Discovering the Implementation Success Factors for IoT and Big Data Analytics in Transportation System

W N Hussein\textsuperscript{1,2,a}, L M Kamarudin\textsuperscript{3,4,b}, H N. Hussein\textsuperscript{4,c}, N A Ishak\textsuperscript{1,d}, A. Zakaria\textsuperscript{3,c} and K J Jadaa\textsuperscript{4,f}

\textsuperscript{1}School of Human Development and Technocommunication, Universiti Malaysia Perlis (UNIMAP), 02600 Arau, Perlis, Malaysia
\textsuperscript{2}AL-Zharaa Medical College, University of Basrah, Basrah, Iraq
\textsuperscript{3}Centre of Excellence for Advanced Sensor Technology (CEASTech)
\textsuperscript{4}School of Computer and Communication Engineering, Universiti Malaysia Perlis (UNIMAP), 02600 Arau, Perlis, Malaysia
\textsuperscript{5}Faculty of Science, University of Basrah, Basrah, Iraq
\textsuperscript{a}waleedn9@yahoo.com, \textsuperscript{b}latifahmunirah@unimap.edu.my, \textsuperscript{c}alhashimy@gmail.com
\textsuperscript{d}maizatul@unimap.edu.my, \textsuperscript{e}ammarzakaria@unimap.edu.my, \textsuperscript{f}khalid.jamil.jadaa@gmail.com

Abstract. The implementation of intelligent transportation systems, or what is otherwise referred to as IoT and big data analytics in transportation system are affected by several factors. Considering the overall impact of a definite and comprehensive plan that involves business, infrastructure, and organizational administration, improved customers satisfaction can better be achieved when all these antecedent factors are investigated and their elements are determined. There is no recorded study on multidimensional implementation model where more than one of them is considered. This paper, therefore, stems from the general background of implementation success factors but aims to discover the generality of the definite plan and procedure that must be executed for a successful implementation of big data analytics and IoT-oriented transportation system. This paper employs a systematic literature review and an in-depth interview to address the obvious limitation. This paper also discussed the qualitative approach that was used to gather data on the successful implementation factors in the transportation system. The deliverable from this research will be the implementation success factors for the big data analytics and IoT-oriented transportation system.

Keywords: Internet of Things; Big Data Analytics; Success factors

1. Introduction

Big data, to start with, is characterized by its speed (Velocity), its heterogeneous nature; structured, unstructured and semi-structured (Varieties) and its size (Volume). It is the much-needed themes and pattern of events in data available in the form of unstructured and semi-structured, while the relational databases are exclusive custodians of structured data. This heterogeneity essentially describes big data, and its volumes start from terabytes (TB) to zettabytes (ZB) \cite{1}. Many business corporations in their daily business activities rely on data for executing many of their business decisions \cite{2, 3}. The analysis and transformation of data through varying techniques such as clustering and association rules, therefore, inform their business intelligent decisions \cite{4}. One of the sources of data used in intelligent transportation systems is Internet of Things (IoT) \cite{5, 6}.
Internet of Things (IoT), on the other hand, is the ever-growing physical objects in the internet protocol (IP) address [7]. It addresses internet connectivity and ensures communication between internet-enabled objects, devices, and systems. These objects can be connected security systems, thermostats, electronic appliances, or alarm clocks [7]. Internet of things (IoT) is rapidly gaining attention among businesses because it produces sufficient data (through the communication of these objects) that can be used for analytics. These objects are estimated to be up to 12 billion devices and have aided how people can be more connected in 26 times [8]. Table 1 shows the characteristics of big data and the descriptive distribution of Internet of Things installation across domains, respectively.

| Category            | Internet of Things Units Installed Base By Category |
|---------------------|-----------------------------------------------------|
| Automotive          | 2013 196.0 2014 189.6 2015 372.3 2020 3,511.1 |
| Consumer            | 2013 1,842.1 2014 2,244.5 2015 2,874.9 2020 13,172.5 |
| Generic Business    | 2013 395.2 2014 479.4 2015 623.9 2020 5,158.6 |
| Vertical Business   | 2013 698.7 2014 836.5 2015 1,009.4 2020 3,164.4 |
| Grand Total         | 2013 3,032.0 2014 3,750.0 2015 4,880.6 2020 25,006.6 |

This research main objective is to discover and identify the implementation success factors for big data analytics and IoT-oriented transportation system. Therefore, this paper contributes to the empirical studies that investigated the antecedent factors to the implementation success of big data analytics and IoT-oriented technologies generally, and specifically for the transportation system. It focuses on multiple aspects of the implementation model and presents a holistic and comprehensive empirical investigation in what is called a unified implementation model. In doing this, the next section of this paper review previous studies of the implementation success factors of big data and IoT based transportation system. The third section presents the methodology used and the fourth section presents the results and discussion. The fifth section the last and concluding part of this paper.

2. Review of previous related studies

Studies on implementation models are studies that investigated or/and proposed models that prescribe and describe factors that must be considered in implementing IoT and big data in transportation systems. Business factor, which describes elements like value-driven customers service [10], and competitiveness [11], and adaptable business strategies [12], influences successful implementation of big data and IoT in the intelligent transportation system. Studies such as [10, 11, 13, 14], reported that the challenges of uncertain markets and business process reengineering are better solved by a tailored-business models.

The infrastructure models attend to both hardware and software technical needs in implementing IoT and big data analytics in the intelligent transportation system [13, 15]. The infrastructure implementation models address the challenges of heterogeneous technologies and interdependency. It also highlights how data mining algorithms and statistical models, such as naive Bayes and logistic regression models, are used in detecting patterns and predicting events like bus arrivals and passengers preferences in the infrastructure model for IoT implementation in transportation sector [16].

The management and administration implementation models for big data analytics and IoT, from past related studies, prescribed customers privacy emphasis [17]. Proper management and strategic administration of the human and infrastructural resources of the big data analytics and IoT-oriented transportation organizations in the sector influence its implementation success [17, 18]. This signifies the management and administration models. This category presents the administrative factor’s elements, such as team coordination and workplace culture [18], data adaptation and management policies to IoT implementation [17].
3. Methodology
This study, being a qualitative research method, employs elements of exploratory and case study analysis. The exploratory approach is to generate a guiding working framework for the study, especially in instances of little or no previous related studies. Therefore, the preliminary study conducted by this study is to identify the state and progress of studies on implementation models of big data analytics and IoT-oriented transportation system. The preliminary study employed a systematic literature review (SLR), a systematic literature review is used in identifying the elements of the implementation success factors for the big data analytics and IoT-oriented transportation system. At this stage, search terms, such as “business strategy/need for big data-based (and IoT) transportation systems”, “technology for big data in transportation system”, and “management for the implementation of big data and IoT-oriented transportation system”, among others, were used. The databases used were from IEEE Xplore, Science Direct, Springer, Web of Science, and Google Scholar. These studies are published, either as conference proceedings or journal articles within the year 2008 and 2018. A total of 468 articles were identified, but only 124 met the inclusion criteria set for this study, and just 21 addressed the research focus of this study. Duplicate and irrelevant studies based on the theme and the search strings are excluded. In addition, a single case study as a qualitative method of research is used to identify the implementation success factors within Konsortium Bas Ekspres Semenanjung (KBES) public transportation bus in Malaysia, being a transportation service company that leverages on IoT and big data analytics. It serves as a single case for in-depth study. With this, the in-depth interview is used to identify the core elements of the implementation factors of big data and IoT-oriented transportation system, which are (a) business, (b) infrastructure/technology, and (c) administrative/managerial due to observed insufficiency of empirical studies on the subject matter for big data analytics and IoT-oriented transportation system. It will be used to validate the elements of the success factors that are identified from the SLR.

In this study, collected data from the in-depth interviews are the technical perspectives of the experts in the big data and IoT-oriented transportation sector. For qualitative approach, an open-ended question was used to collect detailed and unfiltered information about the opinions of the interviewees regarding the core details of the elements of the respective niche-specific implementation success factor of big data and IoT-oriented transportation system. The questions were designed by checking whether the factors and elements in table 2 are significant for the implementation of big data and IoT-based transportation system. Investigating the phenomenon of big data analytics and IoT in transportation system in order to identify the implementations success factors, the interview respondents were probed about their perceptions on: (a) the elements of the business factor, (b) the elements of the infrastructure/technology factor, and (c) the elements of the administrative/managerial factor that influence the implementation success of a big data analytics and IoT-oriented transportation system. In-depth interview was held with engineering, subject matter experts in management, hardware, and software. In the same vein, interview and subsequent data were analyzed using NVivo software to identify themes and sub-themes from the transcription of the responses.

| Table 2. Big data analytics and IoT success factors |
|-----------------------------------------------|
| Factor | Element |
| Business | Technology support |
| | Innovation and Competitiveness |
| Infrastructure | Software |
| | Hardware |
| Management and Administration | Organizational culture |
| | Data security and privacy governance |

4. Results and Discussion
The preliminary review showed that there are insufficient recorded empirical studies on the implementation of big data and IoT-based transportation system. Previous studies have only
investigated business [13, 19] infrastructure/technology [16, 20], and administration/management [21] as factors or/and models separately. Notably, none of these studies investigated multiple factors that contribute to the implementation success of big data analytics and IoT-oriented transportation system. Table 3 shows a summary of the factors and the corresponding elements and sub-themes from the findings of the systematic literature review.

**Table 3. Findings of the systematic literature review**

| Factor                | Element                      | Sub-themes                                      |
|-----------------------|------------------------------|-------------------------------------------------|
| Business              | Technology support           | Electronic system adoption                      |
|                       |                              | Data analytics                                  |
|                       | Innovation and Competitiveness | Cost strategy                                   |
|                       |                              | Standardization and quality assurance           |
|                       |                              | Business model                                  |
| Infrastructure        | Software                     | Augmented/Virtual reality                       |
|                       | Hardware                     | IoT/cloud computing software architecture       |
|                       |                              | Autonomous vehicles                             |
| Management and Administration | Organizational culture | Employee reward system                         |
|                       | Data security and privacy governance | Customers’ data privacy and security |
|                       |                              | Cyber-attack counter measures and strategy      |
|                       | Data governance and legal framework | Research and development initiative |
|                       |                              | Data reusability                                 |
|                       |                              | Data interoperability                            |

Therefore, the interview was done to identify the details of the implementation success factors and their corresponding elements for big data analytics and Internet of Thing-based (IoT) transportation system. The results showed that the business factor binds the shared technologies in the intelligent transportation system. The perspectives of the critical stakeholders in the transportation system revealed that (a) business-related actions for consumer value, (b) organizational tech delivering services, and (c) level and impact of business strategy are the emerged factors. Figure 1, therefore, shows the emerged factors.

![Figure 1. Perceptions of business factors on the success of IoT-oriented transportation system](image)

The results also indicate that technology has been widely adopted because of the suitability, effectiveness, and swiftness of values it brings to the business. A nexus between technology and growth in IoT-oriented transportation system is supported by the emerged response that attests to the positive influence transport technology. Technical skills and expertise for technology service are guaranteed and when there is sufficiency of software for vehicles handling there is a high probability for success of IoT-oriented transportation system. Figure 2, therefore, shows the emerged factors.
Figure 2. Technology factor on the success of IoT-oriented transportation system

The managerial factor, which addressed the management-related elements of the implementation success factor of Big Data analytics and IoT-oriented transportation system showed the organizational model and best training service as success elements. Figure 3 shows the managerial factor on the success of Big Data and IoT based transportation system analytics of the managerial factor theme.

Figure 3. Managerial factor on the success of Big Data and IoT-oriented transportation system

5. Conclusion
Most of the previous studies separately investigated the implementation success of big data and IoT based transportation system. Aside from the significance of a comprehensive study that investigates these factors to identify their interplay in the implementation success of big data analytics and IoT-oriented transportation system, there are also self-acknowledged limitations of these studies. In this paper, the definite plan and procedure that must be executed for a successful implementation of big data analytics and IoT-oriented transportation system have been investigated through identifying the implementation success factors. The success factors highlight business, management, and technology factors. The business factor has three elements which are level and impact of business strategy, business-related actions for consumers’ values, and organizational technology for service delivery. The technology factor has software sufficiency, technical skills and expertise, and transport technology as its elements. The managerial has an organizational model for a transport technology firm and the best training for delivering service.
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