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A review on Vehicular Cloud Computing: Issues and prominent future challenges

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Abstract-
Nowadays Internet of Things has become an important phenomenon in everyone life. Vehicular Internet of Things, which involves communication and data exchange between vehicles are key to realize the vision of intelligent transportation. The vehicles have been equipped with smart devices that offer various multimedia-related applications and services like smart driving, traffic management, weather forecasting, road safety alarms, entertainment and comfort. The smart vehicles produce a large amount of multimedia-related data that require fast and real-time processing. But due to constrained computing and storage capacities, huge amounts of multimedia-related data cannot be processed in standalone devices. Thus multimedia cloud computing has emerged as key computing technology that can process multimedia-related data efficiently while providing improved Quality of Service to vehicular users from anywhere, any time and on any device at reduced costs. Vehicular cloud is getting significant research attention due to the technological advancements in smart vehicles. This paper present taxonomy of vehicular clouds that defines the cloud formation, integration and services and explore the object types involved and their positions within the vehicular cloud. This paper also address potential future challenges and emerging technologies, such as the Internet of vehicles and its incorporation in traffic congestion control in context of vehicular cloud computing.

Keywords: Internet of Things, Vehicular Clouds, Multimedia, Traffic Management, Smart Driving.

1.1 Introduction:

Recently Vehicular Ad Hoc Networks (VANETs) have received significant research attention based on the growing interest in smart vehicles and cities. A smart vehicle is typically equipped with storage and computing computable resources. These vehicles are equipped with built-in sensors to gather a myriad of useful information. A network of these smart vehicles, where vehicles communicate and share information with each other in real-time, can help realize the vision of Intelligent Transportation Systems supporting numerous safety-related applications such as traffic management, emergency alerts etc. Traditional systems such as data loggers used inefficient passive data collection methods in sharing information among various supply chain parties while in an IoT environment offers real-time vehicle monitoring [1]. In order to manage the mutual interference between the device-to-device links and the cellular links, effective resource allocation mechanisms are needed. The resources assigned to satisfy the alteration in demands for services are adapted by dynamic resource assignment techniques.

The smart vehicles in VANETs use Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communications to access the public Internet resources in order to download content or to store content in the Internet cloud infrastructure. It is costly to upload content or to search and pull content to and from the Internet cloud. Moreover, many vehicles in the vicinity would also be searching for contents that have relevance in terms of spatial and temporal scope and local interest. For example, an accident warning message is only of relevance to vehicles in a specific region while a roadwork information dissemination message must remain valid till the roadwork is in progress. Similarly, the neighboring vehicles constitute the majority of consumers that have an interest in the information produced by a vehicle. The application server is responsible to provide real-time services with constant bounds on the delay. Also, many computational tasks can be performed on small databases which lead to overhead reduction. In real-time vehicle monitoring, the EC is useful to offer a real-time and low latency transmission of the vehicles' information [2-3]. For Vehicular clouds RL-based techniques can provide an ideal solution for designing a resource assignment model for vehicular clouds in real-time vehicles monitoring during transportation. RL is a strong tool in managing scenarios that consider real-world complexity and is useful for designing efficient dynamic resource provisioning heuristics for vehicular clouds [4]. RL can solve optimization problems for an individual agent but the application of RL to solve system optimization problems in dynamic, real-time vehicles monitoring is an open research problem. Traditionally, researchers have focused on optimization methods to solve real-time vehicles monitoring problems using prior knowledge, but these methods are not vi-able in dynamic environment that resources change frequently [5]. These days, vehicular communications provide a strong way to connect vehicles with different devices and users in improving transportation. Recently, vehicular cloud networks (VCN) has been proposed as combination of vehicular ad-hoc networks (VANET) and cloud computing to solve some of the exiting challenges of the vehicular networking such as storage, computing, etc. In order to address the challenges for efficient monitoring of vehicles in transit, a vehicular cloud based solution can be adopted. However, the vehicular cloud is a complex setting with soft and hard quality-of-service (QoS) needs on its services [6]. Vehicular data are processed and the information is shared among vehicles to control traffic flow. At present, vehicles have multiple radio interfaces that enable vehicles to communicate with roadside units (RSUs) and other access networks such as 3G/long term evolution (LTE). The availability of different communication technologies in vehicular clouds addresses the problem of intermittent connectivity, but it also simultaneously introduces heterogeneity in communication. There is intermittent communication links requiring high-speed data transfer in a mobile topology, with dynamically altering demands for services with varying QoS requirements. Hence, dynamic and efficient resource provisioning is vital for successful vehicular clouds. Since the traditional cellular networks have limitations such as, inefficient and unsalable packet forwarding, and QoS management, the software defined networking [7].

1.2. Related Work

H.N. Dai et. al [10] stated that the rising significance of wireless vehicular networks indeed related to the growth and acceptance of mobile wireless communications, in which through progresses in wireless channel modeling methods and the succeeding progress of complex digital transmission approaches, providing high data rate communications is possible while following the severe QoS requirements. L. N kenyereye [11] proposed scheme applies privacy to the identification of a vehicle and its data flow through a pseudonym mechanism. This scheme also ensures authorization through secret credentials and authentication through identification-based signatures. Hence, the verification of a user’s information and identification of intruding vehicles are done through batch verification and a pseudonym block list, respectively. Moreover, the requirement for accessing information related to transportation has become a basic need for smart vehicles in VANETs. S. Singh, S. Negi, and S. K. Verma [12] proposed a scheme. This scheme replaces the road side unit with a dynamic cloud for managing overhead on the network and to maintain QoS to the users. The dynamic cloud collects and provides all required information to the vehicles in its range and forwards the information to a centralized controller, so (in case of emergency) a call is routed to the nearest police station and medical emergency response team to overcome the problem. However, the integration of VANETs with cloud computing has become a new research challenge due to scalability and reliability issues, because of the huge amounts of navigational data and safety messages along with event-location information. Lai et al. [13] investigate the effects of cache under modifying channel state information where multiple nodes participate in a decode-and-forward relay mechanism. The authors also presented the selection of secondary nodes to maximize the channel gain. To evaluate the proposed system, authors derived analytical expressions while considering a system with or without cache. Further, the authors conclude that cache-based systems reduce the transmission time. Guo et. al. [14] proposed a time-scaled caching scheme for Adaptive Bit Rate (ABR) video streaming in vehicular networks, in which caching is performed at base station (BS). This scheme manages the video quality, cache placement, and video transmission. The caching in vehicular networks is different from the traditional caching in wireless networks due to high-speed mobility. Feng et. al. [15] presented a framework for distributed Autonomous Vehicular Edge. In the proposed framework, the vehicles can offload computing task to other vehicles. However, the vehicles are assigned on requester priority. Besides the role as requester and enter-trainer, the vehicle can serve as a relay node to enable multi-hop communication. The proposed AVE mainly consists of two modules i.e., flow and beaconing. They include caching requests, discovery of available resources, scheduling of jobs, and data transmission. The latter is responsible for periodic beaconing to maintain a list of vehicles within the vicinity. At scheduler, jobs are served according to ant colony optimization algorithm. The applications are installed on native operating systems of vehicles and the available idle resources are managed in a virtualized manner. Baron et al. [16] presented a Software Defined Net-work (SDN)-based data carrier framework over vehicular networks. The central controller manages the vehicles to optimally route data to the destination node. The net-work consists of offloading spots at different locations. The offloading spots serve as temporary storage points where moving vehicles drop data before deviating from the destination node route. Other vehicles can again load data and offload to the next offload point, until the data reaches the destination node. The SDN controller is connected with the offloading spots and can plan the data movement considering direction of vehicles, data request, and data transfer from offloading spots to the destination. Similarly, the controller also ensures the reliability of data transfer using redundancy and Automatic Repeat request (ARQ)-based techniques. Wu et al. [17] proposed a framework. The framework uses low cost and bandwidth efficient unicast communications for handover of data between vehicles. The vehicles share their location with other vehicles through beacon messages. Before leaving a specified region, a vehicle first offloads to a new vehicle using a fuzzy logic algorithm based on through-put, stability, and bandwidth. To reduce contention at the Media Access Control (MAC) layer, a clustering mechanism is used to limit the number of senders in dense network scenarios. For the formation of the cluster, the algorithm considers channel conditions, number of neighbors heading in the same direction, and velocity of the vehicle. J. Fan, R. Li, X. Zhangn [18] presented the two-level checkpoint strategy to improve job completion rate for different job sizes. The proposed mechanism reduces the risk for missing checkpoint while executing computation-intensive jobs. The node which lies close to the executing node and in between initiating and executing node is used as a first level server for the checkpoint, while job initiating node serves as a second level checkpoint server. When executing node leaves the network, middle node reports checkpoint to initiate new node selection with the previously saved states. Liu et al. [19] proposed a relay-selective multi-hop scheme, in which a vehicular network is integrated with cloud computing to provide media services, e.g., weather forecasting, traffic congestion reports, and road safety alarms. In this scheme, Road Side Units (RSUs) communicate through the cloud via a road-side fixed communications sources. The proposed scheme is efficient at making transportation decisions in severe weather and under controlled traffic problems. Garai et al. [20] presented a QoS-aware three-layer V-cloud architecture that provides a tree-based connection to vehicles in a network. They also proposed authentication and privacy mechanisms via certification for secure communications which exploits public key certificates with zone-based vehicular groups to prevent malicious attacks. Hou et al.[21] propose a model. It forms a cloud based on moving and parked vehicles. The vehicles can also serve as relay node for communication between vehicles and the RSUs. Consequently, RSUs with the help of vehicular computing resources form a Fog. It is worth mentioning that the major benefit of this framework lies in utilization of vehicular mobile cloud for supporting remote cloud services. However, the computing tasks from the traditional cloud can also be migrated to the mobile vehicular cloud. The performance of the proposed scheme has been investigated using real data sets of different cities of China. Vigneri et al. [22] proposed a framework to utilize the vehicles as data caches to reduce the load on cellular infrastructure. In a typical system, edge nodes are used to cache data which a user can directly access without involving the source node through cellular network. In the proposed framework, base station pushes data to avail-able vehicles in its vicinity. The user request for contents is routed to vehicles enabling the user to directly fetch the data from a nearby vehicle. However, if data is not available, the users wait for the Time To Live (TTL) value before forwarding the request to the cellular network. An optimum scheme for management of cached contents and its refresh technique can improve the performance of proposed framework significantly. Mensi et al. [23] proposed a framework to utilize the storage capacity of volunteer vehicles parked in a parking lot or in a traffic jam. The vehicular data center is also connected to the traditional data center. In the proposed framework, a vehicle transfers its stored data to a newly arrived vehicle before moving away. In case, if there is no new volunteer vehicle available, the data is transferred to the coordinator vehicle that holds the data item temporarily until a new vehicle is found. In this model, each vehicle contains a unique data item with no replica being maintained to handle data loss. Data has to be fetched from the traditional data center in case of data loss. The proposed model has been validated through simulations. Wei et al. [24] proposed cache management technique to improve the quality of experience (QoE) for adaptive scale video streaming at an appropriate bit rate. The authors presented the concept of pushing data hop-by-hop to the adjacent nodes. Furthermore, the caching model is presented for the nodes. However, the mobility of the vehicular network makes the selection of potential nodes a complex task. Moreover, average freeze time, freeze ratio, and bit rate were used to evaluate the QoE from the user's perspective. Zhang et al. [25] proposed a VCC framework that com-bines vehicular cloud and cloudlets1 to provide computing capabilities to smartphones. The framework requires two conditions to initiate computational tasks offloading from smartphones. The first condition is the availability of a reliable connection between the smartphone and VCC. Second the availability of appropriate resources in the vehicular cloud. If the vehicle moves away from the vicinity of the smartphone during computation, cloudlet serves as multi-hop between the smartphone and the vehicular cloud node. The authors performed theoretical analysis, and it is shown that the technique has improved the performance and saves energy of smartphones from depletion.

1.3. Vehicular Cloud infrastructure

In VCC, vehicular resource, such as computing, storage, sensing and the Internet are shared for decision-making in traffic management and road safety. The resources and services are subscribed to on demand. Cloud computing uses the underutilized resources of vehicles for a short time. These solutions face the traditional VANET mobility and scalability problem with additional cloud computing-related resource heterogeneity and management issues. [8-9]. The interactions of vehicles, vehicles with the infra-structure, and vehicular cloud with commercial clouds (static clouds) are shown in Figure 1. The data collection and processing at devices start with the data collection at the device level, such as sensors within the vehicle. Then data are sent to the local repository of the vehicle for low-level data processing. The application programming interface circulates these data to related hardware (actuators) to generate alarms or warnings accordingly. Communication in the vehicular cloud starts within the car's communication device itself, which is referred to as in-car communication. The second level is V2V communication for resource and information sharing. Vehicle-to-cloud infrastructure communication is a larger domain of communication for services that are provided by cloud computing over underlying ICTs and a prominent form is cellular technologies.

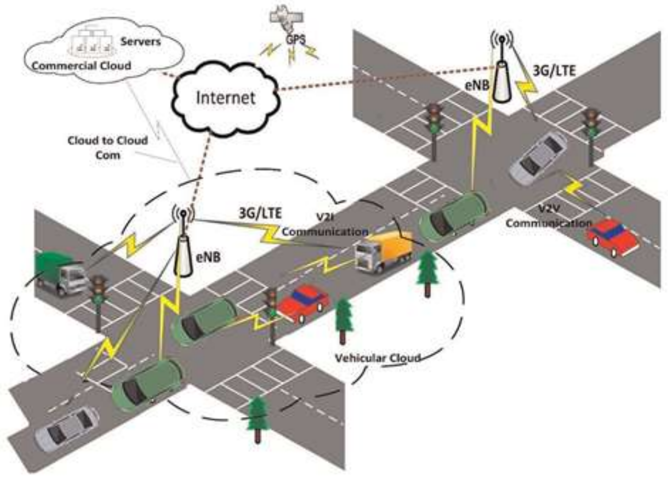

Figure1.Vehicular cloud computing

1.4. Various Types Of Vehicular Clouds

Vehicular clouds are categorized into three broad classes: V2V cloud, a vehicle to infrastructure cloud (V2I cloud) and vehicular clouds merged with other commercial clouds

V2V clouds: Vehicles on the roads or in parking areas form a cloud to share resources or services. These clouds are subcategorized as dynamic vehicular cloud and static c louds. Vehicles on the road formulate a cloud to share information on vehicle dynamics and resources. Moving vehicles and vehicular sensor clouds are examples of dynamic clouds. The sensory information of a vehicle and its surroundings is shared in the form of vehicular sensor clouds. One vehicle can obtain information by another vehicle located at the point of interest using that vehicle's sensors. Such clouds are mostly used for storage and processing purposes.

V2I clouds: These types of clouds use the V2I infrastructure to form a cloud. V2I clouds are further categorized into V2R (roadside infrastructure) and V2cellular clouds. V2R uses RSUs for control information whereas V2cellular clouds rely on 3G/LTE for communication. V2cellular clouds are useful in large areas and V2R clouds are better in small road networks. The traffic monitoring sensors installed along the roads can be integrated to form a cloud, which can be referred to as roadside sensor clouds. These clouds are useful in pro-viding participatory sensing and cooperative sensing.

Integrated vehicular clouds: When other clouds, such as mobile computing and Internet clouds, are associated with vehicular clouds, they are called integrated clouds. If the vehicular cloud is connected to the Internet cloud for GPS and other services, then the cloud is called an Internet-based vehicular cloud, and if the vehicular cloud uses the services of commercial clouds, such as the Google and Amazon clouds, then the vehicular cloud is called a services-dependent integrated cloud. The clouds in this category involve a cost factor because Internet and commercial cloud services are not free.

1.5. Various Issues and Challenges in Vehicular Cloud:

VCC helps overcome the significant challenges of real-time traffic management. VCC faces potential challenges that still require attention for the effective management of road traffic.

Architectural robustness: In multiple cloud collaboration, when each cloud has their network, hardware and software platform, successful service provisioning is difficult. Effective cooperation needs abstraction and flexibility of architecture to provide services. The VCC infrastructure should be sufficiently flexible to incorporate emerging application demands and to share a resource on the move. A level of robustness and service-oriented architecture are more feasible than the traditional layered architecture, such as virtualization.

Resource heterogeneity challenges: Vehicles produced by different vendors have different types of available resources. The type of resources in the vehicular cloud is always changing because which, where, and when a vehicle leaves or join the cloud cannot be predicted and controlled. In cloud cooperation, interoperability is essential to ensure that cloud cooperation is synchronized, reliable and efficient. Mobility and heterogeneity should be managed efficiently for different cloud resources to be utilized efficiently. The formation and operation of a vehicular cloud requires standardization so that cloud management can be done dynamically.

Communication challenges: The VCC relies on the communication infrastructure of VANET and on other access networks. Without a successful communication, cloud computing cannot occur. The use and incorporation of emerging technologies such as 4G/5G telecom technology can help in facilitating communication between vehicles reliably and without delay at a large scale. V2 infrastructure clouds can reduce the delay in response to vehicle requests for data or service in which network components serve as fog nodes. By contrast, a vehicle brings computing facilities closer to the source of the data as an edge node. As a localized computing paradigm, edge computing comprises end devices and is capable of faster response toward the core network. Edge and cloud computing may run in parallel, but edge computing extends the cloud computing capabilities

Autonomous driving: The processing capabilities of a single vehicle may not be sufficient to perform all required processing tasks. Therefore, commercial clouds are subscribed to for such data processing. Vehicular clouds fulfill some of these tasks effectively in proximity. Managing autonomous vehicles in this manner not only saves communication bandwidth but also provides a sort of resilience to the availability of the Internet. VCC supports the processing of data locally over the vehicular cloud first, which is a useful process for autonomous vehicles.

Traffic management challenges: Intersection management is a significant issue in urban intersections that cannot be avoided by simple rerouting. In this case, a birds-eye view of the area can help in managing the situation. More customized route and traffic planning are required in occasional scenarios, such as accidents and sports events. TMS suggest alternative routes and if a large bulk of vehicles follows the recommended route instantly, then the alternative route is likely to become congested as well. In such a situation, the load balancing of road traffic is necessary. The VCC can help by integrating multiple clouds and by processing all information to create a balanced traffic management plan for the overall traffic control of a city.

Incorporation of IoVs: Vehicular networks are larger infrastructures that are available as opportunistic networks for a variety of emerging technologies, such as IoVs and the Internet of Things. IoVs is an unavoidable convergence of the Internet and the Internet of Things that consists of mobile communication systems that connect vehicles and public networks. This enables IoVs to effectively guide and control the vehicles on the road. The connection system incorporates the communication between VANETs and other heterogeneous networks. One of the important components related to VCC is the cloud system. IoVs rely on cloud computing because IoVs generate much more data which can only be handled by cloud computing platforms. The incorporation of the IoVs concept is helpful for the commuter, traffic management authorities, and drivers. IoVs provide a broader perspective of traffic on roads for making right decisions at the right place and time.

1.6 Discussion and Conclusion

The Vehicular cloud computing is a combination of smart vehicles and ubiquitous sensing. Vehicular cloud computing is an emerging area, designed to support delay-sensitive applications. The concept is to employ the computing and storage resources available in vehicles by offering these resources to other vehicles or customers. Vehicular cloud is getting significant research attention due to the technological advancements in smart vehicles. In near future, vehicles are envisioned to become part of a grid network providing cloud services, such as computing, storage, network, and application as a service. This paper reviewed the recent research contributions in the emerging domain of Vehicular Cloud Computing and discussed the issues and challenges of existing work. This paper also explored the recent frameworks to provide computing, storage, and network services through VCC. This survey can help researchers to understand open areas of research under the VCC domain. The VCC is the emerging paradigm that provides a platform to develop viable solutions such as intelligent transportation system. The other areas that need further explorations are security, privacy, quality of services and user experience. The vehicular networks are well suited for the content delivery system.

References:

[1] M. Huang, A. Liu, N. N. Xiong, T. Wang, and A. V. Vasilakos, "An Effective Service-Oriented Networking Management Architecture for 5G-Enabled Internet of Things," Computer Networks , p. 107208, 2020.

[2] G. Sun, R. Zhou, J. Sun, H. Yu, and A. V. Vasilakos, "Energy-Efficient Provisioning for Service Function Chains to Support Delay-Sensitive Applications in Network Function Virtualization," IEEE Internet of Things Journal, 2020.

[3] G. Sun, Z. Xu, H. Yu, X. Chen, V. Chang, and A. V. Vasilakos, "Low-latency and resource-efficient service function chaining orchestration in network function virtualization," IEEE Internet of Things Journal , 2019.

[4] J. Wang, J. Hu, G. Min, W. Zhan, Q. Ni, and N. Georgalas, "Computation offloading in multi-access edge computing using a deep sequential model based on reinforcement learning," IEEE Communications Magazine, vol. 57, no. 5, pp. 64–69, 2019.

[5] Y. Sun, M. Peng, and S. Mao, "Deep reinforcement learning-based mode selection and resource management for green fog radio access networks," IEEE Internet of Things Journal, vol. 6, no. 2, pp. 1960–1971, 2018.

[6] R. Du, P. Santi, M. Xiao, A. V. Vasilakos, and C. Fischione, "The sensible city: A survey on the deployment and management for smart city monitoring," IEEE Communications Surveys & Tutorials , vol. 21, no. 2, pp. 1533–1560, 2018.

[7] A. Brogi and S. Forti, "Qos-aware deployment of IoT applications through the fog," IEEE Internet of Things Journal , vol. 4, no. 5, pp. 1185–1192, 2017.

[8]. Kumar N, Lee J-H, Chilamkurti N, et al. Energy-efficient multimedia data dissemination in vehicular clouds :stochastic-reward-nets-based coalition game approach. IEEE Syst. 2016; 10: 847–858.

[9]. Khalid O, Khan MUS, Huang Y, et al. EvacSys: a cloud-based service for emergency evacuation. IEEE Cloud Computing 2016; 3: 9.

[10] H.N. Dai, R. C.-W. Wong, H. Wang, Z. Zheng, and A. V. Vasilakos,"Big data analytics for large-scale wireless networks: Challenges and opportunities," ACM Computing Surveys (CSUR), vol. 52, no. 5, pp.1–36, 2019.

[11] L. N kenyereye, Y. Park, and K.-H. Rhee, "Secure vehicle traffic data dissemination and analysis protocol in vehicular cloud computing," The Journal of Super-computing, vol.74, no.3, pp. 1024–1044, 2018.

[12] S. Singh, S. Negi, and S. K. Verma, "VANET based p-RSA scheduling algorithm using dynamic cloud storage," Wireless Personal Communications, vol.98, no.4, pp.3527–3547, (2018).

[13] X. Lai, J. Xia, M. Tang, H. Zhang, J. Zhao, Cache-aided multiuser cognitive relay networks with outdated channel state information. IEEE Access. 6, 21879–21887 (2018)

[14] Y. Guo, Q. Yang, F. R. Yu, V. C. Leung, Cache-enabled adaptive video streaming over vehicular networks: a dynamic approach. IEEE Trans. Veh. Technol. 67, 5445–5459 (2018)

[15] J. Feng, Z. Liu, C. Wu, Y. Ji, Ave: Autonomous vehicular edge computing framework with aco-based scheduling. IEEE Trans. Vehicle Technol. 66, 10660–10675 (2017)

[16] B. Baron, P. Spathis, H. Rivano, M. D. de Amorim, Y. Viniotis, M. H. Ammar, Centrally controlled mass data offloading using vehicular traffic. IEEE Trans. Network. Serv. Manag. 14(2), 401–415 (2017)

[17] C. Wu, T. Yoshinaga, Y. Ji, T. Murase, Y. Zhang, A reinforcement learning-based data storage scheme for vehicular ad hoc networks. IEEE Trans. Vehicle. Technol. 66(7), 6336–6348 (2017)

[18] J. Fan, R. Li, X. Zhang, in 2017 7th IEEE International Conference on Electronics Information and Emergency Communication (ICEIEC). Research on fault tolerance strategy based on two level checkpoint server in autonomous vehicular cloud (IEEE, 2017), pp. 381–384

[19] X. Liu, Z. Chen, K. Hua, M. Liu, and J. Zhang, "An adaptive multimedia signal transmission strategy in cloud-assisted vehicular networks," in Proceedings of the 2017 IEEE 5th International Conference on Future Internet of Tings and Cloud (Fi Cloud),pp. 220–226, Prague, Czech Republic, August 2017.

[20] M. Garai, S. Rekhis, and N. Boudriga, "A vehicular cloud for secure and QoS aware service provision, "in Advances in Ubiquitous Networking 2, vol. 397 of Lecture Notes in Electrical Engineering, pp. 219–233, Springer Singapore, Singapore, 2017.

[21] X. Hou, Y. Li, M. Chen, D. Wu, D. Jin, S. Chen, Vehicular fog computing: a viewpoint of vehicles as the infrastructures. IEEE Trans. Vehicle. Technol. 65(6), 3860–3873 (2016)

[22] L. Vigneri, T. Spyropoulos, C. Barakat, in World of Wireless, Mobile and Multimedia Networks (WoWMoM), 2016 IEEE 17th International Symposium on A. Storage on wheels: offloading popular contents through a vehicular cloud (IEEE, 2016), pp. 1–9

[23] N. Mensi, M. Guizani, A. Makhlouf, in Control Engineering & Information Technology (CEIT), 2016 IEEE 4th International Conference On Study of vehicular cloud during traffic congestion (IEEE, 2016), pp. 1–6

[24] Y. Wei, C. Xu, M. Wang, J. Guan, in Networking and Network Applications (NaNA), 2016 International Conference On. Cache management for adaptive scalable video streaming in vehicular content-centric network (IEEE, 2016), pp. 410–414

[25] H. Zhang, Q. Zhang, X. Du, Toward vehicle-assisted cloud computing for smartphones. IEEE Trans. Vehicle Technol. 64(12), 5610–5618 (2015)