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Risk Resilient Supply Chain Management using IoT and Big Data Analytics

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Abstract

In the context of Supply Chain Management (SCM), Internet of Things (IoT) and Big Data Analytics (BDA) play a significant role in the evolution and success of a data intensive application and its respective security concerns. The aim of the research is to assess the suitability of IoT and BDA to strengthen and enhance SCM network. There have been independent research on IoT and Big Data in this domain; however no conclusive systematic study has been done to gather knowledge and expertise in analysis of SCM with respect to a combined application of IoT and big data analytics. The research in the literature has been put to documentation and recommendations for practitioners of SCM in industry have been addressed for future scope of IoT and data analysis.

Keywords : SCM, Internet of Things (IoT), Data Analytics.

I. Introduction

Big Data Analytics (BDA) is defined as a holistic approach to manage, process and analyze the "5 Vs" [XXIX] (i.e., volume, variety, velocity, veracity and value) in order to generate actionable insights for sustained value delivery, measuring performance and establishing competitive advantages. It has recently emerged as "the

next big thing" in management. Some scholars and practitioners even suggest that BDA is the "fourth paradigm of science", or even "the next frontier for innovation, competition, and productivity", or the "new paradigm of knowledge assets". The pervasive dissemination of these tools and technologies is expected to transform the way we currently execute business. This is particularly true of **Supply Chain Management (SCM)**.

Preceding studies of SCM have highlighted the significance of achieving a high level of integration of inter- and intra-organizational processes and information systems in order to achieve a greater level of flawless coordination and reduce recurring efforts and interrelated inefficiencies. For example, the combination of RFID-enabled intelligent products and intelligent services with the existing information and communication technologies in supply chains (SCs) should play a facilitating role – thus making products and services more visible to SC members – and in parallel should offer more opportunities for quick and efficient SC activities. In this context, the access to critical information for informed decision-making becomes not only a prerequisite but also a major challenge. The new age SCM is defined by parameters such as rapid, scalable, intelligent and **connected**. [XXVII]

IoT involves extending Internet connectivity beyond standard devices, such as desktops, laptops, smart phones and tablets, to any range of traditionally dumb or non-internet-enabled physical devices and everyday objects. Embedded with technology, these devices can communicate and interact over the Internet, and they can be remotely monitored and controlled. The devices in this network acquire data about the neighboring environment and they communicate with each other and related software systems through the internet. So, there is a lot of dynamic and rich interaction and a consequently enormous data is generated, the generated information proves to be a source of utility to the dependent services in the existing network. [I]

II. Study of Design.

A. Context of Study

The objective of the literature survey is to encourage the design of IoT which is secured and decentralized so that the data in SCM does not get controlled or accessible by centralized companies.

BDA in SCM is a wide-ranging topic as it constructs upon cross-disciplinary work from various areas. BDA is the union of two disciplines essentially linked: Big Data and Advanced analytics. Formally there is no single characterization adopted for the term Big Data, a buzzword not yet ascribed to any particular author, and that even shows some fight between its authors (Lohr, 2013[XXII]) but on a review by Ward and Barker (2013), Laney (2001) proposed a magnitude data framework that explicated an explosion in data based on the "3 Vs":

• *Volume*: The volume of the Big Data datasets becomes a more relevant factor as it is beyond the capacity of traditional database management.

• *Velocity*: Velocity is referred to as the transmission of data moving from batch processing to real time operation.

• *Variety*: Big Data can be in many different formats. Until now, structured data was the normal standard for data storage in most organisations, using relational databases managed by languages such as SQL. Now semi-structured data like XML and mostly unstructured data in any type that has not table fields could include digital information not "tagged" such as video, free form text or images.

B. Research Goal and Research Questions

Goal 1. To illustrate the application of streaming IoT based big data analytics in identifying and mitigating risk issues in the supply chain. To demonstrate how information management actions can mitigate social risks.

Goal 2. Applying Big Data Analytics on sensor data for security, physical condition of vehicles, unethical behavior, theft, speeding and traffic violations.

This research shall focus on the integration of IoT and big data analytics with sustainability to explain how to mitigate supply chain risk.

To collect substantial evidence in this direction, a systematic and elaborate research review was required which paved away in the formulation of the following research questions:

Research Question 1.

1. What is the potential of IoT and BDA in the SCM?

Research Question 2.

Where should future development effort be directed to accelerate the adoption and use of streaming analysis of the Internet of Things Data by using BDA in the SCM?

To address these questions, the research shall draw attention on the emerging literature on Streaming IoT Based BDA and SCM.

C. Search procedures used in selection of Literature

After a study of 110 research papers and articles on SCM, Data Analytics and Internet of Things, a subset of 24 papers were outlined which facilitated answering the research questions. The exclusion stage of selecting the literature has been done on the basis of abstracts. This selection is based on whether the literature is written on economic aspects or technological aspects.

The set of research papers and articles selected for study has been summarized in list of references. These have been found to be effective in answering the research questions formulated in the previous section.

III. Analysis of Research papers

As the supply chain continues to grow, it's essential to assure that all the carriers in the network; be it shipping containers, suppliers' delivery trucks, or the van out for delivery are connected. Again**, the data** is the prize. Just like cities are using this data to get to emergencies faster or clear up traffic issues, manufacturers are using it to get better products to their clients, faster.

IoT based BDA could help SC stakeholders to reduce their exposure to various risks including the risk of fraud and other malfeasance. In the context of SC execution, BDA could lead to increased efficiency and profitability in the SC by maximizing speed and visibility, improving SC stakeholders' relationships, and enhancing SC agility. [VII]

With the fast-paced and far-reaching development of information and communication technologies (ICTs), big data (BD) has become an asset for organizations. BDA has been characterized by 5Vs: volume, variety, velocity, veracity, and value (Wamba et al., 2015[XXIII]; Assuncao et al., 2015[V]; Emani et al., 2015[XXXI]). Volume refers to the magnitude of data, which has exponentially increased, posing a challenge to the capacity of existing storage devices (Chen and Zhang, 2014) [VI]. Variety refers to the fact that data can be generated from heterogeneous sources, for example sensors, Internet of things (IoT), mobile devices, online social networks, etc., in structured, semi-structured, and unstructured formats (Tan et al., 2015)[VIII]. Velocity refers to the speed of data generation and delivery, which can be processed in batch, real-time, nearly real-time, or streamlines (Assuncao et al., 2015). Veracity stresses the importance of data quality and level of trust due to the concern that many data sources (e.g. social networking sites) inherently contain a certain degree of uncertainty and unreliability (Gandomi and Haider, 2015[IX]; IBM, 2012[II]; White, 2012 [XXXII]). Finally, Value refers to the process of revealing underexploited values from BD to support decision-making (IDC, 2012; Oracle, 2012) [X]. Among those 5Vs, veracity and value, which represent the rigorousness of Big Data Analytics (BDA), are particularly important because without data analysis, other BD processing aspects such as collection, storage, and management would not create much value (Huang et al., 2015; Chen and Zhang, 2014; Babiceanu and Seker, 2016)[XI].

BDA involves the use of advanced analytics techniques to extract valuable knowledge from vast amounts of data, facilitating data-driven decision-making (Tsai et al., 2015) [XXIV]. Supply chain management (SCM) has been extensively

applying a large variety of technologies, such as sensors, barcodes, RFID, IoT, etc. to integrate and coordinate every linkage of the chain. Therefore, not surprisingly, supply chains (SCs) have been revolutionized by BDA and its application in SCM has been reported in a number of special issues (Wamba et al., 2015; Gunasekaran et al., 2016; Wamba et al., 2017)[XXIII].

Nowadays, in SCM the optimization of the supply chain visibility (SCV) is one of the core developments. The SCV is a complex problem due to the interaction between involved people, processes, technologies and information flows. The key target of SCV is to show current activities and involvements along a supply chain. This can be used to collect information for decision makers in many cases, for example, if an interruption occurs. Today, available data sets are often outdated, but actual information is required for decision making. By focusing on logistics and supply chains, Automatic identification and data capture (Auto-ID) technologies like RFID and barcodes are widely used to track handling units and the transported goods [XXV]. The RiskVis framework as developed by [XXI] combines available solutions for visualization of supply chains based on Google Maps and Baidu Maps with analysing approaches for internal and external data [XIII].Therefore, an analyzing module extracts problems and disruptions. Additionally, the existing information about how to handle unplanned disruptions, along with the supply chain network configuration, is available for the system through accommodated interfaces. Furthermore, the data for the risk extraction is stored next to the analytics module on a server cluster.

As of 2011 there has been already a high interest or new solutions to increase the supply chain visibility based on big data analytics. But the existing security policies stopped the implementation and integration of different data sources. The industry spotted high capabilities for solutions based on HDFS and Map Reduce in 2011[XXVI]. The situation about dealing with large amounts of data has not been changed. Existing data is often stored in large files like web logs or in complex XML documents. All those files are transformed into existing structured data as they are demanded by conventional databases. The transformation is necessary, if a further usage is planned.

Current solutions for increasing the SCV are optimizing the collaboration within the supply chain. Additionally, 44% of enterprises improved the internal visibility and 40% are optimizing their operations to improve monitoring, usability or efficiency as the 15 reports [XVIII]. This leads to reconsidering security policies to enable the access to different data sources for analytic methods. The understanding that data is valuable has highly increased throughout the industry. But the valuable information needs to be processed. Following the Gartner survey 20, nowadays around 26-28% of manufacturing companies and retailers invest in big data solutions.

In the transportation sector only 20% of the asked companies have already invested, but with 50% there is the highest value of planned invests within the next two years. The problem addressed with big data (summarized over all industries) is about 32% in improving risk management. A wide spreading of read points, like barcode or RFID reader, leads to an increasing transparency of freight deliveries between companies. When a handling unit is detected, the read points are generating events, which are available in real-time and enabling better transparency and sped up processes. This is achieved due to planning optimization of deliveries and supported detection of bottlenecks and risks. The supply chain management requires new solutions due to the increasing complexity. Existing solutions and IT Systems are not able to address this problem. Therefore, new solutions have been developed in the last years. As the use cases show, there are already systems that not only allow a better handling of the vast amounts of data, but also show how Big Data Analytics can influence business models.

The expectation for the future is that various companies from different industries will form Big Data ecosystems for gaining new business models and providing new services to customers. This will lead to even more rapidly increasing complexity for the SCM.

Research Gaps

According to a new report from Aruba Networks, by 2020, 79% of retail organizations would have adopted Internet of Things (IoT) technology and 77% believe it will transform the retail industry [XXX]. Thus, IoT is surely going to determine the future course of retail organizations and bringing disruptive changes in their supply chain management systems.

Although the expectation of BDA adoption to enhance SC performance is rather high, a recent report found that only 17% of enterprises have implemented BDA in one or more SC function (Wang et al., 2016) [XV]. The main reasons for low uptake are the lack of understanding of how it can be implemented, the inability to identify suitable data (Schoenherr and Speier-Pero, 2015) [XIX], low acceptance, reutilization and assimilation of BDA by organizations and SC partners (Gunasekaran et al., 2017 [XVI]), and data security issues (Fawcett and Waller, 2014 [XXVIII]; Dubey et al., 2016 [XVII]). This motivates our exploration of the existing research and the applications of BDA in SCM. There are a number of literature reviews of BDA applications in the SCM context, but most of them tend to focus on a specific operational function of the SC. For instance, O'Donovan et al. (2015), Dutta and Bose (2015), and Babiceanu and The mentioned transformation is often too time intensive and the stored data is limited for later usage. The distributed processing is needed to extract required information shortly from large datasets. This is not yet implemented due to the restricted accessibility of different internal data sources.

Furthermore, security polices mostly complicate the integration of external data in existing enterprise IT infrastructures. Seker (2016) conducted literature reviews on material flow in manufacturing operations while Wamba et al. (2015) focused on logistics applications.[III] A literature review that takes a broad perspective of SC as a whole and cross-maps with BDA techniques in SCM is yet scarce (Olson, 2015).

IV. Conclusion

Risk evaluation and resilience planning

The Indian logistics industry is estimated to grow rapidly because of favourable infrastructure policies that include "make in India", a national integrated logistics policy, and 100% direct investment in foreign warehouses and store facilities. Some of these initiatives have led to logistics companies' significant improvement, as is reflected in India's logistics performance index (LPI) rank moving from the 54th to the 35th position [XX]. Furthermore, regarding India's gross domestic product (GDP) growth, the logistical industry is projected to grow 15–20% during 2016–2017. The Indian logistic industry consists of four sectors: transportation, warehousing, freight forwarding, and value-added services. Transportation represents 60% of this industry. Logistics chains in Indian firms are either owned by the firm or outsourced to third-party logistics providers. In the event of outsourcing, the company is responsible for its logistic providers' actions because of business interest and corporate image. However, serious social issues are plaguing Indian logistics that not only disrupt the supply chain but also degrade the environment. These issues include workforce safety, excessive fuel consumption, vehicle theft, workforce health, fuel economy, workforce's unethical behavior, workforce security, traffic violations, and natural calamities.

Practitioners recognize the importance of predicting, monitoring and mitigating such issues. However, to our knowledge, no innovative, integrated approach to solve this menace has been presented. In the proposed research, we clarify how integrating knowledge-based big data into the supply chain helps mitigate social and environmental risks.

In addition to a resilient and flexible supply chain infrastructure, businesses need highly accurate risk detection to keep running when failure strikes. With Big Data tools and techniques, logistics providers can secure customer operations by performing predictive analytics on a global scale. The aim of this research is to explore the application of big data analytics in mitigating supply chain risks and to demonstrate how such mitigation can help in achieving environmental, economic, and social sustainability.

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