A Real-Time Information Service Platform for High-Speed Train

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***Abstract*— In this paper, a real-time information service platform for high-speed train was proposed and implemented. With this platform, all passengers of train will freely to get access by Wi-Fi or other wireless network to enjoy movie, music, train information and travel information. Besides, the platform was connected to a FPGA based data processing center to collect train operation data including instantaneous power, traction and braking force, also convertor temperature. The server was designed based on opening protocol, and the data processing center is designed based on FPGA system. We setup a specific scene to verify the feasibility and achieve good results.**

***Index Terms*—Information service platform, FPGA, High-speed Train**

I. Introduction

Rail transport is the most commonly used mode of long-distance transportation in the People's Republic of China [1]. Passenger number of rail transport in 2010 achieves to about 1.64 billion. Only considering the passenger number between two major city Beijing and Shanghai, it owns about 10% of it. With the huge number of passengers traveling every day, how to provide information service for them becomes a problem. Although the Third Generation Communication Network (3G Network), which provided by the major mobile operators, can reach the download speed of 3Mbps [2]. The customers have to pay expense for that. In this paper, a real-time information service platform for Beijing-Shanghai high-speed train is design and implemented. In this platform, a server is established for each train to provide Local Area Network (LAN) service. The platform not only provides necessary information like music, video, travel information and advertisement to passengers, but also collects importation train operation running data and provides the administrators with visual result like traction property curves and braking property curves. Besides, the platform is integrated with Geographic Information System (GIS) to users. Users are possible to check the train information which is permitted according to the user type. Some administrators are authorized to get access to professional management system to read the train running data.

Although the concept of the platform is beautiful, there are still some problems in realization. How to make it adapted to different kind of electronics like smart phone (with different operation systems: windows mobile, Android, ios), Laptops and tablet PC? How to provide information to passengers in the train and users who may get access at any place of the word? In addition, how to collect data of the train into the server in real-time?

In our research work, we designed a web server based on open standards and widely available industry specifications to make different accesses working well, while the data collecting system was implemented by FPGA to process amount of transferring data. Users can easily get access to the platform by Ethernet or Internet. In order to highly improve the communication speed between PC and appliances, FPGA is applied in our system. Thus, different interfaces can be easily integrated in the system to make real-time data collection possible[9].

But how to make the high-speed train connected to Internet? Mobile operators like China Mobile have started to set up Wi-Fi network in nationwide. According to cablevision.com, Cablevision, the largest wireless Internet network provider in USA has Offered Wi-Fi on NY trains. These will make the train connected to Internet to provide service but it's not the major work of this manuscript. [3]

The organization of this paper is shown as follow. The system overview and function definition is introduced in section II. Detailed software design of the platform using java and Ajax is illustrated in section III. In section IV, we introduce hardware implementation for the remote control system. And a user case in section V. Coming up is the conclusion.

II. System overview

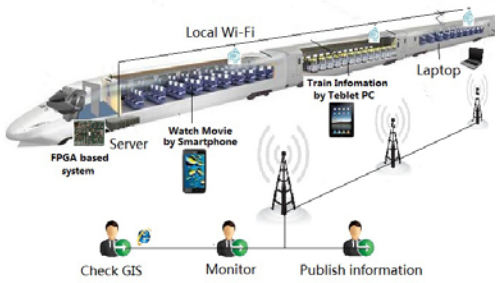

Figure 1. System Function Architecture

A. Platform

The information service platform on high-speed train is shown in Figure1. The server is connected to the internet through Wi-Fi. Wi-Fi is a high-speed wireless communication networks and can support the abundant data flow between users and the web server. Browser and Server based (B/S) structure is integrated in the software system.

User can log in the system by using IE or other browsers in B/S structure. This is implemented by Java language and Ajax.

B. Function Definition

1. Collecting train operation running data.

It is significant that the high-speed train will run with safety. So it requires that the platform will monitor the important parameter when the train is running. Speed, power, traction and the converter temperature are important parameter to evaluate the safety level of the train running. In this system, we collect these data with different kinds of interface including RJ45, RS232, 485, and USB etc. All the data is process by the FPGA and send to the platform. After analyzed, traction property curves and braking property curves is present in the system.

2. Travel information and advertisement distribution channel

In this system, information distribution channel is assigned to corresponding person, including train administrator, advertisers. Train administrator can login to publish announcement of time table of the train, weather report, remaining seats etc. While at the same time, the function is assign to advertisers like travel agency. Travel agency staff can login at the office by browsers to publish travel information according to the train location. For example, they will introduce Tianjin travel information and hotel reservation info to attract passengers. All the information will be published in each screen of each cabin.

3. Passengers Function

Currently, train only offer the same TV program for all passenger without consider the passenger's interests. In order to offer better service, the server is able to offer kinds of music, video, electronic books, and latest news for selection. Passengers not only can enjoy their favorite program, but also free of the expense charge from the mobile operators.

4. Other Visitor's Function

Visitor can login to check the train's information about the GIS, which is shown in Google map. In this case, they know where they are and how much time to the destination.

5. GIS based on Google Map

Google Map offers a public and free map service [4]. Therefore, we can use it to provide a geographical view in our platform. On the basis of Google Map service, we implemented a Browser and Server based system. As long as users can connect to the Internet, they can use our platform. Besides, since the platform supports many different ways of communication between the server and other trains, users can easily add their applications to our platform.

III. SOFTWARE DESIGN OF THE PLATFORM

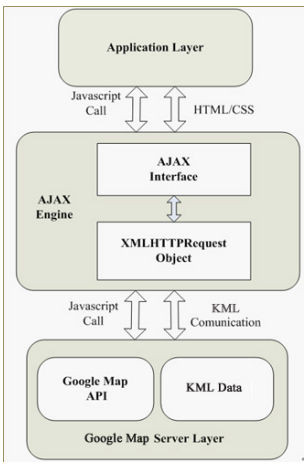

Figure 2. The achitechture of the software design

The architecture of the software design is show above.

A. A Client Design

In order to make it easy for the passengers to access the information service platform, dynamic web is implemented by using JSP and JavaScript. Our friendly user interface for the browser is shown in Fig 3. Ajax mode is applied in our client terminal to make user interact with server in real time instead of traditional web applications. Ajax offers a smooth ride all the way without the page reloading.

A string in set-cookie of HTTP header represents the cookie's information when the server sends the cookie to the client. Cookie can be acquired by using HTTP connection, getHeaderFiled.

B. Web Server Design

The server has three parts. First, there is Google Map server used to provide geographic information. Second, there is a Keyhole Markup Language (KML) Server[5] used to dynamically create KML files and load those KML files to the Google Map Server. Third, there is an application server which is implemented in java language as the core control part in our system. A database which stores users' and real things' information is also connected to the application server.

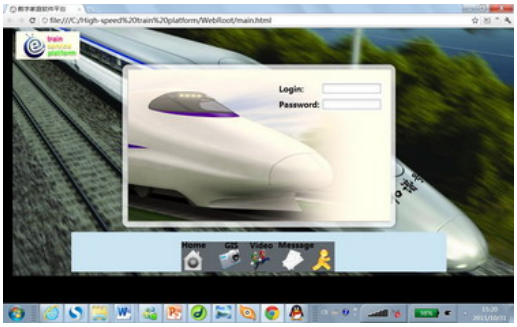

Figure 3. Client interface

As shown in Figure 4, the sever monitor responses the HTTP request from client. The acquired information is processed and classified to transmit to different Servlet. The process is described below.

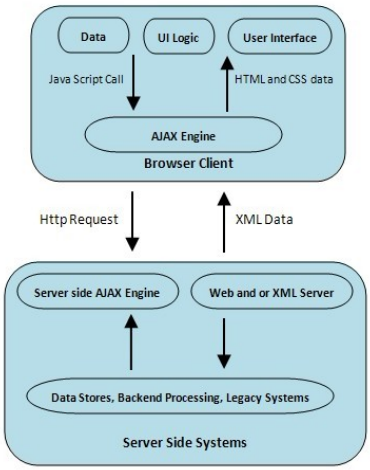

Figure 4. Software Structure of the server

1 The mouse over event handler triggers the Javascript function that populates and sends the XMLHttpRequest. The URL contains the context root, the Servlet mapping that is configured in the web.xml deployment descriptor and the populated query string associated with the request.

2 The Servlet receives the request, retrieves the itemed parameter of the request and create/sends the appropriate response.

3 The XML response is sent back to the browser and the callback function is invoked.

4 The response is parsed, the popup values are populated and the popup is displayed.

C. Database Design

There are two entities in our system. One is user and the other is thing. Thus, we designed two tables in our database for each one. Considering there will be many different kinds of things in our system and data quantity will by huge, Microsoft SQL Server 2005 is adopted for database design in our system. Table1 shows the list UserInfo for registered users' information. There are two fields: "user " and "password". "user " is appointed as the prime key.

TABLE I.
THE LIST USERINFO FOR REGISTERED USERS' INFORMATION

field	type	explanation
user	Varchar(30)	Prime key
password	Varchar(30)	Each user has one password

IV. HARDWARE IMPLEMENTATION FOR THE DATA COLLECTING SYSTEM

A. FPGA and USB Interface Implementation

Modern FPGA has the volume of millions of equivalent gates and hundreds of hardware multipliers. The FPGA clock frequency achieves hundreds of megahertz. FPGA works in fully parallel mode in our system. FPGA is chosen as microcontroller for high throughput data processing in our experiment.

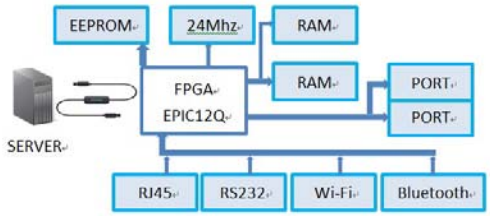

Figure 5. Hardware Structure of the train information processing center.

Fig. 5. Hardware Structure of the train information processing center

Figure 4 shows the hardware design architecture. A communication system connects the PC server and train information processing center. All drive controllers are implemented on a ALTERA EP1C12Q240C8N FPGA device[6].

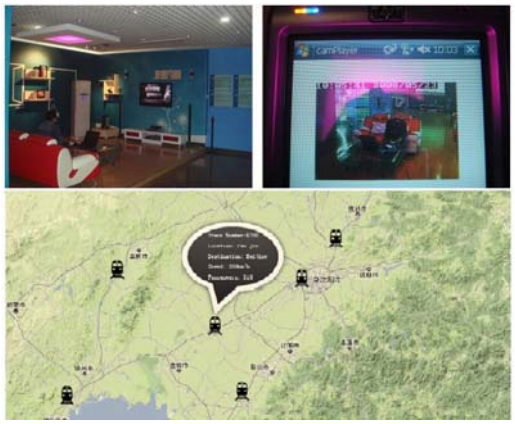

Figure 6. A use case in the specific scene

The static base design on the FPGA includes a USB 2.0 interface, the reconfiguration, memory management, communication and IO functions. The USB 2.0 interface implements the connection to PC or a higher level control system by employing an external USB controller, the EZ-

USB FX2 device by Cypress. This specific high speed USB peripheral controller implements the physical layer and accomplishes several other tasks. Special FIFO memories of the USB controller are connected to the USB interface of the drive controller and deliver the USB data to the FPGA.

The FX2 microcontroller contains an embedded USB 2.0 transceiver and handles all USB transfers with the upstream USB host. It presents a data bus to the FPGA with generic control signals which can be programmed to behave in a custom manner. This interface is called the GPIF (General Purpose Interface).

The FX2 also handles all USB control requests (via endpoint ()), which all USB-enabled devices must support to fully comply with the USB standard. These include responses to device capability interrogations and standard setup requests.

Figure 7 is the prototype of the control system with USB interface. In order to process the abundant data collected from the train, our control system must provide huge capacity of data processing to increase transfer speeds.

For example, the system collects the convertor temperature 10 times a second and the power also at 10 times a second. FPGA can easily handle the huge data transportation in our experiment, which sustains different interfaces (e.g. Bluetooth, Ethernet, RS232 etc.) connecting to different kinds of data type.

V. A Use Case In The Specific Scene: Application In Home

We developed a information service platform and applied at home scene as an experiment to demonstrate the feasibility of visiting and distributing information. Firstly, we developed a user friendly browser interface and recorded it in a XML file located in the server part. Second, we connected home appliances with the application server. Home appliances are worked as the important parts of the train and provide data. We set up a proxy server which is used to establish a link between home appliances and the application server. This proxy server is actually a personal computer which can surf the Internet. To connect home appliances with the proxy server and control those home appliances, Field-programmable gate array (FPGA) is used. The home appliances can access to the FPGA system by different channels such as RJ45, RS232, Bluetooth, Wi-Fi or USB. In the system, Bluetooth protocol is applied to connect air conditioner to collect temperature, while Wi-Fi is used to connect the camera. Fig.6 shows the experiment of our application.

VI. Conclusions

This paper present the design, implementation, and an initial model of a high-speed train information service platform, upon which different kinds of users can get access to acquire/distribute information during the train running. Also the important and abandon data is collected and processed by the FPGA based data processing system. Detail implementation of software and hardware design is proposed. Ajax mode is applied in the client terminal to make user interact with server in real time instead of traditional web applications. FPGA is chosen as data processing center for abandon data collecting and processing in our platform. Special FIFO memories of the USB controller are connected to the USB interface of the drive controller and deliver the USB data to the FPGA to guarantee the real time of data process.

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