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Traffic Efficiency Models for Urban Traffic Management Using Mobile Crowd Sensing: A Survey

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Abstract: The population is increasing rapidly, due to which the number of vehicles has increased, but the transportation system has not yet developed as development occurred in technologies. Currently, the lowest capacity and old infrastructure of roads do not support the amount of vehicles flow which cause traffic congestion. The purpose of this survey is to present the literature and propose such a realistic traffic efficiency model to collect vehicular traffic data without roadside sensor deployment and manage traffic dynamically. Today's urban traffic congestion is one of the core problems to be solved by such a traffic management scheme. Due to traffic congestion, static control systems may stop emergency vehicles during congestion. In daily routine, there are two-time slots in which the traffic is at peak level, which causes traffic congestion to occur in an urban transportation environment. Traffic congestion mostly occurs in peak hours from 8 a.m. to 10 a.m. when people go to offices and students go to educational institutes and when they come back home from 4 p.m. to 8 p.m. The main purpose of this survey is to provide a taxonomy of different traffic management schemes for avoiding traffic congestion. The available literature categorized and classified traffic congestion in urban areas by devising a taxonomy based on the model type, sensor technology, data gathering techniques, selected road infrastructure, traffic flow model, and result verification approaches. Consider the existing urban traffic management schemes to avoid congestion and to provide an alternate path, and lay the foundation for further research based on the IoT using a Mobile crowd sensing-based traffic congestion control model. Mobile crowdsensing has attracted increasing attention in traffic prediction. In mobile crowdsensing, the vehicular traffic data are collected at a very low cost without any special sensor network infrastructure deployment. Mobile crowdsensing is very popular because it can transmit information faster, collect vehicle traffic data at a very low cost by using motorists' smartphone or GPS vehicular embedded sensor, and it is easy to install, requires no special network deployment, has less maintenance, is compact, and is cheaper compared to other network options.

Keywords: traffic congestion; mobile crowd sensing; geographical positioning system; traffic parameters; alternative path selection

1. Introduction

Traffic congestion is the main problem in today's metropolitan areas that has caused difficulties for citizens, especially in crowded areas of the urban. As the population increased, the traffic congestion control in major cities of Pakistan and the world orange has become very serious. The rapid increase of public-private vehicles use has also increased the number of traffic accidents, and the roads are gradually dangerous. Unfortunately, we have little traffic awareness and may not respect traffic rules. Undoubtedly, poor roads management and high-speed driving are the main causes of traffic congestion. Traffic congestion problems in Pakistan are becoming more serious, especially in large cities such as Hyderabad, Quetta, Lahore, Islamabad, Peshawar, Rawalpindi, and Karachi, etc. The traffic jam is another place to waste valuable work time. If someone goes to the hospital in an emergency, the patient can only look to God's mercy. Under the pressure of more and more cars and bicycles, the area where vehicles are parked has been shrinking, especially in the subway. The People do not have traffic awareness. Traffic police and the media should create traffic awareness among the people, but unfortunately, the people gave little attention to following the traffic rules and regulations. The United States Department of Transportation presents traffic congestion in urban areas as the main threat to economic success [1]. In terms of time and fuel consumption annual cost to American drivers due to traffic congestion is estimated to be US$1200. Nowadays, with the rapid development becomes in technology due to the Internet of Things (IoT), vehicles have become modern [2]. They gradually become more equipped with actuators [3], communication devices, Sensors like Global Positioning System (GPS) [4], embedded computers, and mobile devices. Several vehicles have the ability of sensing, communication with others vehicle in the environment, data processing using several protocols [5]. With the development in IoTs [6,7] MCS have a great deal chance to report the growing transportation issue, such as congestion and heavy traffic [8,9] and vehicle safety. The Mobile Crows Sensing (MCS) refers to the volunteered geographic information and geo crowdsourcing model. In which mobile users use their mobile for the collection of vehicular data, communication, computing, and sensing devices to collect, locally analyze, and process, as well as distribute geo-referenced information [10]. The urban transportation system is proposed to improve traffic management system by using MCS. Through the integration of smart terminal technology and mobile communication, MCS technology provides a new way for the transportation system to reduce traffic congestion and vehicle traffic data collection costs [11]. Which is based on several mobile devices they including smartphones, sensor-equipped vehicles. The vehicle's driver's smartphones are members of this sensing framework. The traffic data get by the motorist's smartphone and then send the collected traffic data to a monitoring system like MCS cloud-based framework for processing analysis to acknowledge the traffic authorities and motorist about the current traffic situation. In recent years, the smartphone acts an important role and it becomes necessary in our daily life. There are a set of sensors are equipped in smartphones, in which the GPS [12], microphone, camera, accelerometer, gyroscope, audio, image, light [13]. By using these sensors, everyone can easily collect and share sensing information in today's life. MCS develop in recent times as a capable large-scale data sensing and data collection model in which the data collection task is performed by smartphones at a very low cost. The collected data is then shared and sent to the central controller system. MCS [14] is predictable to become one of the most important technologies which contribute to the vehicular traffic system, healthcare monitoring, logistic, and organization in future smart cities [15]. The cost of the sensing operation and accuracy of collected data are the two main features of MCS. The goal of the project is to analyze the above characteristics and develop an efficient MCS architecture based on the analysis results. MCS is committed to scientific research in the development of efficient MCS architecture, development models, and simulation tools. The movement of goods, animals, and people from one place to another place is transportation, due to the increase in the number of vehicles and population, the traffic system has become more congested mostly in busy hours [16,17]. An estimated graph shows the observed number of average vehicles passed from two common points Faizabad Islamabad, Pakistan and Zero points Islamabad, Pakistan) Faizabad Islamabad, Pakistan towards Zero points Islamabad, Pakistan per minute in Figure 1. The vehicle density is shown on Y-axis and time is shown on X-axis. In initial hours i.e. 1 a.m. to 5 a.m, the vehicle's density is at its lowest because at the late-night time the educational institutes and other organizations are closed and hence most people sleep at this night time. After 7 a.m. the vehicle density increases exponentially and at 8 a.m. the vehicle density reaches a maximum value and the 8 a.m. consider peak hours because in this interval the peoples go to the schools, universities, colleges, and offices. Between 10 a.m. and 3 p.m. the vehicle density decreases. During 4 p.m. the vehicle density again increases exponentially at this time the peoples return home from offices, Colleges, universities, and due to this, the vehicle's density reaches a peak level. Then between 10 p.m. and 12 p.m., the vehicle density gradually decreases. Therefore from 8 a.m. to 10 a.m and from 4 p.m. to 6 p.m. are peak hours and at these intervals, most of the congestion occurs.

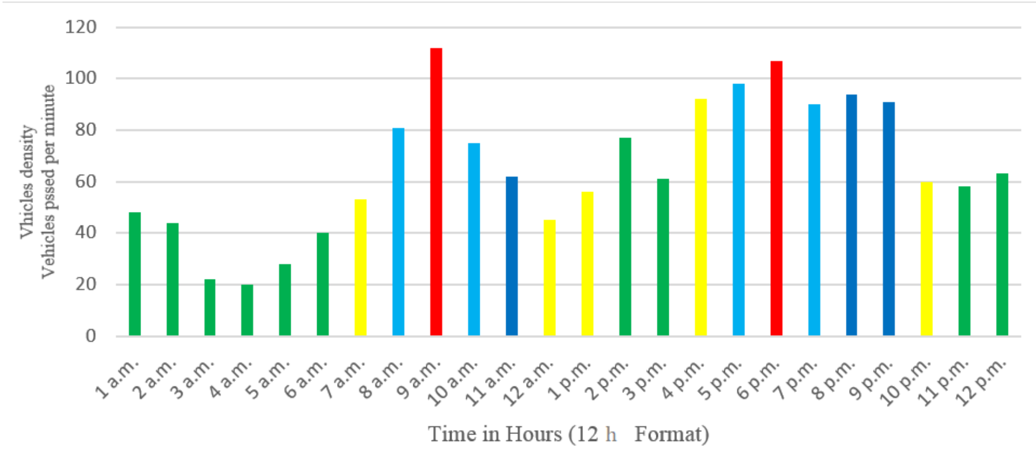

Figure 1. Vehicles passed from the Faizabad Islamabad, Pakistan towards Zero points Islamabad, Pakistan.

There is an enormous need for a system to detect traffic congestion levels and solve this issue by acknowledging the vehicles. Using mobile crowd sensing, monitoring accuracy of traffic increases, thereby resulting in a better traffic management system. In previous work, some existing MCS applications have been researched and developed and they are classified, shown in Figure 2 [18]. From the user's perspective, the existing MCS applications are divided into two categories. The first category consists on the intelligent transportation [11], environmental monitoring [19], urban planning and population relocation [20], geospatial information collection [21], crisis prediction and management [22]. The second category includes smart city [23], sports experience, personal health monitoring, and health care [24], virtual reality (VR) entertainment [25], virtual teaching, and remote education [25]. Today the personal mobile devices are consequently ubiquitous that a wide range of more learning practices and paradigms can profitably use them.

People can move anywhere by vehicle or on foot and who carried a smartphone, therefore the sensing methods can be generally classified into three classes [26], individual sensing, group sense, and community sense because of the various types of phenomena being monitored. The phenomena being monitored relate to individuals in the individual sensing method [22]; in this method, the individual movement patterns (e.g., walking, driving, running, and exercising) are sensed and monitored. In individual sensing, the data is collected for only personal use, and the collected data is not shared with others. In group sensing, collect data for a group of people and they can share it with other people in the group. In the community perception method, people collect data from the community and integrate the collection to predict global trends.

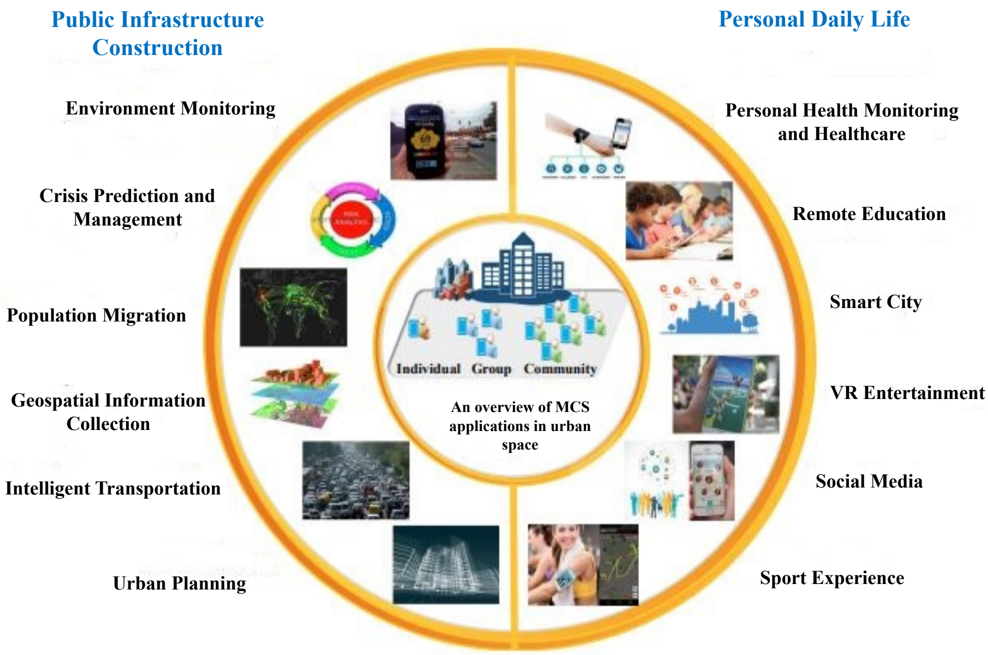

Figure 2. Broad categories of existing work of MCS needed [18].

The purpose of this survey is to present the taxonomy-based literature of traffic management schemes and literate the vehicular traffic data collection schemes. The shortcoming of the previous research work are; mostly traffic management systems are costly due to more sensors deployments for vehicular data collection and more motorist intervention required.

The proposed survey literate the traffic management systems and presents MCS based dynamic traffic efficiency model to provide:

- A realistic dynamic traffic efficiency model which collects the vehicular traffic data at a very low cost by using motorist smartphone.
- To collect data for analysis by using motorist smartphone or vehicular embedded Global Positioning System (GPS) without roadside sensors deployment and vehicle to vehicle communication.
- No need for network infrastructure deployment.
- Today's urban traffic congestion is one of the main problems to be solved by such a traffic management scheme.

Section 1 presents detail of Vehicle Traffic Congestion Control (VTCC). The background of VTCC discussed in Section 2. Section 3 describes existing traffic congestion control models for transport systems. Section 4 presents the comparison of Traffic Congestion Control Models (TCCMs) using thematic taxonomy. Section 5 describes the analysis of traffic congestion control models. Section 6 describes open issues and research challenges. Section 7 describes conclusion and future work.

2. Background

The traffic congestion effects on the urban environment are described in this section. In Pakistan mostly business and other organizations' official working hours are from 8 a.m. to 4 p.m. Most of the organizations start and end their workdays at the same time, as well as educational institutes are opened at 8 a.m. and they worked till 4 p.m. morning shift and 2 p.m. to 8 p.m. evening shift, the arrival time for the employees to the offices, for the students and teachers to the educational institutes becomes same, and hence this cause of traffic congestion. Some other physical factors also contribute to traffic congestion. They are; focusing on timely business trips, hoping to choose a place to live and work, hoping to take a private car to the destination, rapid population and employment growth, and more intensive use of cars, Failure to build new roads and alternative roads. Figure 3 shows the traffic congestion situations in Islamabad Pakistan.

Figure 3. Traffic congestion during peak hours in Islamabad Pakistan.

2.1. Losses and Difficulties Occurrence Due to Traffic Congestion

Traffic congestion losses are wasting of motorist and passengers valuable time [27], In emergency cases loss of life due to late arrival at hospital [6,7], Fuel loss [8,28], Increase road accidents due to over speed taken to reach on time to destination, increased mental tension for passengers and motorist [9,29], increased carbon dioxide emission [30], more diseases due to increased pollution [31], increased cost of travel, more atmospheric pollution [32], increased cost of transportation products, increased cost of doing business; these are some losses and difficulties which occurs by traffic congestion.

2.2. Strategies for Reducing Urban Traffic Congestion

Through infrastructure construction, highway construction, and private participation in road construction, reduce intersections and widen busy roads. The people want to travel on public transport more due to which the number of private vehicles will be decreased. To develop alternative ways whenever possible, implement metro rails in the metro in big and more populated cities. Promote suburban railways, by the implementation of these strategies the traffic congestion can be reduced in our daily life, but due to the economic budget issue of some countries, they do not follow these strategies for urban traffic congestion control.

2.3. Basic Traffic Congestion Control Models in Transportation

Existing traffic congestion controls models (TCCMs) in transportation systems utilize various strategies to manage traffic in different situations refers to multiple traffic scenarios. The dynamic models are investigated by analytical and numerical methods [19]. A dynamic model of traffic jams based on the vehicle motion equation is proposed.

The suggested proposed MCS-based traffic congestion model to manage urban traffic. There is no need for a special sensor network for vehicular traffic data collection. In MCS the motorist smartphone or vehicle GPS embedded sensor are connected to the proposed MCS android mobile application (GetLocation) to collect real-time traffic information and forward it to the traffic management subsystem for further processing to predict traffic flow on each road respectively. Identify vehicles density on each path and compare it with path capacity. The traffic management subsystem uses adaptive algorithms to manage traffic for vehicles efficiently. The function of the urban traffic congestion control system is congestion avoidance and reducing average waiting time. Figure 4 shows the layered functions of the MCS-based urban traffic congestion management system.

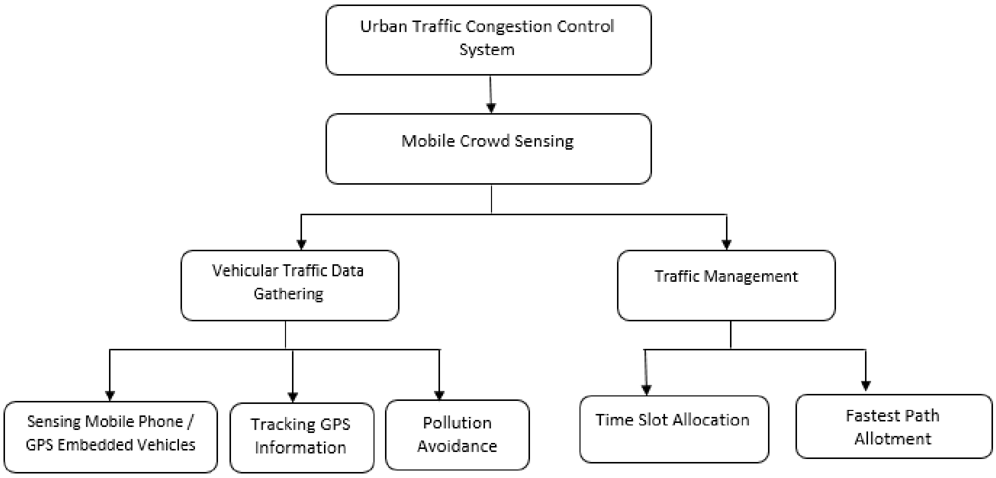

Figure 4. Hierarchal Functionality of MCS based Urban Traffic Congestion Control System.

3. Existing Traffic Congestion Control Models for Transport Systems

Existing traffic management projects for transportation systems utilize a range of strategies to control congestion creation in different scenarios. To develop a better understanding these traffic management models should be classified. It is necessary to discuss the limitations and advantages of existing traffic management models to guide future research in this field. Recently, many projects are related to the Urban Traffic Management Plan (UTMS) are developed. They are focused on traffic congestion and other different parameters, presented in Table 1.

Table 1. UTMS Projects.

Project Name	Year of Start-Completion	Project Supporter	Project Objectives
Adaptive Traffic Signal Control System (ACS Lite) for wolf road, NY	2012–2013	NY State Department of Transportation	Dynamically adjust signal timing according to the situation to meet current traffic flow requirements
Advanced Weather Responsive Traffic Management Strategies	2012–2013	U.S. Research and Innovation Technology Administration	Road weather management was the main objective of this project
Modeling and controlling traffic congestion	2012–2017	European Research Council	Model and optimize large and congested road networks through comprehensive and realistic traffic dynamics and route selection for multiple modes of transportation
Multimodal traffic management schemes for the city of Geneva	2014–2015	Direction générale des transports Etat de Genève	Study the feasibility of large-scale cooperative multi-mode intelligent traffic management solutions and evaluate current traffic management strategies

3.1. Related Projects of Traffic Management

The project titled "Adaptive Traffic Signal Control System (ACS Lite) on Albany Wolf Road" (ACS) began in 2012 and was completed in 2013 [33]. It is a low-cost signal timing optimization system that can dynamically adjust signal timing to meet current demand and traffic demand. The project was about the development of wolf road, USA with funding of £569,800.00. This project aims to determine the signaling efficient system and Siemens ACS-Lite technology in Albany along NY Wolf Road at junctions. The project team is from SenSys Networks, URTC member Rensselaer Institute of Technology (RPI), New

York Annes, and New York City College (non-UTC member Siemens ITS and Associates, Inc. [33].

In 2012, the project "Advanced Weather Response Traffic Management Strategy" was launched with an investment of GBP 206,856.00. Road weather management was the main objective of this project and this project was completed in 2013 successfully [34].

In 2012, a project called "Traffic Congestion Modeling and Control" was launched [35]. The project aims to model and optimize large-scale congested road networks, based on aggregated traffic dynamics and route choice for multiple modes of transport.

A project called "Multimodal Traffic Management Plan for the City of Geneva" was launched in 2014 [36]. The purpose of this project is to study the feasibility of large-scale collaborative multi-mode intelligent traffic management solutions and to review existing traffic management strategies. The project was completed in 2015 under the special guidance of the Geneva Transport Directorate.

3.2. Thematic Taxonomy of TCCMs for Transport Systems

This section presents a thematic taxonomy for the classification of existing TCCMs. Existing TCCMs for transportation systems are grouped into two broad categories based on the proposed thematic taxonomy. In the taxonomy there are six attributes are considered, namely (a) Model Type, (b) Sensing Technologies (c) Data Gathering Techniques (d) Selected Road Infrastructure (e) Traffic Management (f) Result Verification Approach. The taxonomy of traffic congestion control models for transportation systems is shown in Figure 5. The "Model Type" attribute indicates the method/schematic description accepted by a transport system to manage traffic. This attribute organizes one of the given approaches: (a) Static, (b) Dynamic, and (c) Hybrid.

The "Sensor Technology" attribute in the taxonomy represents the choice of sensing and others technology consider in certain studies to measure the results of applied techniques/strategies for traffic management. The sensing technologies are mainly important in traffic management simulation because it affects the calculation of metrics such as vehicles' traffic data sensing to count vehicles during traffic flow, speed estimation, vehicles classification, occupancy, presences, and weight during traveling. The sensing technology includes nine technologies/methods for traffic sensing: (a) RAFID, (b) Magnetic, (c) Acoustic, (d) Inductive Loop, (e) Microwave Radar, (f) Infrared, (g) Video Image Processing, (h) Satellite Imaging, (i) WSN, (j) IOTs and (k) MCS. The "Data Gathering" attribute has different traffic data collection techniques which collect vehicular data during traffic sensing in ITS [37,38]. Various types of obstacles can occur during vehicle to vehicle data sharing and data aggregation [39]. The development becomes ITS by providing high-quality traffic information in real-time to the intelligent transportation system. It has two types of techniques for traffic data gathering (a) Non-intrusive Techniques [40] and (b) Intrusive Techniques. Non-intrusive Technique includes (a) Manual Count, (b) Passive and Active Infrared, (c) Passive Magnetic, (d) Automatic Count, and (e) Video Image Detection. The intrusive technique includes (a) Pneumatic road tubes (b) Piezoelectric sensors (c) Magnetic loops. The "Road Infrastructure" attribute is to design the road facilities and equipment's in a manner to construct routes for vehicles travel. Road infrastructure has two types: (a) Urban Roads and (b) Non-urban roads. The Urban road has the following types: (a) Expressways, (b) Arterial Roads, (c) Collector Roads, and (d) Local Roads. The non-urban roads are (a) National Highway, (b) State Highways, and (b) Local Roads. The "Traffic Congestion Study Levels" attribute describes modeling approaches. There are two modeling approaches scope (a) microscopic and (b) macroscopic. Both are used in traffic flow analysis. The "Result Verification Approaches" is a taxonomy attribute in which there are four ways by using one of them (a) Real-world implementation, (b) Mathematical, (c) Simulation, and (d) Dual; the results are collected and verified. The result is collected and verified by existing traffic congestion control models using either the real-world implementation or simulation.

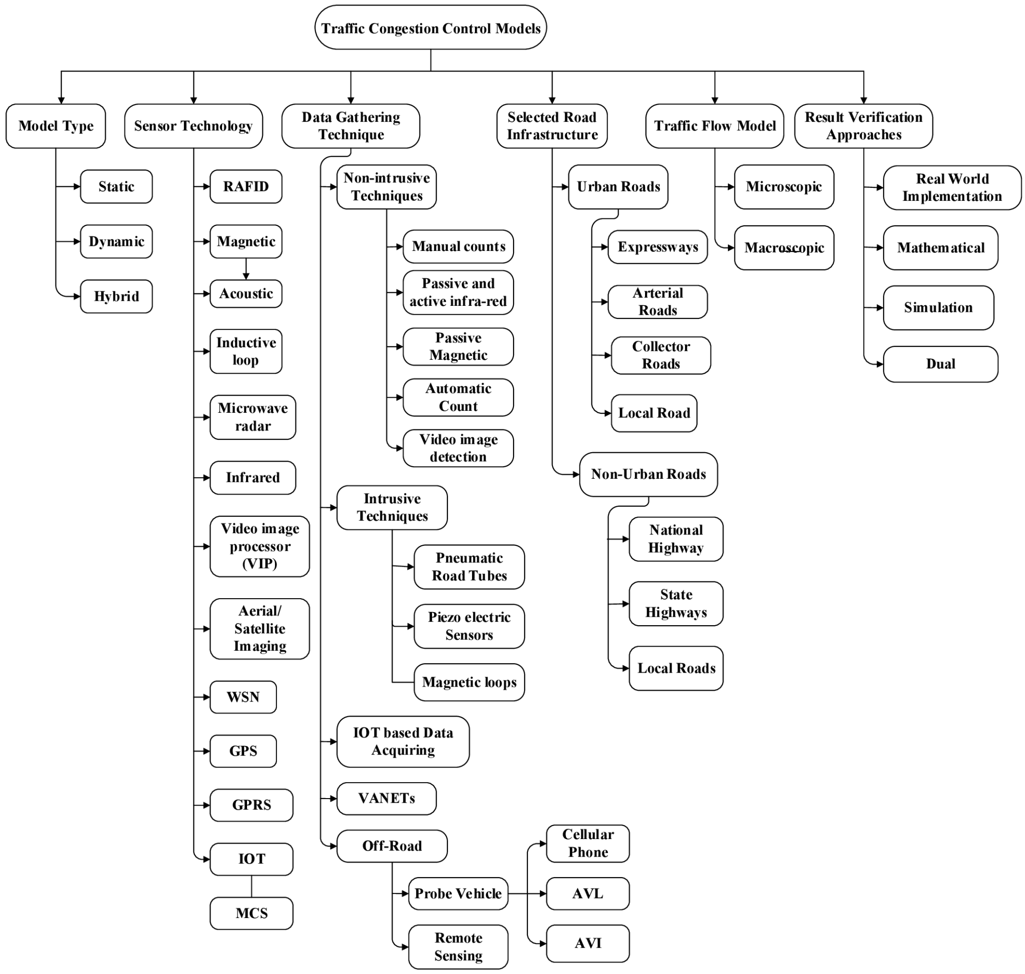

Figure 5. Taxonomy of TCCMs.

4. Comparison of TCCMs Using Thematic Taxonomy

Today's traffic congestion is an important issue, several schemes and techniques have been developed and described in the literature to reduce vehicular traffic congestion. In this section of the paper, a complete summary of related projects, data collection schemes, congestion avoidance schemes based on MCS and WSNs is presented. Initially, the traffic intersection systems were managed by humans in urban cities of the world by using human knowledge and decision. Existing traffic management models for transportation systems utilize a range of strategies to control congestion creation in different scenarios. To develop a better understanding these traffic management models should be classified. It is necessary to discuss the limitation and advantages of existing traffic management models to provide a guideline for future research in this area. Recently a lot of projects are developed on urban traffic management systems they are shown in Table 2. They are focused on traffic congestion and other different parameters, presented in Table 3. A comparison of TCCMs based on the proposed thematic taxonomy is shown in Table 2.

In [41] proposes a mechanism called MRGM. This is a multi-metric traffic jam detection and avoidance mechanism for traffic conditions in urban areas. Here, the vehicle congestion density function (VCD) is used to measure the traffic density, and the congestion status is defined based on this function. PWC is a path weight calculation used to understand the conditions of roads, lanes, and edges. Through this mechanism, the average driving time of the vehicle on the road is reduced, and the fuel consumption is significant. Reduce and control the level of carbon dioxide emissions. This mechanism detects congestion and provides reroute the vehicle with the best route by setting a new route on the path of the vehicle. Simulation results show that it has improvements to existing mechanisms, vehicle fuel consumption, vehicle driving time, and emissions gas.

This [42] work introduced REACT, a traffic management solution that decreases vehicle congestion in smart cities. The solution is based on request-response technology to support the creation of a distributed database containing vehicle traffic information. When vehicles confirm that their database wants road traffic information, the request procedure is executed. Vehicles traveling on the requested road must respond to the requested displacement analysis. In the request-response phase, after considering the distributed database of road traffic conditions, the vehicle verifies alternatives and low-cost routes. Compared with the literature method, this performance analysis shows better traffic and communication, REACT performance, such as OVMT, FIRE-NRD, NRR, and PANDORA.

This article [43] introduces a new type of traffic management system that uses an intelligent roadblock system. The basic concept behind the intelligent system is to determine the location of roadblocks based on the nature and intensity of traffic. Initially, historical data is collected. To this end, different traffic centers are used, which can easily collect the number of vehicles and vehicle speeds at all times. Here, the location of the roadblock is determined by the fuzzy logic system, and the system also focuses on finding the best member limit to achieve better results.

As [44] the perception of urban people has become ubiquitous, the perception of privacy protection has been paid progressively attention. In this article, the author introduces a real-time data gathering mechanism with trajectory privacy (RDCTP) a real-time MCS data gathering mechanism that implements w-event differential. The crowd observes the privacy of users. Each user first allocates a privacy budget according to the trajectory. The privacy of w 1 consecutive locations was previously leaked. Then, he perturbs his position according to the allocated privacy budget and obtains a set of candidate positions. To ensure the effectiveness of the server, we have established an optimization model to select the best position in the candidate set to be uploaded to the server. The experimental results on the Shanghai taxi data set show that RDCTP has achieved high practicability.

In [45], the study uses neural networks as a methodological method for controlling traffic congestion. After testing, the intelligent transportation system has an important impact on the smart city and the traditional system does not have the flexibility to automatically control the adjacent signal timer to minimize traffic congestion. Therefore, an intelligent traffic congestion control system is proposed, which uses machine learning technology to automatically manage traffic signal timers. Implement different sensors on different adjacent signals, collect and share traffic data, and send it to the controller through devices supporting the Internet of Things. In soft real-time systems such as intelligent transportation, time is of the essence. Therefore, if the data received by the signal sensor is delayed or noisy, in this sense, the performance of the proposed (MSR2C-ABPNN) solution may be affected.

In [46], a design for effective management and use of traffic light controllers to effectively control and manage traffic is proposed. WSN and some technologies are used to control the order of traffic flow. At multiple and single intersections these technologies are dynamically adjusted to traffic conditions. The intelligent traffic controllers are used for the operation of traffic infrastructure AHD WSN is used to control traffic signal roads. The controller uses the Traffic Signal Time Manipulation Algorithm (TSMA) and Traffic System Communication Algorithm (TSCA). Simulation results show that the suggested traffic congestion solution is reasonable in terms of average queue length and average waiting time at a single intersection and effective worldwide traffic flow control at multiple intersections. When a new pheromone-based traffic management framework is proposed to reduce traffic congestion, dynamic vehicle diversion and traffic light control strategies are unified.

Table 2. Summary of traffic congestion management schemes.

Study	Proposed Approach	Efficiency	Weakness
Shahi, G.S., et al. [41]	Proposes a mechanism called MRGM. This is a multi-metric traffic jam detection and avoidance mechanism for traffic conditions in urban areas.	This mechanism detects congestion and provides reroute the vehicle with the best route by setting a new route the path of the vehicle.	In this system, if congestion based on VCI which is the vehicle congestion index is found, then information is shared with other vehicles and RSU.
Gomides, T.S., et al. [42]	This work puts forward REACT, a traffic management solution that minimizes vehicle congestion in smart cities	Vehicles traveling on the requested road must respond to the requested displacement analysis. In the request-response phase, after considering the distributed database of road traffic conditions, the vehicle verifies alternatives and low-cost routes.	REACT is a traffic management system based on Vehicular communication. More motorist intervention required under this proposed system
Gomides, T.S., et al. [43]	In this model, the location of the roadblock is determined by the fuzzy logic system, and the system also focuses on finding the optimal membership limit to obtain better results.	In this model, the location of the roadblock is determined by the fuzzy logic system, and the system also focuses on finding the optimal membership limit to obtain better results.	Collect historical data from different traffic centers, collect the number of vehicles and vehicle speeds at every moment.
Ata, A., et al. [45]	Suggested MSR2C-ABPNN model for the intelligent transportation system for collecting traffic data from the controller	Proposed a neural network that uses fitting and time series models. Preprocess the received data from adjacent signal	In soft real-time systems such as intelligent transportation, time is of the essence. Therefore, if the data received by the signal sensor is delayed or too noisy, in this sense (MSR2C-ABPNN) Solution performance may be affected
KM Yousef, et al. [46]	A design for effective management and use of traffic light controllers to effectively control and manage traffic is proposed.	Simulation results show that the proposed traffic congestion solution is reasonable in terms of average waiting time and average queue length at a single intersection and effective global traffic flow control at multiple intersections.	The proposed solution is simulation-based
Rizwan et al. [47]	The STMS model is presented for the smart cities to update real-time traffic details for traffic management to avoid traffic congestion.	Traffic information provides to the user through the user interface like informing the user in a rush situation to follow an alternate route. To explore the traffic density of several places.	The proposed system is only for smart cities. IoT-based system. This system becomes costly due to magnetic devices attached to the vehicles and roadside embedded sensors. Costly due to more sensors deployments on the roads.
Sukode et al. [48]	A context-aware method for measuring real-time traffic status, traffic density, and measurement factors based on dynamic management of traffic signals to control traffic congestion.	Dynamically manage traffic signals observing the traffic density.	More user intervention required in this system. Costly due to requirements of more road side embedded sensors for traffic data gathering.

Table 2. *Cont.*

Study	Proposed Approach	Efficiency	Weakness
Al-Sakran et al. [49]	The proposed framework is based on the real-time traffic information implementation and monitoring architecture of the Internet of Things, RAFID, and WSN using wireless communication	Agent perform specific tasks without user intervention. The proposed system allows gathering real time traffic data generated by sensors. Multi agent system monitoring the traffic flow. A new way of monitoring traffic flow is provides through which improvement becomes in resource utilization and traffic conditions.	Interoperability between different standards, protocols, database systems, data formats, resource types, and heterogeneous hardware is the main problem of the Internet of Things. Storage space issue: vehicles related data will be saving in database, like vehicle number, drivers name and license number etc. Security issues.
Costea et al. [50]	Proposed architecture to monitor and collect real time traffic data to solve the problem of real time controlling and monitoring road vehicles to avoid traffic congestion.	Without any needful of a systematic human control the system has the capability to monitor a large number of locations. Low operating cost due to GPRS technology using.	Many sensors are required to sensed and collect outside environmental information
Lee, S [51]	The proposed scheme is for congestion detection and congestion avoidance in urban areas	Congestion detection and congestion avoidance in urban areas without the need for sensitive vehicle information, such as vehicle speed, vehicle location, and time.	Instead, a histogram model based on lightweight infrastructure is used to detect the degree of congestion in each lane.
Patni et al. [52]	A vehicle-to-vehicle (V2V)-based congestion detection system is proposed, in which traffic congestion is observed through the contribution of each vehicle.	VANETs collect real-time information of speed and position to improve signal on the intersection.	Its performance is not efficient for long-distance. Expensive due to RSU and infrastructure domain.
Susan Jan Pan et al. [53]	Presents a rerouting strategy named Distributed Vehicular Traffic Re-Routing System (DIVERT) is proposed. In the proposed system the vehicles exchanges their information over vehicular ad-hoc networks (VANETs).	It increases the user privacy substantially. The network and CPU load on server reduces through DIVERT system. This strategy protects the driver's location secrecy.	The proposed decision-making process may be inaccurate because the vehicle calculates the alternate route separately.
Djahel et al. [54]	A solution based on vehicle-to-infrastructure communication technology to reduce road traffic congestion in smart cities, where traffic lights at road intersections communicate the traffic light cycle to approaching vehicles.	The Belief-Desire-Intention architecture models the vehicle's reasoning and decision-making methods based on the local knowledge of the vehicle and the knowledge gained from surrounding vehicles and traffic light controllers (TLC) beacon via transmission.	Most actions are taken by the driver. The possibility of vehicles being selfish is in their actions.
El-Sayed et al. [55]	Proposed scheme to the congestion detection and congestion avoidance for urban areas without the requirements of vehicles sensitive information like the speed of the vehicle, location of vehicle and time. For congestion avoidance, the estimated shortest path first and re-routing strategy are used.	It forecasts the traffic congestion in advance and initiates the re-routing plan on time.	The scheme does not require the participation of vehicles. There is no real-time vehicles detection mechanism in the system. No participation of vehicles.

In [47], and STMS model presents to avoid traffic congestion for smart cities to amend real-time traffic details of traffic management. In the suggested strategy, vehicle detection sensors are embedded in the middle of the road every 500 to 1000 m. Through the Internet of Things suite, real-time vehicle traffic information is collected and sent to big data and analysis for processing to analyze traffic density and provide solutions through predictive analysis. A mobile application was developed for the user interface to check the traffic density in various places and provide another way to manage traffic. The disadvantage of this strategy is that it is only suitable for smart cities, and because the sensors are embedded in the road, it is expensive.

In [48], the authors proposed a context-aware approach to measuring real-time traffic status, traffic density and based on measured factors manage the traffic signals dynamically to control traffic congestion on road according to environmental conditions. The proposed architecture of vehicles congestion control and monitoring system is IOT based and consist of two models hardware and software module. The hardware module includes Bluetooth controller, sensors, and microcontroller and the software module includes android application, server, and data mining techniques, etc. By receiving application data from sensors and transmitting the received data to the server, two types of android applications are developed. The other is an android client application, through which you can learn about traffic-related events, such as traffic congestion, Traffic density, traffic condition, and weather condition display and report. It also includes web-based applications for data management and analysis and system administrators. The interface of the client application is easy to use during driving, but in this strategy, user intervention is more based on other strategies.

In [49], the authors proposed architecture to monitor and collect real-time traffic data to solve the problem of real-time controlling and monitoring road vehicles. The real-time data is generated and collected by sensory units. This proposes an intelligent traffic management system for traffic systems based on the Internet of Things. This architecture integrates the Internet of Things and agent technology. A large number of decentralized and highly distributed devices are participating in the Internet of Things. The interface and communication between devices are handled by proxy technology. Agents can work independently and can perform specific tasks with a certain degree of intelligence. The agent interacts with its environment without manual intervention. The agent observes the environment and takes action to achieve the goal. Network devices are connected, and agents can transmit between interactive devices to carry their collected data and execution status. The agent will be able to communicate with human users or agents. Each device has an agent, and each device supports the agent function. The controller of the entire system is an application written for the mobile agent, which defines how it should act and behave intelligently. Seven main IoT traffic agents are used in the system. Send or receive different types of information through traffic mobile agents.

In [50], the author planned a modern traffic monitoring system to optimize road flow to meet current and future road travel needs to avoid traffic congestion. It is suggested that the system improve the efficiency of the road traffic condition monitoring process by providing permanent knowledge of weather-related parameters in different regions. GPRS technology is used to monitor and collect the parameters. Driving speed and vibration are traffic parameters, and temperature and atmospheric pressure are weather parameters and are monitored. In this system, external environment information is collected by sensors, and the collected information is converted in electronic form and transmitted to the data collection module. The acquisition module analyzes the data collected by the sensor. Based on the driving speed and temperature and precipitation information, the logic processing block creates a message. The final high-level management unit message contains information about traffic conditions, weather conditions, and areas, and is transmitted to all onboard units (OBU). The vehicle is equipped with OBU, which can obtain updated information about the current area or destination area.

In [51], the author proposed a scheme for congestion detection and congestion avoidance in urban areas without requiring sensitive vehicle information (such as vehicle location, time, and speed). Instead, a histogram model based on lightweight infrastructure is used to detect the degree of congestion in each lane.

In [52], the author proposed a vehicle-to-vehicle (V2V)-based congestion detection system, in which traffic congestion is observed through the contribution of each vehicle. In the proposed scheme, the traffic is evaluated by using its speed and measuring its broadcast information to other people. However, the speed of the vehicle depends on the driving behavior of the vehicle driver and the vehicle model.

In [53], the author proposed a rerouting strategy called Distributed Vehicle Traffic Rerouting System (DIVERT), which aims to avoid traffic congestion. In the proposed system, vehicles exchange information collaboratively through a vehicle ad hoc network (VANET) to reroute decisions. DIVERT uses Internet and server settings to get global traffic opinions. It preserves user privacy in the form of balances. In the simulation analysis of DIVERT and centralized systems, DIVERT results improved by an average of 92%. However, as far as the average travel time of DIVERT is compared with the centralized system, the average time of DIVERT is a bit smaller than other systems, but it is better from the perspective of non-rerouting. By applying the DIVERT system, compared with other systems, the computational load on the CPU and the network load are reduced. To realize DIVERT, a hybrid architecture is proposed, as shown in Figure 6 in [53]. The architecture consists of two components, one is a central server, and the other is mobile-based software installed on a smartphone (vehicle device).

In [54] DIVERT, there are two kinds of communication. They are the communication between the vehicle and the server. The vehicle and the server communicate on the 3G/4G network technology to send local and global traffic density data. Vehicles that are closer together also communicate with each other through VANETs to estimate local traffic density, distribute traffic information received from the server, and implement a distributed diversion method, as shown in the red line in Figure 2.5 in [54]. In the DIVERT strategy, if the server predicts signs of congestion, the server updates the map information and sends it to the nearest vehicle for tracking.

In [55], the author suggested a solution based on V2I communication technology to decrease traffic congestion in smart cities, where traffic lights at road intersections communicate the traffic light cycle to approaching vehicles. In this approach, a priority-based mechanism is used for the management of V2V and V2I communications. Vehicles traveling on the road section receive the traffic light controller status periodically broadcast by the traffic light controller. Control the vehicle according to the state of the traffic light controller. According to vehicle traffic light cycle information, the vehicle coordinated to determine its speed limit and coordinated with neighbors to take other applicable actions, to undertake the task of the intersection with the least delay and the best efficiency. In this case, when the vehicle takes action, the vehicle should not be selfish. The driving method of the vehicle driver is that each vehicle must adjust its acceleration, lane change, and deceleration, and place other vehicles at the intersection to avoid the possibility of traffic jams. Vehicles receive information from traffic light controllers and exchange periodic beacons with each other. The transmitted beacons are periodically exchanged between vehicles at least 10 times per second. Table 3 shows a summary of existing congestion avoidance schemes available in the literature.

This article [56] describes the current survey Priority-based signals and urban traffic management solutions to reduce congestion and the average waiting time of the vehicle. This survey provides a classification of different traffic and management solutions used to avoid congestion. Existing urban traffic management plans consider prioritizing emergency vehicles and avoiding congestion to lay the basis for future research.

Table 3. Comparison of Traffic Congestion Control Models based on the proposed thematic taxonomy.

Study	Model Type	Technology(s)	Data Gathering Techniques	Road Infrastructure	Traffic Flow Model	Result Verification Approaches
[41]	Dynamic	Multi-metric traffic congestion detection and avoidance mechanism	vehicle congestion density function (VCD)	Urban local roads	Microscopic	Simulation
[42]	Static	REACT	Vehicle to vehicle and vehicle to infrastructure	Urban local roads	Microscopic	Simulation
[43]	Dynamic	Intelligent barricade system	Historical data	Urban local roads	Nil	Simulation
[45]	Static	Neural Network	Neural Network	Urban local roads	Nil	Real-world implementation
[46]	Static	WSN	WSN	Urban local roads	Microscopic	Simulation
[47]	Static	Inductive loop (Sensors Embedded)	IOT based data acquiring	Non-urban local road	Microscopic	Real-world implementation
[48]	Dynamic	Inductive loop (Sensors Embedded)	Piezoelectric sensors	Non- urban local road	Microscopic	Real-world implementation
[49]	Dynamic	RAFID +WSN +IOT+GPS	Piezoelectric sensors	Urban local road	Microscopic	Simulation
[50]	Static	GPRS	Piezoelectric sensors	Urban local road	Macroscopic	Simulation
[51]	Static	GSM/GPRS	GPS	Non-urban	Nill	Real-world implementation
[52]	Dynamic	VANETs	Probe vehicle	Urban road	Nill	Real-world implementation
[53]	Hybrid	VANETs /WLAN (Wi Fi, ZigBee)	Sensor equipped vehicles	Urban Roads	Microscopic	Simulation
[54]	Dynamic	V2I	Mobile/sensor equipped vehicles	Urban Roads	Microscopic	Simulation
[55]	Dynamic	VANETs	Non-intrusive	Urban roads	Microscopic	Simulation

5. Analysis of Traffic Congestion Control Models

This section provides an analysis using a parameter that includes: traveling time reduction, traffic congestion level, average waiting time, vehicle detection. In the above literature different methods for the vehicles data collection are used they are more costly and there are many issues are occurs in these schemes, like roadside equipment's (manual counts, vehicle video detection using cameras, inductive loop, passive infrared, pneumatic road tube counting, piezoelectric sensor, magnetic sensor, acoustic detector) are installed they are further connected with the base station to sense/detect vehicles and collect traffic data.

We proposed an MCS technology-based strategy for vehicle sensing and traffic data collection at a very low cost. In this scheme the motorist mobile phone or mobile sensor-equipped vehicle are used, through which the vehicles are sensed and directly vehicles related data like vehicles location, the average speed is collected without any further roadside equipment's installation and sends to clouds for further processing.

6. Open Issues and Research Challenges

The theme of this survey is related to traffic congestion control in the transport system, to study the existing traffic management models and find out flaws of the existing scheme lead to design such a model which controls traffic congestion occurrence. There are some issues observed in the literature study of traffic congestion control in the transport system are below.

6.1. Costly Techniques Used for Traffic Data Collection

The traffic data collection task is together with the traffic data during traffic sensing in ITS [37,38]. Various types of obstacles can occur during vehicle to vehicle data sharing and data aggregation [39]. The development becomes an intelligent transportation system (ITS) by providing high-quality traffic information in real-time to the intelligent transportation system. It has two types of techniques for traffic data gathering (a) Non-intrusive Techniques [40] (b) intrusive Techniques. The non-intrusive technique includes (a) manual count, (b) Passive and active infrared, (c) Passive Magnetic, (d) Automatic Count, and (e) video image detection. The intrusive technique includes (a) Pneumatic road tubes (b) Piezoelectric sensors (c) Magnetic loops.

6.2. Vehicle to Vehicles Communication in VANET

VANET is a sub-set of MANET [57,58], in which a set of smart vehicles is used on the road. Two types of communication occur in VANETs; vehicles to infrastructure and vehicle to neighbor vehicles communication. In-vehicle to neighbor vehicles communication, the vehicle related important data (vehicle id, current position, destination point, departs time, arrival time prediction value) shares with the neighbor vehicles which are the most important issue [59], because the vehicles data is actually about the motorist and the neighbor vehicle can easily identify the vehicle id, current position, destination point, departs time, arrival time prediction value of other neighbor vehicle and they are the information about the neighbor motorist.

6.3. Data Collection Sensors Battery Life Timing/Energy Consumption

Various existing models become costly due to magnetic devices attached to the vehicles and roadside equipped equipment's/sensors for vehicular traffic data gathering. It consumes a lot of sensor's energy because they sense the areas continuously to collect vehicular data according to traffic parameters.

6.4. Cluster-Based Routing Protocol Issue in VANET

In a cluster-based routing protocol system, various vehicles having the same attribute direction, speed, etc. are grouped to form a cluster in the network. Cluster heads are required to manage each node in the cluster and communicate with other clusters. In the same cluster, packets are sent directly by the path, but if the target node is outside the cluster, the cluster head creates a virtual network infrastructure, which leads to high dynamic network latency and increased network overhead [60].

6.5. Needs More Motorist Intervention

In the literature mostly models are needs more motorist intervention that causes accident occurrence.

7. Conclusions

In this survey paper, a detailed review of the current UTMS is presented. The core challenges related to congestion control, traffic data collection, average waiting time shortening, and intelligent transportation system design requirements are discussed, providing a perspective for UTMS objectives. A traffic management model using MCS is suggested and discussed in Section 2.3 briefly, to avoid traffic congestion occurrences. The major contributions are; to provide a detailed review and suggested MCS based dynamic traffic management model [61] collect vehicular data easily and cheaply through MCS technology using motorist smartphones or GPS embedded vehicles and there is no need for a vehicle to vehicle communication for the exchange of vehicular data with each other. Applying the MCS-based traffic management model solves the traffic congestion problem and saves the extra fuel consumption and motorist time during traveling to the destination at a very low cost by using of motorist smartphone or vehicle embedded GPS sensor. The motorist intervention is very less under this strategy.

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