

Enabling Intelligent and Smart Logistics using Radio Frequency Identification (RFID) in the Context of Industry 4.0 in Saudi Arabia

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Abstract: Logistics is a complete process like a software development model. It is a process starting with the planning phase, then requirement gathering, implementing, and then efficiently delivering. Here efficiency is calculated based on on-time delivery and cost-effective goods. It is a process of managing and controlling the transfer of goods and information from the origin to the destination. The method includes various services like item handling, warehouse management, and ensuring the supply of the right things at the right place and time in the suitable condition. With the development of technologies, the need of an automated logistics business is rising day by day to improve the efficiency of the system by reducing the cost and saving the time. With the increasing demand of the good quality, efficient logistics services, developed infrastructure, skilled staff, the level of inefficiency in logistics is more visible now in the market. Knowledge of the warehouse layout, contemporary machinery (such as reach stackers and pallet trucks), IT (information technology) services and systems like handheld devices and RFID (radio frequency identification), as well as stocking and handling procedures are some of the areas where existing skills are lacking. The logistics industry of Saudi Arabia is also rapidly evolving in the market and is facing challenges of infrastructure, technology, and new types of service providers. This article illustrates the smart strategies in logistics and the impact of industry 4.0.

Keywords: Logistics, intelligent system, RFID, industry 4.0, tracking, planning, goods, and information.

1. INTRODUCTION

Logistics is a complete process like a software development model. It is a process starting with planning phase, then requirement gathering, implementing and then delivering with efficiency. Here efficiency is calculated on the basis of on-time delivery and cost effective goods. It is a process of managing and controlling the transfer of goods and information from the origin to destination [1]. The process includes various services like items handling, warehouse management, ensuring the supply of right items at right place, right time in right condition [2, 3]. With the development technologies, the need of an automated logistics business is rising day by day to improve the efficiency of the system by reducing the cost and saving the time [4, 5].

These are not only reducing the cost of logistics business but also providing efficient services [6]. Better tools and strategies are being suggested to reduce the cycle times, enhance the decision making and adding the values to the customers. As quality is the biggest challenge in the market for the logistics providers, a new architecture of the complete system is required. For that the technology is the solution for the automation of the processes [7].

But along with the challenges of improving the efficiency of the system, there are hurdles for adapting to the new system

also. The companies are little reluctant to adapt the changes in their existing systems [8]. Like difficulty in understanding the new system, more chances or errors with the migration of data from existing to new, addition of cost for new set-up i.e. new hardware devices and requirement of more skilled staff. To overcome these challenges, the use of technology should be very intelligent with a balance of quality and cost [9].

Numerous studies have investigated the topic of outsourcing logistics services in various nations and conducted comparison studies as well. Businesses are trying harder than ever to manage logistics operations strategically to achieve a competitive edge, yet they frequently lack the skills to do it themselves [10]. As a result, outsourcing logistics operations is becoming more popular. The rising emphasis on time-based competitiveness is a key trend that is having an influence on the organisation. While there has been an increase in the use of smart logistic services in the Asian area, it has not been at a consistent rate, and there have been no studies to compare. This report compares the logistics outsourcing practises of businesses in Malaysia and Saudi Arabia to solve this issue [11].

Both Malaysia and Saudi Arabia are participants in the Organization of the Islamic Conference (OIC) and the World Trade Organization. The OIC's member nations have been attempting to work together and exchange experiences. Findings from this study might aid in a comparative analysis and assist discover the links that could be developed in the domain of logistics and shipping given the economies of these two nations' relatively high degree of complementarity. Cur-

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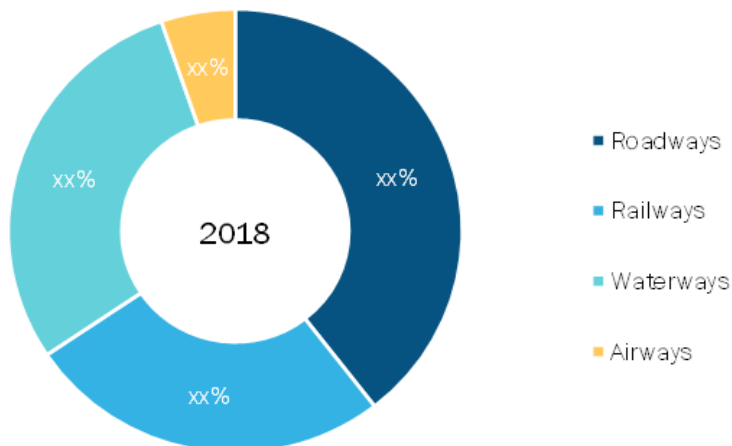


Fig. (1). Illustration of Third-Party Logistics in Saudi Arabia [12].

rently, there aren't many alliances between the two nations in these sectors.

The objective of this thesis work is to give an overview of the concept of “Logistics”. The research is based on both theoretical and empirical studies. The theoretical study is performed by the literature surveys done through the internet, article and the books. The empirical study is conducted by studying various case studies of the warehouses in different size of the companies. The main aim of the thesis work is to study the condition of logistics in an organization. The various performance factors and the challenges of the logistics systems are studied. These factors are calculated by the observing the results of the case studies performed in the companies. The analysis of these factors resulted in measuring the performance and devising new automated solutions for the organizations. With the growth of the economy of countries, the need of high-performance logistic systems is increasing day by day. More efficient and effective solutions are required to satisfy the rising demands of the customers.

2. GROWTH AND CHALLENGES OF LOGISTICS

Logistics provides an efficient and cost-effective method for the flow of goods and is the sector on which other commercial sectors depend. It is the backbone of the economy. The Saudi Arabian Logistics sector is growing rapidly with the increase in economy [13, 14]. Infrastructure, technology, and new service and technology interactions will determine whether the sector is able to turn a profit and assist its clients in lowering the cost of logistics, thereby offering effective services [15, 16]. The logistics sector is currently facing the following major challenges:

Customer needs and expectations: The customer’s expectations and needs is the primary challenge for the logistics and supply chain managements. The survey from several countries shows that customer’s expectations are increasing year by year and that is the reason being ranked at the biggest challenge for the companies. And with the coming next 5 years, the need of the customer’s expectations is increasing, the traditional methods of tracking in logistics and supply chains will fail and will require more investments.

Networked economy: In the past and current years, companies are the independent rulers of the markets. They are used to deliver the services to their customers directly. But now with the survey for the next 5 years prediction, the need of communication among the companies is rising day by day. The cloud computing technologies and more demands of customers are forcing them to integrate with their partners to share the different processes and systems.

Cost pressure: With the increasing demands of the customers, the cost of logistics is the biggest challenge for the companies. As shown in survey the cost is going to increase exponentially in the coming years. But customers continue to expect low logistics prices.

Globalization: The performance of logistics is measured by the reliability and efficiency of the deliveries of goods. But with the increasing global economy, the problems associated with the poor infrastructure and transportation is adding adverse effects on the capabilities of logistics business. Summarizing, regions like Russia, Eastern Europe, Saudi Arabia and Africa are the most affected areas of globalization which amplifies other trends to increase the complexity of the logistics business.

Talent deficiency: The demands and expectations of the customers is increasing year by year resulting in a lot of pressure to logistic and supply chain market holders. To satisfy the demands, there is huge advancement in the information technology. Lot of research and development work is in full swing. But along with that there is a shortage of talent and skilled staff. To overcome this there should be important trainings and qualification programs with the universities and research institutions.

Volatility: In the last years, the companies are getting dependent on each other for a networked structure. As the dependency is increasing, the fluctuations in one sector are affecting the other also. So in coming years, the volatility should be increased to avoid any dramatic changes in the market business.

Sustainability pressure: The industry is facing a significant challenge as a result of this trend. According to the study

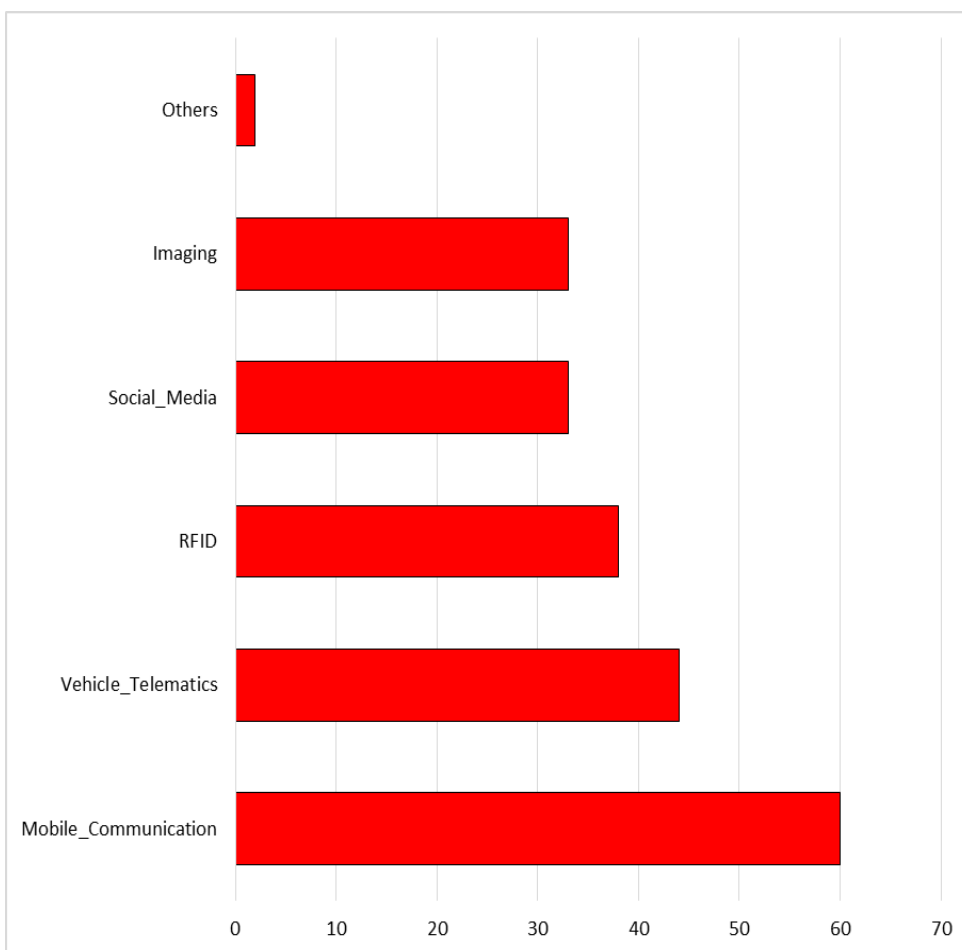


Fig. (2). Latest technologies that can benefit LTS.

results, more than 55% of respondents said that environmental concerns are a component of their logistics business plans. A new factor for the rise in complexity is corporate social responsibility. The implementation and deployment of these strategies, particularly with regard to measurement systems, evaluation, and setting objectives and strategies for logistics sustainability, are, however, fraught with significant uncertainty.

Increased risk: With the continuous increase in the size of the companies, more and more processes are getting involved. Irrespective of the size and geographical position of the company, risk is increasing in all the networks. Challenge to the industries is to make proper strategies around demand and planning phases. Risk in inventory management can make a huge loss to the companies if not maintained. Research and development methods are required to avoid the risks along with the reactive strategies for any failures.

New technology: Along with the investments by companies for improving the performance, the need of spending in the coming latest technologies is also increasing. This is again a big challenge in the logistics and supply chain networks. Technology “Big Data” is a new technology which can help to develop more efficiency in handling the data. The data can be used for better planning and certain outcomes generations. The companies again are in need to invest in the new tech-

nologies so that they can also be a part of the growing competitions.

Lack of industry research and development (R & D): Despite widespread knowledge of the significance of supply chain management and logistics among academics and practitioners, the logistics sector is still underdeveloped. Prioritizing research and development will help to better understand and address the industry's different flaws.

3. MOBILE TECHNOLOGY FOR THE MOBILITY INDUSTRY

Automation of Transport and Logistics operations is linked to the mobile technology. Expectations of the customers in increasing day by day with more demands of better efficient system, accurate results and timed deadlines for pickups and drops. These requirements are putting pressure on the companies for the mobile solutions for their businesses [17]. As per the survey, if mobile technologies and automated processes are embedded with the transportation and logistics operations, the pick-up and delivery times can be reduced by almost 29%. This saving can increase the operational efficiency of the system and customer satisfaction can also be improved.

As indicated in Fig. (2), the survey participants feel that integrated vehicle telemeters (44%) and RFID (38%) give their

business the most promising returns on investment. The logistics industry in all the countries especially Saudi Arabia is most affected by the poor adoption to the technology and low technical skills. With the new technologies coming in the market, more attention is now with the use of RFID, vehicle tracking systems, warehouse management systems and other trace and track technologies. But the adoption is not 100% in all the business domains as the companies are little reluctant of adapting to the new systems [18, 19].

Automation processes are in its infancy because of this reluctance. In addition to the technology related issues, more standardization is required in the business. Along with that as technology is upgrading, more training of staff is required. So, skilled staff is an urgent requirement of the logistics industry. More and more research centres are required to be set up [20]. Along with the technology skills a variety of skills is also required like mobile technology understanding, industry understanding and multi operation skills. The future and scope of logistics industry in Saudi Arabia is very bright and the growth is exponential with the coming years. More and more participation is coming from both private and public sectors which is improving the state of logistics and supply chain management. The logistics companies are now more focused on the efficient business by exploring more ways for investing in cost and time factors [21, 22].

4. BENEFITS OF AUTOMATED POLICY MANAGEMENT

The automated systems and manual systems work on the same principles i.e. to maintain the stock. But the automated systems are more flexible and it is easy to retrieve the information from them. The automated systems are good for business but it is better to run these systems in parallel with the manual systems. This gives a back-up of the system and enables to check for any errors [23-25]. The main benefits of the automated over manual systems are as follows:

Saving of money: Automated solutions give big savings in terms of costs as compared to manual systems. Replacing the manual systems helps in increasing the productivity of the staff which in turns improves their efficiency. The system becomes more robust with low cost of the system with high sales.

Saving of Time: Automated systems save time too by streamlining the inventory control processes. The processes which were performed manually were involved with so many hours and days. The same tasks can be performed only by giving simple instructions with single mouse click event. No time is wasted in the manual checking of the orders and deliveries. The automated data captures technologies like barcode scanners and RFID, make system more efficient business model by eliminating wastage of time.

Accuracy efficiency: With the automated processes, the scope of error reduces as the manual checking and receiving of orders is eliminated. The customers can get easily track their orders and thus removes unnecessary delays.

A company's internal business practises may be kept consistent and effective with good policy management. This can be crucial to reducing the risk of lawsuits from both consumers and staff. Policies and procedures are crucial because

they define and reaffirm the standards that employees are expected to uphold in all of their professional interactions. On the other hand, by outlining what is appropriate and inappropriate in the workplace, they also assist employers in efficiently managing their workforce.

5. SECURITY PROTOCOLS AND ANALYSIS

A security protocol carries out a security-related task and uses cryptographic techniques, frequently in the form of combinations of cryptographic primitives. It is used in communication theory can have various security goals such as authenticate the communicating parties, secret sharing and delegate the rights. In general, the security protocol should not only guarantees that certain information is communicated, but also certain other information is not communicated. This section details the key points involved in designing and analyzing the security protocols [26].

The design of security protocol needs to focus on the security specification for a particular system and perform a detailed analysis of its properties. The appropriate cryptographic primitives selected for the message construction in the communication flow makes the protocol stronger against various threats [27]. The objective of the design should be reducing the communication and computation cost without compromising the security goals. The various security requirements for RFID enabled cloud SCM applications are as follows:

Both parties in a communication channel authenticate another using mutual authentication, which is a two-way authentication. Before exchanging any sensitive information, it is a crucial security requirement that the client and server authenticate each other's identities. In SCM, mutual authentication between the tag and the reader enables the tag to confirm that it is in communication with an authorised reader and enables the reader to confirm the authenticity of an incoming product [28].

Privacy prevents an adversary from extracting information in a communication channel. Privacy requirement of RFID tag implies that an adversary cannot extract the secret information such as a tag identity or track a tag from other tags. An adversary should not be able to trace products through the supply chain.

Anonymity protects the identity of a participant in a networked application. The identities of the tag and the reader are not revealed at any time.

The security protocols proposed for RFID enabled SCM applications using cloud storage should withstand the known attacks such as:

Tag/Reader impersonation attack: An attacker can generate a message such that the back-end server authenticates it as a valid tag/reader. Reader impersonation means that the adversary impersonates a reader so that it can extract useful information from a legitimate tag. Similarly, tag impersonation will attempt to gather information about the reader.

Secrecy attack: An attacker detects the protocol messages for many runs and tries to extract the secret parameters like session variables, pseudo identity, and secret key.

Only if it is considered that the observer or attacker won't be able to deduce details about the sender or receiver from the message's content itself, can messages be said to be unlinkable. In the event that the tag communicates with an authorized reader between the two observations and updates its cryptographic key, this property mandates that an adversary cannot identify a previously seen tag once the tag has updated its secret key material.

Desynchronization: In RFID system it is a threat in which a tag's secret stored in the cloud server and the tags memory is not same, because of an attacker tries to stop the communication between the tag and the reader.

5.1. Protocol Analysis

The security protocol proposed for any system must be analyzed thoroughly before implementation in order to prevent serious attacks. Many formal approaches are available for analyzing security properties. Also, the reasoning is automated to make the analysis for various sessions and gives more technical interpretations than formal method. This section details about GNY logic and ProVerif tool used in this research work for analysis.

5.1.1. Formal Method - GNY Logic

The BAN logic was invented by Mike Burrows, Martin Abadi, and Roger Needham (Burrows et al. 1989). The logic is a logic of belief and action. It contains no logical inversions; therefore it cannot be used to prove a protocol flawed. GNY logic is developed that is an extension of BAN, which is more expressive than BAN logic. The notion of possession, recognizability, and not-originated-here are newly introduced in GNY logic, which are not available in BAN logic [28-30].

The GNY logical postulates and notations as described which are involved in the reasoning process are discussed. A formula is a term used to denote a bit string in a message. Let m and n be the components of a message. The key used for MAC is denoted as k . $F(m)$ denotes a computationally feasible one-to-one function. Let A and B be the participating entities in a protocol execution. Important notations of GNY logic that are used in this thesis are listed below:

$A \triangleleft m$: A has seen the part of the message m itself or any computable content of that message.

$A \triangleleft^* m$: A has been told the formula m which is not originated from A .

$A \ni m$: A possesses m .

$A | \sim m$: A once conveyed m .

$A | \equiv \#m$: A is entitled to believe that m is fresh.

$A | \equiv \phi m$: A believes that the formula m is recognizable

$A | \Rightarrow m$: A has jurisdiction over m .

$A | \equiv A \underline{k} B$: A believes that the k is a secret between A and B

The following are the rules used in this work for protocol verification.

Being-told and possession rules: A belief or a possession of a participating entity in a session is not a member of the corresponding set in a future session.

$$T_1 : \frac{A \triangleleft^* m}{A \triangleleft m}$$

Not-originated here is a special case of being-told rule. In T_1 the formula m is received by A , not created by A .

$$T_2 : \frac{A \triangleleft (m, n)}{A \triangleleft m}$$

T_2 formula implies being told each of its concatenated components.

$$T_3 : \frac{A \triangleleft F(m, n), A \ni m}{A \triangleleft n}$$

If A get the result of F , and if it possesses one of the two arguments, then it is considered that the other argument is been told to A .

$$P_1 : \frac{A \triangleleft m}{A \ni m}$$

The entity A can possess m what it told.

$$P_2 : \frac{A \ni m, A \ni n}{A \ni (m, n), A \ni F(m, n)}$$

If A has two formulas, it can also have the concatenated and computationally viable function F of those formulas.

$$P_3 : \frac{A \ni (m, n)}{A \ni m}$$

A is capable of possessing any one of the concatenated components of a formula if it possesses one.

$$P_4 : \frac{A \ni m}{A \ni h(m)}$$

If A possesses a formula m then it is capable of possessing a one way computationally feasible function of that formula.

$$P_5 : \frac{A \ni F(m, n), A \ni m}{A \ni y}$$

The entity A is capable of possessing y as it has $F(m, n)$ and m .

Freshness rule: If A thinks m is new, it has the right to think any message of which m is a part is new as well as a computationally practical one-to-one function F of m .

$$F_1 : \frac{A | \equiv \#(m)}{A | \equiv \#(m, n), A | \equiv F(m)}$$

Recognizability rules: The formulas that a principal can believe to be recognisable given his beliefs regarding the recognizability of other formulas are defined by the recognizability rules.

$$R_1 : \frac{A | \equiv \phi(m)}{A | \equiv \phi(m, n), A | \equiv \phi(F(m))}$$

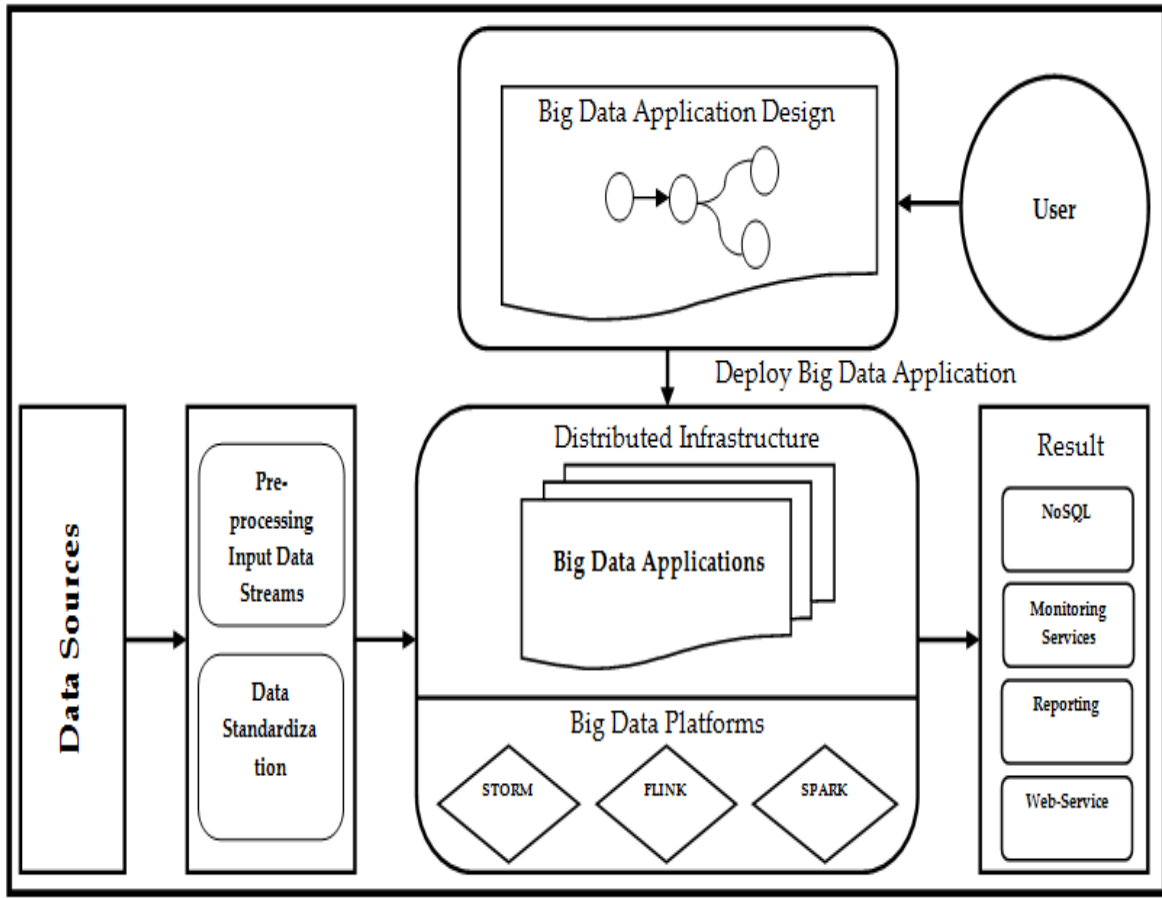


Fig. (3). Conceptual frame work of Big Data in Logistics.

$$R_2 : \frac{A \models \phi(m), A \ni k}{A \models \phi((m)_k), A \models \phi((m)_k^{-1})}$$

$$R_3 : \frac{A \models \phi(m), A \ni m}{A \models \phi(h(m))}$$

$$R_4 : \frac{A \ni H(m)}{A \models \phi(m)}$$

Message Interpretation rules: By analysing the messages they receive, the principal can use these rules to support their opinions of other principals.

$$I_1 : \frac{A \triangleleft *(m)_k, A \ni k, A \models A \xrightarrow{k} B, A \models \phi(m), A \models \#(m,k)}{A \models B \sim m, A \models B \sim (m)_k, A \models B \ni k}$$

$$I_2 : \frac{A \models B \sim m, A \models \#(m)}{A \models B \ni m}$$

$$I_3 : \frac{A \models B \sim (m,n)}{A \models B \sim m}$$

Jurisdiction rules: Trust and delegation are represented by jurisdiction. If A believes that principle B is an authority on some assertion C, then A believes in C if B has jurisdiction over C.

$$J_1 : \frac{A \models B \Rightarrow C, A \models B \models C}{A \models C}$$

$$J_2 : \frac{A \models B \Rightarrow B \models *, A \models B \models B \models C}{A \models B \models C}$$

5.1.2. ProVerif Tool

Security properties of cryptographic protocols are analyzed using ProVerif tool. This tool supports to verify cryptographic primitives like a hash function, bit commitment, symmetric and asymmetric encryption and digital signature. Analysis of authentication, traceability, privacy and secrecy properties can be carried out with correspondence assertions, reachability and observational equivalence mechanisms supported by this tool. Using emacs editor, cryptographic protocols are encoded and given as input to ProVerif. The encoded protocol is divided into three parts namely, declaration, process macros and the main process. The behavior of cryptographic primitives is formalized in the declaration part. The protocol is encoded as the main process which makes use of sub-processes defined in process macros [31-32].

The secrecy of the term ‘S’ in the protocol is evaluated by including query attacker(S) before the main process. The output for the query is true when the parameter is not derivable by an adversary. Events are annotated in the processes to mark important stages in the protocol. This inclusion does

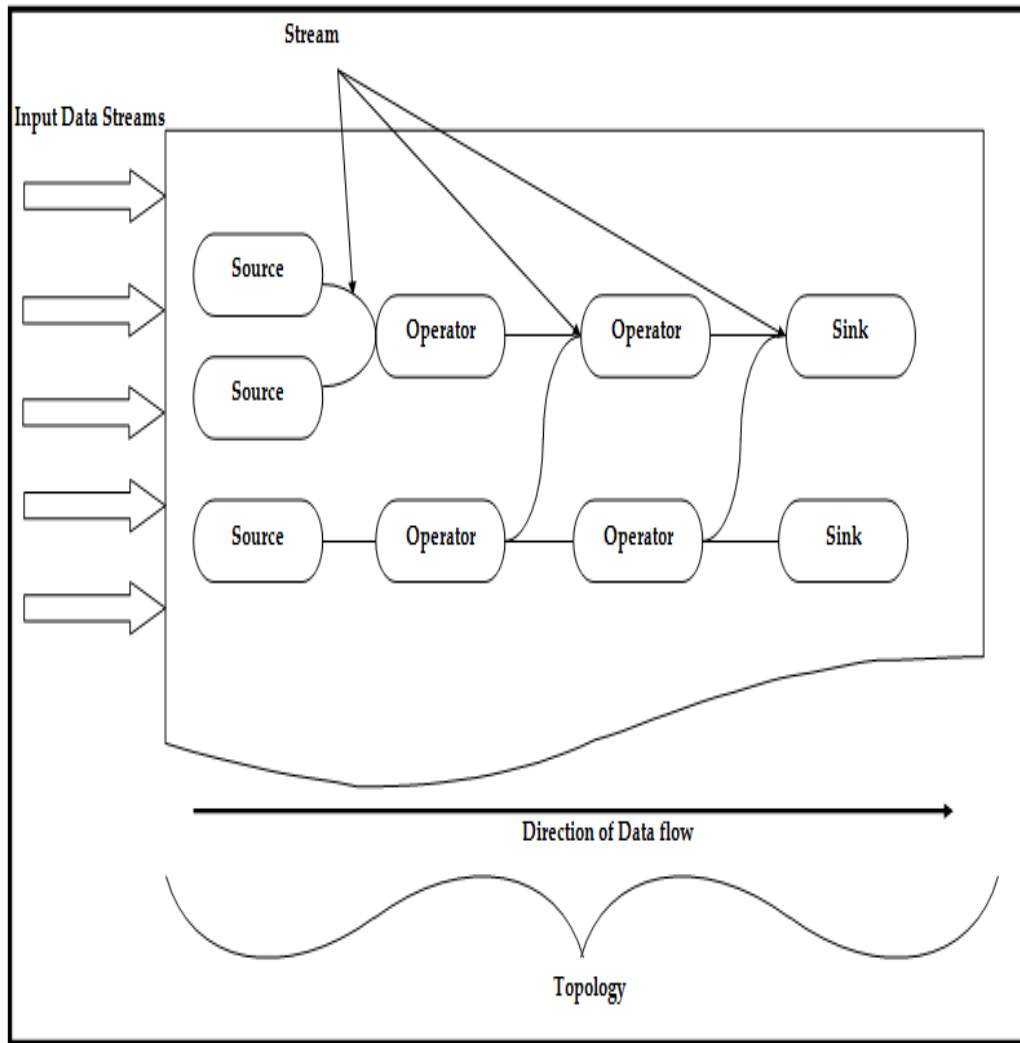


Fig. (4). Big Data Analytics Programming Model.

not affect the execution of the protocol. It is possible to check if an event ‘e2’ is executed, then ‘e1’ has executed previously. A Relationship among the various events can be studied as correspondence assertions. It is extended to as injective correspondence to study the authentication property by ensuring one-to-one relationship.

6. IMPACT OF INDUSTRY 4.0

The architecture of the conceptual framework is composed of four modules such as design of the big data application, input data streams for pre-processing, distributed infrastructure and results [33-35]. Fig. (3) explains the conceptual framework of big data for industry 4.0.

6.1. Big Data Application Design

This module helps the system engineers to extend own big data application with the availability of visual editors. The developed applications are signified as a directed graphs and the vertices helps in denoting the data mining and machine learning methods as well as the construction of programmes. The generation of data is taken place at the programming nodes and similar standards are used in handling the data

from a variety of sources that is shown in (Fig. 4). The obtained data sources are integrated with varied programming nodes. Fig. (4) explains Big Data Analytics Programming Model and Fig. (5) displays the outline of the big data analytics and business analytics in Hadoop framework.

With the help of programming nodes, application logic is generated without taking the internal data and interfaces. A huge number of data sources were accumulated with the platform to reclaim the related information of varied features of a factory. The heterogeneity of the data results with disparate data formats. Therefore, format of the data is a significant challenge in utilizing big data analytics in Industry 4.0.

6.2. Pre-processing Input Data Streams

This module is employed to change data into a general format that is used for further data processing. Pre-processing is developed based on data standardization that explains a general standard for obtaining unstructured, semi-structured and structured data from numerous numbers of varied resources. To maintain the big data use cases, instilled application requires rapid and scalable infrastructures. Pre-processing module plays the central role in the big data framework.

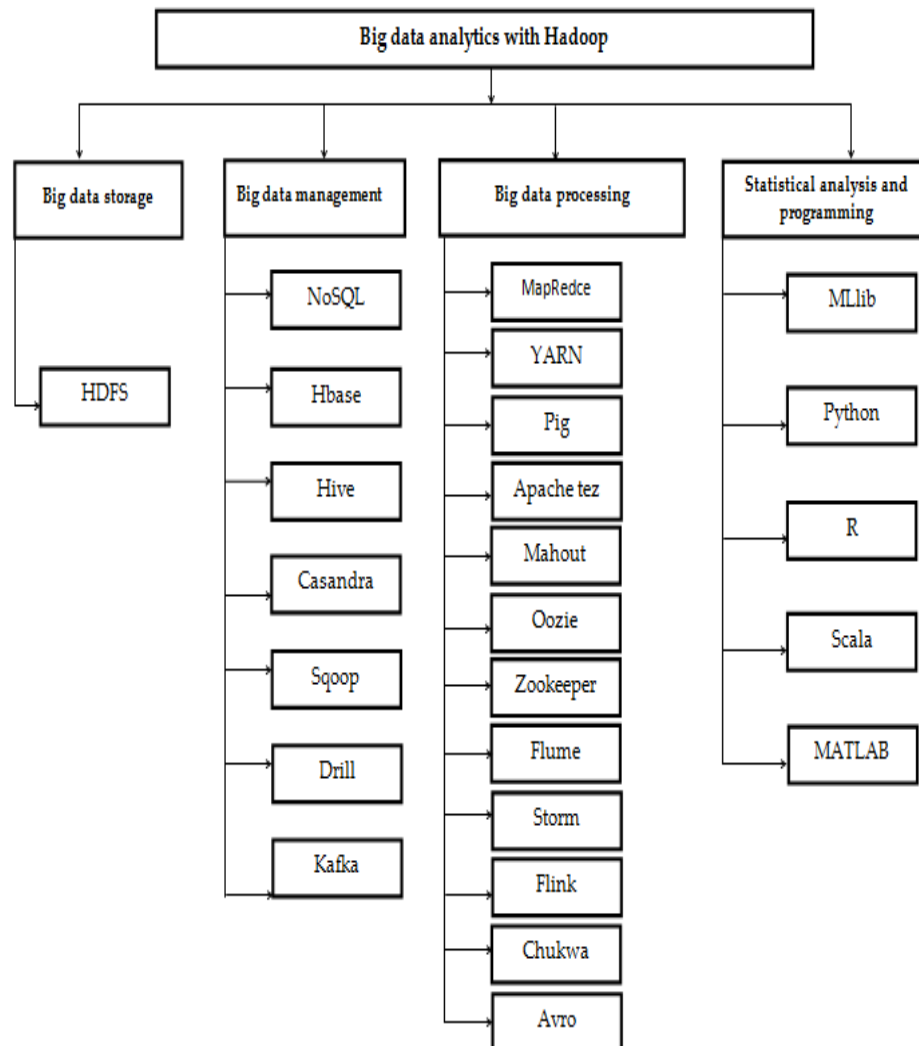


Fig. (5). Outline of the Big data and Business analytical process inside the Hadoop.

6.3 Distributed Infrastructure

The main phase of the big data platform is developed on a Distributed Infrastructure. Automatics deployment of application is carried on the distributed infrastructure that is basically a user defined application. Depends on the use cases, the necessity for processing varies and it relies on the nature of the data. It supports multiple platforms of big data namely Flink, Spark and Storm. Design of the framework depends on the nature of the data format. Use cases and the logic performs major role in designing the framework.

6.4. Distribution of Results

Different kind of forms designed based on the interest of the parties and the results are forwarded to the relevant forms. Channel of every distribution is explained as a programming node in the visual editors. Users are permitted to elect more than one channel of distribution to retrieve the results. In this way, production issue will be forwarded to the relevant staff. Manufacturing process is improved with this kind of framework and the data driven decisions were enriched. Delivery

of the output to the peripheral entities through web services for data visualization or supervising purposes are facilitated with this framework.

7. CONCLUSION

The logistics sector in Saudi Arabia is growing and becoming the most important area of the market now days. The high growth in Saudi Arabia Economy has resulted in the large volume of traffic. This growth of traffic has provided more opportunities in logistics including transportation, warehousing, express deliveries, container services; shipping services and other trace and track solutions. Adaption of RFID system automates various tasks in SCM applications. At the same time, security and privacy risks are also increased at a high rate. Stakeholders of SCM believe and continue to use the RFID system only when the RFID system provides security. Security analysis of the protocols identify the flaws in a protocol. As per the survey, the Saudi Arabia logistics sector is viewed as one of the most challenging sector in the world because of its current and future growth. Despite of so much growth of Logistics business, there are

several complexities which are holding it back. These include inefficiencies in transportation, poor storage structures, a complex tax structure, and low adoption of technology and inefficient technical skills of logistics professionals. By improving and overcoming the above inefficiencies, the logistics costs can be reduced to a great extent. The decrease in this cost finally can improve the situation of logistics in Saudi Arabia.

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