Proceedings of the World Congress on Engineering and Computer Science 2012 Vol I
WCECS 2012, October 24-26, 2012, San Francisco, USA

Deployment of Cloud Computing into VANET to Create Ad Hoc Cloud Network Architecture

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***Abstract*- Vehicular Ad Hoc Network (VANET) has been drawing interest among the researchers for the past couple of years. Though ad hoc network or mobile ad hoc network is very common in military environment, the real world practice of ad hoc network is still very low. On the other hand, cloud computing is supposed to be the next big thing because of its scalability, PaaS, IaaS, SaaS and other important characteristics. In this paper we have tried to propose a model of ad hoc cloud network architecture. We have specially focused on vehicular ad hoc network architecture or VANET which will enable us to create a "cloud on the run" model. The major parts of this proposed model are wireless devices mounted on vehicles which will act as a mobile multihop network and a public or private cloud created by the vehicles called vehicular cloud.**

***Index Terms*: Cloud Computing, Vehicular Cloud, Ad Hoc network, Wireless Network, VANET.**

I. Introduction

Vehicular ad hoc networks (VANETs) vehicle-to-vehicle and vehicle-to-infrastructure communications which can be a reliable and secure system for efficient traffic control. Considering the broadcast nature of the medium, multi-hop routing, multiple communication paradigms and short duration of vehicle to vehicle sessions, the establishment of VANET according to modern day needs can be critical. In ad hoc network, mobile nodes self-organize themselves to create a network without the support of any infrastructure like base-stations. And cloud computing is supposed to be the next big thing because of its scalability, PaaS, IaaS, SaaS and other important characteristics. In this paper, we have proposed a ad hoc cloud architecture that combines the concept of mobile ad hoc network, vehicular ad hoc network and cloud computing to provide better traffic control and safety on the road with an advantage of V-cloud. Our main contributions in this paper will be:

1) To create a traffic control structure using ad hoc network and cloud computing.
2) To create a V-cloud to provide two feasible cloud services – Network as a Service (NaaS) and Storage as a Service (SaaS).
3) To design scalable, multitier ad hoc network architecture, consisting of a small number of wired base stations plus a mobile multihop wireless backbone, serving mobile users over a metropolitan area.

Manuscript received July 09, 2012; revised July 29, 2012

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II. Ad Hoc Multitier Network Overview

Ad hoc multitier network is basically a wireless multihop network architecture used for wide area communication. In this system, wireless devices are mounted on the vehicles such as city buses or private cars which follow the same route for their transport which act as nodes. These vehicles cover the area of the city in both space and time, and can be organized in a multihop wireless ad hoc network backbone that provides network access and general communication services throughout the city. To improve ad hoc network routing scalability and to provide internet connectivity several base stations are sited throughout the city with which nodes can communicate over multi-hop paths. Mobile users and other subscribers can communicate over this architecture using cell phones or laptops or even other vehicles can get internet connectivity from this multitier network. This system decreases the number of base stations around the city as well as gives the vehicles on the run an access to the internet where there is no signal coverage of the base stations. The Network Architecture design is explained in detail in [1].

III. Vehicular Ad Hoc Network and Cloud Computing

Vehicular ad hoc network are different from other ad hoc networks because of their hybrid architecture and node movement. Though ad hoc network, wirelesses LAN, cellular technology for intelligent transport system – all work together in VANET, address routing is the most important of all. VANET can employ vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications for advanced notification of traffic events. In support of traffic-related communications, the US Federal Communications Commission (FCC) has allocated 75 MHz of spectrum in the 5.850 to 5.925 GHz band specially allocated by the FCC for dedicated short-range communications [2].

ISBN: 978-988-19251-6-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

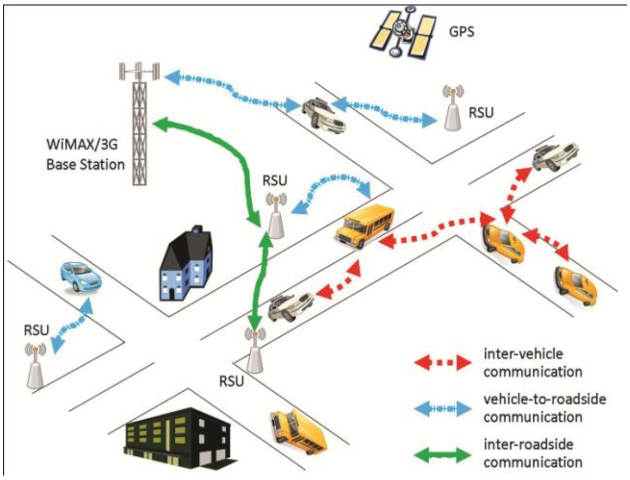

Fig 1. Schematic diagram of VANET architecture.

The notion of cloud computing started from the realization of the fact that instead of investing in infrastructure, businesses may find it useful to rent the infrastructure and sometimes the needed software to run their applications. One major advantage of cloud computing is its scalable access to computing resources. With cloud computing developers do not need large capital outlays in hardware to deploy their service for internet applications and services. Keeping the noble benefit of cloud computing, the idea of Vehicular Cloud (V-Cloud) comes into light [11].

Modern cars are equipped with permanent internet presence, featuring substantial on-board computational, storage, and sensing capabilities which can be thought as a huge farm of computers while their substantial amount of stay on the road. As on the road most of these facilities remain idle, if we can use these huge capacity of computing facilities it will benefit the owner of the vehicle if he uses it as a pay-as-you-go service and the users of these facilities. This makes the makes these vehicles potential candidates for nodes in a cloud computing setup. Rather than keeping these huge resources idle, we propose to use them in the co-operation with various authorities to solve problems which takes longer tome to solve due to the lack of additional resources. In our case, we will explain the situation with traffic in the later section.

IV. Attributes of Cloud in VANET

In the VANET, cloud computing can be used as a Network as a Service (NaaS) or Storage as a Service (SaaS). Not all the cars on the road have internet access. In NaaS, the car with access to internet can offer its excess capacity to the other cars in the VANET upon request. For, SaaS, the vehicles with ample storage capacity share storage with other vehicles which need storage capacity for temporary application. In this paper, we will mainly focus on the NaaS.

It is clear that many drivers will have persistent connectivity to the internet through cellular networks and other fixed access points on the road while driving while some of the cars will not have internet access, but they need to use internet. Upon these types of circumstances, each driver with internet connectivity, who is willing to share this resource, will advertise such information to all vehicles around him on the road. This information may then be multihopped between vehicles on the local vicinity informing them about the existing cars who can act as hop to the internet through mobile ad hoc network (MANET) [3]. By this way every car within a certain range of area can create cloud architecture.

V. Proposed Idea for Traffic Applications

In this model, we propose to use the vehicles on which wireless device are mounted, in the city as the backbone of the network. These vehicles act as the movable nodes. The only fixed part of the network infrastructure are small number of base station nodes and due to the multihop routing capability of the ad hoc network mobile backbone nodes, placement of the fixed base station nodes is significantly simplified [1]. The network thus forms a hierarchical, multitier structure. Network mobile nodes route packets between personal mobile nodes within the ad hoc network, and between personal mobile nodes and the internet, through a small set of fixed base stations.

So while on the road if there is no base stations in nearby, there is actually not a problem because due to the ad hoc network structure all the nodes create a network by hopping the signal eventually to the nearest base stations. Moreover, through VANET, each vehicle can communicate with the other vehicle through V2V network. So, with the ad hoc network created within the traffic can be controlled. Whenever a car will come into a close proximity within a certain region which can make congestion in the road, by V2V the car will send message to the other car and create enough room in the road so that when the green signal turns on every car can move comfortably without making a huge traffic jam due to congestion. The front vehicle constantly sends a communication message for keeping a distance to the rear vehicle and issues a warning message in case of violation. This also helps traffic administration to control and mitigate accidents and identify the mistakes for legal actions. The communication between vehicles to vehicle is exchanged via DSRC standard [3]

Moreover, as every car has internet connections, the wireless sensors connected to the cars for measuring fuel usage, road data, GPS information, CO_2 emission etc. information are automatically sent to a cloud controlled by the traffic police. Now, if any car emits too much CO_2 or breaks traffic law, all the information will automatically be uploaded to the cloud controlled by traffic department and they can track the car by analyzing the IP address of the car or registration or chassis number uploaded into cloud. As every car is equipped with a wireless device for ad hoc network architecture, each wireless device will hold a

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particular address which will also be sent to the cloud through wireless sensors connected to each car. So it will be very easy to track each car by the traffic department.

In another scenario, if a large traffic jam occurs, a huge number of cars with internet access and computational infrastructure facility get stuck. Rather than making the situation complicated with traffic light synchronization, the resources in the cars are used to make a V-Cloud or connect into the cloud controlled by traffic department to reschedule the traffic lights in such a way as to dissipate the traffic jam as soon as possible. The facility is affordable and even the traffic department need not to spend huge amount money for the extra hardware to calculate traffic scheduling program for large number of cars, rather they will use the idle computational facilities in the car which are stuck in the traffic jam.

VI. How the System Works

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 neighboring 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 [4].

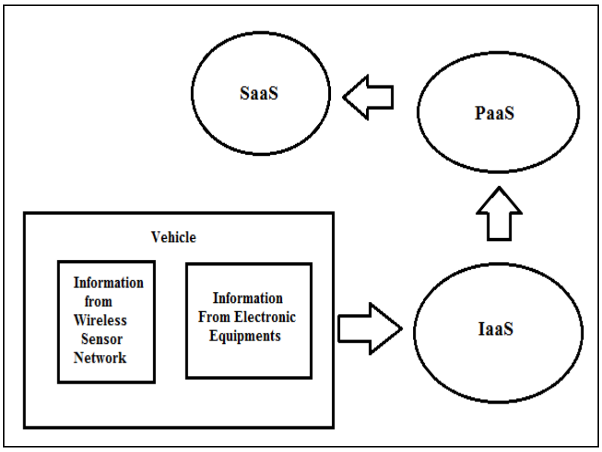


Fig 2. Schematic diagram of cloud architecture which included VANET as IaaS.

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.

VII. Benefits over Other Solutions

At present, traffic monitoring authorities use inductive loop detector (ILD), video cameras, acoustic tracking system and microwave radar sensors, etc. Among these technologies ILD technology is the most popular in which ILDs embedded in every mile or every half mile measure traffic flow by registering a signal each time a car passes over them. But ILD system is too much costly. Each ILD (including hardware and controllers) costs around $8,200 connected by optical fiber that costs $300,000 per mile. Moreover, official statistics show that over 50 percent of the installed ILD base and 30 percent of the video cameras are defective [5]. Therefore, to replace these systems with an effective and less expensive traffic monitoring system, our ad hoc cloud network architecture can be a best choice. VANET can provide drivers with advance notifications of traffic events, the drivers can get the message instantly or even if the driver is busy in that moment the notifications will be saved into the cloud from where the drivers can process them whenever they want, so as the traffic department. Besides, in Bangladesh walkie-talkie used by traffic police has a low range around 500-1000 yards (about 460-920 m) although some walkie-talkie such as FRS Radio (Family Radio Service) and GMRS (general mobile radio service) can provide a range up to 30 miles. But having these kinds of facilities require radio operator licenses. Moreover, they are costly and for increasing their range sometimes repeater is used which is also expensive. Traffic polices also face problem when more information come in their device because they can hardly determine the source of the information. They cannot even catch up the target vehicle because they do not have the specific location or movement of the vehicle.

In context according to our proposed model will upload any traffic information such as IP address of vehicle which breaks traffic law or fuel and pollution feedbacks and also the GPS location in the cloud so that it eases the burdensome task of the traffic police. They can also easily catch up the vehicle by using it’s GPS location without wasting time. In cloud model it takes about 16- 20 ms to upload a 5-10 KB information in the cloud and from the cloud the message will be broadcast which also takes less time than our traditional walkie-talkie system. So, overall about at most 40-50 ms will be needed to get the required information to the police. This is more reliable, autonomous and faster than the other systems.

Other advantages related to our proposals are-

- No matter how far the vigilante car is it is possible to track it down and seize it immediately
- In traditional system if the message about any occurrence is missed or could not captured for some reasons the information is lost as it is not saved. But in this model we proposed to save information about vehicles so that even if the vigilante hides somewhere it’s information is saved in the cloud. So, whenever the vehicle is tracked in somewhere it can easily captured.

- The multilevel view in the cloud can help providing route plan and improving the overall conditions of the traffic system.
- As it is based on autonomous distributed system concept so data is saved with a topmost security in the cloud and it helps to develop a consensus of traffic system.
- It will help the drivers to be more careful about their driving.

VIII. Limitations of Cloud in VANET

Recent years researchers have been concerned about the security of the cloud network in the implementation of vehicular cloud network. However there are other challenges like high mobility of nodes, signal attenuation, network scalability.

A. Security of the cloud networks

Authentication and authorization of the nodes accurately in the intermittent short-range communication relates to the integrity of data [6]. The complexity increases with the increase of nodes. User identity spoofing and tempering data could be the main threat to the network where the attacker pretends to be another user of same priority level. A solution to this problem is suggested in [7] where centrally assigned digital pseudonym generated by the authority should be used.

B. Mobility of the nodes

Interruption of data transmission between faster moving nodes in the highways becomes imminent as the connectivity lasts only for a few moments. On the contrary, during traffic jam congestion of transmitter nodes will create noise and interference [8].

C. Signal Fading

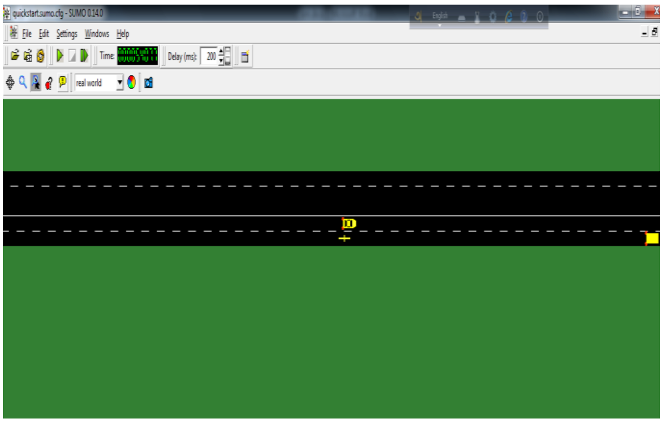
Obstructed by large buildings and other infrastructures in the metropolitan areas the signal attenuates at a higher rate resulting in both deterioration of signal strength and signal quality [6].

D. Network Scalability

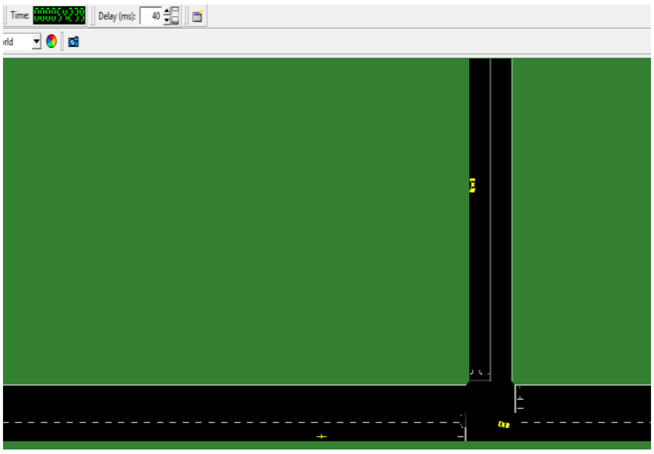
With an increasing 750 million vehicles worldwide [9] and considering the absence of a global authority which will govern the network the scalability of the network is questioned. The communication between vehicles to vehicle is exchanged via DSRC standard [10] and DSRC standard in North America is different from the DSRC standards in Europe.

IX. Simulation

This simulation is done using sumo simulator. It is open-source software helps to simulate vehicular related simulation. Here is the scenario: As every vehicle in our proposed system is equipped with sensor, it sends information about the position and velocity of the vehicle in the cloud. Here we can see (fig 3) a sedan car crosses the speed limit and overtakes a motor cycle. As soon as it breaks the traffic rule, the vehicle is traced. And information is send to the cloud. The chassis number with model, time of occurrence about the car is uploaded into cloud. So nearby police is notified from the cloud system. Then police traces, blocks and takes action against the car. We can see the timing when car crosses the limit. In this simulation there are seven cars including police one. Here the indiscipline car has “carFollowing-Krauss” model type. From the generated xml output file we have got the



(a) Indiscipline car breaking law



(b) Police motorcycle approaches reaches in time to right place to take action

Fig 3. Simulation overview shown in a, b.

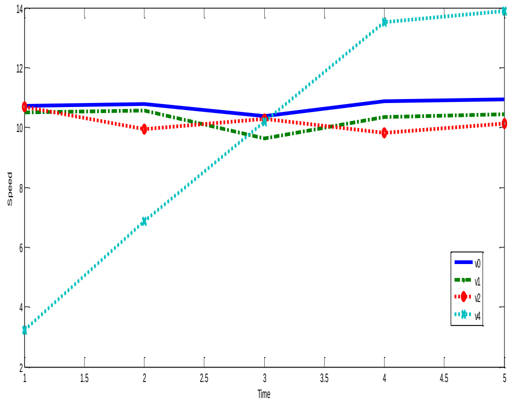


Fig 4. Speed of vehicles in different timestamps.

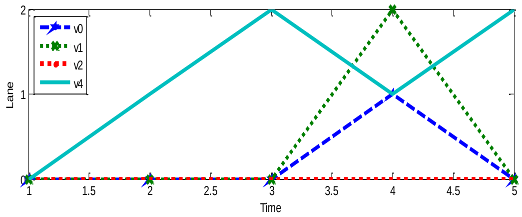


Fig 5. Vehicles in different lanes with timestamps.

timestamp, speed, lane etc information about each vehicles. A short portion is taken and plotted in the graph. It shows the criminal vehicle (v4) crosses the speed limit and not disciplined at all (fig 4). We also took lanes for different timestamp which also shows this car frequently changing it's lane (fig 5). Thus from cloud we can monitor the vehicles and find irregularities when necessary.

X. Conclusion

In this paper we have proposed an idea which is still new and a lot of work needs to be done to make the model perfect. If we can implement the idea practically, not only the present telecommunication industry will get benefitted but also the communication sectors and most importantly traffic control units will be benefitted a lot. It will reduce the necessity of too many base stations around the city as well as create better opportunities for the drivers in a highway to be a part of the internet access when required. It will create a new dimension to the traffic control system. Though we have several challenges to be met to work more efficiently in our proposed model, we believe with our future research it is not far to establish such infrastructure.

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