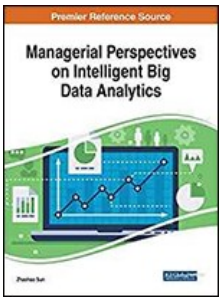

Managerial Perspectives on Intelligent Big Data Analytics

by Zhaohao Sun

Chapter 1: Intelligent Big Data Analytics: A Managerial Perspective

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ABSTRACT

Intelligent big data analytics is an emerging paradigm in the age of big data, analytics, and artificial intelligence (AI). This chapter explores intelligent big data analytics from a managerial perspective. More specifically, it first looks at the age of trinity and argues that intelligent big data analytics is at the center of the age of trinity. This chapter then proposes a managerial framework of intelligent big data analytics, which consists of intelligent big data analytics as a science, technology, system, service, and management for improving business decision making. Then it examines intelligent big data analytics for management taking into account four managerial functions: planning, organizing, leading, and controlling. The proposed approach in this chapter might facilitate the research and development of intelligent big data analytics, big data analytics, business intelligence, artificial intelligence, and data science.

INTRODUCTION

Big data and big data analytics have become the important frontier for innovation, research and development (Chen & Zhang, 2014) (Laney & Jain, 2017). Big data analytics has big market opportunities. For example, IDC forecasts that big data and analytics-related services marketing in Asia/Pacific (Excluding Japan) region will grow from US$3.8 billion in 2016 to US$7.0 billion in 2019 at a 16.3% CAGR (compound annual growth rate) (Roche, 2016). Big data and its emerging technologies including big data analytics have been not only making big changes in the way the business operates but also making traditional data analytics and business analytics bring forth new big opportunities for academia and enterprises (Sun, Sun, & Strang, 2016, Sun, Strang, & Yearwood, 2014; Sun, Zou, & Strang, 2015; McAfee & Brynjolfsson, 2012).

Artificial intelligence (AI) is becoming a core business and analytic competency to transform business processes, reconfigure workforces, optimize infrastructure and blend industries (Laney & Jain, 2017). Gartner predicts that 30% of new revenue growth from industry-specific solutions will include AI technology by 2021 (Laney & Jain, 2017).

Intelligent big data analytics is an emerging science and technology based on AI, and is becoming a mainstream market adopted broadly across industries, organizations, and geographic regions and among individuals to facilitate decision making for business and individual to achieve desired business outcomes (Laney & Jain, 2017) (Sun, Sun, & Strang, 2018) (Howson, Sallam, & Richa, 2018). However, the following issues have not been drawn significant attention in both academia and industries.

- What is the foundation of intelligent big data analytics?
- What is a managerial perspective on intelligent big data analytics?

This chapter will address these two research questions through exploring intelligent big data analytics from a managerial perspective. The first key contribution of this paper is to propose that intelligent big data analytics is at the center of the age of trinity. The second key contribution of this paper is to present a managerial framework of intelligent big data analytics. The framework demonstrates intelligent big data analytics as a science, technology, system, service and management. The third key contribution of this paper is to examine intelligent big data analytics for management as intelligent big data analytics for planning, organizing, leading and controlling.

The remainder of this chapter is organized as follows: Section 2 explores the age of trinity: age of big data, the age of analytics, and the age of AI, and shows that intelligent big data analytics is at the center in the age of trinity. Section 3 proposes a managerial framework of intelligent big data analytics. Section 4 discusses intelligent big data analytics as a management. Sections 5 and 6 provides discussion and implications as well as future research directions of this research. The final section ends this chapter with some concluding remarks and future research directions.

AN AGE OF TRINITY: BIG DATA, ANALYTICS, AND ARTIFICIAL INTELLIGENCE

This section first briefly overviews the age of big data, the age of analytics, and the age of AI, and then looks at the age of trinity and shows that intelligent big data analytics plays a central role in the age of trinity.

The Age of Big Data

The age of big data can be dated back to 2001. At that time, Doug Laney of the META Group (now Gartner) uses 3 Ds: data volume, data velocity, and data variety to represent the characteristics of data management in e-commerce (Laney, 2001). McKinsey Global Institute claims big data as the next frontier for innovation, competition, and productivity (McKinsey, 2011), which plays a catalytic role in the coming of the age of big data. The age of big data has officially arrived in 2012 (Lohr, 2012 February 11), because of the US Government's announcement of "Big Data" Initiative (Weiss & Zgorski, 2012). At that time, the 3 Ds had been changed into 3 Vs (volume, velocity, and variety) which have been explained as three characteristics of big data (McAfee & Brynjolfsson, 2012) (McKinsey, 2011). The age of big data has drawn significant attention in the academia, industry and government since then. The Chinese government also announced its national initiative on big data in 2015 (Sun Z., 2018). The initial 3Vs have been evolved to 10 Bigs to represent the 10 big characteristics of big data in order to meet the ever-increasing global and social demands (Sun Z., 2018). These10 Bigs consists of big volume, big velocity, big variety, big veracity, big analytics, big infrastructure, big service, big market, big value, and big intelligence. We are in the age of big data, and enjoy these 10 Bigs of big data such as big service and big market. For example, 2.2 billion people are enjoying the Facebook commerce and services monthly (Wikipedia, 2018). More than 1 billion people are enjoying the WeChat services and free call worldwide (Wikipedia, 2018). Smart phones have become an indispensable part of our human brains to read, to speak, to write, to listen and to do business. It is possible to use Google searches, Facebook posts and Twitter messages to measure the behaviour and sentiment of every netizen in fine detail (Lohr, 2012 February 11).

The Age of Analytics

Analytics was first in scholar publication in 1936 (Semanticscholar.org). Analytics is "the scientific process of transforming data into insight for making better decisions" (Wang, 2012). Data analytics can be considered as data-driven discoveries of knowledge, intelligence and communications (Delena & Demirkanb, 2013). More generally, data analytics is a science and technology about analyzing, examining, summarizing, acquiring intelligence, and drawing conclusions from data to learn, describe and predict something (Sun, Strang, & Yearwood, 2014) (Gandomi & Haider, 2015). Data analytics has been in academia and industry for a long time although it has not become a disruptive technology until recently (Holsapplea, Lee-Postb, & Pakath, 2014) (Davis, 2014).

The age of analytics has started with the release of "The age of analytics: Competing in a data-driven world" by McKinsey Global Institute in 2016 (Henke & Bughin, 2016). We are in the age of analytics, and enjoy the analytics as a service (Delena & Demirkanb, 2013) (Sun & Yearwood, 20014) (Laney & Jain, 2017) and big data analytics as a service (Sun Z., 2018). For example, Google Analytics provides services like Google map to billions of people worldwide. Clarivate analytics is the largest academic quality publication database to provide subscription services to academia and industry. Tableau, Python and R as software have been used widely to develop big data analytics services. A popular analytics service is that one can enjoy the health analytics service provided by various smart phones in a real-world mode. Big Data and analytics are increasingly critical elements across most industries, business functions and IT disciplines. They are creating unlimited business value possibilities, based on the research of Gartner (Laney & Jain, 2017).

The Age of Artificial intelligence

The age of Artificial intelligence (AI) can go back to 1950 when Alan Turing published his seminal paper titled 'Computing Machinery and Intelligence' (Turing, 1950). AI was first coined by John McCarthy in 1955, defined as the "science and engineering of making intelligent machines" (Wang, 2012). It aims to imitate, extend, augment, automate intelligent behaviors of human being using computing machinery (Russell & Norvig, 2010). In the past six decades, researchers and developers have been working on intelligence of machines (Wang, 2012), neural networks, machine learning and translation (Laney & Jain, 2017), natural language processing, machine translation, expert systems, knowledge base systems, fuzzy logic and systems, genetic algorithms and so on under the flagship of AI (Russell & Norvig, 2010).

The age of AI has officially arrived in 2013 (John, 2013). The significant success and global concern of market-driven AI is another reason for the coming of the age of AI. Autonomous vehicles, advanced vision systems, virtual customer assistants, smart personal agents and natural language processing are all the advanced technology of market-driven AI (Laney & Jain, 2017). Google and Baidu Driverless cars running on the road in USA and China symbolizes the significant progress of market-driven AI. Smart phones as intelligent products provide health analytics, weather, shopping and travel services to one wherever and whenever one is.

Intelligent Big Data Analytics at the Center of the Age of Trinity

Based on the discussion of previous sections, we have been living in the age of big data (Tsai, Lai, Chao, & Vasilakos, 2015), the age of analytics and the age of AI. Therefore, we are living in an age of trinity that integrates big data, analytics and AI, as shown as in Figure 1.

Big data, analytics and AI and their integration are at the frontier for revolutionizing our work, life, business, management and organization as well as healthcare, finance, e-commerce and web services (Henke & Bughin, 2016) (Lohr, 2012 February 11) (John, 2013) (Sun, Strang, & Yearwood, 2014).

Big data has not very big value without big data analytics, just as oil without the significant progress of petrochemical industry. However, the commercial value of big data becomes bigger and bigger with the processing, deep processing, smart processing, intelligent processing of big data. Big data analytics is behind processing, deep processing, second time processing, multi-processing …. of big data. Therefore, big data analytics is more important than big data, and intelligent big data analytics is at the core of this age of trinity, and becomes disruptive technology for the age of trinity in terms of healthcare, web services, service computing, cloud computing and social networking computing (Laney & Jain, 2017). AI-derived business value is forecasted to increase to $US3.9 trillion in 2022 from $US1.2 trillion of 2018 (Pettey & van der Meulen, 2018), 325% jump! Intelligent big data analytics is an enabler for effective management and decision making in the age of trinity.

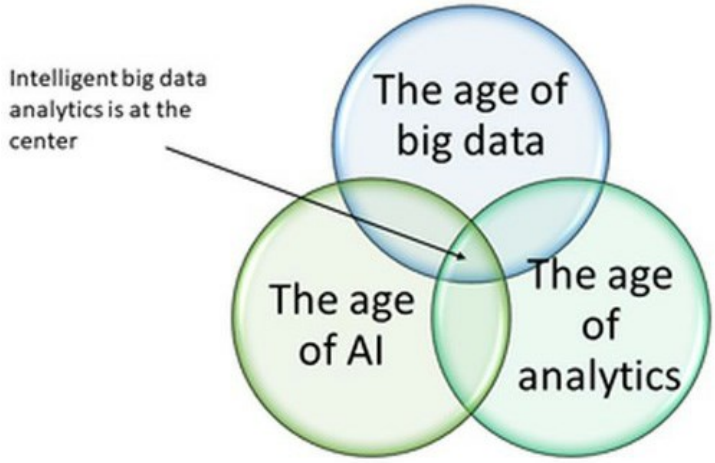

Figure 1: An age of trinity: big data, analytics and AI

It should be noted that Gartner uses advanced analytics to analyze AI, big data and analytics and their impacts (Laney & Jain, 2017). With the further development of the age of trinity, intelligent analytics or smart analytics might be the choice for representing either advanced analytics or intelligent big data analytics, because the general customers hope to use the simple concept to cover what they perceive just as smart phone rather than intelligent phone is accepted in the world.

A MANAGERIAL FRAMEWORK OF INTELLIGENT BIG DATA ANALYTICS

A managerial framework of intelligent big data analytics consists of intelligent big data analytics as a science and technology, intelligent system, service and management for improving business decision making, as shown in Figure 2.

This section will examine each of them in terms of goals, processes for support decision making of business process and organization.

Intelligent Big Data Analytics as a Science and Technology

Like mathematics, intelligent big data analytics (IBA) is science and technology about collecting, organizing and analyzing big data to discover patterns, knowledge, and intelligence within the big data based on AI, and domain-specific mathematical and analytical models (Holsapplea, Lee-Postb, & Pakath, 2014)(Sun, Sun, & Strang, 2018) (Chen, Chiang, & Storey, 2012) (Davis, 2014). Currently, IBA can be classified into intelligent big data descriptive analytics, big data predictive analytics and big data prescriptive analytics (Sun, Sun, & Strang, 2018), as mentioned in the previous section. All these mentioned should be improved through theoretical, technological, and methodological development in order to meet the global and social demands from different parties or individuals for intelligent big data analytics with applications.

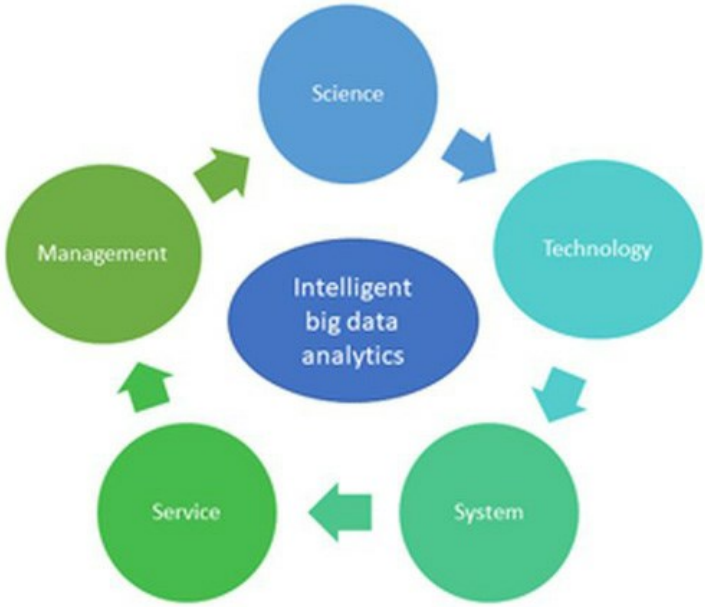

Figure 2: A managerial framework of intelligent big data analytics

Foundations of IBA consists of core foundations and supporting foundations. The core foundations include intelligent data warehousing, intelligent data mining, intelligent statistical modelling, machine learning including deep learning (Al-Jarrah, Yoo, Muhaidat, & Karagiannidis, 2015), intelligent visualization and optimization (Sun, Sun, & Strang, 2018). The supporting foundations include mathematics and statistics including descriptive and predicative statistical methods (Davis, 2014), computing and data science, AI and optimization, domain sciences including business and management science (Sun & Wang, 2017).

Technologies of IBA include intelligent technology, computational technology, web technology and Internet technology, social networking technology, cloud technology, and management technology, to name a few (Laney & Jain, 2017). Gartner predicts that half of IT organizations will apply IBA or advanced analytics in application development to improve application quality and deliver speed (Laney & Jain, 2017).

Intelligent Big Data Analytics as a System

Intelligent systems (IS) encompasses the principles, methodologies, techniques and processes of applying AI to real world problem solving (Schalkoff, 2011). An IS is a system that can imitate, and/or automate intelligent behaviors of human beings and solve problems that were heretofore solved by humans through generating representations, inference procedures, and learning strategies (Schalkoff, 2011) (p. 2). Intelligent systems are built based on the following intelligent techniques: Knowledge representation (Schalkoff, 2011), expert systems and knowledge-based systems (Moutinho, Rita, & Li, 2006), case-based reasoning (CBR) (Sun & Finnie, 2004), genetic algorithms, swarm intelligence (Schalkoff, 2011), neural networks, fuzzy logic, intelligent agents and multiagent systems (Russell & Norvig, 2010), data mining and knowledge discovery from databases (KDD), decision support systems (DSS), and knowledge management (Moutinho, Rita, & Li, 2006), to name a few.

Intelligent big data analytics is designed into intelligent systems and embedded in intelligent systems. This is an application form of intelligent big data analytics as an intelligent system in specific and system in general. There are a number of intelligent big data analytics as an intelligent system in smart mobile phones, in airplane, in supermarket, even in a driverless car. Intelligent big data analytics as an intelligent system has been accepted by business, market, finance, banking, healthcare and other industries in the age of trinity. Recently, Woolworths and Coles, K market in Australia have used intelligent machines with intelligent big data analytics. One scans what buying at supermarket and pays the bill there by clicks. No sales assistants work there anymore. Unmanned stores have become more and more in China nationwide. At Airports, one can check-in using IDS and get boarding card automatedly.

Intelligent big data analytics as an intelligent system can aid managers by extracting useful patterns of information, capturing and discovering knowledge, and generating solutions to problems encountered in decision making, delegating authority and assigning responsibility (Sun & Firmin, 2012).

The relationships among intelligent systems, intelligent big data analytics, and intelligent analytics as follows can be summarized as

$$\text{Intelligent Big Data Analytics} \subset \text{intelligent analytics} \subset \text{Intelligent Systems}.$$

Intelligent Big Data Analytics as a Service

Analytics as a service is relatively new (Delena & Demirkanb, 2013) (Sun & Yearwood, 2014). Big data analytics as a service is an extended form of analytics as a service (Sun, Sun, & Strang, 2018). Big data analytics as a service has been evolved into intelligent big data analytics as a service in the age of trinity. Intelligent big data analytics as a service has been revolutionizing people's work, life and thinking with the healthy development service-centered society (Sun & Yearwood, 20014) (Sun, Sun, & Strang, 2018). Currently, many enjoy intelligent big data analytics services in terms of living, studying, working, moving and socializing. For example, when one drives from one city to a corner of another city, the GPS navigation services can guide the car to arrive the destination optimally. The automation of driving (Vardi, 2016) armed with intelligent big data analytics will make everyone enjoy wonderful driving service from one place to a corner of another city easily, safely and optimally even if he can sleep, enjoy the online chat, and watch movies in the car, until his car arrives the destination and tells him "You have reached your destination, my darling".

Figure 3 is an intelligent big data analytics service-oriented architecture (IASOA), based on the big data analytics SOA proposed in (Sun, Strang, & Yearwood, 2014) (Sun, Zou, & Strang, 2015). In this architecture, intelligent big data analytics service provider, intelligent big analytics service requestor, intelligent big data analytics service broker are three main players.

In Figure 3, intelligent big data analytics service requestors include organizations, governments and all level business decision makers such as CEO and CFO as well as managers (Sun, Strang, & Yearwood, 2014). Intelligent big data analytics service requestors also include business information systems and e-commerce systems. Intelligent big data analytics service requestors require big data analytics services including information analytics services, knowledge analytics services, organization analytics services, intelligent business analytics services, market analytics services to provide knowledge patterns and information (Coronel & Morris, 2015) for decision making in the form of figures or tables or reports (Kauffman, Srivastava, & Vayghan, 2012). More generally, intelligent big data analytics service requestors include people who like to make decisions based on analytical reports provided by big data analytics service provider (Sun, Strang, & Yearwood, 2014). Therefore, a person with smartphone receiving intelligent analytics services like GPS information is also an intelligent big data analytics service requestor (Delena & Demirkanb, 2013; Sun, Zou, & Strang, 2015; Sun, Sun, & Strang, 2018).

Intelligent big data analytics service brokers are all the entities that facilitate the development of intelligent big data analytics services, which include popular presses, traditional media and social media, consulting companies, scholars and university students, and so on (Sun, Strang, & Yearwood, 2014). All these use a variety of methods and techniques to improve intelligent big data analytics services (Sun, Strang, & Yearwood, 2014). McKinsey (http://www.mckinsey.com/) and Gartner as intelligent big data analytics service brokers have played an important role in pushing intelligent big data analytics in businesses and enterprises.

Intelligent big data analytics service providers include analytics developers, analytics vendors, analytics systems or software and other intermediaries that can provide intelligent analytics services. For example, Tableau as a software developer has been promoting intelligent big data analytics (Tableau, 2015). Google is not only a search engine provider, Google Analytics (http://www.google.com/analytics/) is also an intelligent big data analytics service provider. Mobile App Analytics (http://www.google.com/analytics/mobile/), a part of Google Analytics, is also a mobile big data analytics services provider that helps the smartphone customers to discover new and relevant users through traffic sources reports.

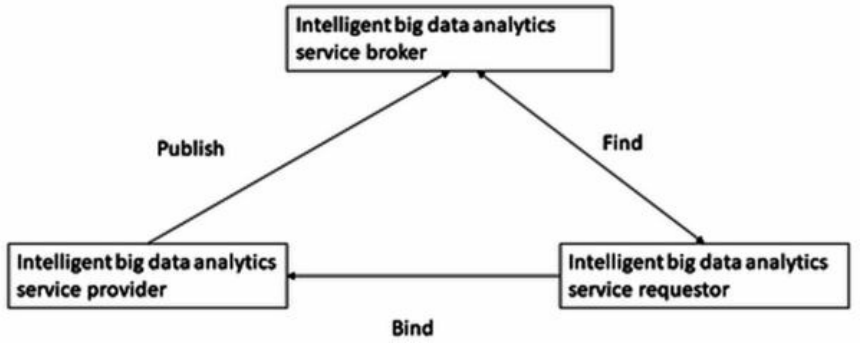

Figure 3: An IASOA

INTELLIGENT BIG DATA ANALYTICS AS A MANAGEMENT

Management is the process of manager's coordinating and overseeing the work activities of others so that their activities are completed (Robbins, Bergman, Stagg, & Coulter, 2012). There are three levels of management: operational management, tactical management, and strategic management, which correspond to activities of operational managers, middle managers

and top managers of organizations respectively (Robbins, Bergman, Stagg, & Coulter, 2012) (pp. 14-19). The main management functions or activities of a manager consist of planning, organizing, leading and controlling (Terry, 1968) (p.133) (Robbins, Bergman, Stagg, & Coulter, 2012) (pp.14-19). Intelligent big data analytics as a management can be briefly represented as:

(1) Intelligent big data analytics as a management = Management of intelligent big data analytics + intelligent big data analytics for management

The following subsections will look at management of intelligent big data analytics and intelligent big data analytics for management to some detail.

Management of Intelligent Big Data Analytics

There are many methods and techniques that are useful for managing intelligent big data analytics, for example, data management, information management, and knowledge management (Sun & Firmin, 2012). These have played a significant role in big data analytics as an intelligent system, because data, information, and knowledge are the foundation for intelligent systems and big data analytics (Sun & Finnie, 2004), as shown in Figure 4. Data management (Laudon & Laudon, 2014), information management (Laudon & Laudon, 2014), knowledge management (KM) (Sun & Finnie, 2005) are well-known in either information systems (Chaffey, 2009) or intelligent systems (Turban & Volonino, 2011). We do not go into each of them, owing to space limitation. For detail see other references such as (Sun & Finnie, 2004) and (Chaffey & White, 2011).

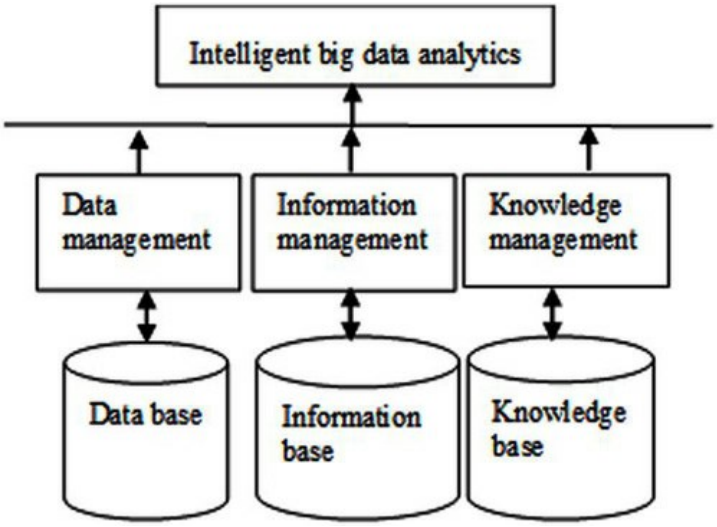

Figure 4: A model of management for intelligent big data analytics

Intelligent Big Data Analytics for Management

Intelligent big data analytics should be applied to each of the main management functions in order to sustain business competitiveness, operate organizations more intelligently at all levels, and enhance management decision making (Davis, 2014), that is, it is important to look at intelligent big data analytics for planning, organizing, leading, and controlling respectively. In what follows, we will look at each of these in some detail.

Intelligent Big Data Analytics for Planning

Planning involves defining the organizations' goals, establishing an overall strategy for achieving those goals, and developing a comprehensive set of plans to integrate and coordinate organizational work (Robbins, Bergman, Stagg, & Coulter, 2012, p. 294). In the process of planning, managers define goals, establish strategies for achieving these goals, and develop plans to integrate and coordinate activities (Robbins, Bergman, Stagg, & Coulter, 2012, p. 14). To this end, the managers should define the nature and purpose of planning, classify the type of goals that organizations use, and describe related types of plans that organizations use, describe project management and discuss issues in planning. A comprehensive set of plans is the outcome of the planning process (Sun & Firmin, 2012).

Intelligent big data analytics for planning aims to imitate and automate some or all planning behaviors of managers of organizations, e.g., in corporate planning (Thierauf, 1982) and supply chain planning (Laudon & Laudon, 2014, p. 303). More specifically, they should imitate and automate definition of goals, establishment of strategies for achieving these goals, and development of plans to integrate and coordinate activities (Sun & Firmin, 2012). To this end, data management, information

management and knowledge management should be the basis for any intelligent big data analytics for planning. Data mining, business analytics, knowledge base systems (KBS), expert systems and intelligent agents have been developed to aid the process of planning. All these intelligent techniques are used as a decision support tool for intelligent planning system (Smith, 1992). Case based systems as intelligent systems can also facilitate the intelligent big data analytics for planning, because "similar goals have similar strategies" for achieving these goals (Sun & Finnie, 2004) (Finnie & Sun, 2003).

Intelligent big data analytics for planning can be also called intelligent planning analytics. Intelligent planning analytics has been used to automate planning, budgeting, forecasting and analysis processes for an organization working together with IBM® Planning Analytics (Cortell, 2017).

Intelligent Big Data Analytics for Organizing

Organizing is to establish effective behavioral relationships among selected work, persons, and workplaces in order for the group to work together efficiently (Terry, 1968, p. 289). In other words, organizing means arranging and structuring work, persons, and workplaces to accomplish the organization's plans and goals (Robbins, Bergman, Stagg, & Coulter, 2012, p. 14). When organizing, managers determine what tasks need to get done, who is to do them, and how the tasks are to be decomposed and grouped, who reports to whom and at what level decisions to be made. They also allocate and deploy organizational resources during the organizing process (Robbins, Bergman, Stagg, & Coulter, 2012, p. 368).

Intelligent big data analytics for organizing aims to imitate and automate all or some organizing behaviors of managers of organizations. More specifically, it should imitate and automate decomposition of tasks, grouping of persons who complete the decomposed task, allocation and deployment of organizational resources. Intelligent big data analytics for organizing also includes intelligent customer relationship analytics (CRA) software and intelligent supply chain analytics (SCA) software. CRA software uses intelligent technologies and big data analytics to organize business processes and marketing activities including customer service and technical support. The main CRA vendors are SAP (www.sap.com), oracle (www.oracle.com) and salesforce.com (CRM, 2012). SCA software as an intelligent system involves using intelligent technology to optimally organize supply activities and associated material flows and information flows to organizations and marketing (Sun Z., 2016). SAP and Oracle are among the leading providers of SCA applications (Chaffey, 2009, p. 379).

The intelligent big data analytics tools for organizing include spreadsheets and project management specific applications. Spreadsheets are regularly used to assist managers to organize information and data. Project management applications e.g. Microsoft Project, are also used to assist managers to organize activities, in particular the planning and scheduling of activities. Tools such as Microsoft Project have intelligent capabilities evidenced through the automation and generation of management reports such as Gantt charts (Larson & Gray, 2011). Their functionality supports the organizational process to improve efficiencies and information quality (Caniels & Bakens, 2011).

Intelligent Big Data Analytics for Leading

Leading is to oversee and coordinate people to work so that organizational goals can be pursued and accomplished (Robbins, Bergman, Stagg, & Coulter, 2012, p. 467). When managers are leading, they motivate their subordinates, help to resolve work group conflicts, influence individuals or work teams, select appropriate communication channels, or deal with individual or group behavior issues (Robbins, Bergman, Stagg, & Coulter, 2012, p. 14). Leading people involves understanding their attitudes, behaviors, personalities and motivations as an individual, or a group, or a community (Robbins, Bergman, Stagg, & Coulter, 2012, p. 469) and helping them to "achieve their respective essential goals as well as their maximum potentialities" (Terry, 1968, p. 451).

Intelligent big data analytics for leading aims to imitate and automate all or some leading behaviors of managers. More specifically, it should imitate and automate how to motivate subordinates, help to resolve work group conflicts, influence individuals or work teams, select appropriate communication channels or deal with individual or group behavior issues, and understanding attitudes, behaviors, personalities and motivations of the individuals and teams (Sun & Firmin, 2012). However, understanding attitudes, behaviors, personalities and motivations of individuals and teams is still a big challenge for research and development of intelligent systems for leading (Sun Z., 2016). Although there are not special intelligent big data analytics for leading, there are intelligent analytics apps that are used to assist leading of managers. For example, enterprise networking sites as limited online social networking services have been available in many large organizations for facilitating leading of managers. Updated communication tools including emails have also facilitated the communications among the manager and his/her subordinates.

Intelligent Big Data Analytics for Controlling

Controlling is to determine what is being accomplished, that is, evaluate the performance and, if necessary, apply corrective measures to that the performance takes place according to plans (Terry, 1968, p. 544). In other words, a control mechanism has five basic elements: establish standards, supervise, monitor, compare and correct work performance (Thierauf, 1982, p. 278). Controlling of operations, processes, quantity, quality, time use, budget and cost are main job of a manager (Terry, 1968, p. 543) (Sun Z., 2016). When managers are in the process of controlling, they must monitor and evaluate the activities to make sure they are being done as planned and correct any significant deviations (Robbins, Bergman, Stagg, & Coulter, 2012, p. 645). Therefore, a control process consists of measuring actual performance, comparing actual performance against the established standards and taking managerial action, taking into account the goals and objectives of the organization (Sun & Firmin, 2012).

Intelligent big data analytics for controlling aims to imitate and automate all or some controlling behaviors of managers of organizations. More specifically, it should imitate and automate monitoring and evaluation of activities, measurement of actual performance, comparison of actual performance against the established standards and recommendations of managerial decisions (Sun & Firmin, 2012).

Intelligent big data analytics for controlling can be also called intelligent control analytics which has "the ability of comprehend, reason and learn from processes, disturbances and operating conditions" (Astriim & McAvoy, 1992). Intelligent control analytics has used intelligent techniques including knowledge base systems, expert systems, neural networks, machine learning, multiagent systems, and fuzzy logic (Astriim & McAvoy, 1992) and big data analytics to process control and process automation.

Currently, digital surveillance and CCTV (closed circuit TV) camera, and intelligent agents have been used to monitor and evaluate activities and recommendations of managerial decisions. The following proposed intelligent control analytics for controlling (ICA), shown in Fig. 5, is based on the intelligent system for process control (Astriim & McAvoy, 1992) (Sun Z., 2016), taking into account big data analytics as an intelligent system.

This ICA is a knowledge-based analytics for controlling. The knowledge base includes the performance knowledge of entity that requires control, called controllee, and knowledge for supervision, monitoring, evaluation and recommendation. The multiagent system includes multiple intelligent agents such as supervisor, monitor, evaluator and recommender. The recommender will propose alternative strategies for adjusting work of the controllee to the manager, the manager will finally select one of the alternative strategies to ask the controllee to carry out (Sun Z., 2016).

We have examined intelligent big data analytics for planning, organizing, leading and controlling respectively. In fact, many intelligent systems include not one but more than one functions of the management functions. The most comprehensive intelligent big data analytics as intelligent systems for enterprise management might be ERP (enterprise resource planning) systems which integrate all management facets of an enterprise, including accounting management, logistics management, manufacturing management, marketing management, planning management, project management, human resources management, SCM, CRM, and finance management (Schneider, 2011) (Laudon & Laudon, 2014). The two major ERP vendors are Oracle.com and SAP.com, as mentioned earlier.

There are still few attempts toward unifying main management functions into intelligent big data analytics to automate planning, organizing, leading and controlling at an organizational level. Any attempt in this direction is significant for research and development of intelligent big data analytics.

DISCUSSION AND IMPLICATIONS

This section will discuss the related work, examine theoretical, technical and social implications of this research.

Discussion

Intelligent big data analytics has drawn some attention in academia and industries. For example, two researches are related to this chapter. The first research (Chen, Li, & Wang, 2015) considers intelligent big data analytics as a big data system and uses collective intelligence model and multiagent paradigm to propose a collective intelligence framework to solve the system integration problem in big data environment. The second research (Kumara, Paik, & Zhang, 2015) uses automatic service composition to present an approach to automate the process in order to infer workflow for data analytics process. Both have not discussed the fundamental problems of intelligent big data analytics nor provided any managerial perspective on intelligent big data analytics.

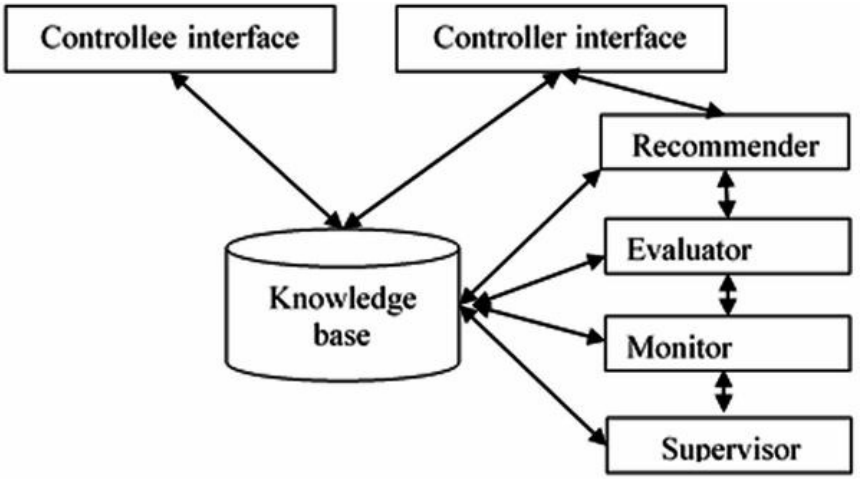

Figure 5: A system architecture of an intelligent control analytics

From an evolutionary viewpoint, data mining is an extended form of data analysis (Kantardzic, 2011). Data analytics is an extended form of data mining (Gandomi & Haider, 2015). For example, data analytics is considered as the whole data mining process or process of knowledge discovery in databases (KDD) (Tsai, Lai, Chao, & Vasilakos, 2015). Therefore, the relationships among data mining, data analytics, big data analytics and intelligent big data analytics can be represented as

(2) $\text{intelligent big data analytics} \subset \text{big data analytics} \subset \text{data analytics} \subset \text{data mining}.$

This means that data mining is a foundation of intelligent big data analytics. However, the difference between intelligent big data analytics and data mining is that the former discovers knowledge not only from database but also from the Web, and the big data are not only big, but also composed of various data types including streaming data, comparing with the traditional data (Tsai, Lai, Chao, & Vasilakos, 2015).

The interrelationship among big data, analytics and AI have drawn increasing attention. Sun and Wang provide a logical approach to it (Sun & Wang, 2017). Intelligent big data analytics is similar to analytics intelligence mentioned in (Wang, 2012). The difference between them is that the latter is limited to the data in cyberspace or the Web. The similarity between them is that incorporating AI into analytics is a huge global and social need in the near future (Wang, 2012). The intelligent big data analytics discussed in this chapter is an answer to address such global and social needs.

Theoretical, Technical, and Managerial Implications

The theoretical implication of this research is that the proposition that big data analytics is at the center of the age of trinity provides a new way for understanding the interrelationship among intelligent big data, analytics, and AI and their integration.

The technical implication of this research is that the proposed intelligent big data analytics for management can attract more researchers and practitioners to undertake the research and application of intelligent big data analytics for planning, organising, leading and controlling to support optimal business process and effective management decision making.

The managerial implication of this research is that the proposed managerial framework of intelligent big data analytics can help managers to better understand intelligent big data analytics as a science and technology, service, system and management and facilitate the use of intelligent big data analytics for supporting their decision making and intelligent management of organizations and businesses.

FUTURE RESEARCH DIRECTIONS

Intelligent big data analytics is an integrated paradigm of big data, analytics and AI. It is also an integrated computing, management and service paradigm and provides smart solutions to business, marketing and services through intelligent technologies, methodologies and applications. Intelligent big data analytics is a term that embodies the realization of a historic vison of how big data, analytics and AI as well as intelligent computing will revolutionize the world of business, organizations, society and our lives, forever and irrevocably (Davis, 2014). It is also a vision that create a society of intelligence through integrating big data, analytics and AI.

A limitation of this chapter is that it should consider intelligent big data descriptive, predictive and prescriptive analytics as one dimension, and the technological components of big data analytics as another dimension. Therefore, one of future research directions is to provide the matrix analysis for intelligent big data analytics.

Another of future research directions is to explore implementation issues for a managerial framework of intelligent big data analytics. The third future research direction is to present an extended framework of intelligent big data analytics for improving business decision making through reviewing the detailed technologies of AI and incorporating each of them into intelligent big data analytics.

CONCLUSION

The objective of this chapter is to provide a managerial perspective to intelligent big data analytics. The paper first looked at the age of trinity as the background of the research, and argued that intelligent big data analytics is at the center of the age of trinity. It then addressed what is a managerial perspective to intelligent big data analytics through proposing a managerial framework of intelligent big data analytics, which consists of intelligent big data analytics as a science and technology, system, service and management for improving business decision making. Then it explored intelligent big data analytics for planning, organizing, leading and controlling to some detail as an in-depth analysis of intelligent big data analytics for management. The proposed approach in this chapter might facilitate the research and development of intelligent analytics, intelligent management analytics, big data analytics, and AI.

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KEY TERMS AND DEFINITIONS

Artificial Intelligence (AI):
Science and technology concerned with imitating, extending, augmenting, and automating the intelligent behaviors of human beings.

Big Data:
Data with at least one of the ten big characteristics consisting of big volume, big velocity, big variety, big veracity, big intelligence, big analytics, big infrastructure, big service, big value, and big market.

Data Mining:
A process of discovering various models, summaries, and derived values, knowledge from a given collection of data.

Data Science:
A field that builds on and synthesizes a number of relevant disciplines and bodies of knowledge, including statistics, informatics, computing, communication, management, and sociology to translate data into information, knowledge, insight, and intelligence for improving innovation, productivity, and decision making.

Intelligent Big Data Analytics:
Science and technology about collecting, organizing, and analyzing big data to discover patterns, knowledge, and intelligence as well as other information within the big data based on artificial intelligence and intelligent systems.

Intelligent System:
A system that can imitate, automate some intelligent behaviors of human beings. Expert systems and knowledge-based systems are examples of intelligent systems.

Machine Learning:
Is concerned with how computer can adapt to new circumstances and to detect and extrapolate patterns.

Management:
The process of manager's coordinating and overseeing the work activities of others so that their activities are completed.