Securing Vehicular Cloud: Merging VANET with Cloud Computing

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***Abstract* -** Although the spread in Vehicular Ad Hoc Network (VANET) research, eventual high-end vehicles are conventional to under-utilize the on Board computation, communication, and Storage resources. So, there is need to *move* from conventional VANET to Vehicular Cloud Computing (VCC) by combining VANET with cloud computing. *Also, VANETs use an open medium for communication and consequently are exposed to security threats that impact their Reliability.* We address some major design concern that will affect the future performance of VCC and provide a set of security and privacy protecting protocols. We address relatively unique security challenges resulted by features of VCC e.g. The challenges of authentication of high mobility vehicles and the complexity of trust relationships among multi players caused by intermittent short-range communication. We propose data trust security model designed for VANETs based on social network theories.Our intention is to help readers better understand the fundamental vehicular cloud computing mechanisms and mark out the potential applications for improving vehicular network and road safety. We present a extensive taxonomy of vehicular networking and analysis between MCC and VCC. In addition, we explain the VCC architecture, and the extensive application scenario. Each vehicle in VCC can connect to the other vehicles or the network infrastructures by using the vehicle to vehicle or the vehicle to infrastructure network communication. We explain a key management method to provide a secure communication channel in the vehicular network. Furthermore, we categorize the vehicular networks based on the security issues and solutions. The security and privacy of VCC, the research challenges and open issues are also considered.

***Index Terms* –** *VANET, Vehicular Cloud Computing, cloud computing, MCC .*

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I. INTRODUCTION

A) Vehicular Cloud Computing

"A group of largely autonomous vehicles whose corporate computing, sensing, communication and physical resources can be coordinated and dynamically allocated to authorized users."

The cloud computing paradigm has enabled the exploitation of excess computing power. The number of vehicles on streets, roadways and parking lots will be treated as plentiful and under- utilized computational resources, which can be used for providing public services.Everyday,many vehicles,spend hours in a parking garage, driveway or parking lot.The parked vehicles are a vast unexploited resource, which is currently simply wasted. Features make vehicles the perfect candidates for nodes in a cloud computing network. vehicle owners may agree to rent out excess on-board resources, similar to the holders of huge computing and storage facilities who rent out their excess capacity and benefit economically. The travellers normally park their cars in airport parking spaces while they are traveling. airport authority will power the vehicles computing resources and allow for on demand access to this parking garage data centre. Similarly, the drivers stuck in traffic congestion will agreed on their on-board computing resources to help city traffic authorities run complex simulations designed to remove congestion by rescheduling the traffic lights of the city.

B) Vehicular Cloud Computing Architecture

1) Vehicle Cloud Architecture (VC)

In V2V vehicles make clusters based on defined road segmentation. Each cluster is organized as a node in cloud computing and there is one cluster header to send all information to other vehicles in each cluster as well as to neighbouring cluster headers. Each cluster header will search country whether any base station is available or not in order to transmit information to cloud computing environment.[1]

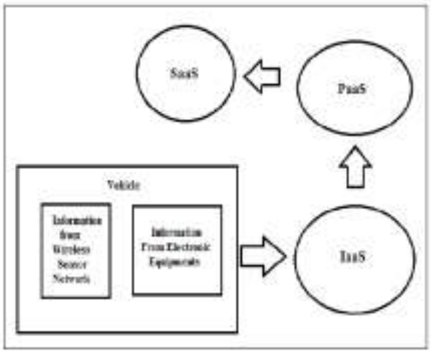

Fig 1: Schematic diagram of cloud architecture which included VANET.

Vehicle cloud architecture includes infrastructure as a service (IaaS), platform as a service (PaaS) and software as service (SaaS) to operate the cloud environment. In IaaS, the wireless sensor network and electronic equipments connected to the cars collect the in-car information, traffic and road information. This information is then passed to SaaS through PaaS. This kind of system will communicate with the users within the cloud, process all information and give useful services such as fuel and pollution feedbacks, traffic and high way management, navigation and tracking, etc.

2) Vehicular cloud computing service Architecture

VANET clouds are suitable for IaaS and SaaS only, whereas PaaS does not seem to be logically appropriate for VANET environment. At IaaS level, the potential services provided by VANET clouds might be Network as a Service (NaaS) where a vehicular node moving on the road might be used as a wifi access point gateway to the internet. The vehicles could rent their resources if the users intending to use the services, are will to pay. At SaaS level, real-time VANET information could be shared with the subscribed users. Additionally, infotainment services and P2P applications are suitable to be used as SaaS.[2]

Fig 2: VCC Service Architecture

3) VEHICULAR CLOUD COMPUTING TAXANOMY

3.1 Vehicular Clouds (VC):

The main players in VC include VANET infrastructure itself, gateways, and brokers as Note that the vehicular nodes serve as service providers in this paradigm. VC is formed in the following manner. First, the vehicles initiate a protocol to select broker(s) among them and identify the boundaries of the clouds following by electing an Authorized Entity (AE) among the brokers to ask for authorization in order to form a cloud. After brokers and AE are elected, then AE invites the vehicular nodes in the premises of the cloud boundary to take part in cloud. Interested vehicles will reply with an ack. If the number of interested vehicles is above certain threshold, then AE will ask higher authorities about permission to form a cloud and provide the potential resources. Upon getting permission, the participants of the cloud will pool their resources to form a rich virtual environment. AE sends the schedule plan to higher authorities and gets implementation authorization. Note that the job in hand can be handed over to the cloud by higher authorities in exchange of some incentives to the participants. AE dissolves the cloud after the job is done.It is better practice to first look for the volunteers before asking authorities for permission. It would save the bandwidth and communication if the number of volunteers for dynamic cloud formation was not enough and in case if it was not possible to form a cloud.The most appropriate example for dynamic clouds is dynamic traffic lights scheduling. Consider a national sports event in a downtown stadium watched by thousands of viewers. When the event is over, everybody wants to go out first and it will create catastrophic traffic jams. The usual traffic lights would not be a suitable option to fade the traffic jam away. The better solution would be to reschedule the scheduled traffic lights in a real-time. In worst case, it would include not only traffic lights in the stadium vicinity, but also the effect of changing one traffic light would affect many others thereby demanding re-scheduling the traffic lights on a large scale. In the aforementioned scenario, AE sends the traffic signals rescheduling plan to the municipality and hence the traffic jams issues can be resolved in a timely manner.

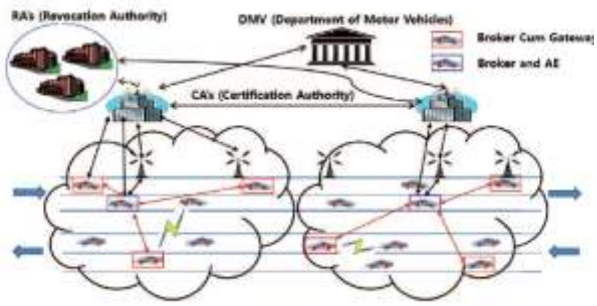

Fig 3: VC

3.2 VANET using Clouds (VuC):

The architecture of VuC where VANET uses cloud services on the move.The virtualization layer is provided by the gateways. Note that RSUs act as gateways for vehicles to the cloud services. High speed wired communication can be used from RSUs to the cloud services. As depicted in the taxonomy of the VANET clouds, the services offered by VuC include CAA, real-time traffic information, and infotainment.

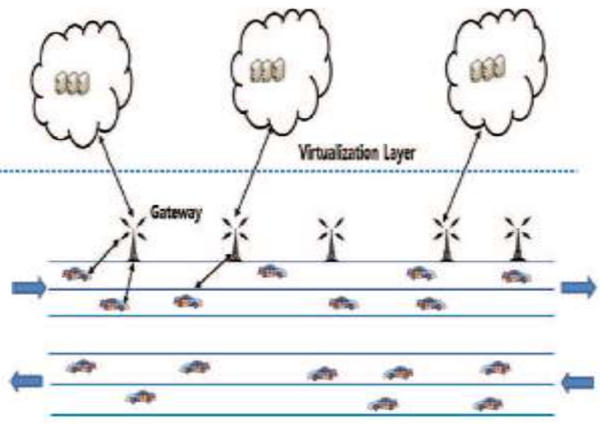

Fig 4: VuC

3.3 Hybrid Clouds (Inter-Vehicle Clouds):

HC is the combination of VC and VuC where VC serves as both service provider and consumer at the same time. The motivation behind HC is that, vehicles moving on the road might rent their resources and might want to use cloud services at the same time. NaaS and P2P are the most suitable examples for such scenarios. Nevertheless due to the ephemeral nature of VANET, connection among vehicular nodes is very intermittent. But yet it can be argued that usually for P2P applications, the size of the files is fairly small making it suitable for short time connection. Other potential applications for this architecture include IaaS in case of VC.[3]

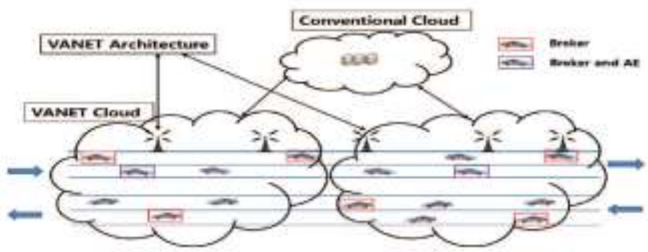

Fig 5: Hybrid Cloud

II. Analysis of Mobile Cloud Computing And Vehicular Cloud Computing

Vehicle Cloud Computing is a new hybrid technology consists of the combination of various networks such as mobile adhoc networks, wireless sensor networks, vehicular adhoc networks, and cloud computing to provide better services for automatic cars such as control car movements and handling navigation system to provide reliable and shorter routes,which also ensures safety. Security and privacy are the two major challenges for all wireless or wired networks that allow users to share the same set of resources. The architecture of VCC can be classified into three layers: networks ,the wireless communication channel and cloud computing. The first part is responsible for collecting the information and events from the environment. Then, this information is transferred to the cloud by using the wireless communication channel as a wireless access point.

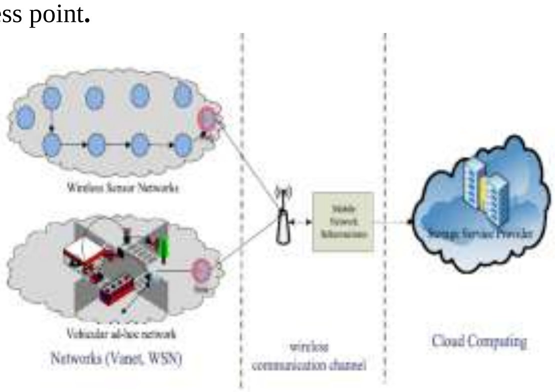

Fig 6: Architecture of VCC

A) Simulation

1) Simulation of Urban Mobility (SUMO): A portable microscopic road Traffic simulation package that offers the possibility to simulate how a given traffic demand moves through large road networks. In addition to these two simulators, other solutions exist, such as Vissim
or Transims, among others. Some comparison studies have been performed between two or more of these simulation platforms . Based on some of these studies, and the more recent developments made to each of the simulation platforms, SUMO was the adopted one. This decision was made partly due to the commercial nature of Vissim (which presented a very good performance), as well as the recent developments that eliminated some of the drawbacks presented by SUMO in earlier analyzed versions.[9]

2) Simulation Steps

As mentioned before, several simulation platforms were analysed;of these, SUMO(Simulation of Urban MObility) was chosen as the trffic simulator. SUMO is an open source tool and a microscopic road traffic simulation package that supports dffierent types of transportation vehicles. Every vehicle has its own route and moves individually through the network. This tool supports trffic lights and is space continuous and time discrete (the default duration of each time step is one second).

There are three main modules in the SUMO package:

1.1 **SUMO**, which reads the input information, processes the simulation, gathers results and produces output files. It also has an optional graphical interface called SUMO-GUI;

1.2 NETCONVERT, a tool to simplify the creation of SUMO networks from
a list of edges. It reads the input data, computes the input for SUMO and
writes the results into various output formats, such as XML, CSV or VISUMnetworks.
It is also responsible for creating trffic light phases.

1.3 DUAROUTER, a command line application that, given the departure time,
origin and destination, computes the routes through the network itself using
the Dijkstra routing algorithm.

As input data, SUMO needs three main _les, representing routes, nodes and edges. The nodes and edges files represent the vertexes and edges in the road graph, respectively. The routes file represents the traffic demand and includes information about all the agents involved in this simulation and their characteristics (departing time, maximum acceleration, maximum deceleration, driving skill, vehicle length and color) and route (list of edges). In terms of outputs,
there are dfferent types available, such as:

1)a raw output that contains all the edges and all the lanes along with the vehicles driving on them for every time step, which results in a considerable large amount of data.

2)log files created by simulated detectors (a simulation of induct loops with the ability to compute the flow, average velocity on the lane, among other values) are written using the CSV format. This

ISSN: 2321-8169
528 - 532

data can be aggregated for specfied time intervals which may be configured by the user.

Finally, this simulator offers a way to measure some metrics such as fuel consumption or pollutant emission, based on the Handbook of Emission Factors for Road Transport (HBEFA) database. It provides emission factors per traffic activity, i.e., it offers a way of measuring CO2 emissions and fuel consumption, among other pollutant factors, for various vehicle categories (such as passenger cars, light duty vehicles, heavy duty vehicles, buses, coaches and motorcycles), being suitable for a wide variety of traffic situations.

B) Pre-Simulation step(SUMO setup)

1. Extracting the map from www.OpenStreetMap.org (*.osm)

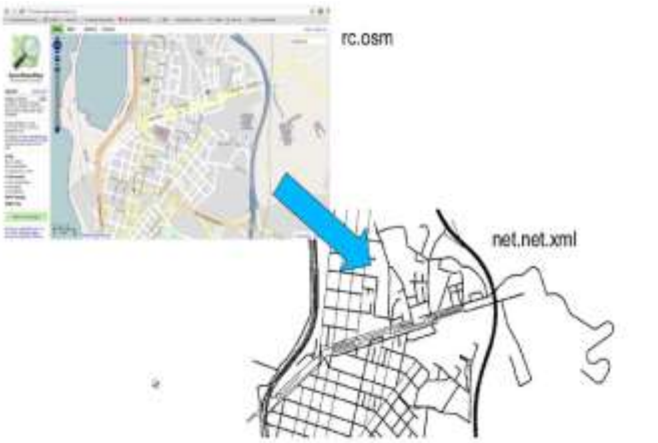

Fig 7: Extracting Map

2. Creating road network file (convert *.osm to net.xml with **netconvertor)**

Netconvert --osm rc.osm

3. Generating random trips for road network file (randomTrips.py)

./randomTrips.py -n net.net.xml -l -e 600 -o trips.trips.xml

4. Convert the trips to routes and traffic flows (duarouter)

duarouter -n net.net.xml –t trips.trips.xml –o routes.rou.xml --ignore-errors

C) Simulation Result

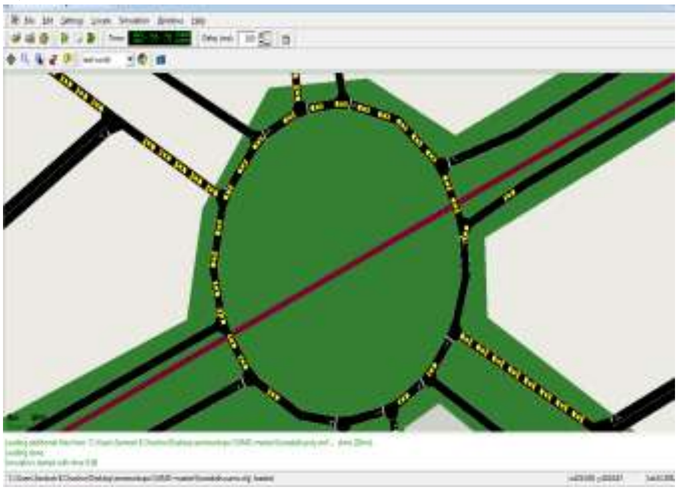

Fig 8: Simulation

D) Application Scenarios

In this section several applications of VC are introduced as possible examples.

1) Traffic management.

Drivers can access vehicular clouds to learn about traffic conditions, including congestion.Drivers will receive optional routes to help mitigate congestion in an autonomous way.

2) Road condition sharing.

Road conditions such as flooding areas, black ice on roadway, etc., can be shared in vehicular clouds. Drivers will be alerted if there are serious road conditions.

3) Accident alerts at intersections.

This will be a service to drivers. In some demanding traffic situations such as fog, heavy storm, and the like, drivers can order this service to alert them of possible accidents intersections..

Another example is that black ice on a bridge can be monitored and alerted by VC Infrastructure, for example a tall building, can include high precision radar to detect car accidents. This infrastructure will cover the whole intersection and frequently scan the intersection. An intelligent algorithm will be applied to each scan result and predict the possibility of accidents of cars.

4) Safety critical applications.

Applications related to life critical scenarios such as collision avoidance, adaptive cruise control, etc., requires strong security protection even surrounding environmental security threats. These applications also are time-sensitive. Therefore, overhead of security routines will be seriously considered.

5) Intelligent parking management.

Vehicles will be able to book a parking spot in vehicular cloud. All the parking spot information will be available on clouds without central control. Requests from different physical places can be transferred to the most desired parking lots.

6) Managed disaster evacuation.

In some disaster such as hurricane drivers can be well organized to evacuate the disaster area.

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528 - 532

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