Architecture And Design Principles Of Cloud Base VANET In Smart Cities

Arindam Pal

Assistant Professor Dept. Of Computer Science, Mahadevananda Mahavidyalaya, Barrackpore India-700120

ABSTRACT:

As vehicles evolve from simple means of transportation to smart entities with new sensing and communication capabilities, they become active members of a smart city. The Internet of Vehicles (IoV) consists of vehicles that communicate with each other and with public networks through V2V (vehicle-to-vehicle), V2I (vehicle-to-infrastructure) and V2P (vehicle-to-pedestrian) interactions, which enables both the collection and the real-time sharing of critical information about the condition on the road network. VANETs are specialized form of mobile ad hoc networks (MANETs) where protocols performed well in MANETs may not be ideal for VANETs due to high mobility, intermittent connectivity and heterogeneity. With the advent of cloud computing paradigm, offloading local resources to a shared pool of resources has been an ideal solution for compute-intensive and memory-intensive applications. Furthermore, it introduces the state of the art in vehicular clouds for smart cities following an introduction of various vehicular cloud architectures. Moreover open issues and future directions are presented and discussed to help stimulate future studies in this emerging research field.

Keywords: Smart cities, vehicular cloud, vehicular networks, Internet of Things, Internet of Vehicles,security

1.INTRODUCTION

Rapid advances in wireless technologies provide opportunities to utilize these technologies in support of advanced vehicle safety applications. In particular, the new Dedicated Short Range Communication (DSRC) offers the potential to effectively support vehicle-to vehicle and vehicle-to-roadside safety communications, which has become known as Vehicle Safety Communication (VSC) technologies. DSRC enables a new class of communication applications that will increase the overall safety and efficiency of the transportation system. Intelligent Transportation Systems (ITS) are the future of transportation. As a result of emerging standards, such as 5.9 GHz dedicated short-range communication, vehicles will soon be able to talk to one another as well as their environment. A number of applications will be made available for vehicular networks that improve the over all safety of the transportation infrastructure. For instance, the system will be able to monitor traffic to 3 coordinate traffic

lights so that traffic flows smoothly. Sensors will use feedback from vehicles to detect traffic jams. Public safety vehicles will broadcast, via the wireless channel, to change traffic signals in order to respond quickly to an emergency. Cars will communicate with one another to drive cooperatively, therefore avoiding collisions and improving efficiency. These are some of the possible applications, in the future, that will be possible with the advent of the DSRC standard. Considering the tremendous benefits expected from vehicular communications and the huge number of vehicles, it is clear that vehicular ad hoc networks (VANET) are likely to become the most relevant realization of mobile ad hoc networks. The appropriate integration of on-board computers, roadmaps, and GPS positioning devices along with communication capabilities, opens tremendous opportunities, but also raises formidable research challenges. DSRC , which is a candidate for use in a VANET, is a short to medium range communication service that supports both public safety and private communication. The communication environment of DSRC is both vehicle-to-vehicle and vehicle-to/from-roadside. The VANET aims to provide a high data rate and at the same time minimize latency within a relatively small communication zone. A number of novel problems are associated with a VANET because of the unique characteristics of the network. To begin, the main differences between a VANET and a MANET is a MANET typically has no infrastructure available. In the case of a VANET, it is possible to strategically place access points along the side of the road, and in turn allow vehicles' access to the services available from the infrastructure. Also, one of the greatest challenges is the vehicles in the network move at greater speeds than most other MANETs, leading to a network that can frequently become fragmented. Furthermore, security and privacy are a crucial concern for a VANET.

VANET CHARACTERISTICS :

The characteristics of a vehicular ad hoc network are unique compared to other mobile ad hoc networks. The distinguishing properties of a VANET offer opportunities to increase network performance, and at the same time it presents considerable challenges. A VANET is fundamentally different from other MANETs. First, a VANET is characterized by a rapid but somewhat predictable changing topology. Second, fragmentation of the network frequently occurs. Third, the effective network diameter of a VANET is small. Fourth, redundancy is limited both temporally and functionally. Fifth, a VANET poses a number of unique security challenges. The topology of the VANET changes frequently because of the high mobility of vehicles. Due to the frequent topology changes, the time that a communication link exists between two vehicles is brief. The reason why the link in a VANET is short lived is because vehicles travel at high speeds, approaching speeds of up to 200 km/h. One solution to increasing the duration a link is valid is to increase the transmission power. The problem associated with increasing a vehicle's transmission range in order to maintain a communication link is that it also decreases the throughput in the network. When vehicles travel in opposite directions, as can be expected, a link is maintained for a very small period of time. Even when vehicles travel in the same direction, with each vehicle having a transmission range of 500 ft, the wireless link between vehicles exists on the average for about a minute. Because vehicles exhibit a high degree of mobility it is difficult to maintain any form of group membership. For example, it is difficult to establish an accurate list of neighboring vehicles. Protocols that rely on group

membership are difficult to implement for a VANET. Nevertheless, the topology of a VANET is also beneficial because a vehicle's movement is constrained by the road. The future movement of a vehicle is predictable. The initial deployment of a VANET has the problem of only a small percentage of vehicles on the road being equipped with transceivers. The limited number of vehicles with transceivers will lead to frequent fragmentation of the network, causing a portion of the 5 network to become unreachable. Even when a VANET is fully deployed, fragmentation may exist in rural areas or during periods of light traffic, such as late at night. Since it could take years before the majority of cars are equipped with a transceiver, the VANET protocols should not assume that all vehicles can communicate. A result of having poor connectivity between nodes is that the effective diameter of the network is small. For this reason, it is unrealistic for a node to maintain the complete global topology of the network. The limited effective diameter results in problems when trying to apply existing routing algorithms to a VANET. Traditional routing protocols are either proactive or reactive. To begin, proactive routing algorithms maintain routes by using tables. Frequent exchanges are needed between nodes to keep the routing information valid. Because the topology changes so rapidly, the routes maintained in the routing tables quickly become invalid. Traditional table-based routing approaches, such as DSDV, consume a great deal of bandwidth. Subsequently, reactive routing aims at establishing a route only when one is needed. The problem with the reactive approach is that a route must be discovered before the first packet is sent, which increases the time to send a message. Neither of these two approaches performs particularly well in a VANET. The problem with the proactive approach is that it does not scale well. The problem with the reactive approach is that even when a route to a destination is found right before transmitting a message, that route may also be very short lived because of mobility. In addition, the expected path life of a route decreases as the number of hops increases. A path may cease to exist almost as quickly as it was discovered. Sending a message a distance greater than three or four hops using traditional ad hoc routing algorithm is likely to result in a routing error. Routing is not likely to play as large a role as it does in other networks. In a VANET, it is more important to send a message towards a certain location. Redundancy is crucial in order to provide specific services such as security. In a VANET redundancy is limited both temporally and functionally. Since links between nodes fail to exist for a significant period of time, it is extremely difficult to implement any form of redundancy. Privacy and security are other issues that must be addressed. First, in order to gain support for the adoption of a VANET the anonymity of the driver must be preserved. For instance, the general public is unlikely to support a VANET if a driver's movement is recorded. If Anonymity features are not included it would be possible for third parties to 6 monitor a driver's daily activities. For this reason, mechanisms are needed to ensure the driver's privacy. Second, a VANET requires a high degree of security. It should not be possible to tamper with the messages in the VANET. To illustrate, the tampering of safety messages would result in automobile accidents occurring, which the system was designed to prevent. If strict security measures are not put in place an attacker would be able inject false data into the network resulting in the flow of traffic being altered and chaos within the transportation system. These are some of the unique challenges related to a VANET. These are not the only unique characteristics of a VANET but they give a basic understanding of some of the issues in a VANET.

A large array of applications are being developed for DSRC. The applications of DSRC are categorized into the following four classes.

• Vehicle-to-Vehicle applications transmit messages from one vehicle to another.

• Vehicle-to/from-Infrastructure are applications in which messages are sent either to or from vehicle to a Road Side Unit (RSU).

• Vehicle-to-Home is a class of application that is used when a vehicle is parked at the driver's residence, for purposes such as transferring data to the vehicle.

• Routing Based applications are used when the intended recipient is greater than one-hop away.
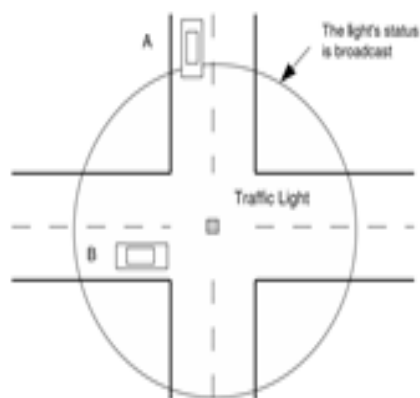
"The traffic conditions in urban areas are not satisfactory due to wasted time, fuel, and travel unreliability, for example, arrive at destinations is time consuming.

Factors affecting level of service:

The level of service can be derived from a road under different operating characteristics and traffic volumes.

The factors affecting level of service (LOS) can be listed as follows:
1. Speed and travel time
2. Traffic interruptions/restrictions
3. Freedom to travel with desired speed
4. Driver comfort and convenience
5. Operating cost.

Intelligent Transportation Systems (ITS) is one solve this problem by exploiting the advances in information technology, for example, dynamically controlling traffic lights based on traffic conditions and routing vehicles using current and historical traffic information.

Intelligent Transportation System is application of computer, electronics, and communication technologies in an integrated manner to provide high safety and efficiency of the transportation system.

ITS services:
1. Uninterrupted internet services
2. Traffic management
3. E-toll
4. Vehicle control and safety
5. Recovery from accident
6. Maintenance

The Internet of vehicles (IoV) is connecting vehicles over internet, letting them talk and making applications. IoV includes different types of communications including vehicle to vehicle v2v, vehicle to RSU v2r, vehicle to toll sensor v2ts and vehicle to internet v2i. IoV is better than GPS, and it solves the GPS unavailability. The technology development and large-scale employment of the IoV introduce new services and also make the existing services more reliable and more efficient. in IoV each vehicle is considered as an object contained a powerful sensor, IT, Arithmetic and logical unit and IP address. All the vehicles either directly or indirectly connected to each others.

To prepare a new routing protocol for wireless ad-hoc network based Smart City I use the following steps:

1. Create a road map of the city
2. Routing Algorithm
3. Routing controller
4. Performance
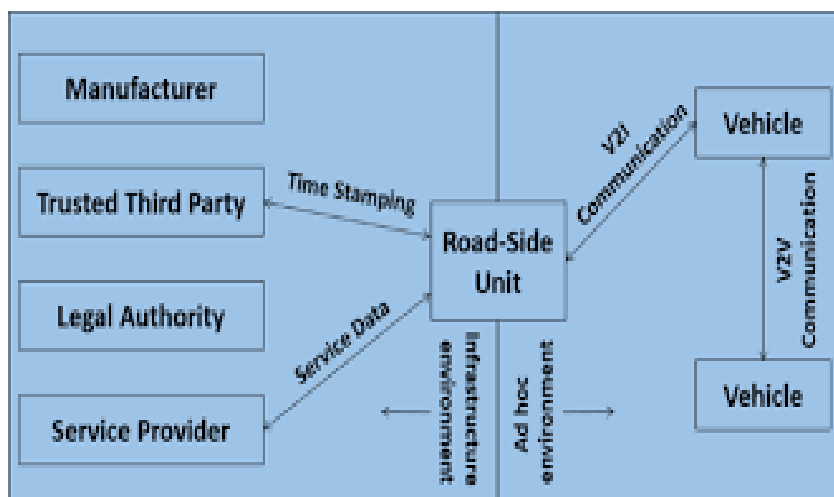
2. VANET ARCHITECTURE:

Intelligent Transportation Systems (ITS) utilize the communication technologies to connect vehicles, people and any facility for more secure, safer, and highly mobile transportation: From vehicular networks to vehicular clouds in smart cities 5 urban environment. Vehicular Networks constitute the key and major component of the ITSs by enabling and integrating the use of various technologies, communication standards and the infrastructures. The city is

turned into a smart connected city by the intelligent transportation systems with the use of vehicular networks and its infrastructure. Every region, facility, driver, passenger and even any pedestrian is envisioned to be connected to the ITS and be aware of local, or region of interest (ROI), or city-wide events and updates/changes on the transportation system even in real-time. Within that architecture, real-time and non-real time information will be used and provided by the ITS and vehicular networks for safety and efficiency.

3. VEHICULAR CLOUD INFRASTRUCTURE

Smart cities call for a new business model for vehicular communications where the vehicles can join a pool of resources and/or offer their resources as service. With the advent of cloud computing paradigm, offloading local resources and rapidly accessing to a shared pool of resources have appeared as a feasible solution to accelerate computing and storage services. Basically, a vehicular cloud is formed by incorporating cloud-based services into vehicular networks. Thus, Computing-as-a-Service (CompaaS), Storage-as-a-Service (STaaS), Network-as-a Service (NaaS) , Cooperationas-a-Service, (CaaS) , Entertainment-as-a-Service (ENaas), Information-as-a-Service (INaaS) , and Traffic Information-as-a-Service (TIaaS) can be received via vehicular clouds. In , the authors model a vehicular cloud as a data center with mobile hosts that have limited computing and/or storage capability. Migration from the conventional VANET model towards the vehicular cloud model enables the vehicular divers to access mobile cloud resources rapidly based on the pay as you go fashion.
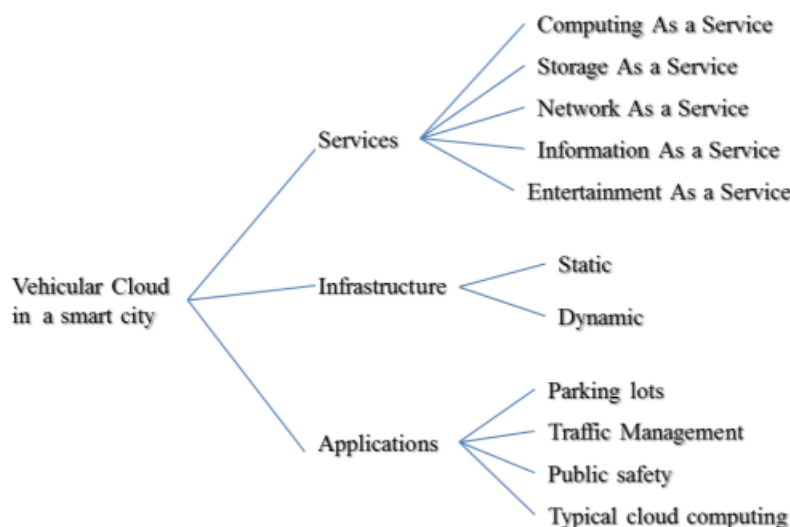
Vehicular Cloud System Design in a smart city

4. VANET CHALLENGES AND SOLUTIONS IN SMART CITIES

VANETs have become unique solution for implementation safety and security standard for transportation system. This intelligent transportation system (ITS) not only standardizes/improvises the overall road safety but also it makes vehicle driving more comfortable and stress-less. With the combination of Road Side Units (RSU) and smart

vehicles the traffic incidents and laws can be monitored by local and centralized system. Under the circumstances, challenges and solutions of VANETs are important aspects for smart cities.

5.OPEN ISSUES AND FUTURE DIRECTIONS IN VEHICULAR SMART CITY SYSTEMS

Vehicular networks still experience several challenges that have to be addressed before they are widely adopted by smart cities. As mentioned above, VANETs operate on a mature communication infrastructure however VANETs can be enhanced by incorporating cloud-inspired operational model as the data collected is huge and needs to be analyzed, interpreted and communicated. Therefore vehicular clouds in smart cities need novel and effective solutions for virtual machine management, vehicular node security, vehicular driver's privacy and context aware services via mobile crowdsensing over vehicular social networks. Vehicular VM management calls for novel solutions that fulfill service quality requirements. Moreover, migration efficiency is still an open issue, thus new algorithms to ensure minimum VM migration latency and minimum service disruption. Furthermore virtualization-based vulnerabilities have to be addressed in vehicular VM management and migration.

Enhanced Distributed Coordination Function(EDCF) provides differential access to the wireless medium by assigning eight priority classes which are referred to as Access Categories (AC). The ACs are labeled 0 to 7, with TC 0 having the highest priority. EDCF functions similar to DCF. The primary difference is that EDCF uses a different set of access parameters for each AC. The AC parameters are used to set CW min[AC], CW max[AC], and AIF S[AC]. The parameters CW min[AC] and CW max[AC] control the minimum and maximum size of the contention window. Assigning larger values to the CW min[AC] and CW max[AC] for a low priority class increases the average time that a low priority class has to back-off before transmitting. On the other hand, the inter-frame spacing is used for the duration of time that a station must wait before it can begin the back-off process. EDCF makes use of the Arbitration Inter-Frame Space (AIFS) to vary the amount of time a station must remain idle before it can decrement it back-off timer. Equation 1 is used to calculate the AIFS value.

$$AIF\ S[i] = SIF\ S + AIF\ SN[i] * slot\ time \quad (1)$$

Choosing a smaller value for AIF SN[i] means that the station will be able to back-off sooner and it will be able to access the channel faster.

A weighted moving average is used to calculate the average reception rate. In a highly dynamic network such as a VANET, the emphasis should be placed on the most recent conditions of the network. To calculate the weighted average, an approach similar to the TCP round trip time estimation is used. Est Reception Rate = α *Est Reception Rate + $(1 - \alpha)$ *Sampled Reception Rate (2) Once the Est Reception Rate is determined for each node, an average of the reception rates is used to determine the local reception rate. Once a node has determines the local reception 35 rate it compares the value against the previous stored local reception rate to adjust the CW that the node uses.

IF (average - previous average >= sliding threshold) Slide the window down

ELSE IF (-(average - previous average) >= sliding threshold) Slide the window up

ELSE Maintain the current window Periodically each vehicle uses this algorithm to adjust the CW.

The number of collisions experienced and the number of nodes contending to access the medium determines if the current value of the contention window needs to be maintained. If a large number of collisions have occurred, SF[i] is used to slide SCW[i] towards CW[i]max. On the other hand, if the number of collisions detected is below a threshold then SCW[i] is slid toward CW[i]min.
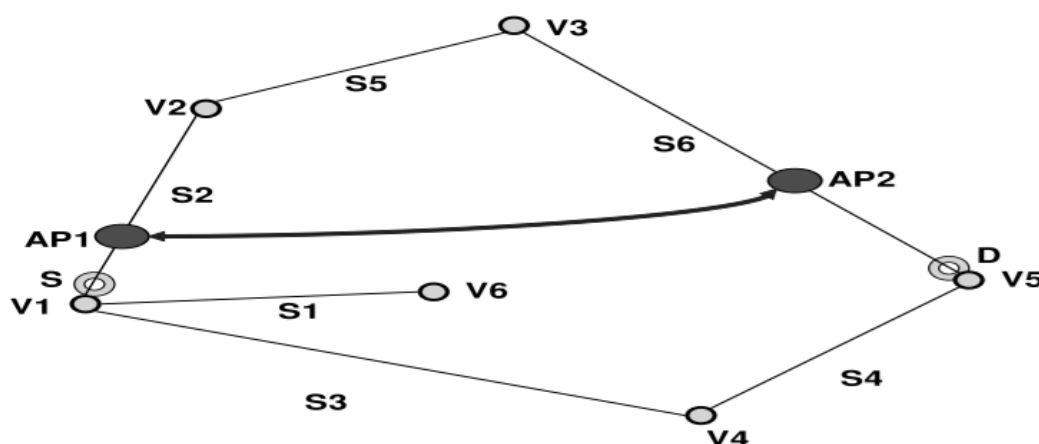

Spatial Model

Using the above example, an outline the major steps of CAR algorithm is given. After the deduction of the Spatial Model Graph G(E, V) as shown in Figure 13, the following steps are followed:

1. source S maps itself and destination D on the graph based spatial model G(E, V);

2. S calculates the shortest communication delay path to D;

3. S sets the Context Source Route CSR = {S, V 2, V 3, V 5} to destination D; CSR consists of a list of intermediate vertices;

4. embed the CSR in the header of all data packets from S to D;

5. forwards the packets along the CSR path.

Road-Side Access Points Aware Routing :

CAR does not require availability of any roadside network infrastructure. However, if available, the packet could be routed through the high speed and reliable wired network via

roadside access points. An enhanced G(E, V) is maintained that includes roadside access points. The vertices added to the enhanced graph represent the roadside access points and the edges between 41 RSUs have a relatively lower weight compared to an edge representing a wireless link (for example, equal to one or two wireless hops) between those vertices. Therefore, when calculating the CSR, the roadside access points have a better chance of being included in the CSR. Again, using the above example, the enhanced graph is shown in Figure. Since the weight of the edge between AP1 and AP2 is relatively very small, the Context Source Route from S to destination D is {S, AP1, AP2, V 5}. The packets from S to D go through a VPN tunnel over the wired infrastructure network. The RSUs are used as entry and exit points into and out of the more reliable wired network. In addition, the number of hops is reduced and therefore latency is also reduced.
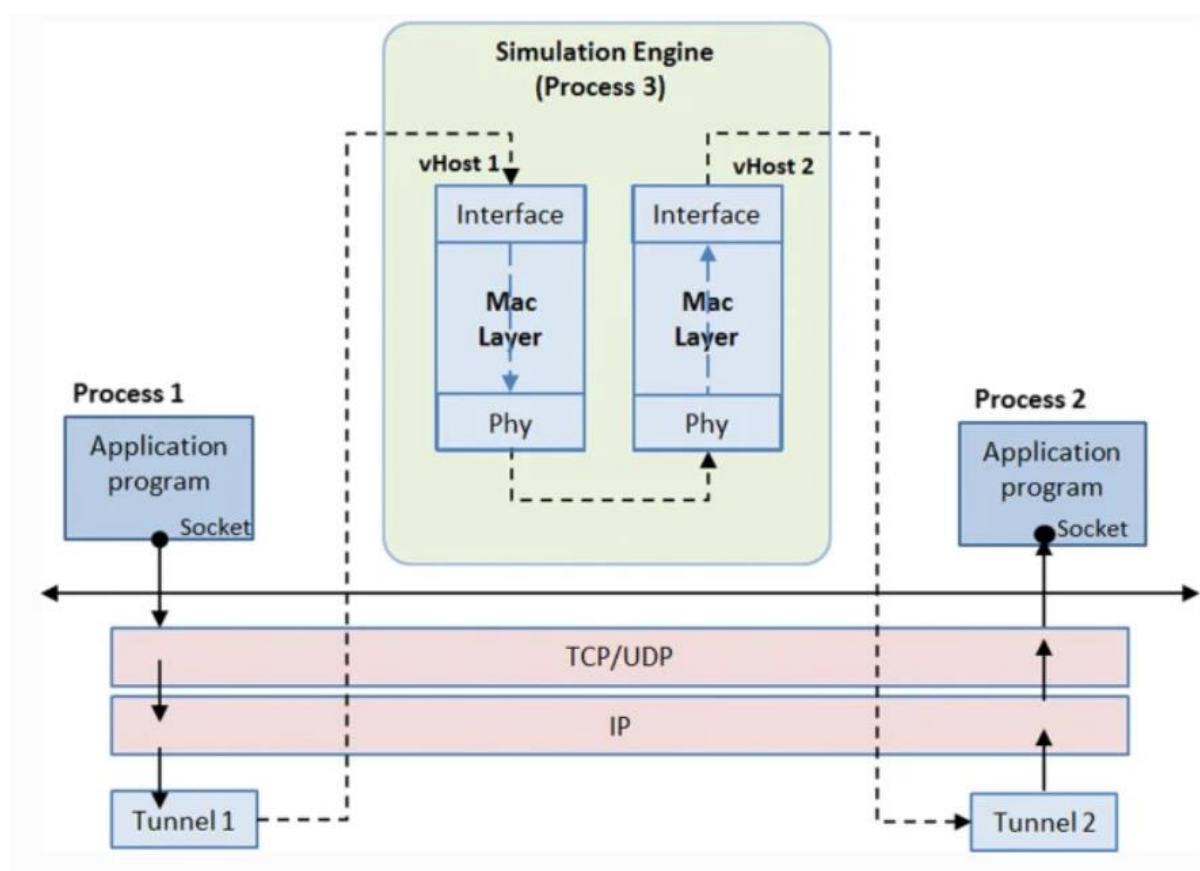
Simulation architecture of EstiNet, host-to-host case.

Technology	Nets Sim	Veins	Eclipse MOSAIC	Esti Net	exCar2X	VENTOS	VANET sim
SDN	X	X		X			
Edge computing		X			X	X	
5G	X	X	X	X		X	

Self-driving cars		X	X		X	X	
Unmanned aerial	X	X					
vehicles (UAVs)							

VANET dataset:

All datasets have the following fields:

- Start time: time in seconds when the request arrives.
- End time: time in seconds when the request is done.
- Time Period: end time - start time
- Packets: number of packets required by this request.
- Rate: number of packets divided by time period, packets per second
- Sender Stopping Distance: in meters.
- Receiver Stopping Distance: in meters.
- Actual Distance: distance in meters between sender and receiver.
- Severity: severity of the request.

Sample code for VANET:

This code explains how to vanet routing protocol broadcast message sending code.

```
void
Vanet RBC Agent::send RBC_pkt() {
int pktsz;
Packet* pkt = allocpkt (); // Create a new packet
struct hdr_vanet_rbc *hdr = HDR_VANET_RBC(pkt);
hdr_ip* iph = HDR_IP(pkt);
iph->daddr() = IP_BROADCAST;
iph->dport() = iph->sport();
hdr->rbc_msg type = VANETTYPE_REGBC; // (necessary for dispatching!)
hdr->rbc_sender ID = vanet ID_;
hdr->rbc_time stamp = Scheduler::instance ().clock();
Mobile Node *pnode = (Mobile Node*)Node::get_node_by_address (vanet ID_);
pnode->update_position (); // update the position, before using it
hdr->rbc_posx = pnode->X(); // include current own location
hdr->rbc_posy = pnode->Y();
```

```
pktsz = hdr->size(); // get packet-size of this type
hdr_cmn::access(pkt)->size() = pktsz; // set it in the simulator
Scheduler::instance().schedule(target_, pkt,
crypto_delay_ + JITTER*jitter factor_);
if(running_ == true)
pkt_timer_.resched (interval_);
}
```
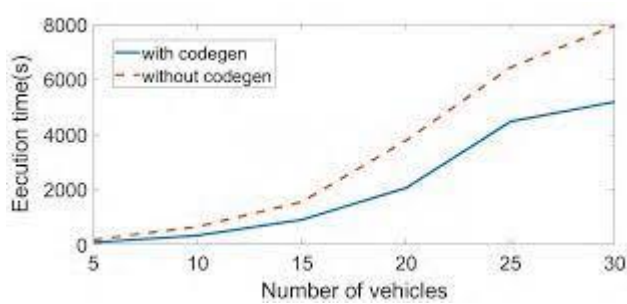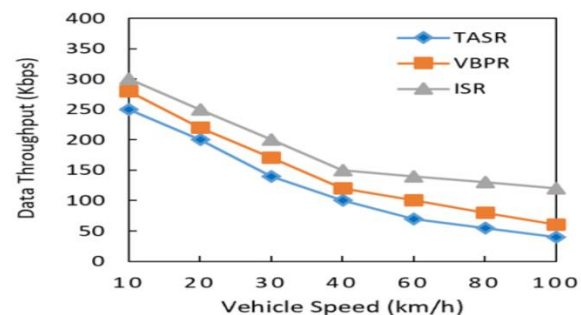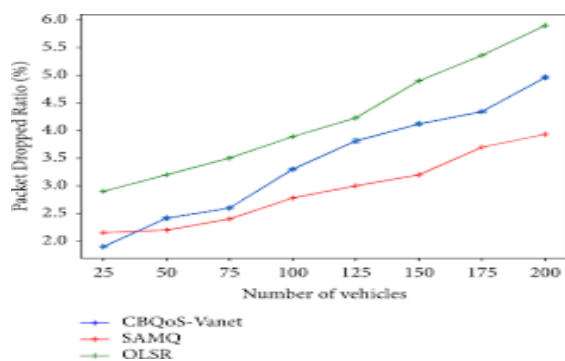

Fig. <u>Vehicular Network Simulation</u>

6. SUMMARY

Connected vehicles have various application areas in future smart cities. Having an established communication infrastructure and standards, VANETs can be adopted in these applications. However, due to continuously increasing demand for computation, storage and communications, a cloud inspired model is required for vehicular networks. This chapter has provided a survey of vehicular networks for smart city applications, and presented an overview of the studies that pave the way towards implementation of vehicular clouds in smart cities. To this end, the chapter has prsented the VANET architecture and the vehicular cloud architectures utilizing the VANET infrastructure. Then the challenges and solutions in VANETs and

vehicular clouds for smart cities have been presented in detail. The chapter has also dedicated one section to discuss future directions and still open issues in this topic.

REFERENCES

[1] GregoryS. Yovanof and George N. Hazapis, "An architectural framework and enabling wireless technologies for digital cities & intelligent urban environments," Wireless Personal Communications, vol. 49, no. 3, pp. 445–463, 2009. CHAPTER 8: From vehicular networks to vehicular clouds in smart cities 22 [

2] Taewoo Nam and Theresa A. Pardo, "Conceptualizing smart city with dimensions of technology, people, and institutions," in Proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times, New York, NY, USA, 2011, dg.o '11, pp. 282–291, ACM.

[3] Rudolf Giffinger and Haindlmaier Gudrun, "Smart cities ranking: an effective instrument for the positioning of the cities?," ACE: Architecture, City and Environment, vol. 4, no. 12, pp. 7–26, 2010.

[4] Doug Washburn and Usman Sindhu, "Helping CIOs Understand "Smart City" Initiatives. Defining The Smart City, Its Drivers, And The Role of The CIO," Forrester, 2010.

[5] M. Gerla, Eun-Kyu Lee, G. Pau, and Uichin Lee, "Internet of vehicles: From intelligent grid to autonomous cars and vehicular clouds," in Internet of Things (WF-IoT), 2014 IEEE World Forum on, March 2014, pp. 241–246.

[6] Euisin Lee, Eun-Kyu Lee, M. Gerla, and S.Y. Oh, "Vehicular cloud networking: architecture and design principles," Communications Magazine, IEEE, vol. 52, no. 2, pp. 148–155, February 2014.