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Internet of Things Enabled Vehicular and Ad Hoc Networks for Smart City Traffic Monitoring and Controlling: A Review

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ABSTRACT

Traffic Congestion is becoming a huge issue in the cities of both developing and developed countries. One prominent solution is to solve this issue in terms of smart cities. In smart cities, all end points including people, houses, buildings, and vehicles are connected to each other through some networking technology. The most considered technologies include Internet of Things (IOT) and adhoc networks. The smart city project can also be applied through the combination of IOT and adhoc network. The literature studies show that a very rare work is done on the combination of traffic congestion, IOT and adhoc networks in terms of smart cities. This paper presents an overview of this technology which will help the readers to consider these technologies related to the smart city-based traffic management.

Keywords – **IOT, Traffic congestion, smart city, adhoc networks, review.**

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I. INTRODUCTION

Nowadays, with the increase in the population of human beings, the vehicles in the cities also seems increasing. This increase in a number of vehicles is often causing the congestions on the roads. Fig 1 depicts an example of road traffic congestion. Car collision avoidance, more secure streets, blockage management is a portion of the objectives of smart cities road traffic management. The development of an effective framework to oversee cautioning messages in smart cities roads-based networks has critical advantages, from the point of view of both street administrators and drivers. Proficient movement alarms about activity episodes will diminish car influxes, enhance street security and enhance the driving.

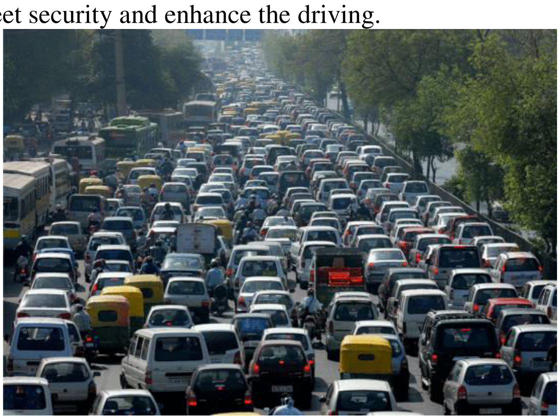

Fig. 1. Example of a traffic congestion [1]

Intelligent Transportation Systems (ITS) depict a productive method to enhance the execution of the stream of automobiles in the streets. The objectives of ITLs are street wellbeing, happy with driving and conveyance of refreshed data about the streets. Numerous recommendations about ITS have been exhibited lately. One of the important aspect of ITS is vehicles traffic monitoring and controlling [2]. This area corresponds to different tasks including Autonomous Driving Management, pedestrians and vehicles safety, and traffic management (Fig.2).

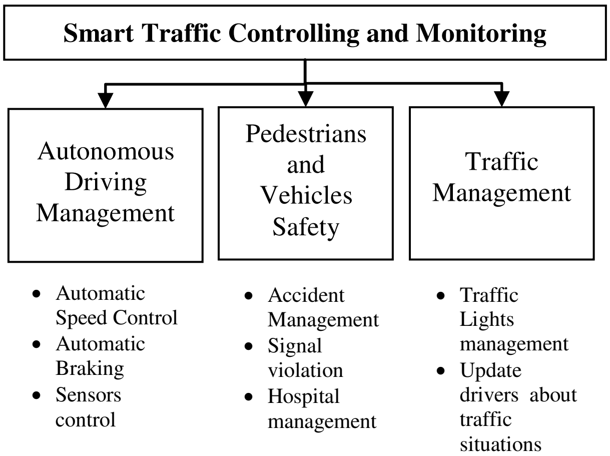

Fig. 2. Smart Traffic Controlling and Monitoring [2]

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IOTs have ability to join various networks with the help of various devices for communications to enhance the managements. Designing a general engineering for the IoT is thus an exceptionally mind-boggling task. Vehicular adhoc networks are self-organizing structures that transfer information from the vehicle to vehicle or from vehicle to access points. The networking is performed by using various devices. The track of such devices is also found in IoT and smart cities machineries.
The main aim of this manuscript is to study traffic congestion in smart cities by using IOT and adhoc networks. It is observed from the available literature that a very rare work is done on the combination traffic congestion, IOT and adhoc networks in terms of smart cities. But the existing works and studying on these technologies reveal that the devices used for communication are overlapping in these technologies. By studying this work, the readers will have the idea of combining these technologies as a whole or in parts.

The manuscript is presented as under: The introduction is represented in section I. Sections II, III and IV represent the introduction to smart cities, IOT, and adhoc networks respectively. In these sections, the key issues, the technological devices, and combination with other technologies is discussed. Section V depicts how to interface ad hoc networks to IoTs. Section VI represents some recent works on IOT, smart cities and adhoc networks are presented in terms of intelligent transport systems to avoid traffic congestions. Section VI depicts the conclusion which is preceded by references.

II. SMART CITY OVERVIEW

A "smart City" offers progressed and enhanced living style to the people. A Smart City [3] represents a business-oriented and appealing environment for the people. In urban settings, people are benefited with different amenities, like PC, tablet, cell phones, Global Positioning Systems (GPS) and sensors. The Smart City estimates are evaluated at many billion dollars by 2020 [4]. This market covers various areas including Smart management, Smart movements, Smart surveillance, smart transportation, smart homes, smart industry, and Smart Situation handlings (Fig. 3).

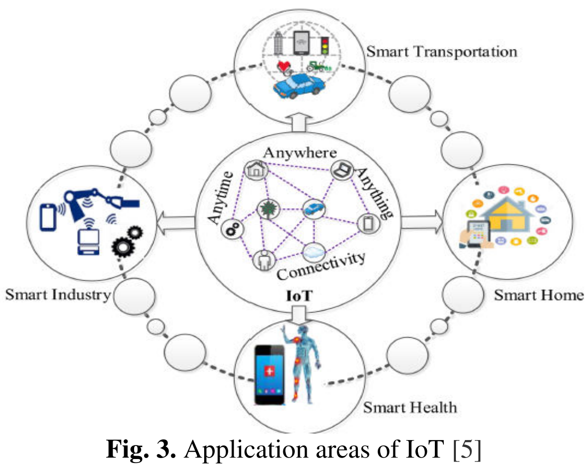

Fig. 3. Application areas of IoT [5]

Regardless, the Smart City has not taken of yet the imagination for specialized and money related boundaries [6].

2.1. Key Issues

The key issues of implementing the smart city include:

2.1.1. Political Intervention

Under the political measurement, the essential hindrance is the privacy and decision powers of the distinctive partners [7].

2.1.2. Compatibility of heterogeneous innovations

The most pertinent issue comprises in the non-compatibility of the heterogeneous devices. In this regard, the IoT opens doors for progressive research to look at this problem [8].

2.1.3. Monetary Issues

Concerning the financial issues, there is a need of a suitable planning.
The advantages of smart cities concepts are more as compared to the key implementation issues. Some advantages include [9] resource saving, efficient traffic handling, improved system scalability, and effective city management and planning. Fig. 4 represent an example of smart cities where the end points (People, vehicles and other things) are connected to each other over the internet.

2.2. Traffic handling schemes in smart cities

The main information of ITS includes every one of the components of the vehicle framework, i.e., vehicles, streets, and individuals. The vehicle data essentially relates to the checking and view of vehicle working conditions, including the development condition of the vehicle and its different status characteristics [10]. The data transmission relies upon the corresponding mediums of ITS. It can be separated into wired and wireless systems. Remote transportation of information incorporates FM radio, satellite and cell phones. For wired transportation of data, Optical fiber correspondence has been broadly utilized. The network systems of wired communication also include WAN and LAN technologies. Satellite-based data transportation is broadly utilized in the powerful area-based monitoring of vehicles and routing. The most well-known cellular systems incorporate GSM, GPRS, and 3G. They have been demonstrated powerful and broadly utilized in ITS related applications. In ITS, Wi-Fi is predominantly utilized for vehicle sensor systems (VSN), and Wi-Fi passageways are frequently utilized at the roadside and may accumulate vehicle information by RFID. Many of these mentioned technologies are also used in adhoc networks. Therefore, adhoc networks can play an important role in implementing traffic monitoring in smart cities.

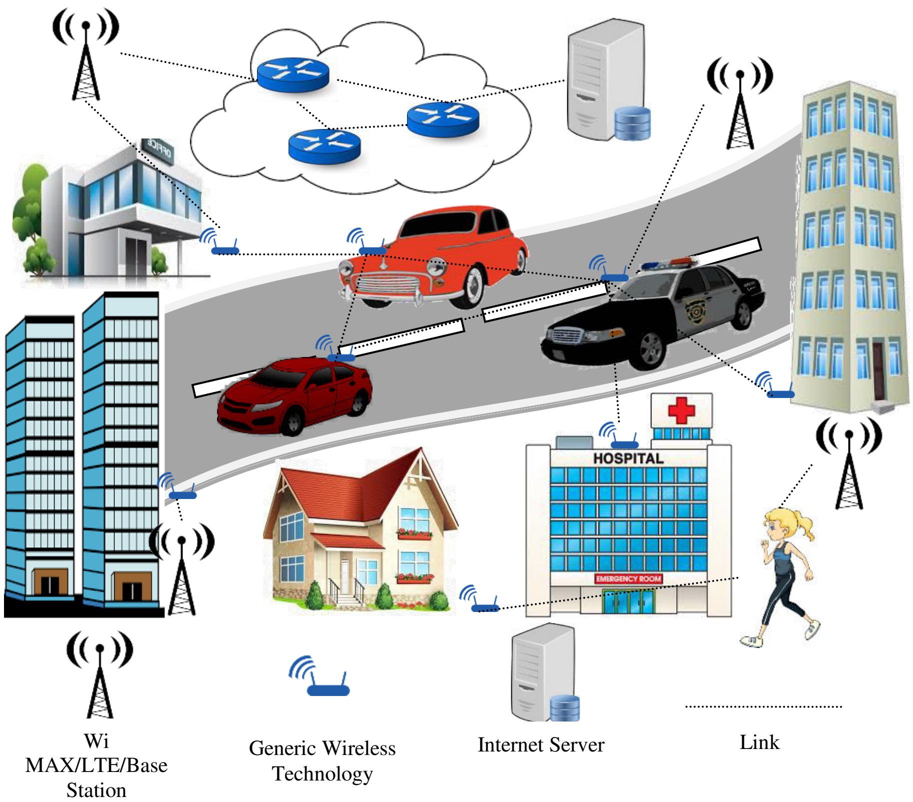

Fig. 4. Example of a Smart City (produced from [11])

III. IOT

The IoT[12, 13] would enable clients to oversee and enhance various devices utilizing the web [14]. A sensor does this procedure to a more prominent degree. They fill in as n connection between the clients and the devices. Sensors gather crude information from ongoing situations and translate them into machine reasonable organization with the goal that it would be effectively exchanged between different "Things". The devices used for deployment of IOT include but not limited to RFID [15], IEEE 802.11 [16], Barcode/QR Code [17], Zigbee IEEE 802.15.4 [18] and Bluetooth [19].

3.1. Problems in implementing IOTs

Some problem areas in implementing IOT technology include [20]:

Scalability: With the adaption of IOT technology, billions of devices will be on the internet. Handling such a huge amount will be a real issue [21].

Engineering Issues*:* It is important to have a satisfactory design that grants simple availability, control, correspondences, and valuable applications [22].

Big Data: *T*here exists a tremendous measure of crude information being constantly gathered [23]. It will be important to create procedures that transform this crude information into usable learning.

Compatibility: There should be some criteria to handle heterogenous devices which will communicate with each other [24].

Security: A security attacks are a big issues [25]. There is a need to develop rules to handle such issues. Security issue are required to address and design carefully in the traffic/vehicular system for communication [26]. Many threats exist such as fake communications initiating traffic disruption or danger that compromising the drivers' secretive information, etc. [27]. Anonymity might preserve communication in which the vehicle identification/tracking for the parties that are non-trusted. At early stage, lack of privacy rules is considered which might outcome in different law that are suitable after deploying the network. In networking field, each vehicle (node) contains permanent unique MAC, so it might be probable to trace a car with it's the driver. For this purpose IEEE 802.11p presents MAC that is assigned dynamically with a duplicate discovery of MAC address [28].

The major goal of IOT is to design an intelligent system on the basis of results that are collected after the analysis of data from the framework. Commonly, messages are controlled that are sent from an edge or cloud to actuators/end devices to regulate physical globe. Therefore, design of the IOT security is required to compartmentalize the cooperated framework. To attain this, we still need to investigate models of the granularity control and the procedures that restrict proliferate of the security breaches [29].

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IV. ADHOC NETWORKS

Ad Hoc Networks [30-32] are self-management networks and divided into various categories. Some categories include [33] (Fig. 5):

1. Mobile Ad Hoc Networks (MANETs)
2. Vehicular Ad Hoc Networks (VANETs)
3. Wireless Sensor Networks (WSNs)
4. Radio Frequency Identification (RFID)

The challenges and issues of different types of adhoc network are elaborated in Table1. A brief overview of these categories and their connection strategies with IoT is discussed as below.

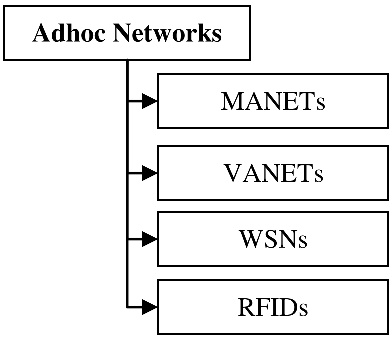

Fig. 5. Adhoc networks types [33]

Table1: Challenges and issues in Adhoc networks

Author	Adhoc Networks	Challenges/Issues
[34, 35]	MANETs	Simulation of MANET routing is a more challenging task. It takes long time to achieve appropriate confidence level.
[36, 37]	VANETs	In this network, selected succeeding hop is a more critical, when V2V communication is performed. In this process routing in the multihop is only option to deliver packet data into the required destination. The problem of routing is more challenging. Distribution of inventive information and data sharing is also a more challenging task.
[38, 39]	WSNs	The shape of the Field of Interest (FOI) plays a vital role in the selection of suitable nodes for the solution of connectivity and coverage problems. To avoid the effects of border sensor nodes in 2D-WSNs., homogeneous nodes, infinite boundary of the Field of Interest (FOI) are deployed.
[40, 41]	RFID	RFID are used successfully in many fields but still require development in active schemes such as Inkjet-printing on the basis of RFID, collision in the readings of RFID and integration.

4.1. MANETs

MANETs are self-sorted out systems which are used without the requirement for any settled foundation [42, 43]. Having considered them to be another worldview of portable remote networks, MANETs have pulled in a great deal of consideration amid the ongoing years. In MANETs, each end point is known as a hub which works autonomously as a switch. With regards to IoT, MANETs could communicate to situations, for example, individuals utilizing cell phones, communication in war situations and vehicle to vehicle communications [44]. MANETs are considered as self-arranging, self-keeping up, self-mending, and self-repairing systems. Fig. 6 represents an example of V2V communication in MANETs

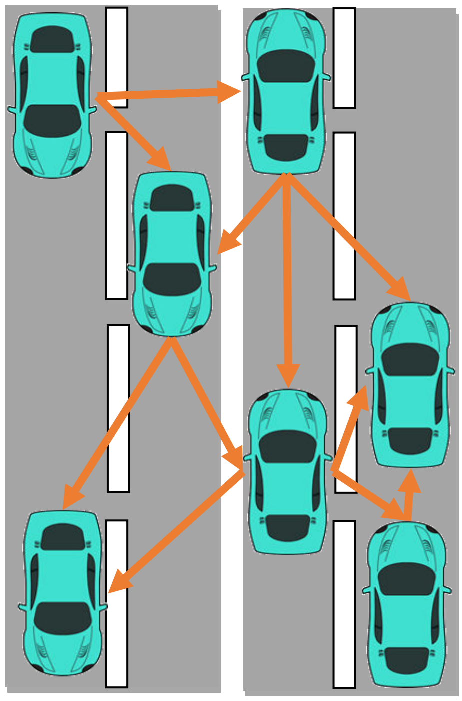

Fig. 6. V2V communication in MANETs [42]

4.2. VANETs

Vehicular Ad Hoc Networks can be noticed as a type of MANETs [45]. It is evident that both VANETs and MANETs share comparable highlights, VANETs arise because of increased wireless communications in vehicles. At present Bluetooth transceivers, Wi-Fi and Zigbee are installed mostly in vehicles for vehicle communications. Fig. 7 shows an example of V2V VANET.

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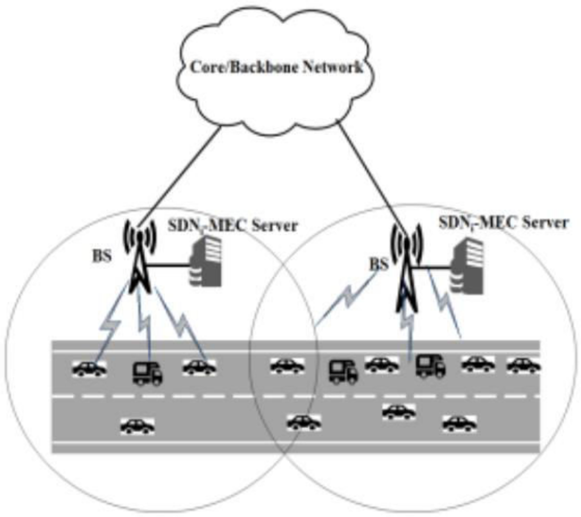

Fig. 7. An example of V2V VANETs [46]

Recently the IEEE 1609 family in Vehicular Networks (WAVE) [47] for Wireless Access became popular and reliable for both V2V and V2I communications. VANETs helps divers to improve their decision making. Wired Network is the backbone for providing data services in VANETs. However, the challenging task is the deployment of Access Points (APs) because of its dependency on parameters like density and traffic conditions. The prominent application areas of VANETs include [48] Navigation, Vehicle monitoring, social networking, and emergency handling

4.3. WSNs

Sensor systems are typically concentrated systems where there is a focal hub accountable for get-together detected information from sensor hubs [49]. The focal hub is known as the sink of interchanges. In general, nodes are static in WSNs [50, 51], so topological changes are due to bad performances of nodes mostly, i.e. low battery problems or medium access problems. Consequently, most of the routing and MAC protocols for WSNs are considered on decreasing the node's power usage to avoid frequent battery replacements. The application areas include Military, Environmental, Healthcare, and Home applications [52].

4.4. RFID

Another promising innovation for supporting Ad hoc networks is RFID [53]. It empowers low-information correspondences between a basic gadget alleged a tag and a tag reader which is ordinarily associated with a PC framework. RFID interchanges have been utilized to recognize and track objects remotely. Two sorts of tags can be employed, 1) inactive tags which don't depend on any vitality source and 2) dynamic tags which contain a vitality source like a battery. The advantage of passive tags is that they do not require any power supply that's why they are cheaper than active tags. The storage capability of a tag is limited by a few kilobytes of data.

V. INTERFACING AD HOC NETWORKS TO IOT

5.1. Interfacing MANETs to IoT

A few methodologies have been presented to interface MANETs systems to the Internet [5, 12, 33]. The hubs in MANETs use IP addresses for directing purposes, such IPs might be utilized to move information over the Internet. In any case, the principle issue of this methodology is that a hub needs a productive method to check whether a specific IP in the MANET is available or not. On a fundamental level, hubs don't know about their specific situations, so it is hard to gather neighboring hubs IPs. One methodology is to utilize two unique IPs, one to impart through the Internet and another to recognize hubs in the MANET. In such a case, hubs can move openly so the objective passage could be variable. If a hub changes to another entryway, another IP address ought to be utilized and the active associations will most likely break. Then again, the expanding utilization of shrewd cell phones empowers hubs to associate with the Internet through cellular devices, for example, 3G and 4G advances. What's more, satellite correspondence can likewise be utilized in safety related applications like military applications and traffic congestions.

5.2. Interfacing VANETs to IoT

Interfacing VANETs to IoT [54-59] is like the methods that are utilized in MANETs. Therefore, the vehicular systems are typically associated with the Internet by methods for APs utilizing a Wireless Local Area Networks (WLAN), for example, WiFi, WiMAx or Bluetooth.

5.3. Interfacing WSNs to IoT

To interface basic gadgets of WSNs [60-65] with the internet of things [66-71] three models can be characterized: 1) the IP overlay over WSN [72], 2) the sensor overlay over IP [73], and 3) the more elevated amount entryway overlays [74]. At the point when IP overlay over WSN, sensor hubs ought to be tended to with IPs as similar hubs associated with Web. In the second model, information is typified in IP data. The portal interprets directing data of Web into WSN steering components.

5.4. Interfacing RFIDs to IoT

The RFID Tags can easily be associated with the IoT [60, 75-79]. RFID readers gather data from Tags and redirect data to the Internet. The RFID readers are used as interpreters of RFID data to internet-based data.

VI. LITERATURE STUDY ON INTELLIGENT TRAFFIC SYSTEMS USING AD HOC NETWORKS OR IOTS FOR SMART CITIES

The above study reflects the introduction of IOT, adhoc networks and smart cities and techniques to interconnect them. The combined work on all these technologies at a time in traffic congestion scenario is very rarely found.

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However, the literature works regarding the combination of two or more technologies are presented in this section. This will help the readers to have future directions to work in the area of traffic congestion related to the above-mentioned technologies all at a time or a part of them.

The work in [1] use GPS and a guiding data of the city having the correct location of the ITLs. This helps the vehicles to find the closest ITL. Every vehicle sends a request message after some interval to get the correct area of each vehicle. This enables to understand the traffic density. The work in [80] depicts the concept of a social network of vehicles by clustering the vehicles on characteristics basis.

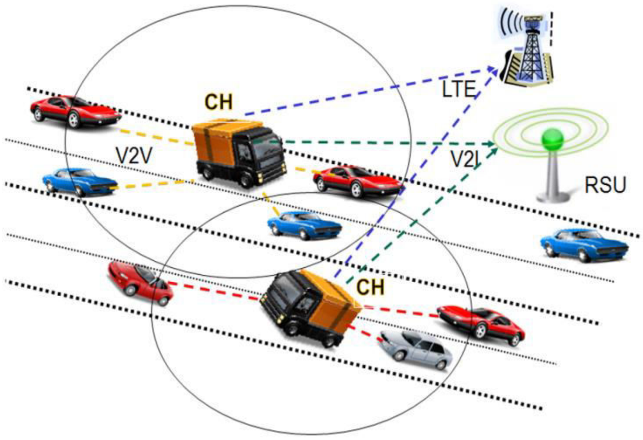

Fig 8. Clustering of vehicles in adhoc networks [80]

It can fundamentally diminish bundle delays and give better range usage in time and space [81]. By making little gatherings of hubs that offer normal attributes, the system gives off an impression of being littler and steadier (see fig. 8). The work recognizes the key factors that influence the conveyance of caution messages between vehicles. Barba et al, propose a smart city where Intelligent lighting system (ITLs) is employed in the intersections of a city. These ITLs are responsible for social affair movement data from neighboring vehicles, refreshing activity insights revealing those measurements to the automobiles. Additionally, ITLs will send cautioning messages to vehicles if there should be an occurrence of mishaps or congestions. FIG. 9. depicts an example of this system. Amid the most recent years, ITS have risen as a productive method to enhance the execution of the stream of automobiles in the streets. The objectives of ITLs are street wellbeing, happy with driving and conveyance of refreshed data about the streets. Numerous recommendations about ITS have been exhibited lately. In this area, a few works about ITS in brilliant urban communities are featured.

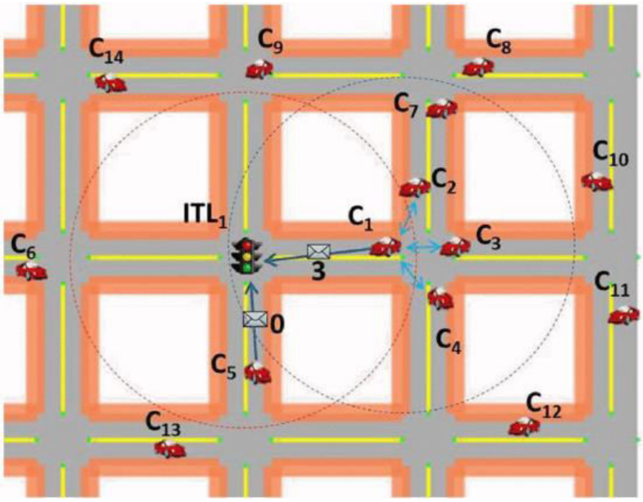

FIG. 9. Visualization of ITL based system on road intersections [82]

The approach in [83] is a review about various functions based information driven transportation frameworks which are upheld by a lot of information acquired from different devices.

In [84] and [85] two versatile activity light frameworks dependent on remote among vehicles and settled controller hubs sent at crossing points are planned and created. These frameworks enhance activity familiarity, lessen the holding up time of vehicles at crossing points and help to maintain a strategic distance from impacts.

In [86], a vehicular cloud (Fig. 10) is made for coordinated efforts among the cloud individuals to create progressed vehicular administrations that individual alone can't make. Not at all like the Internet cloud that is made and kept up by a cloud supplier, the vehicular cloud is briefly made by associating assets accessible in the vehicles and Road Side Units (RSUs). Such arranged assets work as a typical virtual stage on which the productivity of joint effort is augmented.

In [56] the specialists propose a model dependent on VANET and IoT for the self-ruling traffic accidents administration framework. they build up a structure that incorporates all the usefulness of mishap administration, including identification, post-mischance activity administration, crisis vehicle control etc. This methodology lessens the deferral in giving restorative support of the mischance unfortunate casualty and builds the possibility of sparing their lives. In this proposes a model dependent on VANET and IoT for the self-governing mischance administration framework. The researchers build up a system that incorporates all the usefulness of accident administration, including identification, post-mishap activity administration, crisis vehicle control etc.

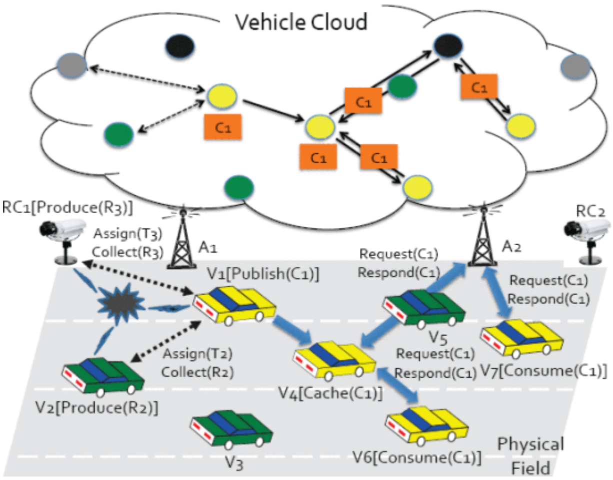

FIG. 10. a vehicular cloud [86]

Amnesh et al. represent a methodology for organizing traffic light with the assistance of remote sensors [87]. Minghe et al. represent a RFID and IoT based information framework for movement checking [88]. George et al. give an approach to dispersal the neighborhood mischance cautioning informing to keep away from auxiliary mishaps [89].

VII. CONCLUSION

This manuscript highlights the different technologies that can help in managing traffic management in smart cities. The core considered technologies include IOT and adhoc networks. An overview on these technologies is presented with the issues and the devices used for communication. It is observed that various devices in IOT and in adhoc networks can be used combinedly to make a hybrid network for traffic congestion management systems in smart cities. In addition, a brief survey of some intelligent transportation approaches is also presented.

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