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Internet of Things (IoT) and its impact on supply chain: A framework for building smart, secure and efficient systems

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HIGHLIGHTS

- Internet of things (IoT) applied in SCM for building a smart and secure system of SCM.
- An efficient framework which integrates (N-DEMATEL) technique with AHP is proposed.
- The proposed framework help researchers to design secure system of supply chains.
- The proposed framework provide secure environment of SCM processes.

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ABSTRACT

The traditional supply chains faces several challenges such as uncertainty, cost, complexity and vulnerable problems. To overcome these problems the supply chains must be more smarter. For establishing a large-scale of smart infrastructure to merge data, information, products, physical objects and all processes of supply chain, we applies the internet of things (IOT) in supply chain management (SCM) through building a smart and secure system of SCM. We have prepared a website for suppliers and managers. We tracked the flow of products at each stage in supply chain management through the Radio Frequency Identification (RFID) technology. Each product attached with RFID tag and scanned through RFID reader and ESP8266 at each phase of supply chain management. After scanning the tag we stores tag id in the database. All information about products will be entered by suppliers and then uploaded to managers. In our system the supplier and manager gets perfect information of the entire life cycle of goods, and this will achieve transparency of supply chain management. For assessing security criteria of proposed system of supply chain management, we also proposed a framework which integrates neutrosophic Decision Making Trial and Evaluation Laboratory (N-DEMATEL) technique with analytic hierarchy process (AHP). The neutrosophic Decision Making Trial and Evaluation Laboratory (N-DEMATEL) technique is utilized to infer cause and effect interrelationships among criteria of smart supply chain security requirements. Depending on obtained information from (N-DEMATEL) the neutrosophic AHP is utilized to calculate weight of criteria and sub-criteria. Then the integrated framework will help researchers and practitioners to design secure system of supply chains. We presented DEMATEL and AHP in neutrosophic environment to deal effectively with vague, uncertain and incomplete information. So the proposed system of supply chain management will be able to overcome all challenges of traditional SCM and provide secure environment of SCM processes.

1. Introduction

A sharp competition environment was created due to the emergence of global markets. The global and competitive environment droves the flow of business via supply chain (SC) because firms are not individually self-adequate. These chains should coordinate their processes to become more competitive and achieve desired objectives of partners.

Supply chain (SC) is a set of processes and entities (suppliers, customers, factories, distributors and retailers) which are interested to fulfill customer order. The plan, source, make, deliver, return and enable are the main processes of SC according to Supply Chain Operations Reference Model (SCOR) [1].

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Supply chain management (SCM) means having the correct item in the correct volume at the correct time at the correct place for the correct price in the correct condition to the correct customer [2]. In traditional supply chain management systems there exist several problems such as overstocking, delivery delays and stock out. These problems returns to several factors such as complexity and uncertainty which exist usually in real supply chains.

The cheaper, better and faster item is the desirable for SC managers. Also maximizing surplus which is the whole payments from end customers minus all costs which incurred via SC. Traditional supply chains are becoming more costly, complex and vulnerable. To overcome these challenges, the supply chains must be more smarter.

We can define smart supply chain as a modern and interconnected system which expands from separated, regional and single firm applications to wide and systematic implementation of supply chains.

For effective management of supply chain, the information technology (IT) plays a very important role [3]. The IT has ability to integrate different processes, suppliers and customers internally and externally via enhancing communication, collection and transfer of data and information and then improve supply chain performance.

One of the most important development of information technology is the internet of things (IOT). The term IOT has coined by Kevin Ashton in 1999 [4]. We can define it as a set of physical and virtual objects which are connected together via a network for communication and sensing or interaction with internal and external environment.

If we define internet of things relates to supply chain management, we can define it as a set of physical objects which are connected digitally for sensing, monitoring and interaction within a firm and among the firm and its SC cementing agility, visibility, sharing of information and tracking to facilitate plan, control and coordination of processes for supply chains.

Our goal here is to apply IOT in SCM for making connection between supply chain entities and processes, identifying products and goods automatically, tracking flow of products at each stage, providing a complete information during the entire life cycle of products, and achieving transparency of supply chain system to overcome challenges of traditional SC.

In order to achieve our goal we designed a website for suppliers and managers. We tracked the flow of products at each stage in SCM through the RFID technology. Each product attached with RFID tag and scanned through RFID reader and ESP8266 at each phase of supply chain management. After scanning the tag we stores tag id in the database. The ESP8266 is a Wi-Fi chip with depressed cost. All information about products will be entered by suppliers and then uploaded to managers. In our system the supplier and manager gets perfect information of the entire life cycle of products, and this will achieve transparency of supply chain management.

For assessing security criteria of the proposed system of supply chain management, we also proposed a framework which integrates neutrosophic Decision Making Trial and Evaluation Laboratory (N-DEMATEL) technique with analytic hierarchy process (AHP). We present the DEMATEL and AHP in neutrosophic environment because security criteria are always complex, vague and inconsistent in nature.

The generalization of classic set, fuzzy set, and intuitionistic fuzzy set, is the neutrosophic set. Each value in neutrosophic set has three membership degrees for representing reality effectively, which are the truth, indeterminacy and falsity degrees. For more information about neutrosophic sets see [5].

The remainder of this research is structured as follows:

A literature review about internet of things and its applications in SCM presented in Section 2. Section 3 illustrates the basic concepts of SCM and IOT. The proposed framework of smart supply chain management presented in Section 4. The integrated model of neutrosophic DEMATEL and AHP techniques for assessing security criteria for SCM system presented in Section 5. For validating the proposed model we solved a case study in Section 6. The conclusions and the future directions of the research presented in Section 7.

2. Literature review

A survey on various applications of IOT and its applications in SCM processes presented in this section. To gather the most pertinent literature to our research we have searched Google Scholar and we have also searched some publishers websites such as Springer, Elsevier, Emerald, and Taylor & Francis.

The impact of internet of things (IOT) on various processes of supply chain management is not known. Since SCOR model divides the processes of SC into plan, source, make, deliver, return and enable, then we will illustrate the impact of IOT on each process with detail in our literature review.

– Enable process of supply chain

The enabling technologies of internet of things usually consists of four major layers which are as follows [6]:

1. Layer for data collection, which use RFID technology and sensors,
2. Layer for transmission process which use stable and mobile networks,
3. Layer for service, and
4. Layer for interface.

The goods are monitored at anytime and anywhere by Yuvaraj and Sangeetha [7] via integrating RFID tags with GPS technology to track product indoor and outdoor. A new concept of cloud of things is developed by Yan et al. [8] for facilitating resource sharing and collaboration between supply chains partners. A framework for collaborative SC presented by Gnimpieba et al. [9] via using various IT enablers with cloud platform. The internet of things technologies regarding to data acquisition in industrial management of asset presented by Kinnunen et al. [10]. The recent trends in smart transportation presented by Singh and Gupta [11]. An IoT architecture was used by Shih and Wang [12] to develop a Time Temperature Indicator (TTI) of SC.

The problems and challenges which relates to IT enablers technologies, researched by several authors. The security and privacy issues presented by Bi et al. [13]. According to several authors, the major enablers of IT are the RFID technologies and sensors. For studying the impact of RFID technology on supply chains, several researches are presented. For papers which published before 2010, you can see [14]. A new technique for RFID optimal deployment in SC network, presented by Chang et al. [15]. Assessing RFID technology as enablers for integrating SC, presented by Wamba [16]. Also for studying the impact of RFID technology on manufacturing and efficiency of SC, Zelbst et al. [17] presented a research. Also, for align RFID with SC strategies, Leung et al. [18] presented a study.

– Source process of supply chain

The request for materials and services by companies is the sourcing process. Planning source activities strategically across the SC, is a sign of supply chain success. The virtualization of supply chain enables by using internet of things according to Verdouw et al. [19]. For tracking and tracing goods through their lifecycle in supply chain a virtual control of SC has been presented. A model for integrating collected data from internet of things strategic planning for product assortments, has been presented by Ng et al. [20].

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