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VAN-Cloud: Security based Architecture and Applications

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Abstract: *Due to increasing traffic and number of road accidents there isneed of Intelligent Transport System. VANET Cloud, VehicularCloud Computing, Vehicular Cloud Network and cloud based Vehicular network are very popular research topics in these days. Nodes or Vehicles in network are equipped with different types of sensors that senses the information. This information can be very helpful to deploy the number of applications like safe Driving, infotainment services, road jam alert etc. The main objective of VANET Cloud is to provide the effective utilization of available resources to provide the services for deploying an Intelligent Transportation System. Today, in the era of advance technology, vehicles are smart enough and havebetter internet connectivity. Therefore vehicles can communicate with cloud directly. This reduces the communication delay and reduces the risk of information leakage. This research paper qualitatively review the VANET Cloud architecture with services, challenges and proposedVAN-Cloud architecture to deploy the secure Intelligent Transport System.*

Keywords*: Vehicular Cloud Computing, Vehicle using Cloud, Vehicular Ad-hoc Networks, Architecture, Security, Challenges.*

1. Introduction

In the era of technologies, a tremendous changes can be seen in Vehicular Networking. Vehicles are equipped with high end sensors, computing devices and battery backup which make the vehicles smart enough. Vehicles are treated as a powerful node in vehicular networks. Vehicles communication between vehicles and vehicle to infrastructure take place with wireless technologies like dedicated short range communication (DSRC) [1], ZIGBEE [2], LTE/4G [[3][4] etc. VANET is the advance version of the MANET. In contrast to MANET, Vehicles in vehicular networks equipped with enough storage space, computational capability and battery life. Cloud computing approach make possible to use these underutilized resources to provide the services to other vehicles. On other hand if we talk about complete vehicular networks then it is impossible for each vehicle to maintain all the records about another vehicles in the network. In such cases the vehicles use the services of cloud computing to enhance the storage, computing capability, internet services. Therefore, cloud computing can be used in two different ways in VANET. First VCC (Vehicular Cloud Computing) [5] where vehicles who are interested to rent out their resources to other vehicles form their own cloud. Second model is VuC (Vehicles using Cloud) or VtC (Vehicles to Cloud) [6][7] where vehicles use conventional cloud services. Cloud computing work on pay as you go approach and provide number of services. VuC can consumes these services of conventional cloud. As Vehicles are assumed to be able to connect to internet so Network as a service (NaaS) can be used to connect to internet in VuC. Vehicles can enhance the storage space and computing capability by utilizing the storage as a service (STaaS) and computing as a service (COaas) of conventional. One more architecture known as hybrid vehicular cloud (HVC) which comprises both the features of VCC and VuC are used to provide better services.

2. Why VANET-Cloud?

Vehicular ad-hoc networks plays a essential role to deploy the intelligent transport system (ITS). With the invention of high end technologies, vehicle are embedded with on board computing devices, sensors and huge storage capacity and battery life. But vehicles are not consuming these resources all time. While at parking stand of cinema halls, hospitals, working places etc., all the resources of vehicles remain idle. These underutilized resources can be utilized to provide the services to other needy vehicles. On the other hand vehicles can use the services of conventional cloud. Conventional cloud provide the services like Network as a service (NaaS), Infrastructure as a service (IaaS), software as a services(SaaS), storage as a services(STaaS) on pay-as-you-go basis etc. Now vehicles can report about the weather, road condition, traffic jam to cloud and more accurate and real time information can be disseminated.

3. VANET- Cloud Architecture

Researcher have proposed the three VAN-Cloud architecture as shown in fig 1: VCC (Vehicular Cloud Computing), VuC (Vehicles using Cloud) and HVC (Hybrid Vehicular Cloud).

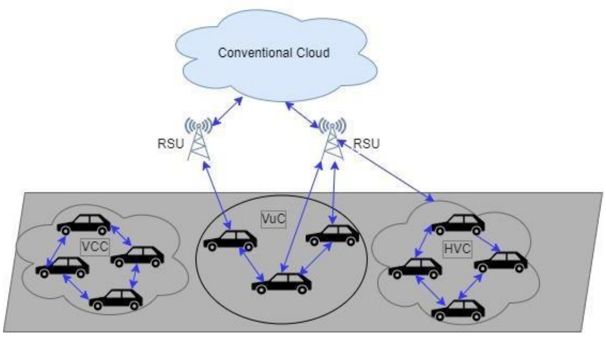

Figure 1: Three VANET Cloud Architecture

On the basis of these studies following architecture, layers, services and communication types have been identified.

3.1 Vehicles using Cloud (VuC) or Vehicles to Cloud Infrastructure (VtC):

In VuC architecture the vehicles on the road communicate with cloud through the RSU that act as a gateway as shown in fig... Vehicles have not much storage space to maintain the information of all other vehicles in the network. Cloud computing contribute at great extent to deploy the smart transport system. Drivers of vehicles now can utilize the cloud services and resources which gives the illusion to drivers that they have enough resources. To address the limits and security concerns of VCC-based services, [8] propose the VCC Service-oriented Security Framework (VCC-SSF).The proposed framework comprises innovative user-oriented payment management and active accident management services, as well as security for convenient and efficient VCC services. VCC-SSF is made up of three layers for the VCC environment: Core Technology, Security, and Application Services. Core layer provides the techniques of communication. The Security Layer offers authentication, encryption, access control, and privacy protection. It also authenticates stationary and moving vehicles and encodes personal data and highly sensitive data. The Application Service Layer in a VCC environment provides services to the driver or user via V2X communication in order to access the acquired data. Payment and accident management are the two options provided.

Author [9] presented the Vehicular Cyber-Physical System (VCPC) and Mobile Cloud Computing (MCC) Integration Architecture (VCMIA) to provide ITS and cloud services for smooth traffic. The user was given access to a mobile traffic cloud through VCMIA's mobile service. Furthermore, it provided real-time traffic information to the user and shared road traffic information with other users using GIS with Traffic-Aware Capability and Cloud-Supported Dynamic Vehicle Routing. Author proposed a cloud-based scenario identification VCPS architecture which provide smooth and integrated communication between the vehicle network and the customer centre. In the VCPS data Centre, the situation-aware VCPS regulated the parking service and distributed computer resources to users.

Author [10] defined three layer VuC architecture where application layer support different types of applications, support layer contains different cloud computing services, network layer support the medium through which the vehicles and infrastructure communicate with each other and las one is perception layer which contain the conventional cloud. Further it this model support the Real time services for intelligent transportation system. Author [11] defined three tiers architecture. Tier-1 is device level which consists of five layers where on the bottom sensor layer, raw data such as temperature, pressure, images, and biological information may be recorded and then stored in a repository for processing on the upper layer. On the knowledge processing layer, low and high level context will be explicitly addressed. Finally, via the context-aware intermediate layer, some outputs will be sent to the higher actuator layer, and actions like as halting the vehicle, slowing it down, and providing warning signals to the driver will be taken. Security is a vital component in the meanwhile. Tier 2 is communication level, it support the various communication types and tier 3 is service layer and it provided different type of services.

There are three levels of the Vehicular cloud model [12]. The Cloud infrastructure layer provides the core platform and environment for the intelligent emergency response system. By analyzing data from many sources, the Intelligence Layer provides the necessary computational models and algorithms for developing the optimal emergency response strategies. The System Interface gathers data from many sources such as the Internet, transportation infrastructure such as roadside masts, mobile smart phones, social networks, and so on.

Author [13] proposed VANET-Cloud architecture consists of three layer. First, client layer defines the end user or vehicles in the network are supposed to utilize the cloud services. Vehicles communicate with upper communication layer which ensure the reliable communication between the end user and the cloud server through service Access point (SAP). And upper most layer is cloud layer which provide cloud service. Author enhanced the architecture by diving the cloud layer further into permanent and temporary cloud network. Permanent cloud network provide the services of conventional cloud (IaaS, NaaS, PaaS) and temporary cloud is formed by the vehicles which promote the idea to use all the underutilized resources of the vehicles like the data storage facility, computation power, network as a service etc.

Author [7] proposed vanet using cloud architecture with three layers: bottom car level layer consists the smart vehicles having the GPS(Global positioning system), radar, high tech sensors and actuators. Next level layer is inter vehicle layer where communication take place between the vehicle to vehicle and vehicle to infrastructure. At the highest level, cars can interact with each other at the cloud level, with vehicles or RSUs acting as gateways. The VANET cloud's underlying infrastructure will determine if a vehicle or RSU is designated as a gateway.

3.2 Vehicular Cloud Computing (VCC)

In Vehicular cloud computing architecture, vehicles on the road contribute to make their own cloud. The idea behind this architecture to use the underutilized resources of the vehicles. Vehicles who are willing to rent their resources becomes supplier and provide grant the access to other vehicles in the network to use their resources on pay-as-you-go basis.

Author [14]proposed a incentive based secure architecture for the vehicular cloud. The design incentivizes vehicles to give their unused resources to the cloud by providing tokens that the vehicles may use to access cloud services. Cloud behave as trusted authority and vehicles who are interested to rent their unutilized resources can give their resources to cloud. Whenever any vehicle send a request to cloud to use the services then cloud broadcast a message and interested vehicle who want to rent it resources, send a work request message to the cloud's service provider manager (SPM) through roadside units (RSUs). With the help of the trusted authority (TA), the SPM checks the vehicle (or driver) and investigates the revocation authority's (RA) prior records.

Table 1: The Summary of Related Literature of VAN-Cloud Architecture

Author	Architecture	Layers	Application	Implementation	Methodology
[8]	**VuC**	Core Technology Layer, Security, and Application Services Layer	Payment Service and Accident Management	No	**-**
[10]	VuC	Application layer Support layer Network layer Perception layer	Services to capture and sharereal-time accident/traffic footages.	Yes	Not defined
[11]	VuC	Three tiers architecture: Device Level Communication Level Services level	Real time services	No	-
[12]	VuC	Three layer architecture: Cloud infrastructure layer, Intelligence Layer and SystemInterface layer.	Intelligent Disaster Management	Yes,	Lighthill-Whitham-Richards (LWR) Model is used to show traffic in city
[13]	VuC VCC	Client layer, communication layer and cloud layer	IaaS, StaaS	No	-
[7]	VuC VCC HVC	Car level layer Inter car level Cloud level	Traffic Information Dissemination	Yes, using VuC Architecture	NS2, SUMO
[14]	VCC	Incentive based secure Architecture consist of VANET and Cloud layer	General services of Vehicles formed cloud: STaas, NaaS, SaaS	No, Only theoretical process of Public and Private key Athentication and generate token.	Not defined
[15]	VCC	Zone Controller, VANET	use of underutilization of resources of vehicles	No	-
[16]	VCC	Vehicle Infrastructure Abstraction Layer Venicle cloud layer Internet Cloud	Smart traffic management	No	
[17]	VCC	RSU -aided Cluster-based Vehicular Clouds	use of underutilization of resources of vehicles	Yes	OMNeT++ 5.3, SUMO

After completing the task, Requesting Reward Tokens (RTS) give the token asreward of services provided by the vehicle. The system [15] utilizes a number of zone authority, each of whom is in charge of a zone (area) that comprises RSUs, vehicles, and customers. Each zone authority acts as a gatekeeper, ensuring that the zone's operations are validated, that the services requested and data flow are managed, and ensure to retain the privacy of vehicles, customers, and cloud organizations. Revocation methods are used to create revoked lists of malicious vehicles. Transportation management systems (TMS) [16] based on VCC outline how traffic data is collected, analyzed, and distributed. If data is handled through the internet, the vehicle cloud must be linked to the traditional cloud. If data is going tobe processed locally, data distribution and resource allocation strategies are utilized.

Author [17] proposed RSU -aided Cluster-based Vehicular Clouds where supplier vehicles (SV_s) send the registration packet to nearest RSU and vehicles who want to opt these services (Consumer vehicles CV_s) send a request packet to nearest RSU. Then RSU proceed for constructing the cluster of such vehicles. Using Euclidean distance the cluster head has been elected.

3.3 Hybrid Vehicular Cloud (HVC)

Hybrid cloud computing model is combined architecture that comprises the features of VuC and VCC architecture. VCC functions both as a consumer and a supplier in this form of cloud. On road vehicles can provide a variety of services by rent out their resources on a pay-per-use basis, as well as the option to request at the same time for services and resources from the conventional clouds. The VANET Cloud is a hybrid cloud that includes both static and dynamic clouds. The static cloud consists of fixed servers located in datacenters, while the dynamic cloud consists of movable vehicle nodes that offer computing services. VANET Cloud gathers data from a variety of media sensors and makes it available to both traditional cloud and end-users. Furthermore, the vehicles may interact with a nearby VANET's Cloud in order to access various internet-based services and applications. A hybrid vehicular cloud may deliver a variety of services, such as smart traffic management and entertainment.

4. VANET Cloud Applications

4.1 Infrastructure as a services

Vehicles are outfitted with numerous sensors, 5G internet access and often fitted with terabytes of storage, allowing them to communicate with other vehicles and infrastructure. Vehicles are not expected to use these resources all of the time, VCC enable them to rent out their resources to other vehicles in the network that are in need. On the other hand vehicles in the VuC design don't have a lot of room to store information about other vehicles in the network. The traditional cloud is treated as a data center that stores large amounts of data and gives drivers the impression that their OBU has ample storage capacity (On Board Unit).

4.2 Software and Vanet applications as a services

VANET-Cloud elements (Vehicles' Components, Conventional Cloud) provide end users with a variety of vehicular software and applications that assist in the discovery of geographic locations and real-time information about vehicles parking places and availability, fuel stations, guesthouses, resorts and other services. Cloud computing allows a company's web server to supply consumers with Internet-based services. Web services are promoted using a vast processing capacity provided by VANET Cloud, which is substantially faster and cheaper than standard web service providers by utilizing the automobiles' onboard computers.

4.3 Gateway as a services

The authors [18] tackled the problem of seamless Internet connection by using cloud-based VANETs. The authors developed a cloud-supported gateway paradigm, known as gateway as a service (GaaS), in this research to enable effective gateway connection and improve the Internet consumption experience for vehicle networks. The suggested system is made up of four parts: a gateway, a client vehicle, a relay vehicle, and a cloud server. The gateway is in charge of connecting automobiles to the Internet. This gateway might be stationary in the form of RSUs or mobile in the form of vehicle itself. The client vehicle is the one that wants to connect to the Internet and asks for GaaS. If the client vehicle is not inside the coverage range of any gateway, the relay vehicle assists the client vehicle in connecting to the gateway. The cloud server is the last GaaS model component.

4.4 Smart traffic light

Traffic efficiency apps strive to improve transport system efficacy by delivering traffic-related information among the drivers and RSU. To deploy the smart transport system information should be disseminated through the VANET. The [19] developed a car-to-car model in which traffic efficiency use cases like enhanced route guidance and navigation and green light optimal speed advisory are depicted with the purpose of improving traffic efficiency. Route guidance and navigation enables infrastructure owners to collect traffic data from a large geographic region, which may be used to forecast future highway congestion. RSUs will then send the projected information to on-road vehicles. It also informs the driver of current and predicted traffic conditions, delays to his destination, and other routes available to avoid particular crowded routes. Clearly, this will boost the overall efficiency of the transportation system. Green light optimal speed advisory tells oncoming vehicles where a signalized junction is and when to switch the light signal, allowing for smoother driving and avoiding stops. With this information, the vehicle may determine the best speed to reach the junction when the traffic light is green, avoiding the need for the driver to slow down or stop. This will likely improve traffic flow and fuel efficiency.

Using Vanet Cloud, dynamic synchronized traffic light conceptis possible. Consider the scenario: thousands of people are attending a sporting event, and a traffic jam may occur at the closing of the game as everyone rushes to leave. The problem becomes more complicated as a result of static traffic light synchronization. In VCC, the vehicles will place their resources at the disposal of a local authority in return for altering traffic lights in order to distribute the congestion as early as is reasonably practicable.

4.5 Computing as a services

The conventional cloud is capable of doing a wide range of computing tasks that are not achievable with vehicles. Vehicles make use of conventional cloud services when they are built using the VuC architecture. When it concerns to VCC architecture, the vehicles do not always employ computer equipment. On a regular basis, vehicles in parking lots might be there for many hours or perhaps the whole day. At that point, all available resources are underutilized. As a result, these unused resources may be employed to offer services to other vehicles in need on a pay-as-you-go basis, so enhancing their productivity.

4.6 Disaster Management

When big catastrophes like cyclones, storms, hurricanes, etc. are forecast, people must be rescued to lessen the effect on their life. However, these large-scale evacuations are not without complications.

For example, during an evacuation, locating critical supplies such as gasoline, water, medical facilities, and optimum routes becomes a challenge [20][12]. Some traffic monitoring equipment are required to provide information in real-time along the evacuation routes. VANET Cloud can handle disasters like tsunamis and hurricanes well [21].

4.7 Health care services

Patients may be diagnosed from any location, even while on the go, thanks to a mobile healthcare service backed by VCC. A healthcare application based on an RFID-enabled authentication technique has been suggested by the authors in [22] for offering first aid or comprehensive medical help to travelling patients as soon as possible while they are on the road. The idea makes use of RFID technology in conjunction with the current transportation infrastructure. The suggested approach makes use of a Petri nets-based authentication model for the authentication of readers and tags.

4.8 Infotainment as services

Due to the usefulness of both entertainment and safety, multimedia services have been a prominent research focus in both cloud computing and VANETs. Therefore, to enhance access to multimedia services, cloud-based vehicular networks (MSCVNs) [23] have been used to link cloud computing and storage with automobiles.

Author [24] proposes cloud-based ITS (CITS) to handle the growing transportation issue with entertainment apps. A tiered vehicle data cloud system was described. The system uses cloud computing and IoT technology. A cloud service for intelligent parking, VANET connectivity to the cloud, and vehicle data mining cloud. The intelligent parking cloud module decides where to park automobiles, and the mobile device with Android application service communicates with the cloud. The CITS is closely connected to the CC-V-layered architecture's smart applications, AI, and perception layer.

5. Security Issue in VANET-Cloud Architecture

Cloud computing for VANETs is still in its development, with just a few companies offering services. Because of this, there are significant obstacles and concerns that must be addressed, but security is one of the critical issue among all the challenges. The vehicular cloud has serious security and privacy issues due to distributed system. The issue becomes more critical in case of VCC architecture where onboard devices are operating as server. The vehicles collaboratively form the cloud and provide the services to another needy vehicles in the network. Users input data and operate programmers in third-party data centers. So, data integrity, regulating access to information, prevent data loss, preserving personal information of users etc. are number of security concerns that must be considered in VCC type architecture. On the other hand nodes or vehicles should be legitimate. Malicious node in the network can send the bogus information in the network to disturb the whole network. When a vehicle's navigation relies on data from the cloud or another vehicle, difficulties might arise. If the information is skewed by an intrusion, time and fuel are wasted, and even the lives are lost. There have been several attempts by different authors [8][25][15] to discover how certain challenges, such as intrusion detection and authentication, may be dealt with in a realistic way. However, it is necessary to do extensive security-related research in order to analyse the efficiency of security, privacy, and authentication in VANET Cloud.

6. Proposed Security based VAN-Cloud Architecture

In this study, considering the security issue, a new Secure VAN-Cloud Model is proposed to maximize the benefits of cloud computing technology. This concept will enable direct contact between the vehicles and the cloud, as well as communication via the RSU. Using typical cloud services, the model was able to create a more effective Intelligent Transportation system with security check. The model is divided into client layer, communication layer and conventional cloud layer. Conventional cloud layer is further divided into security and application layer**.**

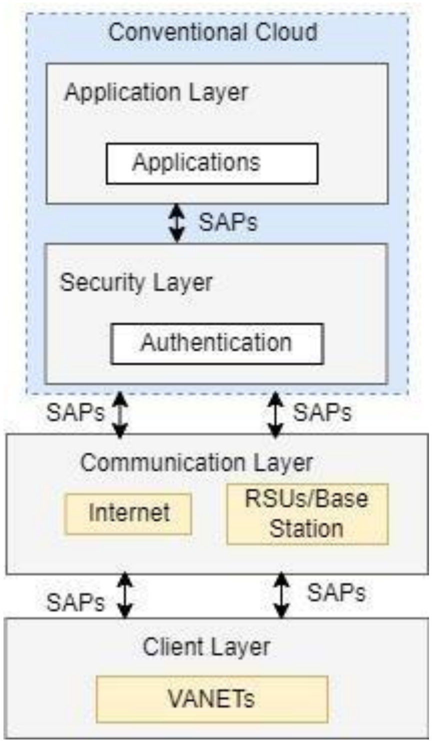

Fig 2: Secure VAN-Cloud Architecture

Client Layer: The client layer is the most fundamental layer of the VANET-Cloud, and it is made up of end users. An end user might be a broad client (i.e., one who does not have a specific need). A VANET entity or a VANET node that is in need of cloud services. In the vehicular environment, the end user may be distinguished by a particular degree of mobility in which they operate. A service access point (SAP) allows a smartphone, laptop, onboard computer, or GPS device to create a service request with the next-level layers. As a result, the top levels send their service answer to SAPs, which the clients get.

Communication Layer: A primary function of this layer is to guarantee that a connection can be established between the client situated in the lower layer and the VANET Cloud data center, or server, in which the information is stored SAPs connect the top layer to the lower layer.

Conventional Cloud Layer: This uppermost layer is made up of data centers that host VAN-Cloud services. These data centers are responsible for delivering VAN-Cloud services to users. The VANET-data Cloud's centers are made up of ordinary stationary cloud data centers (static VANET-Clouds).Clients may access VANET-Cloud services through SAPs via the communication layer. This layer is subdivided into two sub-layers: the Application layer and the Security layer, respectively. The security layer is treated as if it were a third-party authentication system. The token is distributed to the vehicles via the security layer. Every time a vehicle wishes to use the cloud's services, the vehicle must submit a request to the cloud, which must be accompanied with a token. The cloud security layer then verifies the token, and if the token is found to be legitimate, the application layer subsequently provides the services to the automobiles.

7. Conclusion

A variety of applications, including healthcare, disaster management, Infrastructure as a services, Gateway as a services, Smart traffic light, Infotainment as Services, are expected to improve the state of the art of the current transportation system by integrating VANETs with cloud computing. An effort has been made in this review article on the VANETs Cloud, based on the type of architecture, layers defined in architecture, various challenging and services that are given. Despite the fact that the VANETs Cloud concept is capable of enhancing the capabilities of VANETs and Intelligent Transportation Systems (ITS), there are a number of security and deployment issues that must be overcome before this concept can be implemented in the real world, according to an in-depth study of the emerging topic.

A detailed and deeper investigation into finding answers to the concerns and challenges outlined in this review article will be our next step toward ensuring the dependable and safe deployment of VANETs Cloud services in the future.

References

[1] B. J. B. Kenney, "Dedicated Short-Range Communications (DSRC) Standards in the United States," in *Proceedings of the IEEE*, 2011, vol. 99, no. 7,pp. 1162–1182.

[2] M. R. C, M. E. P. Computing, and M. E. P. Computing,"STUDY ON ZIGBEE TECHNOLOGY," in *3rd International Conference on Electronics Computer Technology, vol. 6, pp. 297-301. IEEE, 2011.*, 2011, pp. 297–301.

[3] O. Oshin, M. Luka, and A. Atayero, "From 3GPP LTE to5G : An Evolution," *Trans. Eng. Technol. Springer, Singapore*, pp. 485–502, 2016, doi: 10.1007/978-981-10-1088-0.

[4] I. F. Akyildiz, D. M. Gutierrez-Estevez, and E. C. Reyes,"The evolution to 4G cellular systems: LTE-Advanced," *Phys. Commun.*, vol. 3, no. 4, pp. 217–244, 2010, doi: 10.1016/j.phycom.2010.08.001.

[5] A. Keyvan, "Cloud Computing on Cooperative Cars (C4S)," in *2018 IEEE 11th International Conference on Cloud Computing (CLOUD)*, 2018, pp. 794–801, doi: 10.1109/CLOUD.2018.00108.

[6] R. Hussain, J. Son, H. Eun, S. Kim, and H. Oh, "Rethinking Vehicular Communications : Merging VANET with Cloud Computing," in *IEEE 4th International Conference on Cloud ComputingTechnology and Science Rethinking*, 2012, pp. 606–609.

[7] R. Hussain, Z. Rezaeifar, and H. Oh, "A Paradigm Shift from Vehicular Ad Hoc Networks to VANET-Based Clouds," *Wirel. Pers. Commun. 83, no. 2 1131- 1158.ireless Pers Commun, Springer*, vol. 83, no. 2, pp. 1131–1158, 2015, doi: 10.1007/s11277-015-2442-y.

[8] W. M. Kang, J. D. Lee, Y. Jeong, and J. H. Park, "VCC- SSF: Service-Oriented Security Framework for Vehicular Cloud Computing," *Sustainability*, vol. 7, no. 2, pp. 2028–2044, 2015, doi: 10.3390/su7022028.

[9] J. Wan, D. Zhang, Y. Sun, K. Lin, C. Zou, and H. Cai, "VCMIA : A Novel Architecture for Integrating Vehicular Cyber-Physical Systems and Mobile CloudComputing," *Mob. Networks Appl.*, vol. 19, no. 2, pp. 153–160, 2014, doi: 10.1007/s11036-014-0499-6.

[10] D. Singh, M. Singh, I. Singh, and H. Lee, "Secure and Reliable Cloud Networks for Smart Transportation Services," in *17th International Conference on Advanced Communication Technology (ICACT)IEEE.*, 2015, pp.358–362.

[11] and T. M. Wang, Jin, Jinsong Cho, Sungyoung Lee, "Real Time Services for Future Cloud Computing Enabled Vehicle Networks," in *International conference on wireless communications and signal processing (WCSP), IEEE.*, 2011, pp. 1–5.

[12] Z. Alazawi and S. Altowaijri, "Intelligent Disast ter Management System based on abled Vehicular Network ks," in *11th International Conference on ITS Telecommunications. IEEE.*, 2011, pp. 361–368.

[13] and S. Z. Bitam, Salim, Abdelhamid Mellouk, "VANET-cloud: a generic cloud computing model for vehicular Ad Hoc networks," *IEEE Wirel. Commun.*, vol. 22, no. 1, pp. 96–102, 2015.

[14] K. Lim, I. M. Abumuhfouz, and D. B. Manivannan, "Secure Incentive-Based Architecture for Vehicular Cloud," in *In International Conference on Ad-Hoc Networks and Wireless, Springer.*, 2015, pp. 361–374, doi: 10.1007/978-3-319-19662-6.

[15] I. M. Abumuhfouz and K. Lim, "Protecting Vehicular Cloud Against Malicious Nodes Using Zone Authorities," pp. 5–6, 2015.

[16] I. Ahmad, R. Noor, I. Ali, and M. Imran, "Characterizing the role of vehicular cloud computing in road traffic management," *Int. J. Distrib. Sens. Networks*, vol. 13, no. 5, 2017, doi: 10.1177/1550147717708728.

[17] M. Ben, A. Korichi, and C. A. Kerrache, "RCVC : RSU-Aided Cluster-Based Vehicular Clouds Architecture for Urban Areas," *Electronics*, vol. 15, no. 2, pp. 1–18, 2021.

[18] Y. L. J. S. H. Weng, "Cloud-Supported Seamless Internet Access in Intelligent Transportation Systems," *Wirel. Pers. Commun.*, vol. 72, no. 4, pp. 2081–2106, 2013, doi: 10.1007/s11277-013-1137-5.

[19] R. Baldessari, "CAR 2 CAR Communication Consortium Manifesto Overview of the C2C-CC System C2C-CC Manifesto This document summarizes the main building blocks for a," no. January, 2007.

[20] R. S. Raw, A. Kumar, A. Kadam, and N. Singh, "Analysis of Message Propagation for Intelligent Disaster Management through Vehicular Cloud Network," in *Proceedings of the second international conference on information and communication technology for competitive strategies*, 2016, pp. 1–15.

[21] G. Yan, D. Wen, S. Olariu, and M. C. Weigle, "Security Challenges in Vehicular Cloud Computing," *IEEE TransIntell Transp Syst*, vol. 14, no. 1, pp. 284–294, 2013.

[22] N. Kumar, K. Kaur, and S. C. Misra, "An intelligent RFID-enabled authentication scheme for healthcare applications in vehicular mobile cloud," *Peer-to-PeerNetw. Appl.*, vol. 9, no. 5, pp. 824–840, 2016, doi: 10.1007/s12083-015-0332-4.

[23] M. Jiau, S. Huang, J. Hwang, and A. V Vasilakos, "Multimedia Services in Cloud-Based Vehicular Networks," *IEEE Intell. Transp. Syst. Mag.*, vol. 7, no. 3,pp. 62–79, 2015.

[24] K. Ashokkumar, B. Sam, and R. Arshadprabhu, "" CLOUD BASED INTELLIGENT TRANSPORT SYSTEM "," in *Procedia - Procedia Computer Science*, 2015, vol. 50, pp. 58–63, doi: 10.1016/j.procs.2015.04.061.

[25] R. Hussain, Z. Rezaeifar, Y. Lee, and H. Oh, "Secure and privacy-aware traffic information as a service in VANET-based clouds," *Pervasive Mob. Comput.*, 2015, doi: 10.1016/j.pmcj.2015.07.007.