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Research Paper

Vehicular Fog Computing: The Need for a New Paradigm and its Issues

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Abstract

Smart vehicles participating in VANET have high computing capabilities which lead the demand to support more applications that give safety and effective measures to people. The vehicles in VANET are taking the help of cloud services for communication, computation and storage which benefits in economical way and we call that as vehicular cloud computing (VCC). Due to certain limitations in VCC and also demand for more quality of service applications in smart vehicles a new paradigm called vehicular fog computing (VFC) is proposed which helps to overcome limitations in VCC and provide more quality services to users participating in VANET. Some of the security challenges and possible attacks in VFC are also stated.

Keywords: *Vehicular ad-hoc network (VANET); On-board Units (OBU); Road side Units (RSU); Cloud computing; Vehicular cloud computing (VCC); Fog computing; Vehicular Fog computing (VFC).*

1. Introduction

With the increase in usage of vehicles, the road traffic also increased in huge amount which affects the safety and efficiency of the traffic environment. The present generation of transportation is just not about getting from origin to destination but getting there in a safer, greener and more efficient way. As we see many accidents are taking place in our daily life and also due to in-efficient traffic management, traffic congestion is taking place so road traffic safety and management has become the challenging issues. One possible way to overcome these challenges is to provide the traffic information to the vehicles so that we can use them to analyze the traffic environment.

Present vehicles are regarded as smart intelligent devices that are mobile and equipped with multiple sensors and have computational communication capabilities to perform many tasks simultaneously such as gathering traffic information, improving navigation communication and passenger's entertainment all while enabling safer and more efficient travel [3].

2. Vehicular Ad Hoc Networks (VANET)

The VANET consists of vehicles which are equipped with wireless sensors and on-board units (OBU) which are some special kind of radio interfaces enable vehicles to form short range wireless ad-hoc network [1]-[2] and road-side units (RSU) which are responsible for broadcasting the safety messages periodically to vehicles in-order to participate in vehicle to vehicle (V2V) communication, vehicle to infrastructure (V2I) communication often using global positioning system (GPS) devices to determine the location of the vehicle[1]-[2].

Essentially smart vehicles become just another extension of our digital lifestyles like downloading music, movies and TV shows from the cloud, for directions getting complete routing information with rich visual maps and satellite imagery. When fuel level or battery power starts to get low vehicle will automatically search for fuel or recharge stations providing directions to those with lowest prices all these is possible when smart vehicles will be able to connect over a variety of wireless standards to the internet to intelligent transportation system (ITS) and even to other vehicles within VANET.

A wide variety of applications will be used in VANET to provide the user with useful information for a safe and efficient journey like

2.1 Smart navigation:

Smart navigation provides an intelligent voice guidance navigation which helps to find the optimal path in-order to reach the destination by giving directions efficient travelling.

2.2 Smart traffic lights:

The sensors placed at the intersection sense number of vehicles are coming and send the data to the junction via signals then the traffic signal controller. Then according to the traffic density presented at junctions and by using real-time optimization methods traffic lights will be scheduled at each intersection to control the traffic flow in the city.

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2.3 Road condition detection:

Smart vehicles detect the weather condition and road condition and make adjustments according to that like if raining or it is fog then according to climatic condition speed of the vehicle will be adjusted and information regarding potholes, speed breakers will be given ahead before reaching them in-order to avoid them which will cause less vehicle damage.

2.4 Emergency warning:

Outside sensors of vehicles will enhance wellbeing by recognizing path take offs sense and react to potential threats, for example, not backing off for an up and coming stop sign, persistently distinguishing objects in-front or next to or behind to dodge impact, help with stopping and permit journey control to adjust speed to keep up a sheltered separation from an auto front auto by offering notices to driver.

2.5 Commercial applications:

By providing the drivers and passengers with the information about their interesting products that are available with low price to nearby smart vehicles and also provide multimedia services like music, movies, and videos according to their interest.

3. Vehicular Cloud Computing (VCC)

For processing all the vehicular applications and providing communication among vehicles VANET requires a large amount of storage, computation and communication resources [4]-[5]. Cloud computing offers many services like providing communication, computation and storage facilities using a central cloud or a group of remote servers. With the special features like scalability in computation and storage resources, any place any time and any where accessing without the trouble for keeping large storage and computation devices in vehicles and more importantly "pay-as-you-use" and increasing [3] demand for computation and communication applications in vehicular networks makes cloud computing to integrated with VANET in-order to form a new type of paradigm called vehicular cloud computing (VCC). Remote cloud servers will be deployed at various places. The information that the sensors of the vehicles gathered will be sent to these remote cloud servers through the network for processing and be storing. Fig.1 shows the vehicular network in which the vehicles provide the information or data that they gathered to VCC to process or sort using RSU's.

3.1 Limitations of VCC

A number of connected vehicles are rising day by day with their increasing mobility, as a result, there is a huge demand for applications with high Quality of Service (QoS) [4][5][6] in VCC which supports low latency and uninterrupted services. But there are some major limitations faced by VCC are

3.1.1 Delay in real time responses:

The forward and backward activity between cloud servers and devices in vehicles prompts expanded postponement in handling and reaction to messages.

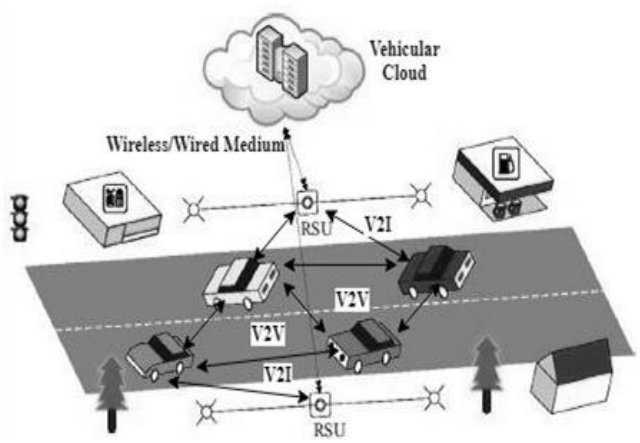


Fig. 1: vehicular cloud network

3.1.2 Increased mobility of users:

Cloud servers are thinking that it's difficult to process billions of administrations demands from highly mobile vehicles.

3.1.3 High wireless bandwidth cost:

Steady correspondence between the vehicle and the cloud server requires high transfer speed. This overwhelming activity likewise caused waste of vitality in numerous wireless devices.

4. Alternate proposals

In order to solve computation and communication problems apart from cloud computing, some other methods are proposed using existing systems [8] but all those have certain limitations

4.1 Cellular Networks:

As third-generation (3G) and fourth-generation (4G) cellular networks contain high computation capacity we can solve the problem with help of cellular networks. But cellular networks are primarily controlled by network operators so it may be great in communication aspect but it is not the effective and efficient way from application aspect.

4.2 Road Side Unit (RSU):

Even thou RSU's expands communication capacity these are really expensive and are really difficult to deploy them along roadside especially on a large scale like for entire city.

4.3 Mobile cloud computing (MCC):

MCC may bring rich computational resources for mobile users but it is costly, also while processing the real-time information it consumes more time because MCC uses client-server communication model and requires high quality of network connections with remote infrastructures.

5. Requirement for new paradigm in VANET

The numbers of connected vehicles are increasing and mostly all the presented connected vehicles are intelligent devices that are mobile and equipped OBU's and multiple sensing devices with great computation/communication [6][12] capability which helps not only for reporting the driving information but also provide traffic conditions, road conditions and weather conditions for transportation planning, road system design and traffic signal control. But the Problems are

- Each vehicle is generating more than 30GB data every day which results in significant bandwidth consumption.

- Sensing data have their own spatial scope and explicit lifetime utility [6]. For example, traffic congestion information may be only valid for few minutes and only those vehicles that are approaching the traffic jam are having interest in that data.

One best solution for solving the first problem is to reduce bandwidth consumption by serving the real-time based vehicle application geographically closer to applications instead of cloud. For determining the scope of the data fine-grained is the need that means instead of processing entire raw data produced by sensors only useful data must be processed, so the data from vehicles are extending to support more applications. Meanwhile, fine-grained data collection increases the burden on data management and centralized data management in the cloud so centralized data management far away from vehicles is not recommended. In order to overcome the above-mentioned problems, a new paradigm is needed.

6. Vehicular Fog Computing (VFG)

Fog computing is a new paradigm of [9] [3] computing which extends or brings the cloud services like computing, storage, and processing to the edge of the network by providing a virtual platform in end-user devices. We can also say fog is a geographically distributed cloud nearer to the user. Fog computing national institute of standard technology (NIST) [7] definition is "Fog computing is a horizontal, physical or virtual resources paradigm that resides between smart end-devices and traditional cloud or data center. This paradigm supports vertically-isolated, latency-sensitive applications by providing ubiquitous, scalable, layered, federated, and distributed computing, storage, and network connectivity". Integration of fog computing in VANET helps to overcome the problems mentioned above and also to process real-time, latency sensitive vehicular applications by forming a new paradigm called vehicular fog computing (VFG).

Fog act as intermediate layer between cloud and vehicles the data that is generated from vehicles first sent to fog nodes depending on the type and priority the data will be processed that means the real-time latency sensitive data with less scope is processed on fog nodes which provides temporary services rest of the data with high scope is sent to cloud for permanent storage. But the present smart vehicles are equipped with high computational and communication capabilities the vehicle itself can act as fog node in VFG. Fig 2 explains the architecture of VFC how the data generated from vehicles and in VANET will process through fog nodes.

6.1 Data Generation Layer:

In this layer, smart vehicles will generate data from multiple sensors that are integrated with vehicles. The vehicles also can act as fog nodes which help in making vehicle level decisions like giving warnings to vehicle such as intersection collision warning, overtaking vehicle warning, emergency vehicle warning, control loss warning, speed limit warning etc., all these are must process with real-time data and latency is not acceptable for those type applications also the scope of data is very limited. So in this layer of VFG data is gathered and pre-processed to support emerging applications.

6.2 Fog Layer:

Fog layer act as an intermediate layer between cloud and vehicles. Integrating RSU's at road intersections can help in expanding network of VANET by enabling infrastructure to infrastructure communication (I2I). We can deploy fog node in RSU's for pre-processing the data received from vehicles in order to make the decision to send it to cloud or process by itself. When a traffic jam happens at one area the vehicles that are coming toward that area need to instruct ahead for this type of applications area level decision need to be taken and no need to send this kind of data to the cloud. So in fog layer data fusion and pre-processing will be done with the data received from vehicles and decision will be taken regarding which data will be sent to cloud and which data will process by fog nodes.

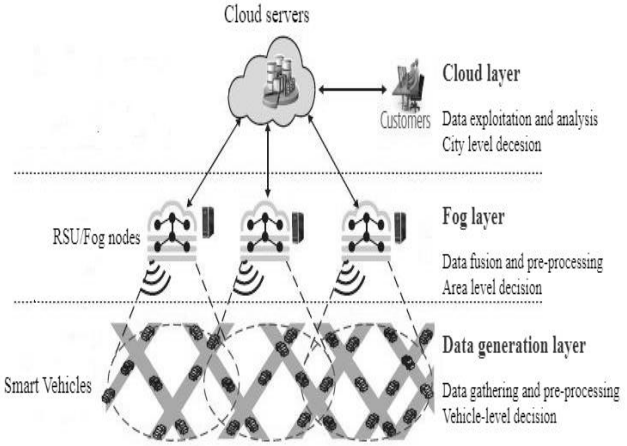


Fig. 2: Vehicular Fog Computing

6.3 Cloud Layer:

Even though fog brings the cloud services near to user fog can't process large-scale applications that kind of applications needs to be processed in the cloud layer. In cloud layer, city level decisions will be taken and the applications which generates a huge amount of data, not latency sensitive and whose applications data can be used for other organizations this kind of applications data can be processed in the cloud. For example, while traveling on roads smart vehicle can detect the path holes this information can be utilized by municipal organizations in-order to find at what places road condition no good in this way both the vehicles and organizations can benefit. Those kinds of applications need data exploitation and analysis in city level. For providing information organizations can provide some benefits in that way more vehicles shows interest to participate in VANET and organization will get the data easily with low cost.

7. Security issues in VFC:

Despite all the tremendous benefits provided by vehicular fog computing, there are some security and privacy issues [6]. As fog nodes are deployed at the roadside and due to its location awareness nature fog nodes can typically face physical attacks which are not possible in the cloud. Due to public accesses of fog nodes attackers can attack many types of attacks like data injection attack, black/grey hole attack etc., [12] by gaining administrative accesses or by altering the function. Some techniques are summarized below to overcome these challenges are

7.1 Confidentiality:

The data generated by vehicles or fog nodes contains lots of sensitive information which will be misused by malicious hackers so confidentiality becomes a primary objective in VFC. In order to provide confidentiality, data encryption must be used and one of the best approaches for providing data encryption is to use proxy re-encryption [6]-[15] with keyword search which allows the cloud to search for requested data reports on fog nodes and share the matched data to other vehicles on behalf of proxy.

7.2 Authentication:

It is necessary to make sure the vehicles and fog nodes that are participating on VFC are trusty worthy otherwise malicious vehicles or fog nodes perform different type's attacks and gives false information to other vehicles in order to confuse them which re-

sults in accidents. Possible attack [14] of vehicles or fog nodes in VFC is:

Table 1: Different kind of attacks on Fog nodes

Attacks	Description
White washing attack	A malicious vehicle or fog node clears it reputation and re-joins the network with a new name.
Sybil attack	The attacker creates multiple identities for multiple fog nodes and manipulates the network.
Impersonation attack	The attacker steals the identity of other fog nodes and attack the network
Extortion attack	A group of attackers will target a fog node by blackmailing or by forcing they will take the sensitive information from that node.
Collusion attack	Multiple users form a group and prove an honest node as malicious node

7.3 Privacy:

Data generated from vehicles must generally relate to some aspects of drivers and passengers regarding where they are going, frequently visited places, their interests etc., all these create privacy issues for vehicles that are participating in vehicular fog computing. For example, if vehicle reports traffic jam to fog node, due to the location awareness nature of fog node it is easy to locate the vehicle based on the accessing fog node [12]. This creates a privacy issue one of the promising methods to protect vehicle privacy is to use anonymity techniques [12] such as pseudonyms, group signatures, and k-anonymity. The anonymity techniques help in hiding the user identity by fulfilling the tasks given to vehicle with the high-quality output.

8. Conclusion

In this article, we present how vehicles can form a network in order to provide safety and effective measure by using different applications. With the economic benefits provided by the cloud vehicular networks are using cloud communication and computation services other methods are also stated which provides efficient services other than cloud but all those have certain limitations which lead to the requirement of a new paradigm. So a new paradigm called vehicular fog computing is proposed by integrating fog nodes in RSU's for providing more quality services to users. The architecture of VFC is explained along with architecture some of the security challenges faced by fog nodes and vehicles, possible attacks for fog nodes are explained.

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