International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 8 (2015) pp. 19659-19666

http://www.ripublication.com

Vehicular Cloud Service Model For Secure Transportation System

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Abstract

The advances in cloud computing and vehicular networks have provided a promising opportunity to improve the vehicle-to-vehicle communication, efficient traffic management, road safety and entertainment for drivers as well as passengers. We proposed a new hybrid technology called Vehicular Cloud Service (VCS) model for urban traffic management using resources like cloud storage, infrastructure service, computing and internet. In this paper, we present a three layer cloud service model using cloud computing and vehicular networks to create an accident free environment. The architecture, design principles and implementation for intelligent transportation system in vehicular cloud computing environment is also discussed in this paper. We have used Vehicular Ad hoc NETwork (VANET) simulator tool, integrating vehicular mobility, wireless transmission simulator and traffic simulator for implementing the vehicular cloud services.

Keywords: Ad-hoc Networks, Cloud Computing, anything as a service and traffic and safety management

I. Introduction

In recent times, VANET has attracted the attention of researchers and car manufactures to improve traffic safety and resource utilization on cloud computing. Traffic information and safety messages is sent, forwarded and received by the vehicles in VANET. The commercial application of VANET is safety related applications and user related applications. The main objective of VANET is to satisfy the user's requirement on road and make their journey safe and comfortable. In addition, vehicles can access internet services, like audio files, movie, and games [3].

A VANET is a collection of moving vehicles and Road Side infrastructure Units (RSU) in a wireless network that can be used by drivers influence services on demand anytime from anywhere [1]. VANETs are an application of Mobile Ad-Hoc Networks (MANETs).

VANET is a self-organized dynamic inter-vehicle network that supports communication between different vehicles (V2V) and the communication between vehicles and road side infrastructures (V2I) [12]. In VANET, communication can be done in two ways. The first way is vehicles can communicate with each other to exchange their information and another way is vehicle can broadcast the message to multiple vehicles through the network until road side unit is reached. The important characteristics of VANET are high mobility, rapidly changing network topology, unbounded network services and time critical [13].

Fashionable vehicles are equipped with processor, better storage unit, communication devices and display unit. These resources available in the vehicles are generally underutilized by the applications [4]. In an attempt to solve the problem of resource underutilizing, Vehicular Cloud Computing (VCC) has been proposed [6] [7]. The VCC is a combination of cloud computing and VANET. Cloud computing is an internet-based computing whereby information, IT resources, and software applications are provided to computers and mobile devices on-demand[5]. Cloud resources are usually not only shared by multiple users but are also dynamically reallocated per demand. Each vehicle in VCC can communicate to the other vehicles or the network infrastructures by using the vehicle to vehicle or the vehicle to infrastructure network communication. VCC is a recent emerging paradigm for efficient traffic management, congestion control and vehicle safety by dynamically using vehicular resources, such as computing power, storage, and information.

Mobile Cloud Computing (MCC) is a new platform combining the mobile devices and cloud computing to create a new infrastructure, whereby cloud performs the heavy lifting of computing-intensive tasks and storing massive amounts of data [11]. In this new architecture, data processing and data storage happen outside of mobile devices. MCC [8]is used by car passengers or drivers to access information from the cloud environment using mobile devices. The users can use their mobile devices to connect to the cloud via internet [10]. Mobile devices are connected with the sensor networks to access traffic information on the cloud. Mobile devices are not efficient for traffic management due to lack of battery life, computing power, processing time, memory, bandwidth and cost [9].

2. Vehicular Cloud System Architecture

In this paper, we proposed the architecture of vehicular cloud services in VANET as shown in Fig. 1. This architecture fully utilizes the resources available in an entire network such as vehicular network, communication network and primary network into the cloud. All cloud can communicate with each other and accessible to all vehicles. With the assistance of modern technologies such as Micro-Electro-Mechanical System (MEMS), wireless communication techniques, internet and cloud computing etc, the future road transportation system will be more powerful, intelligent, flexible and convenient for both drivers and administrative centers. Each of this cloud provides a specific service to the drivers, which are explained as follows:

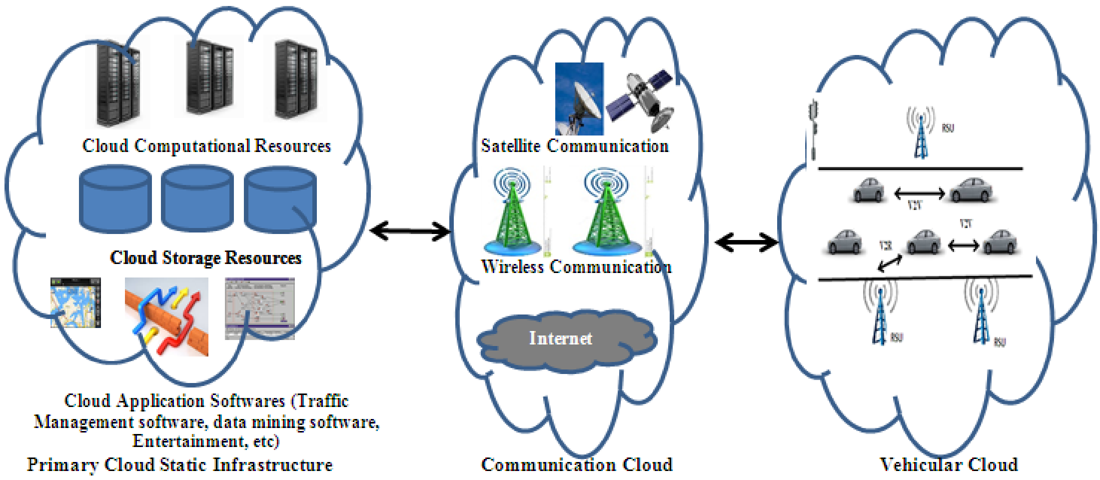

Fig. 1. Vehicular Cloud Services Architecture

2.1 Vehicular Cloud

With the latest technology, vehicles are equipped with cloud platform to access GPS services, road safety messages, video and audio files and traffic information. Vehicular cloud is formed by group of cooperative vehicles, which is formed by V2V communicationscalled inter-vehicle network VANET. Each and every vehiclecan access the cloud and utilize the resources for their own operation. Some of the devices may be equipped with the car while many others may be hand-held devices or attached on the driver to monitor the physical healthinformation. Vehicular cloud computing applies a virtualized platform with elastic resources on demand by provisioning processor for computing and memory for storage dynamically on demand. Due to vehicle mobility, implementation of vehicular cloud platform is difficult compared to the traditional cloud platform.

2.2 Communication Cloud

Communication cloud is formed by collection of road side units and servers. The servers virtualize the resources in the cloud and act as a cloud site. A vehicle can communicate with road side unit by V2R communications. RSUs provide radio interfaces for vehicle to access the cloud. A communication cloud is accessible only by the vehicles available within the radio coverage area. This cloud is responsible for sending and forwarding messages to and from the vehicles and the primary cloud. To prevent the accident on road, roadside sensor nodes measure the road condition at several positions like curve, aggregate the measured values and communicate their aggregated valueto an approaching vehicle[15]. The vehicle generates a warning message and distributes it to allvehicles in a certain geographical region. For post-accident investigation, sensor nodes continuously measure the road condition andstore this information within the WSN itself. When a accident occurs, road condition datastored over a sufficiently long duration can be used for forensic reconstruction of roadaccidents.

2.3 Primary Cloud Static Infrastructure

Primary cloud is established among group of static servers in the internet. A vehicle will communicate with a primary cloud using V2R or cellular communications. It has high configuration resources than communication cloud and vehicular cloud. Data mining services are deployed for predicting the traffic information and safety guidance to vehicle drivers. Providing safety is the primary objective of vehicular communication networks. Vehicles who discover an imminent danger such as an obstacle inform others. Electronic sensors in each car can detect abrupt changes in path or speed and send an appropriate message to neighbors. Vehicles can notify close vehicles of the direction they are taking so the drivers can make better decisions; a more advanced version of turn signals. In more advanced systems, at intersections the system can decide which vehicle has the right to pass first and alert all the drivers. Some of the immediate applications are Warnings on entering intersections, Warnings on departing the highways, Obstacle discovery, sudden halts warnings, Reporting accidents, Lane change warnings.

3. Vehicular Cloud Service Layers

Three layers of cloud service architecture components for vehicular networks, ranging from vehicular service layer, communication layer to application service layer is shown Fig. 2. There are various components in these layers and purposes of each component are described as follows.

Vehicular Service Layer:

The bottom layer relies on two sub-layers: sensing layer and vehicular application layer. Sensing layer consists of various types of sensing devices, which is responsible for monitoring the environment status, road condition, driver's health such as temperature and pressure using body sensors. Then the collated signals or data is stored in the storage unit and it is analyzed by the processor available in the vehicle. Radar, lidar, and sonar can all detect relative location of the vehicles using electromagnetic, optical, and acoustic signals. For any vehicle with a GPS receiver, the system will provide accurate location ant time information for an unlimited number of users in all weather conditions, day and night, anywhere in the world. Thesensed information is shared with the neighborhood vehicles in the vehicular cloud platform to enable the traffic safety for drivers and passengers. This V2V communication will play vital role in reducing the number of crashes, collisions in the road. Also, the information is send to the storage unit in the application service layer and it is analyzed by the software application programs to generate knowledge.

<table>
<tr><td colspan="13">Cloud Application (SaaS)</td><td rowspan="7">Application Service Layer</td></tr>
<tr><td colspan="13">Cloud Software Environment (PaaS)</td></tr>
<tr><td colspan="13">Cloud Software Infrastructure (IaaS)</td></tr>
<tr><td colspan="5">Computational Resources (LaaS)</td><td colspan="4">Storage (DaaS)</td><td colspan="4">Communications (CaaS)</td></tr>
<tr><td colspan="13">Collocation cloud services (LaaS)</td></tr>
<tr><td colspan="13">Network Cloud Services (NaaS)</td></tr>
<tr><td colspan="13">Hardware/Virtualization cloud services (HaaS)</td></tr>
<tr><td colspan="4">Vehicle to Vehicle Communication (V2V)</td><td colspan="4">Vehicle to Roadside Communication (V2R)</td><td colspan="4">Roadside to Vehicle Communication (R2V)</td><td>Communication Methods</td><td rowspan="3">Communication Layer</td></tr>
<tr><td>DSRC</td><td colspan="2">WiMAX</td><td colspan="3">3G or 4G cellular communication devices</td><td colspan="2">IEEE 802. 11p</td><td colspan="2">WAVE</td><td colspan="2">Wi-Fi</td><td>Communication Technology</td></tr>
<tr><td colspan="3">Internet</td><td colspan="3">Wireless Communication</td><td colspan="3">Cellular Network</td><td colspan="3">Cloud Infrastructure</td><td>Communication Networks</td></tr>
<tr><td colspan="2">Processor</td><td colspan="2">Memory</td><td colspan="2">Storage Unit</td><td colspan="2">GIS</td><td colspan="4">Interface Applications</td><td>Vehicular Application Layer</td><td rowspan="3">Vehicular Service Layer</td></tr>
<tr><td rowspan="2" colspan="3">Radar, Lidar and Sonar</td><td colspan="3">Sensors (RFID, ZigBee)</td><td rowspan="2" colspan="2">Camera</td><td rowspan="2" colspan="2">GPS</td><td rowspan="2" colspan="2">RFID</td><td rowspan="2">Sensing Layer</td></tr>
<tr><td>Body</td><td colspan="2">Environmental</td></tr>
</table>

Fig. 2. Component architecture vehicular cloud service

The traffic situation is dynamic and many vehicles are idle on the road or parking area. In this situation, computational and storage resources are underutilized. Some vehicles are lack in memory and processing capability in inter-vehicular network. In the same way, some vehicles have adequate amount of storage and processing capability. These vehicles can join in the cloud environment to share or rent their computation and storage resources to other vehicles. Each vehicle can provide and access the services to and from the cloud environment. The vehicular application layer is responsible for providing traffic information, on-road safety messages, video and audio fileson demand and GPS services to the drivers at anytime from anywhere. The acquired information is transferred from vehicular layer to application layer through the communication layer.

Communication layer:
The middle layer in this architecture is called communication layer, which is divided into three sub-layers. In VCS, the bottom sub-layer is called communication network includes fixed gateways, for exchanging packets among vehicles invehicular service layer andinternet. Some vehicles have internet connection while they are moving. The communication technology layer represents the standards used for exchanging packets between vehicular service layer and application service layer. The VANET provides three way communication methods, such as Vehicle to Vehicle Communication (V2V), Vehicle to Roadside Communication (V2R) and Roadside to Vehicle Communication (R2V). The vehicles can communicate with each other through Dedicated Short Range Communication (DSRC) wireless devices for exchanging data between vehicles. As vehicles are equipped with IEEE 802. 11ptransceivers, they can exchange information either V2V or V2I by using Wi-Fi, IEEE 802. 11p, WiMAX or 4G cellular communications. The vehicle can communicate with the Road Side Unit (RSU) to exchange information with the server in the communication and application service layer.

Application Service Layer:
The application service layer is the top layer in VCS, which is responsible for performing the enormous and multifaceted computations andmaking intelligence decision in least time. Open source or commercial platforms are available for the deployment of cloud called as Infrastructure as a Service (IaaS). On the road while driving most cars have inter connections and some cars do not have internet connections. These under utilized network resources can be rented or shared to other vehicles called as Network as a Service (NaaS). The vehicles have more under utilized storage capacity and it can be accessed by other vehicles that require additional storage to run their applications called Storage as a Service (SaaS). Some vehicles do not have enough storage capacity because of small size and expensive price. The drivers are provided with several free services and information without additional infrastructure called Cooperation as a Service (CaaS). Some vehicles are parked for long period of time, where computing and storage resources are unused and these resources can be by other vehicles called Location as a Service (LaaS) and Data as a Service (DaaS). Many software applications and packages can be accessed by some vehicles in the VCS called as Software as a Service (SaaS).

4. Current Challenges and Future Work

The current challenges in VCS are mobility, volatility, network scalability, authentication and accountability. Each vehicle in this network has high speed, hence the mobility is high. So service provision for short period is not efficient. This system is not suitable for the most of the drivers who wish to keep their personal information protected and private. There is no particular standard for vehicular communication in the cloud. In VANET, security got less attention so far. VANET packetscontains life critical information hence it is necessary to make sure that these packets are notinserted or modified by the attacker; likewise the liability of drivers should also be establishedthat they inform the traffic environment correctly and within time.

5. Conclusions

Cloud computing can process large amount of traffic and safety relate information of different types that can be useful to extract knowledge and add intelligence to the transportation system. The virtualization technology used by cloud computing systems enables the aggregation of heterogeneous large number of resources onto a small number of resources with a single interface. Cloud storage unit collect information from multiple resources and locations, and enables the vehicles to make effective and timely decision for safe and comfortable riding. Hence, accidents and traffic jams can be avoided. Cloud resources like internet, network, processor and storage are rented or shared to with various customers over the cloud. These dynamically allocated resources provide support for the drivers and passengers to reduce the level of accidents and save their life. Vehicular cloud service is the upcoming area and still need to be analyzed by the researchers and academia.

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