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Traffic Management for Cloud Based IoV Environment with MEC, Fog and Cloud Servers – A Survey

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Abstract: Mobile Edge Computing (MEC) technology plays a huge role in the Internet of Vehicles (IoV). However, sometimes it is not able to perform the required tasks with simultaneous active vehicle users, due to the limited resources of the MEC server. Fog and MEC can be an edge-computing model that scales the cloud and its services to the edge of the network. This led to the introduction of new methods and evolved concepts, which means that supported publication methods must be researched.IoV is used to perform compute-intensive and delay-sensitive tasks. In order to reduce latency and power consumption as much as possible, applications are turned off from a cellular device to a remote cloud or a nearby mobile edge cloud for processing. To solve the problems of storage and the large amount of data generated by the IoV environment, on-premises solutions and cloud computing will not be sufficient need, due to the disadvantages of resources and connection density. By distributing computing and storage media at the edge of a wireless point, for example, wireless nodes, edge information system (EIS), as well as modern computing and artificial intelligence, will be a key driver for the development of the actual IoV environment. The proposed model aims to acquire, collect and process local data as well as provide low latency information and algorithmic services. This paper presents the latest developments in EIS for the IoV environment. Strategies and platform issues for such systems are also covered. Notably, typical applications for smart vehicles are discussed. In addition, in this paper, we present a comprehensive survey of fog computing, and discuss how fog computing can meet the growing needs of applications with requirements for privacy, latency, and bandwidth. This study attempts to make a preliminary assessment of several variables of some proposed solutions and certain current guidelines for mobile edge computing and fog computing to choose the suitable adopted model for IoV networks.

Keywords*- Internet of Vehicles (IoV), Mobile Edge Computing (MEC), Decentralized Environmental Notification Message (DENM), Collaborative Awareness Message (CAM), Edge Information System (EIS), Vehicular Ad-hoc Networks (VANET).*

Introduction

The significant development of some cutting-edge technologies such as Big Data and the Internet of Things has made travel services issues more challenging. It is expected that the number of vehicle users of most common models will reach 5 billion by 2050, according to statistics [1]. This is why new technologies have emerged such as: Internet of Vehicles (IoV) which enables the process of many smart applications, providing safe and efficient driving for vehicles [2].

Lower service prices and the opportunity for development and provisioning services are making the cloud widely used and more popular. This is because most cloud employees specialize in both hardware and software technologies, which can eliminate maintenance on the infrastructure. Cloud environments are also exploited in facilities operating on critical infrastructures. This evolving path of Internet of thing (IoT) deployments requires new resources that current cloud setups cannot fully cover. These resources include, for example: support for mobility, geographic distribution, and lower transportation costs [3, 4].

The limited resource of IoV environment is due to the modification of mobile vehicle resources and the mobile computing environment. The use of distributed features for edge mobile computing users can effectively exploit low-power services and reduce the overall device prices. The proposed IoV peripheral computing system solves the problems of many systems. For such an environment, many types of messages can be exchanged, such as collaborative awareness

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messages (CAMs) and decentralized environmental notification messages (DENMs). CAM is a class of periodic messages that are continuously sent by a vehicle to another vehicle or road unit in its vicinity to obtain location, speed, and other essential information [5, 6]. As for DENMs, they are event-driven messages that alert road users and notify them of a particular danger. CAM messages are delivered in the immediate vicinity (single hop) and, in contrast, DENM messages can be delivered in the affected area supporting multiple hops [7].

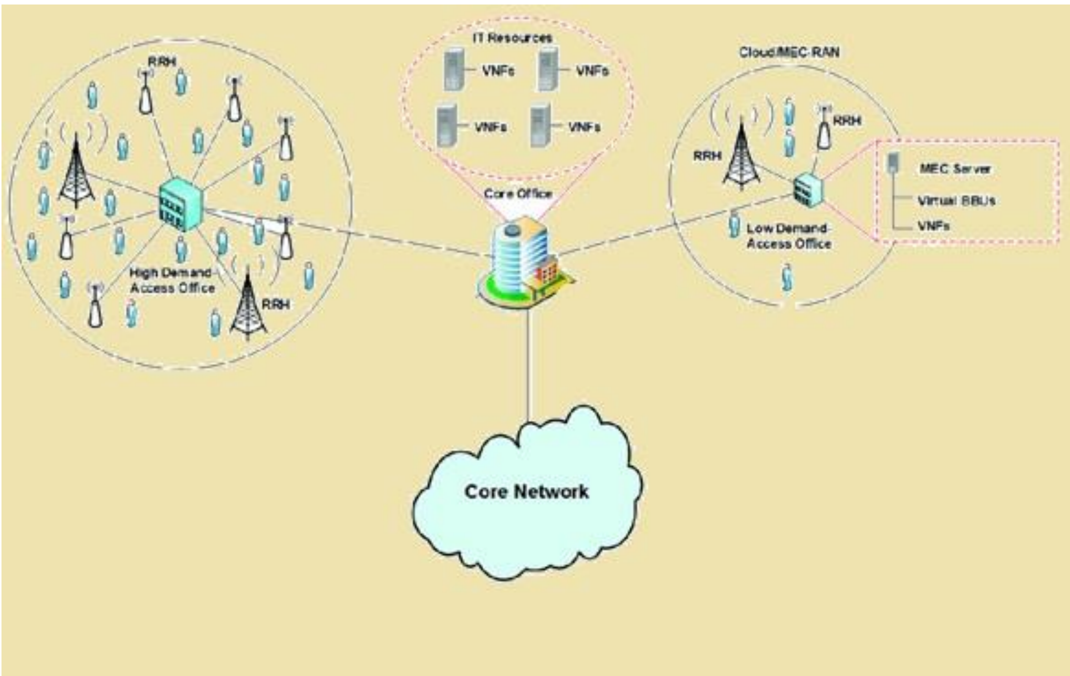
The remainder of this paper is organized as follows: Section 2 provides an overview of the Mobile Computing in IoV. Section 3 gives some research challenges about this topic. Section 4 describes the benefit of MEC and Fog integrated IoV. Section 5 presents some Message Dissemination Facilities (CAM/DENM). Section 6 reports some analysis and discussion with an exhaustive comparison and evaluations of some related works. Finally, Section 7 summarizes the main conclusions of this study and proposes some perspectives.

II. Mobile Computing in IoV

IoV is a new paradigm in vehicle and network communications. Reliable communication links can be reached in vehicles, by the vehicle-to-vehicle relationship, by vehicle-to-infrastructure communications, and in vehicles and infrastructures. Vehicles are increasing in capacity very effectively, and will have the ability to support a large number of modern services. Which will integrate fully autonomous vehicles, the environment, and the Internet of Things. These strategies will lead to the smart IoV era. The Internet of Things will have a promising future with intelligent IoV by deploying computing resources at the edge of a wireless network, for example, wireless access points, EIS, including edge AI, edge computing, and edge caching. This system will provide local data acquisition and processing, as well as short-time content delivery and account services. To solve the problem of centralized data processing in cloud computing, MEC has been proposed by dispensing with the loading of computing functions to edge computing servers [8, 9].

Cloud (MEC, fog computing, etc.) has been launched to improve the quality of service (QoS) of various network structures such as IoV and other real-time (RT) systems. This technology gains higher bandwidth for communications and provides Ultra-Low Latency (ULL) for real-time services. A certain number of software programs require computing resources to remotely access a Mobile Cloud Computing (MCC) server. Cloud-native privacy protection must also be considered for data integrity and communications integrity. The caching approach is used by MEC servers synchronizing with MCC servers, as shown in Figure 1, frequently requested data or frequently used applications are designated for caching belonging to MEC servers [10, 11].

Figure 1: Typical communication requirements based on MEC server.



Great efforts have been made to improve vehicle safety and efficiency. For example, considering communication technologies as the cause of a huge boom in the vehicular system. Vehicle Ad-hoc Networks (VANET) Series Vehicle Ad-hoc Networks (VANET) represents an early competency to support safety-related software, such as collision alert and cooperative cruise management. By using VANET, the network of nearby vehicles can communicate with each other via vehicle-to-vehicle communication (V2V), which helps increase driving security [12, 13].

Increasing traditional mobile services and providing new applications are the most important goals of VANET, in particular, mobile crowd sensing, IoT, vehicle communication and other common requirements need important computing resources, higher bandwidth rates and lower delays when accessing Services. MEC is one of the key technologies for new generation networks [14].

The researchers introduced the latest digital technology in association to edge and fog. It is called the extended cloud, which provides computing needs close to the data content, raising the provided quality of services. Another benefit is also noticed which is to improve the delay in data transmission between endpoints and the cloud. These systems power new services, such as Google Now and Foursquare, for mobile platforms and other applications to manage traffic control of self-driving vehicles, public safety, etc [15, 16].

III. Research challenges

In this section, we focus on the challenges by introducing some strict requirements for the usage of edge computing in vehicle environments.

- Vehicles will continuously transmit their sensor data to the nearest area (edge). To achieve the desired goal, power consumption must be taken into account to avoid loss of quality or interruption of service.
- In cloud computing, the user programs the code and deploys it to the cloud, where the cloud server determines where the computing process takes place.
- Transmission of network edges in the local environment depends on both static factors and dynamic components. Terminal packets can be sent by static RSUs or unmanned aerial vehicles (UAVs) with dynamic MEC servers.
- A mobile edge computing architecture located in close proximity to the end device may have a high infrastructure cost as it will need more installation infrastructure points to cover a given geographic area.
- The mobile terminal computing architecture does not allow traffic density assistance; The amount of latency increases exponentially once the pressure on the limited computing architecture is lifted.
- The cloud computing architecture may be located far from the end device and may need more response time.

Various ITS (intelligent transportation system) programs require vehicle drivers to access some potential local information for untrusted vehicles trying to communicate as a kind of edge. Security management systems with information deactivation mechanisms can bring security to the edge. The researchers presented a test to ensure secure collaboration in an evolving computing environment, securing a working prototype, which does not concern itself with the challenges of vehicular networks [17].

IV. MEC and Fog integrated IoV solutions

An extended computing paradigm has emerged, which is fuzzy computing (FC), which is taken from cloud computing. Fog is a cloud close to users, which drives application services and resources to process and generate data. It is necessary to balance service latency and quality loss, because the distribution of tasks between standing and moving fog packets is a dilemma in multi-purpose development. An event-driven dynamic task allocation model based on Linear Programming Dependent Development (LPDD) and Binary Particle Package Development (BPPD) has been introduced to solve various development issues. An offload model of time-to-time traffic control in IoV devices, discussed in the source, through fuzzy computing, reduces the average response time to output vehicle reports. Although fog computing has short response times and location, the overall connectivity and the very short access time requirements are a hindrance to real-time traffic management [18, 19].

MEC is a development of cloud computing that reduces delay and bandwidth requirements for transmission. MEC features less delay and is energy efficient, as data generation and processing takes place close to users and data sources. MEC also features advanced devices with large computational capabilities, such as vehicles and WiFi hotspots. In addition to the limited resources that characterize MEC, the computing power of intermediate packages is less than that of cloud servers [20].

Fog Computing is an extension of the cloud, as defined by Cisco. Fog computing is a virtualization platform that provides computing and communication services between end devices and traditional cloud computing data centers. This computing is set up in execution phases where content is stored near peripherals; Hardware is physically rated; You also need short access time services. In short, the Internet of Things consists of sensors that direct content into fog packets. Sensors can take in parts of the Internet of Things at the required time, can execute programs to perform operations on stored content, and provide small-field packets for data. Fog packets can also direct stored data to the cloud at predetermined times. As for the cloud, it holds the content from the fuzzy packets and processes them for decision-making needs. The cloud also allows up-to-date instructions for fog packets to be routed through data sort outputs to meet desired application needs [21, 22].

In fact figure 2 illustrates the MEC structure for an IoV environment.

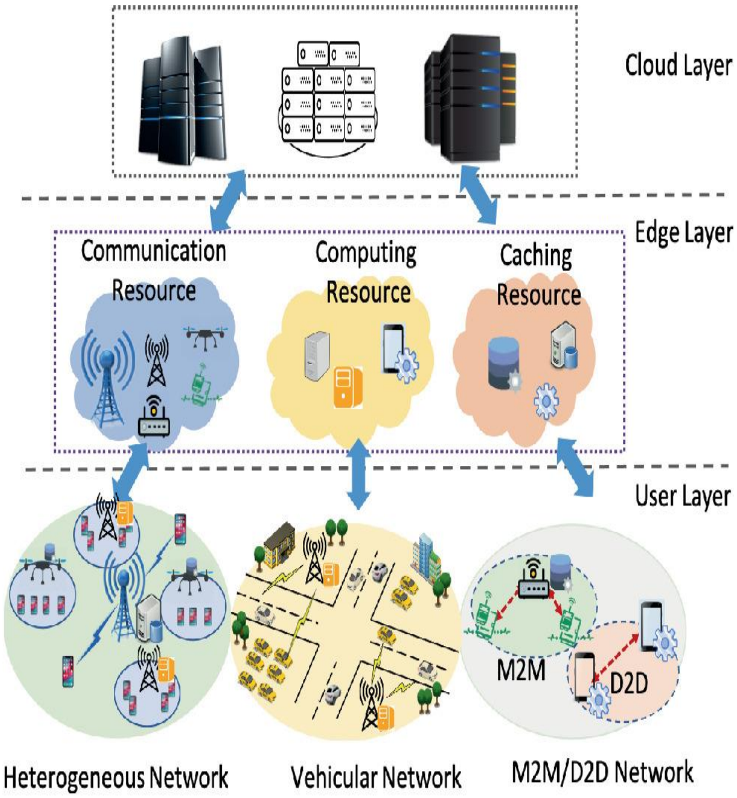


Figure 2: MEC structure of IoV.

In Figure 2 the vehicle edge storage architecture is categorized into cloud layer, mobile user layer and MEC (edge) layer. Communication for mobile users results in an unlimited number of packages.

IV.I. MEC and FOG solutions models

Digital computing through MEC is usually accessed by a large packet of mobile devices with smaller duration and greater efficiency in mobile networks. MEC is also used in function and delay sensitive applications over the mobile network [23]. Exploiting software-defined networking (SDN) and network function virtualization (NFV) capabilities are also envisaged, as well as newer generation technologies. SDN can easily control virtualized networking devices through APIs, and NFV shortens network resource allocation times using virtualization. SDN and NFV allow network developers and enterprise application programmers to update and evolve their formatter, which aims to orchestrate the delivery of media across a set of levels [24, 25]. Some suggested models are detailed in literature as MEC's MEC Model Infrastructure Layers, in [26]. Authors suppose that the architectural classes integrate cloud compute resources and network elements outside of MEC. They consider that MEC servers are installed at the MAC level in a Wireless Access Network (RAN). they focus on the account and discharge stage, to maintain the continuity of the service in the communication environment.

Another model called Open-Fog system which depends on fog in the transport model (traffic control and modern cars is proposed in [27].

V. Message Dissemination Facilities (CAM/DENM)

CAM and DENM applications are a range of specific products and restricted reference communication packages. Therefore, its use in real services is an issue that has not been well discussed in previous research. In this study, reference communication packages that follow the instructions of the Intelligent Transport Systems (ITS) contact model are used as a key reference in optimizing an initial application model for both CAM and DEMN resources.

V.I. CAM messages

Most vehicles and many road infrastructure systems in VANET send CAMs. CAMs contain data about the source such as the vehicle's location, type, position, and speed. Every vehicle is supposed to send a CAM periodically. Where the message receiver translates it into what is called a local dynamic map (LDM). LDM is a database in the same area that is stored in most vehicles and also supports different applications. The efficiency of local awareness is related to the amount of CAMs sent by traffic participants [28].

The CAM model is routed by an ITS-S MR, routed by a Roadside ITS-S AR, and eventually picked up by the ITS Central Station Software Provider (ITS-S AS), where the ITS resources are saved as hosting. Then the messages are decrypted and the incoming data is delivered to the services. However, the best stereotypes are those available in MR.

The CAM message model is proposed in Figure 3, and is compatible with the ETSI scale [28].

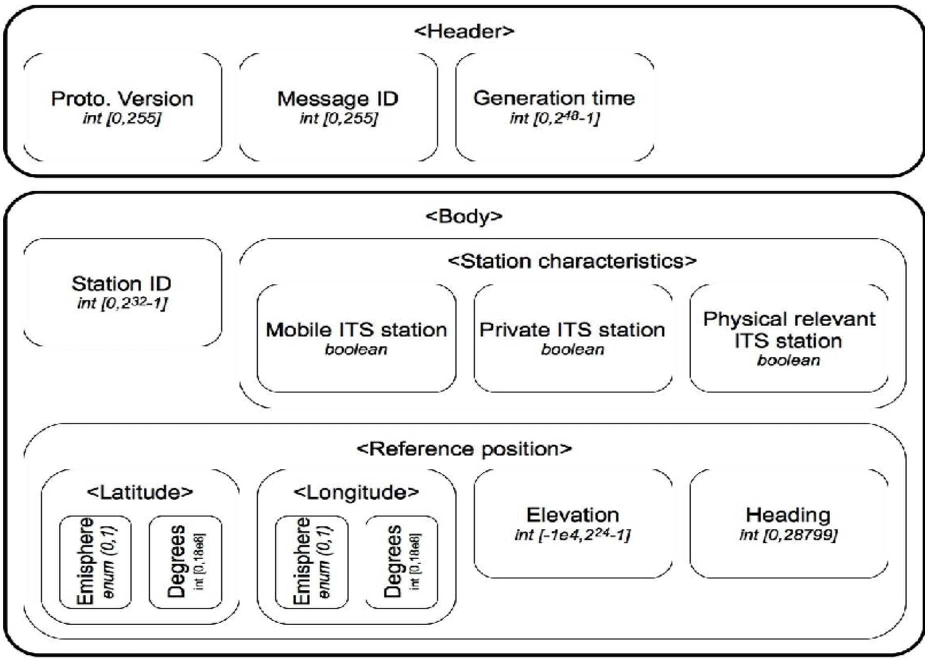


Figure 3: The structure of the CAM message

Header fields, such as message ID version (zero for CAM), protocol, or creation time, are not considered. The required data is entered into the body of the letter and parts of the reference area. A unique station identifier is then assigned by all vehicles and points on the stations, and then the specification of the station is determined by its characteristics. Vehicle stations are physically connected, as they are placed on mobile vehicles. All area reference information is taken from GPS but the required location, which is calculated via CAM model available in MR.

V.II. DENM messages

DENM messages are event-driven messages to send notification of collisions, roadworks or weather conditions. The ETSI standard specifies that DENM can be forwarded as long as the depicted event is still ongoing. The stopping of the message can occur for two reasons, either the expiration of a pre-determined timer or the sending of the exit message [29]. Table 1 shows some use statuses of DENM message.

Table 1: Decentralized environmental notification message (DENM)

Event driven risk warnings	**Use statuses**
Frequency: (depending on the program)	Signal violation warning
Length: variable	Traffic warning
	Emergency electronic brake light
	Wrong driving warning
	Work road warning
	Road adhesion
	Collision hazard warning

DENM messages are accessed by Central ITS-S AS according to service needs that require asynchronous event notification. The AS's Geographical Distribution Unit is responsible for classifying ITS-S ARs on the DENM track in the event area, which ultimately transmits the letters to vehicles in the surrounding areas.

As for the DENM model, Figure 4 shows the fields involved, if the message is in compliance with the standard.

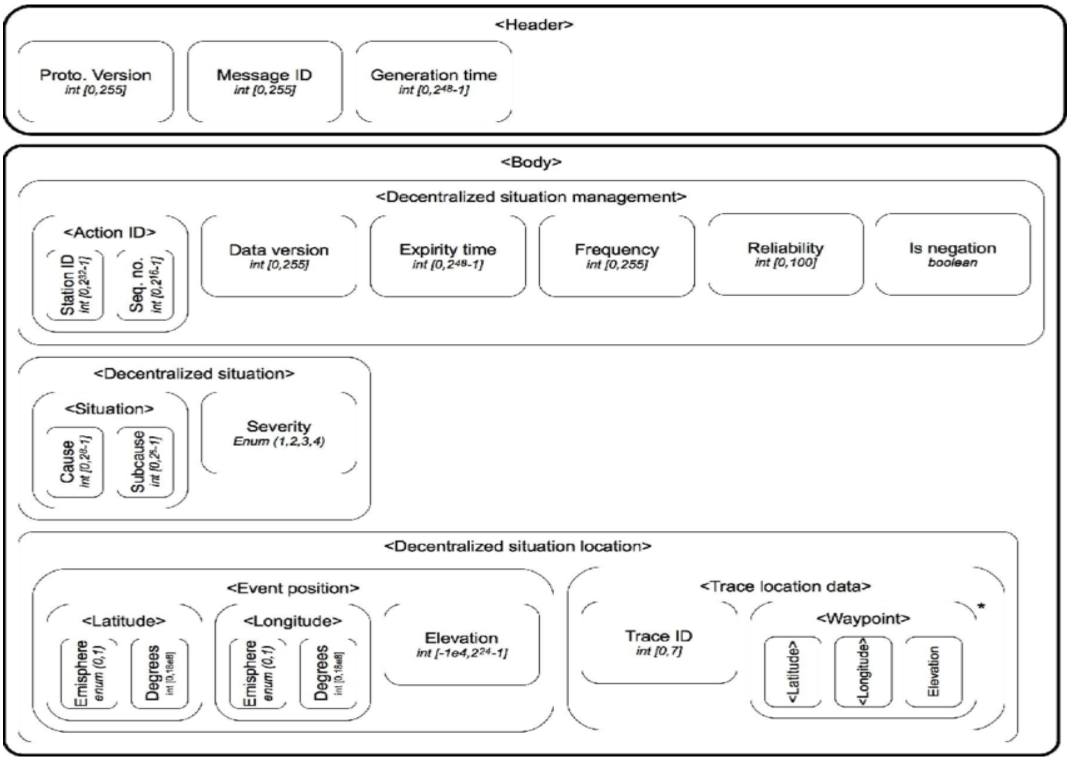


Figure 4: DENM message structure

The title is homogeneous with the header in CAMs, but the original text consists of supporting fields. The decentralized direction control package contains data about the subject (event): the event instance, the station selector pair, the discourse number of the single event selection, the expiration time, and the probability of the event being true. The second packet contains special details about the event in the message [30]. Various services were used to design the CAM and Denm model that allows the experimental evaluation of the intermediate applications of the messages in an actual environment.

VI. Analysis and discussion.

There are a range of MEC surveys that look at issues consistent with fog computing and summarize the number of papers used in fog computing studies. The survey in [31] presents a survey about MEC and demonstrates key enabling techniques. The paper discusses the structure of the MEC, provides an overview of the proposed standardization activities, and presents the main distribution layouts. In addition, authors in [32] presents a survey of the past state of MEC systems with enhanced joint control of computing and radio resources.

The aim of the study in this part is to analyze the problems that arise from connected vehicles at the specified time. We focus on processing data streams after they have been aggregated in real time. Next, we introduce three sections of the data capture, analysis, and then processing business model. The first one focuses on capturing problems from the IoV layer. The second is responsible for processing problem streams. Whereas, the main task of this last component is to compute the travel time index (TTI) in each corner of the path chain of space-time problems that arise from intelligent vehicles. The third element relates to sending and/or providing cloud-level processing output for just-in-time visualization and advanced retouching. These letters should offer high fault tolerance, support for large data streams and short transmission times to stay in the required time zone. Packets of data streams are usually implemented by message broker systems [33].

Controlling the transfer of offload data to compute elements is very important to securing the offload to any user's compute. For models with little throughput to the user, by uploading the software to the MEC provider, it is allowed to change the power of the original station to ensure the availability of the service. If the user changes to an updated service base station, the device is migrated to account packages to handle the issue [34].

In the mobile computing system model, the mobile phone users of the intelligent vehicle and the MEC servers are arbitrarily mobile. They also have access to every MEC computing stack, and are relatively independent. This model is divided into three levels: terminal level, terminal service level, and cloud service level. The cloud service level provides powerful storage and computing capabilities for the cloud computing center, provides full access to various hardware specifications, and sometimes creates transfer steps to the edge server, so that it can provide various services to end users. The terminal service level contains MEC servers or origin stations, wireless points, and simple points that collect data from vehicle users. In the MEC server of the system, there are several MEC models, and based on the request of the vehicle users, the appropriate model is selected to provide them with computing facilities. Finally, the terminal service level contains mobile vehicle users who perform limited task computational operations and send urgent and necessary requests [35].

Each vehicle user in IoV technology creates many independent functions, which are divided into many sub-functions with data extensions. Depending on the requirements of the users, tasks can be assumed to the same user or sent to the MEC provider at the station service level for computation or processed using a cloud center by sending to a cloud server.

The MEC server can more effectively control the data functions uploaded by the intelligent vehicle specialists and upload them to the cloud provider to solve them by the wireless network in the system. Currently, the delay caused by the computing function to control the cloud provider consists of the messaging delay caused by the user bringing the job to the cloud server level, the delay caused by the cloud server control function, the delay caused by the smart car user waiting and the delay caused by the job due to vehicle users smart. The delay in returning cloud processing output to the evolving service level is minimal and low.

High-speed car users in an IoV environment; channel gain, wireless status, and MEC server for vehicle users and their type are varied in the system hardware. The device requires load decisions in different safe, adopt system elements more effectively, and reduce the overall price. It is known that dynamic programming paradigms are more efficient in solving such problems. Also, it cannot be ignored that dynamic programming schemes require huge sums of money to implement, and this needs to create a strategy with all categories of adoption of suggested methods and loading methods to determine the optimal shutdown approach. For this reason, it is difficult to make just-in-time decisions for drivers with a dynamic programming paradigm, and an active learning approach can make just-in-time decisions for many types of users [36].

Table 2 presents comparison results of the proposed model with the relevant literature, based on the following metrics:

- Cost Effectiveness: infrastructure-based costing is an important criterion to consider before deploying any particular architecture.

- Delay/ Latency: It is crucial that the architectures talk about the expected delay or latency that might be incurred by using a particular architecture.

- Simulation/Analysis: Refers to the validation of proposed structures. Verification can be done using mathematical analysis, simulation or real-time implementation.

- Centralized/ Distributed/ Hybrid: The defined architecture can be centralized, distributed or hybrid.

- Scope of application: Several applications can be suggested based on the geometry used. These applications can be related to safety, security, emergency services, convenience, immersive experience, etc.

- Density: It affects the response time and response time of a particular architecture. In a dense network, there will be more pressure on the computing infrastructure.

- Method type: Several methods can be used to perform calculations such as cloud computing, fog computing, mobile terminal computing, etc.

Table 2. Comparison of the proposed model with previous models.

Related studies	Cost Effectiveness	Delay/ Latency	Simulation/ Analysis	Centralized/ Distributed/ Hybrid	Scope of application	Density	Method type
43		√	√	Distributed	Security and road safety		Collaborative communication
44	√	√	√	Central	Safety		Cloud Computing
45		√	√	Distributed	Travel comfort and traffic safety	√	MEC
46		√	√	Hybrid			Fog Computing and SDN
47		√	√	Distributed	Multimedia	√	Edge Computing
48			√	Distributed			Fog Computing
49		√	√	Hybrid	Delay sensitive applications		MEC and SDN
Proposed model	√	√	√	Distributed	Emergency	√	Humidity calculation

In fact, the proposed model try to take into account all the announced metrics when compared to some related works [37].

VII. Conclusion

Currently, communication technologies based on inconspicuous computing are open to further investment, due to its effective security and confidentiality features. Security-related issues have been addressed in the cloud computing stage, and thus it is possible to address them in new technologies. This is because there are similarities between new connectivity systems and the application-based cloud.

In the IoV intelligent computing environment, in order to address the issue of reducing the price of system functions, a system for redundant offloading of "Edge-Cloud" MEC collaborative system is built using a combination of vehicle-mounted mobile devices and a set of edge servers, in which the system bonding and offloading system are introduced and modeling.

In the proposed study, we gave details about fog computing (FC). We proposed a method to respond to the increasing demand for applications that require throttling, privacy, and bandwidth. Fuzzy computing for IoV is more comprehensive in terms of geographic scope, network scalability, hierarchy, and flexibility of FC capabilities, however, finding solutions for FC in IoV network faces additional challenges compared to traditional FC.

The current paper also introduced CAM and DENM messages by following a metric evaluation method on specific traffic patterns with reference services. In the near future, we should be aware of the collaboration between global organizations, in order to articulate the future vision in the field of edge computing (including Fog, MEC, and others propositions).

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