Computers & Industrial Engineering 101 (2016) 572–591

Contents lists available at ScienceDirect

Computers & Industrial Engineering

journal homepage: www.elsevier.com/locate/caie

Big Data for supply chain management in the service and manufacturing sectors: Challenges, opportunities, and future perspectives

Ray Y. Zhong [a,*], Stephen T. Newman [b], George Q. Huang [c], Shulin Lan [c]

[a] Department of Mechanical Engineering, The University of Auckland, Auckland, New Zealand
[b] Department of Mechanical Engineering, University of Bath, Bath, UK
[c] HKU-ZIRI Lab for Physical Internet, Department of Industrial and Manufacturing Systems Engineering, The University of Hong Kong, Hong Kong

ARTICLE INFO

Article history:
Available online 15 July 2016

Keywords:
Big Data
Service applications
Manufacturing sector
Supply Chain Management (SCM)

ABSTRACT

Data from service and manufacturing sectors is increasing sharply and lifts up a growing enthusiasm for the notion of Big Data. This paper investigates representative Big Data applications from typical services like finance & economics, healthcare, Supply Chain Management (SCM), and manufacturing sector. Current technologies from key aspects of storage technology, data processing technology, data visualization technique, Big Data analytics, as well as models and algorithms are reviewed. This paper then provides a discussion from analyzing current movements on the Big Data for SCM in service and manufacturing world-wide including North America, Europe, and Asia Pacific region. Current challenges, opportunities, and future perspectives such as data collection methods, data transmission, data storage, processing technologies for Big Data, Big Data-enabled decision-making models, as well as Big Data interpretation and application are highlighted. Observations and insights from this paper could be referred by academia and practitioners when implementing Big Data analytics in the service and manufacturing sectors.

1. Introduction

Service sector refers to an involvement of service provision to businesses and final consumers such as finance, healthcare, tradesmanship, tourism, computer services, and restaurants (Reijers, 2003). Manufacturing sector is the production of merchandise using raw materials, labors, machines, tools, and so on, referring a range of human activities (Ferdows & De Meyer, 1990). Service and manufacturing sectors play important roles in the economy where service consists of the "soft" part i.e. activities where people offer the knowledge and time to improve performance, sustainability, productivity, and potentiality; while, manufacturing includes the "hard" part i.e. activities where people use the machines and tools to transform raw materials to finished goods, move goods from manufacturers to retailers by vehicles, and carry out disposal of recycling of used goods (Brouthers and Brouthers, 2003).

Nowadays, the service and manufacturing sectors are facing a data tsunami. It was reported from International Data Corporation that over 1600 Exabytes data were created in 2015 from both sectors. Data volume continues to grow tremendously in part because service and manufacturing sectors have much more workforce are progressively being gathered by advanced information technologies such as ubiquitous-sensing mobile devices, aerial sensory techniques, cameras, microphones, Internet of Things (IoT) technologies (e.g. RFID, Barcode), and wireless sensor networks (Alfalla-Luque, Marin-Garcia, & Medina-Lopez, 2014; Dimakopoulou, Pramatari, & Tsekrekos, 2014; Zhong, Huang, Dai, & Zhang, 2013). Such datasets are so immense and complex that it is challengeable to handle using on-hand database management tools or traditional processing applications.

"Big Data", originally referred to the huge flood of data in the range of exabytes and beyond, has extended the scope of technological capability to store, manage, process, interpret, and visualize the amount of data (Kaisler, Armour, Espinosa, & Money, 2013). The concept of Big Data is first exposed in an article from the ACM digital library in October 1997 (GilPress, 2012). It was used to define a visualization challenge for systems with quite large datasets in computer science. Since then, it has attracted great attention from both academia and practical fields. Big Data has greatly stimulated the demand of specialists in the information management so that AG, Oracle, IBM, Microsoft, SAP, EMC, HP and Dell have spent more than $15 billion on data analytics and processing (Syed, Gillela, & Venugopal, 2013). Big Data is supposed to be one of the top 10 prosperous markets in the coming century.

* Corresponding author.
E-mail addresses: zhongzry@gmail.com (R.Y. Zhong), S.T.Newman@bath.ac.uk (S.T. Newman), gqhuang@hku.hk (G.Q. Huang), lanshulin1988@sina.com (S. Lan).

http://dx.doi.org/10.1016/j.cie.2016.07.013
0360-8352/

In 2010, it was estimated that this industry on its own was worth over $100 billion and was growing about 10% a year (Weng & Weng, 2013). From the statistics, it is estimated that the global Big Data market will reach $118.52 billion by 2022 growing at a compound annual growth rate of 26% during the forecast year from 2014 to 2022 (NewsOn6.com).

Service and Manufacturing Supply Chain Management (SM-SCM) have been undertaking digitization for several decades. Since SM-SCM are largely involved in a range of human activities from aeronautical facilities to daily necessities, the performance and efficiency are significant which has driven the initialization of Big Data (Eichengreen & Gupta, 2013). SM-SCM twining with Big Data is able to create better decision-making mechanisms when using natural resources. To this end, large funding initiatives such as Digging into Data explicitly encourage researchers and practitioners to engate in studies which are able to lead better understanding, development, and applications of Big Data.

For a long time, SM-SCM have focused on the collection and storage of enormous data (Dekker, Pinçe, Zuidwijk, & Jalil, 2013). However, it is facing great challenges when contemplating to make full use of such data. In this paper, the challenges are summarized as "5V" given the typical characteristics of SM-SCM.

- **Volume:** An enormous amount of data is generated tremendously every second within SM-SCM from all over the world. For example, it is calculated that a personal care manufacturer generates 5000 data samples every 33 ms, resulting in 152,000 samples per second, 9 million per minute, 13 billion per day, and 4 trillion samples per year (Markopoulos, 2012). The accumulation of bigger and bigger data sets floods the data collector, transfer networks, and storage facilities.
- **Velocity:** The velocity of processing such huge data set from SM-SCM is significant because data-driven decisions should be made as quickly as possible. The velocity mainly relies on the speed of data collection, reliability of data transferring, efficiency of data storage, excavation speed of discovering useful knowledge, as well as decision-making models and algorithms.
- **Variety:** The vast data from SM-SCM are usually variable due to the diverse sources and heterogeneous formats. New types of data will proliferate from various sensors used in manufacturing sites, highways, retailer shops, and facilitated houses. Integrating such diverse data into standard formats requires a more general and complex makeup language.
- **Verification:** There is a great myriad of bad data (e.g. noises, inaccurate attributes, etc.) from SM-SCM Big Data which should be verified so that good data could be picked out. The verification usually has to be carried out under certain authorities and security levels. Thus, the verification process designed and developed as tools to automatically verify the quality and compliance issues may consider different situations, some of which may be so complex that it is challengeable to address.
- **Value:** The value of Big Data is difficult to evaluate in SM-SCM. Firstly, extracting value from Big Data is tough because of the hurdles caused by the previous four factors. Secondly, it is challengeable to examine the impacts on the insights, benefits and business processes within both sectors. Thirdly, the value of reports, statistics, and decisions obtained from Big Data is hard to measure due to the large influences on micro and macro perspectives.

In order to deeply understand the Big Data and stimulate potential techniques to tackle the challenges in SM-SCM, this paper presents a comprehensive investigation of Big Data for SM-SCM. This paper mainly contains four sections: representative Big Data applications in SM-SCM, Big Data technologies, current movement world-wide, as well as current challenges, opportunities, and future perspectives. Key areas in SM-SCM such as finance and economics, Logistics and Supply Chain Management (LSCM), and manufacturing sector are focused in Section 2. Section 3 concentrates on storage, data processing, data visualization technologies, Big Data analytics, and Big Data models for decision-makings which are crucial concerns in SM-SCM. The next section reviews the major region's current movements including North America, Europe, and Asia Pacific. A major discussion is provided in Section 5, of the current challenges, opportunities, and future perspectives in data collection methods, data transmission, data storage, processing technologies for Big Data, Big Data-enabled decision-making models as well as Big Data interrelation and applications. With Section 6 identifying a number of conclusions from the investigation, insights and lessons are explored.

2. Representative Big Data applications in SM-SCM

Illustrative examples of Big Data applications in SM-SCM are presented including finance and economics, healthcare, biology, IT sector, Logistics and Supply Chain Management (LSCM), and manufacturing sector are reviewed.

2.1. Finance and economics

It is estimated that the global Big Data in financial services sector will grow at a compound annual growth rate of 56.69% over the period 2012–2016 (Globe-Newswire, 2013). In most financial institutions like banks, insurance companies, and brokerage firms, Big Data is common due to the enormous transactions and activities. That directly affects the way how individuals, groups, and organizations manage scarce resources. Garel-Jones (2011) reported that how the financial service sector is able to use Big Data analytics to predict the client behaviors, unlocking the insights in the data to better understand customers, competitors and employees to gain competitive advantage. Predictive modelling and real-time decision making play a critical role in seeking a winning edge in the dynamic markets for financial institutions (Peat, 2013). In order to examine the market volatility in financial markets, a Big Data approach was proposed to compute Volume-synchronized probability of informed trading (VPIN) (Wu, Bethel, Gu, Leinweber, & Ruebel, 2013). For a CFO (Chief Financial Officer) who is the key entity for strategic decision making, Big Data offers an opportunity to use the information, trends, and knowledge hidden in the large data sets. To this end, a business intelligence and analytics tool was introduced to use the Big Data for assisting CFO in seeking better data, providing bigger value, and making greater decisions (Chen, Chiang, & Storey, 2012).

It is believed that the capacity for analyzing big financial data is core to successful competition, thus, a large number of financial institutions have taken the initiative on implementing Big Data technologies. For instance, in 2012, a number of financial institutions such as European Hedge Fund, Global Investment Bank, Retail Banking Innovation Leader, Asia/Pacific National Bank, Expanding U.S. Property Insurer, Global European Institution, Investment Research Institution, and Community Bank used Big Data to successfully obtain different achievements such as optimization of price discovery and investment strategies for large portfolio trades and swaps, creation of merchant intelligence and assistance in optimizing offers and pricing to retail customers, tracking social media into finely tuned market campaigns, etc. (Versace & Karen, 2012). Fang and Zhang (2016) investigated the Big Data solutions for the pioneers of the financial practitioners to gain actionable insights from massive market data.