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CHALLENGES AND OPPORTUNITIES OF INTRODUCING INTERNET OF THINGS AND ARTIFICIAL INTELLIGENCE APPLICATIONS INTO SUPPLY CHAIN MANAGEMENT

Master's Thesis in

Industrial Management

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
ANN	Artificial Neural Networks
BS	Base station
CDCs	Central Distribution Centers
CDMA	Code Division Multiple Access
DSP	Digital Signal Processor
EDGE	Enhanced Data rates for GSM Evolution
EPC	Electronic Product Code
FDD	Frequency Division Duplex
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
IT	Information Technology
IoT	Internet of Things
M2M	Machine to Machine'
MEMs	Microelectromechanical System
NFC	Near field communication
OS	Operating System
PIR	Passive Infrared

RAT	Radio Access Technology
RDC	Regional Distribution Center
RF	Radio frequency
RFID	Radio Frequency Identification
SC	Supply Chain
SCM	Supply Chain Management
SSB	Single-Sideband
TDD	Time Division Duplex
WCDMA	Wideband Code Division Multiple Access
WSN	Wireless Sensor Networks

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ABSTRACT:

The study examines the challenges and opportunities of introducing Artificial Intelligence (AI) and the Internet of Things (IoT) into the Supply Chain Management (SCM). This research focuses on the Logistic Management. The central research question is "What are the key challenges and opportunities of introducing AI and IoT applications into the Supply Chain Management?"

The goal of this research is to collect the most appropriate literature to help create a conceptual framework, which involves the integration of the IoT and AI applications into contemporary supply chain management with the emphasis on the logistics management. Additionally, the role of 5G Network is closely studied in order to indicate its capabilities and the processing capacity that it can provide to the AI and IoT operations.

In addition, the semi-structured online interview with the top managers from several companies was conducted in order to identify the degree of readiness of the companies for the AI and IoT applications in SCM. From the retrieved results, the major challenges of integrating the IoT into SCM are the security and privacy issues, the sensitivity of the data and high costs of the implementation at an initial stage.

Moreover, the research results have shown that the IoT applications can positively affect the SCM activities, in particular, the high visibility across the SC, an effective traceability and an automated data collection. Furthermore, the predictive analysis of AI programs can help the SCM to eliminate the potential errors and failures in the processes.

KEYWORDS: artificial intelligence, internet of things, supply chain management, 5G Network

1. INTRODUCTION

1.1. Background.

Nowadays, in extremely rival environment differentiated by sublime consumer's requisitions for products and services with high quality, a close margin of profit and short delivery times, companies are obliged to avail of every valuable feasibility to improve their business operation. To reinforce the commercial competitive excellence of a company in a continuously transforming business world, it is significant to improve the supply chain efficiency by making it more adaptive to assimilate any kind of variances in the volatile business world (Lee & Lee 2015).

Contemporary supply chains have developed towards extremely sophisticated framework including numerous shipment rates, standards of planning, multimodality and continuous data interaction at each sub-system of the network. The main issue of supply chain management (SCM) is to sustain an orderly and constant stream of commodities, data, services and fiscal inputs whereas reducing expenses. In conjunction with elaborations, huge amounts of limitations associating with capabilities, time, manufacturing feasibility, distribution output, and shipping depict modern supply chains. Furthermore, the organizations had to struggle with such issues and elaborations primarily towards temporary earnings (Lee & Lee 2015; Wang & Li 2006).

The appearance of progressive information technologies reinforces the proficiency of the company to control and affect communication. Nevertheless, the degree of data accuracy, the ability to ensure the correct data to the correct individuals, and the usage of communication are still questionable. Thus, growing number of companies have initiated to expand as well as to refine the available information structure to correspond to the dynamic business demands of the company to maintain decision formulation for the unstable business world.

A variety of scenarios and huge amounts of restrictions made allowance for deciding the right step in supply chain management. Due to the immense volume of data, the contemporary SCM needs more sophisticated programs and approaches to analyze the data. Therefore, SCM has to integrate the intelligence management system in order to improve its processes. Taking into account the realization of the growing value of data to supply chain prosperity, supply chain managers have started to implement different approaches to highly control data and make maximum use of it to perform better in work process (Wang & Li 2006). Despite the ongoing potential of Internet of Things (IoT) and Artificial Intelligence (AI), there is no substantial breakthrough to make use of these technologies in order to improve the SCM.

According to Wang and Li (2006), there is a variety of central opportunities, which an organization can use in order to apply a traceability framework, comprising the potential to track back across the supply chain (SC). There are several advantages, which include a completely dynamic path and track traceability network that able to provide actual-time visibility. Moreover, there is calibrated information broadcast among business shareholders and more visibility inside companies that drive to a pervasive and operative manufacture flow. In addition, the improved wireless data transmission can refine the partnership between producer and storekeeper resulting in accurate demands.

In the meantime, cyber community observed the remarkable progress of mobile wireless connections and associated network engineering. Various smart appliances engaged into the elaboration with high rate. This fortified the network with a great amount of applications such as interdependence of domestic devices, smart electricity generation, inter-vehicle connection, database program on the cloud network. Consequently, facilities and appliances are turning into these smart gadgets. Besides, an omnipresent character of the system and rising 5G Network targets to connect all the network devices within a single system. This fosters increasingly intelligent appliances for SCM to engage into the network every day (Singh, Saxena, Roy & Kim 2017).

1.2. Research Gap, Research Problem and Objectives.

There are many scientific papers, which examine only the efficiency of the Internet of Things in the Supply Chain Management, but only a few academic studies consider the potential of the combination of the Internet of Thing and Artificial Intelligence applications. Realizing the significance of these two technologies for the Supply Chain Management can bring greater competitive advantages to organizations.

The single scope of AI's dormant supplement that has not still been entirely studied is the arising principles of work performance of SCM, which demands the understanding of sophisticated, interdependent problem-solving processes and the development of reasonable information framework decisive for mutual decision-making.

Moreover, it is important to indicate that the most scientific studies aim to explore the 5G Network potentials only in the mobile connectivity scope. Therefore, the study seeks to identify the applicable 5G Network interface to the Internet of

Things and Artificial Intelligence applications in order to improve the efficiency of the Supply Chain Management.

The central research question that is addressed by this study: *"What are the key challenges and opportunities of introducing AI and IoT applications into the Supply Chain Management?"*

The primary objectives of the study are:

1. to define and analyze the challenges and opportunities of AI and IoT integration into the SCM
2. to establish the suitable strategy for implementing AI and IoT methods into SCM
3. to identify the major IoT applications that can improve the supply chain process
4. to define the suitability of AI and IoT combination to SCM
5. to identify the SCM issues and propose the IoT based solution for the particular SCM problems.

1.3. Definitions and Limitations.

For some time now, there have been a variety of distinct determinations for the term "s*upply chain management*" *(SCM),* still their general aim is to synchronize and combine every working process associating with an output in a worldwide conventional uniform and operationalize this communication, so all members are engaged in the SC process. According to Lummus and Vokurka (1999), every working process is included in procuring a commodity from raw materials across to the customer comprising providing raw materials and specialties. In addition, it is required to check every working process, such as processing and assembly, warehousing and stock keeping, commission record and commission control.

There are a plenty of considerations for contemporary SCM networks comprising the opportunity to control the detection of a commodity in actual time. As well as, the opportunity to react to customer and retailer requests and concerns in a well-timed action, thereby undertaking the turnover to stay at the most favorable altitudes and maintaining warehouse reserves to an inferior limit and likewise assuring that products reach to the shops in the shortest feasible time (Attaran 2007). All contemporary SCM networks, when operating properly, can ensure the traceability of commodities along the chain. This grants great benefits to the stakeholders in SCM.

Although the SCM includes Logistic Management, Inventory Management and Warehouse Management among others, for this research, the SCM part is limited to only one sub-system, Logistics Management. Because SCM paradigm is quite immense for this type of research, it was decided by the author to take limited SCM concepts in order to properly monitor the research process.

The Internet of Things (IoT), also called Industrial Internet, utilizes the Internet to shape a vast system of intelligent facilities. Whilst the traditional Internet links people to ensure the data flow, the IoT combines machines and facilities with embedded sensors and the integrated circuit, which permits them to transmit and communicate self-consistently across the system. The human's apprehension has been broadened up by using various kinds of definitions, comprising machine to machine (M2M), sensor networks and omnipresent computing. The IoT is commonly described as a method that unites the communications of intelligent facilities, active intelligence, system capabilities and interplay with end users. IoT frameworks are typically composed of three things: apparatus, connection and application (Bandyopadhyay, Balamuralidhar & Pal 2013).

As the limitation, this research focuses only on two IoT technologies, which are Radio Frequency Identification and Wireless Sensor Networks.

Artificial Intelligence (AI) is defined as a combination of a few computational approaches that simultaneously seek to mimic the human's brain cognitive processes and has developed to a composition of computational approaches that help to handle a matter that was formerly troublesome or unlikely to resolve. Artificial Intelligence consists of several different tools and paradigms, for instance, fuzzy logic, evolutionary programming, and artificial neural networks. These appliances show a potential to recognize and explore recent conditions by contemplating several features of "discourse", for example, summation, revelation, unification and revulsion (Gordon 2011).

The study explores limited AI approaches and tools, which correspond and fit the SCM processes. Furthermore, the author analyzes the particular AI methods that can be used together with IoT applications for the improvement of SCM efficiency. Despite, AI applications require the sophisticated programming; this research is considered only from the conceptual point of view.

5G Network is the definition that is utilized to characterize the future generation of mobile networks upward of the 4G LTE modern mobile networks. During some years of scientific studies on future generation network connectivity, there is already an extensive agreement on the 5G maintenance perspectives. Specifically on the opinion that 5G Network will not exclusively be a "business-as-usual" development of 4G mobile networks. However, it will bring up the novel specification ranges, supreme spectral cooperativeness and supreme peak capacity, but will likewise aim at new facilities and modern enterprise frameworks (Elayoubi, Fallgren, Spapis, Zimmermann, Martin-Sacristan, Yang, Jeuxi, Agyapong, Campol, Qi, & Singhi 2016).

In this research, 5G Network is examined only to highlight the importance of this technology to IoT and AI connectivity and efficiency. In addition, the evolution of the network connectivity throughout the years has alluded. Beyond that, the purpose of the examination of mobile networks is that it is important to highlight and identify the suitable 5G Network interface structure for the IoT and AI implementation into SCM.

1.4. Structure of the thesis.

In *Chapter 1* background, research gap, research question and objectives of the thesis are indicated. In addition, the definitions and limitations of the major conceptions of the thesis are highlighted. This chapter provides the synopsis of SCM, IoT, AI and 5G Network.

In *Chapter 2*, the literature review of SCM and its primary segments, such as Logistics Management, Warehouse Management and Inventory Management is carried out in order to give the overall comprehension of the main SCM sub-systems. In addition, the literature review of IoT, AI and 5G Network is conducted. In particular, the outline of the Radio Frequency Identification, Wireless Sensor Networks, Machine Learning, Artificial Neural Networks, Fuzzy Logic and the evolution of 5G Network is realized.

Chapter 3 represents the conceptual framework of IoT and AI in SCM in order to identify the most pertinent IoT and AI approaches and techniques to improve the

SCM processes. Moreover, the proper strategy for the IoT and AI implementation in SCM is represented in this chapter.

Chapter 4 displays the methodology used, the research process and design, as well as the utilized approaches in the thesis. In addition, the research results are displayed and analyzed. In particular, the interview outcomes with top managers are documented and elaborated.

Finally, the *Chapter 5* summarizes and generalize the primary results of the research question and objectives. Additionally, in this chapter, the future research suggestions and the key research findings are ascertained.

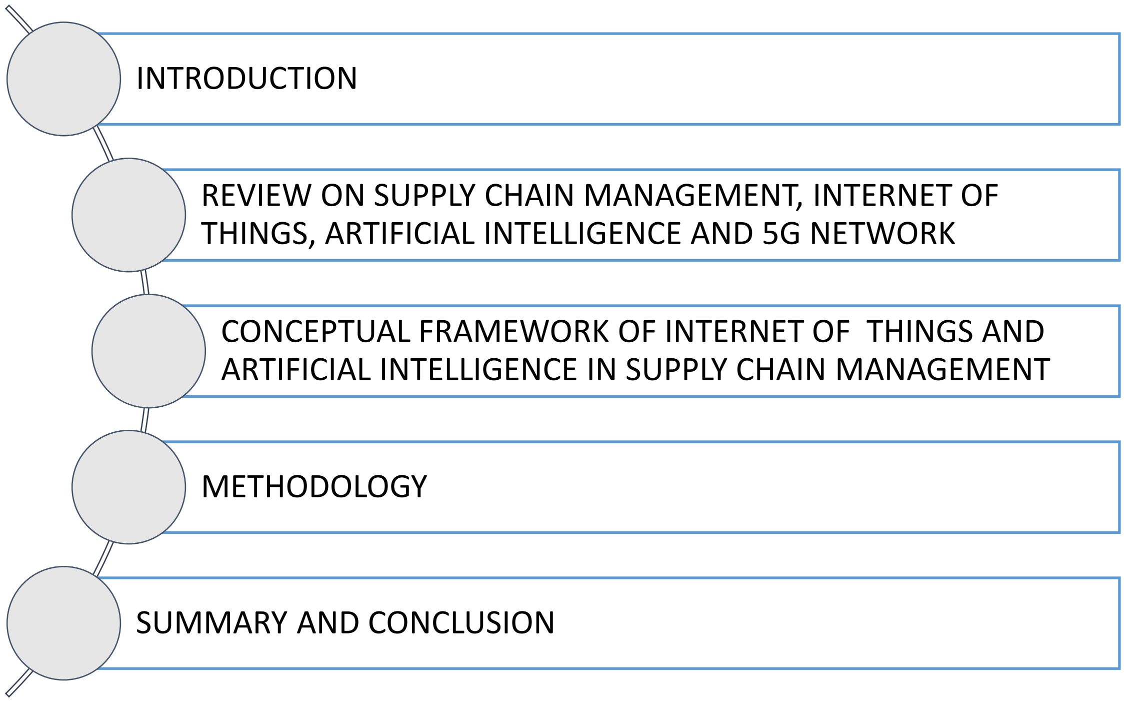


Figure 1. Structure of the thesis.

2. REVIEW ON SUPPLY CHAIN MANAGEMENT, INTERNET OF THINGS, ARTIFICIAL INTELLIGENCE AND 5G NETWORK

2.1. An overview of Supply Chain Management.

Sixteen academic papers were examined and studied in order to provide the full insight of SCM processes and activities. In the table below, the key literature of SCM is displayed. The four major works were used to identify the primary SCM definitions and propositions.

Table 1. Key literature in SCM.

Key literature in SCM.		
Author	Definition	Proposition
Ghiani, Laporte & Musmanno (2013)	Logistics is defined as the subject that explores the dynamic practices measuring the stream of goods and information in an organization, from their initial point at the suppliers up to procurement of the completed goods by the end-users, as well as, by the retail shops or services.	Logistics activities are conventionally categorized on the assumption of their setting. The logistics include four main activities: internal logistics, external logistics, distribution logistics and storage.
Farahani, Rezapourm & Kardar (2011)	Logistics does not comprise only one element but includes a cluster of different functions and disciplines, like procurement, prearrangement, coordinating,	Logistics strategy decisions: customer service, logistics system strategy and outsourcing as opposed to vertical incorporation.

	warehousing, distribution and customer service.	
Rushton, Croucher & Baker (2006)	SCM is mostly strategic planning process, following on from strategic-tactical solutions as distinct from practical solutions.	In a supply chain, it is essential to design a complex data network in which all facilities can obtain records on demand and inventory volume.
Fleisch & Tellkamp (2005)	The effect of inventory error on SC efficiency transforms by the attribute that induces it. Error induced by thievery seems to have the major influence on SC efficiency compared to error induced by slow-selling or poor operation excellence. Reducing inventory error induced by thievery decreases the level of unavailable items and SC expenses. The effect grows when thievery is diminished simultaneously as inventory error is removed.	When RFID tags are attached to particular goods and are simply to be utilized to obtain inventory consistency. It might be utilized for a more extensive series of goods if development in operational excellence, a decline in thievery or in slow-selling or damaged goods can be obtained.

According to Vitasek (2013), the supply chain management is defined as:

Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies.

The definition of SCM has been utilized to interpret the prearrangements and monitoring of goods and data streams on a par with the logistics operations both internally and externally across an organization and among firms (Cooper Lambert & Pagh 1997b).

Although, the SCM notion initially emerged in the beginning of 1980s, right after the 1990s it started to accelerate and gain more attention. Over the course of decades, the growing interest in SCM can be assigned to, first, intensified globalization that has established operational SCM potentials, like worldwide distribution and global manufacture for organizations and has reinforced business struggles on a global rate. Second, the tendency around time and excellence-based rivalry, which demands a closer communication and reconciliation among the company and its suppliers. Third, an immense ambiguity of surroundings by virtue of technological variances, unstable economic situation, and heavy business struggles that requests for vast agility in the supply chain (Mentzer, DeWitt, Keebler, Min, Nix, Smith & Zacharia 2001).

The variety of scopes like purchasing and procurement, shipping and logistics, exploitation control, commerce, organizational theory, information technology systems, and risk management have facilitated to the rapid growth of SCM research (Chen & & Paulraj 2004).

According to Anderson and Katz (1998), supply chain management search for refined efficiency by virtue of utilizing rationally internal and external feasibilities. Furthermore, the concept establishes a coherently articulated supply chain, leads to rising organization competitive advantage and performance.

With a foundation of a numerous of a scientific treatise in concurrent commercial entities, the segment shows the scope which has an effect on SCM structure with integrated IoT and AI technologies inside the conceptual framework represented in Figure 2. This framework is based on a statement of values of operational control theory that underlines the progress of "collaborative advantage" (Chen 2004).

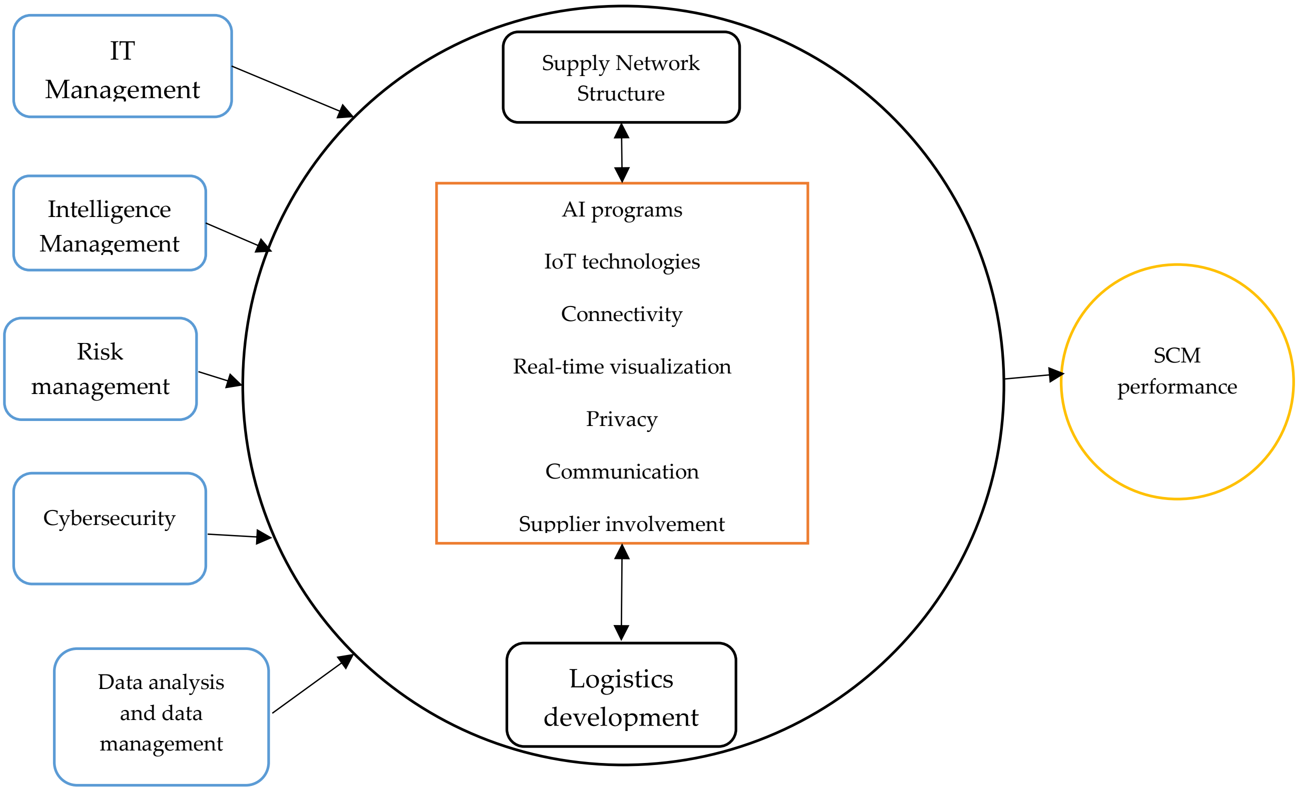


Figure 2. A framework of supply chain structure with integrated AI and IoT technologies (adapted from Chen & Paulraj 2004).

According to Waters and Waters (2007), the recognition and elimination of risks beforehand in SC are the primary principles of SC risk management. In fact, it is quite unlikely to identify every eventual risk, and recognition denotes the most substantial ones that influence the SC. Usually, top-managers are aware of their company's problems and risks, which occur in SC, however, it is difficult to identify risks on proper time.

The risk in supply chains can be determined as the potential obstacles for the original goal that, hence, influence the reduction of lucrative operations at various stages. The main operations may be characterized by the capacity and excellence of outputs at various positions and time in the supply network. A breakdown of service at any point of SC may affect a few other operations at various degrees. Consequently, by way of having persistent lucrative operations, risk evaluation has turned into an essential component of the supply chain-planning mode. Risk evaluation composes of specifications, assessment and detection of risks and hazards in supply chains and resolving problems distinctly to reduce the collateral damage (Kumar 2010).

Logistics Management.

According to Ghiani et al. (2013), logistics is defined as the subject that explores the dynamic practices measuring the stream of goods and information in an organization, from their initial point at the suppliers up to procurement of the completed goods by the end-users, as well as, by the retail shops or services. In addition, it is essential to mention the primary logistics issues, which undoubtedly exist in the service segment. Specifically, in the allocation of some services like water and electricity and cargo transportation.

Figure 3 depicts a graphical process of a logistics system in which the production operation of the completed products is sorted through an assembly stage and executed in distinct plants. In the beginning of the graphical process, the suppliers of materials and components are shown, their role is to start and control the final production operation. The last fraction reflects a generic two-stage allocation network. The manufacturing facilities straightly deliver to the Central Distribution Centers (CDCs), whereas every Regional Distribution Centre (RDC) is linked to a segregated CDC, which has to deliver to the end-user, who likewise can be vendors or shopkeepers (Ghiani et al. 2013).

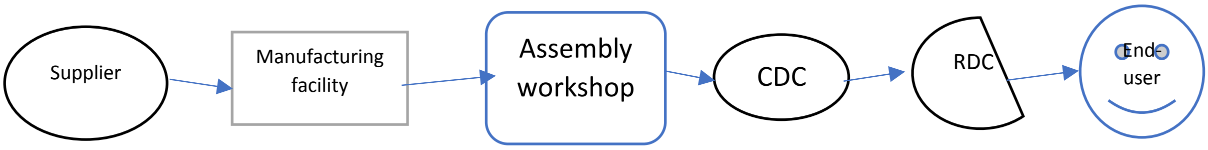


Figure 3. The example of a logistics system (adapted from Ghiani et al. 2013).

Logistics focus areas are usually arranged according to their position referring to the manufacture and allocation operations. Specifically, supply logistics is conducted preparatory to the manufacturing facilities and divides into the control of raw materials, procurement of goods and parts. Internal logistics is executed in the manufacturing facilities and involves getting and stocking up materials, receiving the needed materials from the warehouse in order to keep up the manufacture cycles and then shifting to the semi-processed products. The final stage is to packaging and stocking up of the completed outputs. Lastly, the supply logistics operations are done after the manufacturing facilities and before the market. They deliver to the shops or the consumers. In this mapping, the supply logistics and the distribution logistics are altogether termed external logistics (Ghiani et al. 2013).

The purpose of logistics activities is to receive the proper amount of goods or services to the correct location at the correct time, for the proper customer, and at the proper value. It is conventional that many customers disregard the profound or implied impacts of logistics virtually on every scope of their lives until one of these processes falls out. The logistics notion was established as a solution to the growing demand of a complex network. Its functions include tasks such as mapping out and synchronizing the streams of goods from the logistical installations to the end-users (Farahani et al. 2011).

According to the Vitasek (2013), logistics management is defined as the component of supply chain management that arranges, executes, and manages the rational, valid forward and reverses streams and stock keeping of materials, services and associated data between the departure location and the end-users.

From the perspective of Johnson, Wood, Wardlow and Murphy (1999), the whole logistics operation can be separated into three components:

- inbound logistics, which reflects the motion and warehousing of goods obtained from suppliers;
- materials control, which comprises the warehousing and streams of goods inside a company;
- outbound logistics or physical allocation, which depicts the motion and warehousing of goods from the last manufacture place to the end-user.

Figure 4 depicts the focus areas of logistics, which are two kinds of flows: physical flow and information flow. Physical flow is typically determined as the upstream flow across the logistics system. Its primary role is to deliver goods from a departure location to the shops or end-users. Furthermore, the information flow is elaborated to be reversed, so its primary role is to control downstream to upstream components (Farahani et al. 2011).

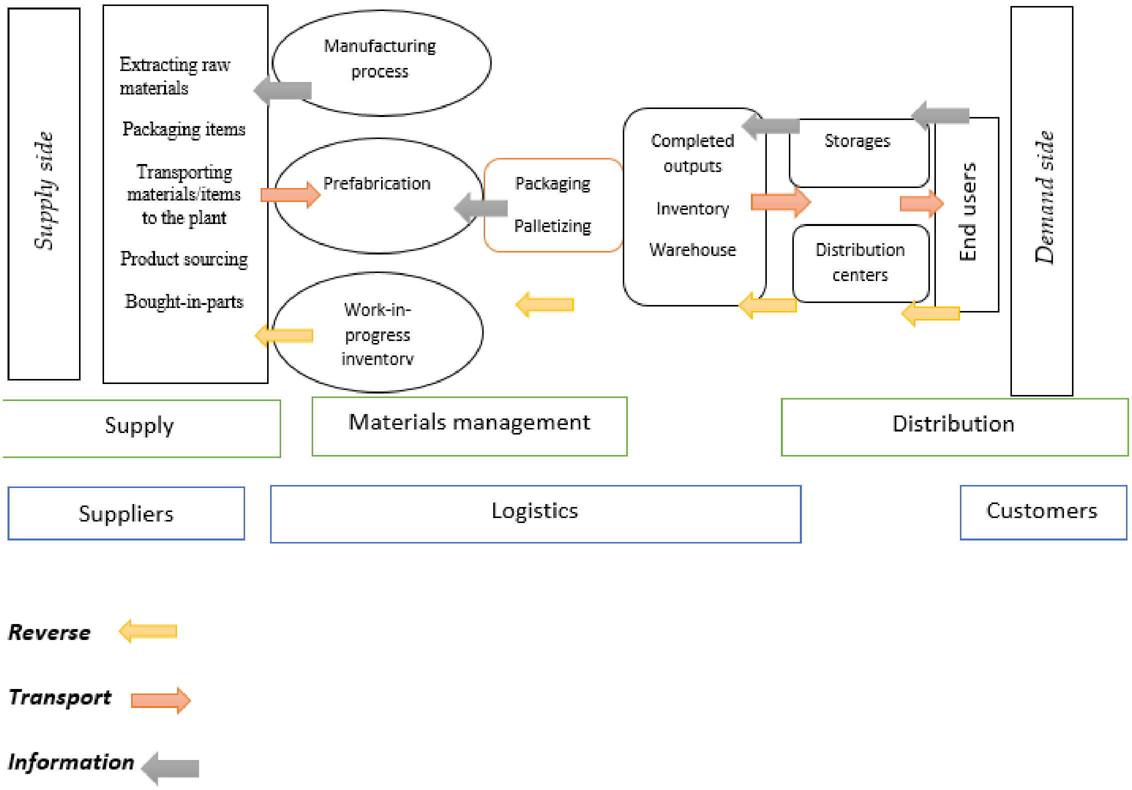


Figure 4. Logistics flow and some of the different logistics terminologies (adapted from Farahani et al. 2011).

Physical flows include the whole operation of logistics networks. Nevertheless, to examine the idea of physical flows methodically, the fundamental elements of logistics networks can be divided into five dynamic scopes, following on from the research results of Ailawadi and Singh (2005): system structure, information, shipping, inventory, warehousing, material handling, and packaging.

Inventory Management.

According to Ganeshan, Boone & Stenger (2001), most of the academic papers research inventory management in the SC from a narrow perspective. Precisely, as far as a simulation is consent, the whole SC, from the suppliers to the direct users, is highly problematic for the scholars to implement correctly the simulation of inventory management. Therefore, most of the scholars apply stylistic paradigm to explore inventory movement. The SC generally includes two elements, an interconnection network between these elements and an expense breakdown that comprises the two elements. Subsequently, the impact of inventory dimensional characters and outputs on capacity are deliberated inside these stylized settings. Notwithstanding, such paradigms are highly feasible, and are optional to ensure an understanding of inventory-associated efficiency, their major drawback originates from the circumstances that the outcomes, apart from several exclusions, cannot be applied in actual SC.

The occurrence of inventory error is familiar almost for every company. According to Raman, DeHoratius and Ton (2001), there are more than 65% of stock keeping units (SKU) in retail stores, which data on a stock count in the inventory management network was incorrect, and specifically, the information system inventory was distinct from a physical inventory.

In most cases, physical inventory has a tendency to be at a lower level than information system inventory. There is always a possibility that units can be stolen or become unsaleable and these factors can decrease the stock availability in physical inventory. Usually, these factors do not influence the information system inventory. In spite of this tendency, there are conditions under which physical inventory can be above information system inventory. Specifically, the provider might supply fewer units by accident than show up in the procurement documentation. That can affect the outcome of the physical inventory system, it could have a greater amount of goods than it would be written in information system inventory (Fleisch & Tellkamp 2005).

The main occasions for errors of information network inventory data can be external and internal theft, unsaleable goods such as low demand products, wrongly delivered goods, as well as misplaced goods (Raman et al. 2001).

According to Fleisch and Tellkamp (2005) research outcomes of the SC simulation, the rectification of inventory error can decrease SC expenses; likewise, it can lower the degree of unavailable items, although, the degree of operation excellence, stolen and unsaleable units continue to constant. SC efficiency can be enhanced onwards, but the inventory error should be liquidated. In addition, the development of the proper strategy and integration the newest technologies into SCM should be done in order eliminate the inventory inaccuracy.

Warehouse Management.

Warehousing is included in logistics operations and it is highly connected to physical flow. As distinct from shipping, which mainly originates on system corpus, warehousing and commodity stock keeping usually locate at branching stations. Warehousing and cargo handling operations, which are frequently alluded to as "transportation at zero miles per hour," occupy nearly 20% of aggregated logistics allocation expenses (Ballou 2004).

Since inquiry for outputs is quite troublesome to forecast promptly and commodities cannot be delivered instantly, stock keeping in companies is obligated. Firms keep inventories to decrease their marginal logistics expenses and to achieve a supreme degree of managing the client relationship by improved correlation among supply and demand. Consequently, warehousing has transformed into an essential department of firms' logistics networks (Farahani et al. 2011).

According to Lambert and Stock (1993), warehousing performs a decisive part in logistics systems, ensuring the appropriate the level of customer relationship performance in association with different logistics operations. Numerous of activities and objectives are executed in warehousing; these can be classified to three fundamental assignations: movement (material handling), storage (inventory holding), and information transfer.

From the conventional point of view, the stock keeping operation was elaborated as the main part of warehouses since they were deliberated as locations for long-term storage of goods. In spite of modern companies attempt to refine their stock changes and shift directives almost instantly across SC systems. Thus, at current days, long-term stock keeping part of warehouses has reduced, and their motion function has obtained more consideration (Farahani et al. 2011).

2.2. Current concepts of the Internet of Things.

IoT is designated as a system, which consists different network-connected devices pertaining to the engineering, physical, and wide social and economic scopes. The physical scope resides in human and devices connected with each other by the assistance of a pervasive wireless network that allows machine connection and interaction between the things and the physical scope. The hardware, software, networking technologies, information, combined platforms, and special regulations are included in engineering scope and they facilitate interplay of the things in the physical scope (Krotov 2017).

According to Bandyopadhyay et al. (2013), the Internet of Things (IoT) utilizes the network connection to create a vast system of intelligent devices. Although the traditional Internet links humans in order to get the needed communication, meanwhile the IoT connects devices and facilities with inserted detectors and permits them to interact substantively across the Web. A series of designations, comprising machine to machine (M2M), sensor networks, smart planet, pervasive computing and ubiquitous computing have characterized the IoT notion. Therefore, IoT is commonly determined as a way to initiate intelligent facilities recognition, dynamic intelligence, system capabilities and communication with clients. IoT design usually comprises of three sections: device, connection and application.

The device section is applicable to collect the information at the moderate degree of the common IoT design. The mechanisms in this section usually involve appliances and applications, utilizing radio-frequency identification (RFID), near field communication (NFC), wireless sensor networks (WSN) and embedded intelligence networks. The connection section encloses access and the underlying framework. The access can ensure steady interaction facilities to combine to a vast extent diverse appliances and tools in the device section. The underlying framework of IoT is an IP connection that can be maintained by different communication engineering utilities such as Wi-Fi, and cellular networks (2G, 3G, 4G and 5G). The access and application section may be coherently linked across these distinct systems. Besides, this section likewise allows cloud-engineering programs that permit perceiving information and records to be observed and utilized smartly for controlling the intelligent appliances (Atzori, Iera & Morabito 2010).

Table 2. The main differences between Internet-enabled and IoT-enabled settings (modified from Weinberg, Milne, Andonova & Hajjat 2015).

Data associated activities	**Internet-enabled**	**IoT-enabled**
Data	Online/Numerical, settings/context mainly created by suppliers	Physical. settings/context mainly created by environment, with many features/contexts built by users
Data entry	Active, User	Passive, Appliances
Data sharing	With other suppliers	With other gadgets
Learning	Engagements with online/numerical realm	Engagements with natural/physical world
Problem-solving	Suppliers, more stationary, less actual time	Devices, active, more actual time

Data.

According to Weinberg et al. (2015), in an Internet-enabled setting, user-based data capturing actions are accumulated by real-time con-function in a numerical outlook. There are many different types of data like; text, image, video, audio, snaps, or remaining identity file based categories of communication. Usually, the records have a tendency to be established, produced, or registered by a user.

The IoT-enabled setting has gadgets, which maintain and register all kinds of information to user actions in the present, non-numerical condition in which a user acts.

Data entry.

Users in an Internet-enabled setting intensively affect appliances to proceed immediately with the system. Specifically, a user can utilize a computer to order the plane tickets online, control the webpages in order to find the suitable tickets or airlines, then order through the system by credit card and all these actions are done in real-time mode.

Users can exploit the IoT gadgets; however, frequently they do not straightly input the data. IoT gadgets independently regulate and extract pertinent information from the cloud and from human´s recent activities.

Data sharing.

User data connected to Internet conduct is generally allocated inwardly inside a company or outwardly with associated outsiders or members, notwithstanding several firms exchange information with others.

In another hand, when using the IoT technologies, data are exchanged with providers and with other various gadgets.

Learning.

Suppliers, sellers, and online platform study their users and their sphere of actions within the numerical outlook, like booking tickets or hotel room in the web and being in social networking sites. Moreover, different actions can be registered in the format of cookies or online bank operation records. Usually, Internet-related conduct information is utilized for studying the user activities.

However, IoT appliances explore user activities by watching their mode of life, aspirations, relative acceptability and their surroundings. Contemplation is in reliance on user behaviors and processes in the present, material world versus the numerical universe (Weinberg et al. 2015).

Problem-solving.

Vendors apply Internet-enabled information for dealing with problems concerning the implication and interaction with users in a befitting way to their interactive behaviors. Most of the decisions are not done in online mode from a user point of view, as several more importantly the direct time may go by between the identification of a user issue and the response to the issue from the main supplier.

Although, the IoT devices are always controlling the settings via detectors and solving problems in active mode and related variances in actual time, certain settings circumstances and user favors (Weinberg et al. 2015).

Data and data-associated operations like elaboration, procurement, broadcast, and explanation are the focal impetus in the framework and application of IoT. Without records and information, IoT does not prevail and more importantly, the IoT existence is about the information and the flow of the data. There is a substantial concern for the company to use the web-related appliances for solving the problems, which related to clicks in the site, comments and likes in a social platform or the income. However, when it comes to IoT, it is very distinct because companies or devices have an access to the data about the settings and surroundings in which human or machine exists (Weinberg et al. 2015).

2.2.1. Radio Frequency Identification in the Internet of Things.

According to Figure 5, RFID appliance divided into three components: an RFID reader, an antenna, and an RFID tag. The reader has four basic elements: a power source, a radio frequency generator, circuits to enhance, assign numerical values, and keep the modulating wave obtained from the tag, and a simple microchip to operate the data in the data storage. This microchip is linked to an outer data processor. A radio frequency antenna is linked to the reader and transmits wireless signals to a tag. Likewise, this antenna gets wireless signals captured by a tag's antenna replication. A radio frequency tag comprises of three components: an antenna which obtains radio signals from a reader, a detector which transforms the obtained signal to ensure the capacity of the tag, a data storage in which the information to be utilized by a supplement, and a backup elementary data processor (Rajaraman 2017).

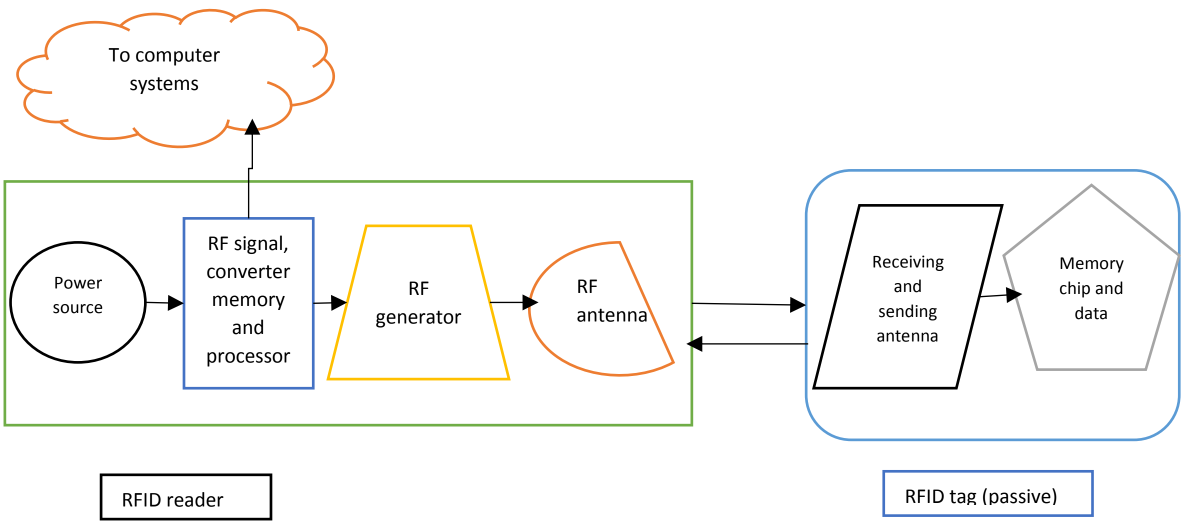


Figure 5. An RFID system with a reader and a tag (adapted from Rajaraman 2017).

The reader is a vital element of the RFID network. Readers may be handheld or stationary as a function of the enablers of the controller. The readers are fitted out with rationally situated antennas which are important for initializing the electromagnetic signal into the surroundings and obtaining a reverse wave from tags that are fairly near to connect with the reader (Keskilammi, Sydanheimo & Kivikoski 2003).

From the perspective of Roussos and Kostakos (2009), a conventional RFID reader has both broadcasting and obtaining characteristics for data interpretation and connection to tags. In view of this, RFID scanners usually are divided into an RF communicator unit (transmitter and receiver), a signal-processing module, a dispatcher console, communication component (antenna) and data transmission interface to a baseline system.

Table 3. Timeline of RFID Applications (Rajaraman 2017).

Year	Event
1942	Transponder in a bomber responds with a unique identity when interrogated by a radio beam. Used to identify friend or foe
1948	Stockman predicted the use of radio signals reflected from objects to identify them.
1971	Passive radio transponder with 16-bit memory, powered by interrogating radio signal invented by Cardillo.
1973	Use of 915 MHz signals to interrogate an RFID tag demonstrated. Both passive and active RFID tags and portable reader used.
1983	Patent granted for an RFID tag design.
2003	Walmart, a big retail store chain in U.S.A., and the U.S. Department of Defence mandate all major suppliers to put RFID tags in items supplied to them. ISO standardises low-frequency (120–150 kHz) RFID tags for animal identification and data collection. It initiates standardising RFID systems (ISO 18000 series of standards) for various applications.
2004	Food and Drug Administration (U.S.A) approves implanting RFID tags in humans and the use of m-chip cryptography for privacy.

In the beginning of 2000s, RFID networks were represented for the first time as tagging to commercial products. The quantity RFID tags is increased after a considerable number of stores requested their suppliers to utilize RFID tags in a supplement to barcodes on goods delivered to shops. After this, RFID technologies started receiving more attention from different types of industries. Due to the high quantity of the manufactured RFID tags, the cost of tags started to decrease in price. At the same time, there was prompt growth in the integrated semiconductor device processing with the distribution of moderate capacity data processing device. As the output accessible to tags is mainly collected from readers, elaboration of moderate capacity data processing devices enhanced the RFID tag industry (Rajaraman 2017).

The types of RFID tags.

According to Nikitin and Rao (2006), a tag is one of the most important features of an RFID network. The main function of the tag is to keep and broadcast the set data concerning the goods or materials to which it is connected. The tag can remain an active condition for a long time, thus it can register inventory or warehousing status directly to the user. Moreover, it can stay in an inactive condition before the activation by a signal from a reader.

There are three types of tags in RFID; they are active tags, passive tags and semi-passive / active tags:

– If the tag has an autonomous transfer of power, then it is an active tag. Consequently, they do not need the reader as a power supply crate (Samson 2011). They have the higher capacity output than passive tags because they have broader diapason of connection and the power to register information at prearranged time length for direct or post data interpretation to the reader. They fit thoroughly to settings of supreme magnetic field noises, by virtue of their potential to transmit more stable radio waves than passive tags can with the assistance of the integrated power supply crate (Jedermann, Ruiz-Garcia & Lang 2009).

- This implies that passive tags do not have the capability to power up autonomously. They only have the radio waves from the reader to actuate its integrated electric connection. Considering that the passive tags do not have integrated current transmitter, they are smaller in scale than active tags. In addition, the cost of passive tags is lower comparing to active tags (Samson 2011).
- The combination of two tags simultaneously is called semi-passive/active tags. Corresponding to passive tags, they are dependable on the radio waves from the reader to actuate the tag. However, at the same time, it obtains energy from its own integrated internal power supply crate to activate its internal circuitry. Certain tags benefit from being capable of saving power by the partial usage of the radio wave and as well as, benefit from the production of a high-powered reverse wave (Samson 2011).

2.2.2. Wireless Sensor Networks in the Internet of Things.

From the perspective of Alfieri, Bianco, Brandimarte & Chiasserini (2006), wireless sensor networks are consisted of modest-sized hardware installations, the sensors, which display sections, things, humans, or examine environment heat level, the presence of sound or concussion events. Therefore, wireless sensors can be applied for distant control and keeping track of things in various settings and for a broad variety of applications. Usually, they have a Microelectromechanical System (MEMS), an energy-conservative Digital Signal Processor (DSP), a radio frequency (RF) circuit, and an accumulator. By virtue of their cost-friendly and uncomplicated characteristics, sensors are described by a few limitations, like a moderate transmit diapason, inferior calculation and data handling potentials, unstable security and data transfer rates, and a constrained accessible power. Consequently, it is important to create an optimal design for sensor networks in order to prevail these constraints.

Wireless sensor networks consist of numerous quantity of small appliances named nodes. A sensor is an appliance, which detects data and transfers it on to a mote. Sensors are utilized to determine the variances to the outer surroundings like tension, temperature, noise, and fluctuation. A mote comprises a data-handling machine, data storage, accumulator, an analog-to-digital transducer in order to link to a sensor, and a wireless broadcaster for drafting a decentralized network. There can be various sensors for various objectives set for a mote. Furthermore, motes can be alluded to as smart dust (Kumar Sarkar 2012).

WSN hardware problems.

According to Kumar Sarkar (2012), the nodes utilized in sensor networks are tiny and have a considerable amount of power limitations. The hardware structure problems of sensor nodes are distinct from other supplements and they are described below:

- Wireless diapason for the overall radio connections permits a mote to transfer remotely, approximately 3 to 61 meters away. Wireless diapason is decisive for providing network connectivity and information gathering in a system. A variety of systems has the nodes, which may not create a communication process for days or may leave the range after establishing the communication process.
- Utilization of data storage microprocessor, such as flash memory is optimal for sensor networks, as they are stable and cost-friendly.
- Power expenses of the perceiving appliances should be diminished, and sensor nodes should be power rational because their constrained energy reserve designates their lifetime.

WSN software problems.

There are different problems in creating an operating system (OS) for sensor networks, which are identified below:

- A sensor node is a primary function for calculation of the acquired information from the specific settings. It works on the acquired information and operates the records in pursuance of the request of an application. Actual-time replication, operating, and distributing of the information are necessary for WSN activities. Therefore, it is essential to control all the activities of sensor nodes synchronically.
- An OS for sensor nodes is required to be hardware autonomous and application definite. It should maintain multihop distribution and elementary digital network user part.

- The OS should have integral characteristics to decrease the rate of accumulator energy. Motes cannot be charged at any time and they have moderate-sized and low-cost features, so it should be in a position to impose constraints on the number of resources utilized by every supplement.
- The OS should have an easy programming model. Software developers should be capable to focus on the application consistency in place of being pertinent with low-level hardware problems like scheduling, allocating, and net handling (Kumar Sarkar 2012).

According to Dargie and Poellabauer (2010), the different types of sensors, which conjointly display wide physical surroundings, are called a wireless sensor network (WSN). The transmission process of sensor nodes creates the network with a base station (BS), by broadcasting and distributing the sensor information to the remote computing and backup system. Specifically, Figure 6 demonstrates two sensor scopes controlling two distinct geographic locations and linking to the Internet by employing their base stations.

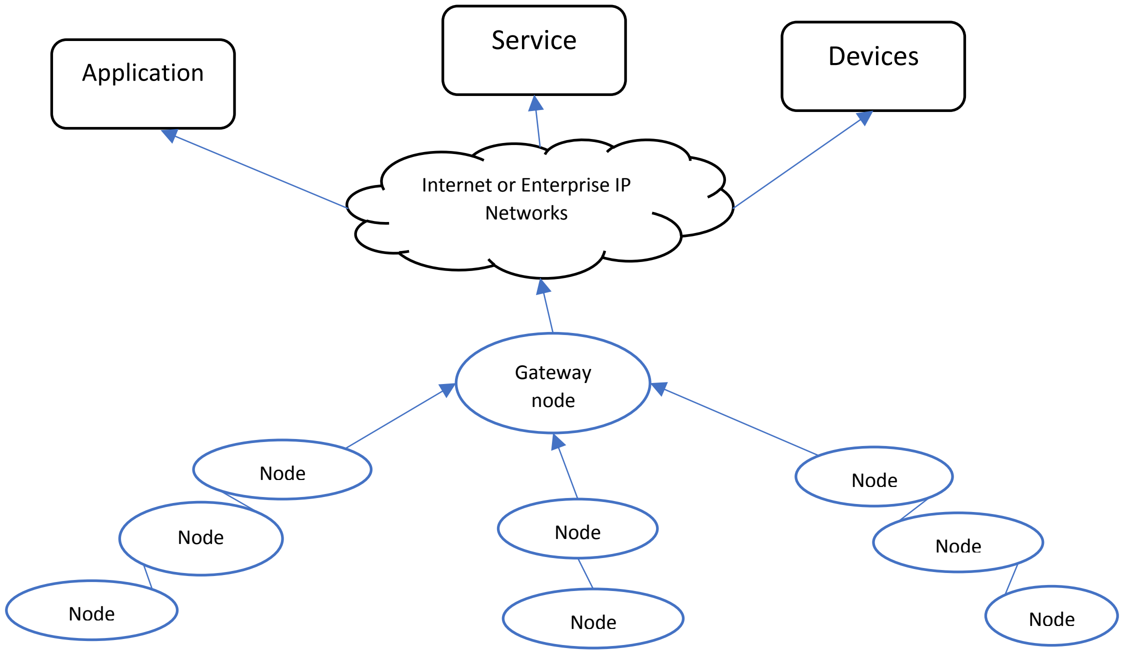


Figure 6. Wireless sensor networks (adapted from Dargie and Poellabauer 2010).

There is a variety of different sensors and each of them has various specifications. Therefore, it is essential to understand the physical properties of the sensors. Table 3 totalizes overall physical properties of the sensors, comprising examples of sensing mechanisms which are applied to detect them. Moreover, physical properties, the classification of sensors can be in respect to a series of different techniques. Specifically, some sensors need an outer electricity source. If the sensors require outer electricity source, they are called active sensors. This means that they have to radiate certain energy to effect a reaction or to observe a variation in the output of the sent signal. In the meantime, passive sensors distinguish the energy in the surroundings and obtain their power from this energy consumption, such as passive infrared (PIR) sensors evaluate infrared-censored impulse emitting from things (Dargie & Poellabauer 2010).

Table 4. Classification and examples of sensors (Dargie & Poellabauer 2010).

Type	Examples
Temperature	Thermistors, thermocouples
Pressure	Pressure gauges, barometers, ionization gauges
Optical	Photodiodes, phototransistors, infrared sensors, CCD sensors
Acoustic	Piezoelectric resonators, microphones
Mechanical	Strain gauges, tactile sensors, capacitive diaphragms, piezoresistive cells
Motion, vibration	Accelerometers, gyroscopes, photo sensors
Flow	Anemometers, mass air flow sensors
Position	GPS, ultrasound-based sensors, infrared-based sensors, inclinometers
Electromagnetic	Hall-effect sensors, magnetometers
Chemical	pH sensors, electrochemical sensors, infrared gas sensors
Humidity	Capacitive and resistive sensors, hygrometers, MEMS-based humidity sensors
Radiation	Ionization detectors, Geiger–Mueller counters

2.3. An overview of Artificial Intelligence.

Artificial Intelligence (AI) is based on technology of developing intelligent machines. AI makes it possible for machines to identify and solve various problems applying human intelligence techniques. AI focus areas consist of two fundamental sections; a paradigm that attempts to simulate the human brain process and paradigm that comprehends and uses the cognitive patterns. The first is the Artificial Neural Networks (ANNs) and the second is the Conventional Artificial Intelligence (Gharbia & Ali Mansoori 2005).

According to Shi (2014), several significant theoretical derivations of AI still require advanced development. There are no major implementation in the scope of AI paradigms, like machine learning, fuzzy logic, common sense knowledge representation and uncertain reasoning. Demonstratively, AI science is in the initial phase of Intelligence Science, a mandatory inter-functional category that intends to compound study on fundamental theories and technologies of intelligence by Brain Science, Cognitive Science, and Artificial Intelligence.

AI study goal is to mimic, amplify and expand human intellectual abilities by using artificial methods and technologies and eventually obtaining machine intelligence (Shi 2014).

2.3.1. Key parameters of Artificial Neural Networks.

The paradigm of an artificial neural network was based on the process of the subsisting human functional brain neurons. Applying the cooperative chain of data processor flashbacks, ANN can familiarize with previous events, differentiate specific characteristic, identify implications and patterns, accumulate things, and cultivate indefinite or discrete data. The bonds link those junctions to each other. Every bond has a digital mass attribute to it. The bonds and their masses are the main conditions of the durable and persistent storage device. The system examines data in a particular manner that the performance of single neuron is an inlet to the corresponding neuron connected to it. The masses are accountable for the amplification or attenuation of the data transmitted across the bond. The bonds are put and the significance of masses are established in a mode named learning. ANN can be comprehended to react to different information specifications pursuant to human's desires or to study implicit interconnections within the records. As soon as the network is presented, ANN can be upgraded to develop its capacity through an impulsive learning mode and be observed in whatsoever controlled or non-controlled settings (Min 2010).

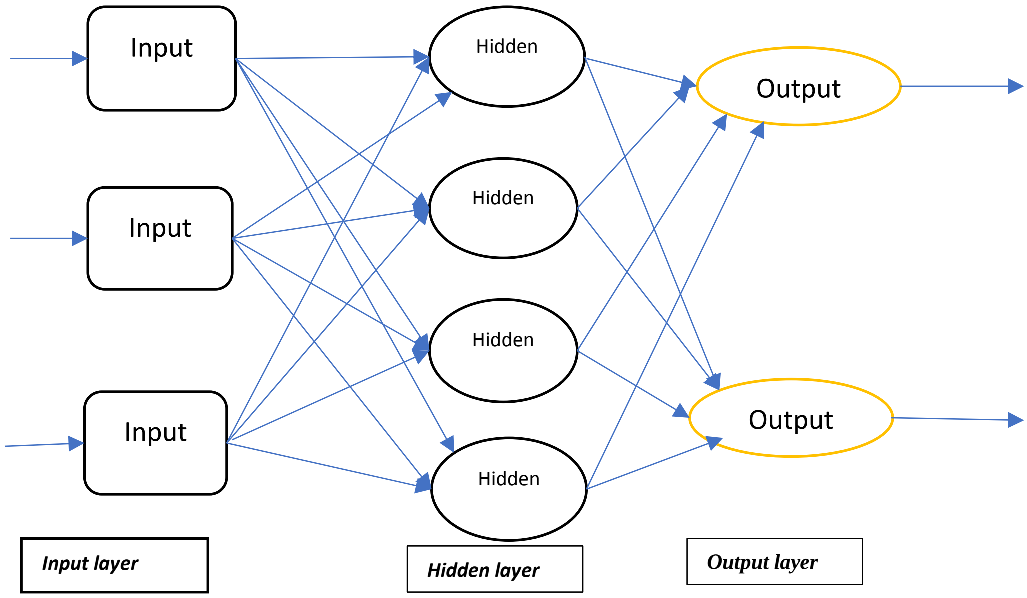


Figure 7. A common type of neural network (adapted from Gharbia & Ali Mansoori 2005).

According to Gharbia and Ali Mansoori (2005), ANN is a linked structure of basic elaborations, blocks, or neuroses. In general, the ANN integrity is constructed in pursuance of the brain nerve cells processes. ANNs are comparatively unresponsive to data falsification, being that, they have the capability to identify the basic connection among pattern input and output variables providing the suitable generalization potential. In addition, a neural network pattern can be exposed to complementary learning for improving its abilities to act under different circumstances. Therefore, it can develop new input and output variances for better cognitive processes.

ANN is a broad outline and conventional analogue formation of the operation interpret previously. ANNs have been created as compilation and conceptual description of statistical paradigms of human cognitive or brain processes, based on the hypothesis that:

- Data handling takes place in many basic outlines which known as neurons.
- Signals proceed between neurons via connection link.
- Every connection link has a concurrent value, which, in a common neural network, enhances the signal being sent.
- Every neuron uses an activation function to its net input to determine its output signal (Gordon 2011).

2.3.2. A formulation of Machine Learning in Artificial Intelligence.

Machine learning is a category of artificial intelligence paradigm. Humans build networks by utilizing computational processes that can train from records or data in a certain sense of being educated. The systems can study and develop with practice and experience, and with time, improve a pattern that can be applied to forecast results of certain problems as part of the prior experience (Bell 2014).

According to Shi (2014), fundamental model of machine learning comprises learning from examples (inductive), analytical learning, discovery learning, genetic learning, connection learning. In previous years, learning from examples has been comprehensively researched. It is concentrated primarily on common notion specification and idea accumulation and offered various kinds of techniques. Analytical learning provides insight into resemblances of the examined challenge with advance familiar source problems. Further uses the answer from the source problems to the examined challenge. Among other things, explication-grounded learning retrieves common rules from a specific sorting out the problem proceedings, which can be utilized to other corresponding issues. Since obtained knowledge is kept in the information baseline, average explications can be passed to refine the performance of prospective problem-solving. Discovery learning is the techniques to find out novel approaches from available measurement records. Genetic learning is predicated on the conventional genetic method, which is created to mimic biological progress through duplication and modification (Mohri, Rostamizadeh, & Talwalkar, 2014).

Thus far, the machine-learning study is in its initial milestone. It requires broad study intensification and motivation for the future research progress. Evidently, the Development in machine learning study will allow the significant progress in AI and cognitive science research. In days to come, study focus areas of machine learning will comprise cognitive paradigms for the learning method, computational learning conceptions, novel learning algorithms, machine-learning networks combining numerous learning approaches (Shi 2014).

Due to high variation probability in data collections and data processing, machine learning cannot be used as on one occasion solution to problems. In addition, it needs human interaction and insight to compose these codes and modes. Practically, the data processor requires a human to get it started, and then it constructs a primary knowledge base (Bell 2014).

2.3.3. An outline of the Fuzzy Logic paradigm.

According to Gharbia and Ali Mansoori (2005), fuzzy logic is a paradigm to augmentation where the principles of derivation are estimate rather than precise. It is beneficial for affecting data that is unfinished, inaccurate, or uncertain. Fuzzy logic has supplements in monitor conception. Whilst making up a program for objects to operate in entangled settings, fuzzy principles may be less complicated to extract and faster to utilize than apparent formulation. As fuzzy logic is applied primarily for better performance, some scholars believe that it is fated by the forthcoming of a large scale of overlapping computing.

As alleged by Zadeh (1965), fuzzy logic is a continuation of the Boolean logic, which is grounded on the Fuzzy Sets Theory. By presenting the concept of extent in the examination of a state in a principle frame, fuzzy logic ensures a valuable versatility for argumentation, which establishes conditions to consider errors and ambiguity compare to the human reasoning. Besides, applying the substantial fuzzy notion of a linguistic parameter, fuzzy logic permits to model human thinking, whence the principals are determined in natural language. Thereby, Zadeh (1965) presented the paradigms of fuzzy set and fuzzy logic to grant a method of reasoning. In addition, this method can show the human's articulation of knowledge, dealing with a problem and generalizing records (Herrera-Viedma 2015).

2.4. General specifications of 5G Network.

It has been forecasted that, in the forthcoming years, mobile traffics will grow approximately by 1,000 times. In order to conform to such tremendous traffic increment, following generation of mobile networks are likewise anticipated to reach a 1,000 times current speed augmentation (Li, Niu, Papathanassiou & Wu 2014).

According to Singh, Saxena, Roy & Kim (2017), various smart appliance entered in the elaboration with large-scale rapidity. Due to prompt development of intelligent and sophisticated technologies, the network started to grow and improve. Nowadays, there is a great number of various kinds of applications and programs, which maintain the interconnection of household devices, smart electricity production and data storage on the cloud. Thus, facilities and supplements are moving into these smart machines. Besides, a pervasive character of the network and ascending 5G technologies targets to link entire network and its technologies within the single network.

The great expansion in network-to-network information influence the method of handling and decrypting a novel approaches from Big Data. Although, in modern society, mobile network and Internet produces the immense amount of the information. There is a new issue is how to elaborate computing mechanisms that pass, collect, comprehend, and operate on specific Big Data (Wei, Blake, Saleh & Dustdar 2013).

Nowadays, the rate of emergence of smart appliances is quite high within industrial systems, embedded with maximum processing power, more extensive storage capacity and various short and long-range transmission interfaces. Moreover, with 5G technology appearance, there will be a variety of before-mentioned network software tools and supplements, which will connect at the same time. Furthermore, due to social behavior of the humans, there are a complementary dependency and close connection between the smart appliances and humans. In general, the smart technologies can help to avoid an error in the sophisticated process by learning and optimizing the social behavior (Singh et al. 2017).

In order to inquire the development of the mobile network connectivity, it is important to create the roadmap of the evolution towards 5G Network Connectivity.

Table 5. Specifications of different generations of cellular systems (Rodriguez 2015).

Generation	Rollout year	IMT requirement for data rate	
		Mobile users	Stationary users
1G	1981	–	–
2G	1992	–	–
3G	2001	384 Kbps	>2 Mbps
4G	2011	100 Mbps	1 Gbps
5G	2021	1 Gbps	10 Gbps

Rodriguez (2015) established the evolution roadmap of 5G Network:

- Before 1G (<1983): All the radio connections were voice-centric and utilized simulation facilities with single-sideband (SSB) control.
- 1G (1983–): All the radio connections were voice-centric. In 1966, Bell Labs had decided to assimilate simulation facilities for a high-capacity mobile network, because at that time the digital radio networks were costly to process. The simulation facilities with FM radios were selected.
- 2G (1990–): Meanwhile, all the radio connections were voice-centric. The shifting from 1G to 2G means moving from the simulation facilities to the digital system.
- 2.5G (1995–): All the radio connections are generally for high-output voice with restricted data service. The CDMA (code division multiple access) systems applying 1.25 MHz bandwidth was employed in the United States. Along with that, European countries enhanced the Global System for Mobile Communications (GSM) to General Packet Radio Service (GPRS) and Enhanced Data rates for GSM Evolution (EDGE) networks.

- 3G (1999–): At that time, the radio connections platform has voice and data facilities. 3G is the first international standard system released from ITU, in distinction from early generation networks. 3G runs WCDMA (Wideband Code Division Multiple Access) technologies using 5 MHz bandwidth. It functions in both frequency division duplex (FDD) and time division duplex (TDD) regimes. Therefore, the shifting from 2G to 3G systems, the network evolved from voice-centric systems to data-centric frames.
- 4G (2013–): 4G is a high-speed data rate plus voice system. The bandwidth of the network is 20 MHz and the transformation of 3G to 4G implies a change of low data rates for the Internet to high-speed data rates for mobile video.
- 5G (2021–): 5G is still to be characterized formally by certification institutions. It will be a system of super high-output and extreme-high-rate data with novel structure enablers customized in the direction of energy-produced grids and decreased power consumption for controllers. Therefore, the development of 4G to 5G systems implies the alteration in the model structure from a uniform-mode network to a multi-mode network.

It is still problematic to anticipate the emergence of 5G Network in the market. Nevertheless, from the conducted tests of 5G interface and architecture by first-in-class companies, it is apparent that 5G Network can deploy earlier than 2021. However, it is quite certain that it will be a disruptive innovation and it will replace the current mobile networks.

For the purpose of comprehending of the 5G Network technology issues, it is essential to determine the enablers for a 5G Network. Several aspects should be considered in order to meet all the requirements of 5G Network implementation. The various technologies will state distinct enablers on the efficiency, and main enablers that will be necessary to be accomplished the definite outlines are mentioned below (Andrews, Buzzi, Choi, Hanly, Lozano, Soong, & Zhang 2014).

Data Rate.

According to Andrews et al. (2014), the primary stimuli for 5G Network development is the maintenance of the mobile data traffic outbreaks. Therefore, there are various measuring methods to identify precisely the data rate.

1. **Aggregate data rate** or **area capacity** alludes to the accumulation of data the network can operate, defined in bits per block area. The overall coherence is that this amount will require enlarging by nearly 1000× from 4G to 5G.
2. **Edge rate** or 5% rate is the lowest data rate that a customer can anticipate to obtain when in diapason of the network. Therefore, it is a significant criterion and has a specific technological sense. Objectives for the 5G edge rate ranges from 100 Mbps (easily enough to support high-definition streaming) to as much as 1 Gbps. Acquiring 100 Mbps for 95% of customers will be quite troublesome, even with primary technological novelties. It demands about a hundred times developed from modern 4G networks have a typical 5% rate of about 1 Mbps, although the exact number changes extensively, the main reasons for that are the load and the cell space.
3. **Peak rate** is the superior data rate, which a customer can expect to attain under any feasible network outline (Andrews et al. 2014)

3. CONCEPTUAL FRAMEWORK OF INTERNET OF THINGS AND ARTIFICIAL INTELLIGENCE IN SUPPLY CHAIN MANAGEMENT

3.1. An assessment of the Internet of Things applications in Supply Chain Management.

The control of logistics processes for SC system is a substantial business operation problem for ensuring valid and optimal client experience. Therefore, production facilities and logistics management should improve their tracking processes and methods in SC. Modern industrial SC methods in production-based companies are searching for the suitable data interaction networks to control at actual-time. Besides, it is essential to control and monitor the records from different members of the SC, in order to implement the SC data control between the members of the SC system (Addo-Tenkorang, Helo, Shamsuzzoha, Ehrs, & Phuong 2012).

Thus far, the term of the Internet of Things is discussed extensively, but there is a significant unanimity on assigning IoT a major part in ensuring the worldwide approach to services and data suggested by billions of diverse appliances, arranging from recourse-limited to potent appliances in a function-compatible manner.

A similar definition that introduces the IoT scope is "industrial Internet", which is articulated on machines manufactured with touch-control devices, thereby making them "intelligent". These appliances frequently fulfill a function as the IT outlines for the IoT. Specifically, industrial apparatus or a transportation cart may supply information to the IoT. This information could also be affiliated with other records to onwards reinforce the characteristics and pervasive significance (Greengard 2015).

IoT is incipient technology, it is on the initial stage of development, and that is why it important to comprehend the business potentials it can propose for modern organizations. In addition, IoT requires the newest technologies and the best connectivity to function properly in SCM. Therefore, the reliability of IoT is still in question and heavily discussed in the scientific world (Greengard 2015).

Within the Industrial Internet system, a broadcast process generally takes place in three different ways: machine to machine (M2M), human to machine (H2M), and machine to a smartphone (M2S) or other appliances (Greengard 2015). The main reason why the Internet of Things so potent is that it binds physical-first outputs and units to each other, in addition, linking them to digital-first appliances, comprising computers and software applications. This facilitates it for all these appliances to proceed on a fraction or multicast framework and distribute information in actual time - constantly via cloud-based computing. Nonetheless, IoT is an incentive scope, especially resulting from the sublime amount of diverse and eventually constrained connected devices, and uncommon and heavy traffic schemes (Greengard 2015).

Gatner (2017) anticipates that the IoT will gain 20.4 billion units by 2020, up 8.4 billion in 2017, and will affect the obtainable data to supply chain associates and how the supply chain proceeds. From manufacturing stage and storage operation to distribution and retail merchandising, the IoT is converting business operation by ensuring more precise and actual-time traceability into the flow materials and outputs. Companies will pump investments into the IoT to assign a new function and remodel plant operation, refine traceability of materials, and leverage allocation expenses.

The implementation of the IoT is quickly accelerating as research-and-engineering, communicative, and rival impact foster companies to develop and reorganize themselves. While IoT technology evolves and rising numbers of companies implement the technology, IoT profitability analysis will be a topic of substantial concern. Consequently, the feasible but ambiguous advantages and extensive capital outlays of the IoT, companies will be required to evaluate cautiously every IoT-enabled potential and obstacles to guarantee that their resources are used deliberately (Greengard 2015).

Things depend upon programming support to obtain signals successfully from each other and to provide reinforced multitasking and communications security. Software should be elaborated with the IoT's alignment, a possible connection, confidentiality, and protection enablers. The concentration on programming support design is proceeding to user-centric, dispersed logic system, intercomputer, and the interplay between machine and human.

IoT applications produce a great number of data that is required to be collected and elaborated in actual-time to assure records concerning the condition, position, technical capabilities, and setting of the applications. The conventional transformation of data process does not operate perfectly in the actual-time streaming information method of the IoT setting. As long as, handling a considerable amount of IoT data in actual time will enhance the extent of work of information centers at a significant rapidity, data handling will turn more situational, more efficient, and comprehensible (Greengard 2015).

Data-processing engineers have invented a definition, meaning of perfect data, which is articulated on the proficiency to adjust information query, retrieval, and basic research in a manner that renders profound comprehension. Obtaining this objective is extremely stimulating since it is immensely troublesome to collect all the records needed for perfect data and then frame an algorithm that considers all the variables in the appropriate manner. As opposed to striving to construct ideal paradigm, data-processing engineers are concentrated on constructing the best feasible pattern applying large data and data evaluation (Greengard 2015).

Security issues of IoT.

The IoT facilities will not be an individual proprietorship decision. Therefore, it is essential for appliances to have a uniform and available admission to a variety of data users and regulators simultaneously, although still withholding profiling information and sole priority of data where that is needed among users. Data utility whereas ensuring information privacy among domestic users is decisive. The suitable identity management should be constructed, as well as, trust relationships between objects to distribute the correct data should be established (Mononen, Teppo & Suihko 2017).

According to Cisco Security Research & Operations, there are sophisticated protection conditions to be developed on a system with feasibly restricted capabilities:

- verify to numerous networks safely
- guarantee that information is accessible to numerous controllers
- control the discrepancy between that data approach
- control confidentiality issues between numerous users
- ensure solid certification of authenticity and data interlock that are not simply discredited
- support utility of the data or the service

- permit for development against the backdrop of obscure risks.

These problems have specific propriety to the IoT where reliable accessibility of information is the utmost significance. Specifically, a determinative production operation can depend upon an exact thermal sensing. When the Denial of Service (DoS) failure occurs in the system, all related sub-systems and technologies should be brought up to date. Under these circumstances, the system should be able to come into critical operation in real-time, like transmit needed information from a supporting connection, or retain the data broadcast. In addition, it should be capable to recognize the lack of data due to a continuous DoS failure and damage of the appliance because of a critical occasion in the site. The development of smart machines and artificial intelligence technologies should help to avoid such decisive cases in the industrial organizations (Mononen, Teppo & Suihko 2017).

The IoT networks maintain modern business paradigms, which engages new members alongside with conventional remote data communications. Besides users and cell phone network controllers, industrial establishments, joint ownership, middleware, and maintenance perform substantial functions.

Figure 10 indicates the fundamental and supporting IoT members and their trust relationships. The supporting actors are the IoT core system service provider, whose role is to ensure the IoT core system for the IoT service provider, and the connection service provider, whose role is to grant connectivity for the IoT appliances and maintenance (Mononen et al. 2017).

The reliability of services and maintenance practice relies on how the controllers manage authentication and information, safety and protection, and how they correspond to the concerted procedures and specifications. The integration of the protection and authentication activities is significant for determining the reliance standards.

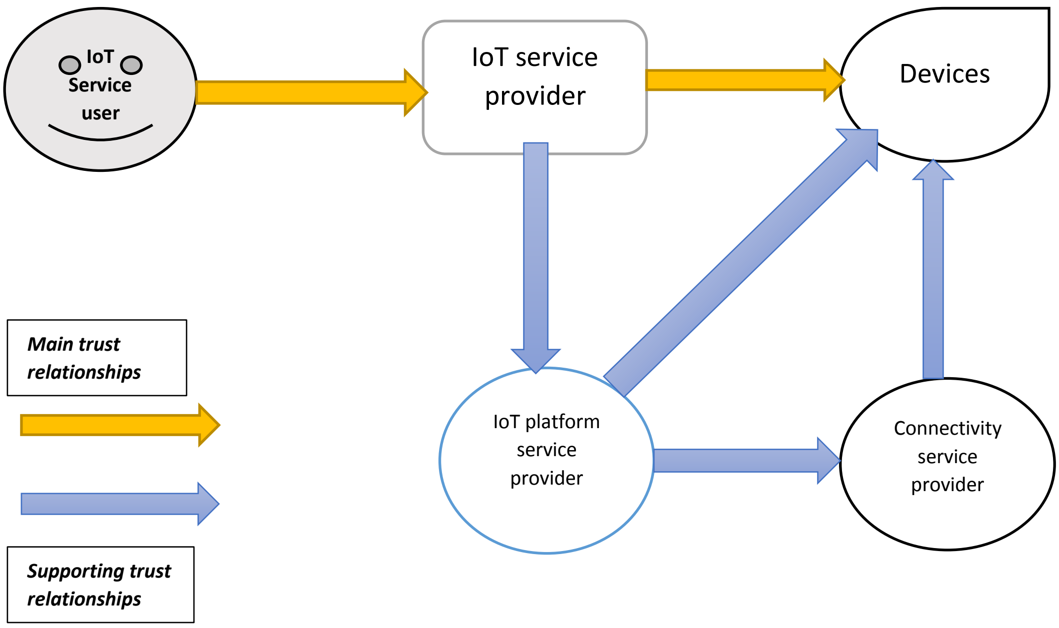


Figure 8. The primary and supporting IoT members and their trust relationships (adapted from Mononen et al. 2017).

Radio Frequency Identification and Wireless Sensors Network in Supply Chain Management.

Whereas vindicated to be an extremely useful technique of recognition in present times food supply chain management supplements barcodes have disadvantages like constrained information output, depending on a through connection sight with reader, feasible haulage in stimulating manufacture conditions, casualties because of wear out caused by illegible notations, thereby, including the continuity of the supply chain.

Tremendous advantages in the scope of SCM have been obtained because of the merger of radio frequency identification (RFID) in different types of industries. Primer benefits of RFID emerging from its aptitude to transmit real-time visibility of the entire SC processes and its consistency to transfer consumer set records that are renewable mechanically or by manual depreciation method at every phase throughout manufacture and shipping. Additional benefits contain SC accountability and traceability to unit layer, entirely computerize radio data broadcast in this way diminishing human deviations, a decrease in commodity service hereby enhancing hygiene norms and suggest the opportunity to control warehouse conditions thus enhancing commodity reliability (Samson 2011).

RFID is a mechanism for electronic tracing and recognition of items utilizing radio waves. Frequently elaborated the following phase in the notched code development, RFID is the most dynamic emerging section of the machine pulling data and spotting market. It has different applications; supply chain management (SCM) is one of the major candidates for successful implementation of RFID (Srivastava 2004).

The progressive pulling data solutions of RFID mechanism, connected with unparalleled product recognition and real-time data arriving from a various data-warehousing system, unfold many novel opportunities for the rational control of supply chain operation and decision assistance. This induces other variable options for using RFID in the supply chain setting, each one with different costs and concurrent profit. While this abundance of options propose versatility and establishes collaboration, nonetheless it makes the assessment of investments in RFID technology a challenging issue (Srivastava 2004).

Many kinds of research have been carried out to assess investments in supply chain engineering such as RFID. As a result of the failure of the conventional reduced flow techniques to estimate the suppleness and the corresponding effect of such technologies on supply chain process, Real Options (RO) analysis has been represented as a fresh technique in the scope of information technology (IT) investment assessment (Dimakopoulou, Pramatari & Tsekrekos 2014).

In these latter days, RFID has appeared as a significant novel technology to trace the motion of commodities in a supply chain. An RFID network includes three primary elements. The first element is a tag with an electronic product code (EPC) to recognize trays, boxes, or personal commodity units. Moreover, an RFID network also demands viewers that can set in motion and obtain data from the tags. The connection between the two is by radio waves. The last element is an information system with an analytics database, which is utilized to keep and control the information detected by the readers. To manage an RFID network, readers dispatch radio-wave signals over definitely predetermined periodicity. Tags obtain the signals in the proximity of the readers. The tags then transfer kept records (such as the EPC number) back to the reader. The reader, sequentially, decrypts and broadcasts this data to the analytics database along with the period and position mark (Chang, Klabjan & Vossen 2010).

Tracking technologies include the obtaining and registration of data concerning the commodities at systematic predefined lapses across the SC. Moreover, Tracking alludes to the potential of the network to keep the route of a definite item or freight transportation across the SC whereby it transfers among different commercial members. The process ensures personal data and sometimes the position of all pertinent records on goods in the SC. In addition, it grants the data on the manufacture, handling, and allocation of every good. In order to execute its objectives successful traceability appliances should perform the succeeding activities: information-bearing capacity, ensuring of a supreme stage of automation, real-time operation, and performance reliability and security (Samson 2011).

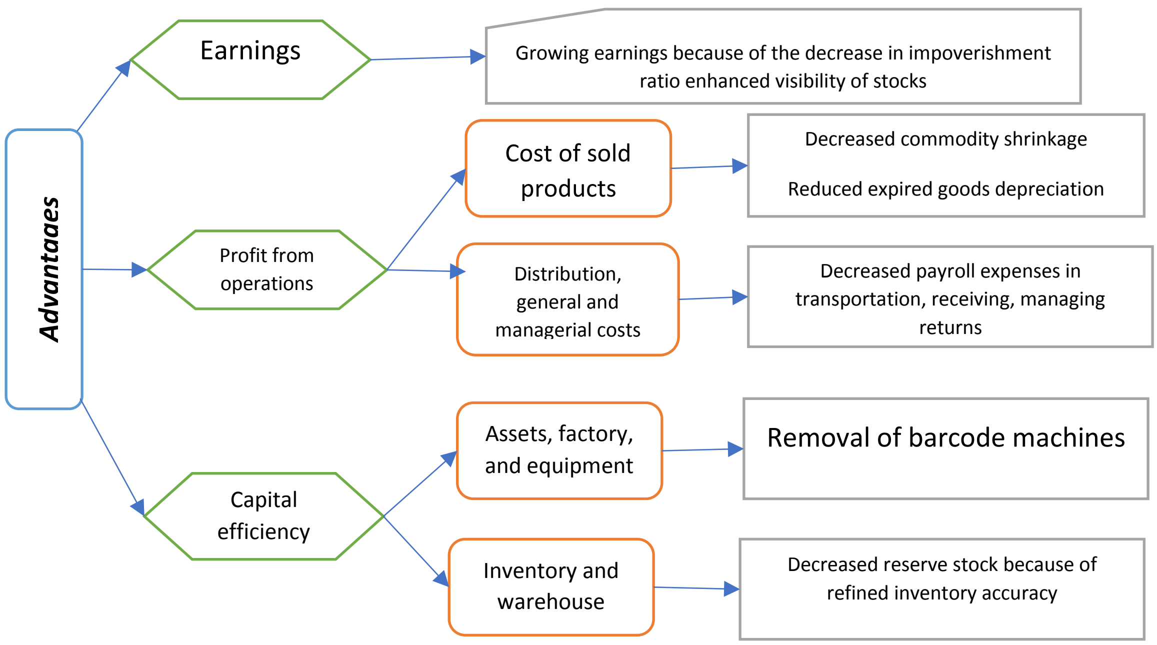


Figure 9. RFID advantages (adapted from Leung, Cheng, Lee and Hennessy 2007).

Figure 9 displays the advantages of RFID in three primary categories: earnings, profit from operations and capital efficiency. It is evident that there are a few advantages of RFID appliances due to the growth of earnings, the reduction of transaction expenses and the augmentation of capital due to the decrease of assets, factory and equipment expenses and inventory and warehouse expenditures (Leung et al. 2007).

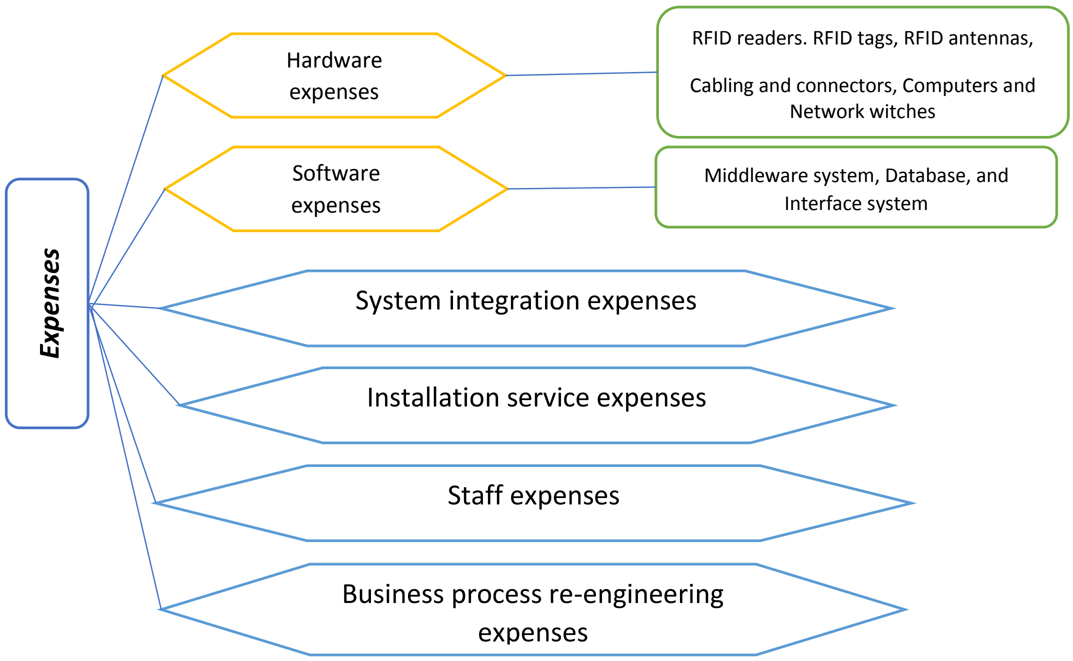


Figure 10. RFID installation expenses scheme (adapted from Banks, Hanny, Pachano and Thompson 2007).

RFID installation needs a significant amount of investments. According to Banks et al. (2007), there are six categories of expenses: hardware costs, software costs, system integration expenses, installation services expenses, staff expenses (training and labor costs) and business process re-engineering expenses. Figure 10 depicts the primary expenses of RFID installation. It is apparent that there are a few considerable expenses and advantages of RFID integration. Therefore, firms have to make a decision if the investment into RFID technology is feasible or not.

The advantage of simultaneous RFID and WSN implementation into SCM may be essential for gathering information from RFID tags and sensors. This method can contribute to improving the scope of maintained operations such as verification and real-time visualization. Considering that the purpose of RFID is the recognition of commodities, WSN is implied for displaying and checking the

SC settings. Moreover, RFID tags are not limited to uncommon authentication of commodities within the SC, however, tags can be related to data arrangement, and detect the unsafe commodities.

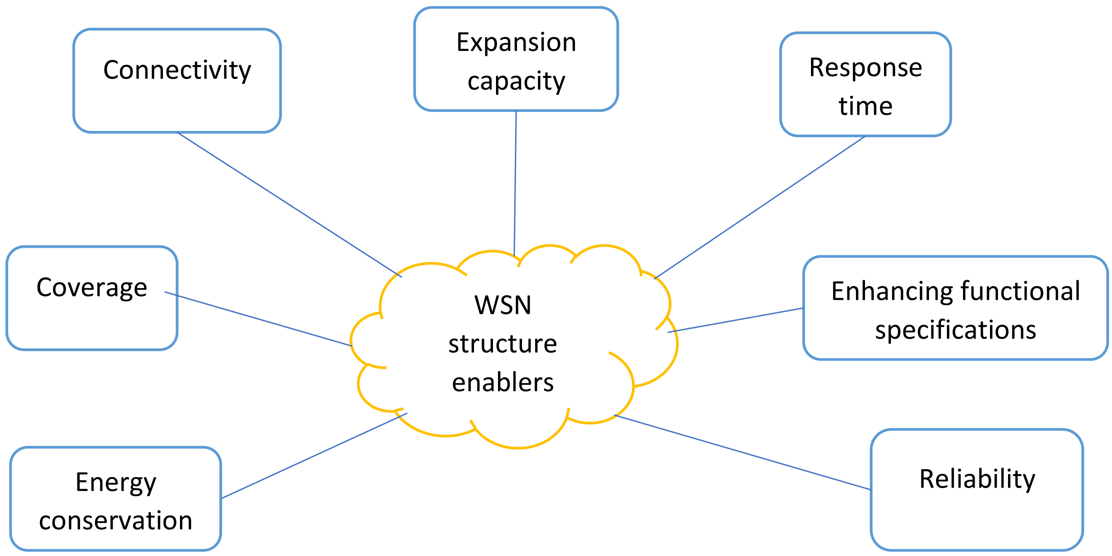


Figure 11. The framework of WSN structure enablers (adapted from Oteafy & Hassanein 2014).

Notwithstanding, the combination of RFID and WSN has a high potential for SCM network, by virtue of several obstacles, the implementation of both technologies can be restrained. The main issue is that these two technologies have a substantial difference in their functions. In addition, RFID appliance is to some extent maintaining single radio-wave reflection between tag and reader, whereas WSN facilitates a larger variety of transmission. Subsequently, they have distinct tasks. RFID is utilized for commodity authentication and tracking. They depend on the obtained data inside the EPCglobal support structure. The data is associated with the feature of tagged objects. Whilst, sensors aim to check and display the physical settings of commodities, but not exactly related to commodities. Besides, they are capable of keeping track of the needed data and correctly inform particular data to the surveillance program (Gomez, Laurent & El Moustaine 2011).

Radio frequency identification in Inventory Management.

One of the latest IT approaches is the implementation of RFID engineering in inventory management network. Initial advantages obtained from RFID development are inventory goods tracing, preparatory transportation notification, and actual-time order status statement for retail dealers and real-time transportation accessibility for suppliers. The supplementary RFID received data could arise in refined inventory management procedures and eventual modern commercialization. One of the major failures to a more comprehensive RFID implementation is the absence of investments efficiency. Many organizations in supply chains are affected by information received from RFID allocation; nevertheless, this information is rarely utilized to strengthen business analytics (Pei & Klabjan 2010).

As an appearance of automatic data reading impetus, RFID technology stumbles supply chain scholars and empirics. Firms have precipitated to elaborate RFID decisions without fully understanding the concept regarding the feasible meaning of RFID to their business area. Another significance of RFID in supply chains is received from improved supply chain visibility. An RFID development refines supply chain visibility, notwithstanding, a majority of advantages in inventory management are yet uncovered. The importance of RFID acquired from employment inputs decrease and corresponding primary profits can be adequately evaluated by case studies. Empirical studies and evidence of ideas are of the restricted area because they have to confide available methods and records. It is not evident how RFID can diminish onwards supply chain expenses through refined visibility. Nowadays, developed assumptions are leading down such assessments. Empirical simulation of inventory management networks with an RFID development is decisive to increase overall comprehension of the importance of RFID (Pei & Klabjan 2010).

According to Gale, Rajamani and Sriskandarajah (2005), RFID has certain essential benefits over conventional notched code: units can be identified from a range without optical communication link of a field of view, numerous tags can be recognized at the same time, and unit definite information can be registered on a tag. The RFID mechanism brings a considerable amount of substantial advantages within supply chains. Such as automatically controlled pulling data without human interference suggests rapid elaboration, more precise inventory documentation, and progressive transportation notifications. Thereby, commodity shortening, transaction mistakes, demands for compensation, misplacement of goods, and inaccurate goods identification can all be lessened. Furthermore, unscrupulous visibility of the output streams, specifically, ensures customers with the correct amount of product at the proper time whereas reducing cushion stock and the chance of reserve depletion.

However, the initiation of RFID appliances represents a plurality of substantial challenges. Constraining factors to adaptation, such as, emerge in conjunction with the lack of worldwide standards and procedures, safety and discretion apprehensions, and reduced read precision in settings with liquids or metals. Especially, the high expenses of realization constantly constrain the assimilation of RFID networks in supply chain system, notably with consideration for the ambiguous investments payback (Gale et al. 2005).

The feasible actualization of RFID-enabled inventory management networks is quite problematic. Initially, storekeepers have to decide structure and design of appliance, which will be utilized, and the items to be tagged. The expenses for RFID tags can change according to their operating standards, with common rebroadcasting transmitter tags being considerably cheap than more sophisticated tags with embedded data storage medium and transducers (Thiesse & Buckel 2015).

In several systems, tags attached to particular goods, while other goods depend on the recognition of whole logistical subdivision (case-level tagging). Furthermore, RFID is a wireless connection engineering and, therefore, is constrained by a few primary tangible restrictions. Specifically, metallic or liquid products can be these restrictions. The portion of detected units may be quite less than 100% of all the units in diapason of the wireless network (Thiesse & Buckel 2015).

Insufficient reading capacity can have a serious effect on the information reliability that every inventory management plan of activities relies on. In addition, outer causes have to be considered when selecting a certain plan of activities. There are various factors, which can influence the RFID tags efficiency, such as unpredicted inaccuracies, improper placement of goods and information error from supplier or retailer. Overall, there is a variety of potential RFID integrations for restocking, inventory control, and warehousing, which efficiency features may vary largely (Gale et al. 2005).

RFID and WSN in warehouse activities.

A warehouse is a vital compound, which connects the manufacturing process with allocation facilities. Moreover, it is known that most of the warehouse processes can be laborious and input consuming. Therefore, the efficiency of these processes not only influences the capacity and working expenditures of a warehouse but as well, the entire SC. Consequently, it is significant to develop a more sophisticated network, which will control and monitor the major processes in a warehouse. Particularly, the integration of RFID and WSN can be considered as a feasible approach.

There is an existing warehouse management network, which role is to gather information of warehouse processes towards identifying and handling different issues in a warehouse. Notwithstanding, the modern WMNs are inefficient of ensuring precisely and promptly warehouse procedures data since they are unable to provide real-time and intelligent information derivation. Therefore, the network depends on human activities, which insert strategic data by hand and that can lead to human errors (Poon, Choya, Chow, Lau, Chan & Ho 2009).

Warehouse activities are important in the SCM scope. Due to their processes, they direct volatile market situation and the ambiguity of manufacture and demand instability. In addition, warehouse activities can stand to gain shipping and manufacture efficiency. Moreover, they can provide large shipment acquisitions to lower supply expenses; warehouses establish a substantial connection among suppliers and clients by vanquishing long distances between them, providing the service of the acceptable customer satisfaction with the service.

Figure 12 depicts that there are a few moments to discuss throughout RFID integration into the warehouse. RFID appliances can be considered in every chosen warehouse activities and it is evident that RFID can give the potential to warehouse efficiency in terms of materials, strategic and communication-related scopes. Besides, RFID technology has both pluses and minuses; therefore, it is important to deliberate all possible failures before the implementation. The given structure varies from the RFID frameworks for other SC operations relative to its domain, as it is exceptionally concentrated on warehousing (Lim, Bahr & Leung 2013).

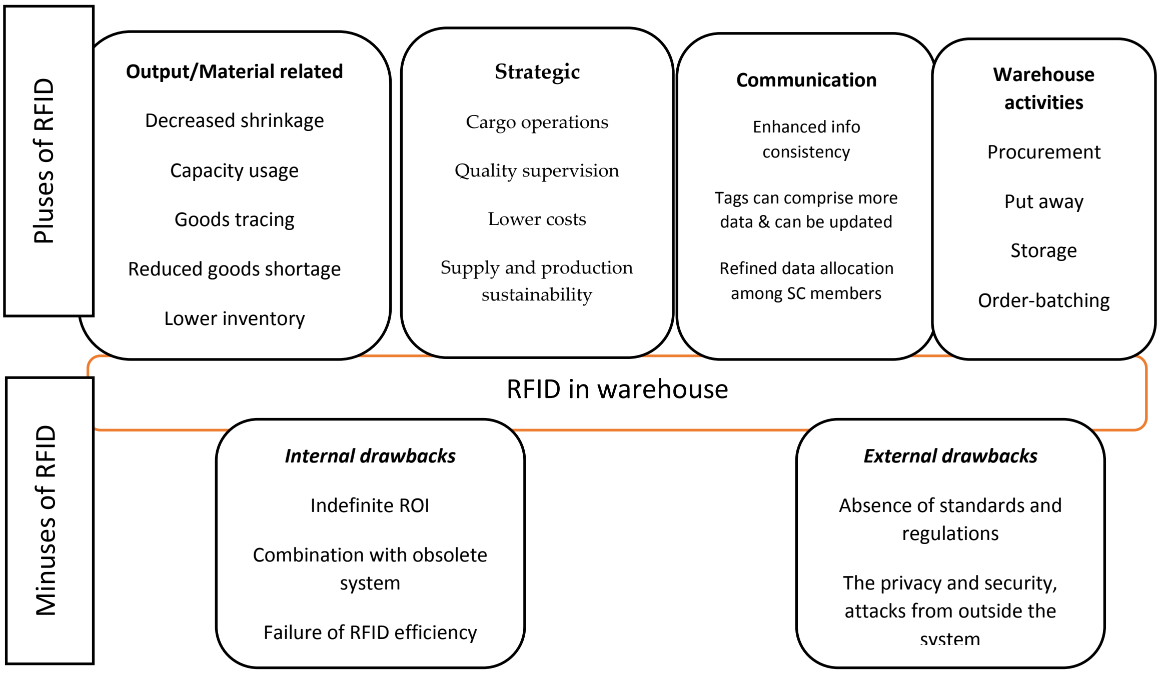


Figure 12. RFID in the warehouse framework (adapted from Lim et al., 2013).

Return on Investments (ROI) is the key feature for enterprises to think over about the integration of disruptive innovation since this can indicate their anticipation of calculable earnings. Purposely, to acquit the ROI for RFID integration in the warehouse, the enterprise need to identify the important issue for the industry that will result in higher profits. Specifically, obtaining reduced stock integrated with dense storage exploitation could uncover a perspective for extra benefits from leasing out the empty storage area. Besides, diminished job opportunities together with shortening in cargo operations can result in complementary accumulations, whereby an aftermath of degraded personnel needs (Lim et al. 2013).

The awareness of ambiguous ROI and indecision to put capital into RFID can be transformed via full assessment of the area of concern that will generate value for the majority of warehouse objectives. In addition, this process will establish a capability for scholars and SC professionals to learn novel methods for SC performance improvement, a decrease of expenses and ROI reform (Poon et al. 2009).

It is important to mention other hindrance for complete the RFID integration into warehouse facilities. The implementation of RFID into existing network and regulations is quite problematic. Therefore, most of the companies are sceptic to adopt the RFID technology. Furthermore, RFID can influence substantially on enterprise IT network and its mitigated implementation into existing network may need time for designing renewed consolidated framework with relevant information base. The assurance of definite mitigated implementation is a significant problem. Nevertheless, it has the opportunity to favor a broad scope of enterprise activities (Lim et al. 2013; Poon et al. 2009).

Due to a significant quantity of stock, the conventional warehouses engage many resources and expenses into its processes. Consequently, contemporary warehouses usually contain a low number of products from a broad diversity of inventory. In order to be convinced that inventory in a warehouse can fulfill the demand of manufacture, scheduling and monitor warehouse provision and structure are important. In addition, it is important to control implements in the warehouse in online mode, for ensuring the products are suitable for manufacture or distribution (Lim et al. 2013; Poon et al. 2009).

The WSN functions are corresponding for controlling and tracking the warehouse goods and activities. Furthermore, it is important to mention that WSN has the capability to track and display the humidity, temperature, and pressure in real time; therefore, these features generate interest among scholars and SC professionals.

The RFID reader is integrated at servicing point and allocation hub to verify the stocking rate and ensure practically real-time data of trading disposition and consumption model of diverse goods. Moreover, real-time data control has the potential to assist in reaching valid demand, supply control, and diminish the Forrester effect. Therefore, scholars obtain the rectified volume of sales data and satisfy the buyer requirements for controlling the displacements of products for allocation design. Information control emerges to be a decisive problem since it requires having appropriate information by eliminating excessive and unnecessary records. Since an immense quantity of information has been obtained, it is necessary to establish a data pool to keep and improve the information quality (Lim et al. 2013).

The RFID and WSN applications in Logistics.

According to Hedgepeth (2006), the most sophisticated installments of the cold supply chain, the temperature controlled supply chain (TSCS), are the different units of shipping, processing, and safekeeping that are not regulated by the initial manufacturer of the commodities and not controlled by the commercial user. The study supplements the conventional metrics of TCSC are expenses, handling and a sell-by date of damageable output and inability to manage temperature when goods transfer through the supply chain can have critical expenses concerning product perception, breakdown, and even the human losses.

The logistics RFID–WSN network implementation outline takes into account a producer whose is responsible for executing a recurrent requisition for its clients.

Due to the probability of potential logistics errors related to transporting the required goods from the manufacturer to its clients, RFID network with embedded sensor circuit is regarded to be integrated into the manufacturer SC for purposes of controlling the forwarded goods during shipping.

There will be always the potential risks of damaged or defected goods, which lead to high expenses and loses in terms of business activities. In addition, it results in customers' dissatisfaction with the logistics service, but the RFID–WSN network implementation outline takes into account a quantity of RFID-used verification posts are to be fulfilled within the shipping road from the manufacturer to its clients, as represented in Figure 13 (Mejjaouli & Babiceanu 2015).

The function of the RFID-used verification posts is to inspect the current records kept on the RFID tags and monitor the condition of data associated with the shipped goods that are transmitted to the RFID tags by the sensor network developed to control the goods condition and positioning.

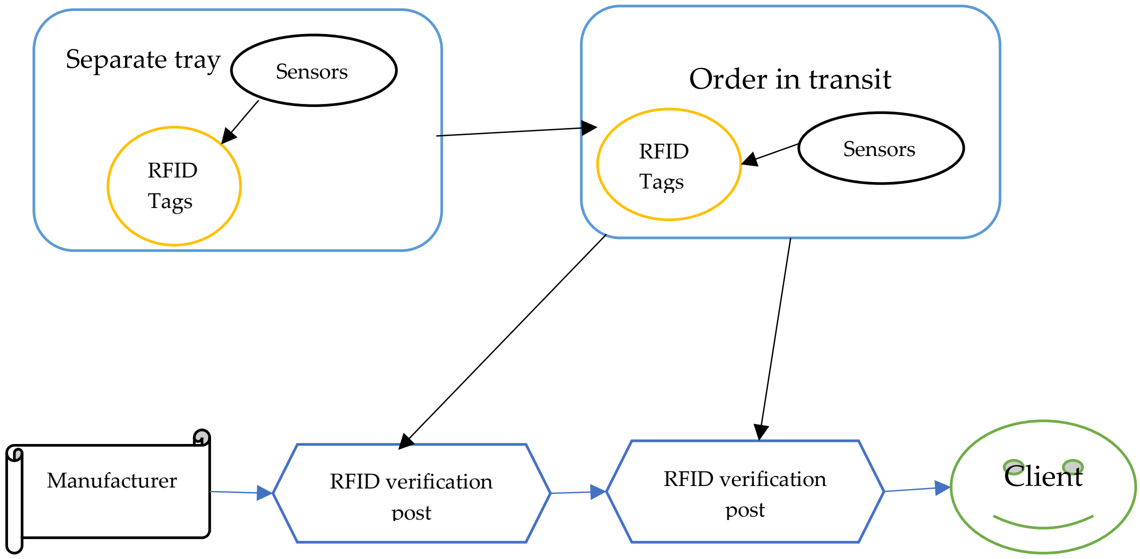


Figure 13. Design of the anticipated logistics RFID–WSN system (adapted from Mejjaouli & Babiceanu 2015).

The RFID technology implementation in industries is common in many academic papers, and it is known as successful technology integration. Moreover, the realization of WSN appliances repeatedly assured the refined processes or engineering potentials. There is a vast possibility to combine the RFID and WSN together in order to improve logistics activities, such as solving problems when it comes to material handling, shipping, information errors and goods losses.

The WSN displays the goods, which are transported in separate RFID-tagged trays. The information registered by the WSN is transmitted to the RFID tags and checked within the transportation track. This application can help with the management of damaged and defected goods; therefore, reduce the shipping expenses of damaged goods. In a few years, the use of RFID tags on transport items will be a standard in logistics. It is a logical step to use these available tags for sensor configuration. There is a great challenge in modern logistics to broaden tracking and tracing through extensive sensor facilities (Mejjaouli & Babiceanu 2015).

3.2. Evaluating the integration of Artificial Intelligence applications in Supply Chain Management.

The AI transforms SC operation into algorithms to display the whole working process. The AI programs are effective in various instances, like detecting failures in the manufacture operation and establishing the appropriate methods to facilitate failures. In addition, AI can also elaborate information from different strategic perspectives, specifically, fiscal data and supervision system (Min & Zhou 2002).

By virtue of the employment of AI in SC, enterprises can set a flexible SC, conferring the possibility to foresee and manage business ambiguity and collapses. Therefore, the utilization AI programs in SC will likewise lead to the development of a framework. The framework will contain an uninterrupted stream of goods and intelligence management from one terminal destination to the other of the worldwide SC process.

It is essential for SC members to familiarize with the augmented information databases and computerize the SC resolving operational issues. Therefore, AI has been advanced by way of an applicable problem-solving method. It assists the company to correspond with the clients, providers, and SC members by promoting data interaction between different commercial organizations throughout the SC. Moreover, AI make it possible to convert physical data to digital form, thus make information flow more efficient for SC activities.

Due to emergent deployments of AI in the SCM, AI has not been entirely utilized to handle SC issues. The main reason for this can be that the issues are too expensive and sophisticated to resolve. Nevertheless, several contemporary AI studies have demonstrated the substantial opportunity of AI methods for applying different types of versatile but operational problems such as; customer relationship management, procurement dealings, operational alignments between SC members, SC reconciliations, joint inquiry scheduling, and B2B agreements that have frequently been unexploited by more conventional analytical applications (Min & Zhou 2002).

The fundamental argument of the insufficiency of AI technology in the SCM scope can be the comparative immaturity and large domain of the SCM subject. Due to the AI dependence on computer software programs, it may cause incorrect results, when it is programmed inaccurately. AI methods can be difficult to realize, as they are so unclear and sophisticated for conventional problem-solving paradigms to perceive. Whilst AI commonly performs properly for definite, precisely concentrated on SC challenges, AI may not operate fully for controlling risk and ambiguity implicated in ubiquitous and international SC settlement scope by virtue of its accumulation of knowledge concerns (Min 2010).

It is essential to mention some benefits of AI implementation into SCM. For example, AI can be combined with a current functional network of different SC members without interrupting data stream within the SC. In addition, AI methods can be used for the real-time system of prices and return selling comprising SC members. Machine learning can be studied onwards to direct the assessment and adoption challenges of exterior suppliers (Min & Zhou 2002).

Machine-learning applications.

The primary opportunity of integrating IoT and machine-learning applications together is the efficiency of processing big data. Due to machine learning applications ability to familiarize with data and get sufficient knowledge from IoT devices, it is a great potential to improve both technologies. In addition, machine-learning methods could help IoT applications to enhance the security and privacy management, complemented by machine learning capability to analyze data stream, it may find the suitable way to solve the IoT security and privacy issues.

Nowadays, there is a variety of machine-learning tools and applications, which can be utilized by every professional programmer or data scientist. The machine-learning programs can be freely downloaded from the Internet, so there is no hindrance for the companies to utilize it. However, the professionals in AI expert systems and applications will be required to adopt the machine-learning programs. In addition, the coding of specific tasks for the machine-learning applications is a sophisticated process; therefore, it will require substantial resources from the company (Louridas and Ebert 2016). Table 8 identifies several well-known machine-learning applications.

Table 6. Several common machine-learning applications (adapted from Louridas and Ebert 2016).

	Python	R	Spark	Matlab	TensorFlow
License	Public domain	Public domain	Public domain	Licensed	Public domain
Distributed	No	No	Yes	No	No

Visualization	Yes	Yes	No	Yes	No
Neural Network	Yes	Yes	Multistage perception classification code	Yes	Yes
Supported languages	Python	R	Scala, Java, Python and R	Matlab	Python and C++
Diversity of machine-learning patterns	High	High	Medium	High	Low
Fitness for a main objective application	High	Medium	Medium	High	Low
Development	High	Very high	Medium	Very high	Low

It is not enough to know how to use only one of the presented machine-learning applications. If the company intends to integrate the machine-learning tools into its SCM system, it needs to acquire at least two machine-learning applications. The reason for this is the sophisticated nature of SCM and not every machine-learning application can be suitable for diverse SCM activities. In addition, the main issue with integrating the machine-learning applications into the legacy system of the company is substantial expenses. Therefore, it is important to evaluate the possible failures before acquiring the machine-learning programs (Louridas & Ebert 2016).

According to Louridas and Ebert (2016), R is in a great demand from individuals with some statistical premises to work with this tool. It has a substantial cluster of machine-learning and statistical-derivation learning resource center.

However, Python is more common for individuals with an informatics prerequisite. Notwithstanding, it is not programmed particularly for machine learning or statistics, Python has comprehensive data collection center for numerical computing (NumPy), scientific computing (SciPy), statistics (StatsModels), and machine learning (scikit-learn). These are substantial cases of C code, so you get Python's convenience with C's rate. Moreover, in machine learning, initially, a data processor inquires to realize a problem by learning from the examples or patterns. The data processor does the same assignment with information it has not interfered before (Louridas & Ebert 2016).

The various machine-learning techniques and algorithms can be applied to IoT, in order to analyze the data, which is obtained from smart devices or sensors. For example, the linear regression can be used to forecast in real time the principles and taxonomy of consistent information. The main goal of this approach used in algorithms is to develop and practice data in a rapid rate (Mahdavinejad, Rezvan, Barekatain, Adibi, Barnaghi and Sheth 2017).

In addition, neural networks are used to forecast the class of data and proximity issues. Due to the high accuracy of intelligent data and it is a complex process to train data, thus it is required to use the multi-class neural network. It is evident that machine-learning methods can be useful for IoT technologies, in a way that it can forecast and compute different problems (Mahdavinejad et al. 2017).

Fuzzy logic.

Another method to SCM effectiveness is the employment of fuzzy logic derivation principles to construct a prognosis pattern that forecasts outcomes of

SC lagging input parameters based on leading metrics and if-then outline. Unahabhokha, Platts & Tan (2007) suggested the fuzzy expert system, which task is to develop a predictive efficiency computational system that obtains forecast output values from input values. A method like this can be utilized to establish objectives on leading measures ground on forecasting of the effectiveness of outcomes.

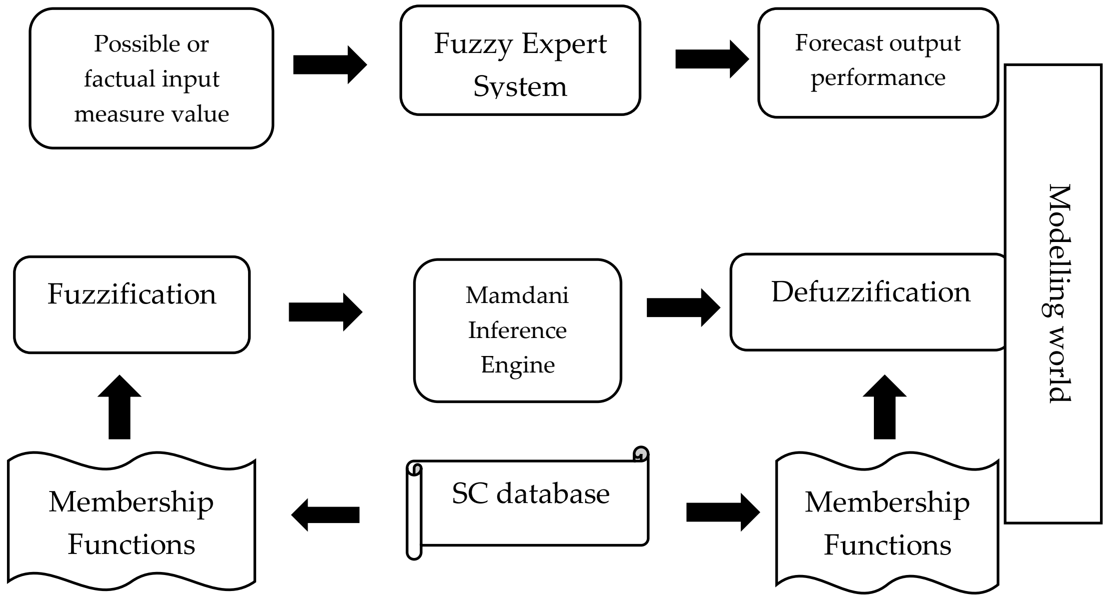


Figure 14. Predictive SC performance measurement (adapted from Ganga & Carpinetti 2011).

The figure above shows a feasible model for the SC performance measurement based on the fuzzy logic. This model requires the data exchange from the real world in order to create the modeling dimension; as a result, the fuzzy logic expert system is able to forecast the SC operating outputs (Ganga & Carpinetti 2011).

There is a substantial potential for integrating the fuzzy logic algorithms patterns into SCM in order to forecast possible outcomes of SC activities. In addition, the fuzzy logic is able to provide the prognosis of the SC effectiveness in different process stages and this information can be used and analyzed by SC managers.

Artificial Neural Network.

According to Chiu and Lin (2004), the SC system is divided into several ANNs in a manner that the virtual client demands and the agents' objectives and limitations are combined in various phases. Specifically, three ANNs, the SC net the manufacture net and the transportation net, are utilized. In the initial phase, the ANN computing pattern is used to outline the supply items to the clients' arrangements. The second phase is to distribute the manufacture items to the clients' arrangements obtained by every supply agent. The conclusive phase is to appoint the transportation associate for the supply and manufacture agents, thus corresponding SC path is established to meet the clients demands with minor working expenditures.

According to the research conducted by Chiu and Lin (2004), the utilization of ANN method for a general supply planning of SC system appears to be efficient. The SC system that performs a custom specific assembly structure has the substantial advantage of removing the requirements for manufacture stock on grounds of a variety of reconciliation strategy. Furthermore, in order to enhance the supply planning, the ANN method was used to balance the agents' availability and strategic accumulations. By way of an improvement, the agent-oriented SC layout and the ANN method elaborated one another to perform a plain computational pattern for displaying the stock, manufacture and transportation activities to the clients' arrangements. Moreover, this computational pattern permits the splitting of an aggregated issue into more insignificant limited sub-issues that can be worked out simply. Hence, this ANN approach can help SC managers to handle a great amount of orders and SC activities.

3.3. The role of 5G Network in the Internet of Things and Artificial Intelligence.

The opportunity for 5G Network advent is growing every year and after the final appearance of 5G, there will be commercialization steps, in order to integrate completely 5G Network into the newest technologies. The initial fundamental progress in the highest peak data rate, which should be between 1 and 10 Gbps. The primary goal of 5G is to maintain successfully the IoT and AI technologies and in this case is the sensors and the connectivity speed.

The features of 5G comprise a variety of essential aspects, such as:

– intelligent radio network: antennas which can run with various coding methods, and virtually in any RF;

– small cells aid to substantially enhance data communication frequency by reutilizing the accessible frequencies;

– software-based method, utilizing virtualization: this technique is extensively utilized with this novel technologies;

- software-enabled radio and networking;

- seamless integrating of broad-range networks;

– multiservice access, multiple addressing (Pujolle 2015).

Design considerations for a 5G network architecture.

5G will be capable maintain in an efficient manner a broad variety of appliances. Moreover, with the anticipated growth of M2M connection, particular devices may require maintaining 10 000 or more low-speed appliances in conjunction with its conventional high-speed mobile subscriber. In addition, this will demand large-scale sales adjustments to the level of management and network control interdependent with 4G, which high capacity sources and finite automation are not made for more variety and broader user base (López, Caraguay, Monge & Villalba 2016).

It is problematic to introduce a very new technology to the market due to the complexity of production estimation and standardization process. In addition, it is important to mention that 5G network is a disruptive technology; therefore, it creates the substantial obstacles for companies to integrate it into their legacy systems. Thus, 5G needs more time to be introduced and understood fully by the mobile network companies.

There is an outline of the 5G network structure, its enablers and necessary procedures to launch this technology. However, the most important feature of 5G is that it has the potential to uncover fully the IoT and AI functionalities.

In particular, it can enhance radio feasibilities, which enable the range enhancement, increase radio disturbance adjustments and maintain functional radio configuration. This operates in higher periodicity, allowing economically viable deployments, smart and functional adjustments of Radio Access Technology (RAT) (López et al. 2016).

It is apparent that 5G radio approach will be an essential prerequisite for IoT, allowing humans and devices to reach the best performance and innovative capacity.

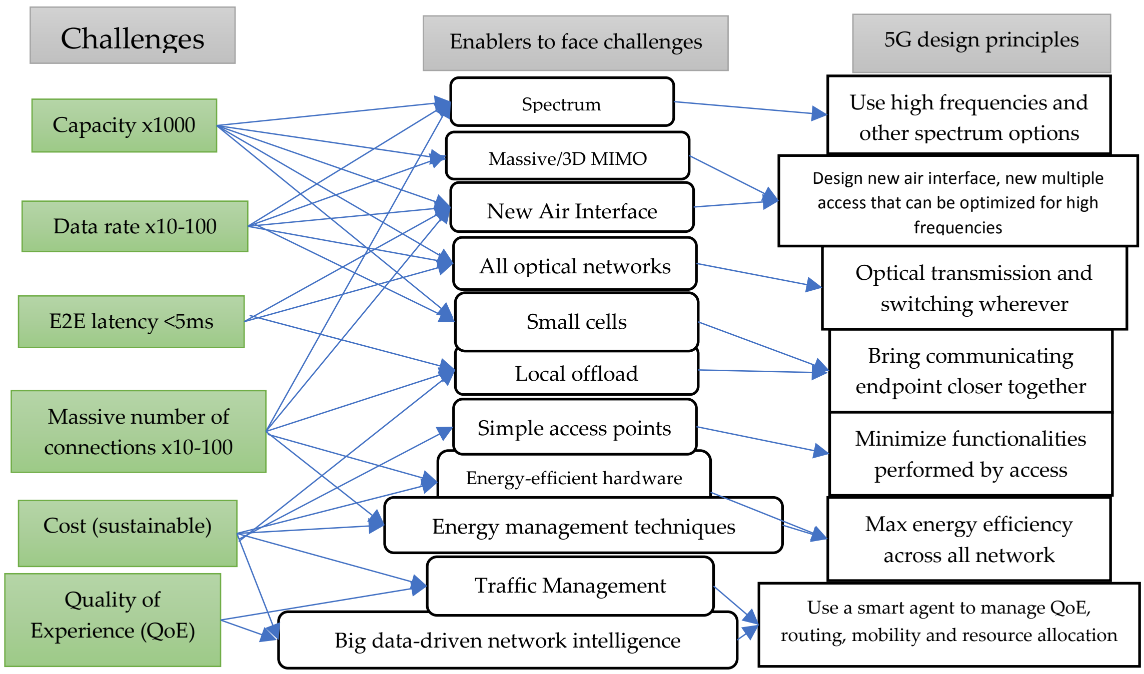
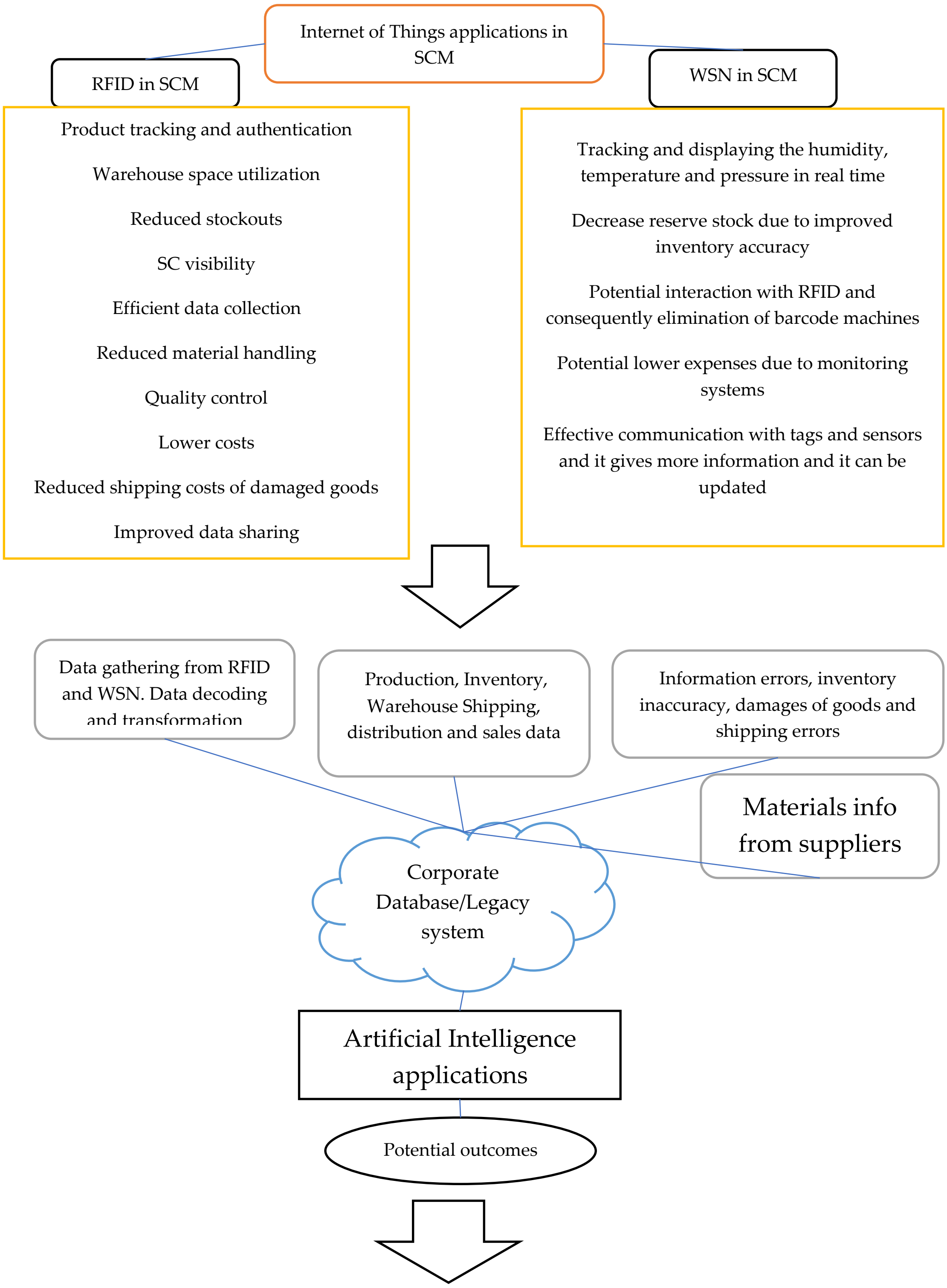


Figure 15. 5G challenges, potential enablers, and design principles (adapted from Agyapong, Staehle, Kiess, & Benjebbour 2014).

5G radio approach is being elaborated with three potential utilization scenarios: enhanced mobile broadband (eMBB), massive machine-type communications (mMTC) and ultra-reliable low-latency communications (URLLC). eMBB concentrates on a comprehensive improvement to the data communications frequency, response time, recipient consistency, output and scale of mobile wideranging access. mMTC is made to permit connection between appliances that are cheap, great in quantity and battery-powered, which deliberated to maintain mobile or machine applications like smart metering, logistics planning, and sensors networks. Conclusively, URLLC will allow appliances and computers to interact with extra high reliability, ultra-low response time and supreme accessibility, making it possible for automobile communication, industrial control, factory automation, remote surgery, smart grids and community security supplements. The preoperational phase of 5G will probably demand the variety of system of procedures and policies. Various spheres comprise definite assets with apparent functions and necessary conditions for cooperation (Zaidi Baldemair, Andersson, Faxér, Molés-Cases & Wang 2017).

3.4. Summary of the conceptual framework of Internet of Things and Artificial Intelligence in Supply Chain Management.

The proposed framework helps to uncover the full potential of IoT and AI technologies through utilizing the 5G Network. Moreover, the efficiency of SC operations can be improved drastically through combining three sophisticated technologies in one framework.



Internet of Things applications in SCM
RFID in SCM
WSN in SCM
Product tracking and authentication
Warehouse space utilization
Reduced stockouts
SC visibility
Efficient data collection
Reduced material handling
Quality control
Lower costs
Reduced shipping costs of damaged goods
Improved data sharing
Tracking and displaying the humidity, temperature and pressure in real time
Decrease reserve stock due to improved inventory accuracy
Potential interaction with RFID and consequently elimination of barcode machines
Potential lower expenses due to monitoring systems
Effective communication with tags and sensors and it gives more information and it can be updated
Data gathering from RFID and WSN. Data decoding and transformation
Production, Inventory, Warehouse Shipping, distribution and sales data
Information errors, inventory inaccuracy, damages of goods and shipping errors
Materials info from suppliers
Corporate Database/Legacy system
Artificial Intelligence applications
Potential outcomes

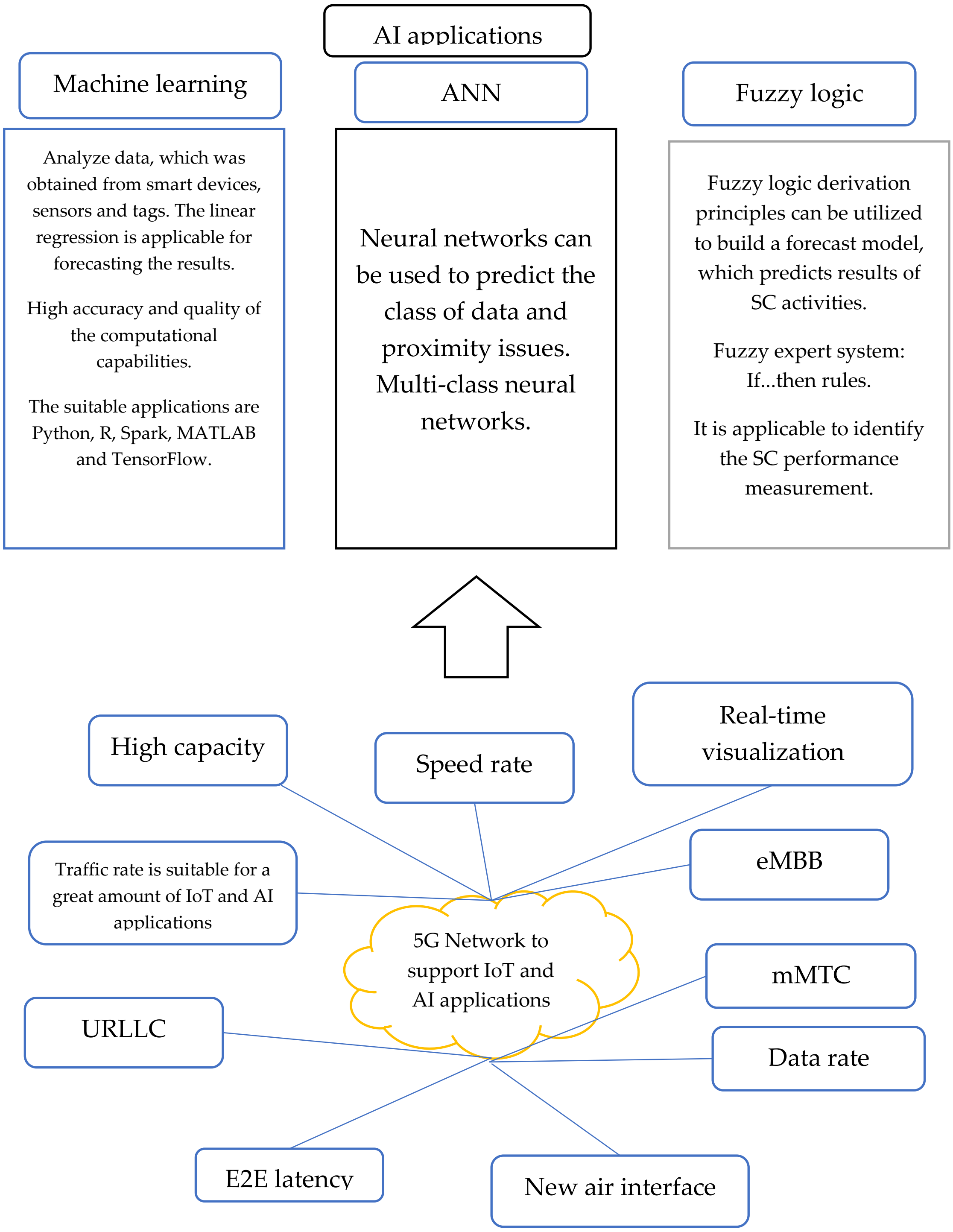


Figure 16. The detailed description of each technology, which involved in the conceptual framework.

The main idea of this conceptual framework is to create a suitable approach of analyzing SCM data, which was obtained from IoT technologies. It is important to highlight the significance of AI applications in this framework. Thus, all the data received from warehouse, logistics and inventory activities through RFID and WSN is stored and observed in company's electronic database. Then, AI applications receive all the necessary information from electronic database in order to compute the feasible inaccuracies in SC operations. In addition, 5G Network and cloud computing are playing essential roles in providing the needed connectivity and delivering the processing capacity to AI and IoT operations.

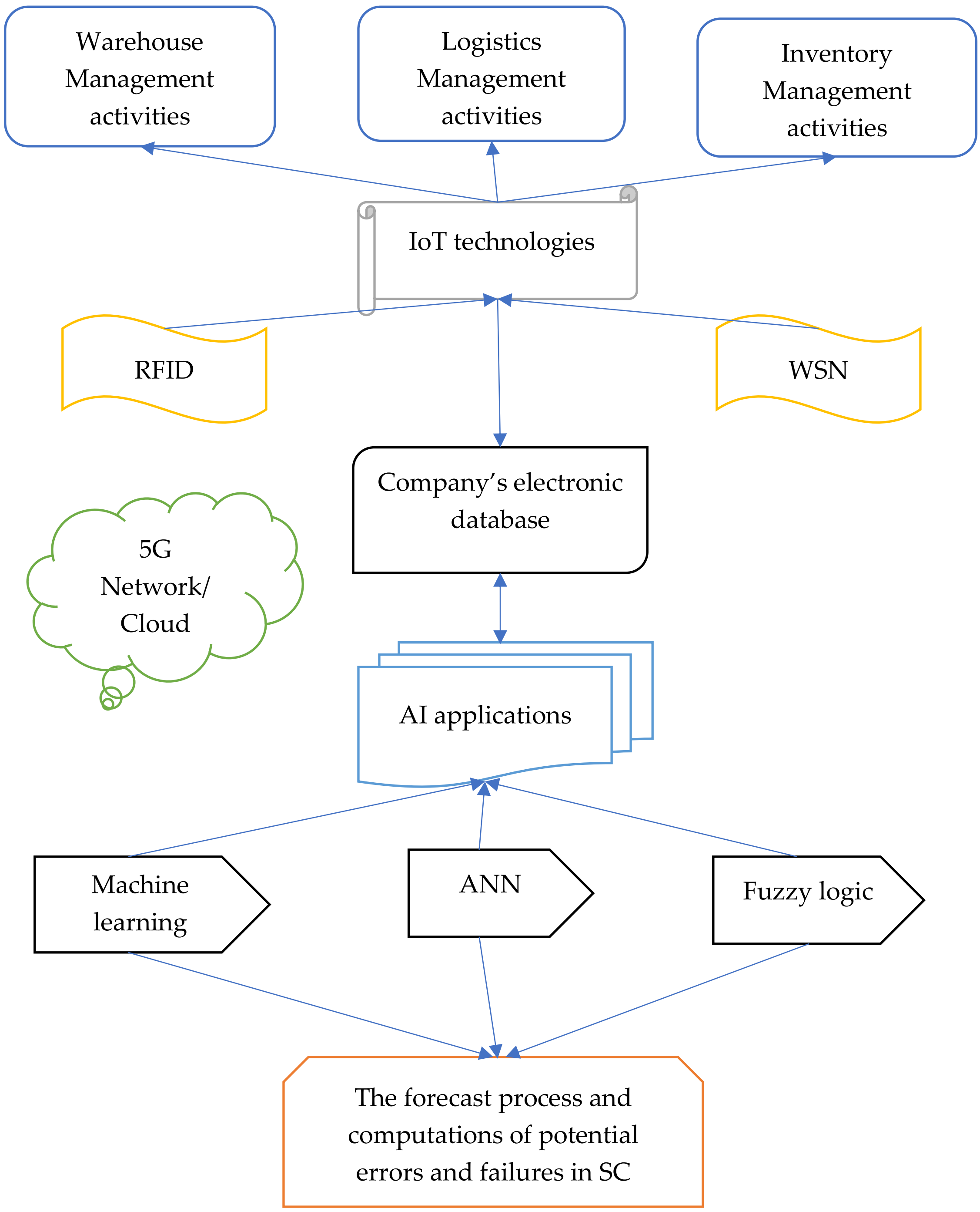


Figure 17. The conceptual framework of IoT and AI in the SCM.

4. METHODOLOGY

This chapter deliberates methods utilized to gather and examine empirical data that are the foundation of the primary statements and derivations of this research. The chapter is separated into different parts, which are research process and research design, qualitative and quantitative research, online questionnaire, data collection and analysis, reliability and validity of the study.

4.1. Research process and research design.

The academic study can be considered as rigorous systematic attempts to explore and reorganize the theories and implementations. Research methods represent the techniques to solve the research problem. This study require both qualitative and quantitative research methods. The online questionnaire comprises open-ended and Likert scale data questions, therefore the mixed research methods are applied to this study. By utilizing qualitative methodology, a researcher is going to control the predetermined conceptions and contemplate the research process, investigating the problems from a comprehensive outlook.

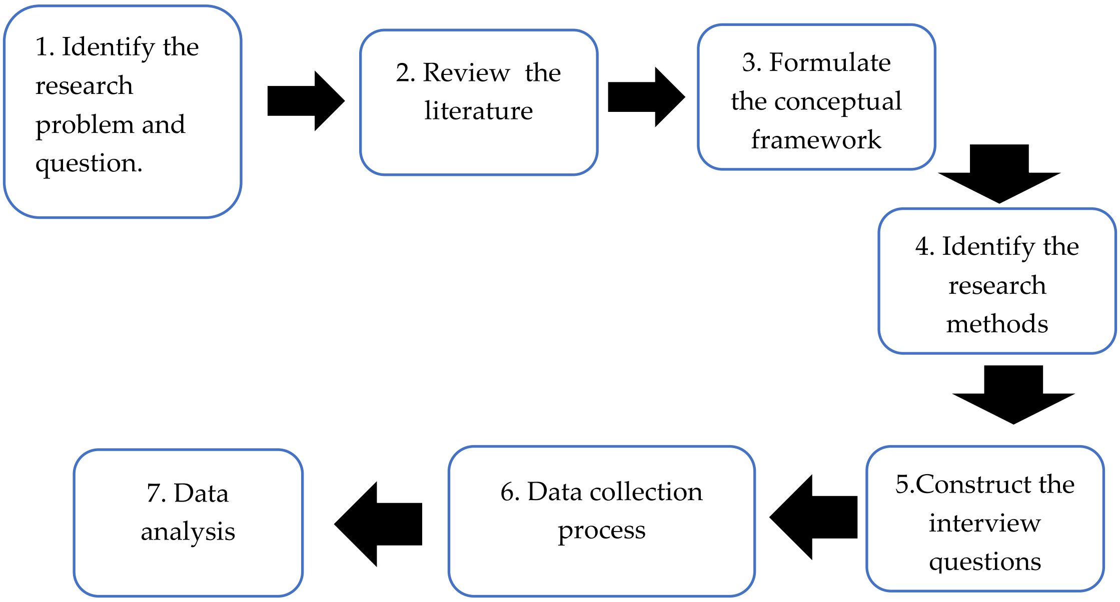


Figure 18. Research process.

Due to the novelty of the research topic, an exploratory design is applied in this study. Specifically, the exploratory design is carried out about a study problem when there are few or no earlier research to allude to or have a reliance on to forecast results. The focal point is on obtaining deeper comprehension and knowledge for subsequent research or undertaken when research problems are in a preparatory phase of the study (University of Southern California 2018).

In addition, a descriptive research design is complemented to the study. The utilization of descriptive method assists in elaborating the matter of 'what' and gives a precise specification of an event or process (Burns and Bush 2000).

Exploratory research is versatile and can handle research questions of any kind and this research design is a beneficial method for acquiring premises on a specific subject. In addition, exploratory research design allows explaining current ideas, as well as elaborating more accurate research problems.

Moreover, this research uses small sample scales and, therefore, results are not generalizable to the population at a significant rate and it is another reason why exploratory design is suitable for this study.

4.2. Qualitative and quantitative methodologies.

Qualitative method.

Qualitative studies frequently utilize a deliberated or purposeful sampling when choosing candidates for interview, since the specimen has purposefully opted in pursuance of the objective of the research. In the online questionnaire, a researcher creates deliberated specimen relying on the incentive for arranging the interviews via the website or email, the chosen information and communication technology, and the intended participants. Shaping factor of specimen permits the scholar to indicate the features that render as the foundation to choose a proper target group (Salmons 2010: 106).

Online questionnaires are utilized for Internet-mediated research (IMR); they are employed to collect primary records via the World Wide Web with the goal of introducing them to study to ensure current data regarding a certain research matter (Hewson, 2010). For this study, the semi-structured online questionnaire was created using the Google form. The online questionnaire was sent to the top managers from various fields and backgrounds.

The goal of qualitative research is not solely to characterize the records but the most substantial actions are the study, explanation, and derivation of the obtained information.

Quantitative method.

The quantitative study is a method for testing an objective hypothesis by investigating the connection between variables. Alternately, these variables can be computed by a specific device, so that quantified records can be studied by utilizing statistical methods (Creswell 2014). Quantitative research administers external norms: outcomes are converted and examined as quantified values, whereas qualitative records are studied by employing the phraseology or behavior of the answerers.

Quantitative method is inclined in the direction of the numerical values. Likely, the most significant feature of this approach is that it summarizes the primary records. Simply put, this method lets scholars to obtain data from fractional factors, systematize it, and, transfer it to a focal clause of computation (Maggie & Andersen 2013).

Table 7. Qualitative and quantitative methods (adapted from Ghauri & Grønhaug 2005).

Qualitative Methodology	Quantitative Methodology
Concentrating on understanding	Concentrating on testing and verification
Focus on understanding from respondent's /informant's point of view	Focus on facts and/or reasons for social events
Explanation and consistent approach	Logical and critical approach
Observations and measurements in natural settings	Meticulous measurement
Subjective 'insider view' and closeness to data	Objective 'outsider view' distant from data
Explorative orientation	Hypothetical-deductive; focus on hypothesis testing
Process oriented	Outcome-oriented

Holistic perception	Particularistic and systematic
Generalization by comparison of properties and contexts of one person	Generalization by population involvement
Based on meaning expressed	Based on meaning derived from numbers
Collection results in non-standardized data requiring classification into categories	Collection results in numerical and standardized data
Analysis conducted through the use of conceptualization	Analysis conducted through the use of diagrams and statistics

The combination of quantitative and qualitative records in the format of mixed methods research has considerable opportunity to enhance the accuracy and improve the study outcomes. By choosing the mixed approach framework that completely corresponds to the assessment's subject, the researcher can contribute significant knowledge about the challenges and opportunities of IoT and AI in the SCM. Moreover, mixed research techniques are mainly beneficial in comprehending variances among quantitative outcomes and qualitative findings.

Online questionnaire approach.

The main source of data gathering for this study was a semi-structured online questionnaire, which was sent to the top managers from various field and backgrounds. Concentrating on an online questionnaire as the primary approach for obtaining new information serves three objectives. First, the online questionnaire can obtain valuable data from practitioners about the usefulness of the IoT and AI in the SCM. Second, due to the novelty of the research topic, it is important to know managers' opinion about the integration of IoT and AI applications into the SCM. Finally, managers can help to answer the research question: *"What are the key challenges and opportunities of introducing AI and IoT applications into the Supply Chain Management?"*

The online questionnaire approach was selected due to the high accessibility, flexibility, and inexpensiveness. In addition, the online questionnaire was sent to the top managers via email.

4.3. Data collection.

The data for this research was collected by conducting online interviews with top managers and workers in fields of SCM, Information Technology, Engineering, and Business Administration. The online questionnaire was sent to different companies, which were located mostly in Europe and Central Asia.

In this research, the content analysis was applied in order to create displayable and reasonable conclusion by interpreting and classifying textual data. By consistently assessing words, qualitative records can be transformed into quantitative data.

Terry College of Business of the University of Georgia explains content analysis as a research method, which permits scholars to retrieve and study the variations of organizational behaviors, intermediary comprehension, and social tendencies. In addition, it has a substantial connection between quantitative and qualitative study approaches.

If carrying out an exploratory research in the scope where not much is studied, content analysis may be appropriate for the plain indication of general problems mentioned in data (Green & Thorogood 2004).

Notwithstanding that, the content analysis is usually deliberated as the most basic research technique; this does not indicate that it inevitably generates elementary and low-quality results. Alternatively stated, it is feasible that primary themes/categories may not be directly obvious, however, the scholar has to be reflective, often contemplate the records from various outlooks, and comply with the phases of data analysis (DeSantis & Noel Ugarriza 2000).

Due to the novelty of this study and the creation of the new conceptual framework, an inductive content analysis was used in this research. The inductive content analysis is utilized in cases where there are no earlier academic studies dealing with the phenomenon, and thus the coded classifications are retrieved from the text records (Hsieh & Shannon, 2005).

4.4. Data analysis and research results.

Interviewees' background information.

In Table 8, the interviewees' background information is presented in order to show a job profile of eight interviewed managers. It was decided to involve different managers from various industries in order to obtain a better comprehension of the challenges and opportunities of IoT and AI in the SCM. In addition, it was important to receive a professional opinion about the possibility of integrating the IoT and AI into the SCM in their companies.

The managers were selected according to their experience and the industry they work in. The online questionnaire was sent to overall fifteen managers, however, due to the personal reasons and restrictions from the companies' authority, only eight managers have replied to the questionnaire. Some of the managers needed to ask permission for the online interview from the company's authority, so they do not violate the rules or disclose sensitive information.

The online questionnaire consists of the background information sections and nine questions related to IoT and AI applications in the SCM.

Table 8. Interviewees' background information.

Interviewee	Industry description	Years of experience	Country
QC Manager	This company delivers combined services of multidisciplinary development and control of projects, primarily in the power, oil & gas and petrochemical industries.	24 years	Italy
Sales Manager	This Japanese company manufactures cars,	2 years	Kazakhstan

	boats, marine engines and other industrial equipment.		
Area Manager	Finnish logistics company	20 years	Finland
Director of Investment Support	Finnish forest company.	30 years	Finland
Design Manager	A Finnish company, which manufactures and services the generators and other types of machinery in the marine and energy market.	18 years	Finland
Lead Risk Manager	House construction savings bank.	22 years	Kazakhstan
SCM Manager	Freelance	18 years	England
QA/QC Manager and Lead External Auditor	Freelance	25 years	Kazakhstan

The key challenges and opportunities of introducing AI and IoT applications into the Supply Chain Management.

The primary research question that was addressed by this study: *"What are the key challenges and opportunities of introducing AI and IoT applications into the Supply Chain Management?"*

When the top managers were asked the question about opportunities of introducing IoT and AI to SCM, some of them gave comprehensive answers and some managers were not sure how to answer this question.

"I think the biggest opportunity of integrating IoT is to provide the enhanced visibility of global supply chain. Due to that project supply chain is becoming more sophisticated and IoT can help managers with ensuring the automated data collection process. I think AI is more for the mediated tool, which can handle the huge amount of data that is coming from RFID tags and sensors." – QA/QC Manager and Lead External Auditor.

"Improvement of quality and efficiency of the SCM processes and deeper integration of SCM into manufacturing processes." – Design Manager.

"Zero. Government-owned companies are very inefficient and crippled with bureaucracy." - Lead Risk Manager.

"Improve production planning, give better customer service and faster responses in SCM"- Director of Investment Support.

"Better real-time management and information for transport "masses" and availability trucks etc." – Area Manager.

"All people can know what is happening in other places at work"- QC Manager.

From obtained interview data about the opportunities of integrating IoT and AI into SCM, it can be seen that majority of managers highlighted the potential of these systems, especially constant visibility and traceability of the SC. However, the manager from Kazakhstan identified that companies cannot integrate such systems due to the bureaucracy; therefore, it can be considered as one of the challenges of integrating IoT and AI specifically in Kazakhstan or other developing countries.

For the question, *"what are the challenges of integrating IoT and AI into the SCM in your company?"* only one manager did not answer. The rest of the managers gave in-depth and explicit answers.

> *"Basically, the IoT has some security and privacy issues. Also, the installation costs are high but I think companies need to consider the expenses as the long-term investments."- QA/QC Manager and Lead External Auditor.*
>
> *"Human and financial resources." - Sales Manager.*
>
> *"Starting cost is challenging when we are not sure does it give us real benefits in future. And of course find time and money to do this kind of implementation." - Area Manager.*
>
> *"IoT service and systems are still quite primitive and infrastructure is expensive to build. The biggest problem is change thinking and working methods in present systems." - Director of Investment Support.*

"Baselining, identifying primary targets and roadmap, strategy and its integration in the overall company strategy, implementation and renewal of infrastructures" - Design Manager.

"No challenges"- Lead Risk Manager.

"Hacking and sophisticated targeted piracy is an increasingly dangerous threat to the shipping industry"- SCM Manager.

It is evident that majority of managers think that financial and privacy issues are the key challenges for integrating IoT and AI systems into SCM. Hence, some of the managers do not want to take such risks and hope that the IoT and AI implementations will make an investment income. It was mentioned that IoT and AI infrastructures are still under the early developing stage and need more time for the advancement. Moreover, it is a time-consuming process in terms of changing the people's mentality towards such disruptive technologies.

The integration of IoT and AI in the SCM.

To the question, *"does your company have Internet of Things (IoT) and Artificial Intelligence (AI) applications integrated into the Supply Chain Management (SCM)?"*, two managers answered, "yes", four replied, "no", one answered "n/a", and one manager answered "other". QA/QC Manager and Lead External Auditor specified the option by answering:

"I am currently working as a freelance but I can say that most of the big oil and gas service companies have the RFID integrated into their SCM. But I am not sure about AI applications."- QA/QC Manager and Lead External Auditor.

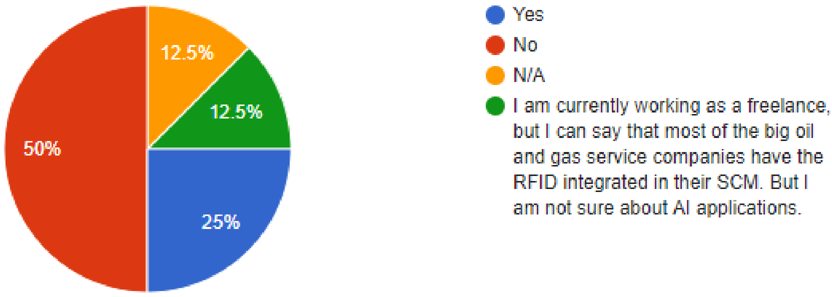


Figure 19. The IoT and AI applications in the SCM.

When the question, *"is your company willing to integrate IoT and AI applications in the near future?"* was asked, three managers answered "yes", one replied "no" and three others chose option "n/a".

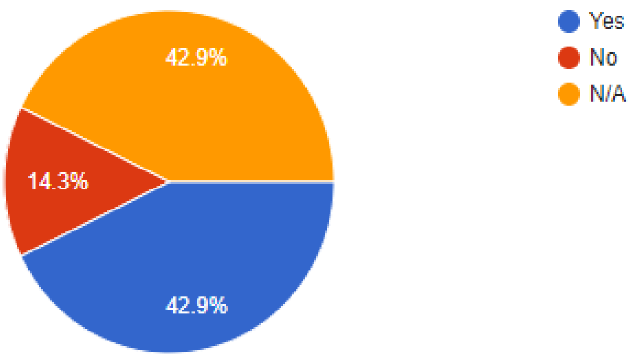


Figure 20. The willingness to integrate IoT and AI applications.

To the question, *"do you agree that it is possible to implement the IoT technologies in your company, in particular, Radio Frequency Identification (RFID) and Wireless Sensor Network (WSN) into SC?"* six managers answered "strongly agree" and two managers chose the option "agree".

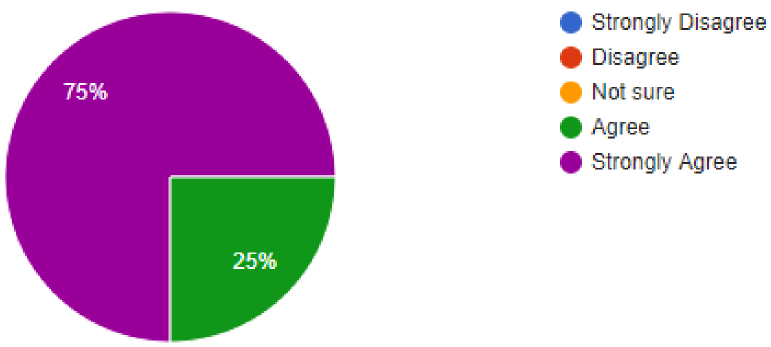


Figure 21. Radio Frequency Identification (RFID) and Wireless Sensor Network (WSN) in the SC.

If the company have already implemented the IoT and AI applications, the managers were asked if they could explain the framework of the processes where IoT and AI applications are involved. Only two managers answered to this question.

> *"RFID, Warehouse logistics, Spare parts movements (while shipping)."- Sales Manager.*

> *"No such thing existing in Kazakhstani banking sector."- Lead Risk Manager.*

The question, *"how likely can IoT and AI improve the SCM in practice?"* was asked in order to obtain the information whether the managers truly believe that IoT and AI applications will bring the benefits to their company or not. From the results obtained for this question, six managers believe that it is "very likely" that IoT and AI can improve the SCM and two managers answered that it is "somewhat likely".

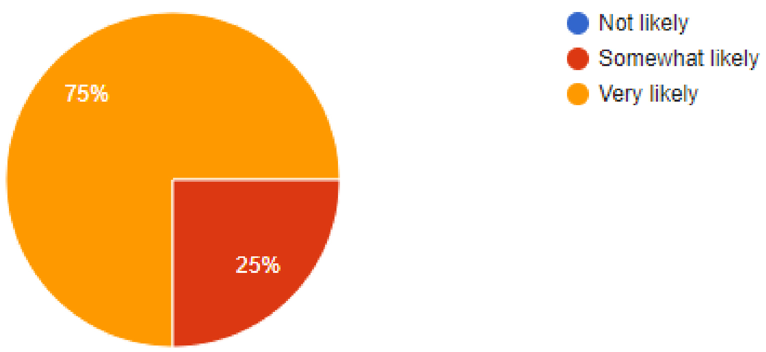


Figure 22. How likely can IoT and AI improve the SCM in practice?

It was important to ask the managers' opinion how likely are they to implement IoT and AI systems in 5 years. Specifically, four managers answered "very likely", two replied "somewhat likely" and one chose the option "other".

> *"You never know, but some elements can be adopted, thanks to competition and industry challenges." – SCM Manager.*

Figure 23. The adoption IoT and AI systems in 5 years.

Additional information.

Finally, the interviewees were asked to add comments or complementary information in order to help them reflect their explicit opinion about the IoT and AI systems in the SCM. It is essential to mention that only four managers added the concluding comments.

> *" It could change the work process totally. But it will take much effort and time to implement such tech in Kazakhstan. People are not ready." – Sales Manager.*

> *"There will be a strong need for AI experts that companies need to create new systems and applications in coming years."- Director of Investment Support.*

> *"AI for banking is applicable in marketing and reaching the customer through a variety of channels. Agile and cost-conscious banks with the accent to mobility and cyberbanking are first to grab AI opportunities. IoT in banking first suggest looking into information security issues, sensitive data leakage and things alike, and represent a serious challenge for deeply conservative managers." - Lead Risk Manager.*

> *"I can say that IoT and AI systems will be highly needed in the modern SCM. Due to the lack of tractability and the necessity of predicting the potential loses or failures in the modern SCM, leading companies will need IoT and AI integrated into their systems in the near future."- QA/QC Manager and Lead External Auditor.*

From the retrieved questionnaire outcomes, it is apparent that most of the managers are interested in these technologies and they believe that it can be implemented into the SCM and other sectors. Certainly, besides identified opportunities, the managers highlighted several obstacles, which can hinder the integration of the IoT and AI technologies in the SCM.

It is substantial to indicate that all answers were kept in original format; just a few mistypes were corrected in order to maintain the rigorousness of the study. Moreover, every managers' answer was reported in this chapter in order to keep the research as transparent as possible.

4.5. Reliability and Validity.

Evaluating the reliability of research outcomes requires scholars to render assessment about the 'correctness' of the study regarding the applicability and relevance of used approaches and the integrity of the derivations. A qualitative study is often criticized for missing scholarly accuracy with a deficient justification of the utilized technique, failing to provide transparency in the analytical activities and the individual belief expose to scholar bias. For the beginner researcher, indicating precision when conducting a qualitative study is difficult since there is no of standard agreement about the norms by which certain study should be evaluated (Sandelowski 1993; Rolfe 2006; Noble & Smith 2015).

The online questionnaire was sent to highly professional individuals who know the scopes of SCM, IoT and AI and therefore, their opinion and feedback are credible.

Several methodological strategies were applied in this study to guarantee the 'trustworthiness' of the research results. First, a personal bias of the researcher was eliminated in order to get clear and credible outcomes. No personal involvements, social stereotypes, and cultural background were involved in creating the online questionnaire and evaluating the findings. Everything was kept specific and precise in the questionnaire structure. The main reason why researcher selected the online questionnaire approach is that she could not apply her unconscious bias to the interviewee.

Second, the researcher kept scrupulous records, showing explicit conclusion notes and guaranteeing explanation of data are consistent and understandable.

Third, the comprehensive verbatim proceedings of interviewees' statements were made in order to sustain the research outcomes.

With reference to Denscombe (2003), the reliability of answers obtained via online study is identical to answers provided by conventional approaches. The uniform results were achieved in a few types of research that carried out and put to a comparison, both e-mail and face-to-face interviews (e.g., Meho & Tibbo, 2003; Murray & Harrison, 2004). These studies found that respondents interviewed via e-mail stayed more concentrated on the questionnaire and gave more in-depth answers than their face-to-face interview. However, this comparison was not made for asserting that the reliability of face-to-face interviews is inferior, but conversely, to focus on the advantages of the online study and online questionnaire. Furthermore, the questionnaire needs to be constructed and elaborated precisely for the interviewees understand it fully.

In accordance with Curasi (2001), data reliability is relying on the interviewee, interviewer, the level of responsibility in arranging an online interview and the experience in online interviewing. Curasi (2001) identified that several online interview respondents gave very brief and highly accurate replies to the formulated questions.

In addition, it is easier for the respondent to present his or her thoughts in online or e-mail questionnaire due to the absence of pressure from face-to-face interviewing. Moreover, the important feature of online interviewing is that participants can fully express their feelings and not to be afraid if they are being judged. Certainly, it is a personal factor and individuals can act differently in different situations, therefore it is essential to understand that there is no ideal study approach that can fit every individual.

In general, online questionnaire provides a capability to obtain, in a conversational way, respondents' reflection, conception, and opinion in their own words. Besides, an online questionnaire is giving an assurance to the respondents since it lets them manage and edit their own answers before submitting it.

Validity alludes to the capability of a construct to determine what it was estimated to measure (Goodwin 2009). There are two main types of validity: internal validity and external validity. Internal validity prescribes how an empirical construct is designed and comprises all of the phases of the scientific study approach. External validity is the method of assessing the outcomes and inquiring whether there are any other feasible causal relationships (Shuttleworth 2008).

To confirm the internal validity, different types of information channels were applied to the study. In addition, the feedback from respondents about the clarity and common ground of the questions were obtained via email. Moreover, before sending an online questionnaire to the top managers, it was decided to test the questionnaire on a test group whether questions are clear or not.

5. SUMMARY AND CONCLUSIONS

The summary and conclusions are formulated in this chapter as well as the key findings of the research are presented based on the online interview outcomes and the results of the conceptual framework. In addition, the managerial implications and the future research suggestions are highlighted in this chapter.

This research was carried out to answer the undermentioned research question: *what are the key challenges and opportunities of introducing AI and IoT applications into the Supply Chain Management?* Consequently, the main idea was to identify and examine all the possible challenges and opportunities that the SCM activities can have when integrating the IoT and AI applications.

The objectives of this study were:

1. to define and analyze the challenges and opportunities of AI and IoT integration into the SCM
2. to establish the suitable strategy for implementing AI and IoT methods into SCM
3. to identify the major IoT applications that can improve the supply chain process
4. to define the suitability of AI and IoT combination to SCM
5. to identify the SCM issues and propose the IoT based solution for the particular SCM problems.

For this study the conceptual framework was created, as well as the online interview was conducted in order to fulfill all the listed research objectives. The main idea of the conceptual framework was to establish a corresponding procedure of evaluating SCM data, which was received from IoT smart devices.

It was essential to consider the significance of AI and 5G network technologies in this framework.

5.1. Key findings of the research.

In this research, the RFID and WSN were selected and examined as the most suitable the IoT technologies for the SCM activities as well as three main AI branches such as machine-learning programs, ANN and fuzzy logic were presented. In addition, the 5G network description and the main capabilities were reflected in the main body of the thesis. It was important to examine the 5G network in this study in order to show the full potential that it can uncover for the IoT and AI applications. Furthermore, the conceptual framework was created in order to display the importance of RFID and WSN in the SCM and the predictive potential of AI systems that can improve the outcomes of SCM activities.

In addition, the main challenges of the IoT and AI in SCM were identified and examined. Moreover, the online interview with the top managers was conducted in order to gain a better insight into the issues and benefits of integrating the IoT and AI technologies in the SCM processes. From the retrieved results, the major challenges of integrating IoT into SCM are the security and privacy issues, the sensitivity of the data and high costs of the implementation at an initial stage. Therefore, it is important for a company to create a suitable strategy for integrating such sophisticated systems and analyze all the possible failures before the deployment.

The IoT applications can positively affect the SCM activities, in particular, the high visibility across the SC, an effective traceability of goods and materials, and an automated data collection. Whereas, the predictive analysis of AI programs can help the SCM to eliminate the potential errors and failures in the SC processes. Furthermore, the feasible AI programs and their functions were displayed in the conceptual framework in order to identify the suitability of AI applications to the SCM.

The strategy and various examples of integrating the RFID and WSN technologies in the Logistics, Inventory and Warehouse activities were examined in the main body of the thesis. Additionally, the online interview results indicated several aspects for the successful integration of the IoT and AI systems in SCM. Specifically, the renewal of infrastructure and legacy system of the company needs to be highly considered before the IoT and AI integration.

5.2. Managerial implications.

The study has uncovered the opportunity for the companies to consider the potentials of IoT and AI systems. Due to the high costs of the RFID and WSN implementation, the formation of comprehensive practical and strategic regulations is essential in order to lead the practitioners to select the corresponding IoT and AI applications for the successful deployment.

In conjunction with the comprehensive managerial implications, the research as well contributes to the scope of conceptualization. Specifically, the research gives a fundamental notion for the combination of two disruptive technologies and implementing them into the SCM systems.

It must be admitted that organizations need to consider the privacy and security issues of the IoT technologies and their influence on the deployment and recognition of RFID and WSN at a customer level. Moreover, it is important to deliberate the overall impact of IoT and AI systems on the SCM processes and to build the executive model for the IoT and AI implementation.

5.3. Future research suggestions.

The primary suggestion for the future research is to develop better IoT maintenance framework in terms of security and privacy reasons. It will help practitioners to adopt the IoT technology more easily and certainly rely on it. In terms of the AI functionality, the future research can develop a more suitable learning program that can be applied particularly to the SCM activities.

The further research of the IoT and AI applications needs to be done; specifically, it will be essential to uncover more types of IoT and AI technologies for the SCM systems or for other types of operational processes. Correspondingly, it is important for other business areas, such as production and strategic management, information technology and intelligent systems, to establish a proper strategy for implementing the IoT and AI applications into their legacy systems. Moreover, the future study direction should draw more attention to the design, operation and development of RFID and WSN devices.

Additionally, it will be feasible to research more profoundly the business and strategic opportunities that IoT and AI can bring to the companies. Specifically, the effect of RFID and WSN devices on firms in different industrial scopes.

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APPENDICES

APPENDIX 1. Interview invitation email for the top managers.

Research Questionnaire:

Dear receiver,

I am writing to ask for your participation in an academic study that is designed to identify the degree of readiness of the companies for the Internet of Things (IoT) and Artificial Intelligence (AI) applications in SCM. There are many scientific papers, which examine only the efficiency of Internet of Things in the Supply Chain Management, but only a few researches consider the potential of the combination of Internet of Thing and Artificial Intelligence applications. Realizing the significance of these two technologies for the Supply Chain Management can bring greater competitive advantages to organizations.

The study examines the challenges and opportunities of introducing Artificial Intelligence (AI) and Internet of Things (IoT) into the Supply Chain Management (SCM). In particular, the main scope of SCM will be closely studied and it is Logistic Management.

Your participation in this online interview is completely voluntary and you may opt out of any question in the questionnaire. All of your responses will be kept confidential. They will only be used for research purposes and will be reported only in aggregated form. The completion of the questionnaire should not take more than 20 minutes of your time.

To participate, please click on the following link: https://docs.google.com/forms/d/e/1FAIpQLSfs8QhwgV5rmFXud00SW1dZ4wBTAmeyOnJa7QPdcPfwxmfB1g/viewform?usp=sf_link

If you have any questions about this questionnaire, or difficulty in accessing the link, please contact aziza2494@gmail.com.

Thank you in advance for providing this important feedback.

Yours Sincerely,

Aziza Tazhiyeva (Master’s degree student)

University of Vaasa

Faculty of Technology

Dept. of Industrial Management

Vaasa, Finland

APPENDIX 2. The online interview questions for the top managers.

1. Background Information:
    - Your name:
    - Company name:
    - Job Title:
    - The years of experience
2. Does your company have Internet of Things (IoT) and Artificial Intelligence (AI) applications integrated into the Supply Chain Management (SCM)?
3. If not, is your company willing to integrate IoT and AI applications in the near future?
4. Do you agree that it is possible to implement the IoT technologies in your company, in particular, Radio Frequency Identification (RFID) and Wireless Sensor Network (WSN) into SC?
5. If you have already implemented IoT or AI into SCM, could you, please, explain the framework of the processes where IoT and AI applications are involved?
6. What are the opportunities of integrating IoT and AI into SCM in your company?
7. What are the challenges of integrating IoT and AI into the SCM in your company?
8. How likely can IoT and AI improve the SCM in practice?
9. If your company is not currently implementing IoT and AI systems, how likely are they to adopt the use of such systems in 5 years.
10. As an expert in this field, do you have any additional information or comment to add on the IoT and AI applications in the SCM?