challenges relating with medical staff:
(1) Insufficient in number
(2) Physical and mental health
(3) Limited prevention and control training.

Practice 2: drug supply chain management

Medicines may not be delivered on time and may be short in supply because of interruption in logistics and therefore disrupting the production. It is essential to have a safe environment as it is an important guarantee for normal drug supply. The pharmacy department employed these four practices as a solution to these problems:
(1) Establishing drug supply schemes based on treatment guidelines and safety norms with accurate temperature and environment.
(2) Implementing online drug procurement.
(3) Managing donated medicine coming from different areas and countries storing is a big task.
(4) Managing environment as per medicine requirement.

Practice 3: Management of off-label drug

The consumption of off-label drugs may raise greater potential drug use risks. Therefore the pharmacists emphasize on adverse drug reactions (ADR), employing the "Adverse Drug Reaction Monitoring System of Medical Institutions". This helps to monitor the adverse reactions of such kind of drugs, analyse its cause and provide timely feedback of the results.

Practice 4: pharmaceutical care with government and IoT guidelines

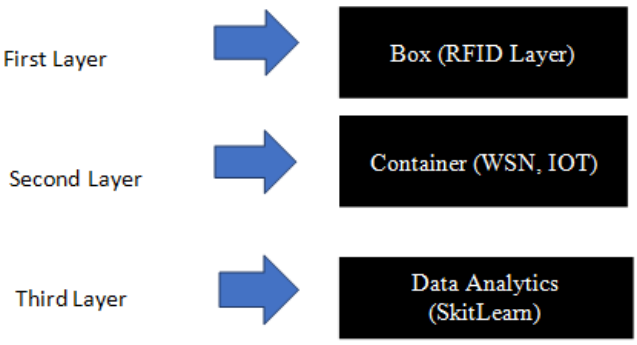
During the pandemic, auspicious pharmaceutical considerations are basic for treatment. Drug specialists have formed a pharmaceutical consideration method as indicated by necessities of various gatherings, gave refreshed treatment plans, checked potential medication connections, centred around exceptional populace drug and actualize remote pharmaceutical help. To have a superior handle on the most recent form of determination and treatment plans for forefront doctors, drug specialists made a rundown of changes. Drug specialists additionally gave a rundown of regular hazard admonitions of potential medication communications and responses finding and treatment plans joined with written works. Pregnant ladies, particularly in central and terminal pregnancy, are inclined to form into serious patients subsequent to tainting with the pandemic.

Gaps in Existing Knowledge

Temperature management is an old concept which every pharmaceutical company is using a traditional concept for managing its supply chain but using IOT is not implemented yet, this was a discovered gap in previous papers.

Research design and methods

Research design



Methods and Sources

First Layer

The procedure is to use the first layer of Radio-frequency identification employing a wireless system which makes use of radio-frequency electromagnetic fields that helps to transfer RFID tag data to a box, containing medicines and vaccines, an all temperature sensitive item, for automation. This technology is suitable for box circulation and tracking. RFID technology can be used in many aspects considering the supply chain. They include management of the warehouse and the inventory, freight transportation, manufacturing and retailing. With this, the supply chain can achieve high performance and tracking. It contains all the data or we can say data is fetch to this which is uploaded in server automatically and contains all the information example temperature what is needed in that boxes, which box required what kind of maintenance and temperature, where is the destination, what should be route, and all.

Second Layer

This is a Smart container which is the main part of my model. This container is loaded with WSN (Wireless Sensor Network) and IOT enabled. WSN is a bi-directional wireless connected network of sensors in multi-hop stages, built from several nodes which are scattered in a sensor field each connected to multiple sensors which can collect the object specific data such as temperature, humidity, speed, etc. and then pass on to the processing units . The sensing nodes in turn communicate in multi-hop Each sensor consists of a transceiver having an antenna, a micro-controller and an interfacing circuit for the sensors as a communication, actuation and sensing unit respectively along with a source of power.

1- From first layer RFID load to sever and with IOT and get information, sensors sense for any human touch to the box it will inform IOT and act as a sanitizer and sanitise the box. It will make our box infection free with the help of sensor camera.

2- IOT helps to track all the packets inside the box and maintain the temperature according to data fetch from RFID.

3- Also help to navigate as priority, if like in COVID 19 there is urgency of box in Utter Pradesh then it takes the decision by its own how to navigate and take faster route to deliver that box to proffered location first.

4- In any changes in route, time of delivery, location, or anything the IOT enabled container receive the information from server and update automatically and send the information to logistics.

5- It will set the temperature according to outer environment and place adjust automatically.

6- In case of any road accident or any kind of damage fill by sensor it will inform the logistic and before reaching to the destination it will update the status for check the packets inside the box then proceed further.

7- Help to trace the location and status of the box and packets inside to multiple ends.

Third Layer

This layer is a data analysis and decision-making layer. **Scikit-learn** is a free software machine learning library. Formerly known as **Scikits** (also **Sklearn**), it is used for the python programming languages. It features include data mining and data analysis through various classification, regression, clustering algorithms. From previous logistics it save all the data in a database and based on previous situation takes based decision in that instant correctly without taking too much time.

Practical Considerations-

1- **End-to-End Visibility**
2- **Warehouse Management**
3- **Spare Parts Supply Chain**
4- **Fleet Management**
5- **Monitoring to Predict Failure**
6- Taking decision based on previous incident.
7- Smart Transportation
8- IOT based government guidelines

Implications and contributions to knowledge

Practical Implications

The advancement of brilliant transportation is for the most part driven by governments or transportation specialists. Effective models incorporate constant traffic and open transportation data sharing, savvy traffic control frameworks, motivation program to direct transportation and to a great extent, advancement of electric vehicle and charging offices and devoted short-go correspondence (DSRC) empowered vehicular correspondence framework.

a) Navigation and Safety: Utilizing the transportation alongside streets and the rails by outfitting with sensors, actuators and handling power, significant traffic data could be shared with the drivers and the public using the transportation medium to accomplish better route and security.

b) Road Planning and Route Optimization: Benefitting from street designs which provide accurate traffic data, administrative specialists could all the more likely arrange and structure the streets. Especially, canny streets can be given a notice depending on their state and atmosphere (e.g. mishaps or roads turned parking lots).

c) Continuous Management:
This is a challenge for asset compelled sensor systems. In this situation, the IoT framework requires to depend on effective assistance portal configuration to limit the measure of information to be sent by continually checking on the information from clients, and clever information arranged middleware configuration to possibly transmit ongoing data.
d) Security and Privacy:
Security, trust and protection are additionally significant factors that have to be considered in pragmatic applications. There are both difficult and delicate path techniques to accomplish various degrees of security. In the case of M2M arrangements these security strategies are accurate since there is a current trust connection between the gadgets and server.

Theoretical Implications

The main provisions of the cold chain are as follows: -- use of refrigeration equipment; — use of controls; –- involvement of trained and qualified personnel. Some medications and vaccines must be stored in a specially equipped storage unit or container (Thermo-box), and the temperature must be recorded daily. Cargo must be transported in specially equipped vehicles or containers with a cooling system. In the event of power failure in refrigerated containers or refrigerating machines, the preparations should be moved to a thermo-box (isothermal container). Special health regulations have been developed to control the quality of certain pharmaceutical and medical products and vaccines. For example, for some of them, the following requirements must be met: -- maintaining the optimal temperature required for storage and transport (usually from 0-8C); — transportation of drugs in thermal containers; — carrying out loading and unloading operations for a limited period of time; –- maintaining particularly low temperatures (-20C) in case of long - term storage, counter storage time (no more than 48 hours). Also, for the effective functioning of the cold chain, it is necessary to: -- regularly, at least twice a day, at all levels of the cold chain, monitor the temperature regime in which a particular drug is stored; –- develop a plan of emergency measures in case of unforeseen circumstances in the cold chain (violations of the temperature regime, etc); –- use specialized thermal indicators at all parts of the supply chain. The cold chain requires certain tools and devices depending on the product, to ensure a suitable temperature and humidity regime. To maintain and control temperature and humidity in real time, you need specialized warehouses, loading and unloading and refrigeration units, transport facilities, as well as a competent organization of the logistics process, which is important for maintaining the quality of goods and controlling significant changes in the conditions of storage and transportation of cargo (temperature regimes). The main equipment required to ensure the maintenance of the desired storage and transport mode may include: thermo containers of various types-products with heat-insulating properties, used locally with refrigerating packages (frozen refrigerating elements); Development of branch and regional management — storage equipment-refrigerating or freezing rooms, chambers-rooms or storage areas where a certain temperature regime is maintained during storage. They are usually used in conjunction with voltage stabilizers to prevent risks of voltage fluctuations in the network; –- thermographs, thermometers, control cards-indicators and other indicators (including freezing indicators) - means for monitoring the maintenance of temperature conditions during transportation and storage. Control cards indicators are designed to follow along with a pharmaceutical or medical product from the moment of its production to the moment of use and to detect changes in the temperature regime. If the temperature changes beyond the acceptable level, the control card indicator changes colour, which indicates that the drug or vaccine was not kept at the required temperature and their further use is prohibited. It is important to note that the controls currently used in the cold chain do not allow you to get information about temperature changes in real time (information about the state of the goods can only be obtained after the goods arrive at their destination) and thus they do not allow you to quickly respond to all undesirable changes, which is their essential disadvantage. At the same time, it is important to note that medical and pharmaceutical products are very expensive goods, and if they are damaged due to non – compliance with the temperature regime, pharmaceutical and logistics companies incur significant losses. In recent years, companies have been actively using high-tech technologies in managing logistics systems, such as radio frequency identification (RFID), wireless sensor devices, temperature control systems, global positioning systems (GPS), and so on. These technologies today often operate independently of each other and are not part of a centralized control system. Since the transmitted data and information analysis systems are integrated insufficiently, the information control implemented in supply chains is not always effective. As a solution to this, a new Internet technology-the Internet of Things – has been actively used in the management of logistics systems. This model generates real-time data from products that are in the vehicle during transport and transmits the information to the company that manages the supply chain. Internet of things technology identifies an object and its current position in the global network. Radio frequency identification and wireless sensor devices are considered key technologies that allow the use of IoT in the supply chain of pharmaceutical and medical products. RFID tags can be equipped with sensors, sensors (thermographs and others) and other additional peripherals necessary for their interaction with the network and monitoring environmental factors (temperature, humidity, etc.), as well as for obtaining information about the location of objects. These innovative tags having a unique addressable ID or IP address are provided with pharmaceutical and medical products during transport. The architecture of the Internet of things is usually divided into three levels: the perception level, the network level, and the service level. Level of perception or data collection: this is the main level of the Internet of things. It can also be called the level of data extraction or information. At this level, all types of necessary data and information are collected from physical devices using sensor devices, RFID tags, readers, and other devices. At the network level, the collected data and information are sent to the network layer, i.e. data is transmitted. Various technologies are used to organize data transfer at the network level, such as the wireless sensor

network (WSN), mobile network and other communication equipment and technologies. This level of architecture is aimed at providing an efficient, reliable network infrastructure. Key technologies related to the use of the Internet of things, such as RFID technology and a wireless sensor network, are used to monitor the temperature and humidity of goods and the medical industry in real time. By adapting this intelligent object health monitoring system, you can create an effective system for monitoring products in the supply chains of pharmaceutical and medical products at low cost. Companies that manage supply chains in this industry can easily monitor all possible violations in the mode of storage and transportation of goods and then immediately respond to changes in logistics processes. To implement an Internet of things system that can continuously monitor the quality and, consequently, further the safety of medical and pharmaceutical products throughout the entire supply chain from production to consumer, it is necessary to take into account several requirements. These include transparency, accuracy and manageability of the logistics system for monitoring the quality of goods. They must be properly regulated at all levels of supply chain management starting from the moment of packaging of goods. Tags based on the use of radio-frequency identification technology of goods with the use of sensors of various functional capabilities, along with an energy source, and a system for processing and storing data by wireless sensor interfaces can be installed in vehicles or containers. Depending on the nature of the product and the method of transportation, both RFID tags without a chip and reusable tags with active wireless sensor nodes can be installed. To implement such a platform based on Internet of Things, it is not always possible to use the technology of radio - frequency identification of goods in the traditional version, since it is not able to solve all the necessary tasks. Therefore, a network platform with various functional capabilities is required, which includes various sensor devices that perform label classification. An intelligent RFID tag with a two-level system architecture has the functionality necessary for managing the logistics flows of pharmaceutical and medical products. The use of radio frequency identification technology is the first level that is necessary for reading information from tags installed on the product. A smart tag that uses RFID technology usually consists of a power and power management device, a digital processor, sensor and memory interfaces, and a radio transmitter. Tag with built-in with its sensor characteristics, it shows the response to changing environments, such as temperature and humidity, thanks to radio frequency measurements. The RFID tag is attached to tablets, capsules, ointments, powder injections, liquid syrups, VAC - tsins, etc. while moving through the supply chain. Each product has a unique identification IP address. This IP address is connected to the main node, which is the second level of the network architecture. The main node acts as a reader for collecting data from the tag and for maintaining communication with the Internet cloud via standard radio interfaces such as WiFi, WiMax, GSM/GPRS and 3G. Pharmaceutical and medical companies must manage extremely complex supply chains. They must operate for a limited time and ensure effective interaction with a required number of participants in the supply chain. Recently, pharmaceutical companies have been paying more and more attention to monitoring the process of transporting goods, and are subject to the world health organization rules that require monitoring the conditions of transportation of pharmaceutical products as they progress through the supply chain. Thus, pharmaceutical companies need accurate information throughout. Instant access to the knowledge about conditions of transportation of goods in real time allows you to quickly make the necessary changes if there are any problems with maintaining the temperature or other conditions necessary to maintain the quality of products. When transporting pharmaceutical and medical products, it is necessary to use temperature control systems and humidity detection systems. Simple product movement monitoring does not provide a complete picture of the quality of the product. To overcome this problem, the Internet of things can be effectively used, which opens up new opportunities for the pharmaceutical business. The article proposes an intelligent monitoring system that uses Internet of things for intelligent pharmaceutical logistics. IoT technology is a network that connects objects over the Internet to transmit the real-time data for the purpose of intelligent moving object detection, namely the location and status of the object, tracking, monitoring and management using radio frequency identification technology of objects using tags, sensor devices, and positioning devices. The Internet of things is a unique platform for monitoring the status of pharmaceutical products in the value chain in real-time, which can provide effective and fast monitoring and tracking of pharmaceutical products in real time at low cost.

Conclusion

Supply chains have to be extremely dynamic in order to incorporate the various anomalies that may occur. In the case of pharma industry, where speed of delivery and quality of product is of supreme importance, the blockers range from temperature sensitive goods to inability to track the shipment. By employing IOT, enhancing the Smart supply chain, such problems can be overcome. RFID tags enable easy tracking and identification of the product, also mapping the shipment to it's respective online database. Such improvements in technological aspects of supply chain can greatly influence performance, and we hope to see more innovations in the near future.

Recommendations and Suggestions

Maintaining such a smart supply chain is a task in itself, but with further improvements and innovation, the process can be smoothed out better. Progress could be made in the tracking of shipments by enabling a cloud database to store all data, and a virtual dashboard that encapsulates all necessary info so that decision making is facilitated. Training sessions can be conducted for employees of an organisation that introduces a smart supply chain. Further, the supply chain can be extended to both suppliers and consumers, which provides data that gives insight towards activity on both ends. This information can be further analysed to optimize logistics and improve the supply chain functions.

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