Data Broadcasting on Cloud-VANET for IEEE 802.11p and LTE Hybrid VANET Architectures

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***Abstract*—Vehicular Ad-hoc Networks (VANET) is an unique category of Mobile Ad-hoc Network (MANET), which promises prospect in the future Intelligent Transporting System by providing inter-vehicle communication of road surveillance, traffic information, road condition etc. However, the high nodes mobility, frequent network change topology, unstable network and small coverage issues in the VANET implementation motivates for a stable design of cloud clustering algorithm. This paper propose a system that combines the traditional 802.11p standard VANET networks with LTE networks to form a hybrid Cloud-VANET that provides low network overhead with a high mobility management and high coverage in VANET networks. This approach enables VANET to have high bandwidth along with uninterruptable data connectivity by reducing the data packet loss and SNIR loss ratio over the network. The OMNET++ and SUMO traffic generator has been used to simulate the network scenario. Simulation results indicates that hybrid VANET architecture improve the overall network stability and performance.**

Keywords- VANET, LTE, Vehicular Cloud Network, Hybrid VANET, Broadcast.

I. INTRODUCTION

With the increasing amount of vehicle and traffic congestion over the world, the Vehicular Ad-hoc Networks (VANET's) are considered as one of the principal element of Intelligent Transport System (ITS) [1]. A VANET consists of set of high-speed and high mobility vehicle equipped with sensors and communication competence device [2]. It turns each of the neighborhood vehicles into a wide range wireless network, which enable vehicles to connect with each other and share contents [3]. Unlike any other mobile networks, VANETs are categorized in highly variable network topology, specific speed patterns, communication conditions etc.

Majority of the vehicular communication concentrates on IEEE 802.11p-based wireless Local Area Network. The Wireless Access in Vehicular Environments (WAVE) IEEE 802.11p [4] standardize the dedicated short range inter-connection between the vehicles and infrastructure located on road side unit (RSU) with data transfer rate ranging up to 27 Mbps and having a short distance around 300 meter.

There are mostly two different types of communications established between the vehicle and RSU: (1) vehicle-to-vehicle (V2V) and (2) vehicle-to-infrastructure (V2I) communication. The VANET supports inter-vehicular communication using multi-hop based message relay, which usually covers very low geographical area of mobile ad-hoc network with vehicle mobility limitations and network size limitation [2]. The messages mostly contain either information about current speed, acceleration, and heading.

Since the VANET has very limited capacity in terms to disseminating critical road safety information over such a large area it creates some major integration issues while considered to implement in real life. The major challenges for VANET implementation are: (1) mobility management, (2) broadcast storm problem [5], (3) network disconnection problem [6], (4) network coverage, (5) data dissemination technique, and (6) high bandwidth. A broadcast storm mostly occurs when a network is overawed with high number of vehicles broadcasting data over the network. Oppositely, the disconnected network only occurs when a network have very low amount of vehicles connected with having distance more than 300 meter.

Until now, many research projects have been carried out, which suggested probabilistic flooding [6] and clustering [7] method to refer the broadcast storm issue over VANET. As a substitute option to the IEEE 802.11p-based VANET network, the utilization of cellular network technology on vehicular network research has conducted on most recently. The Third-Generation Partnership Project (3GPP) enables advance content broadcast/multicast services by providing efficient data dissemination over the network. The

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forth-generation cellular network is an evolution of UTMS (Universal Mobile Telecommunication System), which called as Long Term Evolution (LTE). The LTE standard by the 3GPP offers high-class performance in regarding throughput and low latencies at downlink peak rates of 300 Mbps, uplink peak rate of 75 Mbps, with the latency of less than 5ms.

This paper presents a cloud based vehicular network for IEEE 802.11p-based VANET and IEEE 802.11p-LTE hybrid network to provide an efficient routing protocol with low latency, high reliability along with less congestion.

The main contributions of this paper are as follows:

Firstly, to ensure the anticipated level of network performance, latency sensitivity, reliability, scalability, and a rich set of services this paper presents a model called Cloud-VANET, which facilitate onboard vehicle resources to be connected over cloud interface. Secondly, this model enhances the data storage capability by reaping the sharing access from the neighboring vehicles storage resources. Thirdly, the proposed model allows mobile data access for the vehicles at any moment and in anywhere. Fourthly, the frequent topology change and broadcast storm problem over the VANET has been covered in the proposed model.

II. Related Work

The IEEE 802.11p-based VANETs with high data rates and large coverage of 3GPP communication technology motivates researchers to examine the combination of both technologies [8] and [9].

Olariu et al initially presented the idea of Cloud-Vehicular system. The system named autonomous vehicular clouds (AVC), where independent vehicles actively distribute computing and communication properties to authorized nodes [10].

In [11], Bernstein et al. have made the progress further by perform as a service (PaaS) model to join a large number of nodes in very portable environment. Hussain et al. presented a framework which comprising of vehicular cloud (VC), VANET using clouds (VuCs), and Hybrid Clouds (HCs) in [12]. In those frameworks, vehicles act both roles, i.e., cloud service providers and clients.

Yu et al. in [13] proposed a plan to coordinate cloud computing in various applications of vehicular network. Their proposed architecture allows the vehicles to share the storage, computation and bandwidth resources. However, these design did not had practical implementation details in various connection of VANET such as urban and rural areas.

In [14] the authors present the necessity of a rapid and steady Internet connection using cloud-VANET. In such manner a cloud-server has put forward that supports distributing network gateway details to the vehicles in VANET. In [15] represented the need of assistance and support from the roadside units in order to form peer-to-peer file sharing and other sharing application network. For this the author has proposed a P2P overlay protocol. This protocol follow circulated data dissemination strategy rather than centralized. In spite of the fact majority of the works mentioned the importance of RSU (Road Side unit), but very few of them actually describes the deployment of the same. Therefore, the proposed system represents an advance system, which covers fellow research works problems along with RSU deployment.

III. Proposed System

The effective way to communicate in VANET is through broadcasting critical massages to nearby nodes or cars. The communication method involves in sending and receiving message. In traditional VANET architecture emergency message broadcast dose not involve any cloud interface or RSU. The proposed architecture introduces hybrid roadside unit eNodeB with advance-broadcasting technique, which reduces the network load and resource utilization. The proposed Cloud-VANET hybrid architecture is four-level architecture depicted in Figure 1.

(A) Level -1: Vehicular Cloud Network (VCN)
(B) Level -2: Digital Content Network (DCN)
(C) Level -3: Infrastructure Cloud Network (ICN)
(D) Level -4: Server-to-Cloud Network (S2CN)

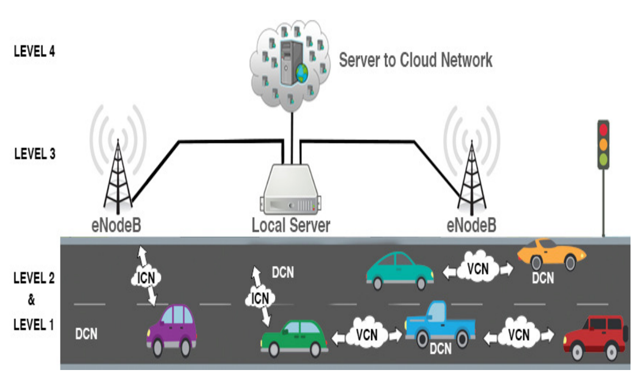

Figure 1. Cloud Vehicular Ad-hoc Network Architecture

A. *Vehicular Cloud Network (VCN):*

In VCN, the local group of vehicles shares their physical resources (car front & back camera, safety equipment's etc.) locally in a small group. These results increase the efficiency level of the network.

B. Digital Content Network (DCN):

DCN is a digital content network in the road, where all the road signboards and traffic signal lights are translated digitally only for vehicles to understand and perform accordingly, such as read speed limit. Alternative to GPS technology also covered in DCN, where global position information is placed in the road track as form of digital content, which is ready to use as location data for the vehicles without using GPS signal.

C. Infrastructure Cloud Network (ICN):

The ICN is mostly originated by neighboring roadside base station or eNodeB where all the vehicles get access for on demand service delivered by the cloud network. Each of this cloud network maintain as local network in a small geographical coverage, where eNodeB is located. The communication among ICNs supported by local server.

D. Server-to-Cloud Network (S2CN):

S2CN is one of the major components of cloud network in vehicular communication system where local servers share their resources in cloud interface. It is unified communication environments, which also have capability to use extensive sharable data storage platform without compromising geographical barrier. It also also performs as bandwidth manager to maintain the load balance in the road.

The data broadcast over the network is segregated into three types such as, a broadcast where critical road traffic data needed to be distributed to entire vehicular network. Second, a broadcast in which the information distributed for each of the node individually. Third, a broadcast created for each group of the vehicles. The technique of broadcasting is using for to circulate the critical information upon requested on eNodeB. This reduces the broadcast storm over the network by minimizing the limited number data dissemination. In the proposed network all the eNodeBs and vehicles are grouped into clusters, conditional to the amount of vehicle connected in, the amount of data request by the vehicles and vehicles mobility pattern. This approach reduces the network overhead along with repeated subscribing, which also solve the network-disconnecting problem. In traditional VANET when a vehicle request an information currently being in base station range, during the data broadcasting, if that vehicle moves to other base station range, it request to subscribe again and the broadcast start again from beginning. However in the proposed method, with the help of clustering broadcast, continue without any stop during the change of eNodeB range.

In this proposed system four levels of data connectivity are involves over the network. First level involves with moving vehicles on the road, which uses 802.11p connectivity. Mostly, this communication sends safety alerts to nearby vehicles and clusters. Second level of connectivity consists between nodes and digital contents on the road with 802.11p standard. The third level involves with moving vehicles and eNodeB's , which uses 802.11p standard. The fourth level connectivity is referring to cloud with every eNodeB-cloud; a Server provides the central control of send and receives messages and coordinates from the eNodeBs.

IV. Cloud Vehicular Networking Operation

In cloud vehicular networking operation, it requires a cloud leader to initiate Cloud-VANET. Each vehicles and eNodeBs has one cloud leader and all the nodes in the cloud communicate with the cloud leaders. If the leader is a vehicle to initiate the cloud, and no neighboring eNodeBs involved in cloud information, then the resulting cloud is vehicle cloud (VC) as shown figure 2. However, if the invitation for cloud is originated by eNodeB, as a leader of neighboring vehicles, it responds to its request results in the formation of infrastructure cloud (IC), otherwise if cloud initiated by server as a leader of neighboring server, it forms (SC).

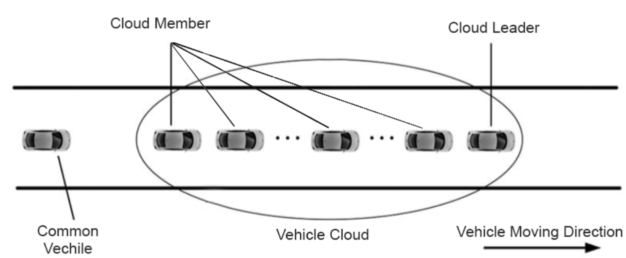

Figure 2. Vehicle Cloud (VC) netowork.

The cloud leader invites cloud members to form cloud by transmitting resources request message (REQs). Any vehicles that want to join the cloud, response to the request message to cloud leader. Once could leader accepts the request via REP message, it stores the member's identification and assigns the application service. The entire cloud member constantly communicates with the cloud leader. Cloud leader is responsible for the maintenance of the cloud it created. If any of the members wants to leave, cloud requests leaving message to cloud leader.

The cloud head enables the network to have a self-management in the number of the nodes with high mobility. For cloud maintenance, Cloud-VANET follows times and packet reception mechanism to avoid unnecessary cloud head releases when two cloud heads pass by each other in a short period of time.

V. Data Broadcasting in Hybrid Cloud-VANET

Data broadcasting for a vehicle mostly varies on its cloud status. If the vehicle status is in state election mode (where vehicles makes a decision about the next state based on information in vehicle location, speed and heading towards), the vehicle broadcast Data_Packet so that it reaches the members of a cloud (CM) in the network. When the cloud leader (CL) generates a Data_Packet, then it checks with vehicle information (VInf) whether the packet has already been received successfully or not. If the vehicles in the cloud receive the data packet at first it checks source of the packet. If the source is from parent cloud (Parrent_cloud), then it multicast to all the CM. Otherwise, the packet is considered from a vehicle with a state election mode. Then the vehicle unicast received packets to its parent cloud to forward the packet until it reach the CL and update its vehicular information.

Similarly, as presented in algorithm 1, when the CL generates or receives a Data_Packet, at first it looks for the source of the packet. If the data packet comes from eNodeB, the CL broadcasts Data_Packet to all the members of its cloud. Otherwise, the packet is forwarded from parent cloud member or another nearby vehicle. In that situation CL broadcast the Data_Packet to its cloud members and creates an LTE_Data_Packet, which forwards to the eNodeB containing the original received packet from the vehicle. Finally, updates CL VInf for the packet.

Algorithm 1: IEEE 802.11p-LTE Cloud Member Algorithm

```
On Data_Packet generation or receive:
Filter ID_Data and REQ_Data;
if (ID_Data, REQ_Data) ∉ VInf then
  if Data_Packet is from Parrent_Cloud then
      Multicast Data_Packet to CM;
  else
      Unicast Data_Packet to Parrent_Cloud CL;
Update VInf;
```

Algorithm 2: IEEE 802.11p-LTE Cloud Leader Algorithm

```
On Data_Packet generation or receive:
Filter ID_Data and REQ_Data;
if (ID_Data, REQ_Data) ∉ VInf then
  if Data_Packet is from eNodeB then
      Broadcast Data_Packet to CM;
  else
      Broadcast Data_Packet to CM;
      Create LTE_Data_Packet and forward to eNodeB
Update VInf;
```

Algorithm 3: IEEE 802.11p-LTE eNodeB Algorithm

```
On Data_Packet generation or receive:
Filter ID_Data and REQ_Data;
  (ID_Data, REQ_Data) ∉ (CL,VInf) then
  Broadcast LTE_Data_Packet to eNodeB-Cloud then
  Broadcast LTE_Data_Packet to CL then
  Forward to Server-Cloud then
      Broadcast LTE_Data_Packet to eNodeB then
      Broadcast LTE_Data_Packet to CL;
Update eNodeB;
```

The proposed algorithm 1-3 reduces the broadcast storm issues over the network by decreasing repeated data broadcasting and keep low overhead. This also includes dissemination of specific data demanded by specific nodes or vehicles, which also helps to reduce the network load. This approach reduces network disconnection problem reducing the repeated subscribing and downloading over the network.

VI. Simulation and Performance Evaluation

In the simulations, to generate realistic vehicular mobility traffic in highway the SUMO traffic simulator [16] is used. More particularly, this paper presented the simulation of Kuala Lumpur (Malaysia) highway scenario shown in Figure 3. The simulation area is around 10 kilometers, have multiple roads and lane, maximum velocity of each vehicle is up to 50km/h with inter vehicle distance of 2.5 meter and highest distance range 300 meters. Simulation parameters are summarized in Table I.

The projected data has been implemented in Omnet++ to analyze the performance of three schemes: (i) IEEE 802.11p standard, (ii) reference scheme [18] and (iii) proposed scheme in terms of data flooding technique. The range of data packet loss gained from the eNodeB is shown Figure 4. It has been observed that for the increasing amount of vehicles in the network, at the same way distance gets reduced with eNodeB and data dissemination increases. In order to analyze in what way the denseness impacts on the broadcast the data packet loss and SNIR loss ratio result are shown in on Figures 4 & 5.

TABLE I. Simulation Parameters

Parameter	Value
Simulation scenario	Highway
Simulation duration	300 s
Simulation area	10 km
Number of car	600
Highest velocity of vehicles	50 km/h
Inter-vehicle distance	2.5 m
Highest transmission range	300 m

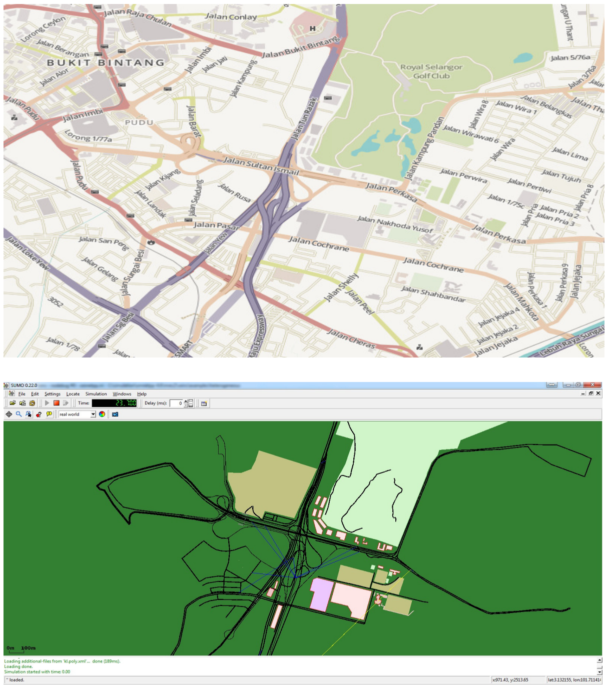

Figure 3. Simulation scenario in OMNeT++

From the performance results it is clear that the reference scheme [18] data packet loss and SNIR loss was reduced about 10% from the IEEE 802.11p standard. At a point of the simulation start, the data packet loss ratio and SNIR loss ratio was almost same for both of the IEEE 802.11p standard and reference scheme [18]. On the other hand the proposed hybrid Cloud-VANET network data packet loss and SNIR loss reduced about 30% compared to the other two schemes. It also presents that the hybrid architecture the SNIR loss ratio remains stable at all possible situation while the IEEE 802.11p a reference scheme [18] varies during the heavy congestion period. From the above it shows that the hybrid network provides better performance in terms of higher bandwidth and network stability management, which enables low overhead and high coverage over VANET.

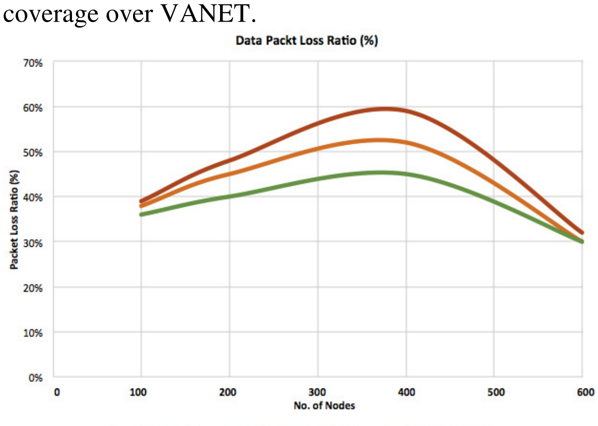

Figure 4. Data Packet Loss Ratio (%)

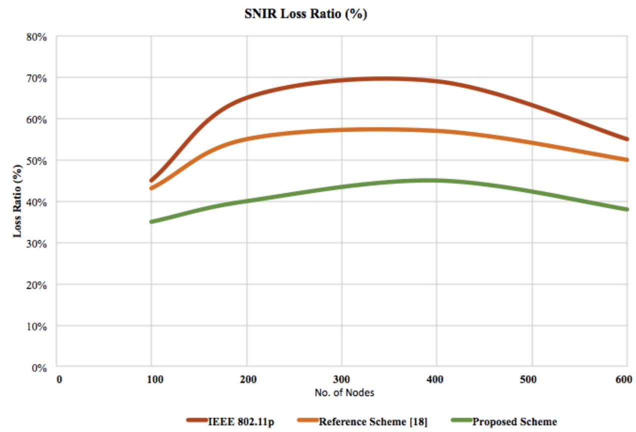

Figure 5. SNIR Loss Ratio (%)

VII. CONCLUSION

In this paper, a novel Cloud-VANET architecture is projected that represent combination of cellular technology LTE and traditional IEEE 802.11p-based VANET networks. In Cloud-VANET, an advance algorithm has been presented where vehicles and eNodeBs are clustered in a multi-hop based cloud. The CL selected as per relative mobility matric, which maintains the cloud structure low consumption of network resources. The simulations demonstrate the hybrid IEEE 802.11p-LTE based VANET, which develops the transmission enactment, delivering a low data packet loss ratio and SNIR loss. This approach provides stable network connectivity in all possible vehicle traffic densities, improves mobility management, enables many applications to be implemented like video streaming, storage share etc. As for future work, we planned to examine the enactment of Cloud-VANET hybrid architecture in complicated urban scenarios.

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