International Journal of Control and Automation
Vol.8, No.3 (2015), pp.75-80
http://dx.doi.org/10.14257/ijca.2015.8.3.10

Adaptive In-Car External Applications using Nomadic Smartphones and Cloudlets

Lionel Nkenyereye***** and Jong-Wook Jang*

**Department of Computer Engineering, Dong-Eui University*
176 Eomgwangro, Busanjin-Gu, Busan, 614-714, Korea
lionelnk82@gmail.com, jwjang@deu.ac.kr

Abstract

Computerized in-vehicle systems are used to generate data about vehicle operations such as vehicle on-board diagnostics and vehicle information obtained from devices mounted on road infrastructures. Detectors located along the roadside are pivotal to Intelligent Transport Systems services, including real time management of driven information. In this paper, we propose a model that affords in-car external applications based on nomadic smartphone, virtual machine-based cloudlets, and car manufacturer's private cloud computing that on one side delivers remote diagnostic and vehicle performance information software as a service and can also be viewed as a doorway to deliver cloud based applications on other side. Virtual machine-based Cloudlet is used to improve response time extended by diverse communication latencies. We designed a remote vehicle assignation cloud computing platform service responsible for real time analysis of vehicle information and providing internet applications to the car user by using a vehicle-to-smart phone applications interface approach, which helps the smartphones to act as a remote user which passes driver inputs and delivers output from external applications.

Keywords: *Connected Car, cloud Computing, external applications, Vehicle-to-application, Cloudlets, vehicle on-board diagnostics*

1. Introduction

Mobile phones, portable navigation units known as nomadic information and communications technology devices [1] are nowadays being used within the automotive cockpit [2] by car owners or drivers while driving their vehicles. However, some car manufacturers have developed their own applications data centers to collect more data, whose task is to provide cloud-based applications to car users [3]. The connected car carries forward to the use of in-car telematics, a range of technologies that leverage efficiency connectivity, whether over the internet [4]. The connection-based method is essential as it consists of catching information using Bluetooth, 3G or 4G LTE technologies via smartphones. In the context that / the presence of using nomadic devices while drivers operating the car has managed to connect car to other devices within the car/vehicle / as well as networks and services outside the car, smartphones feature a dashboard with a screen from which the operations of these connections should be handled by the driver. Beside of smartphones features, Vehicle-to-vehicle and vehicle-to-infrastructure[5] involved carrying out the interconnectivity and communication between ad-hoc vehicular networks (VANETs) [6] and the networks are not fully integrated into vehicles, CAN protocols diversify from one car manufacturers which points out a wide obstacle for establishment of external applications using in-vehicle gateway platform [7] which is not integrated in all vehicles. Microsoft MAUI

ISSN: 2005-4297 IJCA

[8] noted that some applications might encounter workable difficulties from nomadic smartphones, due to the high latency mobile cloud infrastructure connection.

According to those challenges previously described, a vehicle-to-applications smartphones interface approach that helps the vehicle to act as a remote user which passes driver inputs and delivers output from external applications through virtual machine based cloudlet is proposed in this paper to deliver in–car external applications and other services offered by actors in automotive ecosystem to the car owners. Moreover, uncertain, unreliable worldwide identification of vehicle's owner by all interested in automotive industry constitutes also a challenge. However, in order to deal with data from vehicle diagnostics data and offered external applications and services, a scale computing that features real time analysis, integration, monitoring and security process is proposed in this paper.

The rest of the paper is organized as follows. Section I present an introduction. The section II provides a background and existing work. The section III describes the proposed model environment. At the end of this paper, we present the implantation and its results. The result of the study is followed by a conclusion and future works.

2. Proposed Model Environment

2.1. Remote Vehicle Assignation Service Event Processing

Figure 1 summarizes the Remote Vehicle monitoring cloud-computing service proposed in this paper that might be owned by car manufacturers. The remote service event processing consists of real time processing, integration, secure access and monitoring.

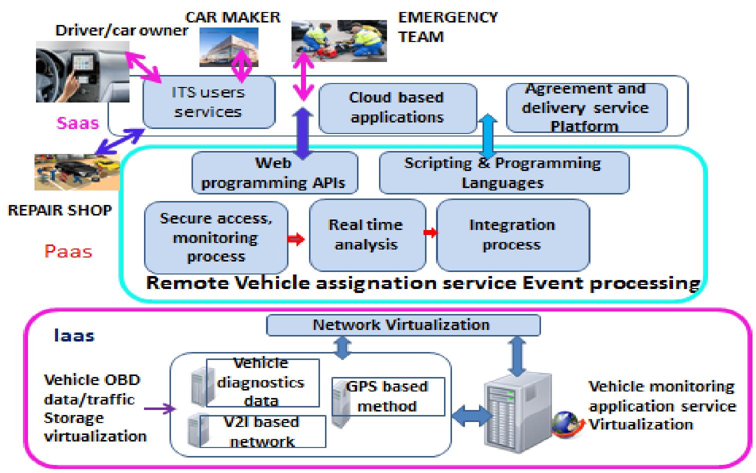

Figure 1. Remote Vehicle Assignation Service Cloud Computing Model

1) Secure access and monitoring: Global identification considerations are necessary to ensure that the sensor devices and the user car have an authorized profile.

2) Real time processing consists of collecting data from the vehicle. While data is uploaded via 3G or 4G LTE and HTTP protocol, data is transferred over the Internet in JSON exchange format for easy processing on the web service. The analysis takes place in web service. Advanced queries based on SQL are still performed and triggers a predefined task to the dashboard based web application and to user car in case an abnormal or MIL (Malfunction indicator lamp) occurs for instance.

2.2. Processing In-car External Applications Architecture

Figure 2 summarizes processing in-car external applications architecture that lead to the implementation of the remote vehicle diagnostics software as a service. The proposed model is composed of a cloudlet based Virtual Machine. The VM-based approach is less powdery than alternatives such as software virtualization, process migration, virtualize at the hardware level to encapsulate the entire operating system that it can be left out and resumed.

The reason establishing the connection between cloudlet and car manufacturer private cloud computing is to enhance computational tasks which are not originally maintained on the private cloud computing but on other cloud based applications.

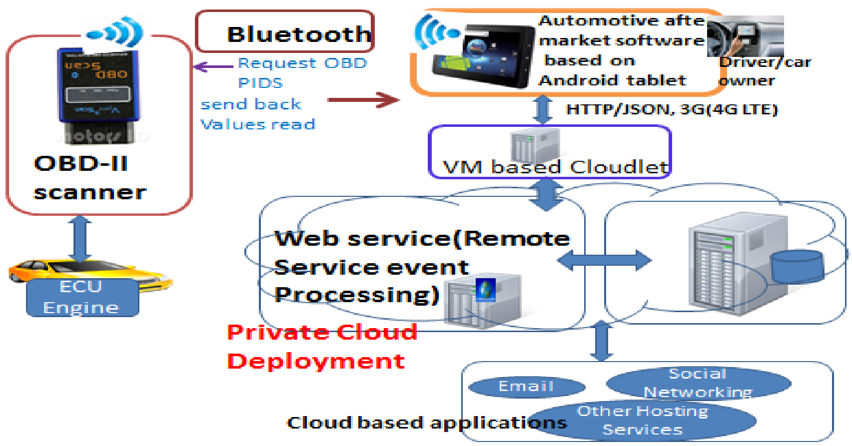

Figure 2. Remote Data Acquisition System on the Cloud

3. Implementation and its Results

In order to evaluate the remote vehicle diagnostics software as a service, we have considered the cloudlet as a physical computer that holds Linux Ubuntu 14.4 operating system, Core i5, 4GB memory.

3.1. Wireless Connection Environment

There are various ways to raise a physical communication between a hardware computer such as server, a PC and a mobile device. Among those ways, in this paper we chose Wi-Fi because it the most used technology for establishing communication between a mobile device and a Personal Computer (PC).

There are two common topologies with WLAN to implement wireless communication between a physical server and the nomadic smartphones tablet using Wi-Fi [15]: Wireless ad hoc network and Wireless Access Point. In this paper, we chose to set up a Wireless Access Point (WAP) at the cloudlet so that the mobile device based android can connect to the cloudlet. There is a need for an access point that establishes traffic between Wireless LAN and wired Local Area Network (LAN). The Wireless Access Point in this paper is a NETIS WF2419 300Mbps Wireless N Router which is a combined wired and wireless device. It is compatible with 802.11b/g/n devices and provides a wireless

Figure 3 shows login before requesting engine performance and values uploaded into database. Vehicle OBD-II diagnosis data that have been collected, along with the current position of the vehicle provided by the GPS are then saved in the database locates in automotive industry's datacenter in the format of JSON objects through HTTP protocol. Figure 4 shows a screen shot while the car owner requests from the cloud on-board diagnostics saved during his trip

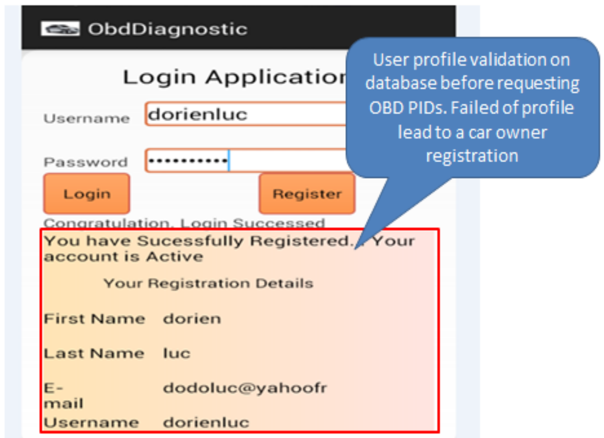

Figure 3. Validation Car User Profile on Cloud before Requesting OBD-PIDs

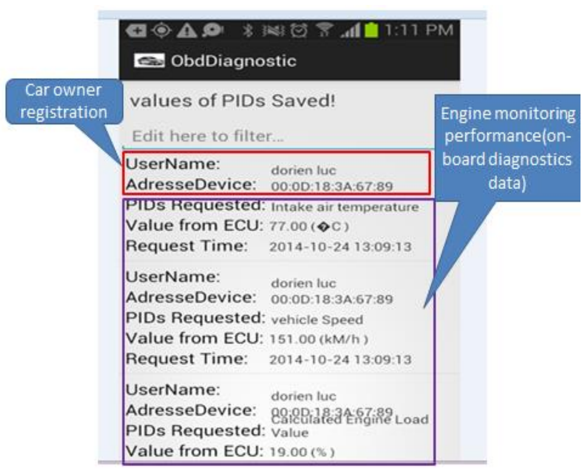

Figure 4. Request of On-board Diagnostics Data Saved on the Cloud by the Car Owner

3.2. Experimental Result

To test the implementation model we performed several process using our android application known as remote vehicle on-board diagnostic data analysis software as a service to both the Cloudlet and to cloud computing.

Our major goal is to study the ability of cloudlet based virtual machines to improve the response time while a process is being executed on the cloudlet, for example when the car owner keeps editing files downloaded from the cloud based application.

The Figure 5 reports the result of the latency measurement. The network delay was measured with values between 46 and 54 milliseconds. The login task on the cloudlet was reported a delay between 26 and 33 milliseconds, retrieval of stored data was evaluated with a value between 33 and 44 milliseconds. The network delay averages was measured just below 50 milliseconds.

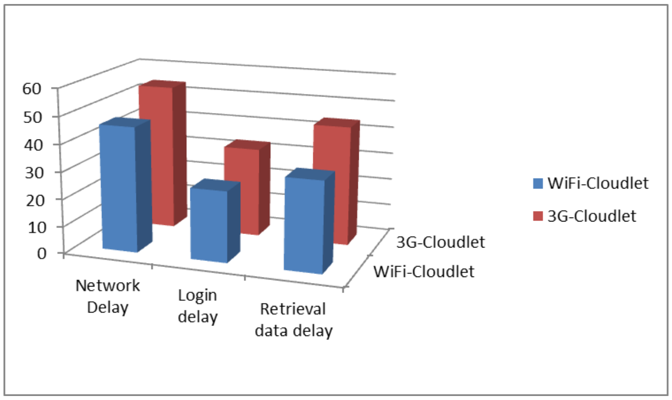

Figure 5. Response Delay in Different Tasks Processing

According to the result from the implantation, it seems that Wi-Fi is preferable over the use of 3G, since it uses less power than the power used while using the 3G connection. Also it gives us about 22 milliseconds for both tasks running (login delay and retrieval data delay). The processing delay shows surely that using cloudlet-based virtual machines is entirely recommended in processing with less delay using Wi-Fi to cloudlet connection using Wireless Access Point.

4. Conclusion

In this paper, we have argued that concerns about uprightness of data from traffic and on-board diagnostics are a major step for vehicle owners, authorities and businesses looking to take up cloud computing, cloudlets and nomadic smartphones that enable in-car external applications and others services. We present a cloud computing which enables data remote vehicle assignation service event processing through virtual machine based cloudlets. A remote vehicle diagnostics software as a service attests the concept of vehicle to cloud capable of collecting diagnostics data. Experimental results showed that the proposed model cloud environment achieved the goals in reducing the communication latency when the nomadic smartphones process tasks to take place remotely. Our next purpose is to implement a full prototype to evaluate other value-added services

Acknowledgements

This research was supported by the Brain Busan 21 Project in 2014 and Nurimaru R&BD Project (Busan IT Industry Promotion Agency) in 2014.

References

[1] L. Kleinrock, “Nomadic Computing –An opportunity”, CCR-4/95.
[2] J. O’Kane and R. Trimble, “Automotive cockpit modularity: migration issues for local tier 1 suppliers”.
[3] J. Ahola, “Vehicle services opportunities benefit from the cloud”, Applying cloud technologies for business Magazine, pp. 78-79.
[4] Honda announces Android-based in-car infotainment system, http://www.androidos.in/2014/10/honda-announces-android-based-car-infotainment-system/

[5] Future of Privacy Forum, “The Connected Car and Privacy Navigating New Data Issues”, (**2014**), November 13.
[6] S. Gillani, I. Khan, S. Quresh and A. Qayyum, “Vehicular Ad Hoc Network (VANET): Enabling secure and Efficient Transportation System”.
[7] P. Park, H. Yim, H. Moon and J. Jung, “An OSGi Based In-Vehicle Gateway Platform Architecture for Improved Sensor Extensibility and Interoperability”, 2009 33rd Annual IEEE International Computer Software and Applications Conference, pp. 140-147.
[8] Microsoft Corporation, “Mobile Assistance Using Infrastructure (MAUI),” 2011, http://research.microsoft.com/en-us/projects/maui/