

## Internet of Things in Supply Chain

Matthew N. O. Sadiku<sup>1</sup>, Paul A. Adekunle<sup>2</sup>, Janet O. Sadiku<sup>3</sup>

<sup>1</sup>Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX, USA

<sup>2</sup>International Institute of Professional Security, Lagos, Nigeria

<sup>3</sup>Juliana King University, Houston, TX, USA

### ABSTRACT

Internet of things (IoT) is a network of automated smart-enabled devices communicating with one another without human input. In essence, the IoT connects devices to the Internet. IoT is really catching on to the supply chain industry. Statistics and expectations confirm the growing popularity of IoT adoption in supply chain efforts. The Internet of things (IoT) is a solution capable of automating supply chain processes, offering better visibility and control, optimizing inventory, and enabling predictive maintenance. IoT solutions can help significantly optimize supply chain management and logistics processes, bringing in the transparency and cost-effectiveness that cannot be achieved otherwise. The purpose of this paper is to investigate the role of IoT in supply chain.

**KEYWORDS:** *Internet of things, IoT, industrial Internet of things, IIoT, supply chain, supply chain management, SCM*

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### INTRODUCTION

The Internet of things has been around for a while. It basically connects devices to a wider, intelligent network. Leveraging the IoT to connect machines can create a more intelligent, efficient, and safer facility. There is no doubt the Internet of things has smartened and better connected the world of commerce. When people talk about the “smart homes,” “smart factory,” or “smart supply chain,” they are talking about the IoT. In the supply chain, IoT solutions can help track, manage, and deliver goods. Applications can help automate or monitor specific picking and packing processes.

Supply chain management (SCM) is a complex field that handles and optimizes the supply chain process of goods and services. IoT in supply chain management is taking center stage. It involves using various sensors and IoT devices to gather and store information about goods. It is transforming how companies monitor and control their supply chains, improving visibility, reducing costs, and enhancing operational efficiency. It also helps businesses track, monitor, and manage products and inventory levels. Since many elements must work together, the

Internet of things (IoT) can help to improve connection and communication between different devices. IoT supply chain management is transforming how companies monitor and control their supply chains, improving visibility, reducing costs, and enhancing operational efficiency. With IoT-based supply chain management, businesses can monitor every aspect of their supply chains, from asset tracking to route optimization and demand forecasting. Supply chain operators can check where the products are in real time, whether in a warehouse or waiting on a store shelf. IoT in supply chain management is illustrated in Figure 1 [1].

### OVERVIEW ON INTERNET OF THINGS

The concept of the Internet of things (IoT) has been around since the late 1990s, but it gained momentum in the 2000s with the rise of Internet-connected devices. The Internet began with some military computers in the Pentagon called Arpanet in 1969. It expanded throughout the 1980s as a set of four parallel military networks, each at a different security level. The core technology which gives the Internet its particular characteristics is called Transmission

Control Protocol/Internet Protocol (TCP/IP), which is essentially a set of rules for communication [2].

Internet of things (IoT) is a worldwide network that connects devices to the Internet and to each other using wireless technology. IoT is expanding rapidly and it has been estimated that 50 billion devices will be connected to the Internet by 2020. These include smart phones, tablets, desktop computers, autonomous vehicles, refrigerators, toasters, thermostats, cameras, alarm systems, home appliances, insulin pumps, industrial machines, intelligent wheelchairs, wireless sensors, mobile robots, etc. Figure 2 illustrates some applications of the Internet of things [3].

There are four main technologies that enable IoT [4]: (1) Radio-frequency identification (RFID) and near-field communication, (2) Optical tags and quick response codes: This is used for low cost tagging, (3) Bluetooth low energy (BLE), (4) Wireless sensor network: They are usually connected as wireless sensor networks to monitor physical properties in specific environments. Communications technologies in Internet of things are portrayed in Figure 3 [5].

IoT technology enables people and objects to interact with each other. It is employed in many areas such as smart transportation, smart cities, smart energy, emergency services, healthcare, data security, industrial control, logistics, retail, structural health, traffic congestion, manufacturing, and waste management. The Internet of things is extensively developed world-wide with a focus on civilian applications such as electric power distribution, intelligent transportation, healthcare, industrial control, precision agriculture, environmental monitoring, etc. Figure 4 shows a typical representation of IoT [6].

## INDUSTRIAL INTERNET OF THINGS

The growth of the internet of things (IoT) is drastically making impact on home and industry. While the IoT affects among others transportation, healthcare, or smart homes, the Industrial Internet of Things (IIoT) refers in particular to industrial environments. IIoT is a new industrial ecosystem that combines intelligent and autonomous machines, advanced predictive analytics, and machine-human collaboration to improve productivity, efficiency and reliability. It is bringing about a world where smart, connected embedded systems and products operate as part of larger systems [7].

The industrial Internet of things (IIoT) refers to the application of the Internet of things (IoT) across several industries such as manufacturing, logistics, oil and gas, transportation, energy/utilities, chemical,

aviation and other industrial sectors. A typical industrial Internet of things is shown in Figure 5 [8].

IIoT is often used in the context of Industry 4.0, the Industrial Internet and related initiatives across the globe. Industry 4.0 describes a new industrial revolution with a focus on automation, innovation, data, cyber-physical systems, processes, and people [9]. With Industry 4.0, the fourth industrial revolution is set on merging automation and information domains into the industrial Internet of things, services, and people. The communication infrastructure of Industry 4.0 allows devices to be accessible in barrier-free manner in the industrial Internet of things, without sacrificing the integrity of safety and security [10].

## IOT IN SUPPLY CHAIN

A supply chain is the systematic process of managing the flow of operations from acquiring raw materials from suppliers, manufacturing products, and distribution of manufactured goods or services to retailers for onward submission to end customers. It is a complex system involving multiple stages, from producing raw materials to handing the finished product to the end customer. And across all these stages, Internet of things technologies can be beneficial. Figure 6 shows IoT in different stages of the supply chain cycle [1]. The Internet of things (IoT) has played a transformative role in supply chains over the last few decades. Reshaping the way goods are tracked, stored and managed, IoT's integration into supply chain operations has resulted in greater visibility and control.

Supply chain management, as depicted in Figure 7, is elaborated as the right item intended for the right customer at the right price under the right condition at the right place, and time in the right quantity [11]. The Internet of things is an integrated system of intelligent interconnections fused with wireless sensory networks, big data, and cloud computing. The role of IoT in supply chain management has enabled real-time monitoring of every stage of the chain to provide seamless movement of goods and information. IoT is having a transformative impact on supply chain management.

## EXAMPLES OF IOT IN SUPPLY CHAIN

It is always expedient to learn from the real-world leaders who implemented the Internet of things into their supply chains. Many large-scale companies currently benefit from integrating IoT with supply chain processes. As shown in Figure 8, some examples of companies successfully leveraging the power of IoT are Amazon, Volvo, Maersk, and Nissan Motor Co. [12]. Here we briefly consider a few of them [1,13]:

- *Amazon*: This international e-commerce giant ships approximately 1.6 million packages daily, processing about 20 orders per second. Today, the company has more than 200,000 IoT robots working inside its global warehouse network, helping perform tasks that require speed and lifting heavy loads. In 2022, Amazon has invested \$1 billion into warehouse robotics. The company decided to leverage this tech to reduce manual labor and offer faster delivery times. The company enhances its warehouse management with IoT devices that scan QR codes and identify products. It uses IoT to manage intermediaries, forecast product sales, and optimize shipping. Amazon has been using a fleet of IoT-enabled robots for warehouse management operations by scanning the QR code on packages.
  - *Maersk*: Maersk is a Danish shipping business that accounts for 18% of worldwide container commerce. This shipping company uses IoT to track containers in real-time. Being responsible for 18% of global container trade, Maersk has invested in the Internet of things to improve visibility, safety, and cost efficiency in its sea freight operations. It introduced a system called Remote Container Management, which monitors the temperature and humidity in shipping containers and helps operators prevent perishable cargo spoilage. The company uses IoT-enabled sensors to track temperature, humidity, and other parameters in refrigerated containers. It actively utilizes IoT systems in asset tracking, cargo monitoring, warehouse automation, route optimization, and security.
  - *Nissan*: The car manufacturer has deployed IoT automation for connecting its various industrial plants. Nissan uses IoT supply chain to link its multiple industrial units. Their main factory in Sunderland, UK, also boasts intelligent warehouse management systems, where IoT technologies work together to increase the warehouse's productivity and efficiency, thus minimizing human error.
  - *Volvo*: Volvo Group, which includes companies like Volvo Trucks, Volvo Penta, and Volvo Logistics, actively uses IoT technology in its logistics operations and supply chains to enhance efficiency and reduce costs. Volvo uses IoT supply chain to track its vehicles' components from several countries and vehicle deliveries to its global customers. Volvo uses a connected cloud-based system to track car parts' shipment from across the globe and vehicle delivery to Volvo's international suppliers.
  - *Walmart*: Walmart uses IoT to monitor temperature, energy use, and other environmental conditions during the storage of fresh produce. They automatically adjust their HVAC systems to ensure the highest quality standards for the stored food. Walmart, the leading retail giant, worked with Symbotic to bring high-tech automation to its supply chain.
  - *FedEx*: One of the vivid examples of IoT in supply chain management is FedEx. This transportation company uses cloud solutions that receive data from the fleet and create the most time and cost-efficient routes possible based on weather forecasts, traffic, and other real-time data from other sources.
  - *DHL*: DHL and its partner created a custom, low-profile sensor to detect roller cages inside and between DHL facilities. Sensors have low power consumption and a battery that can hold a charge for 15 years. Operators then use sensor data to decrease shrinkage via a cloud-based management platform. DHL's IoT-enabled system provides operators with data to ensure high availability of roller cages. DHI innovative center is shown in Figure 9 [14].
  - *Siemens*: Siemens uses IoT to improve product quality through real-time data capture and analysis. By integrating IoT into the production lines, Siemens monitors several factors to ensure it meets quality standards.
  - *Caterpillar*: This company has collaborated with Uptake to create IoT-based predictive maintenance solutions. The joint platform gathers real-time data from sensors to enable proactive maintenance by predicting failures before they occur.
  - *Bosch*: When it comes to Bosch leveraging IoT, the company monitors valuable assets and prevents theft by integrating IoT sensors and real-time data solutions. With greater visibility into asset location and status, Bosch can respond faster to potential threats.
- APPLICATIONS OF IOT IN SUPPLY CHAIN**
- IoT can bring many transformations in managing supply chain and logistics. The IoT applications are not just isolated improvements; they work together to create a completely transformed supply chain ecosystem that helps you make better decisions across your entire operation. We now consider different ways in which the supply chain industry is currently using IoT within its operations [11,13]:
- *Warehousing Management*: Warehouses are a basic part of the supply chain; they are used to

store products and manage the inventory level. IoT is changing the way warehouses and distribution centers operate. Using IoT devices for warehouse management, companies such as DHL, Amazon, and Walmart are using solutions such as RFID tags and sensors to streamline their warehouse operations. Finding the right product and constantly tracking its quantity in a large warehouse can be difficult. Consider a warehouse that handles a few thousand products for an e-commerce company. The warehouse leverages data from its IoT devices that automatically track the quantity of each product and raise an alert or automatically place an order to replenish the stock once it falls below the defined threshold. When IoT is used in combination with artificial intelligence (AI), it can fully automate the warehouse with minimal human supervision.

- *Tracking and Monitoring:* When it comes to real-time tracking and monitoring, IoT sensors on goods and vehicles provide real-time location data, enabling tracking from source to destination. Companies such as DHL, Maersk, Amazon, and Nestlé are harnessing IoT for real-time tracking and monitoring within their supply chains. DHL use IoT sensors to monitor shipments' location and condition throughout their journey as well as ensure goods remain in the optimal environment. Figure 10 shows DHL in operation [15].
- *Predictive Maintenance:* Traditional maintenance schedules based on fixed intervals are ineffective, as they may miss critical issues between cycles. Such an approach can lead to over-maintenance, replacing parts or performing tasks that are optional at the time. In contrast, predictive maintenance uses IoT sensors that continuously collect data from equipment and vehicles, providing real-time insights into their condition. Using IoT sensors, predictive maintenance detects signs of wear and tear on equipment enabling the company to schedule maintenance proactively. By taking this approach companies such as Caterpillar and Siemens can reduce unexpected downtime, keep operations running smoothly and extend equipment life.
- *Fleet management:* Sensors installed in vehicles, trailers, and trucks provide real-time data on the location, speed, and condition of each asset. Enterprises can track their entire fleet on a digital map, enabling better visibility into operations. To optimize routes, reduce fuel costs and enhance driver safety, companies are utilizing IoT in supply chain operations to manage their fleet. IoT solutions in fleet management enhance these operations by monitoring vehicle conditions, fuel consumption and driver behavior. Companies using IoT for fleet management include DHL, Amazon, Walmart, UPS, Maersk, and FedEx. Fleet managers can analyze real-time traffic data, road conditions, and weather forecasts to make data-driven decisions and choose the most efficient routes. This reduces fuel consumption, minimizes travel time, and enhances on-time deliveries.
- *Demand Forecasting:* IoT data from sensors and connected devices can predict demand trends to help companies better manage their inventory and reduce waste. IoT solutions for demand forecasting are being used by Amazon, Coca-Cola, Unilever, and Nestlé to collect data from multiple sources to help companies align production schedules with demand.
- *Asset Tracking:* With IoT asset tracking capabilities such as RFID or Bluetooth, it is easy to monitor the inventory's movement minute-by-minute and further enhance the warehouse's operational efficiency. Increasingly valuable across supply chains, companies are incorporating IoT-enabled GPS trackers into their operations for asset tracking and theft prevention. This enhanced visibility reduces the risk of theft and loss for companies such as Bosch, DHL, Maersk, and Tech Mahindra so that they can respond quickly if an asset deviates from its planned route.
- *Quality Control:* By incorporating IoT sensors for quality control and inspection in supply chain processes, companies in the industry can benefit from improved product consistency and reliability, as well as minimize defects and recalls. Companies such as DHL, Walmart, Maersk, Siemens, and Bosch are transforming their quality management across their supply chain.
- *Temperature Control:* For companies that work in pharmaceuticals and food, IoT solutions are being utilized to monitor temperature, humidity and other environmental conditions. Hapag-Lloyd uses smart containers equipped with IoT sensors to monitor temperature and humidity. The company gains real-time data to ensure its sensitive goods remain in optimal conditions throughout the journey.
- *Energy management:* Monitoring energy uses in warehouses, factories and transportation fleets, IoT is helping companies to reduce their carbon footprint, lower energy costs and improve

sustainability. Companies such as Siemens, Amazon and Schneider Electric are reducing their environmental impact by tracking energy consumption, emissions and waste along the supply chain.

- *Smart Transportation:* The efficiency of transportation can be improved by the strict monitoring of vehicles, cargo, and safe driving. A full-fledge vehicle-tracking system was used to monitor the location (global positioning system) based on geographical coordinates, and the status of the vehicle has been updated in the database system. An application of IoT in the context of smart transportation is to monitor the driver's health and behaviors. The physiological condition of the driver was remotely tracked through low-power wearable WSN which has significantly helped to reduce roadside accidents by taking certain preventive parameters.
- *Smart Packaging:* The traditional approach to packaging has significantly changed to intelligent, interactive, and aware packaging with the emergence of IoT technology. Tracking and tracing of packages have improved incredibly on the introduction of smart packages that make decisions on the fly. Smart labels fixed on packages are machine readable with sensors attached to the system using Bluetooth, RFID, and NFC. Presently, NFC and RFID are mainly utilized in IoT; however, with the advent of new techniques and procedures, real-time monitoring will greatly improve packaging quality.

## BENEFITS

Using IoT across all stages of the supply chain management process helps all parties involved have a clear picture of the product's journey, from collecting raw materials to delivering the finished goods to retail locations. IoT technologies let supply chains better manage their operations from production through to delivery. The technology is also improving productivity, reducing costs, and enhancing customer satisfaction. IoT technology in the supply chain can facilitate transparency and improve business performance. IoT devices have always been relatively affordable, but the latest innovations are bringing the price point down further. Other benefits include the following [16]:

- *Automation:* Automation allows companies to use their personnel more effectively, reduce operational costs, and improve general warehouse. Automating and optimizing the most time-consuming and complicated tasks reduces human mistakes, supply chain bottlenecks, and disruptions. When order placement occurs, the

IoT enables automated transmission of the information. Barcode scanners, QR code readers, and RFID tags automatically gather data on goods, streamlining inventory management and warehouse space allocation. IoT facilitates the use of robotics, which can automate tasks and reduce labor costs associated with managing warehouses and transportation.

- *Enhanced Visibility and Tracking:* The Internet of things is the eyes and the ears of the entire supply chain. The IoT in supply chain management offers real-time tracking and automated data collection, which are essential for optimizing processes and improving the decision-making process. It helps monitor the product's location, movement, and condition, as well as inventory levels and internal policy compliance.
- *Improved Efficiency and Productivity:* Using IoT in supply chain means dealing with a lot of data that can be analyzed to introduce operational improvements. Beyond that, supply chain operators benefit from the automation of certain processes, like inventory management, shipment tracking, predictive maintenance, and more.
- *Optimized Inventory Management:* The IoT lets supply chain operators monitor inventory levels in real time. It helps them handle their goods more precisely, preventing overstocking or stockouts and ensuring they always have the right products available at the right time.
- *Enhanced Demand Forecasting:* IoT is how businesses gather and study real-time data, ultimately making more informed predictions about future demand. As a result, supply chain operators adjust their production and distribution strategies following the needs of consumers.
- *Reduced Costs and Risks:* The impact of IoT on supply chain management is profound; it allows businesses to predict issues, streamline inventory management, and reduce operational risks. Cost efficiency is another benefit of leveraging IoT in supply chain management. The Internet of things lets businesses optimize delivery routes, predict maintenance needs, avoid overstocking, dodge product damage or spoilage, and reduce manual labor.
- *Collaboration:* IoT can enhance transparency and promote collaboration across all levels of the supply chain. It helps solve problems proactively and improve overall performance. IoT enables constant monitoring of performance metrics and feedback loops, allowing continuous improvement. Organizations can use this

information to refine and optimize their supply chain processes continuously, adapt to new challenges, and respond more quickly to customer needs.

- *Cooperation:* Supply chain cycle involves multiple parties: manufacturers, delivery providers, warehouse managers, and more. Therefore, when different teams operate different data sources, bottlenecks happen and damage the efficiency of the entire process. With IoT solutions for logistics and supply chain management, these parties can build a unified system based on the same cloud and thus have access to accurate information in real time.
- *Risk Elimination:* Sharing data could be risky for organizations for property data involved. The main task of IoT is to collect data, and this data can be used for contingency planning and preventing various bottlenecks by analyzing the reasons for them happening.
- *Sustainability:* If you have been thinking of implementing a green strategy into your business for a while, IoT can be the first step in that direction. IoT sensors are often used to inform managers of how energy and resources are used during different stages of the supply chain. This helps executives make an informed decision regarding the choice of renewable sources of energy, switching to electric vehicles, and more.
- *Tracking Location:* IoT devices can help you track the position of goods at all times, be it inside a large warehouse or on a ship. If you ship the products on a wrong route, the IoT system delivers automatic alerts to fix the problem.
- *Monitoring Storage:* Many goods are prone to damage from environmental conditions such as humidity, heat, pressure, and cold. IoT devices can gather the environmental data from a warehouse or a truck and automatically adjust the conditions.
- *Improve Contingency Planning:* With IoT and data analytics, managers can predict and plan for contingencies such as traffic, weather, possible accidents, or other delays. Managers can develop flexible contingency plans based on the movement of goods and use real-time alerts to mitigate risks.
- *Transparency:* There is increased demand for supply chain transparency and traceability. As goods travel larger distances and exchange more hands, there are more chances of disruptions in the supply chain operations. Internet of things can

help businesses in managing such unprecedented situations. IoT technology in the supply chain can facilitate transparency and improve business performance.

Some of the benefits of IoT in supply chain are shown in Figure 11 [16].

## CHALLENGES

While leveraging IoT in supply chain is highly beneficial, there are still some challenges with using IoT in your supply chain. For IoT in supply chain management to fetch results, the technology has to be accompanied by compatible software and backend solutions. Your existing systems need to be integrated to newer technology. Integrating IoT into supply chain management processes can be a costly investment. The biggest challenge is not the technology; it is getting your team comfortable with using it. Other challenges include the following [16,17]:

- *Cost:* The IoT-based supply chain is confronted with numerous financial and environmental challenges. The higher cost of smart gadgets, especially RFID, does not allow the penetration of technology into the open market. Even though IoT reduces supply chain costs, the implementation of IoT solutions with all necessary equipment requires a significant investment. Organizations must budget for these expenses and carefully evaluate the return on investment to justify the initial one. While implementing an IoT infrastructure requires investment in hardware and software, the resulting benefits outweigh the initial costs. These benefits include cost savings and various optimizations.
- *Data Security:* Transitioning to a fully connected supply chain requires careful consideration of data security. Hacking attacks, data breaches, and weaknesses in data storage can damage a company's reputation and lead to operational failures. Devices and sensors collect a lot of IoT logistics and supply chain data, which has to be thoroughly protected. Therefore, businesses may require an expert team capable of introducing robust security measures.
- *Scalability:* An important thing to remember regarding security is that your strategies and solutions must be scalable to accommodate the increasing number of devices within the growing IoT network. As supply chain operations expand, the IoT system's scalability becomes a concern. Scaling up to meet the growing demands requires careful planning in order to deal with the

complexity of adding more devices and data sources.

- *Lack of Regulations:* Another challenge that supply chain operators may face is the absence of standardized protocols and regulations for IoT devices. It is essential to follow the relevant industry regulations and collaborate with a legal team to ensure the system's compliance. Businesses must collaborate with legal teams to ensure their IoT systems comply with all relevant industry regulations.
- *Integration:* As with any technology implementation, it comes down to how easy it is to implement, integrate, and see a return on investment. Integrating the Internet of things in supply chain processes involves using specific devices. Although integrating IoT systems will not disrupt existing operations, it is expedient to consider upgrading network systems or investing in new software platforms that can handle big data to ensure smooth integrations. When you revise and prepare your infrastructure and security strategies to accommodate IoT integration, it is important to choose suitable devices and infrastructure for your organization. It is vital to remember that IoT integrations involve more than hardware. They also include setting up the necessary network architecture to handle large volumes of IoT-generated data efficiently. By integrating IoT into supply chain operations, companies gain greater control, improve efficiency, and increase customer satisfaction with more reliable and streamlined processes.
- *Interoperability:* The IoT devices and sensors used throughout the supply chain often come from manufacturers. This poses a challenge in integration and interoperability. Yet, leveraging universal communication protocols might help create a cohesive supply chain system.
- *Safety:* IoT devices continuously stream large amounts of data, some of which may contain sensitive information. Developing a comprehensive strategy can ensure the safety of stored and processed data.
- *Security Threats:* Before switching to fully connected systems, you need to have a secure IoT architecture. Vulnerabilities in data can result in outside attacks and leaks. By implementing machine learning (ML) and cryptographic hardware monitoring, managers can mitigate security threats. You do not want key elements of your factory or distribution reachable online by the public or cyber attackers.
- *Skill Gap:* The warehouse staff and vehicle drivers need to be trained and educated about the security practices and the guidelines for using corporate IoT-based supply chain management platforms.
- *Data Storage:* The large pool of data that IoT systems generate is both a benefit and a challenge. There needs to be enough server power to store and process the collected data. There is also the possibility of too much data to deal with, which can be overwhelming if you do not know how to manage it. Some companies struggle with not just storing this data, but making sense of it in real-time.
- *Data Shortage:* The Internet of things services depend on collecting massive amounts of data. However, with that comes the responsibility of ensuring enough server power to store and process all the collected data. This calls for hiring data scientists and analysts to make sense of the data and arrive at IoT-based insights.
- *Poor Connectivity:* IoT platforms and devices rely heavily on Internet availability and other short distance technologies such as Bluetooth and NFC. IoT in supply chain management cannot function without a stable internet connection. Imagine if a fleet driver moves from one location to another, which does not have a reliable network; how can the sensors detect if something has gone wrong in the fleet? IoT in supply chain management requires a high-level server farm to operate smoothly.

## CONCLUSION

The Internet of things has been quietly revolutionizing the supply chain industry for some time. The transformational potential for the IoT in logistics and supply chain is undeniable. With IoT-based supply chain management, businesses can monitor every aspect of their supply chains, from asset tracking to route optimization and demand forecasting. IoT in supply chain management is pushing barriers to revolutionize the efficiency, performance, and output of businesses' logistics operations. By connecting nearly everything from parcels to people, the IoT is enabling supply chain and logistics companies to track and trace freight in real time, make data-driven decisions that improve operational efficiency, perform predictive maintenance on assets and infrastructure, etc.

As supply chains become more complex and demanding, we need tools to manage things from end to end and adopting IoT technology will become increasingly crucial for businesses to remain

competitive. The adoption of IoT into supply chain operations helps deal with this increasing complexity. IoT has become a key player in optimizing operations. More information about Internet of things in the supply chain industry can be found in the books in [18-22] and a related journal: *IEEE Internet of Things Journal*.

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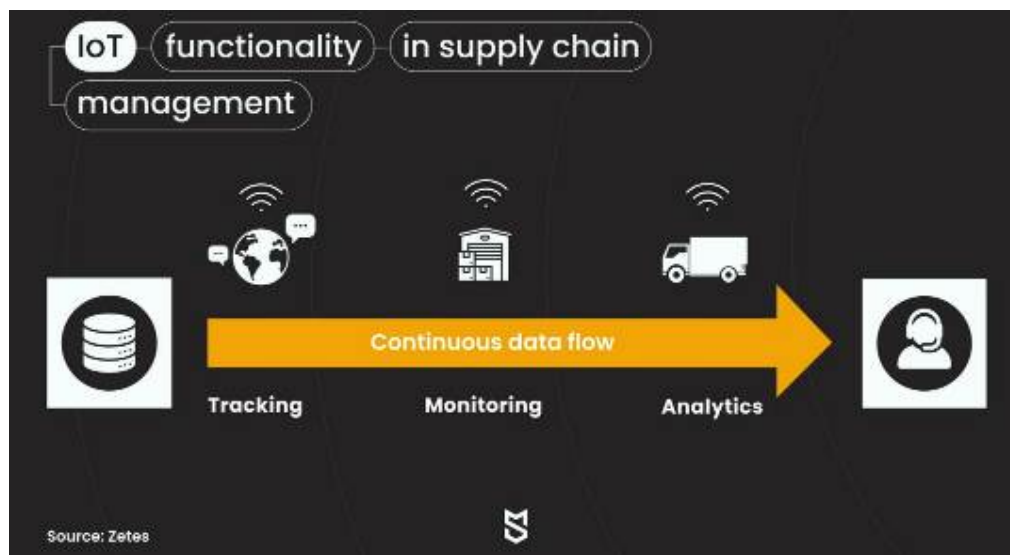


Figure 1IoT in supply chain management [1].

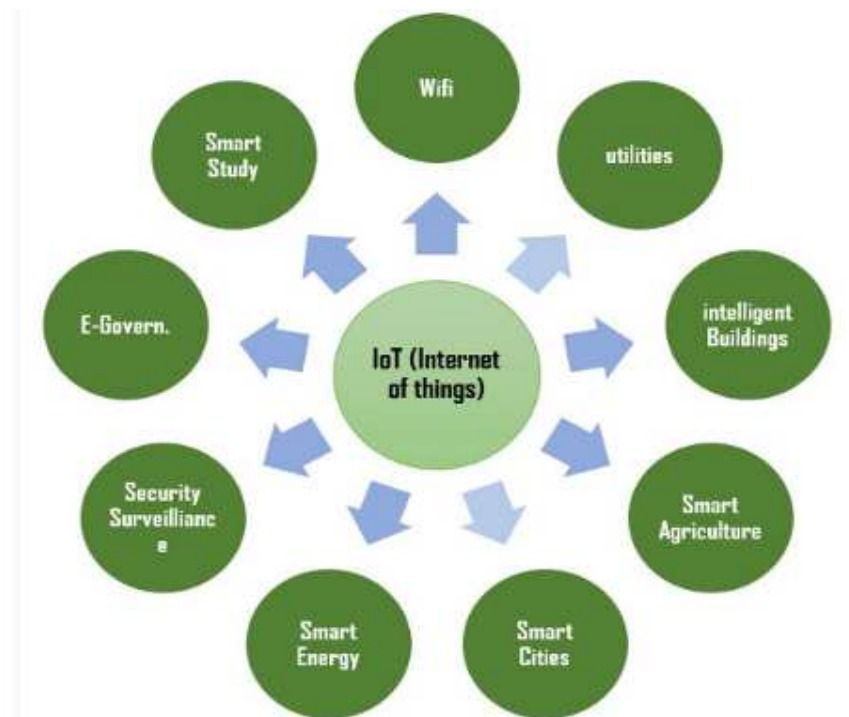


Figure 2 Applications of Internet of things [3].

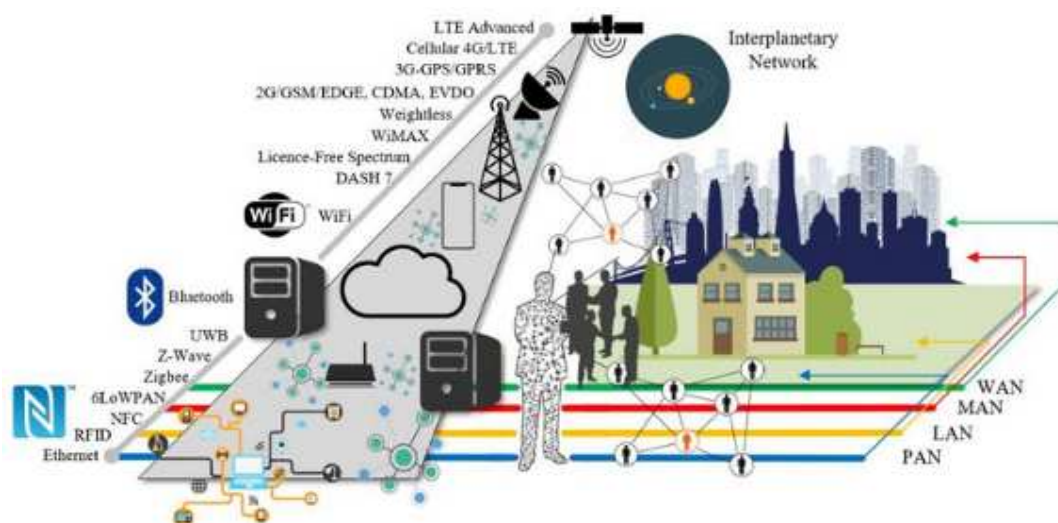
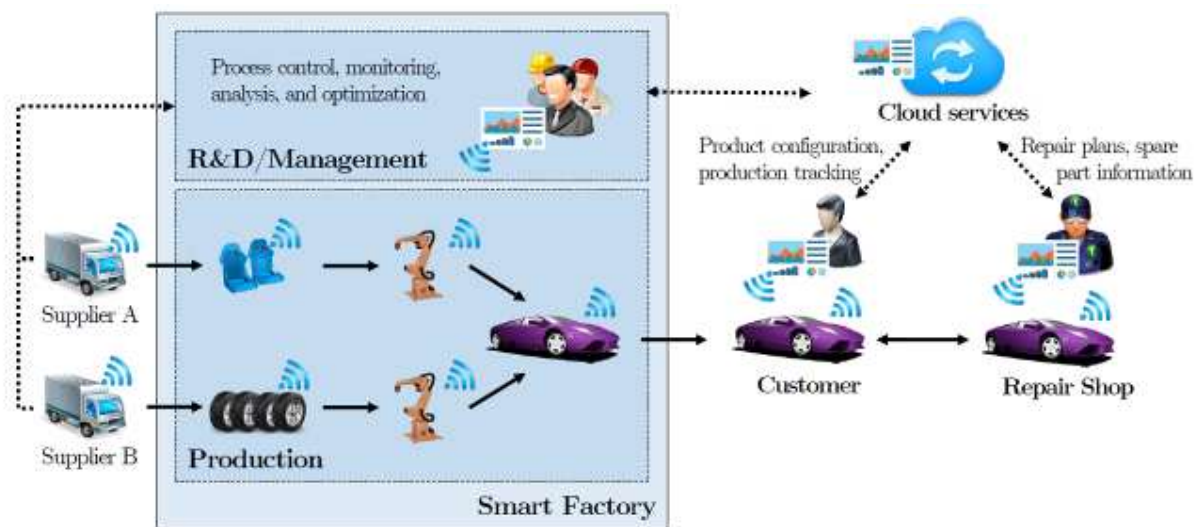


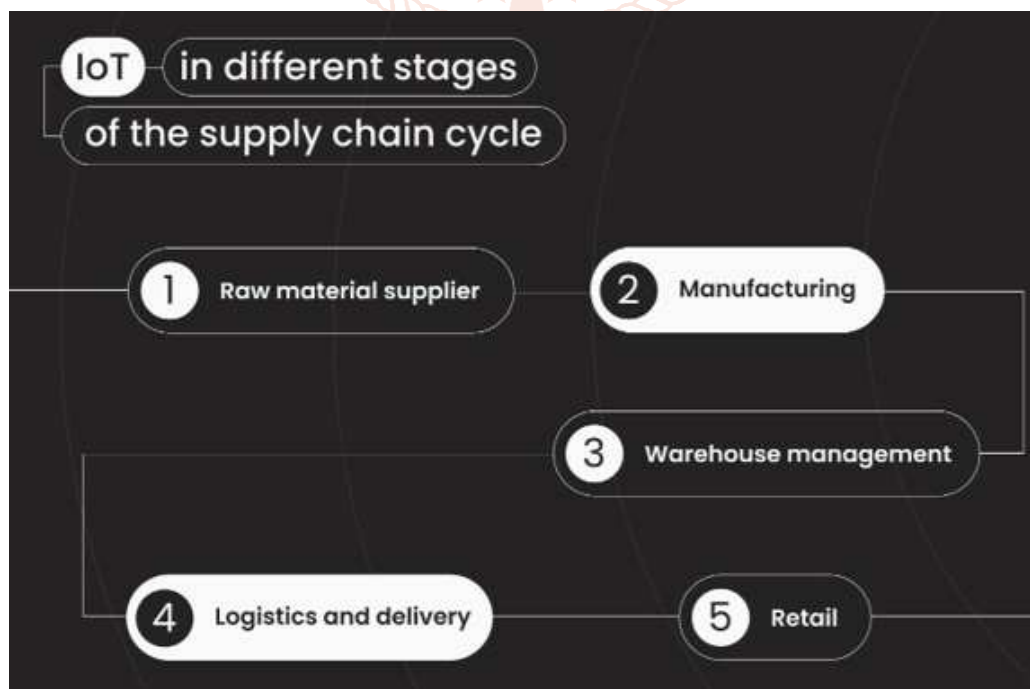
Figure 3Communications technologies in Internet of things [5].



**Figure 4** A typical representation of IoT [6].



**Figure 5** A typical industrial Internet of things [8].



**Figure 6** IoT in different stages of the supply chain cycle [1].



Figure 7 Supply chain management process [11].



Figure 8 Examples of companies using IoT in SCM [12].



Figure 9 DHI innovative center [14].



Figure 10 DHL in operation [15].

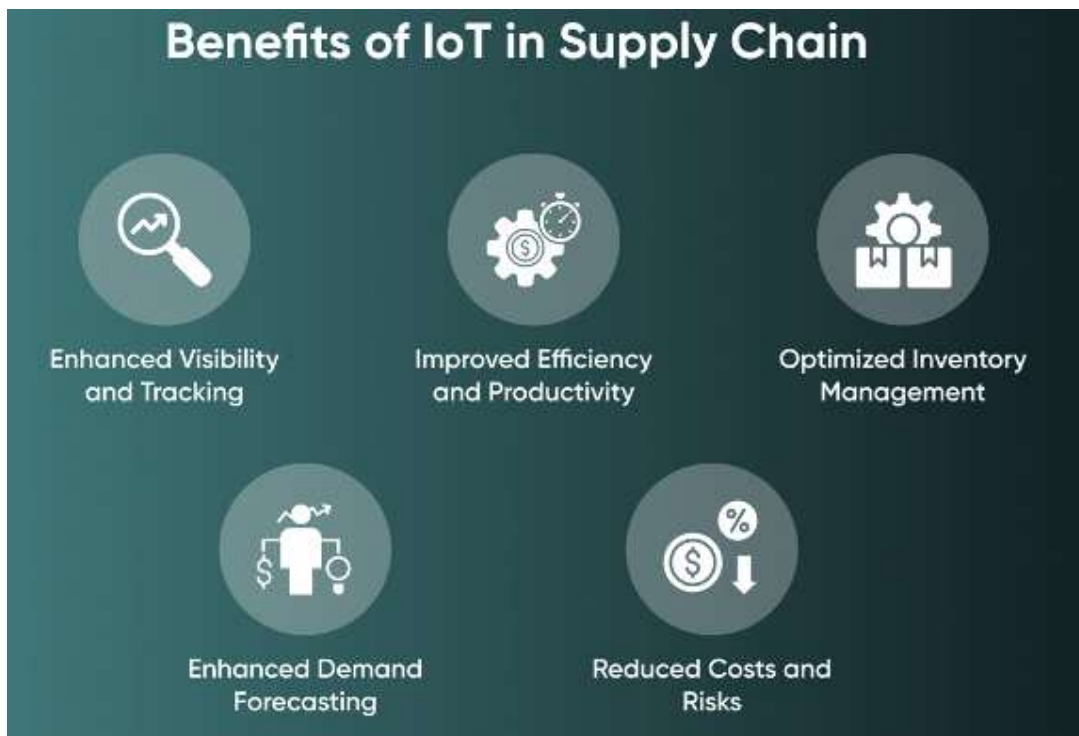


Figure 11 Some of the benefits of IoT in supply chain [16].