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Research paper

Design and Implementation of Remote Monitoring and Control Service of Electric Vehicle Based on CoAP Protocol in IoV Networks

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Abstract

Background/Objectives: Electric vehicles are cost-effective, environment friendly and its use is growing day-by-day in many developed countries. To further enhance the performance of electric vehicle and user experience, we propose a remote monitoring service in mobile platform using CoAP protocol. And we design and implement of remote monitoring and control service of electric vehicle based on CoAP protocol in IoV networks.
Methods/Statistical analysis: In this paper, we propose an electric vehicle remote monitoring system based on the CoAP protocol, which enables us to monitor and control the services of electric vehicles via mobile Phones. For analysis, we have used an electric vehicle emulator to conduct these experiments.
Findings: We find it feasible and effective to use CoAP protocol for the communication between vehicle emulator and mobile application. We have successfully monitored and controlled the state of the vehicle emulator through mobile application using CoAP protocol. The following are the vehicle emulator states include engine state (start or stop), door state (lock/unlock), head lights state (turn on/off), interior light state ((turn on/off)), head lights status, audio state (turn on/off), alarm state (turn on/off), and the trunk state (lock/unlock).
Improvements/Applications: For these experiments, we used electric vehicle emulator instead of real electric vehicles, and implement our design successfully. We have planned to optimize our design by using real electric vehicles instead of emulators in our future work.

Keywords: *Electric Vehicle, Remote Monitoring, IoV (Internet of Vehicles), CoAP Protocol, Mobile Platform.*

1. Introduction

With developing technologies, Internet of Things (IoT) has been used many service sectors of smart city. with the advancement of these technologies, we will build a smart city and allow you to provide more comfort for the life of a smart home and humans life [1]. Smart Homes can automatically perceive changes in the home environment, respond dynamically to responses and help residents to lead a more comfortable life [2]. A smart home can have a multi-tiered monitoring system that uses a three-tier context-editing model for Context-aware Services. [3]. Furthermore, smart Homes is a Three-level context authoring model based on situational awareness services. The Internet based surveillance system to build things. In addition, you can use a security solution at the network level to monitor network activity and improve device-level protection to sense apprehensive behavior [4]. The live of users is easier and more convenient by using Smart home. In addition to smart cities, homes, and car development is also convenient, and some studies can be found in literature on the internet of things for smart cars. Some developers are developing a system Internet that allows users to monitor and control their environment Parameters. [5]. Similarly, a system that can receive cost-effective means to monitor vehicle performance and track information through Bluetooth communication on mobile devices [6]. Other developers are focusing on providing an automated and efficient EV (Electric vehicle) load management system by leveraging the benefits of IoT technology to ensure a pervasive awareness and an interactive physical world view with various sensors and wireless equipment [7]. Now a day's scientist focus on developing flexible dynamic power control infrastructure for charging cars batteries. Depending on the power requirements of the family where the vehicle is jammed, the infrastructure will dynamically adjust the charger for the electric battery [8].

For remote monitoring of vehicles, network mode-based monitoring and Communication service systems as well as protocol analysis models traditional Reactor A shared data synchronization and thread pool optimization design that can be used to improve the model and Seda mode processing Events. [9]. It is also a smart box (OBSB) of car, Universal Packet wireless service (GPRS) Using a distributed system to monitor the diagnosis and location information of a vehicle from the distance achieved by the use of a car microcomputer system known as a remote Server. [10]. Some studies recommend vehicle classification and speed measurement in a portable road vehicle surveillance system [11]. In [12] author propose a remote-control system for lithium batteries in electric vehicles and improve the real-time monitoring and safe operation of lithium batteries in electric vehicles to reduce battery cost.

We present a remote service of electric vehicle based on CoAP protocol in IoV (Internet of Vehicles), which provides two services to the users i.e. control and monitoring service. Figure 1 shows the IoV-concept of monitoring and control there are two modules, remote models for electric car electric vehicles: monitoring modules and control Modules. Monitoring modules can provide users with status information from electric vehicles including engine state, battery state, door state, audio state, and trunk state, head lights state, interior light state, and the alarm state. The control module offers user control services that allow users to control electric vehicles, such as unlocking locks and doors, unlocking locks or trunks, turning the Audi on or off, turn off one or headlight, internal lights on/off, turn on/off alarms, and start/stop the Motor. The electric vehicle is controlled and monitor by an interface which is provided by mobile client

The main page provides an interface for controlling the electric car, providing access to all features and control pages, the Status page provides an interface for monitoring electric vehicles, the page of the Layout the user can set the IP address of the electric car to connect with the electric car.

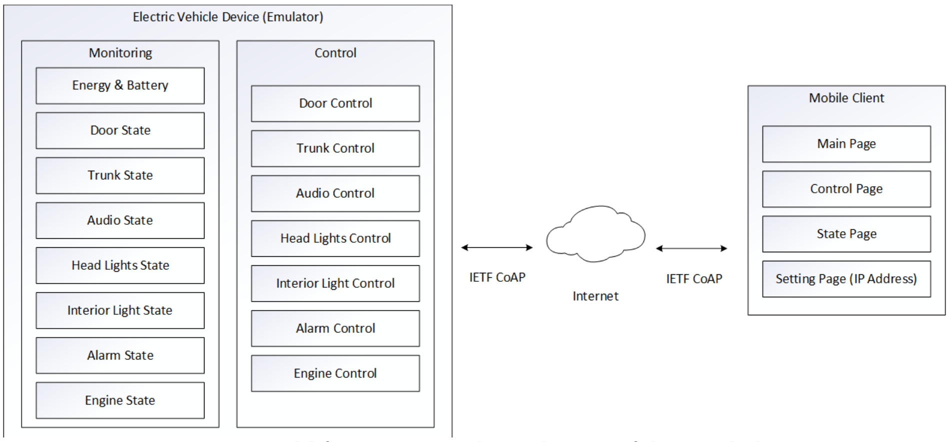


Figure 1:. Remote model for monitoring and control service of electric vehicle in IoV

This paper is organized in several sections. Section 2present the design of the remote monitoring and control service, section 3 shows the experiment results, and the section 4 is the conclusion and future works.

2. Design of Monitoring and Control Service of Electric Vehicle

Figure 2 shows the design of remote monitoring and control service of electric vehicle in IoV. This service consists of two parts: an automatic emulator and an application Client. Vehicle emulator, Power Cell module, spine module, malfunction module, Security module, network module, door module, module, Flashlight module, GPS Module 10 modules including engine modules, and COAP servers, in a vehicle emulator. The power and battery modules can check the battery Condition. The audio module, which can turn the audio module, Trunk can lock/unlock the Trunk. The Flashlight module can turn on/off the lights. Inner Light module for on and off the headlight. The GPS module allows you to turn the GPS security Alarm module You can start/stop the security service (security alarm). The motor module can start/stop the ENGINE. Network modules can configure network settings and enable or disable network Ports. Doors module is able to lock/unlock the doors. The COAP server can collect requests from clients and respond accordingly. Application clients include the main page module, the control page module, the configuration page module, the status page module, and the application Client's COAP Client. There are four Modules. On the home page, you can see all of the Application's features, such as controls, settings, and Status. Control side to control the vehicle Emulator. The user can set the IP address of vehicle by using configuration page. The vehicle emulator battery is shown in status page. The COAP client can send requests to the control of the emulator of the vehicle or obtain the state of the battery of the vehicle Emulator. Figure 3 shows the sequence diagram of our proposed remote monitoring and control service. When App Client send “get battery state” request to Vehicle Emulator, Vehicle Emulator will return battery state to App Client When an app client sends a "start/stop engine" request to the vehicle emulator, the vehicle emulator starts/stops the engine and returns true/to the application Client. When an app client sends an "open/close audio" request to the vehicle emulator, the vehicle emulator switches the sound on and off and returns the True/false application Client. When an app client sends a “lock/unlock " request to the vehicle emulator, the vehicle emulator locks/unlocks the door and returns true to the application Client. When an app client submits a “lock/unlock-trunk " request to the vehicle emulator, the vehicle emulator locks/unlocks the route and returns true/to the application Client. When the app client sends a "turn headlamp on/off" request to the vehicle emulator, the vehicle emulator switches the headlights on and off and returns the True/false application Client. If the app client is requesting “internal light power ",

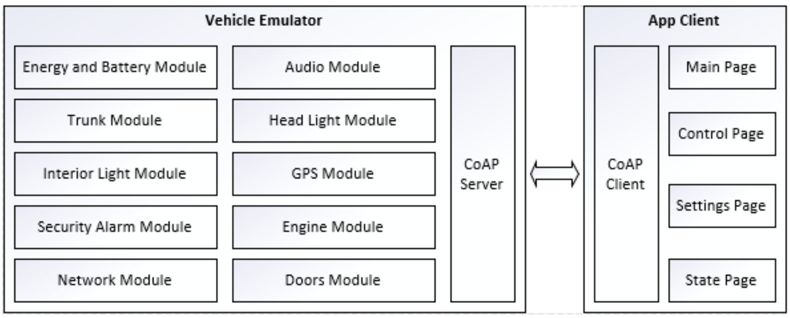


Figure 2:. The block diagram of remote monitoring and control service for IoV

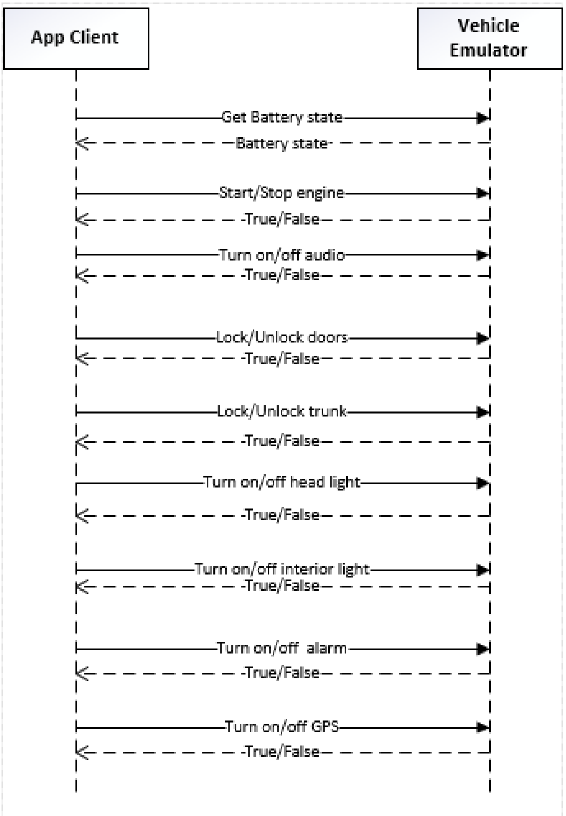


Figure 3:. Proposed operational sequence diagram of remote monitoring and control service in IoV

3. Implementation and Results

Table 1 shows the development environment of vehicle emulator. And, table 2 shows the development environment of mobile client.

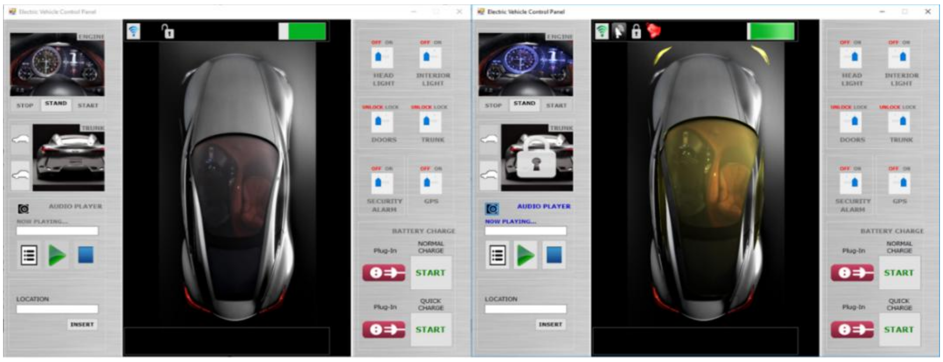
Table 1: Development environment of vehicle emulator

Component	Version
Windows OS	10
Visual Studio	2015
CoAP.NET	v.4.0.30319

Table 2: Development environment of mobile client

Component	Version
Android Studio	3.0.1
Android SDK	27

Figure 4 shows the implementation result of Vehicle Emulator. Figure (a) shows the initial state, figure (b) shows the state that all modules have been opened. Figure 5 shows the implementation result of App Client. Figure (a) shows the main page, there are three buttons in the main page: the control button to start the control page, the battery button to start the state page, and the settings button to start the settings page. Figure (b) shows the control page, there are eight buttons to control different modules include engine, audio player, doors, trunk, head lights, interior light, alarm, and GPS. Figure (c) shows the state page, which is able to show the battery state of Vehicle Emulator. Figure (d) shows the setting page, which is able to let users input the IP address of Vehicle Emulator.



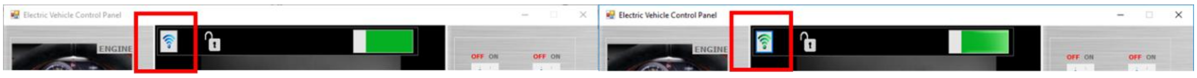
(a) Initial state (b) Turn on state

Figure 4. Results of vehicle emulator

(a) Main page (b) Control page (a) Battery state page (d) Setting page

Figure 5:. Results of mobile client

Figure 6 shows how to start the network (CoAP) connection. Click the image in figure (a) is able to start the connection, and the figure will change as figure (b) (the color of the internet icon will change from blue to green).



(a) Stop Internet connection (b) Start Internet connection

Figure 6:. The way to start the network connec**tion**

Figure 7 shows how to control the engine. Click the stand button and then click the start button will start the engine, click the stop button will stop the engine. Figure (a) shows the engine-start state, figure (b) shows the engine-stop state.

(a) Engine start (b) Engine stop

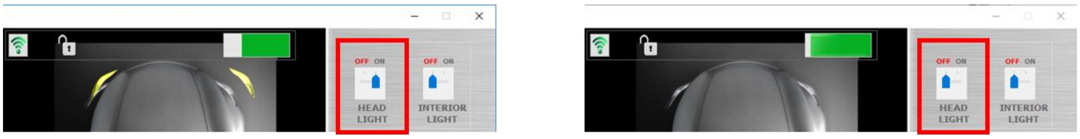
Figure 7:. The way to control the engine

Figure 8 shows how to control the audio player. Click the small icon will start the player, click the icon again will stop the player. Figure (a) shows the player-on state, figure (b) shows the player-off state.

(a) Audio on (b) Audio off

Figure 8:. The way to control the audio player

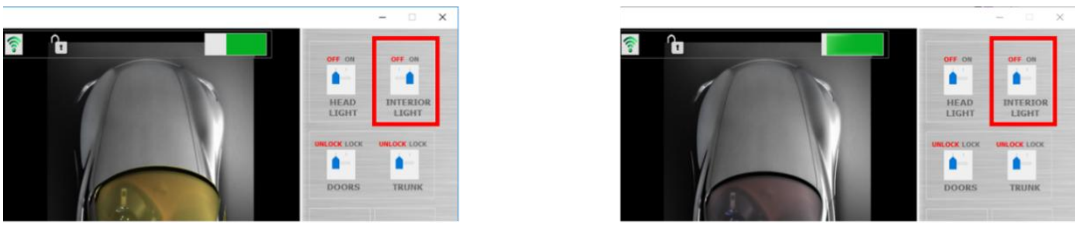
Figure 9 shows how to control the head lights. Move the marker to "ON" will turn on the head lights, move the marker to "OFF" will turn off the head lights. Figure (a) shows the lights-on state, figure (b) shows the lights-off state.



(a) Head lights on (b) Head lights off

Figure 9:. The way to control the head lights

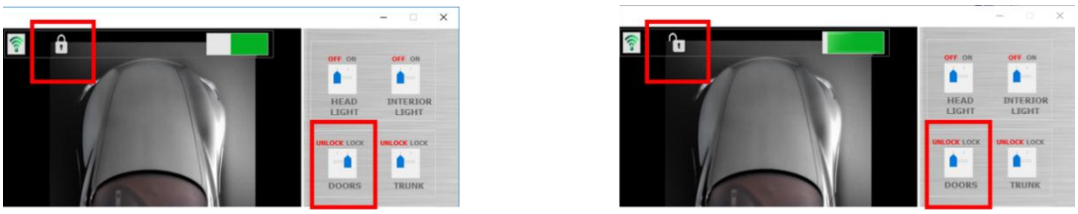
Figure 10 shows how to control the interior light. Move the marker to "ON" will turn on the interior light, move the marker to "OFF" will turn off the interior light. Figure (a) shows the light-on state, figure (b) shows the light-off state.



(a) Interior lights on (b) Interior lights off

Figure 10:. The way to control the interior light

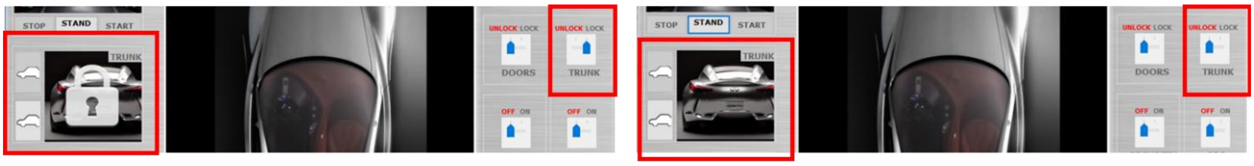
Figure 11 shows how to control the doors. Move the marker to "LOCK" will lock the doors and the lock icon will turn to locked, move the marker to "UNLOCK" will unlock the doors and the lock icon will turn to unlocked. Figure (a) shows the doors-lock state, figure (b) shows the doors-unlock state.



(a) Doors locked (b) Doors unlocked

Figure 11:. The way to control the doors

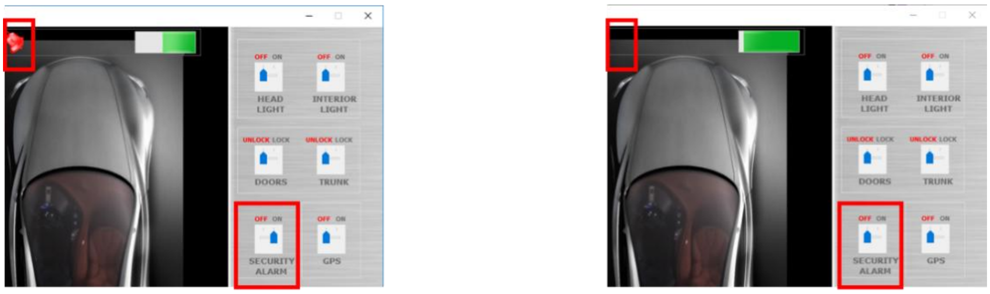
Figure 12 shows how to control the trunk. Move the marker to "LOCK" will lock the trunk and the trunk icon will turn to locked, move the marker to "UNLOCK" will unlock the trunk and the trunk icon will turn to unlocked. Figure (a) shows the trunk -lock state, figure (b) shows the trunk -unlock state.



(a) Trunk locked (b) Trunk unlocked

Figure 12:. The way to control the trunk

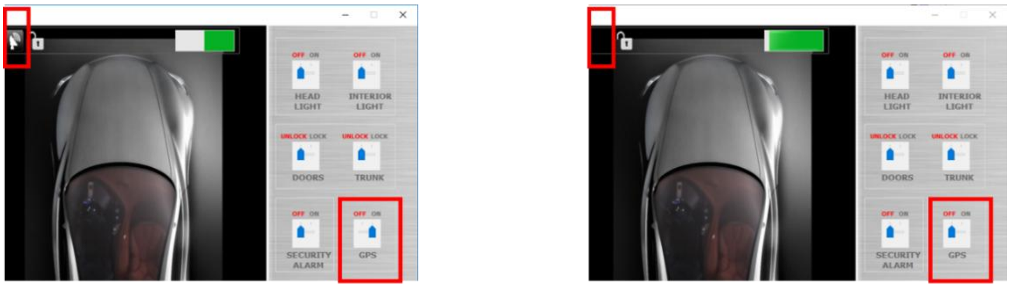
Figure 13 shows how to control the security alarm. Move the marker to "ON" will turn on the alarm, move the marker to "OFF" will turn off the alarm. Figure (a) shows the alarm-on state, figure (b) shows the alarm-off state.



(a) Alarm on (b) Alarm off

Figure 13:. The way to control the security alarm

Figure 14 shows how to control the GPS. Move the marker to "ON" will turn on the GPS, move the marker to "OFF" will turn off the GPS. Figure (a) shows the GPS-on state, figure (b) shows the GPS-off state.



(a) GPS on (b) GPS off

Figure 14:. The way to control the GPS

4. Conclusion

In this paper, we present the remote monitoring and control service for electric vehicle based on CoAP protocol in mobile platform. And we develop the remote monitoring and control service of electric vehicle based on CoAP protocol successfully. This service provides users monitor service and control service for their electric vehicles through their mobile phones. During our experiments, we used electric vehicle emulator instead of real electric vehicles. We have monitored and controlled the state of the vehicle emulator include battery state, door state, trunk state, audio state, head lights state, interior light state, alarm state, and the engine state. After these experiments, we considered that it is feasible and effective to use CoAP protocol for the communication between vehicle emulator and mobile application. In the future, we will optimize our design by adding more remote controlling functions and test using the real electric vehicles.

5. Acknowledgment

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