A Gateway and Framework for Telematics Systems Independent on Mobile Networks

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ABSTRACT—In this letter, we analyze the problems with the existing telematics service systems that have been dependently developed and provided on a specific mobile network infrastructure. Then, we suggest methods to solve the problems and propose an architecture of the gateway and framework to implement our methods. We also verify the effectiveness of the suggested architecture through a comparison with an existing telematics system. With this architecture, it is possible to develop service applications without knowledge of the underlying mobile network technology and the system integration methods.

Keywords—Telematics, navigation service, gateway, framework.

I. Introduction

The existing telematics services have been dependently developed and provided on specific systems of a mobile network. This creates a situation where services cannot be provided on other mobile networks. Also, telematics service providers are unable to provide telematics terminals with the telematics services on the Internet without dependence on specific mobile networks.

To provide an environment where telematics services can be developed independent of the underlying mobile network systems, a new telematics gateway and framework is required. With this kind of telematics gateway and framework, the developers can compose service applications without knowing about the underlying mobile network technology and the detailed method integrating the related systems, such as the servers of a public emergency center, a traffic information distribution center, and so on.

In section II of this letter, we suggest methods to solve the problems with the existing telematics server systems. In section III, we propose an architecture of the gateway and framework to implement the methods. We verify the effectiveness of the suggested architecture in section IV and conclude in section V.

II. The Existing Telematics Server System

The existing telematics server systems consist of server applications, a short messaging service center (SMSC) connection component, the related servers' connection component, HTTP, and TCP/IP. The server applications provide client applications in a vehicle with telematics services such as emergency service, remote door unlocking, and remote vehicle diagnostic service through the wireless application protocol (WAP) gateway [2] in a mobile network.

If a telematics server system uses a WAP 2.0 gateway [2] in the mobile network to provide services to the telematics terminal, a good performance cannot be guaranteed since the gateway intercepts a message from an origin application and passes the message to a target application. It also cannot ensure end-to-end security between the telematics client application and server application.

To solve the problems with the existing gateways, it has been suggested to include the wireless optimized TCP [3] in the gateway and framework. The suggested method ensures a better performance than the WAP gateway and end-to-end security for applications. It also enables telematics service providers (TSPs) to provide services to telematics terminals without dependency on the mobile phone network and to do business on the Internet.

To develop the server application in an existing environment, developers by themselves should integrate the related servers

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one by one. However, this retards the development of applications and blocks the emergence of quality applications. The framework to solve the problems will be suggested in section III.2.

III. The Suggested Gateway and Framework

Figure 1 shows the architecture of the suggested telematics gateway and framework to solve the problems with the existing telematics server system. It enables developers to write telematics server applications independent of the gateway of the mobile network. It also enables developers to write applications without knowing about the interfaces of the systems of the mobile network that are related to authentication and billing systems, and without knowing about the details to integrate related servers such as the E911 rescue server, the police reporting server, and traffic information distribution server.

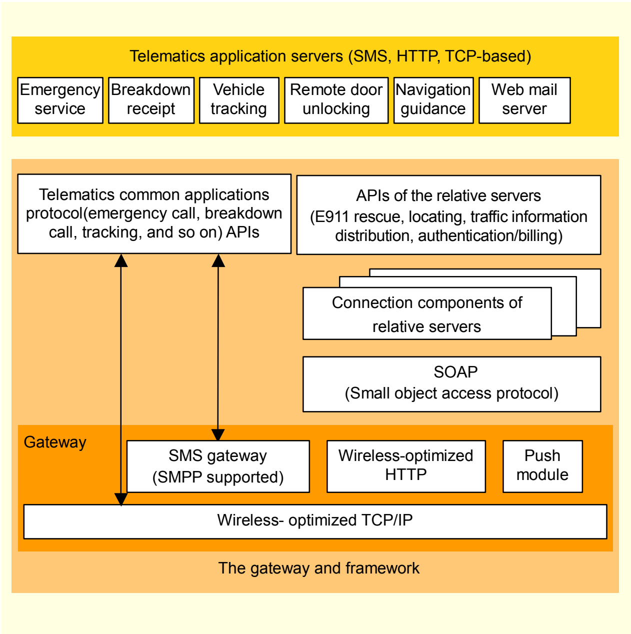

Fig. 1. The architecture of the suggested telematics gateway and framework.

1. The Gateway Architecture

As shown in Fig. 1, the gateway consists of the wireless-optimized TCP, SMS gateway, wireless-optimized HTTP, and push module.

A. Wireless Optimized TCP

The traditional TCP is made for controlling the transmission of messages between applications in wired networks such as the Internet. When the TCP protocol is used without being optimized in an environment where the wired and wireless networks coexist, it causes a serious decrease in the volume of transmission data.

This is because the TCP interprets causes of packet loss in a wireless link layer as congestion that has occurred in the network and performs congestion control unnecessarily. It causes a decrease of throughput and applications to be unable to provide service.

To solve the problems, a TCP optimized for use in an environment where the wireless and wired networks coexist is required. The TCP investigates whether a delay of acknowledgments is caused by a wireless link error or congestion of the wired network and performs the transmission control appropriate for the occasion. The TCP follows an end-to-end scheme [7]. One of its merits is that the end-to-end scheme can preserve end-to-end semantics. The TCP supports a selective acknowledgement [5], fast retransmission [6], explicit congestion notification [10], and the limited transmit mechanism specified in IETF RFC 3042 [11].

Besides this one, schemes [4] to improve the performance of the TCP in wired and wireless networks include a split connection [9] and link-layer schemes [8].

B. The SMS Gateway

The SMS gateway enables the telematics server application in the internet to send a short message to the telematics client application. It receives a short message from the telematics server application and requests an SMSC server to deliver the message to the telematics client application by using a short message peer-to-peer protocol.

C. The Push Module

The push module enables a TCP-based telematics server application to push a message to the telematics client application. When the telematics server application wants to send a message to the specified client application, it requests the push module to send a message to invoke a client application. An SMS-based application in a telematics terminal receives the message and invokes the specified application. The client application connects the server application and receives the message from the server.

2. The Framework

The suggested framework enables application developers to write new telematics applications by using application programming interfaces (APIs) of the related servers that it supports without knowledge of the integration details of the related servers distributed in the networks. The framework supports various connection components which can connect a telematics server application into external related server applications.

A. The Common Telematics Application Protocol APIs

The APIs provide standard protocols required to implement common telematics services such as an emergency call service, breakdown call service, stolen vehicle tracking, remote door unlocking service, alert service, and so on. Application developers do not have to either design or program the protocols. The protocol conforms to a global standard, which enables the services to be interoperable.

B. The APIs of Related Servers

The APIs of the related servers enable the developer of applications to write applications easily without knowing about the details to integrate the servers and without knowing a port number of the server or IP address of the host of the server. It also enables a developer to write code in order to be able to invoke a function in the remote server as if the developer is invoking local functions.

C. The Connection Components of Related Servers

The connection components are used for the developer of a telematics application server to integrate the related servers and to add them in the framework. The connection components can be implemented as a simple object access protocol (SOAP) [1] client to exchange a message with the related server through the SOAP server in the related server host. For this, the related server should be exported into the internet by registering its description—written in Web Service Description Language and dealing with how to connect with it, what service to provide, and how to interact with it—into a UDDI (universal description, discovery and integration) registry or its own web site. Developers of a client application need only to write the SOAP client by referring to the description about the related server. However, integrating the telematics server application into the related servers via software is not required.

IV. Comparisons with the Existing Telematics System

In this section, we compare the telematics system used over the suggested gateway implemented by members of our project with the existing telematics system in order to prove the merits of the suggested one through a qualitative effectiveness and quantitative performance comparison.

1. Usability of Telematics Systems

Figure 2 shows that the emergency server application over the suggested gateway framework can provide terminals with services through several different mobile networks. To provide

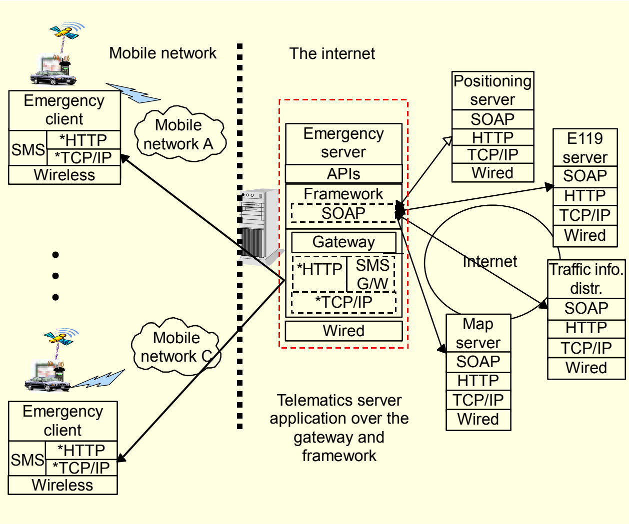

Fig. 2. The telematics server application independent on the mobile network.

the service through other mobile networks, the main part of the existing telematics system has to be redeveloped for the mobile networks.

The gateway framework enables TSPs to do telematics service business on the Internet without dependency on a specific mobile network.

The suggested gateway and framework therefore increases usability of telematics systems.

2. Ease of Application Development

The gateway and framework enable developers to write SMS-based, socket-based, and http (web)-based telematics applications without knowing about the underlying mobile network technology, detailed methods to integrate related systems, or application protocols which define the message formats and message exchanging sequences. Consequently, the gateway and framework increases productivity of the application development.

3. Performance of Message Transmission

In order to prove the quality of performance of the proposed architecture, we did a test performance of a message transmission of an existing telematics system using the gateway of the mobile network and the telematics system over the suggested gateway and framework.

A virtual mobile network [12] and wide area network (WAN) are made using Shunra Cloud emulator S/W, which introduces the network parameters such as bandwidth, latency, and packet loss that characterize a WAN and wireless link to a LAN environment.

A snoop is adopted as the gateway in a mobile network since thus far it has the best transmission performance among the solutions that are supportable in a mobile network, such as I-TCP (Indirect TCP) [9].

WAN and wireless network parameters of a test environment are shown in Table 1. A Gilbert model is adopted as an error model.

As shown in Fig. 3, the results of the test show that the performance of a message transmission of telematics systems over the suggested gateway and framework is higher than the performance of a message transmission of the existing telematics system using the gateway in a mobile network. The throughputs were measured at frame error rates when the client application receives 1 MB of data from the server application.

Table 1. Network parameters of test environment.

MSS	WAN delay	Wireless delay	Band width
1460 Bytes	Min: 59 ms, Avg: 97 ms Max: 452 ms	10 ms	2 Mbps

Window size	Good state transit probability	Bad state transit probability
5 kB–64 kB	0.0087	0.1491

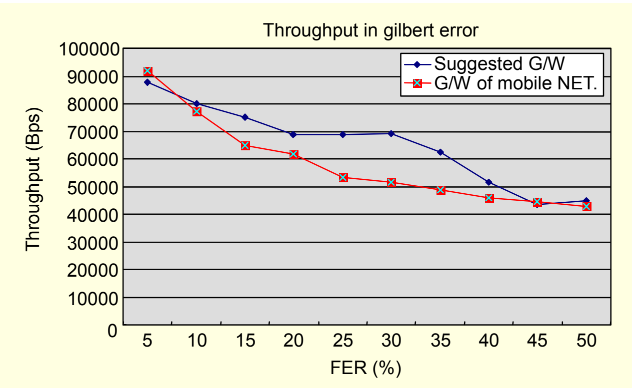

Fig. 3. Throughputs of the telematics system using the gateway of the mobile network and the telematics system over the suggested gateway.

V. Conclusion

In this paper, we suggest methods to solve the problems with the existing telematics server systems and an architecture of the gateway and framework to realize the methods.

This gateway and framework enables a developer to compose telematics service applications with independency on a mobile network. As shown in Fig. 2, once service applications have been developed, they can be provided for through all kinds of mobile networks. They do not need to be customized for other mobile networks.

The gateway and framework also enables people who want to do the business of telematics services over the Internet to do so and enables developers to compose various applications easily. The architecture can be used as a guideline for the development of telematics systems that can provide services on the Internet with independence on mobile networks.

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