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Unified Implementation Framework for Big Data Analytics and Internet of Things-Oriented Transportation System

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Abstract: This study presents the scholarly basis for this study. It reviews literature on transportation system, this study also presents the range of information technologies used in transportation industry and their roles in building a modern transportation system. The need for and the viability of implementing IoT and big data-enabled in transportation system is argued with highlights of the prospects and challenges of the implementation process. This study also presents the methodology that will be used to gather data to see how big data and IoT have influenced the transportation domain.The potential benefits and issues of IoT and big data analytics in transportation systems are presented to give an understanding for the need for a unified framework for IoT and big data implementation in the transportation domain. Outcome from this research will be a proposed framework for big data analytics and internet of things-oriented transportation System.

Key words: Big data, IoT, transportation system, IT, business model, unified, things-oriented

INTRODUCTION

Transportation systems entail the interdependent actions of the vehicle (which is the equipment), the guide way (also known as route) and the operations, i.e., the set of procedures for the purpose of moving persons and goods from one point to the other (Chen and Schonfeld, 2017; Staley and Moore, 2009). Efficient transportation system, therefore, entails careful and diligent handling of the operations such as schedules, timetables, control systems, traffic management and crew assignment, to enhance passenger's convenience and provide overall economic and social well-being for the country and the people (Ezell, 2010; Moore *et al*., 2010). Traffic systems are also analogous to networks because the value is the quality of information it encloses (Liebenau *et al*., 2009; Taleb *et al*., 2005). A functional transportation system handles traffic signal, traffic congestions and the use of the enclosing information provides intelligent decision guide for road users and managers (Staley and Moore, 2009; Ezell, 2010) . The actors in the transportation system are therefore empowered by intelligent systems which handle all processes and devices, ranging from commuters, to operators of highway and transit network, to the concrete devices including traffic lights (Ezell, 2010; Taleb *et al*., 2005). The intelligent systems provide actionable information that support decision making in critical instances such as driver's choice of the route to take, the time to travel and passenger's decision on whether to use personal car or take mass transit. It also helps the policy makers in deciding whether or not building new roads or optimizing traffic signals will solve observed traffic bottleneck. Finally, it provides objective metric for holding transportation service providers responsible and accountable for their service delivery (Ezell, 2010; Baptista *et al*., 2012). The transportation system has potential benefits from harnessing the strengths and functionalities of Internet of Things (IoT) and applying the analytics of its big data. IoT is defined as the process and technological framework that explains the interaction, interconnection and interdependence among data, people and associated electronic objects over the internet (Wang and Li, 2016; Zhou *et al*., 2012). IoT is also aided by the sensory and communication abilities of the connected physical electronic objects. Through these objects, the environment is monitored and reported and communicating electronic objects are programmed to act according to the information received (Wang and Li, 2016; Diez *et al*., 2016; Leng and Zhao, 2011). Different varieties, large volume and high velocity data (big data) are generated due to the intercommunication among the physical electronic objects (Weng and Young, 2017). Therefore, exploring the analytics of the generated big data for prescription,

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description, prediction and actionable insights become necessary. IoT and big data analytics have become the dawning technological revolution and due to its enormous benefits, they have been adopted in diverse domains for varying purposes. IoT and big data analytics have been utilized in manufacturing, agriculture, banks, oil and gas, healthcare, retail, hospitality, food services among others (Thulesius and Brumberg, 2016). Automated and robotic manufacturing (Kara and Carlaw, 2014) automated teller machine's fraud detection (Menaga *et al*., 2017; Rajmohan *et al*., 2017) and human profile security alert (Hussein and Al-Hashimi, 2015; Anonymous, 2016a-c; Blowers, 2015) are applications of IoT and big data analytics recorded in manufacturing, banking and security, respectively to mention a few. The transportation industry is also one of the early adopters of IoT and big data analytics (Thulesius and Brumberg, 2016). Its applications in tracking shipment, freight monitoring and transparent warehousing, signify the benefits of IoT and big data analytics in the transportation industry as recorded in the transportation sector of countries like England, Germany, Portugal, Singapore (Ezell, 2010) among others. However, can be said to still be at the teething stage.

The aim of this research is to investigate the common and current deployment of transportation system with regards to IoT and big data analytics .This is to determine whether the deployment of big data analytics and IoT should be part of technology trend or it is a must to have for every domain, especially in the transporatation domain. In addition, this research aim to idietify the factors related to the deployment of transportation system whose technological backbone is the IoT and big data analytics.

MATERIALS AND METHODS

Figure 1 shows how this research will be carried out. In this research, both qualitative and quantitative approaches will be used by using a structured questionnaire and interview. Qualitative research approach was chosen in this research to identify IoT and big data analytics for Malaysian transportation domain in-depth which will require interview of respective stakeholders, especially in relationship with the component models that gravely lack empirical research studies, to create a corpus of data that will then be used in the development of the framework. For quantitative approach, questionnaire will be used for its evaluation. The proposed framework would specify the business, infrastructure/technology (hardware and software), administrative/managerial needs for the successful implementation of big data and internet of things-oriented transportation system. The "unified" framework is to integrate all the component models and presents a unifying front for their implementation. This will also solve the observed practical problem associated with implementation of IoT and big data technologies in the transportation industry.

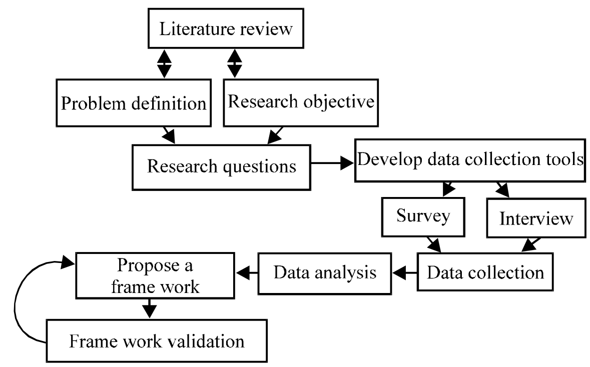

Fig. 1: Key stages in the research process

RESULTS AND DISCUSSION

Transportation system; An overview in Malaysia: Historically, as related by Anonymous (2014), the first railway track of 12.8 km which stretched the tin mining town of Taiping to Port weld in Peninsula Malaysia was built in 1885. It was also in 1885 that steam locomotive service was introduced to Malaysia transportation system. In the early 20th century, there were additional connections from the Northern states to Singapore, South of Peninsular Malaysia and also to Southern Thailand, North of Peninsular Malaysia. After the second World War (WWII), specifically in 1948, the British administration implemented the Malayan Railway Ordinance by establishing Malayan Railway Administration which later became Keretapi Tanah Melayu Berhad with the establishment of Railways Act 1991. In 1995 an electrified commuter train service of 3 lines, 45 stations along 175 km was introduced. The developmental growth of Malaysia transportation sector is remarkable owing to country's understanding of its role in national development. Malaysia government has identified the influence of mobility of goods and services in driving economic progress and growth (Ariffin and Zahari, 2013; Masuri *et al.*, 2012). The 8th Malaysia Plan, that is the roadmap for development in Malaysia, puts emphasis on the role of public transportation in improving the quality of life in the urban areas (Jaafar *et al.*, 2014; Schwarcz, 2003). In view of this, the country's transportation system which comprises of land, rail, water and air transport is designed to drive the country's ambition of vision 2020 by developing the country into an industrialized nation of 7% annual economic growth. The national transformation program, dubbed National Key Result Area (NKRA) and set to improve urban public transport is one of the forefront national level policies on urban transport plan in Malaysia. The drafted Land Public Transport Master plan comprises of Urban Rail Development plan, Bus Transformation plan, Taxi Transformation plan, Interchange and Integration plan, Land Use plan and Travel Demand Management plan. It was drawn to collectively achieve the national transformation plan and support Malaysian economic growth (Ariffin and Zahari, 2013). Malaysia transportation system is striving to be globally competitive to achieve this projection. According to Transport Statistics Malaysia, 2015, Malaysian international and domestic airport facilities operate 24 h with total passengers excluding transit passengers of 85, 948, 179 within the year 2006 and 2015. The airport facilities also handled cargoes of 959, 042 metric tonnes and 857, 232 mails within the same year span. There is also remarkable freight traffic of 1, 474, 35 as the number of registered vehicles on Malaysia roads within the year 2006 and 2015. The Malaysia transport capacity for the year 2006-2015 is depicted in Fig. 2. These figures indicate that Malaysia transportation sector is thriving with massive international and local demands to meet.

Information technologies in modern transportation system: Information technologies are now deployed and massively used in the transportation system and this is evolving a research and industry-oriented paradigm known as Intelligent Transportation System (ITS) (Hodge *et al*., 2015; Sivaraman and Trivedi, 2013). Intelligent transportation system is an emerging platform which is evolving many products and services. Notably, it is remarkably contributing and adopting technology-driven transportation system and massive deployment of the information technologie (Ezell, 2010). Global Positioning System (GPS), Dedicated Short Range

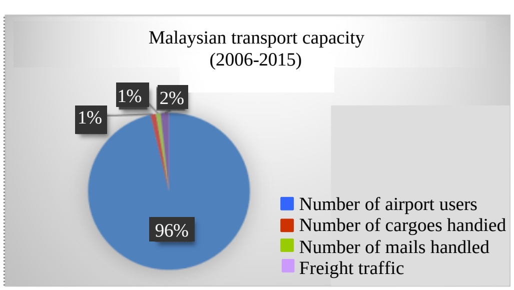

Fig. 2: Malaysian transport capacity (2006-2015)

Communications (DSRC), wireless networks, mobile telephony, radio-wave beacons, roadside camera recognition and probe vehicles are examples of information technologies that have been deployed and adopted in modern transportation system.

Global Positioning System (GPS): Global Positioning System (GPS) is a United Stated-owned space-based navigation radio system. It has array of applications in surveying and mapping, power grids, disease control, intelligent vehicles, among others (Baska, 2013). The signal used by GPS receivers embedded in vehicles On-Board Units (OBUs is a term that is commonly used for telematics devices) are from several different satellites for calculating the position of the device which in this case is the position of the vehicle. It needs the line of sight to satellites which can affect the GPS use in the settings of downtown "Urban canyon" effects. The location to be determined is usually within 10 m. The core technology used in navigations of in-vehicle and route guidance systems is GPS. Countries like Holland and Germany is using OBUs equipped with satellite-based GPS devices to record miles travelled by automobiles and trucks and this is used in calculating the transportation fee of the passenger (Ezell, 2010).

Dedicated-Short Range Communications (DSRC): DSRC is a short-to-medium-range wireless communication channel which operates in the wireless spectrum of 5.8 or 5.9 GHz and designed specifically for automotive uses (Kenney, 2011). It allows two-way wireless communications between the vehicle and RoadSide Equipment (RSE) using embedded tags or sensors. DSRC is a key enabling technology for many intelligent transportation systems such as vehicle-to-infrastructure integration, vehicle-to-vehicle communication, electronic road pricing, electronic toll collection, adaptive traffic signal timing, congestion charging, information provision, etc. It is a subset of Radio Frequency Identification (RFID) technology (Ezell, 2010; Kenney, 2011). In the United States, DSRC works on the 5.9 and 5.8 GHz band in Japan and Europe. The US Federal Communications Commission (FCC) in 2004, unusual for a US regulatory body, prescribed a common standard for the DSRC band both for promoting interoperability and discouraging competition limitation through proprietary technologies (Liberti and Rappaport, 1999). DSRC is a very important technology in the evolution of intelligent transportation system.

Wireless networks: Wireless networks are computer s that are connected to any cable but rather use radio waves to connect devices to the internet. It enhances fully distributed mobile computing and communication (Anonymous, 2016a-c). It is the commonly-used technology for internet access that ensures rapid communications between the roadside and the vehicles but within a range of only a few hundred meters. This range can however be extended by roadside node or each successive vehicle passing information onto the next vehicle or node. South Korea is an example of country that is advancing the usage of WiMAX technology through the increasing use of WiBro. WiBro is an infrastructure for wireless communications in transmitting information on traffic and public transit throughout its transportation network (Suryavanshi and Koul, 2015).

Mobile telephony: Mobile telephony supports provision of telephone services to freely-movable phones without being bothered of the quality of the services due to changes in the geographical locations. The intelligent transportation systems also use mobile telephony such as third or fourth generation (3G or 4G) mobile telephone networks to pass information from one node, or point, to the other (Ezell, 2010). However, vehicles fitted with this technology may need additional network capacity and the operators may have to cover these costs. More importantly in certain safety-critical situations in the intelligent transportation system, mobile telephony may not be appropriate, since, it may be too slow (Zhao, 2000).

Radio-wave or infrared beacons: Infrared beacons are easily identifiable objects which help in transmitting modulated light beam in the infrared spectrum (Anonymous, 2016a-c). They are similar to radio-wave in the manner they perform two-way communication with travelling vehicles. Vehicle Information Communications System (VICS) in countries like Japan makes use of radio wave beacons on expressways. The infrared beacons are used on trunk and arterial roadways for communicating traffic information in real time. The VICS also makes use of 5.8 GHz DSRC wireless technology (Ezell, 2010) and this suggests the interoperability and interdependence of the information technologies that are driving the intelligent transportation system paradigm.

Roadside camera: Roadside cameras are cameras that employ Automatic License Plate Recognition (ALPR), using Optical Character Recognition (OCR) technology, for identifying vehicle license plates. The information obtained is being passed to back-office servers, digitally (Hadi *et al*., 2014; Ruta *et al*., 2011). It is mostly used for zone-based congestion charging systems as used in London. It is a camera or tag-based schemes which can be used for different purposes. This kind of system uses cameras situated on roadways whereby drivers goes in and out of congestion zones. This is used in assessing and posting charges to drivers for their roadways use within the congestion zone and identifying traffic offenders (Ezell, 2010).

Probe vehicles or devices: Probe vehicles or devices are vehicles that are designed to collect traffic data in real time (Zhao *et al*., 2011). Many countries deploy “Probe vehicles” (often taxis or government-owned vehicles equipped with DSRC or other wireless technology) to help in reporting the speed and location of interested vehicles to the central traffic operations management center where the aggregation of the probe data is used in generating an area-wide picture of traffic flow and identifying congested locations (Zhao *et al*., 2011). Extensive research has also been carried out on the use of mobile phones which drivers often use as a means of generating real-time traffic information with the GPS-derived location of the phone indicating the movement of the vehicle. In Beijing as an example, more than 10,000 taxis and commercial vehicles have been outfitted with GPS chips sending travel speed information to a satellite, this sends the information down to the Beijing Transportation Information Center where the data is being translated into average travel speeds on the entire road in the city (Herrera *et al*., 2010). This shows the interconnection in mobile telephony, GPS and DSRC in the effective deployment of probe vehicles and devices.

Intelligent transportation system: Intelligent transportation systems is a composite of information technologies strategically combined and deployed with the use of data-driven insights, to make transportation process more efficient and result-oriented (Ezell, 2010). It is a consortium of technologies and electronic applications that is wide and growing in usage. Many industries and sectors such as healthcare, manufacturing, security, amongst others are already being revolutionized by Information Technology (IT) (Hsu *et al*., 2015). The transportation sector is also presently experiencing the technology-driven transformation. Countries like Portugal, Singapore, Germany and Britain are taking the lead in the transformation of transportation systems to heavily technology-enabled infrastructure which is evolving into intelligent transportation system (Liebenau *et al*., 2009). Intelligent transportation system is now a major tool of solving age-long challenges of surface transportation.

Intelligent transportation system is built on an “Infostructure”, i.e., information-driven infrastructure to support the physical transportation infrastructure. The Intelligent Transportation Systems (ITS) applications and systems make use of communications, control, electronics and computer technologies for improving the highway performance transit (rail and bus) as well as air and maritime transportation systems. The composite technologies that make up intelligent transportation system include but not limited to real-time traffic information systems in-car navigation (telematics) systems, Vehicle-to-Infrastructure Integration (VII), Vehicle-to-Vehicle integration (V2V), adaptive traffic signal control, ramp metering, electronic toll collection, congestion pricing, fee-based express (HOT) lanes, vehicle usage-based mileage fees and vehicle collision avoidance technologies.

Internet of Things (IoT) and big data analytics: The Internet of Things (IoT) and big data analytics are the major backbones in developing intelligent transportation system. IoT is the process and technological framework that explains the interaction, interconnection and interdependence among data, people and associated electronic objects over the internet (Calado *et al*., 2015; Zhou *et al*., 2012; Wang and Law, 2007). IoT is also aided by the sensory and communication abilities of the connected physical electronic objects. Through these objects, the environment is monitored and reported and communicating electronic objects are programmed to act according to the information received (Wang and Li, 2016; Diez *et al*., 2016; Leng and Zhao, 2011). Basically, IoT consists of the adding sensing and communication capabilities to varieties of physical objects, then, connecting them together over the internet for different purposes. These purposes range from monitoring their environment, status report and receiving instructions, to taking action based on the information they receive. Therefore, theoretically any object can be used as a source of information about another object (Diez *et al*., 2016; Leng and Zhao, 2011). Big data on the other hand, is different varieties, large volume and high velocity data (Zikopoulos *et al*., 2011; Dumbill, 2012) but are usually generated due to the intercommunication among the physical electronic objects (Diez *et al*., 2016). Big data analytics divulges novel information and insights on the workability of this physical objects and interaction, thus, allows improvement in terms of their functioning. Furthermore, communication between machine to machine devices and cross-platform data analytics enable interaction between these devices much like human's interaction over the internet (Zadrozny and Kodali, 2013; Zins, 2007).

IoT and big data are currently responsible for the number of smart devices connected to the internet and it is expected to exponentially rise between 24 and 50 billion with smartphones, tablets and computers representing only 17% of the stipulated figure and the rest being all other physical objects like clothing, furniture, automobiles, home utilities, etc. (Anonymous, 2016a-c). Continuous innovation in IoT is further being driven by the democratization of R&D financing through models such as Kickstarter and Indiegogo and peer-to-peer learning through open source electronic prototyping (such as Arduino). Over the next decade, 16.8 trillion value is estimated to be at stake in IoT and the value is attributed to IoT in transportation and logistics is roughly one tenth of that (Anonymous, 2016a-c). Therefore, exploring the analytics of the generated big data from the IoT for prescription, description, prediction and relevant actionable insights in the transportation section become necessary.

IoT and big data analytics-based transportation information systems: IoT and big data analytics have been used as infrastructural technology in designing and developing certain information systems for the transportation sector. These IoT and big data analytics-based transportation information system are intelligent transportation systems. In the following sub-sections, advanced traveler information systems, advanced transportation management systems, intelligent transportation pricing system and advanced public transportation system are discussed.

Advanced traveler information systems: Advanced traveler information system provides drivers with real-time travel and traffic information including routes and schedules of transit and directions of navigation. It also gives information regarding congestion, weather conditions, accidents or ongoing road repair work. Traveler information systems informs drivers of their precise location in real-time, current traffic or road conditions surrounding roadways and helps them with optimal route selection and navigation instructions, makes the information available on multiple platforms, both in and out of the vehicle. Advanced traveler information systems also entails in-car navigation systems as well as telematics-based services, navigation route, crash notification and concierge services. The concierge services include location-based services, mobile calling or in-vehicle entertainment options, e.g., music or movie downloads (Ezell, 2010).

Advanced transportation management systems: Advanced Transportation Management Systems (ATMS) is also an intelligent transportation application which focuses on the traffic control devices such as ramp metering, traffic signals and the dynamic (or "Variable") message signs located on highways. The message signs provide drivers with real-time messaging regarding traffic or status of highway (Ezell, 2010). Centralized traffic management centers of cities and states, worldwide are run by Traffic Operations Centers (TOCs). These TOCs rely on information technologies in connecting sensors and roadside equipment, vehicle probes, cameras, message signs and other devices together for creating an integrated traffic flow view and accidents detection, dangerous weather events or other hazards associated with roadway. These are achieved with adaptive traffic signal control and ramp metering (Anonymous, 2007a, b; Atkinson and Daniel, 2008).

Intelligent transportation pricing systems: Pricing and toll fee collection is another functionality of intelligent transportation system handled by intelligent transportation pricing systems. Electronic Toll Collection (ETC) is the most common application in this regard (Ezell, 2010). It is now better technologically-supported, hence allows “Road user charging” where tolls can be paid automatically by drivers using a DSRC-enabled on-board device or tag placed on the windshield (such as E-Z Pass in the United States). Australia, Malaysia, the United States and Japan have implemented a single national ETC standard, thus, prevents the need of carrying multiple toll collection tags on cross-country trips because various highway operators of ETC systems do not have interoperability.

Advanced public transportation systems: Advanced Public Transportation Systems (APTS) are generally public transportation management technologies. A typical example of APTS is Automatic Vehicle Location (AVL) which enables transit vehicles to report their current location. It therefore, aids construction of real-time view of all public transportation system assets for the traffic operations manager. APTS assist in making public transport more attractive for commuters by enhancing their visibility into the status of arrival and departure as well as overall timeliness of buses and trains. This category also includes systems of electronic fare payment for public transportation systems such as Suica in Japan, and T-Money in South Korea. These applications support transit users to constantly pay fares from their smart cards or mobile phones, using near field communications technology. Advanced public transportation systems, particularly those providing “next bus” or “next train” information are becoming increasingly common globally with Washington DC, Paris, Tokyo and Seoul, taking the lead (Ezell *et al*., 2009).

IoT and big data benefits in transportation system: Previous studies have reported the benefits of IoT and Big data in transportation system (Jadeja and Modi, 2012; Johnson, 2009). Among the benefits that can be seen through IoT and Big data are: increase in the safety of driver and pedestrian, improvement in the transportation network and operational performance (such as congestion reduction), enhancement of personal mobility and convenience, delivery of environmental benefits and boosting productivity and expansion of economic well-being (such as employment growth). Table 1 shows the benefits provided by using IoT and big data in transportation system.

Problem and issues with the deployment of intelligent transportation system: There are some problems and issues reported with the deployment of intelligent transportation systems whose technological backbone is the IoT and big data analytics. IoT and big data analytics technologies are heterogeneous in nature (Day and Khoshgoftaar, 2017). There is therefore, need to create a smart network of things which interact with each other and integrate many different technologies proprietary. This helps in processing different business, different logistical chain actors and even technologies from different parts of the world (Sivarajah *et al*., 2017;

Table 1: Benefits of big data and IoT

Benefits	Description	Reseachers
Increasing driver and pedestrian safety	IoT and big data analytics-dependent information technologies employed in the transportation sector reduce accident rate, thus increase driver and pedestrian safety. A wide range of intelligent transportation systems such as real-time traffic alerts, cooperative intersection collision avoidance on-vehicle systems such as anti-lock braking, lane departure, collision avoidance and crash notification systems increase safety	Johnson (2009), Jadeja and Modi (2012)
Improving the operational performance of the transportation network	Intelligent transportation system improves the transportation network performance of a country by maximizing the existing infrastructure capacity and reducing the need to build additional highway capacity	Johnson (2009), Jadeja and Modi (2012) and Weiss (2007)
Enhancing mobility and convenience	Intelligent transportation system enhances driver mobility and convenience by reducing congestion and maximizing the transportation system operational efficiency	Masuri *et al.* (2012), Jadeja and Modi (2012)
Delivering environmental benefits	Intelligent transportation systems deliver environmental benefits by reducing congestion, enabling smooth traffic flow, teaching motorists the efficient way of driving and reducing the need to build additional roadways	Miller (2008), Jadeja and Modi (2012)
Boosting productivity, economic and employment growth	Intelligent transportation systems boost productivity and expand economic and employment growth It does these by ensuring that people and products arrive at their designated destinations in a quick and efficient manner that improves the transportation performance of the country	Miller (2008), Jadeja and Modi (2012) and Johnson (2009)

Bhadani and Jothimani, 2016; Hussein *et al*., 2013). Moreover, the large disparities in the type of data as well as the different equipment types, operating systems and technological standards are a great challenge for management and interchange of a centralized data. Also, a lack of technical standards for ITS technologies makes it difficult in ensuring that systems purchased by different localities can be included (Bhadani and Jothimani, 2016; Zheng *et al*., 2016). It was reported that one of the ways to solve this issue is by requires continuous work on uniform central deployment framework among the IT providers. There can be an intelligence system that allows the devices to communicate among one and another and focus on the modular approach of open technology standard, thus, enables integration of new technologies into existing ones (Marjani *et al*., 2017). The interdependency of big data and IoT has also being discussed in recent publication such as computerized smart signals, ramp meters, roadside cameras and local traffic operations centers, must be essentially coordinated, so that, they can be used independently. Communities or regions can therefore, independently decide whether to fund and deploy ramp meters or adaptive traffic signal lights, since, these applications should independently be deployable (Samad and Parisini, 2011; Khan, 2017). The uncertain market has also reported to be an issue the uncertain marketplaces may also inhibit the development of intelligent transportation systems. Companies are more than willing to self-fund research and development investments for new products and services, including new desktop operating systems, software programs, even entirely new jetliners, since, there is a clear customer. However, for intelligent transportation systems, participating companies in some countries may not have clear sense of the customer's understanding, needs and financial worth (Ezell, 2010). Fear for transparency has also being discussed in recent publication freely-flowing and accessible data ensures transparency and this may compromise competitive advantage among market competitors. IoT technology depends on free flow of data from smart devices to a central platform which coordinates the data aggregation, analysis and interchange. However, many proprietary firms of related IoT and big data analytics applications and information systems hesitate to share information with a central (national) authority because of its openness to competitors (Simo, 2015). Another issues also being discussed which is business process reengineering, IoT requires the adoption of a new technology, rethinking and reengineering of the entire processes of business linked to it. This poses an obvious challenge because of the time and effort that must be invested in it for optimal benefits (Barbaresso *et al*., 2014). In addition, the institutional barriers consider to be an issue, deployment of intelligent transportation system is always faced by institutional barriers. These include jurisdictional challenges such as the level of government that has responsibility for or jurisdiction the deployment. This poses challenges to organizations whose service delivery scopes are inter-jurisdictions. The process of seeking funding, prioritizing funding projects and even how information is shared must be subject to legal provision (Zhou and Gifford, 2010).

These factors are expected to be considered while implementing IoT and big data analytics in transportation system for optimal benefits and results. Also, the implementation factors are considered as antidotes to implementation challenges of IoT and big data analytics in transportation system. They are expected to strategically solve or show potential of solving, the challenges of heterogeneous technologies, interdependency, uncertain markets, fear of transparency, business process reengineering, best practices and institutional barriers.

Based on recent publication, the implementation models can be classified into business (Ogbuokiri *et al*., 2015; Dragan *et al*., 2017; Ju *et al*., 2016; Dijkman *et al*., 2015), infrastructure (Dragan *et al*., 2017; Guerrero-Ibanez *et al*., 2015; He *et al*., 2014) and management and administration (Tezel and Aziz, 2017; Sorbeo, 2015) models. The business models prescribe and describe the business factors such as value-driven customers service (Ju *et al*., 2016), innovation and competitiveness (Ju *et al*., 2016) and adoptable business strategies (Diez *et al*., 2016). The infrastructure models attend to both hardware and software technical factors in implementing IoT and big data analytics in transportation system. These include the statistical and data mining algorithm suitable for transportation systems (Menon and Sinha, 2013) the technical architecture for data extraction, storage, security and analysis (Menon and Sinha, 2013; Bitam *et al*., 2015; Hussein *et al*., 2013) and the applicable electronic communication technologies. The third category of the implementation model from past related studies is the management and administration models (Tezel and Aziz, 2017). This category presents the administrative factors such as team coordination and workplace culture (Guang-Hua, 2011) data adaptation and management policies to IoT implementation (Yan *et al*., 2014; Komninos *et al*., 2011; Sicari *et al*., 2015). In our research, the business implementation models should address the challenges of uncertain markets and business process reengineering. The infrastructure implementation models should address the challenges of heterogeneous technologies and interdependency while the administrative and management implementation models address the challenges of fear of transparency and institutional barriers.Our research will explore the issues with transportation system further during the data collection process.

CONCLUSION

The transportation system has potential benefits from harnessing the strengths and functionalities of Internet of Things (IoT) and applying the analytics of its big data. However, there are some risks and issues that need to be considered when implementing big data analytics and IoT in transportation system. The implementation of big data and IoT technologies and its development will lead to main changes in transportation domain and its competitive space. These changes may create opportunities or could be new threats to the domain. In this study, the potential of big data analytics and IoT has been discussed to give a good understanding of the deployment of intelligent transportation systems and to acknowledge the factors that may affect the implementation. The methodology that will be used is also described. This study aims to investigate the potential of big data and IoT within transporation domain and to examine the current uses of intelligent transporation system in Malaysia with regards to big data and IoT. The investigation is done to identify whether implementation of big data and IoT in the transportation domain should be developing the country into great benefits. The finding of our research will be use to propose a framework for big data analytics and internet of things in transportation system.

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