Mobile Cloud Computing in Service Platform for Vehicular Networking

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Abstract. Recently, with the development of advanced network techniques, innovative control theories, and emerging cloud computing, vehicular networking serves as one of the most important enabling technologies. Together with an explosive growth in the usage of smart phones, their applications and emerging of cloud computing concept, mobile cloud computing (MCC) has been introduced to be a potential technology for mobile services. In this article, we first introduce the survey of vehicular networking and MCC. Next we illustrate the concept, structure and development of the service platform based on mobile cloud computing for vehicular networking. Then we give a new service model called Mobile-as-a-Personal-Proxy (MaaPP) of the service platform. Finally, we outline the relevant research challenges. We hope to inspire more technological development and progress for MCC applications.

Keywords: Mobile cloud computing · Services platform · Vehicular networking · Service model

1 Introduction

In recent years, the Internet of things (IOT) has become an information industry revolution after the computer, the Internet and mobile communication. Vehicle networking is a concentrated expression of IOT used in intelligent transportation system. With the development of advanced network techniques, innovative control theories, and emerging cloud computing, vehicular networking serves as one of the most important enabling technologies, and is producing some novel telematics application scenarios [1, 2]. These applications are more than novelties and far-fetched goals of a group of researchers and companies. Vehicular networking that aims to streamline the operation of vehicles, manage vehicle traffic, assist drivers with safety and other information, along with provisioning of convenience applications for passengers is no longer confined to theories, and test facilities of companies [3]. Up to now it has become increasingly obvious that vehicular networking opens new vistas for location-based services, such as vehicle maintenance services (VMS) and the fast-growing mobile entertainment industry [4, 5]. Obviously, vehicle networking is a large and complex system, integrating cloud computing, data communication, wireless sensing, computer networks and other advanced technologies, with the need for large amounts

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of data storage, processing, analysis, and provides a variety of convenient and efficient services between vehicles - road - people.

Mobile cloud computing (MCC) is the combination of mobile computing, cloud computing and mobile networks to bring benefits for mobile users, network operators, as well as cloud providers [6]. And MCC can involve other mobile devices and/or servers accessed via the Internet. Applications are run on a remote server and then sent to the user [3]. It shows that MCC has faster update, richer applications, stronger extension, individuation and sociality. Therefore, mobile cloud computing and vehicle networking combination can achieve complementary advantages and has very important practical value [7–10].

At present, the integration of vehicle networking and MCC still have their own problems, such as the structure of service platform, the service mode etc.. Consequently, we propose the concept, structure and development of service platform based on MCC for vehicular networking in Sect. 2. Section 3 analyzes a new service model called Mobile-as-a-Personal-Proxy (MaaPP). Section 4 describes the challenges of vehicle network and MCC. Finally Sect. 5 concludes this paper.

2 Concept of Service Platform for Vehicular Networking

The propose to build the service platform based on MCC for vehicular networking is to cover the owner, car manufacturers, service provider, 4S service centers, after-loading equipment manufacturers, vehicle rescue, auto insurance and car community etc., expanding the new car life industry chain model.

The platform concept is based on SoLoMo (socialization, localization, mobility) of automotive information services. So the platform give full play to the easy handling, portability, mobility and online of smart phones and the smart phones become the drivers' service access point. Through mobile data networks, smoothly upload the vehicle dynamic and static information; take the initiative to push service information from the platform. Thus the drivers, vehicle, travel, services and other information smoothly communicate between the cloud and the client to make car life safer, more convenient and more comfortable.

The platform is based on MCC technology framework to develop SaaS (Software as a Service) environment with large data center networking and to establish compute and storage resources paid on demand. By means of a variety of application markets, the platform publishes all kinds of application software which can run on Android, Ios, WindowsPhone, Blackberry and other mobile devices, and provide services for car manufacturers, service provider, 4S service centers, after-loading equipment manufacturers and other customers at the same time.

The basic structure of the platform is shown in Fig. 1. So, the development of the platform includes the following aspects:

- Universal authentication and data transmission protocol

To establish a set of common protocol for vehicle terminal authentication and data transfer, so it is safe and convenient for smart phones to connect with the vehicle

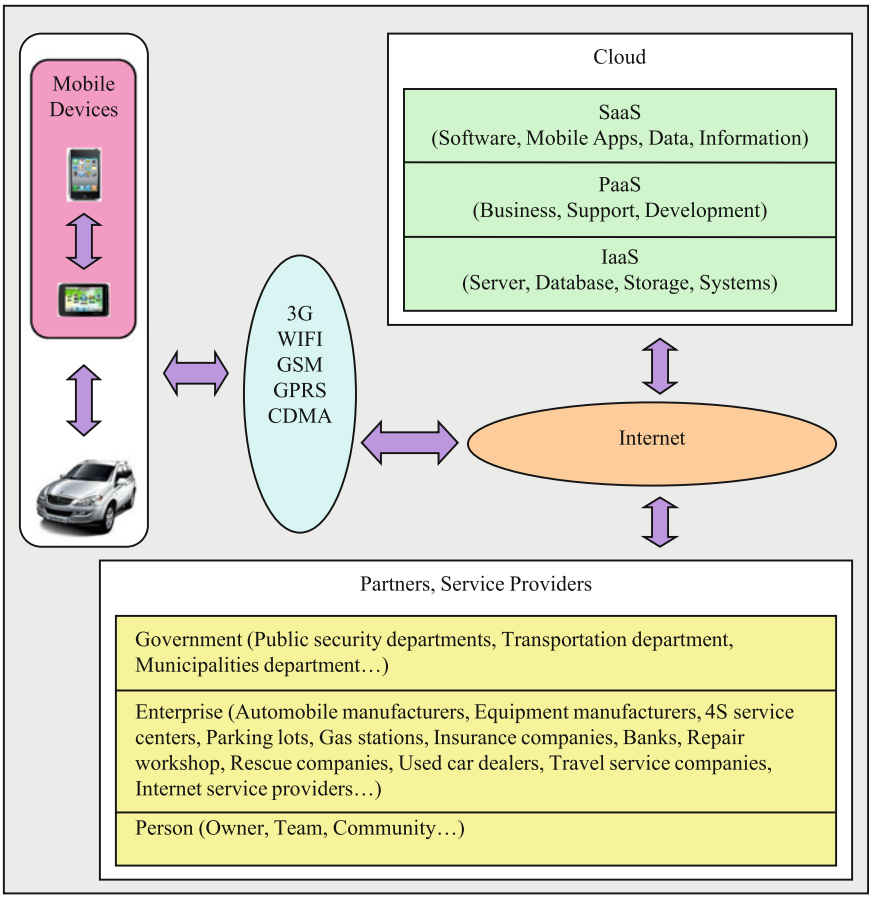

Fig. 1. A basic structure of service platform for vehicular networking

terminal, recognize identity and upload/download data through Bluetooth and other digital networks.

- Intelligent navigation based on real-time traffic weight

By getting real-time traffic information and forecast data service provided by Baidu, Google and other companies, and combining with the user's navigation need, the optimal route is calculated and sent to the user's mobile phone, and then be sent to the car intelligent terminal by the Mobile phone Bluetooth.

- Cross-platform mobile applications

Based on the open source PhoneGap mobile development framework, developing contents include:

– Bluetooth communication: mutual authentication and data transmission with vehicle intelligent terminal.

– Real-time traffic: get real-time traffic information from the cloud to return to the Navigator.
– 4S Services: find nearby 4S shop, expired maintenance services, reservation services and car repair requests.
– After-loading equipment manufacturer Services: service list acquisition, service requests.
– Road and accident rescue: the service contract management, service requests.
– Car safety: tire pressure monitoring, online diagnostics and security reminders.
– Running track: vehicle track playback.
– Car insurance: insurance guide, instructions, accident processing, fast processing and insurance Tel.
– Parking assistant: finding a nearby parking lot, parking meters and parking memo.
– Mobile Community, Illegal queries, etc.

• Software services

Using HTML5, CSS3, JavaScript and MEAP technology develops the following services:

– 4S shop merchant system: customer management, service project configuration, service contract management, service reservation management, service tracking feedback, service promotion, maintenance registration, maintenance valuation, maintenance records, maintenance schedule registration, pick-up reservations and vehicle inspection.
– After-loading manufacturer systems: customer management, service project configuration, service contract management, service reservation management and service tracking feedback.
– Rescue providers: customer management, service project configuration, service contract management, service reservation management and service tracking feedback.
– Car insurer: customer management, service project configuration, service contract management, service reservation management and service tracking feedback.
– Owners application: vehicle condition analysis of historical data, vehicle track playback, purchase service and appointment service.
– Data applications: data analysis, data statistics, data forecasts, data charts, dashboards analysis and real-time analysis.
– Other systems.

3 Mobile Cloud Service Models of Service Platform for Vehicular Networking

Current MCC has three-type service models: Mobile-as-a-Service-Consumer (MaaSC), Mobile-as-a-Service-Provider (MaaSP), and Mobile-as-a-Service-Broker (MaaSB) [11]. In MaaSC, mobile devices are pure consumers to achieve service provided by cloud, and most existing MCC services fall into this category. MaaSP is different from MssSC in the role of a mobile device is the service provider, and the

services provided by mobile devices are diverse and abundant. MaaSB can be considered as an extension of MaaSP in that it providers networking and data forwarding services for other mobile device or sensing nodes.

In the service platform based on MCC for vehicular networking, we propose a new service model called Mobile-as-a-Personal-Proxy (MaaPP) [12]. The architecture of MaaPP can be found in Fig. 2.

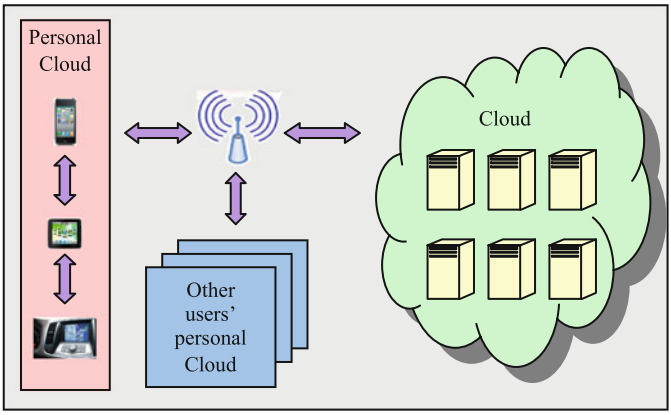

Fig. 2. Mobile as a Personal Proxy (MaaPP)

The concept of Personal Cloud (PC) is defined as the set of all mobile devices owned by a user. Each PC has a main component called Personal Cloud Hub (PCH), which is the point where the devices are registered and also provides data synchronization, communication among other PCs and secure access to the PC from Internet. Multiple PCHs, one for each user, may also be linked together creating relationships among users as it happens in social networks. Each device placed inside a PC has one component called Personal Proxy (PP).

One of the demos presented is travel application. It enables user to manage his point-of-interests while a user is traveling. Relevant data are automatically synced between the user's devices. Syncing mechanism of the app is based on the personal cloud middleware. The application enables the interaction with the in-car navigation system. When the car is parked, the smart phone can pick up the guidance.

In MaaPP, each user can be represented by PCH. Users' behaviors and attributes can be collected from real world (e.g., people, social networks, and environment or mobile devices) in real time and sent to the cloud to perform the related analysis and processing. Besides helping mobile devices execute tasks more efficiently, cloud is able to accomplish some tasks that are not possible to be achieved in traditional client-server architecture. Both physical systems and virtual systems are seamlessly connected as a whole in MaaPP. So the mobile devices and clouds are interactive and the service flow is bidirectional.

4 Challenges

The main goal of MCC is to provide users a convenient and quick way to access the data from the cloud by using their mobile devices. While enhancing the user's convenience, a lot of problems still remain in the realization of MCC [13–15]. In this section, we explain in brief the technical challenges:

- Mobile Network Cost and Scalability: MCC applications can have very high demand on wireless network bandwidth, having implications on the capacity of the mobile networks, in particular during peak demand periods, potentially negatively impacting network latency, packet loss, and response time, with the consequent negative impact on user experience. Moreover, the high wireless bandwidth requirement may prohibitively increase the wireless data bills of mobile users, making MCC applications impractical.
- Availability: Service availability becomes more important issue in MCC than that in the cloud computing with wired networks. Mobile users may not be able to connect to the cloud to obtain service due to traffic congestion, network failures, and the out-of-signal. We must ensure that the real-time performance must meet the specific application requirements. Therefore need to find a solution, such as better migration technology, better communication mechanisms, and multi-agency coordination mechanism.
- Heterogeneity: MCC will be used in the highly heterogeneous networks in terms of wireless network interfaces. Different mobile nodes access to the cloud through different radio access technologies such as CDMA, GPRS and WLAN. As a result, an issue of how to handle the wireless connectivity while satisfying MCC's requirements arises (e.g., always-on connectivity, on-demand scalability of wireless connectivity, and the energy efficiency of mobile devices).
- Information sharing: Currently, the business model of vehicular networking is not uniform, and different models have different applications. So that the information can not be shared with each other. Through MCC, solve the sharing problem, but also need to consider the transmission speed, information security etc..
- Security and privacy: Mobile devices such as cellular phone, PDA, and smart phone are exposed to numerous security threats like malicious codes and their vulnerability. In addition, with mobile phones integrated global positioning system (GPS) device, they can cause privacy issues for subscribers.
- Standards development: Vehicular networking depends on many technologies across multiple industries. But the enterprises and departments of vehicular networking industry chain alone develop with the lack of industry standards. Thus, the required scope of standardization is significantly greater than that of any traditional standards development.

5 Conclusions

In recent years, with the development of advanced network techniques, innovative control theories, and emerging cloud computing, vehicular networking serves as one of the most important enabling technologies. In this article, we first introduce the

survey of vehicular networking and MCC. Next we illustrate the concept, structure and development of the service platform based on mobile cloud computing for vehicular networking. Then we give the MaaPP service models of the service platform. Finally, we outline the relevant research challenges. We hope to inspire more technological development and progress for MCC applications.

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