

# Integrating Smart Transportation System for a Proposed Smart City- A Context in Sri Lanka

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**Abstract**— Smart transportation is playing a vital role as an important building block in smart city, providing solutions to many issues that relate to traffic on the road. This influences safety and quality of living (QoL), the main goals of smart city development. Smart transportation system in an urban area will save time, save environment by reducing fuel consumption and unwanted driving time. In such case, investigation of different aspects, different functionalities of smart transportation, purposes, research methods, technologies and research gaps to be filled are obligatory. This study presents a literature review based on previous related studies done on smart transportation in smart cities in order to understand the research area as well as the future research needs and gaps to be fulfilled. Here it summarizes different perspectives of smart city and smart transportation considered in studies, types of the researches performed, reported problems which are addressed in studies, purposes of deploying smart transportation, reported benefits and problems and technologies which are compatible in this research area.

**Keywords**— Smart Transportation, QoL, Smart City, IoT

## I. INTRODUCTION

Within the most recent 50 years, city measurements have been expanding to an ever-increasing extent, everywhere throughout the world. By 2050, 70 % of the populace will live in urban areas [1]. Urban areas can be identified as both spots of opportunities and spots of maladies. Opportunities, since urban areas are places where individuals live and meet, where organizations are settled, and schools and colleges are generally situated [2]. Maladies that spread due to city traffic jams, contamination and waste generation have gone more terrible than elsewhere and furthermore the average cost for living is high [3].

It has become a much challenge to public administration and municipalities to create a practical and sustainable urban development considering the need of both making openings for work and protecting nature, providing individuals in city with the best living conditions.

Smart City is viewed as a triumphant urban technique which utilizes technology to uplift the personal satisfaction or QoL in urban area, both enhancing the environmental quality and conveying better service to citizens [4].

Sri Lankans spend a lot of time on roads for travelling. The stringent traffic comes across in slowing the pace of every vehicle, despite public or private [5]. Traffic congestion, air pollution and loss of much needed man

hours occur due to daily unmanageable entrance of more than 500,000 vehicles [6]. Some government statistics shows that the total vehicle population has increased from 3.39 million in 2008 to 6.33 million in 2015 in Sri Lanka and also states that 65% of the road space is used by 38% of the passengers [7]. Thus, utilization of these is highly needed.

The congestion increases as people shift from public transport towards private transport. Thus, a solution for the high traffic is to improve public transport where buses can carry 40-50 passengers for one bus. It will help in reducing the number of vehicles on the road, thus making usage of road space more efficient [8]. The fact that level of service provided by the public transportation sector is low is the widely accepted opinion in the present Sri Lankan society. To curb this massive, unproductive cost, it is vital to take measures to modernize and improve public and private transport [9].

The ultimate goal of this research is to understand and find out the key challenges and unfilled gaps in smart transportation in Sri Lanka. By identifying those key factors based on previous literature, the objective is to suggest solutions to overcome these barriers and fill the existing gaps between smart transportation and general transportation system in Sri Lanka. This paper provides a literature survey which provides studies of smart transportation in smart city. Purpose of this is to find the gaps and research areas where high concern is needed and to understand methods techniques used in performing studies in same area.

Other sections of this paper flow according to following. This section further discusses the introduction of the domain. The background of smart city, smart transportation and related research will be presented in section 2. Section 3 provides a view about methodology which is used for the study. Section 4 will represent the Results of this study. The discussion and conclusion will be presented in 5th section and also the current problems which remains and future direction.

### A. Internet of Things

Internet of Things or mostly referred to as IoT is an progressive paradigm that visualize not so distant future, where daily assets will contain digital communication transceivers, microcontrollers and appropriate protocols enabling them to communicate with each other and users.

[10]. IoT provide range of devices like home devices, vehicles, supervising cameras, sensors and many which give service to public administrations, companies and citizens. This mostly searches application in some different domains, such as automating home, industry automation, medical aids, elderly assistance, intelligence energy management and smart grids, healthcare, traffic management, automotive, and many others [11].

In this intricate situation, the use of the IoT to facilitate administration purpose became a consideration as this can lower the cost of administration and increase the efficiency and effectiveness of process in this way the smart city idea came to place

**B. Smart City Concept and Services**

It is not practical to provide a common unique definition for “Smart City,” but it is accepted that ultimate objective of this is to provide better use of public resources, by accelerating quality of services given to people, by lowering costs of administration. This aim can be achieved by the deploying an urban IoT [12].

Different smart city aspects can be identified as waste management, structural health of buildings, air quality, traffic congestion, noise monitoring, smart parking, smart lighting and city energy consumption [13].

**C. Smart transportation**

Smart transportation is enabled by number of technologies like IoT, GPS, Wireless Technologies and Sensing Technologies. Applications of smart transportation are commonly wide scoped and complicated as those are working with heterogeneous and dynamic devices and data. Smart Parking systems, intelligent public transportation systems, traffic management systems, smart taxi applications, smart traffic light systems, disaster precaution systems are common functionalities of smart transportation [14].

**II. RELATED WORK**

In this part it represents a secondary study. A study that is based on analysing the primary studies, the existing research papers. A mapping study basically provides an overview of a particular topic and finds any sub topic to be considered where it needs more primary studies. A tertiary study is done in order to search for the way of presenting secondary studies on smart transportation in smart city before going to the secondary study presented here [15]. As there is a research gap in Sri Lanka on smart transportation for smart cities the search was done on all smart transportation and smart city related studies regardless of the country.

In performing this, the search string with three metadata fields as title, abstract, keywords as shown in Table I is used. In the electronic databases mentioned below the search string was used to retrieve relevant studies: Emerald Insight, ACM Digital Library, Science Direct, Research Gate, IEEE Xplore and Springer Link.

When performing the tertiary study to retrieve secondary studies done on Smart Transportation, researcher used the search string in Table II in same six electronic databases. In performing the tertiary study done to retrieve secondary studies in Smart Cities, the same six electronic databases were searched using the search string shown in Table III.

As Smart transportation system has become a most researched topic there are many studies on smart transportation systems. Here discussed are the most related works that found for this research title as below.

**Table 1. Search Terms of Smart Transportation for Smart City**

Areas	Search Terms
Smart City	“Smart City”, “IoT and Smart City”, “Digital City”
Smart Transportation	“Smart Transportation”, “Intelligent Transportation Systems”, “Smart Traffic Monitoring”
Review	“systematic literature review”, “systematic review”, “systematic mapping”, “mapping study”, “systematic literature mapping”
Search string: (“smart transportation”, “intelligent transport systems” OR “smart traffic monitoring”) AND (“systematic mapping” OR “mapping study” OR “systematic literature review” OR “Literature review” OR “systematic literature mapping”)	

**Table 2. Search Terms of Smart Transportation**

Areas	Search Terms
Smart Transportation	“Smart Transportation”, “Intelligent Transportation Systems”, “Smart Traffic Monitoring”
Review	“systematic literature review”, “systematic review”, “systematic mapping”, “mapping study”, “systematic literature mapping”
Search string: (“smart transportation”, “intelligent transport systems” OR “smart traffic monitoring”) AND (“systematic mapping” OR “mapping study” OR “systematic literature review” OR “Literature review” OR “systematic literature mapping”)	

**Table 3. Search Terms of Smart City**

Areas	Search Terms
Smart City	“Smart City”, “IoT and Smart City”, “Digital City”
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Andrea Zanella, Nicola Bui, Angelo Castellani et al, in their study titled as Internet of Things for Smart Cities [16] has done an overview on IoT smart city and found what are the parts of smart city and had created an urban IoT architecture considering web service after analyzing all those services.

Matthew N.O. Sadiku, Adebowale E. Shadare, Sarhan M. Musa in their study *Smart Transportation: A Primer* [17] have talked about what is smart transportation and in that they say IoT, wireless technologies, sensing technologies and GPS enabling technologies for Smart Transportation. And here they categorize applications of smart transportation into three main categories as smart cities, smart vehicles, and electric vehicles and also at the end they discuss about some barriers of enabling smart transport systems. They are system vulnerabilities for security breaches, limited resources, and low public awareness on new technologies.

Dina Fitria Murad, Bahtiar Saleh Abbas, Agung Trisetyarso et al, in their study titled as *Development of Smart Public Transportation System in Jakarta City based on Integrated IoT Platform* [18] has mainly focused on enabling smart public transportation system integrated with smart phones. They have done a survey by taking samples from population using questionnaire. It is a research on how public will accept this. And found that public is in a need of such kind of system to ease and fasten their daily routine.

Thanh N. Pham, Ming F.Tsai, Duc B. Nguyen et al, in their work on cloud based smart parking system based on IoT technologies [19] that can be identified as an aspect to be developed in order to make a city smart, are proposing a system that helps users to find a free parking space at the least cost automatically. The findings invent a parking network architecture and algorithm to update status of car park. Here as future work they mention about implementing the system in real world using RFID and WSN.

Parag Gawade and Prof.Meeankshi conducted a research on *IOT Based Smart Public Transport System* [20]. Here they emphasize on inventing a smart transport system to make travel less exhausting and more secure choosing public bus as the transportation mode.

J.Sherly and D.Somasundareswari in their work on *Internet of Things Based Smart Transportation Systems* [21] are inventing a system which sends location information to database for every five minutes and map showing positions of vehicles using parking sensors and roadway sensors and propose a mobile app to order a parking space and to pay parking fee.

Mehal Zaman Talukder, Sheikh Shadab Towqir, Arifur Rahman Remon and Hasan U. Zaman in their study on *An IoT Based Automated Traffic Control System with Real-Time Update Capability* [22] are proposing a system which can optimize the traffic flow pattern to facilitate traffic congestion problem in crowded area. In this paper as future work they propose to enhance system using more sensors and implement it.

A study on *Intelligent Traffic Monitoring and Guidance System for Smart City* [23] focus on intelligent traffic monitoring system using graph theories and formal methods as a solution for traffic jams. Here they propose a model for intelligent traffic monitoring and guidance system. For future researchers they propose to improve

and extend the proposed system to be implemented in real world scenarios.

Sachin Vidyasagar, Aditya Varma, Hari Charan, S. Renuga Devi, A. Rajesh has done a research on *A low cost IoT based crowd management system for Public Transport* [24] to find a solution to the crowding problem using smart seats to detect and display seat occupancy.

Andres Jimenez, Vicente Garcia-Diaz, John Anzola showed from their study titled as *Design of a System for Vehicle Traffic Estimation for Applications on IoT* [25] propose a modular system to detect traffic using Gunnar Farneback method to detect the dense optical flow in stream of video. From their findings they propose future researchers to make a WSN implementation on system to monitor area of city and represent the information in cloud real time to estimate traffic jams.

In the systematic literature review done by Dina Fitria Murad, Achmad Nizar Hidayanto and Harjanto Prabowo on *IoT for Development of Smart Public Transportation System* [26] they explored opportunities and challenges for the application of IoT on public transportation to find out how important to implement a system and how will the society accept the system.

Hsin-Te Wu and Gwo-Jiun Horng conducted a review on *Establishing an Intelligent Transportation System with a Network Security Mechanism in an Internet of Vehicle Environment* [27] and there they propose *IoV* (Internet of Vehicles) system environment and also integrate intelligent transportation systems in traffic signal control to add emergency vehicles.

According to the work done by Tai-hoon Kim, Carlos Ramos and Sabah Mohammed on *Smart City and IoT* [28] there are many available technologies when considering the development of smart transportation system in IoT based smart cities and also, they emphasize some unsolved challenges that future researchers should focus.

### III. RESEARCH METHOD

According to the guidelines given by Kitchenham and Charters [29] the research method used in this study is defined. The method involves three main stages. In selection at first current status on studies on smart transportation in smart city is considered. Then secondly the studies are taken through a selection process to retrieve the relevant. Here following selection criteria was used in: (i) defining terms and search strings (ii) selection of sources (iii) defining the inclusion and exclusion criteria (shown in Table 4) and (iv) defining the way of data storing. Thirdly in this selection stage, publications until June 2018 were considered and a total of 388 publications were returned as result as 189 from IEEE Xplore, 73 from ACM Digital Library, 20 from Springer Link, 87 from Science Direct, 13 from Emerald Insight and 6 from Research Gate were found. To extract most relevant, sub selection process was performed on these selected publications.

In the first stage, duplications were removed, retaining 115 publications (reduction of 70%). In the second stage, selection criteria (inclusion and exclusion criteria) on the

title, abstract and keywords is applied, resulting in 37 papers (reduction of 68%). In the third stage, considering full text the selection criteria were applied resulting 11 studies (reduction of approximately 70%). As 4th stage, snowballing was performed resulting in 7 papers and by applying selection criteria over title, abstract and keywords, 3 papers remained (reduction of 57%) and on them selection criteria were applied considering the full text and only one paper selected (overall 86% reduction from snowballing).

Finally, from 12 papers which came up till the 5th stage, direct search was done on publications authored by the researchers and research groups involved in these studies which resulted 4 papers and by applying all selection criteria 1 most appropriate paper was selected. At the end of this searching process totally 13 papers were retrieved as the final result including, 11 from the sources, 1 from snowballing and 1 from direct searching researchers and research groups. Summary of the selections in selection stages are shown in Table 5 clearly emphasizing the progressive elimination of studies in the selection process. Table 6 presents bibliographic references of selected studies. Unique identifier (#id) is given to each study in this table and those identifiers are used to represent those studies in the rest of this paper.

In the paper following research questions were addressed.

- RQ1** When and where the studies published?
- RQ2** What are the aspects focused in Smart City perspective?
- RQ3** What aspects of Smart Transportation are focused in research?

- RQ4** What is the type of the research conducted?
- RQ5** Which problems are reported related to smart transportation in smart cities?
- RQ6** What are the purposes of implementing smart transportation systems?
- RQ7** What are the aspects of the transportation that was considered in context of smart city?
- RQ8** Which technologies are used to provide smart transportation in smart cities?
- RQ9** What main conclusions have been reported regarding using smart transportation methods for smart cities?

*A. Limitations of this Mapping*

As only few specific databases were selected to perform searches which may lead to loss some important studies which are in other databases. But as snowballing and direct search was performed using references of selected studies this limitation was addressed up to some extent.

When performing direct search on researchers and research groups those information were taken only from the selected studies there may be a chance of missing some important studies due to that.

When search is performed on some databases as a filter option the year range was given (2014-2018). This will create a huge chance of missing some related and well performed studies which were done before the lower year margin.

**Table 4. Search terms of the tertiary study on smart transportation for smart city**

Areas	Search Terms
Smart City	"Smart City", "IoT and Smart City", "Digital City"
Smart Transportation	"Smart Transportation", "Intelligent Transportation Systems", "Smart Traffic Monitoring"
Search string: ("smart city", "IoT for smart city" OR "digital city") AND ("Smart Transportation" OR "smart traffic monitoring")	

**Table 5. Bibliographic reference for selected studies**

ID	Bibliographic reference
#1	Zanella, A., Bui, N., Castellani, A., Vangelista, L. And Zorzi, M., 'Internet Of Things For Smart Cities - IEEE Journals & Magazine' (Ieeexplore.Ieee.Org, 2014)
#2	Matthew.N.O. Sadiku, Adebowale. E. Shadare, & Sarhan M. Musa. Smart Transportation: A Primer. (2017, March).
#3	Murad, D. F., Abbas, B. S., Trisetyarso, A., Suparta, W., & Kang, C. Development of smart public transportation system in Jakarta city based on integrated IoT platform - IEEE Conference Publication. (2018, April 30).
#4	Pham, T. N., M. T., Nguyen, D. B., Dow, C., & Deng, D. A Cloud-Based Smart-Parking System Based on Internet-of-Things Technologies - IEEE Journals & Magazine. (2015, September 09)
#5	Gawade, P., & Meeankshi, A., Prof. IOT Based Smart Public Transport System. (2017, July).
#6	Sherley,J., & Somasundareswari,D. INTERNET OF THINGS BASED SMART TRANSPORTATION SYSTEMS. (2015, October).
#7	Talukder, M. Z., Towqir, S. S., Remon, A. R., & Zaman, H. U. An IoT based automated traffic control system with real-time update capability - IEEE Conference Publication. (2017, December 14).
#8	Latif, S., Afzaal, H., & Zafar, N. A. Intelligent traffic monitoring and guidance system for smart city - IEEE Conference Publication. (2018, April 26).
#9	Vidyasagan, S., Devi, S., Varma, A., A., & Charan, H. 'A low cost IoT based crowd management system for public transport - IEEE Conference Publication. (2017, November 24).
#10	Jiménez, A., García-Díaz, V., & Anzola, J. Design of a System for Vehicle Traffic Estimation for Applications on IoT.

	In Proceedings of the 4th Multidisciplinary International Social Networks Conference (MISNC '17). ACM, New York, NY, USA, Article 15, 6 pages. (2017, July 17).
#11	Murad, D. F., Meyliana., Hidayanto, A. N., & Prabowo, H. IoT for Development of Smart Public Transportation System: A Systematic Literature Review. International Journal of Pure and Applied Mathematics. (2018).
#12	Wu, H., & Horng, G. Establishing an Intelligent Transportation System With a Network Security Mechanism in an Internet of Vehicle Environment - IEEE Journals & Magazine. (2017, September 14).
#13	Kim, T., Ramos, C., & Mohammed, S. Smart City and IoT Elsevier B.V. Future Generation Computer Systems. (2017, July).

IV. RESULTS AND DISCUSSION

Here described are the results that gained for the research questions which were previously presented under section III. In this section tables are used to present the results of the research questions. In those tables the reference ID which was given in Table V is used to indicate the respective study.

As Fig.1 presents the results for RQ1: Classification by publication year and source, it shows the distribution of selected studies from 2014 onwards which is very recent. As this topic is subjected to many researches this time it is much better to choose most recent studies as the relevant technologies also developing rapidly. The selected studies were published in tow main vehicles: Journals and Conferences. Journals have been the main forum for presenting Smart Transportation in Smart Cities, encompassing 61.5% (8 studies in 13). Conferences are the publication forum of 38.5% (5 out of 13).

Distribution of the studies according to the research focus from the Smart City perspective as the results of RQ2. Most of the papers address a specific aspect of smart city (11 out of 13 – 84.6%) for providing smart transportation facilities. With respect to Smart Transportation, majority of the studies discussed aspects related to the Smart Transportation process as a whole or focusing on one of its activities as results for RQ3.

The distribution according to the research types, the results of RQ4 are as described here. Nine studies out of all considered 13 (69.2%) studies propose some solution for Smart Transportation in Smart City. In addition to presenting a solution proposal, most of them also discuss some sort of evaluation: 6 studies also report an Evaluation Research (46.2%), while 4 studies report a Validation Research (30.8%). The 6 studies with an Evaluation Research discuss a practical implementation and its consequences. Three studies (23.07%) present only a solution proposal.

When consider the distribution over the years considering the purposes of having Smart Transportation which was identified under RQ6. It illustrates that “Prevent unneeded driving time and fuel consumptions” (9 studies – 69.2%) and “Reduce vehicle waiting time on traffic jam” (5 studies – 38.5%) have the largest focus.

When consider the types of transportation as the results for RQ7, on which the studies mainly focus on, Public transportation is discussed in 4 studies (30.8%). When considering public transportation there were 6 main purposes separately as bus trip monitoring , bus fee online payment, bus arrival time estimation, accident reporting and safety, alcohol detection in driver, Seat availability. On

the other hand, 9 studies out of 13 (69.2%) have discussed private transportation.

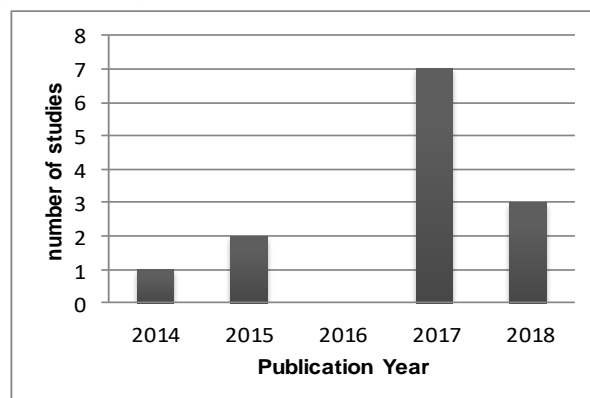


Fig. 1 Distribution of studies over the years

As the results of RQ9 and RQ10 which consider about benefits and problems reported in integration of smart transportation systems in smart cities are described as follows.

The main aforementioned benefits are perceived in the selected studies are,

- A. Time Saving: Smart Transportation system helps to estimate traffics and then drivers can choose alternative paths and also some systems automatically suggest shortest paths thus it reduce the time spent on roads unwantedly. And also smart public transportation systems helps to view bus trips thus people do not have to spend time on a queue.
- B. Cost Reduction: These systems will reduce the driving time thus fuel consumption is less it will le to save money.
- C. Eco Friendly: As the driving time and waiting time on traffic are reduced CO2 emission by burning fuel will reduce.

The most highlighted and discussed benefit is “Time Saving” (76.9%).

The main problems aforementioned are perceived in the selected studies as described in below

- A. Security Breaches and Attack Vulnerability: These systems contain sensitive information of public. Mostly all stored information is recorded in cloud architecture thus it has to be more secure to prevent from breaches if not public data will be compromised.
- B. Digital Divide: Here it talks about public acceptability towards the system.
- C. Limited Resources when Comparing to Increasing Number of Transportation Assets

## V. CONCLUSION

Based on Kitchenham and Charters (2007), a mapping study provides an idea, in the preceding phases, of lack of existing researches, this can be a base for future researchers. This study presents a systematic mapping on factors influencing Smart transportation system in smart city. Nine research questions were discussed: (i) Study distribution over years; (ii) research focus from the Smart City perspective; (iii) focus of research in Smart Transportation perspective; (iv) type of research; (v) problems that reported in studies; (vi) purposes of implementing Smart Transportation in Smart Cities; (vii) types of Transportation typically considered in converting to smart; (viii) technologies used in implementing smart transportation in smart city; (ix) main conclusions (benefits and problems) reported on the implementation of smart transportation in smart cities.

Smart Transportation in Smart city has shown to be a very promising research area, since converting in to smart transportation helps in making urban life more comfortable by saving money and time and also will be environmentally friendly approach, as shown by this systematic mapping. Most vital contribution is to highlight some aspects associated to smart transportation in smart cities, which will be helpful to conduct future research works which are related to this topic. In this context, we highlight below conclusions: (i) Smart transportation in smart cities is a mostly considered topic; (ii) the major problem in society to have this kind of system is to save time and cost that uselessly spent for transportation; (iii) Prevent unneeded driving time and fuel consumptions is the main purpose of having smart transportation system in smart cities; (iv) Mostly considered type of transportation is public transportation in order to convert in to smart transportation and also private transportation in smart parking, traffic monitoring and automatic path suggestion; (v) advanced technologies that used to provide smart transportation in smart cities are sensors, Arduino, GSM/GPS, WSN, Mobile software.

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