**Journal of Process Management and New Technologies**
**www.japmnt.com ISSN: 2334-735X (Print) ISSN: 2334-7449 (Online)**
**Vol. 10, Issue 3-4, 2022, pp. 9-21**

# HIGH EFFICIENCY PUBLIC TRANSPORTATION SYSTEM: ROLE OF BIG DATA IN MAKING RECOMMENDATIONS

**Mesbaul Haque SAZU[1*], Sakila Akter JAHAN[2*]**

*[1]Case Western Reserve University, Cleveland, Ohio, USA, mesbasazu@gmail.com*
*[2]Independent University, Bangladesh, Dhaka, Bangladesh, sakila.j@protonmail.com*

***Abstract:*** *With increasing urbanization across the world, the demand for smart transportation methods to support everyone, as well as freight, becomes more vital. To tackle the challenges of growing congestion on the roads, big data analytics (BDA) strategies can be used to offer insights for real decision-making, and policy designing. This study has two primary goals. First, this study evaluates academic literature regarding BDA for smart commuter routes programs; and next based upon the studies, it suggests a framework that is effective, but comprehensive in making recommendation to drive down the congestion and increase efficiency of shared transportation system. The study believes that the framework suggested is solid, versatile, and adaptive enough to be implemented in transportation systems in large cities. Using the framework, system will be managed in a centralized system, allowing much more efficient transportation across cities. Further studies should be conducted over a long period, in smaller cities as well, to make improvement on the framework.*

***Keywords:*** *Decision-making, public transportation, big data analytics*

Type of paper: Original scientific paper
Received: 22.05.2022
Accepted: 01.07.2022
Available online: 08.08.2022

## 1. Introduction

Development in almost all nations has led to immoderate utilization of individual automobiles, producing unbearable expenses to the public. To lessen the effects of the inescapable higher utilization of individual means of transport on traffic congestion, interpersonal expenses, governments are investing significant effort in determining transportation-need in the cities. With the presumption, researchers are working on Advanced Transport Structure as well as communication technology for improving transit performances.

Development within cities impacts quality of living. Mobility and accessibility for members of society are vital in the transportation network to enhance the quality of living. Wise (2022) has shown the connection between mobility and citizens' well-being and how they are interrelated to each other. Thus, a community should design smarter modes of commuter routes. Transportation is one of the most essential aspects of maintaining day to day activities in any area, more so in cities, while it's also considered as one of the most significant contributors to global warming and environmental worsening.

* Corresponding author

Recommendation making system (RMS) will be the programs that will be designed to help increase efficiency of transportation in urban areas. RMS will be synergistic, involving solutions and engineering principles to create and enhance several types of commuter routes methods (Ghasemaghaei & Calic, 2020). Recommendation making system (RMS) will be the programs that will be designed to help increase efficiency of transportation in urban areas. RMS will be synergistic, involving solutions and engineering principles to create and enhance several types of commuter routes methods (Ghasemaghaei & Calic, 2020).

Research on RMS has become priority due to the huge quantities of information which were untraceable and impractical previously, however with cloud computing, it is readily available to evaluate, process, and analyse them (Gobble, 2013). Its goal is to make "smarter" streets, users, and vehicles with the use of info processing, marketing communications, management, along with consumer electronics solutions. It is additionally likely to enhance the functioning and security of commuter routes vehicles by giving more effective routes and collision warning (Gunasekaran et al., 2017). Furthermore, developments with BDA analytics, cloud processing, and then machine learning allow it to be easy to economically use information, determine patterns, and conduct tasks. They were in the past costly, hard, and impractical using traditional tools. Regarding RMS, many literatures have attempted to using computing tools to improve transportation, including critical reviews of algorithms for information evaluation, and automobile tracking solutions (Hussein, et al., 2018). Perhaps the application program on the Internet of Things (IoTs) with software to protection problems, traffic prediction has also been developed (Hao et al., 2019).

This research paper has primarily 2 goals. Firstly, the study presents a review of academic literature on BDA analytics for efficient transportation management. On the other hand, to provide a framework to build a structure to use BDA in RMS. For the first goal, a literature evaluation has been conducted that is systematic, reproducible, and explicit due to a methodological perspective, to recognize, assess, and understand the current entire body of electronic documents around the topic. To accomplish the 2nd goal, an exhaustive evaluation of assessed architectures or frameworks for information evaluation is carried out. This research paper thus creates an easier, but comprehensive framework.

The paper is segmented in several sections. Section two contains the literary review of the studies conducted on smarter transportation system using different tools like vehicle location tracker, data analytics etc. The strategy we employed for this assessment is discussed with section three. Section four provides the findings of the assessment, as well as descriptive analyses. In section five, we show an introduction to a suggested structure for BDA analytics in RMS. In section six, the research paper shows a comparison between previous literature and the RMS system. Section seven concludes with several concluding remarks, while section eight provides several possibilities for potential studies.

## 2. Literature Review

### 2.1. Big Data management

In the past several years, the innovative transport structures have played a part in the massive development of solving the transportation problems (Aversa et al., 2021). Up to date information is generated in large volume and in high velocity by widespread and affordable detectors (Balbin et al., 2020). Transportation methods have gained from the advancement of such devices and technology, which usually involve phone, offering acquisition of large set of information which may not have been obtainable in any other way. Information can

subsequently be saved and analyzed, enhancing the ability to better examine the best complicated transport structures (Brajesh, 2016). That is the age of usage of BD for conveyance.

Tracking and pinpointing the location of others is today allowed by recognizing technological tools with high accuracy (Balbin et al., 2020). The latest growth, as well as prevalent use of mobile technological tools, help with the quick development of information for transportation need analysis, though privacy issues are being considered (Bresciani et al., 2021). Nevertheless, many daily trends can be found, giving possibilities for technicians and researchers (Fiore, 2019). Recently, the subject has caught the interest of many scientists (Li & Zhang, 2021). They explored the possibility of information amalgamation methods for congestion information, the use of GPS devices for obtaining congestion information (Montoya-Torres et al., 2021). They found need transportation trends, as well as recommendation-making programs for transportation contingent on location service solutions and backed by topographical information gathering structures (Morabito, 2015).

## 2.2. Congestion management

Babar and Arif (2019) created a new neural net-based traffic congestion estimation technique, which automatically considers the temporal and spatial relationship of huge traffic congestion information. The scientists executed a mass encoder plan to discover general congestion flow (Chiang & Yang, 2018). The article provided by Antons and Breidbach (2018) offers an introduction of the features offered by the Safety Laboratory for saving, applying, and incorporating congestion data, and presents an exhaustive evaluation of large-scale information handling as well as TIS incorporation (Biuk-Aghai et al., 2016). Gofrani et al. (2018) provides many insights into typical methods used for combining congestion information from various origins. Additionally, they executed many information amalgamation methods and put them on them for a situation when studying to effectively calculate congestion velocities (Alrumiah & Hadwan, 2021). The research shows that predictions from information amalgamation strategies, regarding loop sensors information and automobiles information, tend to be more correct and stable than predictions, contingent on specific information origins (Lee et al., 2014).

Ayed et al. (2015) suggested a program for framework, that conducts the structure for a certain set of visitors who need metrics. The researchers present a novel method of the visitors issue city-wide, wherever framework is deployed, confronting BD centers. Gohar et al. (2018) produced an inspiring proposition elaborating the ways information driven insights can lead to smart and recommendation-making metro planning procedures, dependent on allowing for a connected system. They provide a structure for possible ramifications that the incorporation of BD to the process can be in favor of enhanced standard of living, and smart development of upcoming urbanized gatherings. Zhuang et al. (2021) currently uses a few people's Advanced Transport Structure information gathering strategies to assess congestion attributes on highways. The evaluation is based on the utilization of historic deductive loop sensor information, and includes adjustable sign, floating automobile, climate, as well as adjustable velocity limit information to evaluate its accuracy and relationships. Unlike that, some tools use real congestion flow information contingent on the inductive loop detector information (Ayed et al., 2015). Zhu et al. (2019) encapsulates a multiple detector information amalgamation technology utilized globally to enhance the authenticity of predictions of automobile congestion engineering factors. The researchers explore the primary areas of information amalgamation methods that could influence the reliability and stability of information beneficial for smart transport methods, congestion handling, and remote sensing uses, etc. (Lekhwar et al., 2019).

## 2.3. GPS enabled IoTs for vehicle location tracking

Transportation information has considerably improved, as instrumented automobiles have acquired congestion information, like automobile congestion sensors paired cell information network, as well as Worldwide Satellites Structure (Antons & Breidbach, 2018). Many geographical position-based facilities are readily available via smart mobile phones and automated vehicle location tracking devices (AVL), making it possible for an exhaustive evaluation of transportation trends (Babar & Arif, 2019). The prevalent use of GPS phones offers a chance to acquire beneficial and reliable information on congestion situations and automobiles' conditions dependent on interconnected equipment, as well as a cooperative Advanced Transport Structure. WSS enabled phones are a cheap way to compute transit time, as well as appraise congestion flow problems (Kayser et al., 2018) explored the functionality of a novel functional program for computing congestion velocity and transit times, which relies on information from a connected telephone service network. The effect of online facilities on transport devices is examined in who signified the possibility of GPS furnished phones as widely obtainable web traffic congestion observing methods to offer dependable visitors information instantly (Keskar et al., 2021). Yang et al. (2017) suggested a visitor observing technique contingent on GPS enabled cell devices, applying the comprehensive scope offered by the connected network in numerous cities. Zheng et al. (2015) unveiled a visitor observing technique dependent on virtual transport channels and executed it with a GPS phone program to capitalize on the authenticity of instant traffic congestion approximation and resolve security issues.

## 2.4. Smartphones usage to understand usage pattern

A report evaluated the ability of phones job receptors to recognize potentially harmful automobile interactions for automobile moves dependent on surrogate security methods (Lee., 2018). Phone sensors are examined in terminology of velocity information (Ghofrani et al., 2018). The researchers discovered that the inaccuracy probability is just a fraction of the unpredictability issue facing congestion predictions and established a connection between phone swiftness and GPS regionalization inaccuracy (Gohar et al., 2018). Wright et al., (2019) provided a structure for installing a phone primarily based measurement process for streetcar congestion observing and consumption-based insurance. The suggested structure can allow high quality congestion observation to minimize congestion, accidents, environmental effects, and expenses (Leveling et al., 2014). With the evolution of technological tools in phone structures, the latest revolutionary implementation could focus on instant analysis of need transportation, without any compromising consumers' security (Nguyen et al., 2018). As evidenced in Advanced Transport Structure, as well as Information Technology, assist various phases of transport and logistics chains, offering updated information to people and transportation managers, in building recommendation-making programs for continuously feasible transportation (Lee et al., 2014).

## 2.5. Gaps in previous research: Exploring routes of production

While some researches have been conducted on making transportation system more efficient, and some suggestions also have been made, no literature covers how big data can be used to develop a decision-making system using already available tools like smartphone. No other literature also takes advantage of all the scientific studies, and the methods recommended. This study is novel in taking suggestions from available literature and suggest a novel way of managing transportation using already available devices like smartphone or GPS devices.

## 3. Research Design

### 3.1. Methodology

To handle this literature evaluation, an organized process was implemented by becoming much more explicit within the number of scientific studies and utilizing reproducible and rigorous analysis techniques. A vital necessity with going over the literature is that every phase of the assessment procedure needs to be identified within a process intended to direct the entire, thus lowering the attainable processing power sources of bias, which in turn develop from experts producing idiosyncratic choices during various phases of the assessment process.

This evaluation set about using a hunt within the Web of Science data source under the suggestions. Web of science may be the biggest data source of peer reviewed literature covering proceedings, scientific journals, and books. Web of science has an extensive introduction to investigation results in science, technology, medicine, humanities, and arts, along with sensible resources to monitor, evaluate and analyse investigation. The search engines string employed was "bigdata" and "smart transportation structure". Without the need to restrict the publication seasonality, documents came out through 2015 till February 2022.

### 3.2. Data collected

There were 231 files in total. Thirty documents were not publicly offered, or perhaps beyond the range of the evaluation. A preliminary group of 201 shortlisted research papers is examined for information. These documents are categorized to recognize if the shortlisted is effective, suggest a mathematical design, a structure, review an exploration or maybe real-life situation, and to determine the trouble of smart commuter route structure, for example automobile traffic prediction, path preparation, path brilliance or maybe safety measures, etc.

## 4. Findings

For systematic tasks created within the files, bibliometric and descriptive analyses have been completed. The location where the contribution of researchers, institutions, country in addition to their affiliations is analysed, aside from the potential for gathering the systematic panorama linked to the area of RMS, as well as big data. The figure one displays the evolution of written documents published annually. Because in 2021 there has been a rise in publications: seventy % of the papers had been posted between 2017 and February 2022. In 2017, the variety of published research papers is 15% more than the prior 12 months, and a growing pattern since in that case, that shows that the subject areas of RMS. And as in that case, Big Data has brought on unique significance.

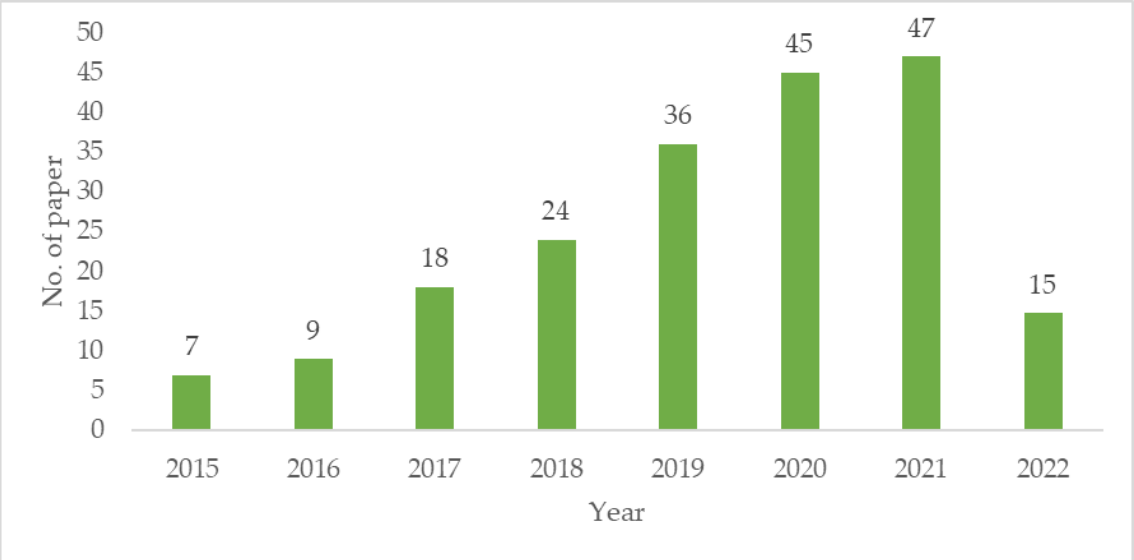


**Figure 1.**Total publication per year

From the Web of science repository, the final explanation is provided, displaying the quantity of scanned documents, based on the nation in which the institutions on the experts are placed. Germany, USA, China, and UK are probably the leading 5 nations within the rank. Additional nations with more than 5 research papers are Hong Kong, Canada, Italy, and Australia.

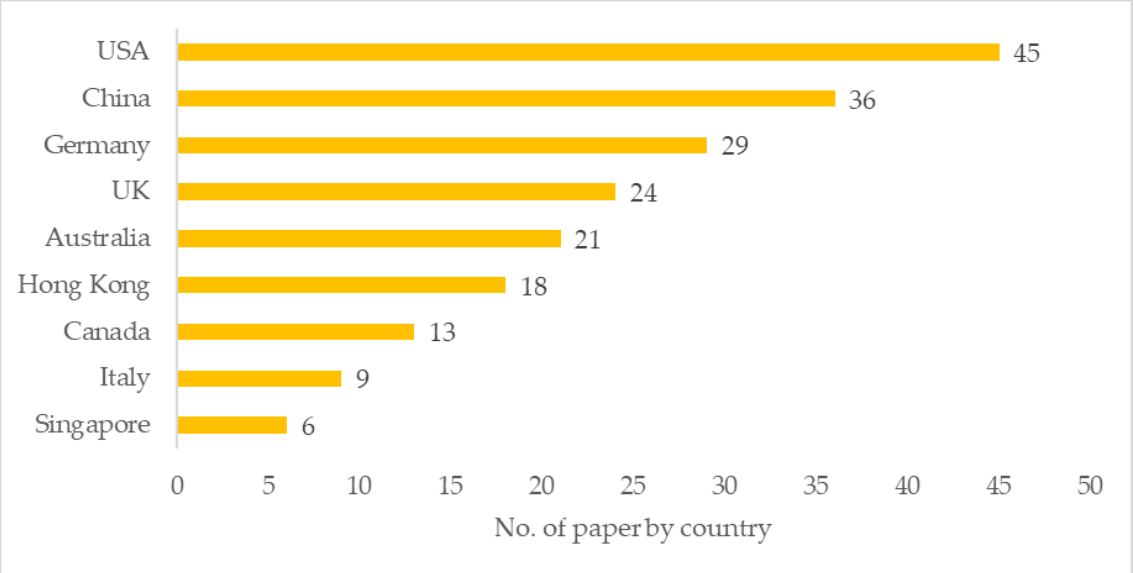


**Figure 2.** Publication by country

Based on the review in Figure 2, forty % of documents examine a situation when researching or maybe an application program. For instance, fifty-nine % utilizes mathematical modelling, while twelve % engages computer simulation strategies. In the ten percent of scanned documents, visualization equipment is present. In only three % of shortlisted papers, a software program framework or even structure is recommended. Due to its difficulties, most studies (thirty-eight %) is focused on problems. Thirty % of written documents evaluate traveling occasions to foresee web traffic circumstances. Six % of is effective evaluates security problems, and seventeen% of is effectively utilizes signal recognition to recognize automobiles, items, and more. Of these, twelve % suggest methods for detection of events, events, or

accidents. Only two of the examined papers additionally considered productivity as well as renewable problems (eight % of papers) and path or course preparing (seven% of documents). Finally, only two % thinks of certain challenges in such systems, for example Data Mining, information secrecy, information control as well as warehousing, connectivity, involving others.

Because of the intricacy of its programs and the reasons which methods acquire, large details as well as its paradigms deal with a never-ending number of areas and topics. Within the shortlisted data source, the first subject brought into concern will be the "Computer Science", in which 36.2 % of the is effective has it because the key part of searching, and then "Engineering", with 30.5 %. There is also an amazing fascination with interpersonal science (6.0 %), components science as well as mathematics (5.7 % each), company, management as well as accounting (2.5 %), largely considering company versions, physical science, and decision science (1.8 % each), environmental science and processing power (1.4 % each).

A bibliometric evaluation was carried out, aside from the prior descriptive presentation of outcomes. Bibliographic examination is a group of investigation methods that will learn bibliographic content quantitatively in an established arena. The technical developments within bibliometrics software application have facilitated the improvement of this type of analyses, turning into a progressively well-liked method to assess the body of expertise waring.

## 5. Recommendation making system (RMS)

As stated before, this research paper creates upon the prior reviewed papers to suggest the design of a structure for BDA analytics within RMS. Figure three presents a schematic of suggested structure. The first component is the compilation of information, which could be practiced by hand or even utilizing automated methods. The former calls for individuals to gather information which could be less expensive, as well as enables the group of big quantities of information, but tends to be more delicate to make mistakes while also gathering further processing and information. The second means implementing the assortment by using technologies, for example receptors. Many types of automatic tools are pneumatic tubes, radars, induction circuits, or maybe video cameras.

The solutions employed for information compilation should put into action correspondence protocols for the transmission of information. Probably the most analyzed correspondence solutions within this regard are: IEEE 802.11 process corresponding to Wi-Fi. Additionally, there are GPS oriented fixes also to real time visitors, that will focus on wireless correspondence back links in the satellite degree, that it'd stand for better expenditure found correspondence solutions. Likewise, treatments relating to the 802.15 process (Bluetooth) are believed for real time traffic measurement methods, in which vehicle owners are required, as well as the interconnection of theirs for this wireless community.

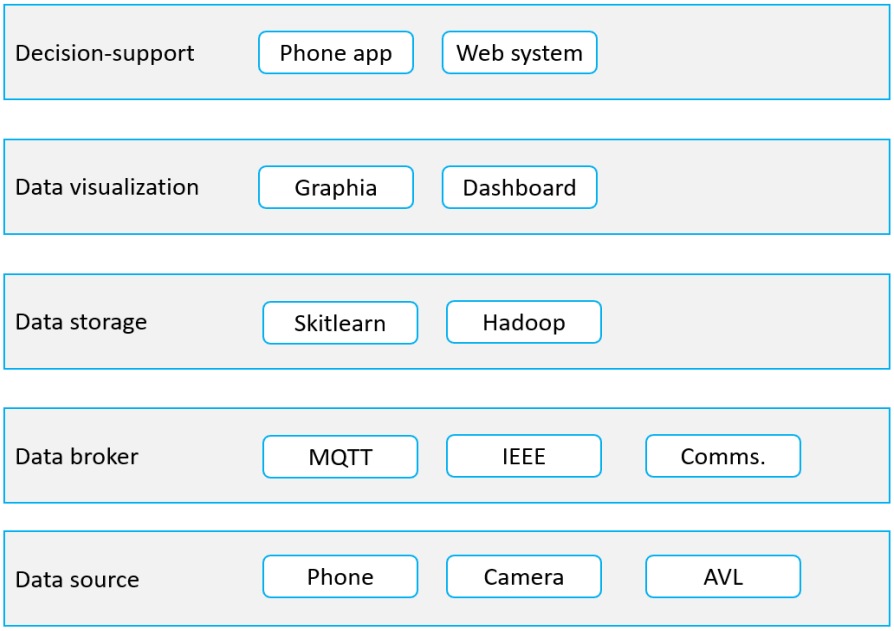


**Figure 3.** Data analytics system for RMS

The information management and storage space level control the structure and formatting of the information by the receptors, as well as planning them inside in such a manner that it enables the session and removal of all the info (Zhu et al., 2019). With this level, the heterogeneity of the processing power sources is directly into a bank account (e.g., a video clip has information from Freeway capturing documents, while within radars information will be the signal variants which will afterwards be translated as vehicles) (Zhuang et al., 2021). Additionally, of terminology of BDA terminology, commuter routes information fulfils the basic qualities of amount, speed, variety, value, and accuracy. The analytics level needs SEO algorithms targeted at fixing web traffic difficulties. These are comprised of executions and applications of optimization algorithms, as well as machine learning, which reply to certain issues. One of the more regular uses within OSs for mobility will be the evaluation of visitors (Wright et al., 2019). A Deep Learning software uses neural networks to understand a representation. The algorithm learns the generic attributes of the visitors flow and keeps up with the spatial and temporal correlations of the information to boost the amount of prediction, or even to foresee accidents (Yang et al., 2017).

Visualization and decision help levels enable the screen of info to ensure it is instinctive for all those of control of generating choices (Niebel et al., 2019). One method to imagine features movable uses, web traffic pages. Inside transportation and logistics, information visualization enables a far more comprehensive introduction from the temporal and spatial characteristics of mobility of cargo and people (Trabucchi & Buganza, 2018). A significant issue of urban planning and logistics is how you can reduce the environmental, economic, and social impacts of commuter routes. The basic simple fact of realizing and knowing the characteristics of transportation enables the improvement of infrastructure to boost the effectiveness of the design and transport programs of using street representatives' policies (Silva et al., 2020). These solutions enable the building of high temperature maps to recognize reasons for higher street congestion, reduced flow rates of speed, highways inside an express of fix, regions with higher environmentally friendly contamination, areas with higher utilization of bicycles, buses, taxis, and more (Ittmann, 2015).

The information gathered could be consumed, for instance, to determine the spot of strategies OSS's because of the consolidation of products sent out with heavily populated urbanized facilities (Biuk-Aghai et al., 2016). Moreover, the identification of schedules by which urbanized tolls are recharged to individual cars to reduce environmental impact and congestion also affects it. It also enhances the division routes of freight pickups to supply or pick up items on period, inside the situation of e commerce for instance (Yang et al., 2017). With regards to urban planning and mobility, the methods help support the redistribution of visitors to stay away from reasons for higher congestion, as well as boost the usage of alternate highways when necessary. When there are ample details, the solutions help decision-making for the design of mass public transportation, like different subway collections, BRT programs, bike paths, involving others becomes more accurate (Ayed et al., 2015). From our prior functions, the importance of utilizing information analytics to foresee amounts of congestion wearing areas that are urban, and then to assess the effect of automobile traffic mishaps on automobile motion capability within the northern place, has become validated.

## 6. Comparison between previous suggestions and the RMS system

Previously suggested methods of managing transportation system have been helpful in developing the framework suggested in this study. However, previous studies were mostly inconclusive, and lacked the depth of application in larger cities. Moreover, very few studies have used the technological marvels like big data that can have significant impact on determining the best possible solution. In the table below, you will find a brief comparison.

**Table 1**. Comparison between previous suggestions and RMS

| Points of comparison | Previous studies | RMS |
|---|---|---|
| Completeness | Previous studies have made suggestions that does not take into consideration of other scientific studies and are not complete (Issa et al., 2014) | RMS takes into consideration of all the scientific studies published, and recommends a tool that's comprehensive and versatile |
| Usage of big data | Only a few suggested the use of big data in developing a framework, that too for only understanding pattern occasionally (He, 2021) | RMS uses big data continuously to improve recommendations, hence they will improve over time |
| Updates | Once made, no further development suggested (Neilson, Ben Daniel, & Tjandra, 2019) | RMS recognizes that improvement is a continuous activity, thus it gradually improves over time |
| Target city | Most previous studies are conducted in only one specific country like either USA or China, and hence make suggestions that are appropriate in such countries (Yu et al., 2021) | RMS is a comprehensive system that takes into consideration of the world's largest cities, be it in developing or developed countries. |
| Tools | Previous studies focused mostly on automated vehicle location tracker, which must be | RMS recognizes the ubiquity of mobile phones that can generate plethora of useful data to make effective |

| | | |
|---|---|---|
| | installed on vehicles. Since this equipment must be purchased or that the vehicle must come equipped with it, makes it less likely to be implemented and effective (Shakya & Smys, 2021) | recommendation. Since, almost anyone living in big cities have access to smartphones, the framework is more readily applicable and does not require any additional tracking related expense, unlike the previous studies |
| Changes in recommendation | Validity of routes suggested by recommended tools mentioned in previous studies are fixed for certain period, like weeks or months or even years (Zhang & Guo, 2021) | RMS's recommended routes changes continuously, making it more dynamic and effective, taking into consideration of route's busyness |

As we see in the comparison in Table 1, previously suggested methods were incomplete, does not take advantage of computing powers of readily available tools like phones and do not update continuously. However, RMS is a dynamic recommendation making system that is versatile, readily applicable, and takes the best of all previous studies.

## Conclusion

Global economic development and increased urban population have given rise to presence of more vehicles on the road. That has resulted in increased cost of maintenance for authorities, higher traffic congestion and climate worsening (Balbin et al., 2020). This study evaluates the appropriate literature centred on BDA analytics for smart commuter routes methods to tackle the issue. The study gathers data about related literatures from 2015 to 2022 and assesses them to understand the suggested tools. An ensemble of 201 shortlisted research papers was categorized and examined in information, showing an exponential development after 2018. The documents dealt with algorithm advancement, information evaluation for automobile traffic flow prediction, accident identification, vehicle behaviour, safety issues, among others. Several of the problems discussed within the assessed documents provided information on visualization, optimization, and route planning. Based on the assessment, a framework is designed to create a structure for RMS. The structure is feasible yet comprehensive with the confidence that it uses data acquisition, storage, and processing, in addition to all those associated with decision-making and visualization. Implementing the framework, large cities can smartly use big data gathered from devices like phone and vehicle tracker to make recommendations for best possible route. Using big data, it allows confident system to be built that will be versatile, dependable, and smart to reduce congestion, improve traffic management and lead to cost reduction for government and transportation authorities. It will also make transportation system more efficient, as it is based on scientific methods presented on the scholarly papers.

While the study suggests a comprehensive framework, further studies should be conducted to explore the application in smaller cities, along with using newer tools as they become available. Other studies should be carried out to further reduce the costs, especially for developing countries like Bangladesh, Vietnam, and Indonesia which have a significant portion of population living in cities. One other aspect is to use a longitudinal data to experiment and explore feasibility.

## References

Alrumiah, S. S., & Hadwan, M. (2021). Implementing big data analytics in e-commerce: Vendor and customer view. *IEEE Access*, 9, 37281-37286. https://doi.org/10.1109/ACCESS.2021.3063615

Antons, D., & Breidbach, C. F. (2018). Big data, big insights? Advancing service innovation and design with machine learning. *Journal of Service Research*, 21(1), 17-39. https://doi.org/10.1177/1094670517738373

Aversa, J., Hernandez, T., & Doherty, S. (2021). Incorporating big data within retail organizations: A case study approach. *Journal of retailing and consumer services*, 60. https://doi.org/10.1016/j.jretconser.2021.102447

Ayed, A. B., Halima, M. B., & Alimi, A. M. (2015). Big data analytics for logistics and transportation. 4th international conference on advanced logistics and transport (pp. 311-316). IEEE. https://doi.org/10.1109/ICAdLT.2015.7136630

Babar, M., & Arif, F. (2019). Real-time data processing scheme using big data analytics in internet of things based smart transportation environment. *Journal of Ambient Intelligence and Humanized Computing*, 10(10), 4167-4177. https://doi.org/10.1007/s12652-018-0820-5

Balbin, P. P., Barker, J. C., Leung, C. K., Tran, M., Wall, R. P., & Cuzzocrea, A. (2020). Predictive analytics on open big data for supporting smart transportation services. *Procedia Computer Science*, 176, 3009-3018. https://doi.org/10.1016/j.procs.2020.09.202

Biuk-Aghai, R. P., Kou, W. T., & Fong, S. (2016). Big data analytics for transportation: Problems and prospects for its application in China, (pp. 173-178). https://doi.org/10.1109/TENCONSpring.2016.7519399

Brajesh, S. (2016). Big data analytics in retail supply chain. In Big Data: Concepts, Methodologies, Tools, and Applications (pp. 1473-1494). IGI Global.

Bresciani, S., Ciampi, F., Meli, F., & Ferraris, A. (2021). Using big data for co-innovation processes: Mapping the field of data-driven innovation, proposing theoretical developments and providing a research agenda. *International Journal of Information Management*, 60, 102347. https://doi.org/10.1016/j.ijinfomgt.2021.102347

Chiang, L. L., & Yang, C. S. (2018). Does country-of-origin brand personality generate retail customer lifetime value? A Big Data analytics approach. *Technological Forecasting and Social Change*, 130, 177-187. https://doi.org/10.1016/j.techfore.2017.06.034

Fiore, S. E. (2019). An integrated big and fast data analytics platform for smart urban transportation management. *IEEE Access*, 7, 117652-117677.

Ghasemaghaei, M., & Calic, G. (2020). Assessing the impact of big data on firm innovation performance: Big data is not always better data. *Journal of Business Research*, 108, 147-162. https://doi.org/10.1016/j.jbusres.2019.09.062

Ghofrani, F., He, Q., Goverde, R. M., & Liu, X. (2018). Recent applications of big data analytics in railway transportation systems: A survey. *Transportation Research Part C: Emerging Technologies*, 90, 226-246. https://doi.org/10.1016/j.trc.2018.03.010

Gobble, M. M. (2013). Big data: The next big thing in innovation. *Research-technology management*, 56(1), 64-67. https://doi.org/10.5437/08956308X5601005

Gohar, M., Muzammal, M., & Rahman, A. U. (2018). SMART TSS: Defining transportation system behavior using big data analytics in smart cities. *Sustainable cities and society,* 41, 114-119. https://doi.org/10.1016/j.scs.2018.05.008

Gunasekaran, A., Papadopoulos, T., Dubey, R., Wamba, S. F., Childe, S. J., Hazen, B., & Akter, S. (2017). Big data and predictive analytics for supply chain and organizational performance. *Journal of Business Research,* 70, 308-317. https://doi.org/10.1016/j.jbusres.2016.08.004

Hao, S., Zhang, H., & Song, M. (2019). Big data, big data analytics capability, and sustainable innovation performance. *Sustainability*, 11(24), 7145.

He, G. (2021). Enterprise E-commerce marketing system based on big data methods of maintaining social relations in the process of E-commerce environmental commodity. *Journal of Organizational and End User Computing (JOEUC),* 33(6), 1-16.

Hussein, W. N., Kamarudin, L. M., Hussain, H. N., Zakaria, A., Ahmed, R. B., & Zahri, N. A. (2018). The prospect of internet of things and big data analytics in transportation system. *Journal of Physics: Conference Series.* IOP Publishing.

Issa, N. T., Byers, S. W., & Dakshanamurthy, S. (2014). Big data: the next frontier for innovation in therapeutics and healthcare. *Expert review of clinical pharmacology,* 7(3), 293-298. https://doi.org/10.1586/17512433.2014.905201

Ittmann, H. W. (2015). The impact of big data and business analytics on supply chain management. *Journal of Transport and Supply Chain Management,* 9(1), 1-9. https://hdl.handle.net/10520/EJC169773

Kayser, V., Nehrke, B., & Zubovic, D. (2018). Data science as an innovation challenge: From big data to value proposition. *Technology Innovation Management Review*, 8(3), 16-25. http://doi.org/10.22215/timreview/1143

Keskar, V., Yadav, J., & Kumar, A. (2021). Perspective of anomaly detection in big data for data quality improvement. *Materials Today: Proceedings,* 51(1), 532-537. https://doi.org/10.1016/j.matpr.2021.05.597

Lee, H. L. (2018). Big data and the innovation cycle. *Production and Operations Management*, 1642-1646.

Lee, J., Kao, H. A., & Yang, S. (2014). Service innovation and smart analytics for industry 4.0 and big data environment. *Procedia cirp, 16*, 3-8. https://doi.org/10.1016/j.procir.2014.02.001

Lekhwar, S., Yadav, S., & Singh, A. (2019). *Big data analytics in retail. In Information and communication technology for intelligent systems* (pp. 469-477). Springer, Singapore.

Leveling, J., Edelbrock, M., & Otto, B. (2014, December). Big data analytics for supply chain management. In 2014 IEEE international conference on industrial engineering and engineering management (pp. 918-922). IEEE. https://doi.org/10.1109/IEEM.2014.7058772

Li, L., & Zhang, J. (2021). Research and analysis of an enterprise E-commerce marketing system under the big data environment. *Journal of Organizational and End User Computing (JOEUC),* 33(6), 1-19.

Montoya-Torres, J. R., Moreno, S., Guerrero, W. J., & Mejía, G. (2021). Big data analytics and intelligent transportation systems. *IFAC-PapersOnLine,* 54(2), 216-220. https://doi.org/10.1016/j.ifacol.2021.06.025

Morabito, V. (2015). Managing change for big data driven innovation. In Big Data and Analytics (pp. 125-153). Springer, Cham.

Neilson, A., Ben Daniel, I., & Tjandra, S. (2019). Systematic Review of the Literature on Big Data in the Transportation Domain: Concepts and Applications. *Big Data Research, 17*, 35-44. https://doi.org/10.1016/j.bdr.2019.03.001

Nguyen, T., Li, Z. H., Spiegler, V., Ieromonachou, P., & Lin, Y. (2018). Big data analytics in supply chain management: A state-of-the-art literature review. *Computers & Operations Research,* 80, 254-264. https://doi.org/10.1016/j.cor.2017.07.004

Niebel, T., Rasel, F., & Viete, S. (2019). BIG data–BIG gains? Understanding the link between big data analytics and innovation. *Economics of Innovation and New Technology,* 28(3), 296-316. https://doi.org/10.1080/10438599.2018.1493075

Shakya, S., & Smys, S. (2021). Big Data Analytics for Improved Risk Management and Customer Segregation in Banking Applications. *Journal of ISMAC,* 3(3), 235-249. https://doi.org/10.36548/jismac.2021.3.005

Silva, E., Hassani, H., & Madsen, D. (2020). Big Data in fashion: transforming the retail sector. *Journal of Business Strategy,* 41(4), 21-27. https://doi.org/10.1108/JBS-04-2019-0062

Trabucchi, D., & Buganza, T. (2018). Data-driven innovation: Switching the perspective on Big Data. *European Journal of Innovation Management, 22*(1), 23-40. https://doi.org/10.1108/EJIM-01-2018-0017

Wise, J. (2022). *How much data is created everyday in 2022?* https://earthweb.com/ (21.05.2022).

Wright, L. T., Robin, R., Stone, M., & Aravopoulou, D. E. (2019). Adoption of big data technology for innovation in B2B marketing. *Journal of Business-to-Business Marketing,* 26(3-4), 281-293. https://doi.org/10.1080/1051712X.2019.1611082

Yang, C., Huang, Q., Li, Z., Liu, K., & Hu, F. (2017). Big Data and cloud computing: innovation opportunities and challenges. *International Journal of Digital Earth,* 10(1), 13-53. https://doi.org/10.1080/17538947.2016.1239771

Yu, R., Wu, C., Yan, B., Yu, B., Zhou, X., Yu, Y., & Chen, N. (2021). Analysis of the impact of big data on e-commerce in cloud computing environment. *Complexity*, 1-12. https://doi.org/10.1155/2021/5613599

Zhang, X., & Guo, P. (2021). Research on E-Commerce Logistics and Traditional Industry Integration Mode Based on Big Data. *Journal of Physics: Conference Series* (p. 042052). IOP Publishing.

Zheng, X., Chen, W., Wang, P., Shen, D., Chen, S., Wang, X., & Yang, L. (2015). Big data for social transportation. *IEEE Transactions on Intelligent Transportation Systems*, 17, 620-630.

Zhu, L., Yu, F. R., Y., W., Ning, & Tang, B. T. (2019). Big Data Analytics in Intelligent Transportation Systems: A Survey. *IEEE Transactions on Intelligent Transportation Systems,* 20(1), 383-398.

Zhuang, W., Wang, M. C., Nakamoto, I., & Jiang, M. (2021). Big Data Analytics in E-commerce for the US and China Through Literature Reviewing. *Journal of Systems Science and Information*, 9(1), 16-44. https://doi.org/10.21078/JSSI-2021-016-29