Remote Vehicle Diagnostic System Using Mobile Handsets

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***Abstract*— This paper proposes remote vehicle diagnostic system with handset, which has same functionality of conventional scanner, automobile diagnosis device. It consists of remote server, mobile handset application and a connecting device. Remote server has vehicle diagnosis database. Mobile handset application relays automobile signals and controls the flow of data packets. Using connecting device, user can send and receive signals between automobile and handset. Since remote server performs vehicle diagnosis, diagnosis history can be updated automatically. In addition, value added service can be provided easily. When there is a new automobile, the diagnosis database can be updated in the server. Thus, it is not necessary for each scanner to be updated individually. With the proposed system, self-diagnosis by users is possible using mobile systems, which is cost-effective and easy to use.**

I. Introduction

With the advance of communication technologies, various data services are provided in the market and new killer services are shown replacing the saturated voice call market in the mobile communication. With this trend, data services using serial ports are increasing. Nowadays, game consoles are connected to mobile handset and using gyro module, motion based service are provided.

Telemetry services are remote control and measurement services. Users can control local devices remotely using mobile handsets that connect to remote control servers. Meanwhile, different from this common concept of telemetry services, the concept of Smart Telemetry Service[1] has been proposed. In STS, the local device is controlled by the remote server using handset.

In automobile diagnosis market, the functions of conventional scanner are imported to telematics devices customized according to automobile. Although new car systems follow international standard ODB-II, there are so many previous car systems that do not obey this standard. Therefore, it is difficult to make telematics devices that accommodate various car systems.

In this paper, we propose remote vehicle diagnostic system for various car systems. The proposed system is based on Smart Telemetry Service technology and uses remote server, simple connecting devices(or converting board), and wireless handsets. It is possible to cover various car systems by downloading software routines in handset and upgrading the server.

Moreover, to overcome time delays in mobile networks, dedicated protocol is added for vehicle diagnostic system. In the proposed method, vehicle diagnostic operation is executed directly from remote server. Additional car system can be covered by only upgrading server program. Various services can easily deployed based on the diagnosis history which remains in the server.

The remainder of this paper is organized as follows. At first, we explain the concept of Smart Telemetry Services and the configuration of remote diagnostic system. Then the problem of time delay and our solution are discussed. To show the effectiveness of the proposed method, experimental results are shown. Finally, future works are discussed.

II. Smart Telemetry Services

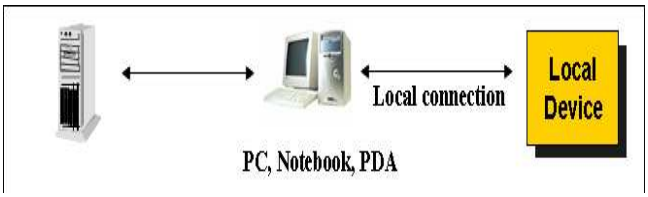
Different from general telemetry services, Smart Telemetry Service(STS) is based on the mobile handsets carried by users. STS makes remote server control local devices directly which do not have network capability. That is, it requires users to carry mobile handsets. It is useful when most operations can be executed in the remote server without changing local devices.

It is different from previous data communication scheme that uses mobile handsets as simple CDMA modem. The difference of previous scheme and the proposed method is depicted in Fig.1.

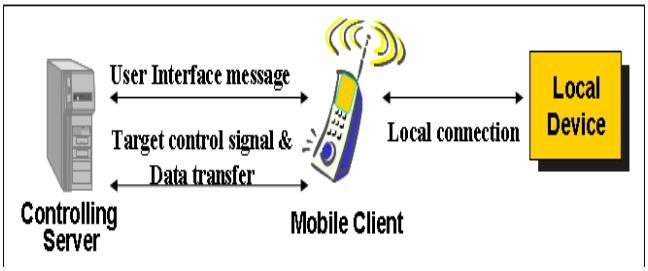
Fig.1 (a) shows the previous data communication scheme. In this scheme, notebook or PDA systems connect to remote server by using mobile handsets as CDMA modem. In this case, it can be applicable only for network-capable devices such as notebook or PDA. That is, it cannot be applicable for the previous network-incapable local devices.

Fig.1 (b) shows a typical scheme controlling these network-incapable local devices. In this scheme, using notebook or PDA, local devices can connect to remote server through wired or wireless network. Recently, market trend goes to converge mobile handsets and PDA. However, due to time and cost, it is not appropriate for common users.

(a) a scheme for previous data communication services



(b) a previous scheme for network-incapable local devices



(c) the proposed scheme

Fig. 1. Comparison between previous schemes and the proposed scheme

Fig. 1 (c) shows the proposed scheme that remote server controls local devices through mobile handsets. In this case, mobile handset roles as a virtual cable interconnecting local devices and remote server through CDMA networks.

The proposed scheme is effective for controlling previous network-incapable local devices from remote server. It is done by downloading application for mobile handsets.

In this scheme, one of the important problem is the time-delay in wireless networks and internet. For most vehicle diagnostic protocols including ODB(On-Board Diagnostics)-II, it requires to exchange signals within pre-defined time to keep connection after connection establishment. Since such condition cannot be guaranteed in wireless networks, it is necessary to design dedicated protocol that resolves this time-delay problem.

III. Configuration of the Proposed Vehicle Diagnostic System

In Fig.2, the configuration of the proposed vehicle diagnostic system is depicted. Remote server and application on mobile handsets exchange information on TCP/IP. Mobile handset application acts user interface operation or relaying data for remote diagnostic operations to ECU(Engine Control Unit) through converting board. Mobile handsets and converting board are connected through UART with voltage level of 0

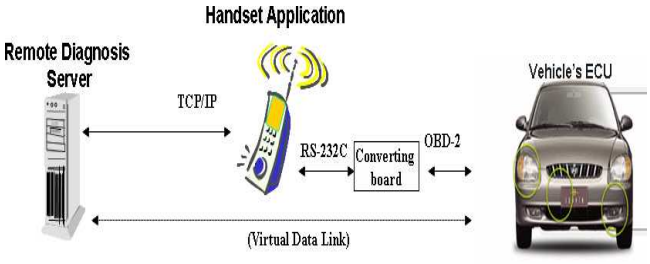


Fig. 2. Configuration of the proposed vehicle diagnostic system

to 5[V] and converting board changes voltage level and the communication scheme for ODB-II protocol or others.

Users can select automatic diagnostic operation for existing car system or manual diagnostic operation for other car systems using user interface menus provided by remote server. After selecting the type of car system and connecting the cable between converting board and ECU, users can start diagnostic operation. According to the protocol between mobile handsets application and remote server, the control data from remote server bypasses to ECU through converting board.

Through the pre-defined establishment sequence and diagnostic protocol, ECU and remote server exchange data related to diagnostic operation. Then, remote server analyzes the diagnostic data. Finally, users can check the result through mobile handsets. Such results are saved automatically in remote server and various additional services can be provided easily with them.

In this paper, we concentrate on the parts of Diagnostic Trouble Codes(DTC) and MIL (Malfunction Indicator Light) codes which are frequently used for commercial stand-alone scanner. Although commercial stand-alone scanner has additional functionality like analog signal measurement, this functionality is rarely used. For the proposed cost-effective diagnostic system, we have no choice but to consider only the parts with digital signal.

Fig.3 shows the procedure of the proposed system briefly. The procedure can be summarized as follows:

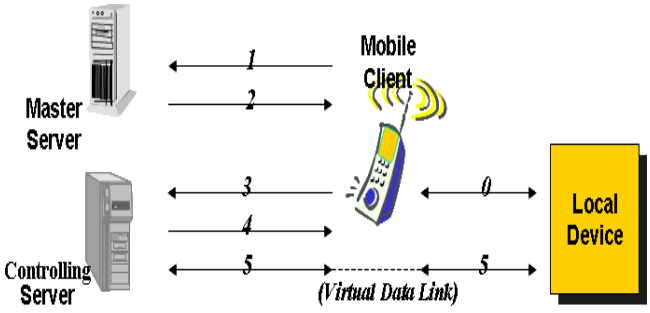


Fig. 3. Procedure of the proposed vehicle diagnostic system

- Step 0 : The handset and automobile are connected using a converting board.

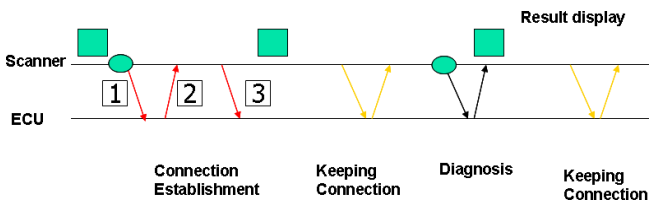
- Step 1 and Step 2 : Handset sends the service request signal to master server.
- Step 3 and Step 4 : Automobile (local device) is connected to controlling server through wireless handset.
- Step 5 Using virtual data link, data is transmitted and analyzed. After that, the results are displayed in handset.

IV. Protocol for Resolving Time-Delay Problem

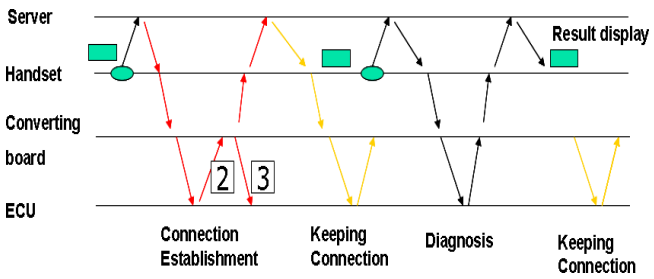
To illustrate the basic concept of the protocol for resolving time-delay problem in wireless networks, exchange of diagnostic data is depicted in Fig.4. Here, square parts represent messages shown to users from stand-alone scanner(or remote server) and ellipse parts represent key input from user in scanner(or mobile handsets). Arrow lines represent data flow between scanner(or mobile handsets through converting board) and ECU.

There are several timing requirements in the protocol between scanner and ECU. Typical examples are related to the connection establishment and keeping connection. When scanner sends signal 1 to ECU for connection establishment, ECU response signal 2 within pre-defined time to notify ready condition. In this case, scanner should send signal 3 within a certain amount of time. However, if remote server checks signal 2 and send signal 3, such timing requirement cannot be satisfied. It is due to the unpredictable time-delay in wireless networks and internet.

To resolve this problem, we design and apply dedicated protocol that manipulates local response. By using this protocol, application program on mobile handsets generates local response directly during sending response to the remote server. Therefore, timing requirement of vehicle diagnostic protocol can be satisfied during notifying server that connection is established successfully.



(a) Communication sequence between scanner and ECU



(b) Communication sequence for the proposed system

Fig. 4. Communication sequence of data for diagnostic operation

After connection establishment, it is also necessary to send connection keeping signal within pre-defined time to make connection alive. If remote server sends these signals for keeping connection, unpredictable time-delay in wireless networks and internet makes it impossible to guarantee timing requirement for keeping signal. Moreover, unnecessary data exchange on wireless network results in the increase of the cost for data communication. With dedicated protocol for keeping connection, application program on mobile handsets can generate these signals periodically after first receiving command related to this operation. Therefore, we can satisfy timing requirement for keeping connection and also reduce unnecessary data exchange through wireless networks.

V. Experimental Results

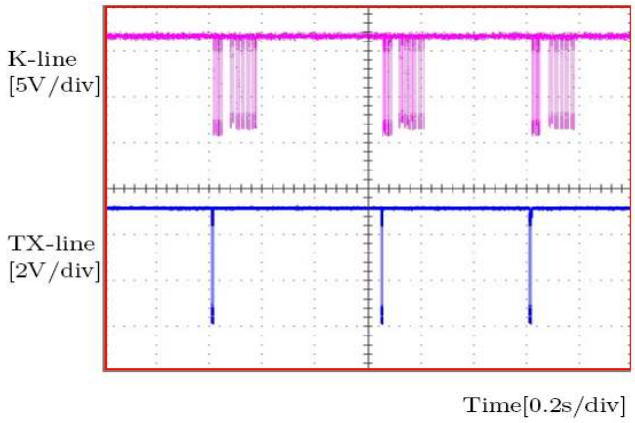
To show the applicability of the proposed system, we construct diagnostic program for remote server, application programs for mobile handsets and converting board respectively. In constructing database for vehicle diagnostics on remote server the system for converting board, we cooperate with Nex-tek Cooperation, which is major company producing commercial stand-alone scanner.

Application program on mobile handsets is implemented on BREW environment[6]. LCD display and keypad of mobile handsets act like dummy terminal through which users can command desired operation and can see the results of diagnostic operation. 8-bit micro-controller(PIC16C73 of Microchips Co.) is used for converting board. Assembly coding is adopted for main function requiring real-time performance. For serial communication between converting board and mobile handsets, internal serial ports are used. For communication between converting board and ECU, software-generated serial communication scheme through Digital input/output pins is utilized. In designing hardware of converting board relating signal level conversion and selecting output pattern for various car systems, schemes in the commercial system is referenced.

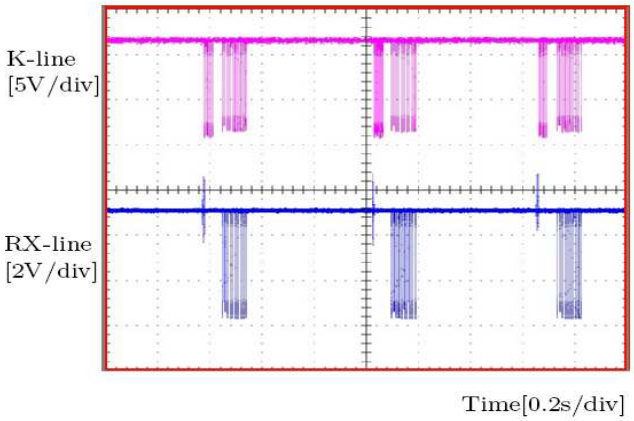
Fig. 5 shows the waveforms of diagnostic operation. ECU of ATOS (Hyundai Motor Company)[7] is diagnosed. The upper waveforms of (a) and (b) show signal on K-line through which converting board and ECU communicate diagnostic data, while the lower waveform of (a) shows signal on TX(transmit) line from handsets to converting board. After connection establishment, application program on mobile handsets generates signal for keeping connection periodically as shown in the lower waveform according to the protocol and the command from remote server. Although the response of ECU is sent back from converting board to mobile handsets though RX(receive) line as shown in the waveform of (b), to remove unnecessary data exchange on wireless networks, it is discarded according to the protocol and the command from remote server.

VI. Conclusion

In this paper, we propose remote vehicle diagnostic system with handset, which has same functionality of conventional



(a) Waveform of K-line and TX-line



(b) Waveform of K-line and RX-line

Fig. 5. Waveforms of diagnostic operations

scanner, automobile diagnosis device. Since diagnostic algorithms are located on remote server, we can construct lost-cost vehicle diagnostic system.

The proposed system consists of remote server, mobile handset application and a connecting device. Remote server has vehicle diagnosis database. Mobile handset application relays automobile signals and control the flow of data packets. Using connecting device, user can send and receive signals between automobile and handset. Since remote server performs vehicle diagnosis, diagnosis history can be updated automatically. With the proposed system, self-diagnosis by users is possible using mobile systems, which is cost-effective and easy to use.

Future work can be done for spreading the proposed system for various VM platform of mobile handsets and elimination of wired connection between mobile handsets and converting by using cost-effective wireless PAN(Personal Area Network) technologies.

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