Development of Center for Remote Engine Starter

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Abstract

The remote engine starter (hereinafter, referred to as "RES") we have put on the North American market starts a vehicle engine in accordance with the remote operation made by the combination of a specific smart key and a vehicle ECU, to adjust the temperature of a vehicle cabin to be comfortable and to warm up the vehicle engine for smoother driving start before a user starts driving the vehicle.

This time we have developed new service that allows a user to "start/stop the vehicle engine" and to "check vehicle state (state regarding locking and vehicle position)" from the position where the user can not see the vehicle, by use of the RES newly equipped with a GSM communication function and a GPS reception function based on the conventional RES, and the SmartPhone application newly developed for user operation.

This paper introduces "center system" that allows this new service.

1 Introduction

Conventional RES for North American market is a product for adjusting the temperature of a vehicle cabin to be comfortable before a driver gets in the vehicle in a cold region such as Michigan in winter or in a hot region such as Arizona in midsummer. The driver can start a vehicle engine by operating the remote control of a wireless door lock system, which is convenient for the driver with no need to carry two controllers. This is the advantage for this product.

This time we have newly developed "mobile-phone-linked RES" that is much further advanced than the conventional product, with the connection between a vehicle and Smartphone via a center.

"Mobile-phone-linked RES" is composed of Smartphone application that controls a vehicle in addition to the remote control of the conventional wireless door lock system, RES ECU that is equipped with a GSM communication function and a GPS function for capturing vehicle positions, and a center system that connects those above seamlessly.

The major functions provided by the "mobile-phone-linked RES" are the following four functions: "engine start/stop function," "door lock/unlock function," "Carfinder function for checking vehicle positions," and "information function for checking vehicle conditions." This paper introduces the outline of the center system we have developed.

2 Entire Center System of Mobile-Phone-Linked RES

2.1 Advantage of FUJITSU TEN's Center System

Each of **Fig. 1** and **Fig. 2** shows the entire system configuration of the mobile-phone-linked RES.

We have developed the center system based on the standard technologies used for general WEB application system development, using JAVA for development language and database for data storage.

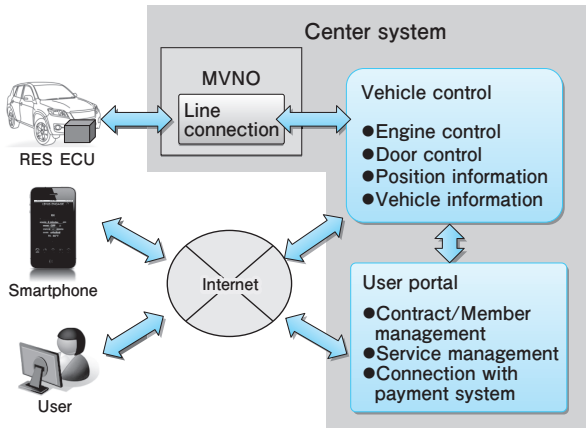


Fig.1 Center System Configuration of Mobile-Phone-Linked RES

The reason why we used general technologies for development is to develop the system in shorter period and to flexibly adapt environmental change relevant to a rapidly-upgrading ICT technology, enhanced security measures, etc., and also to flexibly expand the size of the entire system in accordance with the spread of service use.

The system requires only a short period for minor system modification before service start in the countries where various conditions (e.g. use environment of the Internet, laws for personal information management) are different from North America where provision of the service has started already.

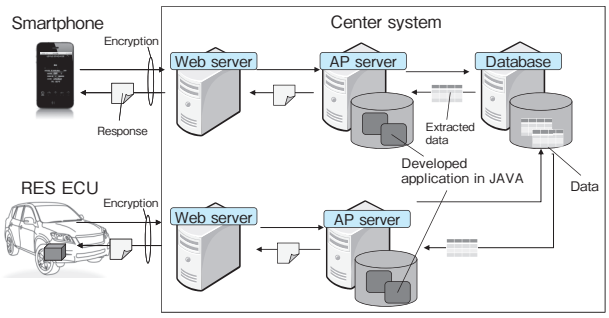


Fig.2 System Configuration

2.2 Connection System between Smartphone and RES ECU

As for the basic sequence of the system, when Smartphone application is run, a login screen is displayed. Then, when a user enters his/her authentication information (user ID, password) and pushes an OK button, the authentication information is transmitted to the center system. The center system judges whether the user is proper based on the transmitted authentication information, and then transmits a start-up instruction to an RES ECU. **(Fig. 3)**

The RES ECU confirms whether the received start-up instruction corresponds to the proper instruction transmitted by the FUJITSU TEN's center system, and then connects to the center system through the GSM communication function.

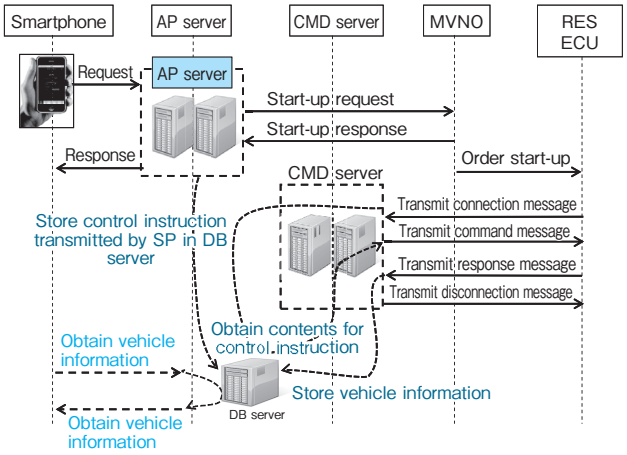


Fig.3 Basic System Sequence

2.3 Access Control by Smartphone Application

The Smartphone application controls accesses based on the authentication information (user ID, password). (Fig. 4)

The communication between the Smartphone and the center system is executed with the signals coded by SSL(1) due to protection of the authentication information.

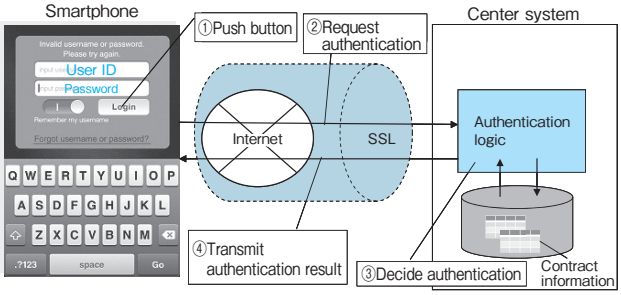


Fig.4 Flow for Authentication

2.4 Prevention of Operational Error by Smartphone Application

Since the Smartphone application provides the function for starting an engine and unlocking doors from the position where the user cannot see the vehicle, the function to prevent the operation different from user's intention has been newly introduced.

The user has to enter a four-figure PIN code(2) to execute these functions on the Smartphone application. Only when the entered PIN code meets the PIN code stored in the center system, the engine is started and the doors are unlocked. (Fig. 5)

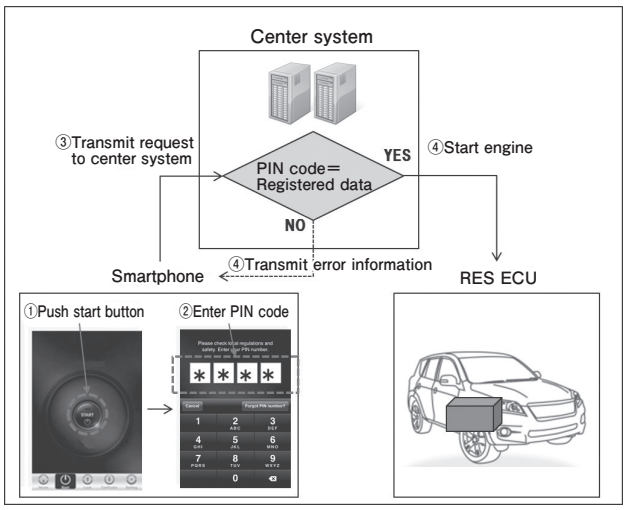


Fig.5 Response to Unintended Operation

2.5 Prevention of Unauthorized Access to RES ECU

The RES ECU equipped with the GSM communication function is exposed to risk of unauthorized access from outside.

The start-up instruction transmitted by the center system includes identifiable information to identify that the start-up instruction has been transmitted by FUJITSU TEN center system, in order to prevent the unauthorized access to the RES ECU. Moreover, the RES ECU has a function to break off the details of the start-up instruction transmitted by other than the FUJITSU TEN center system, if any. (Fig. 6)

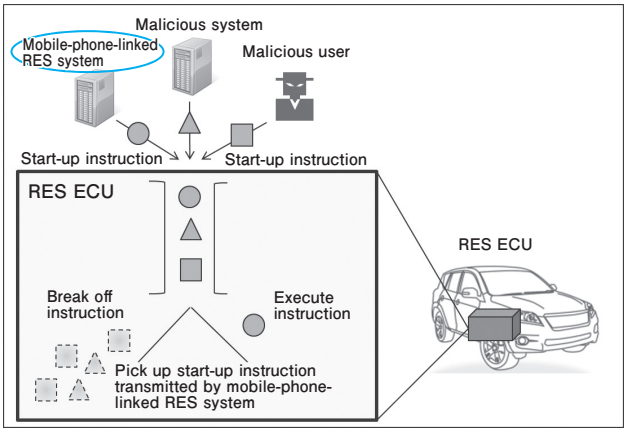


Fig.6 Prevention of Unauthorized Access

2.6 Protection of Control Message from Third Party

To secure safety of the entire vehicle, we have adopted TLS1.2(3) that provides an upgraded encryption communication protocol for transmitting and receiving control messages between the center system and the RES ECU. (Fig. 7)

We have developed the application for communication between the center system and RES ECU through TLS1.2.

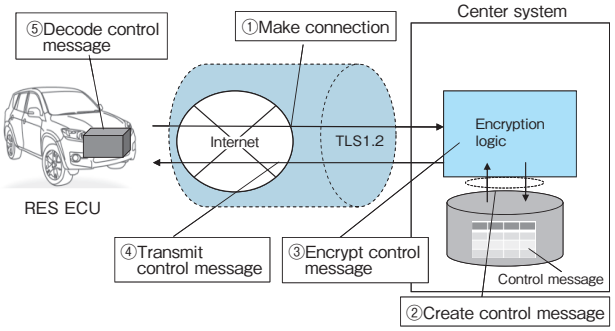


Fig.7 Flow of Processing for Encrypting Control Message

∗(1) "SSL" is one of the protocols for transmitting and receiving encrypted data over the Internet. "SSL" stands for Secure Socket Layer.

∗(2) "PIN code" is a so-called ID number. "PIN" means the number for identifying an individual, standing for "Personal Identification Number."

∗(3) "TLS1.2" is communication protocol that provides higher level of security. In TLS1.2, SHA256 is newly available as hash algorithm. "TLS" stands for "Transport Layer Security."

2.7 Fail-Safe of Vehicle Control System

The center system has redundant structure of server apparatus with a load balancer so as to secure communication with the RES ECU.

Moreover, in the structure of the center system, in case of application halt, the server promptly restarts the application so that the service will not halt. (**Fig. 8**)

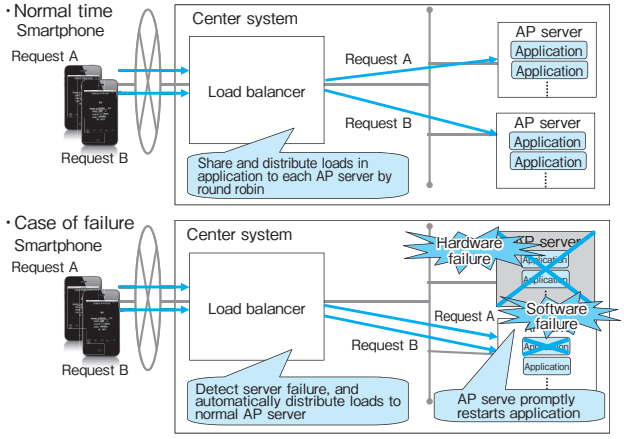
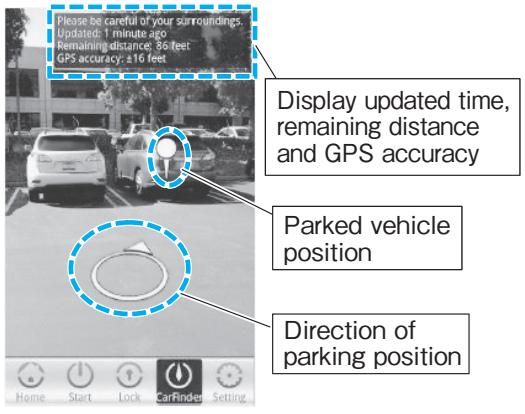


Fig.8 Structure of Fail-Safe

3 Use of Vehicle Position Information (Carfinder)

3.1 Function of Carfinder

Carfinder function allows a user to check the information on the direction and the distance of his/her parked vehicle on his/her Smartphone only by holding up the Smartphone toward the direction of the vehicle. (**Fig. 9**)



Carfinder display screen

Fig.9 Example of Carfinder Used

3.2 Structure for Displaying Vehicle Position on Smartphone

In order to execute the function, every time the Smartphone application is run, the Smartphone issues to the RES ECU an instruction to transmit the position information received from GPS, via the center system. (**Fig. 10**)

The Smartphone executes this function to specify the vehicle position using the position information of the Smartphone obtained by a build-in GPS and the position information of the RES ECU transmitted to the center.

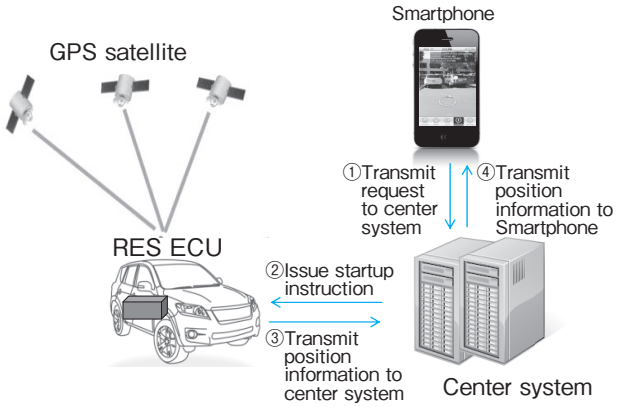


Fig.10 Method for Executing Carfinder Function

3.3 Prevention of Transmitting Uncertain Vehicle Position Information

The accurate position information of a parked vehicle may be unavailable in the environment where communication with GPS satellites is impossible, such as a place surrounded by tall buildings and an underground parking lot. In such a case, the RES ECU transmits to the center system the information that indicates the position information is undetermined, in order to prevent the user from being confused with the uncertain vehicle position information. (**Fig. 11**)

When receiving the information that indicates the position information is undetermined, the center system updates the position information to be stored in database as being undetermined for the purpose of prevention of the erroneous position information from being transmitted to the Smartphone application.

In case where the vehicle is parked outside a GSM communication area, the center system monitors response from the RES ECU for a certain period of time, and also updates the position information as being undetermined if no response is received in time.

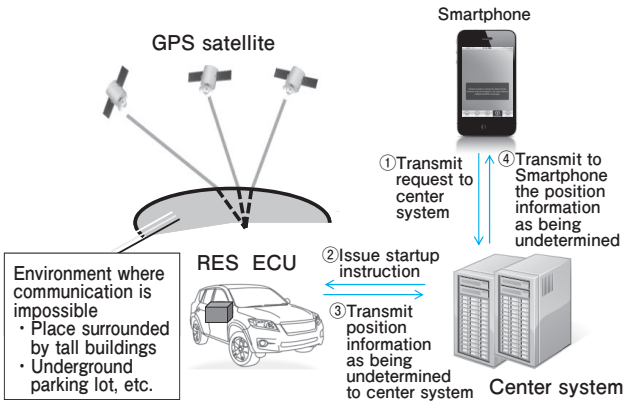


Fig.11 Prevention of Transmitting Erroneous Position Information

4 Conclusion

We have developed the "mobile-phone-linked RES" for use as a dealer option for North American automaker since October 2012.

The development of the center system connecting a user and a vehicle has brought us the future potential of connection service, such as enhanced function of "mobile-phone-linked RES," expansion of sale region, and provision of new service based on this system.

We will keep working on developing safety, security, and convenient services for vehicles with this system so as to continue to provide more comfortable driving environment to customers.

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