Chapter 3
Challenges and Opportunities in Vehicular Cloud Computing

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ABSTRACT

Vehicular ad-hoc networks (VANET) have become an important research area due to their ability to allow sharing resources among the users to carry out their application and provide services of transport and traffic management. VANET communication allows exchange of sensitive information among nearby vehicles such as condition of weather and road accidents in order to improve vehicle traffic efficiency through Intelligent Transportation Systems (ITS). Many technologies have been developed to enhance ITS. Recently, vehicular cloud computing (VCC) has been developed in order to overcome the drawbacks VANET. VCC technology provides low-cost services to vehicles and capable of managing road traffic efficiently by using the vehicular sources (such as internet) to make decisions and for storage. VCC is considered as the basis for improving and developing intelligent transportation systems. It plays a major role in people's lives due to its safety, security, trust, and comfort to passengers and drivers. This chapter investigates the vehicular cloud computing. The authors first concentrate on architectures. Then, they highlight applications and features provided by VCC. Additionally, they explain the challenges for VCC. Finally, the authors present opportunities and future for VCC.

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INTRODUCTION

For the past few years, Intelligent Transportation Systems (ITS) attracted the attention of many researchers for the purpose of improving the traffic monitor, road safety, and signals utilization. Vehicular Ad-hoc Networks has been proposed as ITS environment due to its ability to managing traffic, enhance road safety using GPS information, computing power, and media. A VANET is communicating among the vehicles by using a wireless network to provide services of transport and traffic management (Whaiduzzaman, Sookhak, Gani, & Buyya, 2014). There are two components of VANET architecture: hardware and software. There are three types of communication in vehicular ad hoc network: 1.) vehicles-to-road infrastructure (V2R); 2.) vehicle-to-vehicle (V2V), and; 3.) vehicles-to-sensors (V2S) communication (Kumar, Singh, Bali, Misra, & Ullah, 2015; Eltahir, & Saeed, 2015). In the V2V, the vehicles communicate with another by using On Board Units (OBU), while the vehicles communicate in the V2R with infrastructure units like road side units (RSUs) (Eltahir, Saeed, Mukherjee, & Hasan, 2016).

Many technologies have been found to enhance Intelligent Transportation Systems (ITS). Some of the solutions to face the challenges of VANET were proposed such as Cloud computing and later than appearance Mobile Cloud Computing and Vehicular Cloud Computing (VCC) (Whaiduzzaman, Sookhak, Gani, & Buyya, 2014). In Cloud Computing, users share resources such as applications, location, and storage over the Internet. The increasing of mobile applications and mobile devices new technique appeared called mobile cloud computing to overcome shortages of Cloud Computing. Vehicular Cloud Computing (VCC) has a big effect on the ITS specially when using the resources of vehicles like computing power for instant decision making, the internet, storage, GPS, and sharing information on the cloud. VCC has many benefits such as low energy, real-time services of software, platforms, and infrastructure with QOS to passengers and drivers. And also VCC prove, better road safety, and secured intelligent urban traffic systems. The list of acronyms which appeared in this chapter is given in Table 1.

This chapter is organized as follows:

- Firstly, offers an overview of vehicular ad-hoc networks.
- Discusses the cloud computing and mobile cloud computing.
- Provides an overview of Vehicular Cloud Computing (VCC).
- Present and discuss about related work.
- Explains the architectures and organization of VCC.
- Focuses on the applications of the VCC.
- Discusses the challenges.
- Finally, talk about opportunities and the future for VCC.

VEHICULAR AD-HOC NETWORKS (VANET)

A VANET is a communications between the vehicles to exchange sensitive information like a condition of weather and road accidents to improve vehicle traffic efficiency through ITS. The main aim of VANET is to obtain the highest safety on the road (Sugumar, Rengarajan, & Jayakumar, 2016). Vehicles, Infrastructure Domain, and Road Side Unit (RSU) are the contents of VANET architecture (Bhoi, & Khilar, 2014). In a VANET, the communications between vehicles by using wireless equipment such as OBUs for

Table 1. List of acronyms

CaaS	Cooperation as a Service
CC	Cloud Computing
DaaS	Data as a service
DSRC	Dedicated Short Range Communication
INaaS	Information as a Service
ITS	Intelligent Transportation Systems
MCC	Mobile Cloud Computing
NaaS	Network as a Service
OBU	On Board Unit
PaaS	Platform as a Service
RSU	Road Side Unit
SaaS	Software as a Service
STaaS	Storage as a Service
V2I	Vehicle-to-Infrastructure
V2S	Vehicles-to-Sensors
V2V	Vehicle-to-Vehicle
VANET	Vehicular Ad-Hoc Networks
VCC	Vehicular Cloud Computing
VCN	Vehicular Cloud Network
WAVE	Wireless Access in Vehicular Environment

V2V and RSUs for V2R. This communication happens when the Dedicated Short Range Communication (DSRC), which is a standard, developed by the USA, and enabled IEEE 802.11p. A VANET classified into two types based on network topologies: infrastructure-less (ad-hoc) and infrastructure-based (Cushman, Rawat, Chen, & Yang, 2016). The V2V communication is transmitting data by using broadcasting or multicasting. The broadcasting is classified into naive and Intelligent, naive broadcasting which generate the collision, but the collision is decreased when using intelligent broadcasting. In a VANET to avoid accidents or congested, the vehicle broadcasts messages called beacons (Rajput, Abbas, & Oh, 2016) contain very important information like location, direction and a speed of it. This beacon makes a VANET is attractive areas for engineers and researcher, many papers focus on a VANET application and characteristics. The VANET had many important characteristics like high mobility, a dynamic environment, and relatively low antenna heights on the vehicles and RSU (Viriyasitavatm, Boban, Tsai, & Vasilakos, 2015). These characteristics make the VANET facing more issues and challenges. However, a VANET has some shortcomings, therefore new technology appeared called a cloud computing.

CLOUD COMPUTING (CC)

Nowadays, cloud computing (CC) is an active area because delivering services to users over the internet through sharing resources such as applications and storage. In the CC, when tasks sharing by users, it can carry out their tasks fast and efficiently as well as decrease the computation time (Bajpai & Singh, 2016). Addition, the providers of cloud service manage a network infrastructure for collection the computing power enormous from a number of servers. Cloud computing has some main characteristics like (Verma, & Kaushal, 2011; Habib, Hauke, Ries, & Muhlhauser, 2012):

- Multi-tenancy or sharing of resources
- On-demand self-service
- Ubiquitous network access
- Rapid elasticity
- Measured service

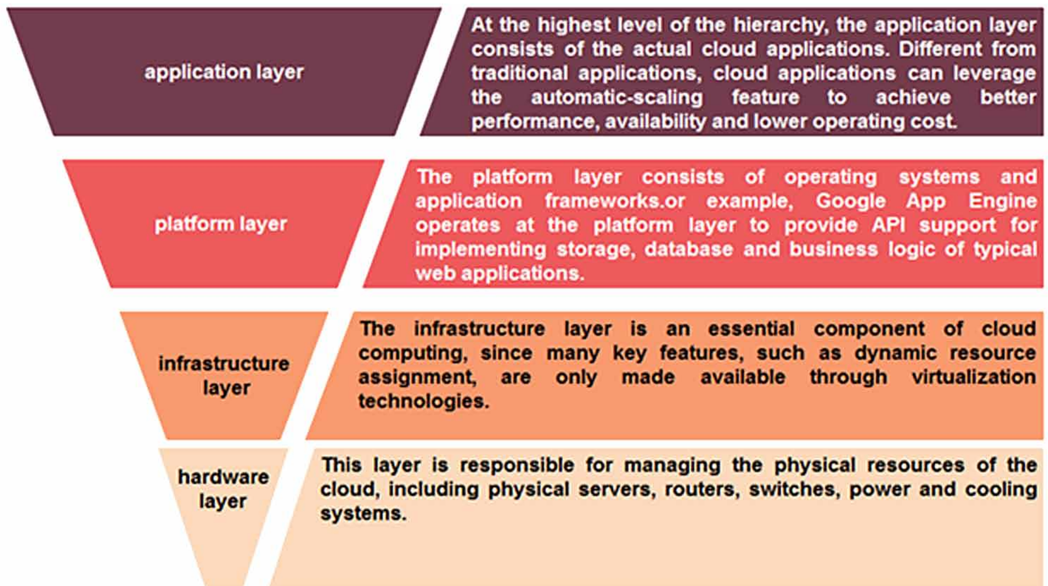
CC has several features which provided advantages for a business domain such as No up-front investment, highly scalable, lowering operating cost, easy access and reducing business risks and maintenance expenses (Zhang, Cheng, & Boutaba, 2010). Moreover, it has many advantages such as connecting services, shared architecture, flexible nature, and metering architecture (Hindia, Reza, Dakkak, Awang Nor, & Noordin, 2014). The cloud computing architecture separates into 4 layers: the hardware layer, the infrastructure layer, the platform layer and the application layer, demonstrated in Figure 1. CC is categorized into four models: public, private, hybrid and community. Each of these models is divided into three service models: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) (Cardoso, Moreira, & Somoes, 2014).

MOBILE CLOUD COMPUTING (MCC)

In mid-2007, a new technique was appeared which called mobile cloud computing. and it become attractive area for business domain because of a spread use of a mobile applications with low cost. When the processing and storage for data was occurring outside of the mobile device, this infrastructure called mobile cloud computing. The applications moved from mobile phones to the cloud, to share applications, data storage and mobile computing among the mobile devices (Singh, Kaur, & Sandhu, 2015). So, the Mobile cloud computing using in a wide range of application like crowd computing, natural language processing, sharing GPS, image processing, sensor data applications, querying, sharing Internet access, and multimedia search (Fernando, Loke, & Rahayu, 2013).

Mobile cloud computing has several advantages: a) all users anywhere and anytime; can be access to services; b) the services provide information to users such as location and context; c) Improves processing power and capacity of data storage; d) extending the battery lifetime; e) Mobile computing has found many solutions to overcome cloud computing problems (Singh, Kaur, & Sandhu, 2015; Shravanthi, & Guruprasad, 2014; Dinh, Lee, Niyatio, & Wang, 2013). Most of the mobile applications, such as mobile commerce, mobile learning, and mobile healthcare, benefited from the MNC advantages. The architecture of mobile cloud computing classified based on data centers layer and the cloud service standard model that includes Platform as a Service (PaaS), Infrastructure as a Service (IaaS), and Software as a Service (SaaS) (Singh, Kaur, & Sandhu, 2015; Fernando, Loke, & Rahayu, 2013). Although it has several advantages and services provided to users, it faces many challenges like computing offloads, low bandwidth, quality of services, and security for mobile users.

Figure 1. Cloud computing architecture



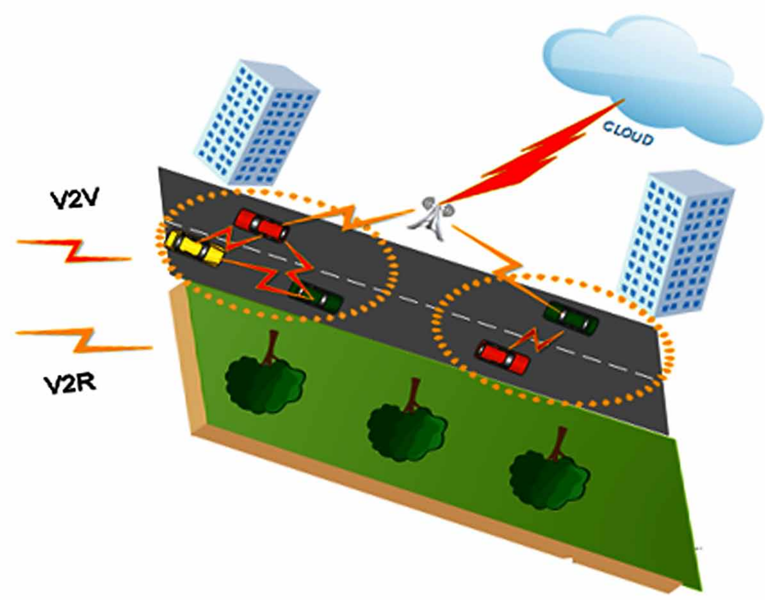
VEHICULAR CLOUD COMPUTING (VCC)

Vehicular cloud computing (VCC) is an extension of mobile cloud computing (MCC). In VCC vehicles, the resources and services could arrive in real time for information from anywhere. This makes passengers and drivers access numbers of new applications to provide various services (Othman, Madani, & Khan, 2014; Ahmad, Noor, Ali, & Qureshi, 2016). So, VCC considers the basis for improving and developing intelligent transportation systems and rich environment for researchers. Additionally, it plays a major role in people's lives due to providing safety, security, trust, and comfort to passengers and drivers. The basic objective of VCC is to provide low-cost services to drivers, and to reduce accidents, congestion of traffic. The traditional cloud computing provided services such as software, storage, and computing resources, but in the vehicular cloud appeared other services. Figure 2 shows the vehicular cloud computing, which exchanges information between the vehicles or between cloud data center, and vehicles for the vehicular through RSUs in order to computing or storing.

The VCC services classified into three types: 1.) Network-based services; 2.) Sensing-based services, and; 3.) Cooperation-based services (Mekki, Jabri, Rachedi, & ben Jemaa, 2016).

- **Network-Based Services or (NaaS):** Where some vehicles on the road have Internet, and it can be used by others vehicles which that haven't Internet.
- **Cooperation as a Service (CaaS):** When the driver and passengers access to the applications and use the services like a road condition, and traffic information of this type (Sharma, & Kaur, 2015).
- **Sensing-Based Services:** Where vehicles can share sensing information between them to improve the knowledge of drivers (Mekki, Jabri, Rachedi, & ben Jemaa, 2016).

Figure 2. Vehicular Cloud Computing



The vehicular cloud infrastructure provides services to several domains such as scientific application, social networking, education, and business etc. Vehicular Clouds provide services, like Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Application as a Service (AaaS), Software as a Service (SaaS), and Storage as a Service (STaaS), to vehicle when connected via OBUs to get unlimited storage and computing power (Ahmad, Noor, Ali, & Qureshi, 2016). The VCC improves the road traffic management and or by reducing the risk of life, cost and time.

RELATED WORK

Recently, Baby et al. proposed a new method known as Vehicular Cloud for Roadside scenarios (VCR). VCR architecture has separated into two types: the public cloud and private cloud communication. The main aim is to provide safety and non-safety services in vehicular applications through the public and private vehicular cloud to fulfill max benefit (Baby, Sabareesh, Saravanaguru, & Thangavelu, 2013). Chang, Yao-Chung, et al. used Software-Defined Networking (SDN) architecture to assist a vehicular cloud serving system and or by achieving highly efficient services. The design based on SDNBroker system which is an SDN application to schedules resources using the linear programming algorithm and improves network routing using Dijkstra's routing (Chang, Chen, Ma, & Chiu, 2015).

An intelligent transport system (ITS) had a high impact on people's lives because it provide several applications, safety, and other information to the passenger and drivers as well as manage traffic of vehicles. So, the author has (Meneguette, 2016) proposed VehIcular Cloud Transport Management (VIC-TiM) to a management a big city as well as to provide mechanisms for storage of information and allow carrying out heterogeneous communication among the several vehicles. Azizian et al (2016) proposed a new solution to solve the service delivery problem more efficiently by using VC based on transmission scheduling methods. Distributed clustering algorithm (DHCV) was used to fulfill this proposed through creating a cloud of vehicles have fixed size and regulate vehicles inside cloud according to mobility (Azizan, Cherkaoui, & Hafid, 2016). After that applied transmission scheduling methods to improve delay and throughput for the service delivery.

In (Garai, Rekhis, & Boudriga, 2015) the authors proposed a cloud Communication-as-a-Service (CaaS) have three aims in their: firstly, provide a continuous communication to vehicles when the move outside area uncovered through Roadside units, secondly overcome from resource limit, and lastly supply high Quality of Service (QoS). The architecture was separated into three layers based on a tree topology: Vehicular Cloudlet (V-Cloudlet), Roadside Cloudlet (R-Cloudlet), and central cloud (CC).

Merging vehicular social networks and mobile wireless communications became future of networks, so, Li, Ting, et al. proposed a new method to support marketers known as On Selecting Vehicles as Recommenders for Vehicular Social Networks (SV-VSNs) (Li, Zhao, Liu, & Huang, 2017). Three algorithms to improve were present efficiencies for marketers based on benefit factor, coverage factor, and geographical track to select vehicles in vehicular social networks. The obtained result was effective when applied in real traffic in some cities.

Recently, location-based services (LBS) use become widespread to assist people and make life very easy, but facing some issues such as privacy. To solve this problem, Zhu et al. (2016) suggests a new scheme called efficient and privacy-preserving LBS query scheme in the outsourced cloud (EPQ) (Zhu, Lu, Huang, Chen, & Li, 2016). The EPQ depends on the encryption mechanism especially spatial range query algorithm over ciphertext (SRQC). EPQ proved excellent for facing the most security threats, and adding an effective performance in the cloud server.

Road traffic complexity leads to one of the important issues which are a collision. Many research puts approaches to solving this issue, in (Riaz, & Niazi, 2016) offers a comprehensive study for a survey of vehicular cyber-physical systems (VCPS) from the collision-avoidance perspective. In addition to aid researchers through giving solutions to avoid a collision and understanding communication of vehicular cyber-physical systems.

VEHICULAR CLOUD COMPUTING ARCHITECTURES

The architecture of Vehicular cloud computing was based on three layers, which are: inside-vehicle layer, cloud computing layer and the communication layer, as shown in Figure 3.

- **Inside-Vehicle Layer:** Also called an on-board layer. In an Inside- vehicle layer, before establishing communication among the vehicles, firstly the vehicle sense the environment, road condition and collecting information inside the car or other parameters by using a number of sensors such as vehicles' internal sensors and smartphone sensors (Ghafoor, Mohammad, & Lloret, 2016). The collated information either store on the cloud or considered as input for other software programs in the application layer.
- **Communication Layer:** The communication layer is the next layer used to enable communication between vehicles and vehicular clouds through cellular communication devices such as 3G or 4G, Wi-Fi, WiMAX, Wireless Access in Vehicular Environment (WAVE), IEEE 802.11p or Dedicated Short Range Communication (DSRC) (Mekki, Jabri, Rachedi, & ben Jemaa, 2016). The communication on this layer is classified into two: vehicle-to-vehicle (V2V) and vehicle-to-

infrastructure (V2I). The connection among the vehicles needs an equipment such as On-Board Units (OBUs) and GPSs to make the internet available on moving devices. In V2V, communicate between vehicles is directly established to provide traffic safety and related applications for the passengers and drivers. Unlike the V2I where the communication is indirect among vehicles, infrastructures and the cloud to exchange Information over wireless networks like satellite, 3G (Whaiduzzaman, Sookhak, Gani, & Buyya, 2014).

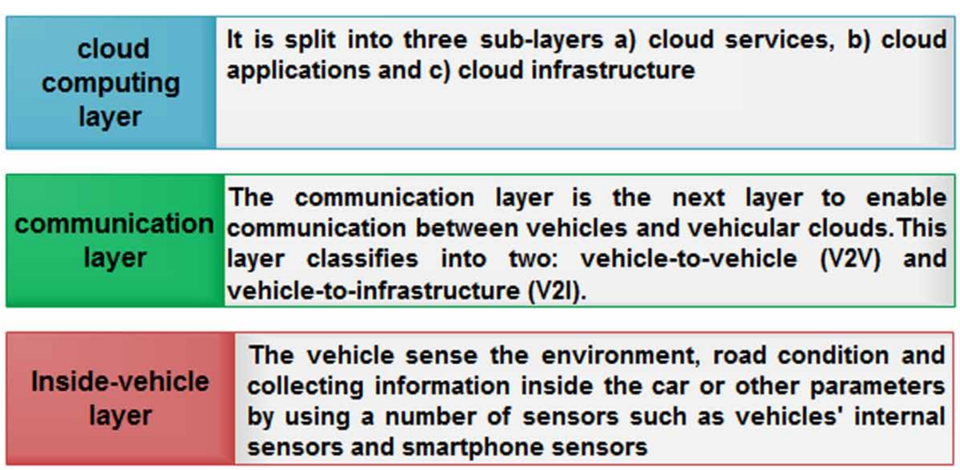
- **Cloud Computing Layer:** The last layer called cloud computing layer. It is split into three sub-layers:
    - Cloud services.
    - Cloud applications.
    - Cloud infrastructure.

Cloud infrastructure consists of computation cloud and cloud storage. Cloud storage, which is responsible for storing all information that is collected in the on-board layer (Sharma, & Kaur, 2015). Cloud computation plays an important role in improving network performance by using computational tasks such as the health and behavior of the driver in cloud storage. Cloud applications consist of many applications and services used by passenger and driver these applications like health, human activity, and environmental recognition. Figure 4 illustrates most details for vehicular cloud computing architecture.

Several services such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Application as a Service (AaaS), Software as a Service (SaaS), Network as a Service (NaaS), Information as a Service (INaaS), Data as a service (DaaS), and Storage as a Service (STaaS), consider basic parts of cloud services. Several vehicles on the road, one of them have internet and another doesn't have the internet. The vehicles have internet can provide access the Internet for other vehicles that need Internet this process know as Network as a Service (NaaS) (Sharma & Kaur, 2015).

The services have permission to exchange information among the vehicles in the same cloud. Often the drivers want the important kind of information like news of large events, advance warnings, and road conditions. The Information as a Service (INaaS) response for supplying these information to a driver.

Figure 3. Layers of the architecture of vehicular cloud computing



When the passenger and drivers on the road used all hardware to run the applications at the same moment, this leads to need an additional storage. So, some vehicles have a higher capacity for storage and it can provide the repository for storage to other vehicles that have low storage capability. It knows virtual network hard-disk and also called Storage as a Service (STaaS) (Mershad, & Artail, 2013).

ORGANIZATION OF VCC INFRASTRUCTURE

Vehicular cloud computing can classify into two types: static VC and dynamic VC (Ghafoor, Mohammed, & Lloret, 2016; Hussain, Son, Eun, Kim, & Oh, 2012; Olariu, Khalil, & Abuelela, 2011).

1. **Static VC:** Earlier, people spend a lot of time in shopping, airport, work, and hospital and when parking their vehicles. Most companies are thinking to take benefit from advantages of parking because those vehicles consider idle computing resources. Static VC creates center data storage when combining between a computer cluster, storage resources, and computational power of the participating vehicles. Figure 5 shown static VCC.
2. **Dynamic VC:** Dynamic formation of VC because of the high mobility of the vehicles and the speedily change among the networks. One of the vehicles on the cloud, known as cloud head, is responsible to invite all near vehicular to join for formation dynamic VC, as shown Figure 6.

APPLICATIONS OF VEHICULAR CLOUD COMPUTING

Because of sharing resources among the vehicular and RUS with clouds, the VCC provides a vast range of applications like in an airports as a data center, traffic management, road safety message, managing

Figure 4. Vehicular cloud computing architecture

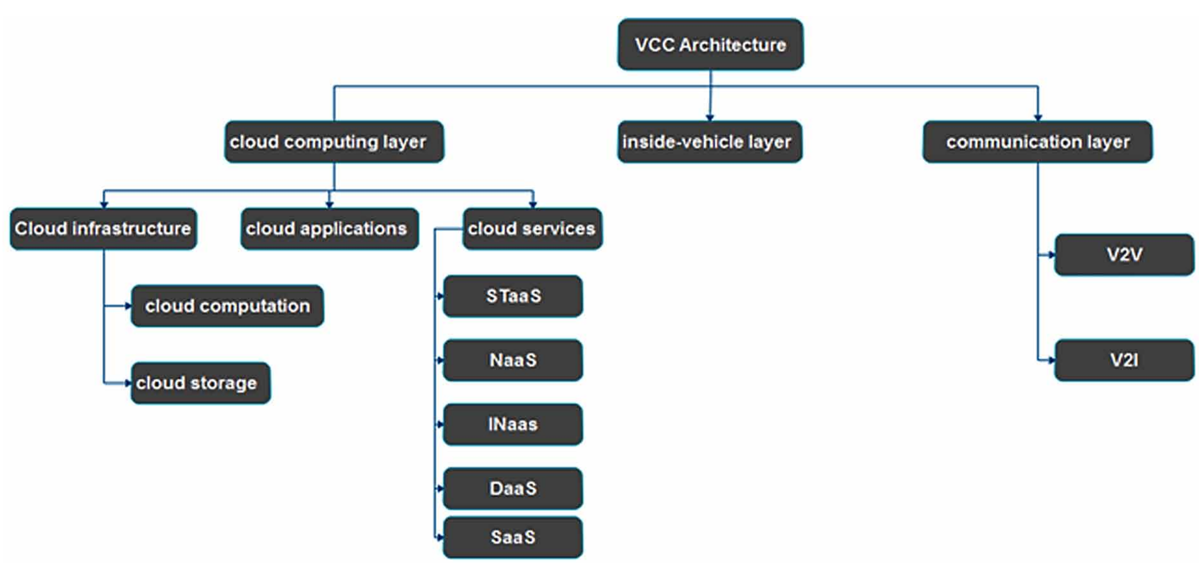


Figure 5. Static VCC

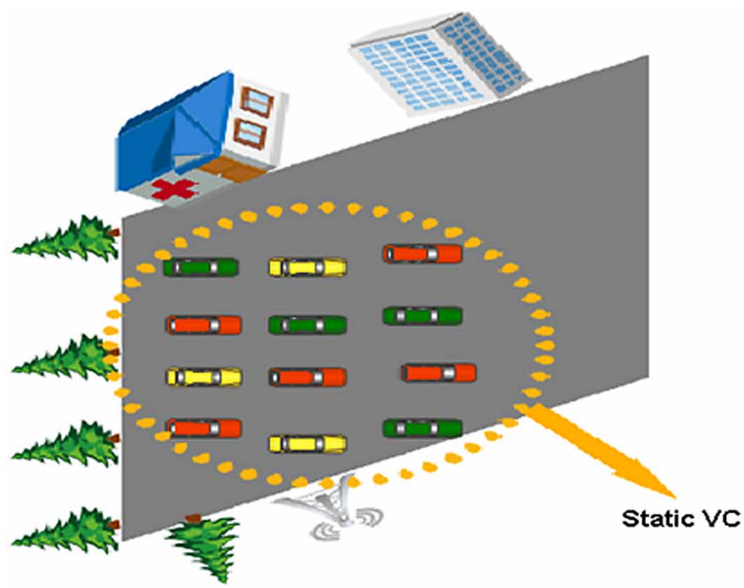
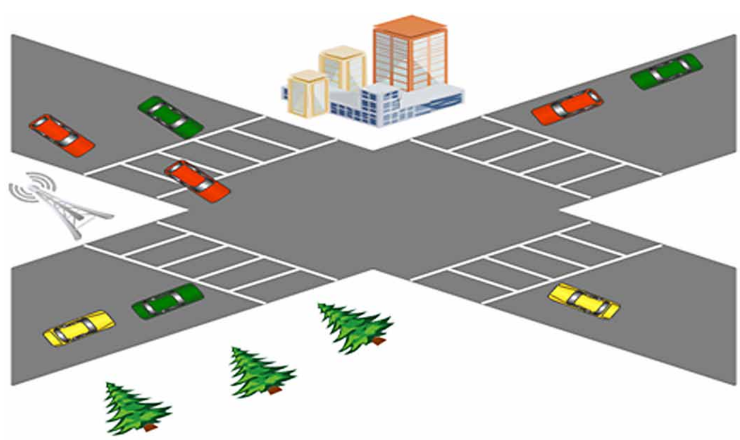


Figure 6. Dynamic VCC



parking facilities, real-time navigation, vehicle maintenance, accident alerts at intersections, parking lot data cloud, and managing evacuation etc. (Whaiduzzaman, Sookhak, Gani, & Buyya, 2014;Ghafoor, Mohammed, & Lloret, 2016; Yan, Wen, Olariu, & Weigle, 2013; Gu, Zeng, & Guo, 2013; Olariu, Eltoweissy, & Younis, 2011). The following paragraph described several applications:

1. **Road Safety Message:** It is one of the important alerts on road because the VCC contributes to road safety. Modern vehicles have a sensor, to monitor road and provide road safety for drivers and passengers, to query the state of roads such as risk, flooding areas, overcrowding, temperature, and speed, to evaluate the situation of other vehicles and alert drivers.

2. **Traffic Management:** The result of the increasing number of vehicles, the traffic management plays an important role on the road to find the best solution for several problems which face drivers and passengers such as wastes the valuable time and energy of human, threatens the health of citizens and needs the huge computational effort to be solved. One of the solutions which provide to manage the road, drivers receives reports about status for traffic (e.g., congestion) from VCs. Reduce frequent congestion is one of the important application types for traffic management. In the congestion, some drivers want to transform the road (Yan, Wen, Olariu, & Weigle, 2013). This decision depends on the last information on the vehicular and itcloud provide an efficient solution to the drivers. This information being available after calculating the impact of the local road and the cause of the congestion in the traffic flow.
3. **Real-Time Navigation:** Navigation is a static geographic map for vehicles in traditional networks, but the VCC has a virtual-reality application which the drivers can move freely without hurdles. To provide a real-time navigation for vehicles. the 3D space for interaction with the virtual environment was used.
4. **Management Parking:** In the populated areas, it is difficult for drivers to find parking space. The VCC allows drivers to book parking easily supplying near and suitable space because all information related locations parking found in the cloud.
5. **Managing Evacuation:** The disaster authority uses the model the road to monitor traffic to execute an evacuation. Therefore, evacuation events can be divided into cases where prior notice of an imminent event is provided. In the VCC, vehicles and vehicular cloud are taking part of the evacuation process to make decisions on the current situation.
6. **Data Center Configuration:** In mall, hospital, work, and the airport, the people are parking their vehicles for several hours or days. During this period, the vehicles are considered inefficient resources. Can benefit from parking to build a data center. The vehicular takes part of the cloud through connected to the Internet by cable. But one of the important challenges of parking data center structure is dynamic, because of time for arrival and spends per vehicles in parking unknown.
7. **Improving Traffic Signals:** Traffic signals have high significant on the road to assign a length of signal cycle and green phase lengths. Thus, VCs can maximize the signal system performance by making dynamic use of a vehicular network.

VEHICULAR CLOUD COMPUTING CHALLENGES

In the vehicular cloud computing, the mobility of nodes is very high and topology changes in the network frequently so appeared issues and challenges facing the VCC such as message confidentiality, trust management, securing vehicular communication, authentication, secure location information, the safety of messages, and the interoperability of different clouds. In this section, all these challenges can be discussed and concentrate on the issues correlated with ITS applications like security, traffic management, navigation systems, and congestion detection (Whaiduzzaman, Sookhak, Gani, & Buyya, 2014;Gu, Zeng, & Guo, 2013; Chaqfeh, Mohamed, Jawhar, & Wu, 2016; Aloqaily, Kantarci, & Mouftah, 2015; Ahmad, Kazim, Adnane, & Awad, 2015; Karagiannis, Altintas, Ekici, Heijenk, Jarupan, Lin, & Weil, 2011).

1. **Threats for Vehicular Cloud Computing:** All VCC components: vehicles, passengers, messages, wireless communication, and architectures need security against attackers. In vehicles, attackers attempting to access application unit and enter malware in it, while wireless communication considered between the vehicles or RSUs via V2V and V2R communication the best environment for the attackers, because it contains some vulnerabilities. The wireless communication threats classified into:
   a. **Denial of Service (DoS):** It blocks communication by using reject any members to forward important messages to other vehicles or the cloud.
   b. **Data Tempering (Modification):** In this type, the attacker objects the messages when the routes to other vehicles or RSUs and after that can modify and alter it.
   c. **Jamming:** DoS attack to make jamming in the channel for wireless communication which carries the messages.

There are also several threats like repudiation, information disclosure, and sybil attack. To provide secure vehicular cloud computing, communication takes considering requirements for security like authentication, integrity, and confidentiality.

2. **Authentication, Privacy, and Liability:** In VCC, the communication depends on the integrity of messages and authentication of the users. To increased authenticate between RSUs and vehicles in the vehicular networks, the vehicles used aliases to deception the attackers for not track their communication and activities. Also, exchange information between the vehicles requires being privacy and trust. The privacy is one of the most important challenges in VCC. Many researchers are working to find methods and solutions used to protect the privacy of the vehicles in a vehicular network. The passengers and drivers have controlled exchange information and determine, what the information open on networks, and what the information keeps private and can't broadcast on the networks.
3. **Service Delay and Location:** Because to the topology in the network changes quickly, the time and location play an important role on data packets sent by applications for vehicular networking. In VCC, the most applications depend on the information on the current location of a vehicle such as collision, congestion avoidance, and traffic status. The vehicular networks use devices like GPS, filtering, inter-cell position, and radar to check the location information. Many researchers proposed several methods to check the location information. These methods can classify into three types: active location, active location and general location (Whaiduzzaman, Sookhak, Gani, & Buyya, 2014).

In vehicular cloud computing, the delay can impact on price for service. So, the passengers and drivers are interested about service delay, because the increase of service delay leads up to increase the price for service.

4. **Confidentiality, Integrity, and Trust for Messages:** At VCC, messages split into four types: the first one using to send alerts or warning messages called short message, second known as media message, utilize when the vehicle needs services from other cloud or vehicles, Priority message is third one employed to end the warning messages, the last one acknowledge message after deliv-

ery of messages send these to confirm access. Most applications for a vehicular network focused verification and trust to provide a secure communication. Confidentiality is an important issue, all messages in the network can't read by an unauthorized user, but after encrypting the messages and allowing only access to authorized users. Therefore, the RSU registers all vehicles and users that enter the domain to increase confidentiality by using secure and encrypted communication. Furthermore, to safeguard the networks from security threats such as denial of service, forgery and jamming attack, must verify the integrity for receiving messages.

5. **Securing Vehicular Communication:** In the environment of a vehicular cloud, from the important providing secure communications to avoid attackers and reduce security holes like traffic tampering, privacy violations, forging messages, and preventing communication by utilizing cryptographic algorithms (Ahmad, Kazim, & Adnane, 2015; Falchetti, Azurdia-Meza, & Cespedes, 2015). The big problem facing the cryptographic algorithm is key management, so found a method for the solution this problem. The Vehicular Public Key Infrastructure (VPKI) is one of the methods key management to guarantee confidentiality and integrity of the message in vehicular networks.

OPPORTUNITIES AND FUTURE FOR VCC

The vehicular cloud computing plays a major role in people's lives due to traffic management and providing safety, security, trust, and comfort of passengers and drivers, so considered very rich environment for researchers. It considers the basis for improving and developing intelligent transportation systems. However, the development and improvement process still constrained by several factors such as challenges and issues for VCC. Several applications and services appeared in the last days result from exploiting the resources by the vehicular cloud. Future of VCC in next days benefits from underutilized resource and exploits it to the maximum extent such as to benefits, capacities of storage and computation which owned by modern vehicles, and time which wasted in the parking. So, some companies are thinking to rent resource from the parking to carry out some application or task.

In (Dressler, Handle, & Sommer, 2014), the authors present a new method, known Virtual Cord Protocol (VCP), depends on the benefit from parked vehicles to create a cloud for storing information and to provide network communication between the moving vehicles and the vehicle storing the requested data. The inter-domain routing techniques used to enable dynamic cloud services and to achieve the communication between the moving vehicles and cloud. W He, et al proposed a new architecture for IoT-based vehicular data clouds, by integrating several devices, cloud computing, and IOT to Share resources and exchange information among the passengers, vehicles, and roadside infrastructure (He, Yan, & Da Xu, 2014). The (He, Yan, & Da Xu, 2014) study and face two vehicular data cloud services: the first one is intelligent parking cloud service and the second is the mining vehicular maintenance data service. Although finding several challenges this method provides enormous opportunities for technology in the vehicle industry.

Wan et al (2014) proposes a context-aware architecture with mobile cloud support and two crucial service components, namely cloud-assisted Context-aware Vehicular Cyer-physical systems (CVCs). This paper studies context-aware dynamic parking service as a case study to improve QoS and the performance of CVCs. Addition, discuss the challenges and find potential solutions (Wan, Zhang, Zhao, Yang, & Lloret, 2014). It will consider this attractive field for researchers in the near future.

To benefit from sensors such as map, radar, and lidar the authors proposed a new method to detect the vehicles on the way or parked on the roadside to provide the best motion, the easiest method to pass the parked vehicle, and assuring safety for drivers and passengers (Mei, Nagasaka, Okumura, & Prokhorov, 2015). Additionally, assist drivers to make the decision to choose the smooth and safe path to avoid harassing from other vehicles.

The traffic accidents and traffic flow issues are major challenges for VCC, maybe occur when the vehicles parked on the way illegally. So, the authors presented the new system to monitor traffic and detect traffic flow to avoid accidents by using cumulative dual foreground differences (Wahyono, & Jo, 2017). The results appeared that the method is efficient and can be considered as part of the intelligent traffic monitoring system, but possibly generate false results when producing a noisy foreground image.

The nature VCC has open communication medium, fast topology changes, and dynamic. Thus, one of the key challenges is exchange information due to nature VCC can be fake and lead to sharing false information between drivers and passengers. Sharma et al (2015) presented a new method by using Elliptic Curve Cryptography (ECC) to provide security for communication to guarantee authentication, integrity, confidentiality, and privacy between sender and receiver (Sharma, Bali, & Kaur, 2015). The ECC has several advantages to against various attacks like spoofing attack, replay attack.

Huang, Cheng, et al presented new method, Privacy-Preserving Trust-Based Verifiable Vehicular Cloud Computing scheme (PTVC), to improve safety for traffic and offering services to passengers and drivers (Huang, Lu, Zhu, Hu, & Lin, 2016). The mechanism PTVC system merges between the best advantages of VCC, techniques of verifying, and requirements of privacy, to select the trustworthy vehicle among the vehicles to create a vehicular cloud. The PTVC scheme proves is effective, secure and robust against several attacks.

CONCLUSION

In this chapter, we first talked about vehicular ad-hoc, cloud computing, mobile cloud computing, and we listed all the related to vehicular cloud computing such as architecture, organization, application, challenge, and future. Firstly, we discussed architecture for VCC and then a detailed explanation of the tasks of each layer and clarification of types of services. After that, we talked about the type of organization for VCC infrastructure. Because of sharing resources among the vehicular and RUS with clouds, we highlight for applications providing by VCC like an airport as a data center, traffic management, road safety message, managing parking facilities, real-time navigation, vehicle maintenance, and accident alerts at intersections, etc. Addition, we will survey the issues and challenges facing the vehicular cloud computing resulted from high mobility and the fast topology changes in the network. Finally, we discussed opportunities and the future for VCC that can be the basis to open research directions.

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