International Journal of Pure and Applied Mathematics
Volume 117 No. 20 2017, 911-916
ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version)
url: http://www.ijpam.eu
Special Issue

ijpam.eu

Big Data: Transforming Logistics and Supply Chain

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***Abstract*— this paper aims to explore the applications of Big Data in Logistics and Supply Chain Management by pinpointing various challenges that may have to be faced by logistics companies employing Big Data. This paper reviews the importance of Big Data in Logistics based on scholarly articles. The paper also highlights different challenges faced by logistics operation by employing Big Data and how Logistics Cost Optimization is achieved using Big Data. Moreover, Big Data in Logistics is an emerging aspect which has both pros and cons. But the future growth of Big Data in Logistics cannot be predicted. Applying Big Data in logistics can have positive impacts on cost and inventory management, customer satisfaction, route optimization etc. thus increasing the overall efficiency in performance of logistics operations.**

1. INTRODUCTION

Big data refers to capturing and storing of a large volume of data that can be used for analysis. A very large amount of data is being generated globally on an everyday basis and traditional data application software is inadequate to deal with such complex data [1]. Big data is characterized by 5 dimensions described below:

- ***Volume-*** There is no sampling done in big data it just captures and tracks every data. Therefore the volume of data collected is huge. Most of the present enterprises have storage systems to store terabytes and petabytes of data. The challenge lies in efficiently managing this large volume of data.
- ***Velocity-*** The data movement in today's world is real time and is on a fast pace. The data keeps getting updated within fraction of seconds. Big data is represented by this high velocity of data.
- ***Variety-*** Data can be in multiple forms. It is necessary to arrange these data into a single format in order to make it applicable. Therefore this variety of data also represents Big Data.
- ***Veracity-*** Veracity refers to the orderliness, messiness or trustworthiness of available data.
- ***Value-*** The value aspect in Big Data refers to the non-exploitation of datasets and it is a more subjective aspect.

Logistics refers to the management of flow of things between a point of origin and a final point of consumption. Logistics of physical items includes the following:

- Material handling
- Production
- Packaging
- Inventory
- Transportation
- Warehousing
- Security

The business efficiency and performance of logistic management lies in the ability to manage; access and analyze vast volumes of data. Optimizing the routing of goods and services can have a high influence on the profitability of any firm [1]. More complex data is to be managed as logistics management and transportation becomes more data driven. Today's data sources include sensors, operational systems, social media, websites, forecast systems etc. [2]. With 'big data' solutions, data can be ingested at higher rates, stored longer and can be analyzed faster and it will enable logistics companies to meet all these requirements [3].

2. APPLICATIONS

- ***Last mile of shipping can be quickened***

The last mile of shipping accounts for almost 28% of total cost of delivery [8]. It is highly inefficient and may have many obstacles like increased time of delivery, difficulty in parking vehicles in urban areas, ability to efficiently handle the package by professionals without damage etc. However, track of the packages can be kept up to this point [2]. The spread of Internet of things and usage of Big Data enables the shippers to view the delivery process from start to finish. Big Data can be used to optimize delivery strategies thus improving performance.

- ***Transparency in reliability***

Transparency is an important characteristic that is always considered by shippers, carriers and customers. To achieve transparency in the whole process, sensors are provided in vehicles. Data obtained from these sensors can be used to estimate time of delivery thus avoiding bottlenecks down the supply chain process [1]. Further, logistics companies can use this data when bidding for new contracts.

- ***Route Optimization***

The best use of Big Data in logistics is logistics optimization [7]. Optimization of routes helps in reducing cost and avoiding late shipments [2]. For instance, if too many vehicle are put on one delivery route, it may lead to usage of assets unnecessarily that may have been better utilized elsewhere. On the other hand, if enough number of vehicles are not allocated in one delivery route, it may lead to late shipments which can negatively affect the brand image and client relationship. Other challenges in optimization of routes include change in fuel costs, highway repair works, weather conditions and other environmental factors. Big Data helps to overcome these challenges by integrating data obtained from sensors in vehicles, road maintenance data, weather forecast etc. into a system so that decisions can be taken accordingly.

- ***Shipment of sensitive goods***

Maintenance of perishable goods is a key challenge for logistics companies in the case of food manufacturing industries. Big Data and internet of things helps in retaining the freshness of such goods by different techniques. For example, a truck carrying dairy products can have temperature sensors installed within the storage space so that a record of temperature can be kept. Traffic condition forecast is also another technique and it ensures that a higher quality of sensitive goods are shipped and delivered.

- ***Automation of Warehouses and the Supply Chain***

Integration of Big Data with technology has a very high potential to enhance logistics performance. It leads to the automation of Supply Chain system as a whole. Many business organizations are adopting automation technologies for example Amazon has robots to grab items from shelves and automated drones for delivering goods. Self-driving vehicles are another example.

3. BENEFITS OF BIG DATA IN SUPPLY CHAIN MANAGEMENT

Big data has high potential for improving efficiency and effectiveness thus producing higher quality outputs [1]. The concept of intelligent supply chain has arisen from Big Data Analytics [10]. The following are the benefits offered by Big data:

- More accurate operational information is provided.
- Supplier change and timely corrections are enabled.
- Transparency of information is allowed.
- Gives greater visibility throughout the Supply Chain.
- Traceability of products and services is improved which is an important aspect of Logistics.
- Helps in identifying supplier problems.
- Early warnings are provided regarding defects in goods and services in Supply Chain thus avoiding recalls.
- Supply Chain and inventory risks are minimized using Big Data.
- Improves decision-making process in Logistics thus making the decisions precise.
- Exact time of delivery can be determined by leveraging Big Data to track delivery routes and to provide information regarding weather conditions and traffic conditions along the delivery routes.
- Detail analysis of vendor performance can be performed like aspects including vendor profitability, customer complaints and feedbacks and on-time service.
- Improves service quality and enables personalized service.
- Helps to establish customer purchase behavior by analyzing data from all channels including social media websites and mobile websites.
- Development of data-driven new business models can be done employing Big Data.
- Next generation products and services can be improved.
- Generate more profitability by predicting future outcomes having greater confidence level.

4. BIG DATA FOR CUSTOMER SATISFACTION

Big data has proven to have significant impact on customer satisfaction. Companies use data generated from social media like Facebook, Instagram etc. to gain understanding on consumer preferences [9]. In this way, demand and sales can be anticipated and supply chain can be coordinated accordingly so that wastage of money in shipping superfluous units can be avoided. There are other techniques that logistics companies adopt in order make customers happy. Delivery of tangible goods requires a face-to-face contact with the customers [1]. Big Data helps in ensuring that this criterion is achieved in the most efficient manner and makes the whole process user friendly. Amazon has adopted the method of 'anticipatory shipping' to improve customer satisfaction in which the demand is anticipated considering purchase patterns of customers, time spent in viewing a product and search patterns [9]. Some companies like DHL provides options like 'My Choice' to the customers that enable customers to manage delivery points via mobile devices and can avoid the inconvenience of staying home for receiving a package. Big Data is being used for precise customer targeting and differentiation to optimize interaction with the customers. Big Data, in general, helps logistics industries in decision-making which is data-driven, formulate strategies and implement innovations.

5. INTEGRATION OF 5V's OF BIG DATA WITH SUPPLY CHAIN MANAGEMENT

Big data is a trending concept in today's world. Estimates show that almost 90% of the data present today was created in the last two years. Thus to describe this overwhelming

amount of data it is divided into five dimensions as described earlier in this paper [1].
The integration of 5V's of Big Data with Supply Chain management is described in brief:

- ***Volume***

A very huge amount of data is generated every second. This data can be easily managed and controlled using devices like sensors, bar codes and other means like ERP (Enterprise Resource Planning) and database technologies.

- ***Velocity***

In Supply Chain management, the velocity of data relies on the speed with which data is collected, how efficiently the data is stored, how useful data is excavated from existing available data, algorithms and decision-making models.

- ***Variety***

The data generated from Supply Chain is highly variable in nature as they are generated from diverse sources in heterogeneous formats using various sensors used in highways, manufacturing plants, retail shops etc.

- ***Veracity***

The verification of quality and reliability of data is performed under different circumstances and it is highly complex in nature.

- ***Value***

The examination of the impact on data insights and business processes within the Supply Chain is highly challengeable. This should go hand in hand with the value of reports, statistics and interpretations.

6. BIG DATA FOR SMART CITY TRANSPORT

The concept of smart city integrates two main aspects namely the logistics (transportation) aspects and emerging technologies which is made use of to implement all the activities of smart city [2]. Logistics in smart city focuses on disaster and emergency management. All the activities are considered from a sustainability point of view. This includes capturing and analysis of data. Big Data helps in extracting data either from sensors or households, having all the five characteristics. Integration of city systems is an important aspect for smart city development. Big data enables to manage the large quantity of unstructured data collected by interlinking it [13].
Dealing with CO_2 footprint is an important aspect from logistics point of view [2]. Every individual firms focus on transportation optimization, reproducing landscapes, local productions control thus leading to a distributed logistics system rather than centralized logistics system [5]. This has the potential to increase the profitability of the firms by reducing cost of transportation.
GPS data is used to analyze vehicle speeds and to determine bottleneck ratios. This enables smart city to track problematic routes and locations to minimize bottlenecks in traffic conditions [2]. Another method used is passenger tap-in data. Passenger transactions are determined using these data to establish passenger behavior patterns throughout origin destination and waiting times [4]. Even though GPS enables to determine bottlenecks, cause of bottlenecks cannot be determined using the same which is one of the major drawbacks [13]. However, useful models related to origin-destination can be developed using the data extracted.

7. METHODS AND TECHNOLOGIES IN BIG DATA

Big Data is the backbone of Intelligent Supply Chain management system. Data quality and data processing capability is improved using Big Data. Predictions for future [are] made using Big data by deploying various predictive analytical methods like statistics, data mining and modeling by analyzing past and existing data [8]. Correlation analysis can be done using Big Data to establish the type of relationship between different variables. Data quality is an important aspect for analysis as far as Big data is concerned.
Five technologies make Supply Chain management more effective and they are: Internet of Things (IoT), Mobility, cloud computing, Big Data and predictive analysis. The above mentioned technologies are highly inter-linked [6]. Sensors are provided by Internet of Things and Mobility which enables real time data acquisition even while moving. Thus Big data is produced by these sensors in one form. The analysis of the collected data is done using predictive analytical techniques [8]. Cloud computing refers to the process of performing these analysis [12]. In this way cloud computing and Internet of Things are inter-connected. All these technologies perform in integration to make data storage and retrieval cheaper in Big Data analysis [8].
The major tools used in Big data analysis are:

- Query and reporting
- Data Mining
- Data Visualization
- Predictive Modeling
- Optimization
- Simulation
- Natural language text
- Geo-spatial analytics
- Streaming analytics
- Video analytics
- Voice analytics

An estimated data shows that about 91% of companies use Query and reporting, 77% of companies use Data Mining, 71% of companies use Data Visualization, 67% of companies use Predictive Modeling, 65% of companies use optimization, 56% of companies use simulation, 52% of

companies use Natural language text, 43% of companies use Geo-spatial analytics, 35% of companies use Streaming analytics, 26% of companies use Video analytics and 25% of companies use Voice analytics [8].
Cloud services play a vital role in Big data analytics. Core architectural principles of Cloud service in Big data are described below [8]:

- ***Broad network access***

Enables Big Data cloud to be made accessible and available over a wide reach of network by diverse client platforms through standard mechanisms.

- ***Multi- tenancy***

Enables allocation of Big data cloud resources so that multiple tenancy can be achieved and data isolation can be guaranteed.

- ***Resource pooling***

Allows allocation of Big data cloud resources in a location-independent fashion so that it is accessible by multiple tenants for simultaneous allocation and re-allocation of resources through simple abstraction.

- ***Rapid scalability and elasticity***

Enables Big data resources to be automatically and rapidly scaled up and down on demand.

- ***Measured service***

Enables transparency in monitoring, controlling, billing and reporting of Big data cloud resources.

Other than cloud infrastructure services, the following are required to support Big data in general:

- Hadoop related services and tools
- Cluster services
- Special data analytics tools like events, logs, data mining etc.
- Databases with good data quality
- Servers
- Massively Parallel Processing (MPP) databases
- Security infrastructure

8. LOGISTICS COST OPTIMIZATION USING BIG DATA

Employing Big Data in logistics is one of the most effective ways for cost optimization [4]. The three levers for optimizing cost are described below:

- ***Mode and route Mix***

Big Data enables the determination of the most suitable mode of transportation and junction points that will optimize goods flow in terms of cash [7]. For instance, shipping small quantity of goods may be optimally inefficient but it can reduce delivery time, decrease in-transit inventory and make the most out of working capital.

- ***Warehouse and Distribution center networks***

Identification of number and location of warehouses and distribution centers can be done using Big Data. Decisions on whether to serve different customers from a particular warehouse or to have distribution centers for hosting multiple products can be made and this will optimize asset utilization and enables negotiations for lower shipping rates [7].

- ***Shipping Rates***

Big Data can be used to establish transparency in pricing and cost structures across routes and modes. Overpaying routes can be effectively avoided thus optimizing cost employing Big Data.

9. CHALLENGES

The major Challenge in employing Big Data is that it is often wrong, outdated or incomplete. On an average almost half of the working time is spent in handling and maintaining huge volume of data that is available in the form of Big Data. This can adversely affect the time that can be utilized for innovation [10]. Poor data quality can lead to higher cost of functioning of Supply chain leading to a steep increase in the wastage of resources and money[14]. Low proficiency in technology by professionals will end up in manual data entry and handling, ultimately leading to less accuracy in data. Critical points in supply chain are often disrupted by manual and faulty data entries [1].
The visibility of Big Data in supply chain is often low as logistics experts may have large volume of data in hand but they may lack expertise to analyze it due to the absence of a user-friendly graphical interface [15]. Another major challenge includes the volume of data available.
Volume of available data may differ based on regions, for instance, in small economies and rural areas, only a small volume of data may be available unlike metropolitan cities and urban areas [10]. This can have an impact on logistics and supply chain activities in these regions. To overcome the above mentioned challenges, Big Data analytics should be carefully embedded with supply chain operations [11]. People with adequate knowledge in Big Data analytics should be employed to work in pace with logistics so as to obtain actionable insights [14].

10. CONCLUSION

This paper presents an overview of applications of Big Data in logistics and Supply Chain management including a brief description of how Big Data impacts customer satisfaction

and cost optimization in logistics. It also discusses various challenges in the domain. Big Data analytics is in the initial phase of development and the tools, techniques and knowledge to handle these tools is a major challenge and therefore is not able to entirely meet all the requirements. However, efforts are being made from different fields by experts to explore all the hidden values in this domain. Data quality, technical feasibility, privacy etc. are some of the challenges to be dealt with. If these challenges are correctly addressed, Big Data can create a revolution in Logistics sector [5]. The future growth of Big Data analytics is however unpredictable. Big Data in logistics has a great potential for increasing competitive advantages of firms.

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