To study impact of IOT in supply chain management

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Abstract- **The Internet of Things (IoT) is a global platform that connects physical things and devices to a network over the internet so that they can be located, recognised, and managed. Nowadays, IoT is essential for managing the supply chain. The implementation of Industry 4.0/Internet of Things (IoT) technologies offers prospects for more sustainable management, as has become clear to businesses as a result of the fourth industrial revolution and the digitization of supply chains. The Internet of Things (IoTs) is a global network of intelligent devices that are connected to the Internet and have been promoted as a way to enhance supply chain integration (SCI). Many industries are facing lot of issues and weaknesses with respect to Supply Chain Management. This paper looks at the various difficulties faced by supply chain management and how IoT provide a solution. It aims to assess how IoT will affect inventory and logistics management. Various warehouse visits were done, and a survey form was created in order to understand how IOT is implemented. Study Findings reported that IoT has already benefited almost all phases of the supply chain. IoT supply chain has many advantages, like increasing the productivity of factories, providing real-time product location information, automating warehouses, improving cold chain management and much more.**

*Keywords-***Internet of Things (IOT), supply chain management, warehousing, challenges, retail, Radio Frequency Identification**

INTRODUCTION

The growth of Industry 4.0, a novel industrial digital technology, has a positive impact on supply chain management. Many sectors face numerous issues and shortcomings when it comes to supply chain management. The Internet of Things (IoT) is one of today's most talked-about topics, and it was a major topic before the turn of the century. It encompasses a wide range of technology and devices that can be linked to practically every element of life or business, ranging from entertainment to national security. When it comes to the supply chain, it can and will be a powerful disruptive force that improves efficiency and traceability while also providing more differentiation and innovation. Supply chains (SCs) have experienced digitization and a tremendous impact in the form of alliances between suppliers, manufacturers, and customers to enable transparency throughout the product lifecycle since the advent of Industry 4.0 inside manufacturing and production environments.

Supply chain management (SCM) refers to having the right thing for the right customer in the right quantity, at the right time, in the right place, for the right price, and in the right condition. The cost, complexity, and vulnerability of traditional supply chains are increasing. Today organisations face lots of new issues when it comes to supply chain management. Several of the challenges are:

- Lack of Asset Visibility
- Ineffective stock handling
- Logistics or transportation inefficiency
- Fast-Changing Markets
- Unforeseen Delays
- Ineffective Supply Chain Risk Management

To overcome these obstacles, good supply chain management is required. Nowadays, information technology (IT) plays a critical role in properly managing the supply chain. The Internet of Things is one of the most essential IT developments (IoT). The Internet of Things (IoT) is designed to improve supply chain integration by linking things via the Internet. It may result in improved process effectiveness and innovative methods of management.

LITERATURE REVIEW

Kevin Ashton, co-founder and executive director of the Auto-ID Center at MIT created IOT for the first time in 1999. Kevin Ashton's explanation of the Internet of Things (IoT) stated that the system of interconnected physical items that frequently make use of the Internet and are equipped with electronics, software, sensors, and network connectivity.

According to Chopra and Meindl's well-known book (2010), SCM is the control of all resources and flows in the supply chain, with the main purpose of increasing supply chain surplus, or total value generated. IoT connects machines, products, people, and supply chain managers, establishing new conditions for supply chain professionals ((Banker, 2014, DeGroote et al., 2013 and Eddy, 2014 cited in Li, B. and Li, Y., 2017). With the help of IoT technology, supply chain traceability is now possible with full information, which was not possible before with Traditional technology (Zhou and Piramuthu, 2015). IoT provides various benefits to SCM, as mentioned by many authors in their studies, such as Aich et al. (2019) which listed the following advantages of using IoT to manage supply chains: Information continuity and traceability, Information accessibility, Link between Information flow and material flow, and Decrease in the code of conduct violation and fraud. According to Evtodieva et al. (2020), Several advantages have been seen

as a result of using IoT to manage SC. Predictive analytics for Demand Forecasting, Warehouse automation will reduce the enormous costs associated with it, Chatbots in Procurement which will minimise cost of transactions and sales cycle time by replacing people in the procurement processes, Intelligent transportation systems, Through "Location Tracking," which provides real-time information about cargo location, it is possible to monitor and manage incoming and inside facility flows, and monitoring of sensitive goods. Moreover, Gunawardena et al. (2018) stated that IoT as an enabler for suppliers, customers, and internal integration will provide Sharing information with vendors who utilise IoT technology can increase understanding of collaborative planning, forecasting, and partnerships. However, IoT has a significant impact on supply chain performance because IoT-based supply chain information systems are capable of coordinating and integrating organisations' internal and external activities. Mastos et al. (2020) presented evidence of the impact of an IoT solution on sustainable supply chain management (SSCM) performance by conducting a case study involving a scrap metal producer in the lift industry and a waste management company, in order to demonstrate how the deployment of a cutting-edge industry 4.0 solution has the potential to improve sustainability both at the firm and supply chain level. Qin et al. (2017) provided a methodology for evaluating the impact of RFID on the issue of inaccurate inventory brought on by the bullwhip effect, which occurs when information is distorted across the supply chain. The shortfall and holding costs rise as a result of the inventory loss.

By building a simple analytical framework, Ng et al. (2015) we were able to examine the influence of IoT in SCM. By employing one of two methods, they demonstrated how to transform data collected by IoT into meaningful information to aid the supplier or producer in supply chain management. The first strategy stated that in order to match client demand, many product types must be produced. The second approach said that the supplier has the ability to develop standardised but flexible products that can be customised to meet the needs of consumers. These two methods can be more profitable by maximising the added value of clients. Mostafa et al. (2019) showed a diagram of all the supply chain functions that benefit from the application of IoT.

Fig. 1 Benefits of using IOT in SCM Functions
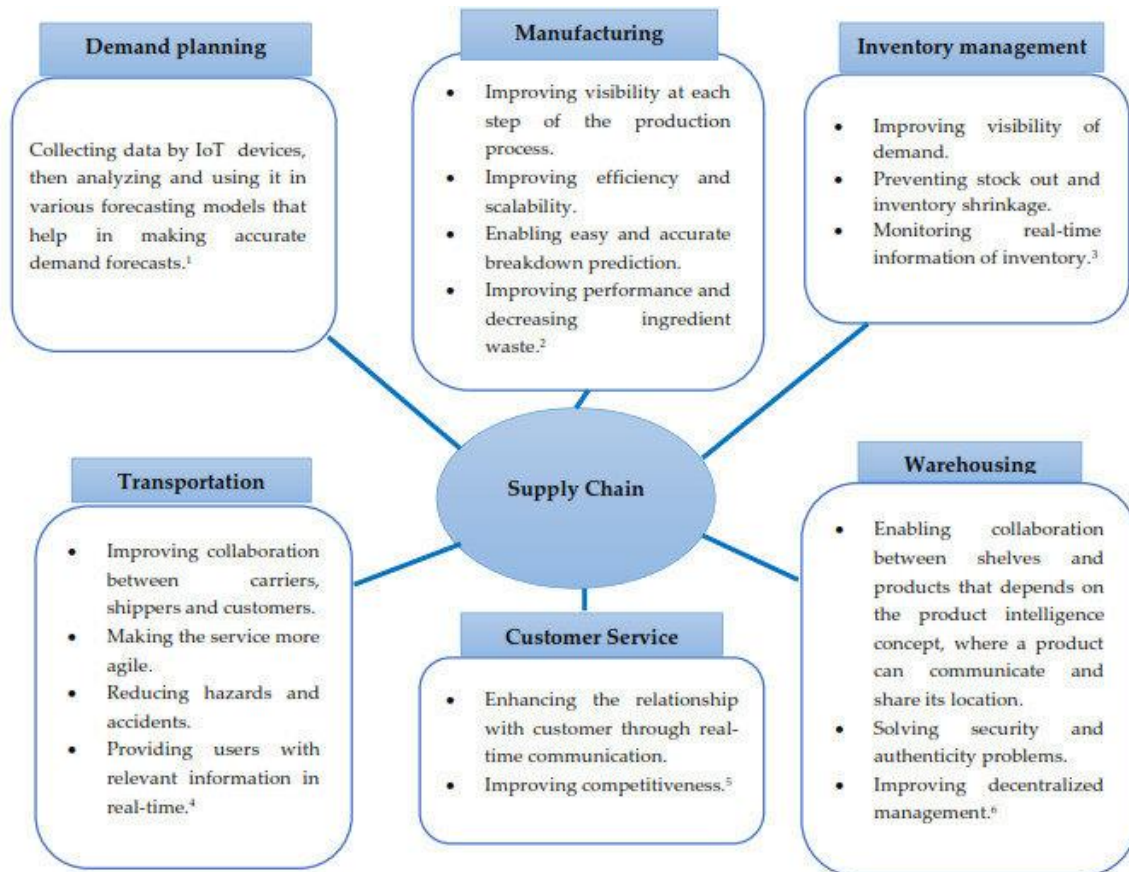
Source: Impacts of Internet of Things on Supply Chains: A Framework for Warehousing. Social sciences. 2019

Objective of the Study
- This report's objective is to investigate how IOT affects supply chain management.
- It also tries to find the components of IOT infrastructure, different stages of supply chain management and its benefit when IOT is used at every stage.
- Along with that, it also studies how IOT can be implemented at the warehouses.
- In order to find the impact of IOT, we understood the technologies being used in Supply Chain and their viewpoint with respect to IOT.
- Also, highlighting various challenges observed in Supply Chain because of the impact of IOT.

Components of IOT infrastructure

IoT is regarded as one of the key pillars of Industry 4.0 that helps businesses in enhancing and strengthening their competitiveness in the market and has a significant influence on the development of the modern economy. The IoT architecture is organized into four fundamental levels.:

- Perception Layer
- Transmission
- Computation Layer
- Application Layer

Each layer has built-in security vulnerabilities that are related to it.
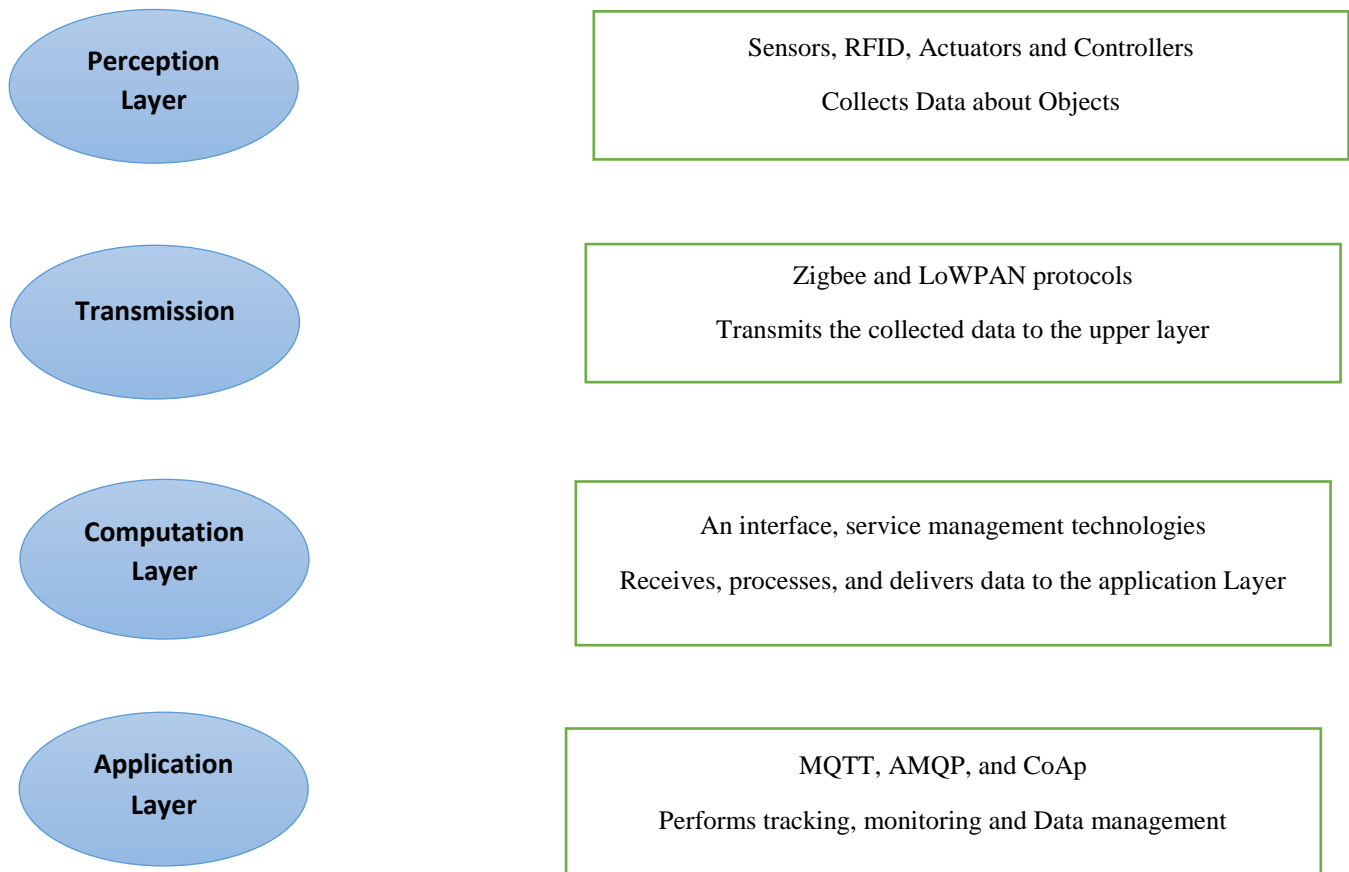
Fig. 2 Architecture of IoT application
Source: Author's Study

Perception Layer, also known as sensors Layer, it has a main function to identify, track and collect Data from Objects by using technologies such as RFID tags that are used to identify and track objects, actuators that are used for monitoring and tracking the status of objects and Wireless Sensor Networks (WSNs). The Collected Data is then transmitted to the transmission Layer.

The transmission layer serves as a channel between the objects and the cloud. It offers data transmission routing across the network. This layer uses a variety of protocols, including low-power wireless personal area networks (LoWPANs), which offer excellent communication with minimal energy use and self-organization. Zigbee is a wireless network technology that provides the benefits of low cost, low energy consumption, minimal complexity, reliability, and security. Wi-Fi and 3G are other wireless network technologies that can also be employed.

The transmission layer and the application layer benefit from efficient and secure services provided by the computation layer. This layer uses interface technologies to ensure the effectiveness and security of the data transferred. Data collection, exchange, and storage are among the services that service management is used for.

Application Layer is the last layer, in which data is tracked, monitor and managed.

Research Methodology
Scope of Study
As new technologies have developed, businesses have been able to take advantage of a variety of opportunities and get an edge over their competitors. Logistics and supply chain management (SCM) have experienced remarkable conceptual changes. This study helps us to understand us how IOT technology has impacted Supply Chain Management. The purpose of this research is to understand is IOT implemented or not in different organizations, what is the overall effect on supply chain and how they are planning to execute it in future. The study also focuses upon various challenges faced in IOT supply chain.
**Limitations of Study**

The scope of this study is limited to 93 responses and has been interviewed those who are part of warehouse operations. Because of the organization policy restrictions, it was not possible to get the responses from every stage of the supply chain management team.

Data Collection Technique

As part of this research, warehouse visits were done, and a survey form was created in order to understand how IOT is implemented. In Total 93 responses were received. Also, one of the interviews was done with Supply chain Head of one of the retail sector organizations. The research also includes visiting various websites, articles and collecting related data.

Data Analysis

The first portion of the interview was on the interviewees' employment roles, how long they had experience in similar industries. Out of the 10 different warehouses, 4 warehouses belong to 3PL companies, 3 warehouses belong to the retail industry, one warehouse belongs to the footwear industry and the remaining belongs to the service industry. The experience of the employees or managers varied from 6 years to 13 years. From the questions asked, below is the status of the companies that use IOT or not.
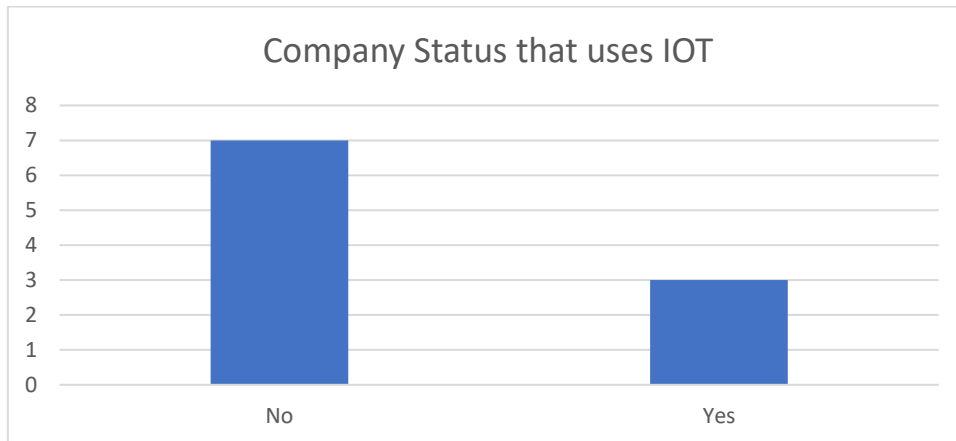
Fig. 3 Company Status that uses IOT
Source: Author's Study

Out of the 10 total 10 companies, 3 Company uses IOT and 7 company stated that they do not use IOT.

However, because the focus of this study is on the use of IoT as a technology in supply chain management, it was important to question the respondents if they use any form of technology to control the flow of their products through their supply chains. The responds received showed that all of them are using different technology in their supply chains for managing and tracking their flow of product as shown in below Table.

Sr. No.	Technology
1	SAP ERP
2	ORACLE Supply Chain ERP
3	RFID
4	Oracle ERP international System
5	RFID, Bar codes
6	Warehouse Management System
7	Online banking

Table 1. Technologies used by the companies to track their products across supply chains.

It had been demonstrated that all the interviewees were currently employing various types of technologies to track the items and control the flow of their supply chains. When asked about the possibility of implementing the IoT in their operations and supply chain management at the conclusion of this section, all the interviewees expressed a remarkable level of enthusiasm for the concept. After discussing with the supply chain head for one of the organizations we came to know that IOT can be used for maintenance purpose in warehouses. In warehouse there are different machines used such as Hand Palette Truck (HPT) or BOPT (Battery Operated Palette Truck). These machines can be traced and accordingly their maintenance activities can be planned. This will help to maintain and improve productivity throughout the process.

In the transport sector, the results demonstrate the widespread adoption of IoT-enabled fleet management, vehicle monitoring, and route optimization solutions. Using IoT retina scanners and onboard facial recognition, driver fatigue was tracked by measuring pupil size, blink frequency, facial expressions, and driving behaviour. IoT engine monitoring technology was utilised to monitor and trace products that are temperature-sensitive while sensor networks in cold-chain logistics reported vehicle emissions and idle time.

IoT is crucial for enhancing suppliers' operational and information management, as well as their ability to communicate with retailers and perform better in terms of forecasting, inbound delivery, receiving, and traceability.

Also, based upon the responses received from Google form survey, below is the word cloud analysis prepared. The word cloud helps to analyze text quickly and gain important information from data provided.

Fig 4. Word Cloud Analysis

Source: Author's Study

- From above word cloud we can say that, due to the execution of IOT in supply chain the visibility in supply chain will be increased, minimizing human errors, Lead time will be reduced. This will also lead to improvement in workers safety as while working manually with the help of Hand Palette Truck (HPT) or BOPT (Battery Operated Palette Truck) number of accident chances are more.
- There are also number of challenges analysed because of the execution of IOT in supply chain. They are Low Privacy level, energy consumption would be more, more skill workers need to be recruited. As IOT tracks and sends data, hence a greater number of data would be generated.
- Warehouse Management System (WMS) is one of the software that is used mostly to manage supply chain operations. Through RFID and bar code scanner, the articles are being scanned and tracked throughout. This data is stored in WMS software.
- Out of all the processes carried out in warehouse, most of the time is being utilized by the picking process. Execution of IOT in picking process will not only help to improve warehouse efficiency but also reduce excess stock at the store level. Automated Storage Retrieval System (ASRS) is one of the applications of IOT that can be implemented in warehouses to improve overall efficiency at warehouse level.

Below are the six stages of a simplified model of Supply Chain Management and its impact on IOT:

Raw Material Supplier

Raw Material Supplier Stage is one of the stages with one of the lowest levels of Internet of Things solution implementation. The advancement of robots and their broad application in the exploitation of natural resources at that time will directly affect the direction of the Internet of Things in the future. Some providers of raw materials have already benefited from the Internet of Things supply chain. For example, The Internet of Things (IoT) uses a network of connected sensors to offer a wide range of data to farmers. IoT devices can collect data on things like animal health, pesticide application, dam levels, and soil moisture. Farmers can maintain ideal conditions on their farms with the help of this data.
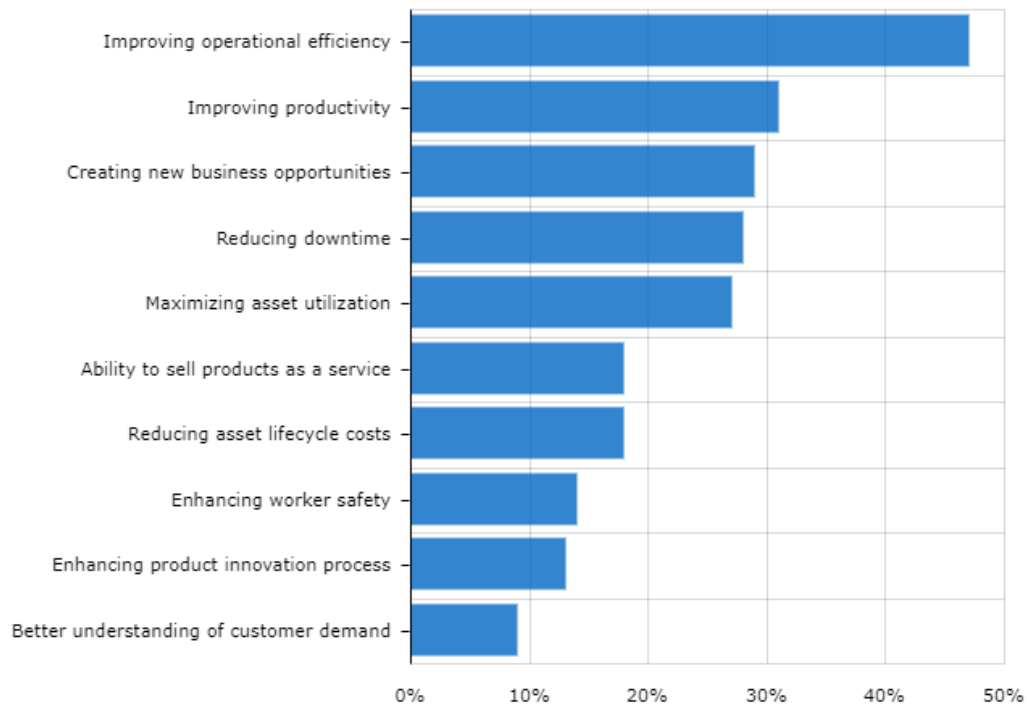
Manufacturer

IoT supply chain offers several advantages for producers, including the ability to maximise production efficiency. By using data that IOT systems provide, it may be possible to provide answers to certain significant questions, including:

- How can operational effectiveness be increased?
- How to decrease manufacturing downtime?
- How to improve asset utilization?
- How to include eco-friendly practises into your production process?

By recognising defective devices with high levels of energy consumption and either replacing or fixing them, sensors can assist in the detection of resource leakage. Timely maintenance reduces downtime because employees may solve failures or other maintenance issues before the equipment really breaks down. Also, it saves a lot of money.

According to Morgan Stanley company's report, some manufacturers were able to find the answers to all the issues mentioned by deploying Internet of Things technology and increase their operational effectiveness.

Fig 5. Morgan Stanley – Automation World Industrial Automation Survey
Source: https://www.morganstanley.com/ideas/industrial-internet-of-things-and-automation-robotics

One of the major concerns that manufacturing process are facing is that they are accompanied by environmental pollution. IOT Supply Chain makes it possible to adopt eco-friendly practises including reducing water consumption, creating less waste during production, and utilising renewable energy.

Distributors

Transportation of the goods is the distributor's responsibility. Because of Internet of Things precise delivery times and real-time information on product locations can be provided. Using real-time data from a variety of sources, such as carriers, airlines, border crossing locations, port authorities, meteorological satellites, and ordinary satellites, distributors may keep an eye on the entire delivery route and optimise it. The IoT system will instantly alert if there are any shipment delays or route changes.

Warehousing

Warehouses may track their inventory accurately and in real time by using IoT devices. By placing sensors on all resources, products, and goods, warehouses may quickly track and analyse inventory positions, stock levels, and items that enter and leave the warehouse in real-time. Radio Frequency Identification (RFID) sensors are used in warehouses to create such a robust inventory system that they can monitor product movement and track the position of every item inside the facility. Environmental sensors help keep track of perishable commodities safety by monitoring storage conditions.

Fig 6. Retail Store Warehouse   **Source: Author's Study**

Retailer

The use of IoT sensors speeds up the loading and unloading of goods since RFID tags store all pertinent information about each package's contents, enabling retailers and other parties to fully understand each delivery's contents. The Internet of Things (IoT) supply chain open the way for cutting-edge checkout-free shopping.

Implementation of IOT in Warehousing

SCM performs several tasks, including those related to production, inventory management, distribution, routing, and marketing. Because warehouses can hold thousands of products, it is important to make the most of them in order to guarantee precise and quick performance and satisfy client demands. IoT applications in warehousing have the potential to have a significant impact because they can be used to monitor numerous processes there in real-time and can eliminate manual interferences. Everything can be connected, enabling the analysis of the enormous volumes of data gathered from these connections and the generation of insights that can be utilised to support choices and improve overall performance.

As soon as the products passes the inbound logistics, the reader mounted on the gate reads information about the items contained on tags affixed to them. This makes inventory levels visible in real time and avoids stock outs. The position, type, and expiration date of the goods are read by readers mounted to forklifts and displayed to the driver on an additional screen. Attached sensors notify the driver on the screen when the product has been placed on the shelves. Sensors are also used to monitor the Heating, Ventilation, and Air Conditioning (HVAC) system in order to reduce energy consumption, assure product quality, and ensure warehouse safety. The warehouse management system (WMS) receives all the data collected by readers and sensors, analyses it, and transforms it into actionable information. The same procedures apply to pick up orders; When an order is delivered, the driver goes to the location of the product that is displayed on the attached screen and uses the forklift's attached readers to make sure it matches the order. The moment the order leaves the warehouse, the inventory level is updated. This reduces counterfeiting and improves the efficiency, simplicity, and accuracy of order fulfilment.

In traditional methodology, when the items entered to the inbound logistics area, one person is assigned who performs all the stock checking and scans the product manually with the help of given machine. As soon as the product is moved to the next area i.e., put away, picking or outbound logistics, accordingly the details get updated. This details then gets updated into the warehouse management system.
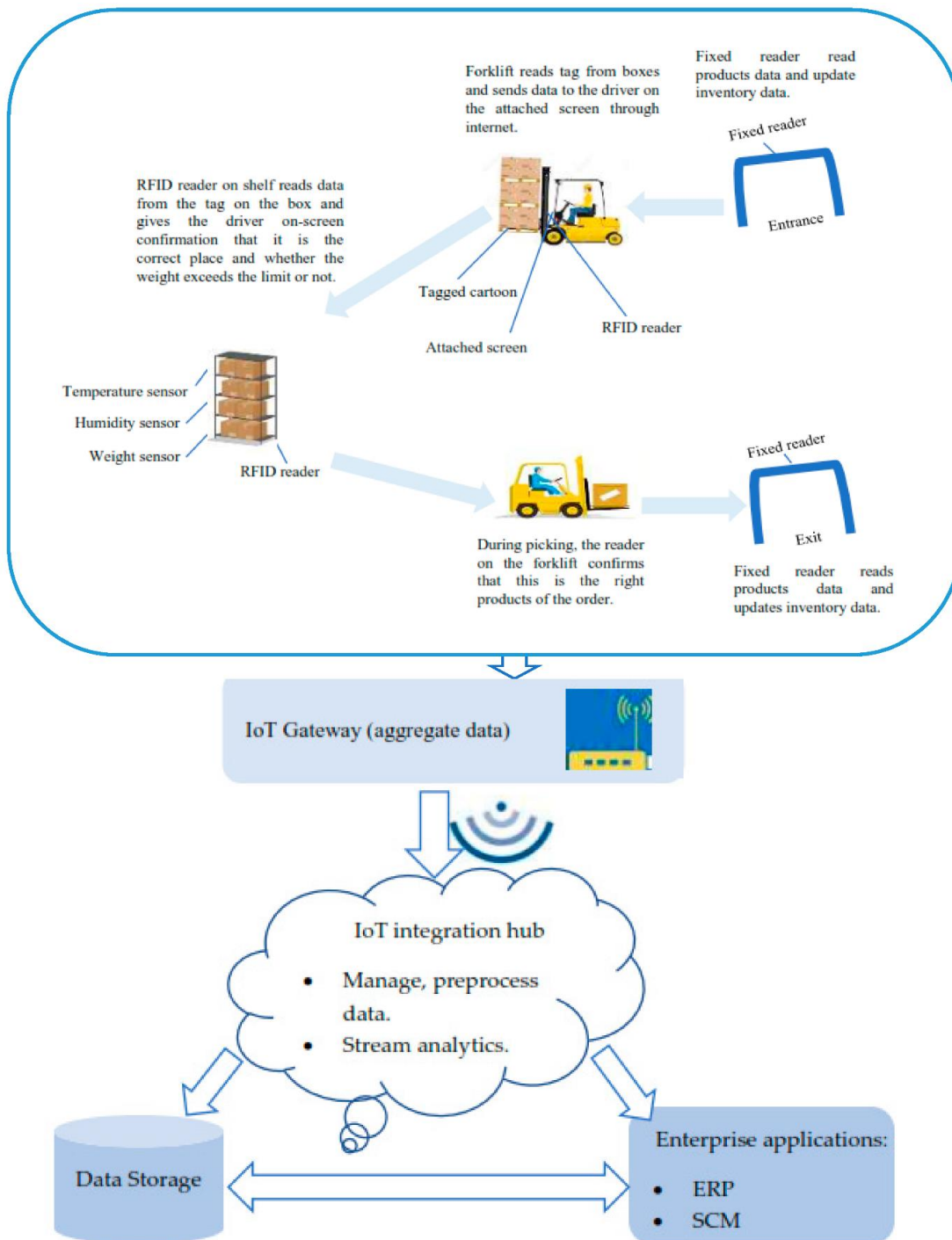
Fig 7. Proposed framework of implementing IoT in a warehouse.
Source: Impacts of Internet of Things on Supply Chains: A Framework for Warehousing. Social sciences. 2019

Challenges:
Following are the challenges observed in IOT supply chain.

- **Lack of security of IoT devices**

IoT-based Distributed Denial of Service (DDoS) attacks are becoming more frequent every day.
The Internet of Things (IoT) technology being misused as a result of the low security of linked devices.

- **Low Privacy Level**

IoT devices have the ability to collect and communicate sensitive information about their users.
Data transfer security and a restriction on unauthorised connections from outside the system must be provided by IoT solutions.

- **Energy consumption**

The Internet of Things (IoT) consists of electrical devices that are intended to run continuously for a long time. If the battery life of every IoT device is not exceptionally long, maintaining such a large IoT system can be quite time- and resource-intensive.

- **Talent Shortage**

The number of experts who can create IoT systems, support them, and evaluate data coming from IoT devices is severely lacking.

- **A large volume of information**

Any IoT system produces a significant amount of data that needs to be transferred, stored, and processed. In terms of transferring and storing millions of gigabytes of data, the conventional solutions for these activities are not particularly helpful.

CONCLUSION

IoT is one of the technologies that is thought to be the most promising for managing and enhancing supply chains. Warehouses are essential components of the supply chain that help any industrial business succeed. Therefore, new technologies are attracting a lot of interest from a diverse range of businesses in an effort to increase performance and reputation, which will lead to an increase in customers and profit.

IoT devices and the data they gather have been demonstrated as key factors in the supply chain and logistics sector's increased productivity and greater service quality over the past few years. The following 5 categories of business activity are included in a basic supply chain model.: providers of raw materials, producers, warehousing, retailers, and distributors.

IoT leverage has already benefited almost all phases of the supply chain. IoT supply chain has many advantages, like increasing the productivity of factories, providing real-time product location information, automating warehouses, improving cold chain management and much more.

However, there are still several issues that the IoT supply chain is intended to solve. The Internet of Things is a highly potent technology, and we think that the advantages it will add to the supply chain will improve living conditions everywhere!

RECOMMENDATIONS

As part of this research paper, we tried to find out how IOT has impacted the overall supply chain. By doing appropriate research we were able to find out that IOT has benefited supply chain in various aspects such as reducing lead time, minimizing human errors, increased in supply chain Visibility, Improved worker safety. This will help to increase the overall productivity in supply chain.

In order to execute this to a more efficient level, the challenges mentioned such as Poor security of IOT devices, Low privacy level, Shortage of skilled labours, handling large amount of data needs to be overcome.

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