A Cloud Based Information Integration Platform for Smart Cars

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Abstract. Current in-car computers have limited processing capabilities, and the content in smart car applications is poor extension. Even more, tradition software install approach which was used in smart cars lacks neither economy nor convenience. To solve these issues, we introduced a Cloud based Information Integration Platform for Smart Cars that has the ability to encourage flexibility in smart cars and enhance the value of them. To achieve the smart control and information sharing in smart cars, the platform collects data on the CAN bus automatically, with the ability to process CAN bus messages in Clouds. The Smart Car Information Service as the user interface was used to implement smart cars applications through customized business process. This fill up the information processing gap between the smart cars and cloud computing. Furthermore, we can use this platform for different purposes in smart cars.

Keywords: Web Services; CAN bus; Cloud Computing; Smart Cars.

1 Introduction

The smart car is the future trend in automotive improvement. With the development of automotive electronic technology, the smart car technology is evolving rapidly. Currently, the traditional in-car computers in smarts cars have limited processing capabilities to run many functions, such as navigation and display real time information. It is not smart enough without the information sharing among the real world and the computer. Thus, the smart car technology has the potentials to make the car easier to control, more dynamic and economical, and safer to drive. To achieve these benefits, in-car information systems need to be seamlessly integrated with the external information services, supporting the transfer, exchange, and sharing of information among them. Our motivation is to design a new information integration platform for smart cars to enhance the ability of processing the real time information from the smart cars and reduce the delay of smart car applications development. The mission is comprehensive applications of smart cars electronic control technology, car network technologies and intelligent control technologies.

Currently, a smart car mainly uses Controller Area Network (CAN) bus as the network connection. In this paper, we focus on the novel use of CAN bus applications and cloud computing technologies. Our primary contribution is the synthesis of ideas,

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some of them are novel in their respective areas. The proposed platform seamlessly integrates the in-car information system with the external cloud information services, allowing smart car applications to be developed. A data conversion approach is developed which is able to convert the data from binary code in CAN bus to the XML format so that they can be processed by CAN message service in Clouds. As the participant to the smart cars information integration platform, the designed smart car information service can be easily extended by integrating various services to support new use case scenarios.

The rest of the paper is organized as follows. The second section reviews major technologies that are related to this research. In Section 3, we describe the architecture of the proposed platform in details. Then we present a use case scenario as a sample application to active our designed platform in Section 4. Finally, Section 5 concludes this paper and outlines our future work.

2 Related Technologies

The proposed Cloud based information integration platform for smart cars provides a novel approach to connecting the in-car system with external systems. This can lead to the development of new smart car applications. The platform is developed based on the technologies and components as follows.

- The in-car computer is a core of our platform. Traditionally, it is a mini PC or a SCM (Single-Chip Microcomputer). For example, the CarTel [1] node was described as a kind of in-car computer which runs on the Linux 2.4.31 kernel. An in-car computer can connect to the Internet via 3G or 3.5G networks, such as CDMA 1x EVolution Data-Only (EVDO), High-Speed Downlink Packet Access (HSDPA), and mobile WiMax [2].
- The Global Positioning System (GPS) navigation system in a car provides route planning, and even voice guidance [3-5].
- Controller Area Network (CAN) is a serial communication bus designed to provide simple, efficient and robust communications for in-car networks[6]. The car's electronic equipments were connected by this control network. One subset of a modern vehicle's network architecture [7], shows the trend towards incorporating ever more extensive electronics
- With Software as a service (SaaS), Cloud computing can provides the applications to users for use as a service on demand, either through a time subscription or a "pay-as-you-go" model. Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services [8] .

3 Architecture

3.1 Components and Design

The Cloud based Information Integration Platform for Smart Cars has two different layers, namely the hardware layer and the services & software layer.

The hardware layer in this architecture acts as the basis of the Cloud based Information Integration Platform for Smart Cars. This layer includes the CAN bus subsystem and an in-car computer. The CAN bus subsystem has frequent internal communication, thus requiring high demanding real-time control. Most of the car electronics belong to the CAN bus subsystem. In a smart car, an in-car computer will collect messages from sensors via CAN bus. The gateway controller which is between CAN bus and in-car computer can converts CAN bus messages allowing the in-car computer process the CAN bus messages in the IT data bus.

In our designed platform, the gateway controller provides one procedure to deal with standard CAN bus messages. With the gateway controller, messages from each node in the CAN bus can be read or written by the in-car computer. This process is a two-way transmission in CAN bus which provides an information sharing platform for all kinds of electronic control systems to share information [9]. Currently, most cars use two different CAN buses in network connection, a high-speed CAN bus and a low-speed CAN bus.

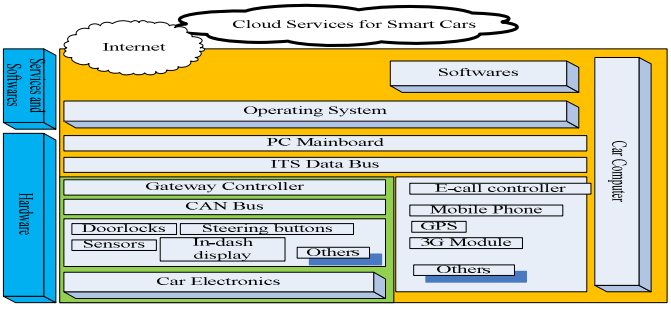

Fig. 1. Architecture of Cloud based Car Information Integration Platform

The main mission of the high-speed CAN bus is to connect the engine controller (ECU), ASR and ABS controllers, airbag controllers, and those instrument clusters have same basic features. The high-speed CAN bus in a car could run more real-time-critical functions to enhance the safety, comfort, and added-value of passenger car and improve its service quality and performance [7, 9]. For less speed demands, the low-speed CAN bus is used to run a few small wirings that are connected together to form several subsystems. These subsystems use the gateway to share information and coordinate ECUs. The low speed CAN system deals with the connection with central locking, power windows, mirrors and lighting, etc. [10]. The speed of a high-speed CAN bus in a drive system can reach 500kbps, while the speed of the low-speed CAN bus in an electronics system is 100 kpbs [9, 11].

For processing the information in smart cars, the in-car computer will collect information from the gateway controller and delivers those CAN bus messages to the smart car information service in Clouds. It is a bridge between a smart car platform and the Cloud based information services.

Global Positioning System (GPS) and wireless communication technology were used in the in-car computer as important roles. We need GPS sensor to provide the information of smart car's location to the smart car information service in Clouds.

The bandwidth of the current wireless network is sufficient for the communication between the smart car and the Cloud based services. The communication device also provides mobile networking access of several Mbit/s to laptop computers and smart phones.

The Cloud based Information Integration Platform allows smart car users to use smart car applications as services in Clouds. It provides intelligent processing, cloud computing capability and infrastructure to users and various smart car services. In addition, the design of the Cloud based Information Integration Platform uses the master-slave structure. The overall distribution of the network structure is a tree. From the perspective of the network topology, the entire communication system is organized by the in-car computer. GPS, wireless, gateway controller, CAN bus and automotive electrical components were controlled by in-car computer in a smart car.

3.2 Workflow and Messages

We present a smart car information service to execute a custom developed smart car applications in Clouds. Each service feature of smart car information service has its backed smart car application with different well-defined business process for smart cars. Each smart car information further makes use of core services that include CAN bus message service in the Clouds. To adopt cloud processing, the smart car information service as a smart car services interface is available for cloud computing in designed platform. In additional, there are many existing technologies in the cloud that can be modified or enhanced to support new smart car applications. As shown in figure 2, one smart car service can acts as service consumer to use the functionality exposed by the other services. In other words, each cloud based service for smart cars can invoke other designed in-car applications by defined business process in Clouds.

Fig. 2. Cloud Services for Smart Cars

To achieve the smart car control, we connect the IT data bus and the CAN bus via a gateway controller in designed platform, the principle as shown in Figure 3 below. Currently, the in-car computer uses the IT data bus to exchange messages among GPS, 3G module, Bluetooth and so on. The IT data bus requires high data transfer rate of modules connected together. The gateway controller exchanges messages between IT data bus and CAN bus on mission. In our designed platform, the CAN bus uses the standard protocol with the high data transmission rate to control the smart car electric system, such as the door lockers, LED displays and steering buttons.

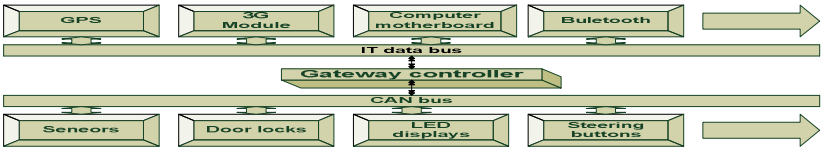

Fig. 3. CAN and IT data bus

To explore what and how to collect context information from a smart car, we present a CAN message service as the core smart car service in clouds to process CAN messages which are from smart cars. This service is used in data exchange, applications integration and XML data management. The CAN message service saves its content data from CAN bus in XML format in thr Clouds. Access is available through the designed smart car information service as the interface. The process is shown in Figure 4.

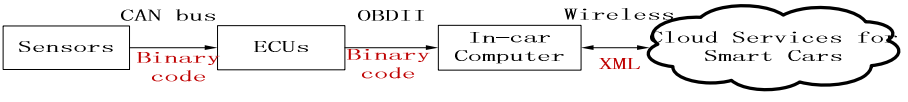

Fig. 4. Data conversion process

Some smart car services in Clouds are the periodic context data updates. For example, a traffic condition report service could similarly send to the navigation service periodic updates of local traffic conditions so that affected users could adapt their travel plans correspondingly.

3.3 Discussion of Designed Architecture

The designed Cloud based Information Integration Platform for Smart Cars is economical and practical for both car users and smart car service providers.

The new platform does not require high cost hardware as the smart equipment for users. Our platform can be built with current in-car devices with low cost, cause the in-car computer in designed platform just provides a terminal of those smart car applications. Cloud processing for smart cars allows car users to start small and increase budget only when there is an increase in their smart car services or applications needs. In Clouds, the appearance of infinite service resources available on demand, quickly enough for provisioning applications which come from smart car service providers or car companies. In addition, the cloud based services for smart cars are dependable and secure. Users do not need to worry about the problems like safety and privacy while using smart car services in Clouds.

For information and entertainment providers, using SOA and SaaS in Cloud based Information Integration Platform can help smart car service providers to reduce the cost of smart car applications design, development, deployment and services support. By adopting the platform, smart car application developers can design different products in application layer, while using common hardware standards to achieve flexibility, functionality, low cost and success.

Furthermore, Cloud based Information Integration Platform for Smart Cars possibly can help automotive manufacturers and their suppliers follow the rapid development of consumer product technology. By selecting our platform, car manufacturers can reduce the overall investment, but also shorten the learning cycle, improve function and reduce the costs.

4 Scenario

4.1 Scenario Process

Now, we show how we can apply smart car information service and CAN message service in the cloud based information integration platform for illustration. We choose the smart car repair scenario as the primary example. A sample is presented in this section to demonstrate the functions of the J1939 TestFeatureSet. An ECU will be tested for tire pressure control, which is simulated in CANoe [12]. The process of this scenario is described as follows.

1. The sensor that monitors the tire pressure will submit an error message to CAN bus once an abnormal tyre pressure is identified (yellow tyre as in Figure 5). The error message will be sent to the smart car information service, and then the smart car information service can find all the details of the abnormal tyre, such the maker, model and so on. Meanwhile, the screen in the smart car displays the error message to driver for warning. It will prompt driver to go to the car repair station.

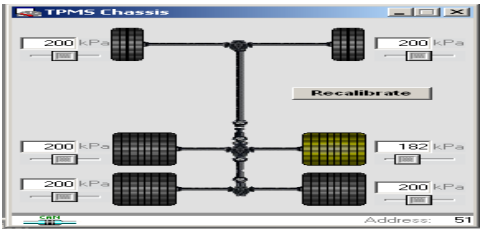

Fig. 5. CANoe simulation

2. We call the Geocoder service[13] and stored repair stations information in the station database service as static context before the next step. Those static and dynamic context elements were collected in different steps as shown in Figure 6. The static context in the station database service includes station locations, categories, station names and reviews of products and services.
3. The in-car computer collects the dynamic information from CAN bus and GPS receiver, then submits them to the smart car information service via wireless network. The dynamic context comes from CAN bus messages provides some information about travel range, time, broken car part and car location to user. Some other dynamic context likely time, day, data and weather condition will be collected from other source.

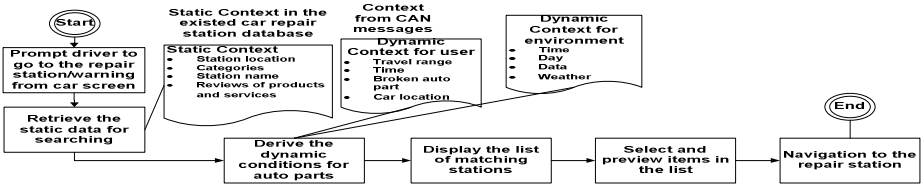

Fig. 6. Application activity diagram with example context elements

4. The smart car information service in this example presents a list of available repair stations. We use the Google Maps Service to overlay available car repair stations data which from the smart car information service.
5. The smart car information service finds addresses of repair stations based on the existing database. It then returns a point location that contains the latitude-longitude coordinates of those stations.

The smart car information service will give you a handy navigation at the fine step in the scenario.

4.2 Smart Car Information Service

We designed a smart car information service to apply the proposed Information Integration Platform for Smart Cars. Our platform allows the smart car services to run in the cloud computing environment by using Business Process Execution Language (BPEL) which is used in a business-process level contract for aggregating multiple services.

By using Web Services in Clouds, smart car applications lend themselves very nicely to the designed smart car environment. They are easy to invoke, produce a discretely formatted response, and are usually parsed easily using event-driven XML parsing which is less memory intensive than tree based parsing.

CAN bus message is one of the inputs of the smart car information service. The smart car information service currently collects CAN messages and other data from IT data bus, monitors the location information and gathers a variety of data from the On-Board Diagnostic (OBD II) interface on smart cars.

The smart car information service allows different combinations to be selected for demonstration to highlight service interoperability. The composition structures can be specified using composition approach in Clouds, e.g., SwinDeW-S [14]. As we described above, a variety of smart car services can call each other to set the new smart car service with different business process in Clouds. Thus, it is possible to provide a smart car application store for end user to select the services they need.

4.3 Data Conversion and CAN Bus Message Service

The CAN message XML file needs to be changed before the data is stored into the database. By adopting XML technology, those CAN message elements were stored in a XML file as the figure 7 below:

Fig. 7. A message episode from CAN bus under XML format

The "Data" field in the CAN bus message was augmented with some attributes. In our scenario, the second bit represents the pressure of tyre. For example, we got a data string from a normal status:

```
Data 10 C8 60 24 FF FF FF FF
```

The highlighted value C8 indicates that the type pressure of 800kPa is at the normal level. Figure 8 shows the data collected from the CAN bus in the simulation platform. In that time point (second 70.261140), the tyre pressure is below the normal. B6 means only 728kPa in the tyre. According to the CAN bus simulation, we can get the status of the tyre which was broken. The warning message from the CAN message service will let the driver knows that there is a tyre should be replaced soon.

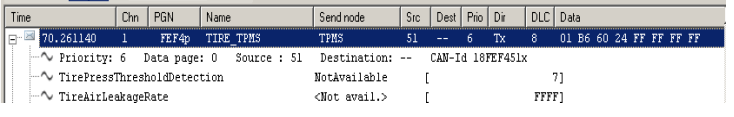

Fig. 8. Data example in simulation

In this work, we designed the CAN bus message service to collect the data from in a smart car. In the scenario, CAN bus message service was invoked by the smart car information service to apply the car repair process.

The CAN bus message service WSDL provides all the information about the CAN bus message service that can be read by a service client. The WSDL defines an interface of the CAN message service in Clouds. The CAN bus message service get a request to deal with a CAN message file which can be uploaded to the Cloud. There is one port in the CAN message service which is used to process specified SOAP messages for upload CAN message file.

4.4 Message Flow

An open and simple protocol was designed to use smart car information service over the Internet for smart cars. The message flow in our scenario is shown in figure 10. The in-car computer will collect messages (CAN and GPS) periodically.

In the scenario, the information service starts by issuing a diagnosis service request. Then the information service forwards the CAN diagnosis request periodically to the

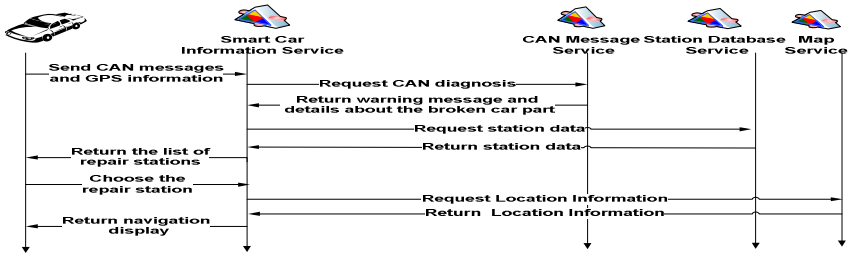

Fig. 9. Message flow in Scenario

CAN message service in which the CAN bus information from the smart car is stored. After that, the car information service finds an appropriate stations list by querying a station database service. The selection of stations could be based on the location, user pre-specified preferences and feasibility of the travel range. After the user chooses the station, the smart car information service sends the location information request to the map service. Finally, the location information is returned to the smart car information service and then to the smart car for information display and navigation. The figure 11 below shows the search result page which was displayed by the smart car information service.

Fig. 10. Search Result of Designed Service

5 Conclusion

This study presented the architecture of cloud based information integration platform for smart cars. Experimental investigations showed that the platform is a feasible scheme. Our results confirm that we can use current technologies to build the platform in smart cars. The designed platform can use the CAN bus messages that make applications context aware. The designed system provides the information from the in-car devices to the car terminal, network, Clouds and smart car application services at all levels. An open and simple protocol was designed to share the data over

the Web Services. Cloud computing services can be enhanced with SOA based services to create new smart car services that exceed the capabilities of traditional in-car computer. Combining these creates the opportunity to develop a completely new paradigm of consumer services.

Further work is underway to further explore the software layer in the platform. Different cloud service deployment models will be considered in details as well. The methods used in this paper appear to be rather case-specific and possible extensions and applications of these methods to generic design cases require further study.

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