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Infotainment as a Service in VuC

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Abstract-Shifting VANETs to cloud has been a significant step in improving VANET technology further to provide road safety by leveraging the power of cloud infrastructure. In this paper, we discuss VANET Using Cloud (VUC) architecture for providing Infotainment as a Service (IaaS). IaaS aims to provide information along with entertainment to improve the driver passenger experience as well to increase their comfort during travel. It allows users to access upload or download multimedia content like music, images, videos on the go. When an event such as an accident occurs then pictures of site of interest are captured and are uploaded on cloud. These pictures can then be used as forensic evidence later. We also outline the various infotainment applications in VANETs.

Keywords- VANETs, VuC, Cloud, Infotainment

I. INTRODUCTION

Over the past few years there has been a significant increase in the number of vehicles and a number of technologies have been developed to improve the driving experience. Wireless technologies which has become an essential part of communication, underwent many recent advances and introduced a new type of network called Vehicular Ad-Hoc Networks (VANETs).VANET is a subclass of MANETs(Mobile Ad-Hoc Networks) that uses vehicles as mobile nodes to provide communication between the vehicles and also with the RSU(Road Side Units). The vehicles are provided with wireless transceivers that allow them to communicate with other vehicles. It turns every participating car into a node or a wireless router, creating a huge network. As the cars fall out of range of signal and the network, new cars join in forming a mobile internet where the vehicles are connected to one another.

The network disseminates the information through the nodes of the network and those vehicles contain communication components called OBU(On-Board Unit),that consists of wireless modules and sensors. The sensors monitor and transfer the information about the vehicles while the information between the OBU's are exchanged by RSU. RSU provides driving data along with internet access to vehicles. The data from the vehicles can be sent to the driver or the RSU or also be broadcasted to other vehicles based on its nature and importance.

RSU and the vehicles may communicate important driving information such as traffic assistance or notifying the vehicle about an event that has occurred (e.g. Accidents) using wireless LAN. The main goal of VANETs is to ensure a safe and comfortable driving experience. VANET has various features like mobility, dynamic in nature, real time processing, etc with RSU's using wireless technology. VANET have many applications like traffic control, share of multimedia information, etc. VANET cloud is a new concept that combines both VANET and cloud computing to provide safe, reliable and infotainment rich services. It is a hybrid technology that has a remarkable impact on traffic management and road safety by instantly using vehicular resources, such as computing, storage and internet for decision making. The goal of VOC is to provide several computational services at low cost to minimize traffic jams, accidents, travel time and to provide solutions to events that has occurred.

II. VANET CLOUDS ARCHITECTURES

As shown in the Fig.1 VANET clouds can be classified under 3 major categories [20] namely Vehicular Clouds(VC), Vehicles using Clouds(VuC), Hybrid Clouds(HC).

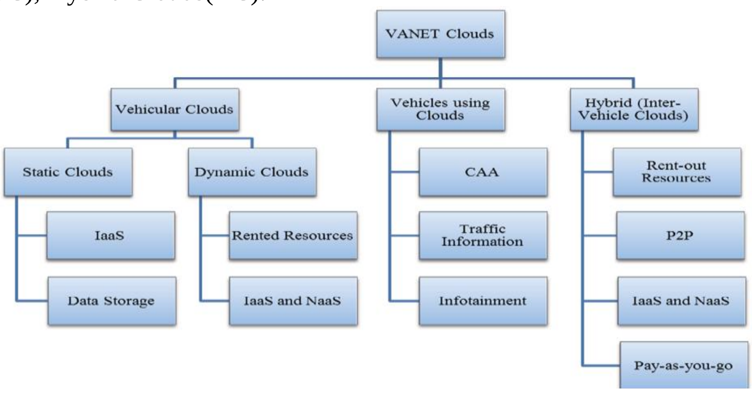

Fig 1. Taxonomy of Vehicle Cloud

- **Vehicular Clouds(VC):** The main players in VC include VANET infrastructure itself, gateways, and brokers. The vehicles first 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. Once brokers and AE are elected, AE then 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. Finally, AE dissolves the cloud after the job is done. Vehicular Clouds is further divided into Static Clouds and Dynamic Clouds from movement point of view. Static clouds refer to the stationary vehicles providing cloud services. Dynamic clouds are formed on demand in ad hoc manner. The most appropriate example for dynamic clouds is dynamic traffic lights scheduling.
- **Vehicles using Clouds(VUC):** VuC allows the Vehicles to connect to the traditional clouds where VANET users can use cloud services on the move such as infotainment, traffic information, and CAA. Here, the virtualization layer is provided by the RSUs that act as gateways for vehicles to the cloud services. High speed wired communication can be used from RSUs to the cloud services.
- **Hybrid Clouds(HC):** HC is the combination of VC and VuC where VC serves as both service provider and consumer at the same time. In HC, vehicular clouds will communicate with traditional cloud for services exchange. The vehicles and RSUs will serve as gateways on the VANET part thereby communicating with the gateways of traditional clouds. The aim of HC is that, vehicles moving on the road might rent their resources and might want to use cloud services at the same time.

III. SERVICESPROVIDED BY VANET USING CLOUD

There are many services offered by VANETs like STaaS, Naas, Taas, etc some of which are listed below.

i)*TIaaS(Traffic Information as a Service)*: Using this service the vehicles can get fine grained traffic information from the cloud, about the vehicles in front of them to construct local and extended traffic views. This traffic information can be shared with cloud and also with other vehicles. They also assist the drivers and warn them about any turns or road conditions ahead such as congestions and avoid accidents. It helps to manage city traffic, provides road safety for a safe driving experience.

ii)*Naas(Network as a Service)*: The cars that have internet access can share their excess capacity with other vehicles upon request while on the move. while driving, the drivers may need internet access which they can rent from neighbouring cars on road. The vehicle that is ready to share its resources must advertise this information to all the other vehicles on the highway.

iii)*STaaS(STorage as a Service)*: Some vehicles may require additional storage to run their applications. Such vehicles can use the ample on-board storage capacity available in other vehicles. Due to the small size and inexpensive price of storage, it is expected that the On-Board Computer will have terabytes of storage.

iv)*CaaS(Cooperation as a Service)*: It uses the appliance where the subscriber states their preferences for a service, and the cars subscribed to the same service will help to give the subscriber some important information about the service or by announcing the information to the network.

v)*IaaS(Infotainment as a Service)*: In IaaS, a key component is the data dissemination that informs all the users about a service they can be interested in, in a particular area. VANET can share information among them such as images, videos, weather information, gas station and restaurant address, music, maps, etc.

vi)*Pictures on the wheel as a service*: In this service the On Board cameras of the vehicles are used to deliver the images to the users. Mobile phones can also be used for this service. The Pictures-on-Wheels service selects a group of vehicles to take photo shots or videos of a given urban landscape for limited timeframe as requested by a customer. Vehicles should register to the centralized cloud manager, to participate in this service.

IV. RELATED WORKS

Many research attempts have been made to improve infotainment systems from various aspects. We review existing commercial infotainment systems and related research works. Presently, companies mostly use proprietary platforms to develop their own infotainment systems. Some automotive manufacturers and major IT companies have started to develop open source platforms for infotainment systems like GENAVA In-Vehicle Infotainment (GENIVI), these platforms are hard to use because of the lack of related standards[15].

Although infotainment systems have been around for decades, the topic of cloud based infotainment systems is still new and emerging. Only recently have a reasonable and feasible architectures been proposed[17] .Among these proposed architectures, web services are the principal means of implementing the Internet access. This is a method that supports machine communication over the network.

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Currently, there are two ways for the systems to use the Internet sources. One is directly invoking web services from the Internet. In their prototypical implementation, they directly display the route calculation results from Bing Maps web services. The other approach is to create a middleware server to customize services so that the server grabs the data from the Internet[15][16]. Some of the existing infotainment systems are as follows Implementation of the Android-Based Automotive Infotainment System for Supporting Drivers Safe Driving[18] While some researches on automotive infotainment systems focus on the users' convenience, some similar works focus on the driver safety. Additional functions such as black box and self-diagnosis were added to the automotive infotainment systems, based on the android platform embedded hardware. The highlight of their work is the setup of an architecture using an Android platform that is independent from current automotive development platforms like GENIVI.

An In-Vehicle Infotainment Software Architecture Based on Google Android Gianpaolo Macario[17] also proposed an Android based architecture for in-vehicle infotainment . In [17] ,an architecture that can attach third-party applications based on the Android platform. In this work [17], a safe mechanism for third-party applications to access vehicle data. For instance, they granted permission to applications to gather the temperature and speed values; they also used Google Android features to handle inter-application communication. To verify the feasibility, they implemented a prototype system using this architecture. Unfortunately, they did not provide related experiment results and their architecture doesn't adopt the cloud technology.

Integrated Embedded System Architecture for In-vehicle Infotainment National Chia-Yi University developed a system called Mayday, which provided location based services for vehicles through Wifi and (General Packet Radio Service)GPRS[19] .

GPRS is a packet oriented mobile data service on the 2G and 3G cellular communication system's global system for mobile communications . To meet the need for vehicle the Internet access from anywhere, a distributed service-based architecture was proposed based on Jini middleware technology[15]. They proposed an embedded system architecture, which consists of the service and control station segment (SCS), and the mobile segment (MS). This system took the location information from a GPS receiver for infotainment purposes, the system had an in-vehicle network that worked as a LAN server to provide a connection to stream data with other devices such as PC, PDA, and tablet.

V. VANET USING CLOUD ARCHITECTURE

The VANET system can be divided into three domains namely mobile domain, infrastructure domain and generic domain. The mobile domain includes the vehicles and the portable devices like smart phones. The infrastructure domain comprises of RSU entities like traffic lights and infrastructure management centres such as Traffic Management Centres(TMCs) and Vehicle Management Centres. The generic domain is composed of an On-Board Unit(OBU) and one or more Application Units(AU).

There are four types of Vehicular communication Architecture:

In-vehicle communication: Here, the system can detect the performance of the vehicle. Also the stress level and drowsiness of the driver can be detected, which is critical for driver and public safety.

Inter-vehicle communication: Also referred to as vehicle-to-vehicle (V2V) communication or pure ad hoc networking that allows the vehicles to communicate among each other without any infrastructure support. Any important information obtained from sensors on a vehicle, or from other vehicle, can be sent to neighbouring vehicles. It provides a platform for data exchange to the drivers where they can share information and warning messages to improve driving. This architecture provides greater flexibility in content sharing and increases network reliability.

Vehicle-to-road infrastructure (V2I) communication: It provides real-time weather and traffic updates for drivers and also provides environmental sensing and monitoring. The vehicles may use cellular gateways and wireless LAN access points to connect to the Internet and enable vehicular applications.

Vehicle-to-broadband cloud (V2B) communication: In this type of communication, vehicles communicate via wireless broadband mechanisms such as 3G or 4G. Since the broadband cloud

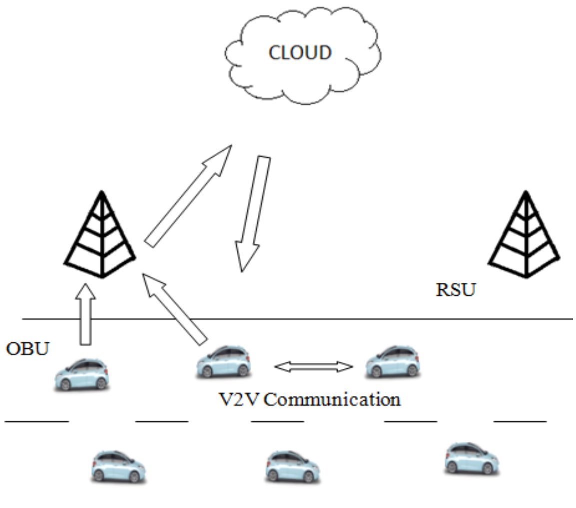

Fig 2: VANET using Cloud Architecture

may include more traffic information and monitoring data as well as infotainment, it will be useful for active driver assistance and vehicle tracking.

The figure 2 shows the basic architecture diagram of VANETs over cloud. Here, the OBUs are the vehicles on the road that can upload data to the cloud and can also send request for information from the cloud. The request from the OBU is sent to the cloud via RSU. The RSU sends the request to the cloud. The cloud then searches for the information requested and either sends it directly or through the RSU to the requesting OBU.

When the vehicles communicating with each other are in close range, they use Vehicle-to-Vehicle communication. But when they fall out of range, Vehicle-to-Infrastructure communication is used.

Whenever an event such an accident occurs, the vehicles near the site of interest broadcast an alert message to the approaching vehicles.

VI. INFOTAINMENT AS A SERVICE

Infotainment is a combination of Information and Entertainment [15], which means information and entertainment served together. Regarding vehicles, an infotainment system can provide applications for navigation and music, so as to enhance the driver and/or passenger experience. The first infotainment system was introduced in vehicles by Motorola in the form of a radio in 1930. This is the basis for the infotainment system. In subsequent years, auto manufacturers around the world accepted this idea that driving should be enjoyable. Chrysler introduced a record player in the cars, and in 1965, Ford released the first tape player. These innovations are followed by the introduction of cassette-tape players, stereo systems, and in-dash CD players. With the development of Bluetooth and hardware storage, the in-car infotainment system has integrated satellite radio, mobile devices, and local stored multimedia together.

Using the navigation application, the infotainment system can bring us something more than just entertainment. Before the invention of the navigation system, long road driving meant a bunch of fold-out maps. We also used to get route information from online services such as Google map, or Yahoo map, print the out the results and use them as the tour guide. The navigation system changed this situation, as it gives convenience to the users, allowing them to follow the route dynamically. Also, these positioning services are very helpful to the tourists and holidayers.

Apart from this, [14] many services have been developed to make users more comfortable. For example, using the infotainment services the users can interact with other users. Users can also be updated with other entertainment related news like match updates, advertisements from local merchants, gas stations and so on. The users can also get updates regarding latest sales n discounts in a mall using the infotainment services.

Infotainment services can also be used for informational purpose. For instance, the users can get information about the availability of doctors and their appointments in a hospital. It can also be used to get updates on weather and road conditions for a safe driving experience for the users.

One of the important uses of VANETs using Cloud is that vehicles can be used as witnesses for events. Here the vehicles in vicinity take pictures of the area of interest and upload it to the cloud. These pictures can later be used as evidence to get a better idea about the event.

Integrating Cloud with VANETs allows users to upload and download music, video and other multimedia content to and from the cloud. Different parts of video from different users can be merged and shared in the cloud that can be served to the users.

VII. APPLICATIONS

According to [5] the applications of VuC are mainly divided into 2 broad categories.

Safety applications can be used to reduce the number of road accidents. Harsh weather conditions like heavy rain, fog or snow may lead to accidents. According to some survey , 60 percent of accidents could be avoided if drivers were provided a warning half a second before the collision occurs. Some of the safety applications include.

1. *Accidents:* Since the vehicles travel at high speed, the drivers have less time to react to the vehicle before them. If an accident occurs, the approaching vehicles often crash before they can come to a stop. These vehicles could be given a warning of an accident that has occurred further along the road, thus preventing a pile-up from occurring. This way safety applications could be used to provide drivers with early warnings and prevent an accident from happening in the first place.

2. *Intersections:* Due to the intersection of two or more traffic flows, driving near and through intersections is one of the most complex challenges that drivers face, and the collision rate is high. A safety application could warn the driver of an impending collision, and thereby reduce the number of collisions.

3. *Road Congestion:* Providing drivers with the best routes to their destinations would reduce congestion on the road and maintain a smooth flow of traffic, thereby increasing the capacity of the roads and preventing traffic jams. It can also indirectly reduce the number of traffic accidents because drivers would be less frustrated and more inclined to follow traffic regulations.

4. *Privacy and security:* While safety of the passengers is a major concern, the privacy should also be taken in to account. In case of collisions, the vehicle may send information about its passengers to the nearest hospital and the local authorities. The data sent should be available only to the necessary receivers. A secure and private way of communication should be provided, so that no private information is available to the public or malicious user. If a malicious user could provide false alarms to vehicles or infrastructure it would be possible to cause severe damage or unnecessary activity for the authorities. Malicious users could also be able to eavesdrop data traffic in the VANET and for example steal "identity" of any individual or vehicle communicating in VANET. VANETs should also be prone to DoS (Denial-of- Service) attack.

User Applications include providing users with information, advertisements, and entertainment during their journey. Two basic user-related applications are

1. *Internet Connectivity:* Constant Internet access has become a daily requirement for many of us and because many user applications also require Internet connectivity, providing this facility to vehicle occupants and other VANET applications is important. This also means that the usual business framework will be present seamlessly in vehicles, without a requirement for specific redevelopment.
2. *Peer-to-Peer Applications:* To alleviate boredom, peer-to-peer applications also are an interesting idea for VANETs. Passengers in the vehicles could share music, movies, and so on and chat with each other and play games. They also could stream music or movies from special servers during long journeys.

VIII. CHALLENGES AND SOLUTIONS

The challenges in VANETs using Cloud are as follows

1. **Complexity:** The complexity of authentication and authorization of the nodes accurately in the intermittent short-range communication to maintain the integrity of the data, increases with the number of vehicles. Tempering data and user identity spoofing could be a main threat to the network.
2. **Efficiency:** Since the connection of vehicles under the VANETs is wireless. The limitation of bandwidth has restricted data transmission. Also, the stability of the network affects the efficiency of infotainment system.
3. **Redundant data**: Standard APIs return information with a lot of redundant data, that reduces the system's efficiency and complicates data format, which is not suitable for data fusion.
4. **No Standard:** Vehicle manufacturers build their own infotainment systems by cooperating with different IT companies. There is no standard for developing a cross-platform infotainment system..
5. **Trustworthy Sources:** There are a number of sources that provide similar information. For example, we can obtain weather information or music ratings from the cloud resources. The problems are determining which resource we should trust more, and how to integrate information from multiple sources.
6. **Restricted User operations:** The limited interactive interface and driving environment restricts users' operations. The operations can't be complex and prolonged. For example, the driver cannot input complex commands like typing destination names into system while driving. For this reason, we need to provide efficient services with a concise and clear interface.
7. **Mobility of the nodes:** In VANET the speed of each node is high. Connection is created for short time and terminated also. These vehicles never met again. So, Mobility Security is a hard challenge and each node in the network should be mobile.
8. **Short term Connectivity:** Vehicular networks lacks the relatively long life context, so personal contact of user's device to a hot spot will require long life password and this will be impractical for securing VC.
9. **Privacy of the users:** We need to give identity to each vehicle to avoid attacks, but this solution will not be appropriate for the most of the drivers who wish to keep their information protected and private. Therefore, we need to include privacy and authentication in infotainment systems.
10. **Liability:** Liability will give a good for legal investigation and this data can't be denied (in case of accidents), in other hand the privacy must not be violated and each driver must have the ability to keep his personal information from others such as Identity, Driving Path, and Account Number for toll Collector etc..
11. **Network Scalability:** It is an important issue as there is no global authority to govern the standards for a network, for example: the standard for DSRC in North America is deferent from the DSRC standards in Europe, the standards for the GM Vehicles is deferent from the BMW one.
12. **Bootstrapping:** Bootstrapping is another important challenge because at this moment only few number of cars will have the equipment required for the DSRC radios, so if we make a communication we have to assume that there is a limited number of cars that will receive CMR.
13. **Security:** Security is one of the major concerns in VANETs. The existing VANETs use Public Key Infrastructure (PKI) and Certification Revocation Lists (CRLs) for their security. The Expedite Message Authentication Protocol (EMAP) for VANETs replaces the time consuming CRL checking process by an efficient revocation checking process.
14. **Signal Fading:** Due to obstruction by large buildings and other infrastructures in metropolitan areas, the signal attenuates at higher rates resulting in lower signal strength and quality.
15. **Interrupted data transmission:** Since the connectivity between the faster moving vehicles in the highway last only for few moments, the data transmission is interrupted frequently. Congestion of transmitter nodes during traffic jam will introduce noise and interference.

IX. CONCLUSION AND FUTURE WORK

In this paper, the integration of VANETs with the cloud to provide the users with a more comfortable journey has been discussed. The basic architecture of VuC and the various services provided by VuC were discussed. We have also seen some of the applications and challenges faced by VuC.

Infotainment services provide the users with information and entertainment applications to make the driving experience more comfortable. Using cloud, the multimedia content shared by the users can be merged, images of events can be retrieved that can be used as witnesses in events, etc.

In future, a system that allows multimedia content to be merged and, a system that takes pictures of events and upload it to the cloud could be proposed where the pictures taken from the vehicles serve as witnesses to the events.

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