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APPLICATION OF RFID AND BARCODE TECHNOLOGY IN INCREASING EFFICIENCY OF SUPPLY CHAIN MANAGEMENT AND INVENTORY MANAGEMENT.

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ABSTRACT :

Radio Frequency Identification (RFID) and barcode technology have revolutionized supply chain management and inventory management practices by providing efficient tracking and monitoring capabilities. This abstract explores the application of RFID and barcode technology to enhance the efficiency of supply chain and inventory management systems.

RFID technology utilizes electromagnetic fields to automatically identify, and track tags attached to objects. In contrast, barcodes consist of a series of parallel lines that represent data through variations in the widths and spacing of the lines. Both technologies offer unique advantages and can be integrated into supply chain and inventory management processes to streamline operations.

One significant application of RFID and barcode technology is in inventory management. By affixing RFID tags or barcode labels to individual products, companies can accurately track inventory levels in real-time. This enables businesses to optimize inventory levels, reduce stockouts, and minimize excess inventory, leading to improved inventory turnover and cost savings.

Furthermore, RFID and barcode technology enhance the efficiency of supply chain management by facilitating visibility and traceability across the entire supply chain network. As products move through different stages of the supply chain, RFID tags or barcode labels enable stakeholders to track their location, status, and condition in real-time. This visibility improves inventory accuracy, reduces lead times, and enables proactive decision-making to mitigate disruptions or delays.

Moreover, RFID and barcode technology enable automation in supply chain and inventory management processes. Automated data capture and processing minimize manual intervention, reduce errors, and enhance overall operational efficiency. This automation also enables seamless integration with enterprise resource planning (ERP) systems, enabling companies to synchronize inventory data with other business functions such as sales, procurement, and production planning.

Keywords -- RFID technology, supply chain management, value chain, technological innovations, and supply chain optimization

INTRODUCTION :

In the realm of modern supply chain and inventory management, the integration of radio frequency identification (RFID) and barcode technology has emerged as a transformative force, revolutionizing the way businesses track, manage, and optimize their operations. RFID and barcode technologies serve as indispensable tools, offering unprecedented visibility, accuracy, and efficiency throughout the supply chain and inventory management processes.

Barcodes have long been a staple in inventory management, providing a simple and cost-effective method of tracking products and assets. However, their capabilities are limited to line-of-sight scanning and manual data entry, which can be time-consuming and error-prone. On the other hand, RFID technology enables automatic and contactless identification of items using radio waves, allowing for real-time tracking and monitoring without the need for direct line-of-sight.

The combined utilization of RFID and barcode technology enhances the efficiency and effectiveness of supply chain and inventory management in several ways. Firstly, it enables seamless visibility into the movement of goods throughout the entire supply chain, from manufacturing facilities to distribution centers to retail stores. With RFID tags and barcode labels affixed to each product or pallet, organizations can accurately track their inventory in real-time, facilitating better demand forecasting, inventory optimization, and order fulfillment.

Moreover, RFID and barcode technology improve inventory accuracy by reducing the incidence of errors associated with manual data entry and human intervention. Automated data capture minimizes the risk of misplaced or mislabeled items, ensuring that inventory records remain up-to-date and reliable. This not only streamlines operations but also mitigates the potential for stockouts, overstocking, and inventory shrinkage, ultimately leading to cost savings and improved customer satisfaction.

Efficient supply chains are the foundation of the contemporary economy.
The success and popularity of XPO Logistics and Amazon attest to this. These businesses have all gained a competitive edge by integrating cutting-edge technology into their supply chains to facilitate operational and strategic choices. Variations in consumer needs, abrupt and erratic changes to supply routes, significant uncontrollable interruptions (like the COVID-19 epidemic and the lockdowns that followed), and legal and compliance challenges related to cross-border commodities movements all pose constant challenges to supply chains. Data science and Industry 4.0-enabled enterprise systems that have the ability to improve cost reduction and sustainable performance throughout supply chains (Munoz-Ausecha et al., 2021).

Large volumes of primarily real-time data are sourced, stored, cleaned, and analyzed in supply chains using data science. RFID technology has the capacity to produce large amounts of streamed real-time data, which can be quite helpful in supply chain optimization. chains. In recent years, RFID has become widely used in a variety of businesses (Wamba et al., 2013). RFID sensors can give important real-time data for tracking, identifying, and ensuring the security of items as well as inventory levels (Zhang & Wang, 2018).

Fig. 1 shows an RFID system in action. The main components of this system are the reader, reading tags, and final servers, which are used to track data in real time for numerous applications. We previously examined Shiraishi et al.'s (2008) research on UHF RFID based on indoor estimation. Wang et al. (2013) described the indoor tracking mechanism for RFID placement. Zhu et al. (2020) provided an explanation of the application of RFID technology for related uses. In addition to its high degree of compatibility with IT infrastructure, ease of use, and interoperability across functional domains, RFID is a digital enabler that helps organizations transform into digital entities (Deepu & Ravi, 2021; Kamble et al., 2019).
Because RFID creates automated sensor data that can be further evaluated for automation and optimization, the technology aids in the digitization of supply chains. According to Musa et al. (2016), RFID technology works by detecting the existence of an object, gathering data, and storing that data. Data-driven insights are produced by system data analysis, and these insights guide optimization decision-making (Fanti et al., 2017). RFID provides real-time data that increases overall efficiency and accuracy, which can enhance inventory levels, tighter delivery routes, and improve the client experience (Choi et al., 2017).

RFID is used in a number of sectors, such as consumer products, retail, and finance, to enhance a number of functional areas, including sales, returns, and inventory management, leading to an overall gain in productivity (Eksiouglu, 2014; Sharma et al., 2020a, 2020c). RFID deployments are driven by commercial organizations because of their high returns on investments (ROI). By lowering stock levels, response times, and reordering capabilities, industrial RFID use has increased performance (Zhang & Wang, 2018; Ding et al., 2021). Supply chain visibility and transparency boost order fulfillment, collaboration, enhanced quality, and throughput record accuracy (Delen et al., 2007).

OBJECTIVE OF THE STUDY :

1.To Study the use of RFID And Barcode

1) Definition of RFID and Barcode Technology

At its simplest, an RFID system consists of an RFID tag that contains a microchip and an antenna, and an RFID reader that emits radio waves. When the tag passes through the reader's electromagnetic field, it detects the reader's activation signal. The reader decodes the information encoded in the integrated circuit of the tag, and then the information is transmitted to the host computer for processing. In contrast, a barcode is a machine-readable representation of information on a surface in visual form. To read the barcode, an optical scanner scans the barcode with a laser or camera, and then the data collected by the scanner is sent to a computer database. What are the differences between RFID and barcode technology? First, RFID works with radio frequency, while barcode uses optical signals. This means that RFID is more versatile and does not require direct visibility, as information can be read from the RFID tag in a certain area of the reader's electromagnetic field. On the other hand, the position and direction of the barcode in relation to the reader is crucial, which makes collecting barcode data more labor-intensive and time-consuming. Second, the RFID system can read and write data to the RFID tag, but the barcode system can only collect data from the beams and send it to the computer database without the ability to write. Finally, RFID tags, which can be made of paper and attached to products and packages for a long time, last much longer than barcode tags, which can wear or deteriorate over time. Barcode labels, on the other hand, are cheaper, but must be replaced if damaged. In conclusion, RFID and barcode technology are automated systems for the most accurate data capture and processing without human intervention. The main difference between the two comes from the way data is collected and processed. Although barcode technology is a more traditional way of collecting data, RFID technology offers more potential benefits in the long term and is therefore increasingly used today compared to barcodes.

2) Review literature :

For a review of secondary literature. 138 articles were found in the first search. 89 articles remained in the list after the duplicates were removed. This list yielded 70 articles when it was restricted to journal papers alone. 52 articles were kept after a cursory review of these was done to eliminate those that had nothing to do with our investigation. Ultimately, following a thorough examination of the abstracts and contents, we selected 25 publications for additional in-depth investigation. A number of factors were found in the chosen papers. The thorough explanation is covered in the section that follows.

3) Supply Chain Management :

A supply chain, also known as a logistics network, is the network of companies, individuals, technology, activities, data, and assets used in the transportation of goods or services from supplier to client. Natural resources, raw materials, and componentry are transformed through supply chain operations into a final product that is shipped to the final consumer.

In Used goods can re-enter the supply chain at any point where their residual value can be recycled thanks to advanced supply chain systems. As a result, a large number of interactions in the supply chain will take place between various businesses that are primarily interested in maximizing their profits within their own domains and may not be very aware of or interested in the other participants. The self-organizing, loosely connected network of companies that band together to sell goods and services has been dubbed the "Extended Enterprise" in more recent times.

2.1) Supply Chain Modeling

The Supply Chain Council created the SCOR (Supply Chain Operations Reference) model, which gauges the overall performance of the supply chain. The model serves as a process reference for supply-chain management, which includes every link in the chain, from the supplier to the buyer. When assessing the overall effective performance of a supply chain, it takes into account a number of elements, including as inventory and asset turns, production flexibility, warranty and return processing costs, and delivery and order fulfillment performance.

2.2) Supply Chain Management

The phrase "supply chain management" (SCM) was coined in the 1980s to describe the necessity of integrating the essential business operations, starting with the end user and ending with the original suppliers.

Original suppliers are those who offer goods, services, and data that benefit clients and other stakeholders. The fundamental tenet of supply chain management (SCM) is that businesses engage in a supply chain by sharing information about production capacities and market variations.
Using resources like distribution capacity, inventories, and other assets as efficiently as possible is the main goal of supply chain management. Theoretically, a supply chain aims to minimize inventory while matching supply and demand.
Working with suppliers to remove bottlenecks is just one aspect of supply chain optimization. Other strategies include strategically sourcing to balance transportation costs and lowest material costs, implementing Just-In-Time (JIT) techniques to optimize manufacturing flow, maintaining the proper mix and location of factories and warehouses to serve customer markets, and maximizing distribution side efficiency through the use of location/allocation, vehicle routing analysis, dynamic programming, and, of course, traditional logistics optimization.

3) Radio Frequency Identification (RFID):

The Indian market has progressively advanced to the point where an increasing number of industry sectors are recognizing the necessity for RFID technology adoption. As of right now According to CyberMedia Research, when the market conditions change, the usage of RFID technology will increase and reach a substantial level by 2015. The corporate environment of today is one in which things change swiftly. Companies need to be equipped with the technology, knowledge, and tools necessary to respond to these changes quickly and effectively.
Using a wireless, non-contact technology, radio-frequency electromagnetic fields are used in radio-frequency identification (RFID), which transfers data from a tag affixed to an object, in order to facilitate tracking and automatic identification. In contrast to a bar code, the tag can be embedded in the monitored object and is not limited to the reader's line of sight. In essence, RFID, or radio frequency identification, is an enabling technology. RFID has the distinct benefit of not requiring human intervention, which results in significant commercial value.
Access management, tracking goods, tracking people and animals, toll collection and contactless payment, machine-readable travel documents, tracking sports memorabilia to confirm authenticity, airport baggage tracking logistics, and airline applications are just a few of the many uses for RFID technology.

- Subway and toll passcards
- Transportation equipment such as highway
- Construction firms

3.1) Operation of RFID

The things to be identified are tagged or labeled using a radio-frequency identification system. Interrogators or readers are two-way radio transmitter-receivers that communicate with tags by sending a signal and receiving a response. Typically, the readers send their observations to a computer system that is running RFID middleware or software.
The data on the tag is electrically kept in a non-volatile memory. An RF transmitter and receiver are minor components of the RFID tag. To read the tag, an RFID reader sends a radio signal with an encoded message. After receiving the message, the tag answers with its unique identifier. This could just be a unique tag serial number, or it could contain product-specific data like a manufacture date, stock number, lot or batch number, or other special information.
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tag, an RFID reader sends a radio signal with an encoded message. After receiving the message, the tag answers with its unique identifier. This could just be a unique tag serial number, or it could contain product-specific data like a manufacture date, stock number, lot or batch number, or other special information.

RFID tags come in three varieties: battery-assisted passive, active, and passive. An active tag's internal battery powers its ID signal, which it broadcasts on a regular basis. Tags can be read-only, with a factory-assigned serial number that serves as a database key, or read/write, allowing the system user to write object-specific data into the tag. Write-once, read-many field programmable tags allow the user to write an electronic product code on "blank" tags. RFID lowers the possibility of human error and saves a significant amount of unnecessary expenses. Industry is currently using it more and more as a successful replacement for bar codes.

The Department of Information Technology is primarily focused on RFID R&D and offering RFID-based technological solutions to Indian companies. The large-scale "National RFID Program" project was launched in April 2007 with this goal in mind.

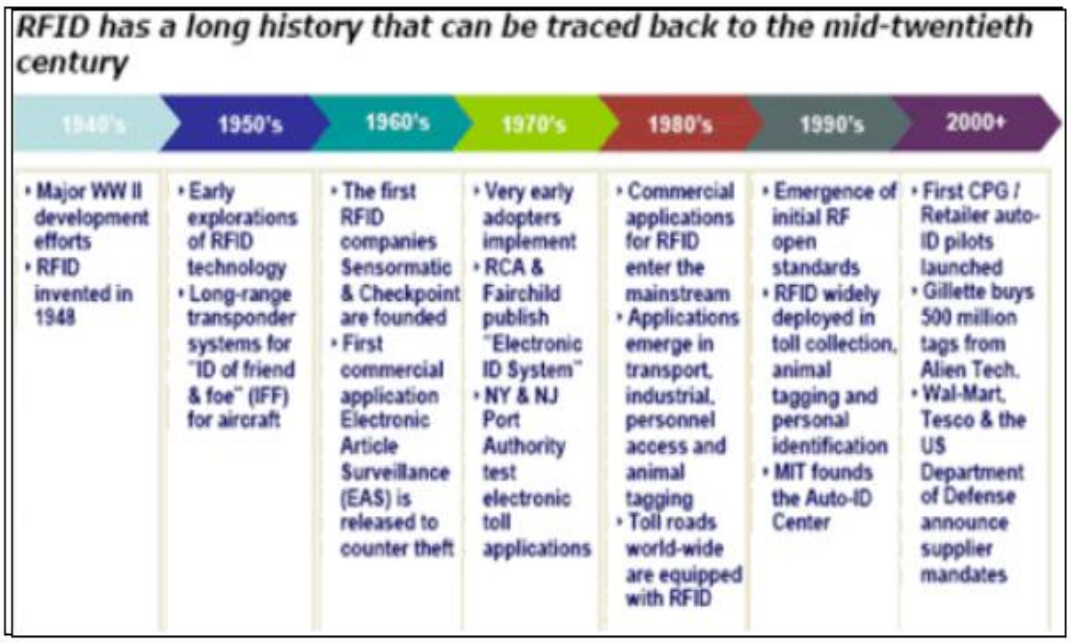

Table 1.

4) Use of RFID in Industries

Similar to major worldwide retailers like Tesco, Wal-Mart, and Carrefour, which employ radio frequency identification (RFID), Future Group and Reliance Retail are only beginning to implement RFID.RFIDAI, or the RFID Association of India, is a non-profit that promotes RFID technology and is the driving force behind it in India.

For a variety of factors, primarily related to the market, the association has not been able to make a noteworthy push thus far. However, it is dedicated to helping the Indian business grow to a respectable level.

One of the biggest and only private Fortune 500 companies in India, Reliance Retail, has been testing RFID technology and is getting ready to roll out applications at a lot of its hypermarkets and supermarkets. These stores already have data ports and wireless computer networks installed by the corporation, which can handle RFID systems.

Reliance Retail is committed to driving process compliance to maintain low productivity levels. It views RFID as the ideal tool for: ensuring adherence to retail processes and monitoring activities in stores.driving process compliance on a near real-time basis as a key performance indicator (KPI) to support its operations. Reliance Retail has always been focused on improving business processes. tracking of reusable fresh food crates; tracking of high-value items at the item and case levels; and labeling of different commodities on pallets and cases Raise productivity, decrease shipping and receiving mistakes, and improve read rates (the act of reading data from an RFID tag by transmitting radio waves to it and translating the waves it sends back into data).

Supermarkets and hypermarkets are the means by which Pantaloon Retail Indian Limited (PRIL), the retail division of Future Group, runs its outlets. Big Bazaar, a PRIL hypermarket, was a cross between a department store and a supermarket. Low pricing and the greatest deal available to clients were the Big Bazaar store's unique selling pitch. Customers were given the impression that they were in an Indian bazaar (market) by the way the stores were designed. For a major retail enterprise like Future Group, the move makes perfect commercial sense and will provide them a competitive edge. The use of RFID technology may assist Future Group in a number of ways. RFID boosts productivity since it provides whole supply chain visibility and works wonders when making decisions or handling aging or perishable commodities.In 2004, Future Group made a deliberate move to use RFID technology.

5) RFID applications :

Prior writing examined different utilizations of RFID, successful execution methodologies, and best practices (Delaunay et al., 2007; Chanchaichujit et al., 2020). Reception obstructions to RFID, its business applications, and the benefit of involving RFID in supply chains was talked about by Chase et al. (2007), Lim et al. (2013), Chongwatpol and Sharda (2013) and Abdullah et al. (2020). As per one gauge, RFID worldwide business sectors will ascend to $15.84 billion USD (Shree et al., 2020) by the second from last quarter of the monetary year 2021-22. RFID adds to more than $1.3 billion of income across the inventory chains of both assembling and administration businesses. The expense of a singular tag, notwithstanding, is still moderately high, which acts obstructions for applications such like marking merchandise. For broad utilization, RFID label costs should be a small portion of the edges on products, particularly in the retail area. Cost appears to be the principal prevention to RFID execution. Hence, numerous specialists dealt with an other, practical plan (Abdullah et al., 2020; Adikari et al., 2021; Arjun et al., 2021). Table 2 portrays the writing summing up RFID applications in different enterprises. The top to bottom writing survey brought about the accompanying contemplations for consolidating RFID in supply chains: • The business determines and directs the vital necessities of enhancing supply chains, particularly the assembling tasks. • Exchanging systems and guidelines set by business partners give the restricting boundaries to the use of RFID to the stockpile chain. • Displaying and concentrating on the current "with no guarantees" working circumstances and corporate arrangements is vital for figuring out the issues and challenges in the current stockpile chains. • The production network streamlining process is influenced by the kind and amount of information sources (unrefined components) and results (items or articles) being produced and shipped. The writing concentrate on additional uncovered that RFID's capability to enhance processes is expanded in a business that produces and transports in excess of 1000 items.

5.1) Application of RFID in SCM optimization in the light of industry 4.0

According to Núñez-Merino et al. (2020), supply chain management (SCM) is strongly integrating information, material, and financial flows with technology and is rapidly moving toward the use of digital technologies. In the past, the use of traditional radio frequency tags and sensors for intra-organizational performance was the only commercial use of SCM. Smart sensors are becoming more and more common in control systems and route operations, such as inventory management and logistics, thanks to the development of Industry 4.0 technologies, such as cloud computing (Ivanov et al., 2018). Consequently, there is an improvement in operational effectiveness, productivity, and excellent visibility throughout various operations. Specifically, supply chain technology like RFID and IoT assist the company financially. With the technological extension and commercial usage of robotics and augmented reality, supply chains are getting further optimized (Chauhan & Singh, 2019). Industry 4.0 is paving the way for future factories that have smart warehousing and optimized logistics. Business benefits include advanced levels of agility, transparency, efficiency, and traceability in supply chain activities (Fernández-Caramés et al., 2019). Data automation is an essential base for deploying Industry 4.0 to supply chain activities. Without data, businesses struggle to optimize their operations and supply chains. Rafiquea et al. (2022) discuss the relevance of RFID and Industry 4.0 technologies in the context of a technology or ganizational-environmental (TOE) framework. One of the most suited and most convenient digital technologies to use is IoT, which is simple to integrate into an already-existing supply chain. By connecting smart items, the Internet of Things (IoT) generates an ecosystem of both digital and physical objects. Industry 4.0's related technologies are built on the IoT. Kamble et al. (2019) talked about how important IoT is to the retail industry.

Table 2
RFID applications in various industries.

Contributors	Level of Analysis	Tools	Context
Xiao et al. (2017), Huang et al. (2019), Chu et al. (2021)	Firm	Thematic Analysis	Commercial off-the-shelf (COTS) RFID-equipped robot for precision location in supply networks.
Benčić et al. (2019), Popović et al. (2021)	Firm	Cost Analysis	Technology enabled distributed ledger and IoT enabled supply Networks
Rodger (2017)	Healthcare Industry	Entropy Model	Markov blanket entropy approach that aim to minimize inventory cost, waste reduction and enhancing sustainability.
Ray et al. (2015)	Firm	Heuristic Techniques	Near-optimal allocation of monitor aims to minimize energy consumption.
Lu et al. (2017)	Transportation Industry	Dolph-Chebyshev Antenna Array	With low fluctuation and consistency in data fetching and execution, far-filed RFID systems are established.
Joshi (2016); Xiao et al. (2017); Huang et al. (2019), Chu et al. (2021)	Cross-Industrial	Experimental	The aim is to reduce the execution time of fetching and execution of image processing.
Toyoda et al. (2017), Kshetri (2022)	Product Design	Experimental	Cost performance analysis and deployment of blockchain-based decentralized application platform.
Cuthbertson and Piotrowicz (2011)	Cross-Industrial	Experimental	Algorithm designing and testing was done to know the RFID viability in cross-industrial supply chain.
Karuppuswami et al. (2018), Herrojo et al. (2019), Fathi et al. (2020)	Dairy Industry	Experimental	Sensitivity analysis to evaluate the quality and supply of material by suppliers
Sharma et al. (2021), Zhu et al. (2020)	Transportation & Vehicle Tracking	Theoretical Analysis and Experimental	A novel and effective close detection approach was used to enhance real time supply chain process.
Sidorov et al. (2019), Paul et al. (2022)	Cross-Industrial	Theoretical Analysis and Experimental	Gong, Needham, and Yahalom logic has been developed to understand and evaluate storage, computational, and communication costs.
Björk et al. (2011), Chen and Kaakkurivaara (2019)	Inventory Control and Object Tracking	Theoretical	Tree Hopping (TH) protocol was testing to know the effect of RFID for inventory positioning and tracking during its in-transit status.
Chen et al. (2017, 2013)	Warehousing Management	Experimental	E-ERMI framework was developed and simulations were conducted to evaluate its performance in various application areas including inventory management, supply chain management, and distribution and retailing.
Shafique et al. (2019); Svub et al. (2020)	Pharmaceutical Industry	Structured Modeling	Embedded technologies including big data, IoT leads to benefits to the decision-makers in the sector to enhance the performance of supply chains.
Joshi and Dwivedi (2020)	Pharmaceutical Transportation Management	Experimental	Traceability system in a delivery van of the drug distributor in the city of Bilbao.
Sidhu et al. (2020)	Switch Gears Firms	Conceptual Framework	conceptual design approach is used to develop the functional design of switchgear for inventory performance enhancement.
Joshi and Dwivedi (2020)	Healthcare Industry	Theoretical Analysis and Experimental	Monitoring and Tracking Patient (MTP) for effective record keeping system.
Nezhad et al. (2021)	Textile and Clothing Manufacturing	Theoretical Analysis and Experimental	Enhanced tracing capabilities of the firm. Warehousing efficiency periodically increases due to the appropriate use of RFID technology.
Oghazi et al. (2018)	Multiple Industries	Case Analysis and Experimental	Integration of RFID with Enterprise Information System helps supply chain to become more responsive and efficient.
Chanchaichujit et al. (2020); Corches et al. (2021)	Multiple Industries	Thematic Analysis	Enhanced industrial usage of RFID as a benefit-driver and sustainable competitive advantage.

Table 3
Benefits and Challenges of using RFID.

Benefits	Cost Reduction	Usage of RFID leads to positive ROI and High returns with waste reduction across the cost centres (Hijazin & Zhang, 2019; Sharma et al., 2022).
	Enhanced Product Quality and Safety	High visibility towards the material in transit (Sharma et al., 2020a; Koohang et al., 2022)
	Inventory Discrepancy Reduction	RFID technology provides two key advantages to the supply chain: first, the visibility allows precise inventory monitoring and replenishment, and second, reduction in causes of discrepancies (Ustundag & Tanyas, 2009), between inventory record and the actual inventory (Delaunay et al., 2007; Sarac et al., 2010). These RFID advantages result from improved visibility and control (Kumar et al., 2021).
Challenges	Standardization	The standardization benefits are lost if multinational organizations have to invest in different RFID technologies (Smith, 2021).
	Privacy and Legal issues	Simple and secure tags that ensure personal data privacy are required before consumers trust and retailers implement RFID on a mass scale (Ben-Daya et al., 2019).
	Other Barriers	Adoption issues and other contemporary issues (Abdullah et al., 2020; Lim et al., 2013).

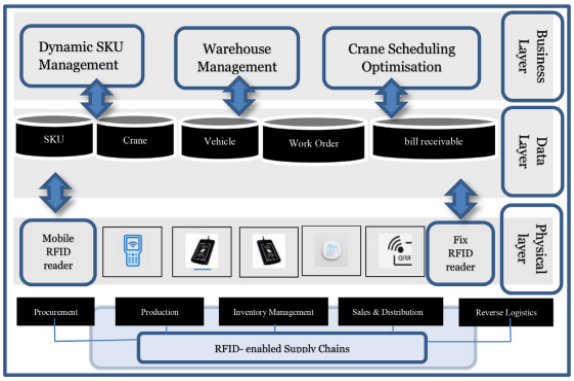

Table 4
Supply chain management process and RFID applications.

Supply Chain Management Processes	Description
Demand Management	RFID-generated data ameliorates inaccuracies due to human error. RFID can also generate sufficient volumes of data for analysis. Timely data for each item and in the aggregate enables analysis and generates insights. Predictive analytics on aggregate data matches demand with supply. Aggregate analytics-based planning is enhanced by sufficient and accurate RFID data that reduces costly buffer stocks while matching the demand (Kushwaha et al., 2021; Kato, 2021; Arjun et al., 2021; Adikari et al., 2021).
Order Fulfillment Management	RFID data facilitates process automation in materials handling, shelving, cross-docking, and retrieval.
Manufacturing Flow Management	RFID technology helps streamline assembly lines. Streamlined automation in the assembly line reduces throughput time. RFID-enabled automation and tracking also improves the visibility of products and their velocity in the supply chain (Arjun et al., 2021; Kapoor et al., 2021).
Returns Management	Customer returns add to the inventory pile. RFID technology provides downstream visibility of negative demands (Konstantakopoulos et al., 2021), thereby helping the organization understand its real inventory in real-time.

6) Discussion

The study that follows a methodical examination of the literature to investigate the state of academic research on decision support systems and RFID in the context of Industry 4.0.

The purpose of this study is to determine the value of RFID in improving supply chain management and operations. The evaluation addressed a number of topics, including as organizational strategies for implementing new technology, like RFID, and sustainable

advancement, contemporary methods,
information system techniques to supply chain design and management, as well as the advantages of Industry 4.0 and RFID.

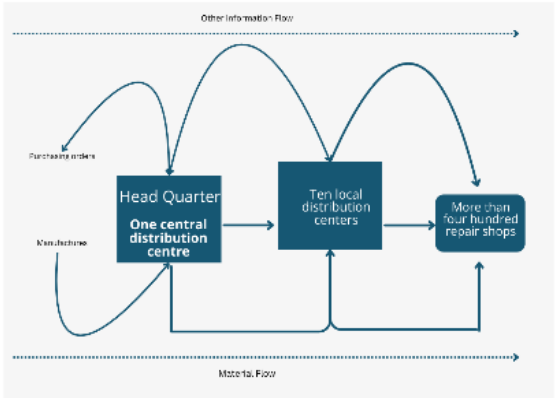

Fig 3. Layout without RFID

From the standpoint of industrial strategy, the adoption of RFID may be seen as a cost driver that moves towards optimizing the function of the supply chain through digitization (Sarkar & Shankar, 2021).

The combination of RFID with Industry 4.0 technologies has the potential to improve operational excellence and generate value for enterprises. The integration of RFID technology into the supply chain must take into account industrial strategy, business operations, and technological infrastructure (Guo et al., 2019; Kamble et al., 2019; Pandey et al., 2021). Principal advantages of using RFID-enabled robots includes cost savings, inventory monitoring, quicker reaction times, and enhancements to a company's general operations within the supply chain and logistics sector (Casamayor Pujol et al., 2021). This article provides examples of how RFID is used in different supply chain scenarios.

In addition, the review looks into possible inefficiencies in the management and operations of inventory techniques (Ustundag & Tanyas, 2009; Zhang & Wang, 2018; Reyes et al., 2021) and suggests RFId as a way to streamline business procedures. A statistical analysis is conducted to develop and evaluate two scenarios that highlight the benefits of RFID in corporate processes. RFID, for instance, lowers mistakes caused by human operations. The general There are less logistical expenses and losses brought on by lost resources and goods.

According to Abdullah et al. (2020), there is a 20% gain in overall income when faults in the supply chain process are decreased.

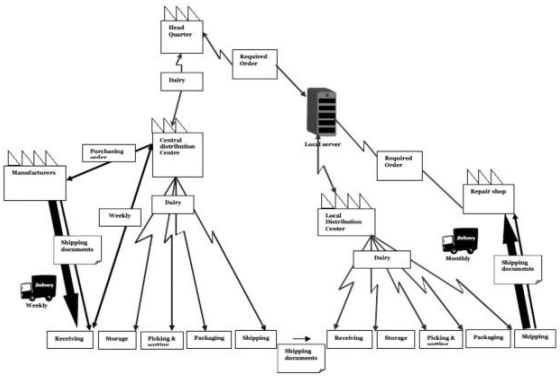

Fig 4 Layout with RFID.

The outcomes show that savings of 84% or more might be realized in terms of both lag time and overall transit time (Newman-Casey et al., 2020). The second benefit is the approximately 60% reduction in time required to provide materials, which increases a supply chain's overall efficiency by about 80% (Bianco et al., 2021; Paul et al., 2022). RFID is a widely accepted global technology that offers significant adoption across various industries. These industries include healthcare supply chains (Cui et al., 2022; Mohanty et al., 2022), transportation management, and location tracking. (Subbulakshmi and others al., 2022; Ummapathi, et al., 2022), aerospace and defense operations (Goritiyal, et al., 2022), ur ban planning (Sharma et al., 2020a; Yang et al., 2021), retail operations (Kamble et al., 2019; Bellini et al., 2022), tourism supply chain management (Bose et al., 2022), and smart manufacturing (Ra□quea et al., 2022; Sharma et al., 2021). RFID-enabled technologies have a wide range of applications that demonstrate their significance in enhancing supply chain traceability and overall business effectiveness (Syed et al., 2022). These applications are primarily in areas like agriculture and food supply chains (Mai et al., 2010; Liu, 2022; Ramasubramaniam & Kartikayani, 2022). Despite its benefits, supply chain management using RFID technology frequently faces a number of difficulties, such as retail management. In difficulties with logistics include security across several RFID tags in a wide sense.

problems related to operations and manufacturing, such as data administration and supplier and focal company compatibility issues. The advent of Industry 4.0 in supply chain operations necessitated functional data decisions and solutions in a number of domains, including distribution, warehousing, procurement, production operations, and logistics (Campego et al., 2020).

The Internet of Things (or RFID-IoT) has advanced through the integration of automated sensors and ubiquitous computing to enable smart operations. This has made ubiquitous data accessible to all supply chain participants, including distributors, producers, and consumers. The information at hand increases process tracking and efficiency and gives clients a better service experience.

The role of RFID IoT in maximizing supply chain efficiency and cost effectiveness sup ports the data analysis and formulation of the decision support

system to support digital transition to smart factories (Teixeira et al., 2022), warehouse management (Lim et al., 2013 ; Xu et al., 2013); cargo trans portation, (Baygin et al., 2022) and other societal applications including mobility (Auer et al, 2022 ; Sharmila et al., 2022), attendance systems (Kariapper, 2021); food production and distribution (Lao et al., 2010), and physical retailing (Pantano & Willems, 2022). We have put up an RFID-IoT-enabled Decision Support System in an effort to address the issues mentioned above.

Figure 5 displays an intellectual foundation for an RFID-IoT enabled Decision Support System. The foundation of the framework mostly rests on an organization's capacity to absorb RFID inside an Industry 4.0 framework. The authors offer a conceptual framework for an RFID-Internet of Things decision support system based on the thorough review. In the foreseeable future, the framework work can serve as the guide for both qualitative and empirical research.

It is possible to comprehend the study's practical consequences by creating a number of industrial examples.

7) Conclusions, limitations and future research directions

This research examined sources that produced significant papers on RFID technology and decision support systems in the context of Industry 4.0 that were published in journals and dexted in Scopus databases between 2000 and 2021. Additional research ought to focus on the ways in which many related technologies, such as artificial intelligence and the Internet of Things, might improve supply chain efficiency. The review addressed a wide range of topics, such as organizational strategies for implementing new technologies, such as RFID, sustainable development, contemporary methods, information system approaches for supply chain design and management, and the advantages of Industry 4.0 and RFID. The outcomes show that Potential savings of up to 84% of the total time spent on transportation and lag, as well as a roughly 60% decrease in the amount of time needed to provide the resources needed to increase a supply chain's overall efficiency by over 80%.

RFID technology is widely recognized as a worldwide technology that offers significant acceptance across several sectors, including healthcare supply chains, and offers industrial advantages.

This study has reduced the expenses associated with using RFID technology while providing recommendations on the operational efficiency of supply chains. The primary contribution of this work is its examination and assessment of several RFI application techniques in supply chains with the intention of attaining cost efficiencies and efficiently saving time. This investigation's purview is restricted to examining how RFID affects supply chains. Future studies should look at how RFID-IoT and the physical internet interact, as well as how real-time data processing may help supply chains continue to make the best decisions possible.

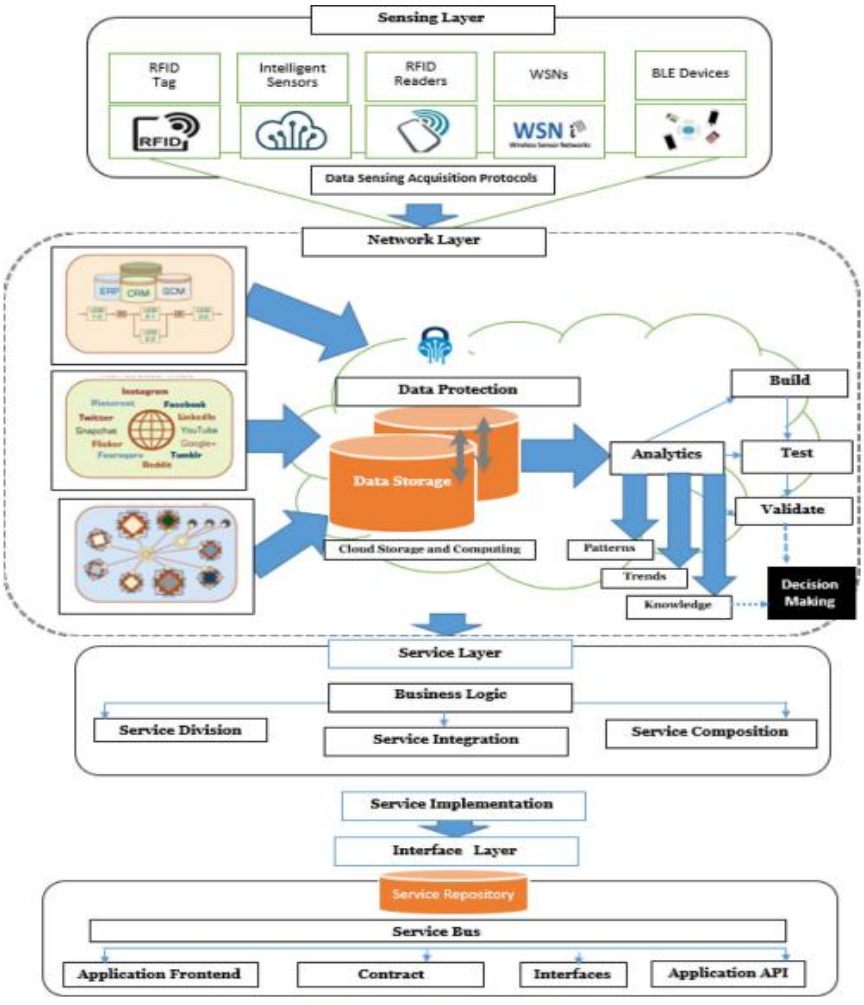

Fig. 5. Proposed conceptual framework for a RFID-IoT-enabled decision support system.

Fig 5. Proposed conceptual framework for a RFID -IOT-enabled support system.

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