

Using Internet of Things to Implement Smart Supply Chain Management in Industry 4.0 Context: A Conceptual Framework

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Abstract:- Supply Chains are the essence of any business, impacting the entire value chain from the procurement, manufacturing, quality, delivery, mobility, and costs of a business's products and services to ultimately profitability and return on assets. To avoid disruption, and become resilient - which is the utmost necessity of the hour, businesses need to digitally transform immediately. The rapid rise of innovations and operational evolutions such as Industry 4.0 and the upcoming Industry 5.0 is leading to a profound new era of the integrated digital supply chain.

Although the Internet of Things (IoT) is said to be a cornerstone technology for the newly emerging Industry 4.0 era, there is no empirical data on IoT utilization in supply chain management. The supply chain management and logistics operations can be greatly improved with the use of Internet of Things (IoT) solutions, offering transparency and cost-effectiveness that is only possible with the use of this cutting-edge technology. The use of IoT in Supply Chain Management (SCM) makes it possible to manage and monitor assets in real-time, offers data for advanced planning and optimization, increases the effectiveness of storage and transportation, and promotes sustainability. This paper discussed the supply chain management, its problems, the ways IoT is revolutionizing Supply Chain Management, and the challenges and opportunities that face applying smart SCM, and propose a conceptual framework for smart SCM.

Keywords:- Supply Chain Management, Internet of things.

I. INTRODUCTION

Restructuring supply chain operations is essential for effective expansion as they become more complex. A major obstacle to simplifying supply chain management is the inability to dynamically modify and carry out plans in response to shifting market conditions. Due to the market's ongoing change, it is essential to be able to detect changes in demand and act quickly. Next-generation technologies that link data with people are necessary for this capability. Management of the supply chain is essential to running any kind of organization. The use of IoT devices has transformed supply chain management (SCM). Understanding where items are, how they are being held, and when they may be expected at a particular location is considerably simpler.

A. The Major Pillars of Supply Chain Management

The process of delivering a product from a raw material to a consumer is called supply chain management. Supply management, product and demand planning, sales and operations planning, and supply planning are all included [1].

Supply chain management is becoming a crucial component of every business. Every firm engages in inventory management, purchasing, warehouse operations, and transportation. All of these tasks go under the umbrella of supply chain management, where each function is carried out after consulting with the others. There are a few pillars that support supply chain management in order to maintain effective supply chain practices as shown in Figure 1. Without these pillars, no firm can maintain an efficient supply chain system.

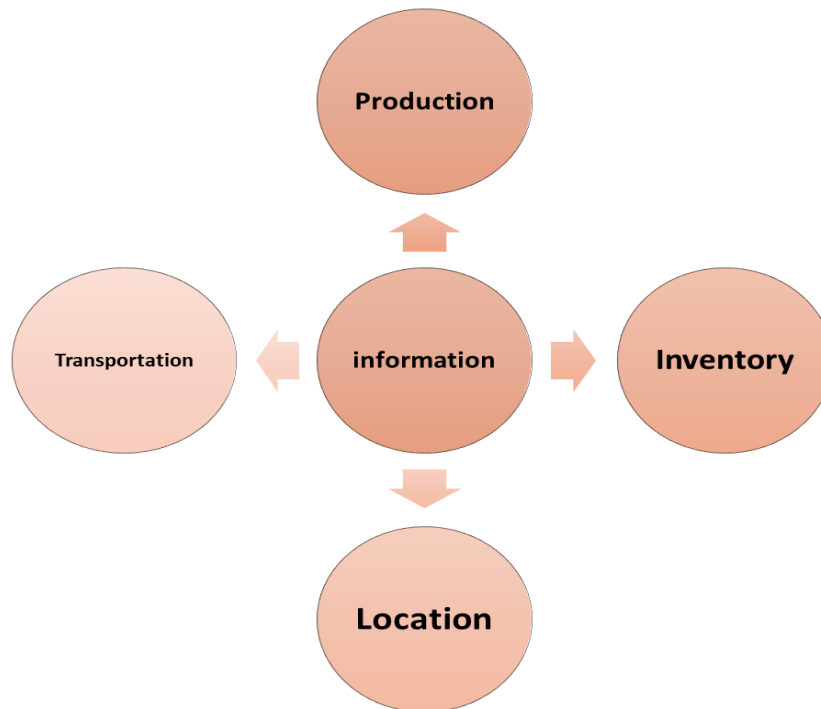


Fig. 1: The Five Pillars of SCM

B. Global Supply Chain Management Environment issues

The majority of well-known international brands currently dominate the worldwide market. Global market convergence, or the propensity for local markets to begin to converge around a set of comparable goods or services globally, has been a consistent trend over the past three decades.

The eventual outcome of the global market convergence is that businesses who have been successful in selling their goods or services now have access to the entire world for marketing and sourcing. Because of the unstoppable expansion of global mass media, such as the Internet, TVs, radios, news media, and movies, our globe has effectively shrunk into a small global village, which is one of the causes of the global market convergence [2].

One of the most frequent causes of supply chain management issues is the COVID-19 pandemic, which keeps upsetting the ecosystem by posing new and unexpected challenges to both productivity and profitability. There are many challenges that face supply chain management from product-based companies around the world will encounter in 2022. Such as: network complexity, process complexity, range complexity, material scarcity, difficult demand forecasting, restructuring, inflation, organizational complexity, and digital transformation [3].

II. THE ROLE OF IOT ARCHITECTURE TO IMPROVE SCM

The Internet of Things (IoT) is a network of physically connected objects that can send, receive, and exchange data. In most cases, data or Wi-Fi networks are used to connect IoT devices to computer systems.

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IoT implementation in SCM is mostly used for tracking and monitoring (supply chain management). Workers in warehouses and fleets can now keep an eye on the inventory and movement of their merchandise thanks to technology. But the IoT offers more than just the possibility for asset management. The following are the important takeaways on how IoT can transform supply chain management [4]:

- Location tracking in real time. Supply chain managers have access to a consistent stream of real-time information about the whereabouts of the commodities thanks to the Internet of Things.

Monitoring the storage environment. Supply chain managers can evaluate the temperature inside the vehicle, pressure, humidity, and other circumstances that could affect the product's quality to determine how the goods are being transported.

- Project the product's arrival and mode of transportation. IoT devices give supply chain managers more options, which enhances decision-making and boosts the precision of delivery projections. A supply chain IoT company can estimate the actual delivery date and identify and reduce hazards in real-time.

A. *IoT and Industry 4.0*

The 4.0 Industry, Internet of Things (IoT), big data, and artificial intelligence are at the core of the fourth industrial revolution, often known as Industry 4.0, a subject that has drawn significant interest in both academic and professional circles. It also requires changing people's work habits and supply chain management, as well as integrating factory production with the entire product lifecycle and supply chain activities [5].

One of the essential components of Industry 4.0 is the capacity of businesses to employ digital technology to record and analyze data in real time and then deliver crucial information to industrial systems. In this modern, dynamic business environment, the majority of supply chains are using information technology to increase automation and manufacturing performance in order to stay competitive in their global supply chains [6],[7]. Presently, Industry 4.0 is concentrating on information sharing and supply chain integration (also known as smart supply chains), the synchronization of data generation and analysis with manufacturers to cut down on lead times, and the bullwhip effect brought on by incomplete information [8].

Through this integration, businesses may also work with industrial capital to co-create more valuable goods, assets, and services while focusing on their core competitive advantages and sharing product-related engineering capabilities in internal industry forums. Industry 4.0 takes into account both new delivery systems (smart products) and the transformation of manufacturing processes (smart manufacturing) based on new information technologies. Along with the delivery of commodities and raw materials (smart supply chain), new information technology-enabled employee performance models are also taken into account (smart work) [9].

According to reports, the IoT will facilitate the emergence of the Industry 4.0 age of automation and digitalization. Industry 4.0 introduces smart products, a smart supply chain, and intelligent services like quality-controlled production, logistics, and maintenance. In contrast to the three previous industrial revolutions, which focused on mechanical power (Industry 1.0), mass production (Industry 2.0), and the digital revolution (Industry 3.0), Industry 4.0 is concerned with intelligence [10], [11].

B. *Smart SCM and Supply Chain 4.0*

Flexibility, agility, and reactivity are more crucial than ever as the modern supply chain evolves at an unheard-of rate. An item is wise if it: Intelligent, Instrumented, and Connected Using the Internet of Things, a smart supply chain can overcome any weak points in the system (IoT).

IoT quick fixes for traditional supply chain problems include: Tracking of goods 2. Enhancing Transactional Efficiency End-to-end visibility of the complete supply chain is provided through this [10].

Supply Chain 4.0 includes the use of big data analytics and advanced robotics in supply chain management as well as the Internet of Things (IoT) application. This includes the advantages of utilising sensors nearly everywhere, building networks to connect different pieces, and automating most supply chain components, all of which can be used to assess and greatly enhance performance and customer satisfaction. (2) As a result of Supply Chain 4.0, the emphasis of the supply chain management function has dramatically changed to sophisticated planning procedures, such as analytical demand planning, which are now well-established and developed business procedures in many organizations. Supply chain managers must reconsider how they plan their supply chains in light of the disruption brought about by Industry 4.0 [11].

C. *Essential component of SCM*

A smart supply chain must include the following components in order to function:

- **A digital backbone:** is It's crucial to have the ecosystem digitized first in order to fully harness the great potential of modern supply chain technologies like AI, IoT, and blockchain. The advantages of integrating smart supply chain technology will probably be diminished if even a small portion of your supply chain network is dependent on paper-based information sharing. All of the technologies that make up a smart supply chain require real-time access to data.
- **IoT:** In the context of the supply chain, IoT enables remote equipment failure identification and gives decision-makers granular data on the status of devices and their environment.
- **Artificial Intelligence (AI):** Supply chain firms can streamline planning and reduce interruptions brought on by unforeseen events.
- **Blockchain:** A smart supply chain is the ideal setting for this technology. Blockchain gives a supply chain network an immutable record, ensuring that data is trustworthy and won't be altered. This enables businesses to have faith in the outcomes of their AI models. In general, blockchain creates a setting that is far more dependable and transparent for businesses and end users [12].

D. *The Use of IoT in revolutionizing Supply Chain Management*

Supply chains and the Internet of Things are now intricately interwoven. In fact, one of the most well-liked applications of the IoT is logistics tracking. IoT in supply chain management is challenging and risky; when things go wrong, the entire sector is frequently affected. IoT supply chain technologies rely on the visibility of materials and goods throughout the production and delivery process, assisting managers from manufacturing to shipping and delivery with monitoring logistics, optimizing production, securing goods in transit, and improving efficiency and

customer service. In the end, these technologies help prevent bottlenecks in crucial supply chain networks. Here are five ways IOT is transforming SCM [13], such as: Inventory planning, tracking of shipments and assets, upkeep and repair, quality Assurance, and storage and condition tracking.

III. A PROPOSED FRAMEWORK

The traditional supply chain confronts a number of difficulties, including cost, complexity, vulnerability, and uncertainty. The supply chains must be more intelligent if these issues are to be solved. The researchers propose the following recommended framework for Smart Supply chain Management System for creating a large-scale of smart infrastructure to unite data, information, products, physical objects, and all supply chain operations.

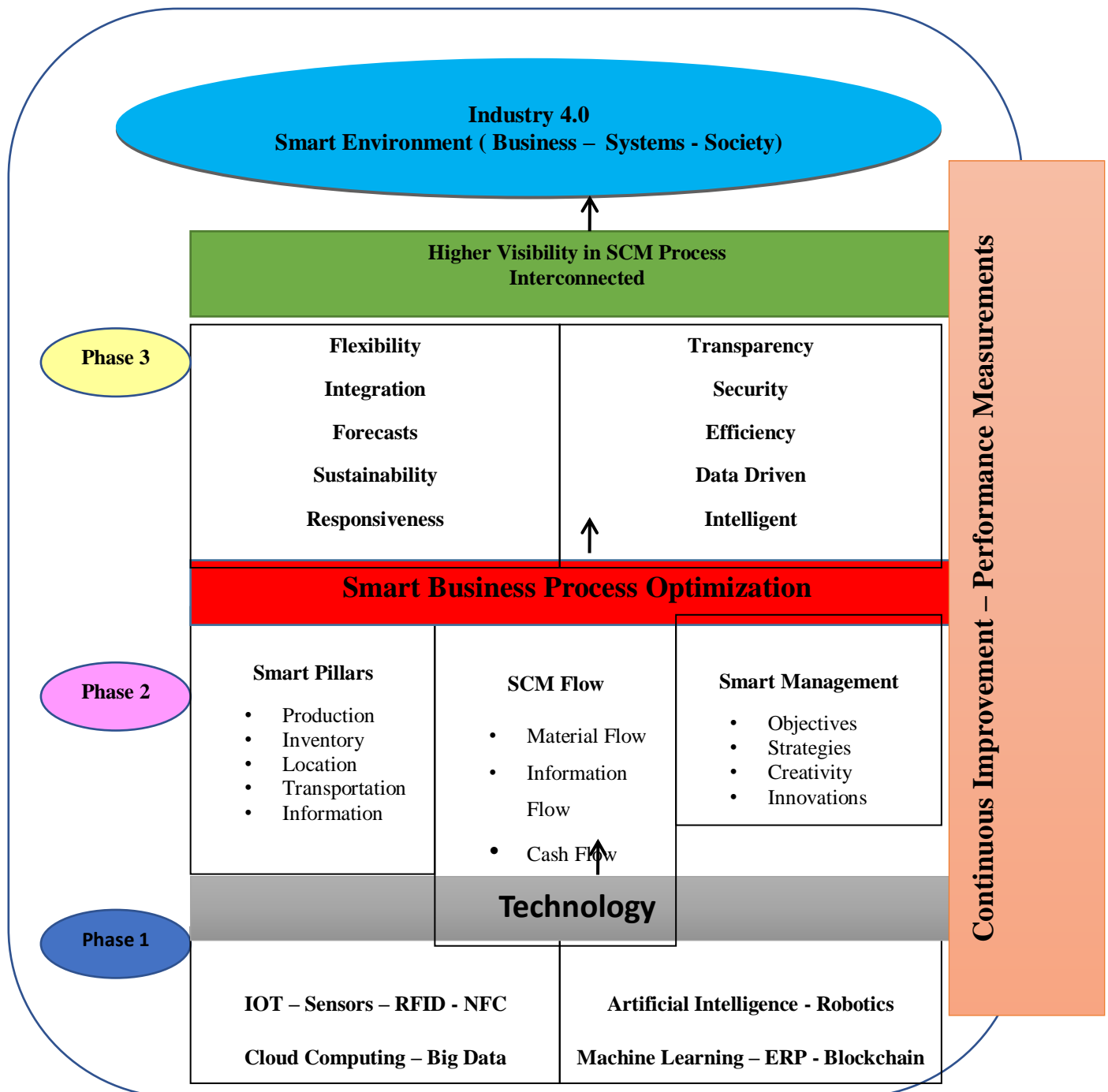


Fig. 2: A Proposed Framework of implementing IoT in SCM

The proposed framework for a smart supply chain, as shown in figure 2 includes the following phases to accomplish the goal:

- **Phase 1:** This is the first stage of the smart supply chain, during which time the Internet of Things, sensors, RFID technology, cloud computing, and big data are mostly implemented. Given that potential consumers and shipments might come from anywhere in the world, IoT-based systems are crucial for managing complicated, omnichannel supply chains. By providing the data that AI, machine learning, and predictive analytics need to provide useful insights, these devices increase supply chain visibility.
- **Phase 2:** The implementation of Smart Business Process Optimization in all SCM flows (material, information, and currency), as well as all managerial aspects (objectives, strategies, self-organizing, interconnected smart SCM may change how the network is configured and optimize itself in response to alterations in the external environment and alterations in organizational objectives.
- **Phase 3:** This phase is in charge of high visibility in the SCM process and the interconnection of various systems, including Industry 4.0-enabled smart automobile manufacturing, smart commerce, smart healthcare services, and even smart cities. Intelligent decision-making, efficient operations, and responsiveness are the goals of the connected smart supply chain management, effective data collection, and real-time communication.

This suggests that the ultimate purpose of the smart supply chain is to support business strategy, facilitate the adoption of Industry 4.0, and help meet the objectives of the economy, the environment, and society.

A. SCM Opportunities and Challenges

To make the vision of Industry 4.0 a reality, the majority of business procedures must be digital. The transformation of conventional supply chains into an ecosystem of interconnected, intelligent, and highly effective supply chains will be a crucial factor.

➤ *The Opportunities of implementing IoT in SCM*

IoT offers the SCM a promising application. IoT technology enhances the following supply chain procedures [13], [14]:

- **Improved Transparency**

Retailers may develop effective strategies by learning more about their goods, customers, and demand by integrating IoT technologies into supply chain management.

- **Greater Efficiency**

The entire supply chain speed is exponentially increased by smart route-planning tools and IoT tracking technologies because they reduce the time it takes to make decisions, shorten the feedback loop, and proactively address delay issues.

- **Risk Mitigation**

In order to discover unforeseen issues or supply chain saving points like resource leaks, inefficiencies, and equipment failure. IoT solutions can take advantage of the influence of technology and machine intelligence.

- **Cost cutting**

IoT solutions can decrease the cost of unplanned downtime and save production time from regular maintenance by monitoring a variety of data and giving quick warnings with notifications if something goes wrong. This increases enterprises' ability to mitigate risks.

- **Enhancing Sustainability**

IoT sensors can improve business sustainability in a smart supply chain by providing management with pertinent information on how energy and resources are used throughout the supply chain and product cycle. IoT solutions help executives implement green plans at different phases and integrate initiatives at scale by improving information and boosting awareness. Examples of such initiatives include actively choosing renewables, electric vehicles, and energy-efficient workplaces.

B. The Challenges of implementing IoT in SCM

Many businesses continue to manage deliveries and track assets using outmoded legacy systems in spite of the growing demand for digital transformation. By utilizing IoT in the supply chain, it is possible to address a number of issues related to outmoded operating procedures and technological advancements. However, deploying smart SCM presents a number of IoT implementation issues, including [15], [16]:

➤ *Skills Gap*

Warehouse employees and truck drivers will need extensive training to adjust to managing networked systems. It takes a lot of effort to describe the security procedures and the rules for utilising company platforms.

Given the dearth of specialised IoT training, finding a team with the necessary skills to create a solution tailored to the business is a challenge in and of itself. Supply chain managers should be aware of the fact that recruiting and employing talented workers might take a lot of time given the global talent shortage in technology.

➤ *Increased Difficulties with Data Storage*

One of the many benefits the Internet of Things offers supply chain management is large data pools. The burden of obtaining sufficient server power to store and interpret all the gathered data, though, comes with that power. To guarantee that they draw the appropriate conclusions from IoT-based insights, company management will need to create data governance policies and hunt for data scientists and analysts.

➤ *Security Threats*

Before fully converting all operations to connected platforms, supply chain managers also need to focus on building a safe architecture. Vulnerabilities in data processing and storage can open the organisation to

outside attacks and leaks, ruining its reputation and raising the risk of collapse.

➤ *Connection problems*

A reliable Internet connection is essential for IoT. Since fleet drivers frequently change locations, a trustworthy network is not always available. Supply chain managers must put up with the connectivity issue for the time being while 5G becomes more widely available and Internet coverage expands.

IV. CONCLUSION

In this Research paper, we provide a quick overview of both the IoT and supply chain management technology. Then, we undertake a thorough analysis of how to implement the innovation of the supply chain system in the IoT context after conducting a systematic research on the characteristics of the IoT supply chain system. And based on this, we suggest an architecture for a smart SCM system along with several implementation steps.

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