A Smart Exhibition System of Power Measurement Vehicle based on the GIS and GPS Techniques

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Chao Tang[1], Jufang Xie[1*], Yiyi Zhang[2], Dong Hu[1] and Jiao Li[1]
[1] Southwest University, Chongqing, China
[2] Guangxi University, Nanning, China

***Abstract*—In order to integrate a kind of engineering vehicle smart exhibition system into the gateway measurement management system of the electric power department, a set of embedded smart exhibition, platform of power system engineering vehicle, centered on GIS and GPS, was developed and introduced in details in this paper. The system, which was composed of vehicle terminal, server software platform and monitoring center, took Windows NT Server, Oracle software and VB.NET as the developing tools and brought in the N-tier Architecture and the reusable component technology, could display the real time information of engineering vehicle using the GIS and GPS technologies. The trial operation of this system in the Chongqing Power Electrical Corp. indicated that, with the special developed structure, the application program development has no connection with the software platform, the heterogeneous database interaction is very convenient, and the system is open, safe and efficient. This smart exhibition system enhanced the dispatching management on the power measurement engineering vehicle, significantly improved the reaction ability on the sudden accident of power equipment and power measurement equipment, and played an important role in the safety maintenance of power grid as well as the loss decrease caused by the measurement errors of power measurement equipment.**

***Index Terms*—power system, engineering vehicle, smart exhibition, GIS, GPS**

I. INTRODUCTION

In accordance with the planning of the State Grid Corporation in China, the strongly unified smart grid with extra-high voltage network will be developed preliminarily in 2014. The foundation of the smart grid will be 'strong', but, a strong grid can never be built without daily detection and maintenance work. Therefore, supervision and coordination of vehicles used in electric engineering system is increasingly importance to electrical companies.

At present, both domestic and foreign studies on the monitoring and supervision systems of engineering vehicles have already made some progress in many areas, such as the fire prevention of oil field, mine, and forest. By integrating the GPS satellite positioning technology, geographical information system, and supervision system, Changqing Oil Filed Corporation has developed a multifunctional and easily-adopted vehicle supervision, management and coordination system which covers the whole oil filed by applying modern communication technology [1]. Literatures [2-6] elaborated on the urban public traffic monitoring system and electronic bus stop board system which use GPS, GPRS, GIS, Zigbee, and sensor technology based on the 'Internet of Thing' to promote public transport service. This system will not only provide a convenient ride to the public citizens, but also ensure that the administrators of public server will be able to have real-time accurate operation status of buses, which will contribute to a better planning and management of urban buses in the future. Literature [7] introduces a set of real-time vehicle supervision system designed by Google Maps API based on general packet radio service (GPRS), global positioning system (GPS), AJAX and Oracle. Literature [8] showed that the electricity rescue vehicles should develop a set of comprehensive application system which integrates computer information processing technique, network communication technique, GPS satellite positioning technique, GIS, and electronic map. This study also described the design philosophy and methods of function realization for GPS/GIS coordination and management system.

Referring to related domestic and foreign studies which applying advanced techniques such as GPS, GIS, and GPRS into vehicle management, it is possible to have real-time information about route tracking of electric vehicles, and realize end-users perform functions such as accurate positioning, speed controlling, coordination and inquiry on targeted vehicles in a nationwide range by GPS satellite and operator's service network of CMCC or Unicom. However, in domestic electric system, few studies on smart management system specialized for engineering vehicles were reported.

Considering the issues above, based on GPS and GIS techniques, using Windows NT Server as the operational system platform and Oracle database management system and VS.NET system as the development tools, this paper elaborated on a smart exhibition system of on-site engineering vehicle for electric power measurement. The system has many useful functions including real-time monitoring on vehicle, intelligent coordination management, accessible area limitation, and automatic over-speed alarm. It even can automatically highlight the three nearby vehicles on the electric GIS map when fault on certain part of the meter device is detected, and this will great facilitate the coordination management. The system will promote the capability of handling the unexpected electric incidents of electric enterprises, critical meter device faults, and bugs, which will make very important progress on the

safety guarantee and stable operation of the grid, and will provide technical support for developing a strong smart grid. Compared with the other existing management systems, this system is specialized for the users of on-site operation and management of the important power facilities, and it possesses more advantages in system stability, compiling, transplantation, and user interface as well, which owns a better application prospect.

II. ARCHITECTURE OF THE SYSTEM

A. System composition

The intelligent on-site exhibition system of electric power meters device engineering vehicle based on GIS and GPS was inserted into the gateway electric meters device status management system of Chongqing Power Electric Science Research Institution. The system is mainly consisted of three parts, namely server software platform, vehicle-mounted termination, and background monitoring center (Fig. 1).

Server software platform, mainly consisted of Web server, communication server, database server, etc., is the core of the system. The communication server receives the data from vehicle-mounted terminations, and then transmits the data to Web server and database server. The system mainly focuses on collection, processing, and storage of positioning data recorded by vehicle-mounted GPS termination, as well as commanded response and processing of orders from client software.

Vehicle-mounted terminations will be installed on vehicles, comprised of GPS module, sensor, antenna, electronic display, etc. The terminations are mainly used to send positioning information of vehicles.

Background monitoring center is mainly consisted of client monitoring termination, and it realizes remote supervision and management by software. The client software was applied to real-time monitoring on vehicles, intelligent coordination and management, accessible area limitation, automatic over-speed alarm, etc.

B. Overall Architecture

During operating processes of on-site meter vehicles, GPS receiving device on vehicle-mounted termination first calculate present longitude and altitude of the vehicle by receiving data, and then send the calculation results to server software platform of the monitoring center through GPS sending device. Background monitoring center will receive such positioning information of vehicles and store these data into database after interpretation. Finally, users will be able to handle with coordination information by bowering and consulting the real-time information like current location and status of the vehicle. Real-time precise positioning on vehicles will be easily realized by matching with GIS information provided by Google map, which facilitates monitoring management and guiding to vehicles. In the meantime, it is also available to track vehicle curves and driving time of one certain vehicle (Fig. 2).

As for network topology, vehicle-mounted GPS locates in outer network, therefore its data is stored in the server of Chongqing GPS Data Recording Corporation, while Chongqing Electric Power Corporation has strict rules on network division, hence a safety server between the outer network and inner network is required for guaranteeing

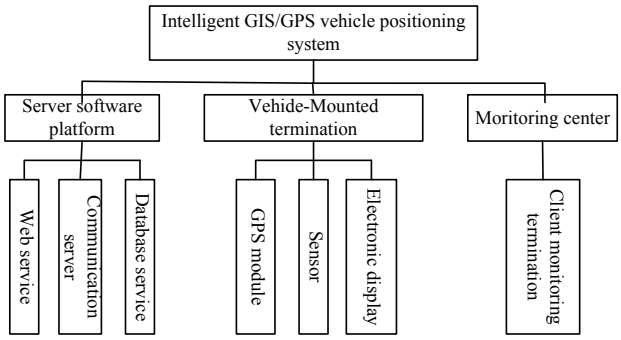

Figure 1. System structure diagram

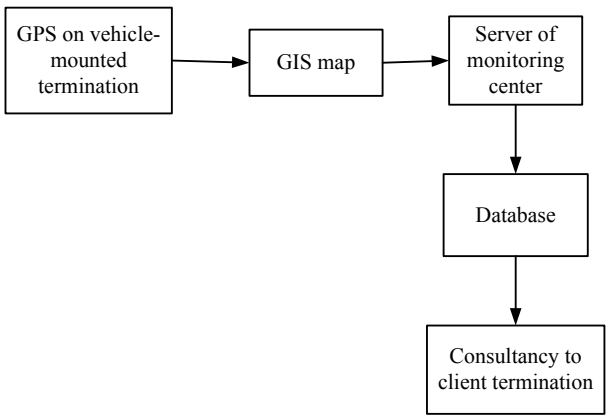

Figure 2. Data flow diagram

safety of data transmission when GPS data from the outer network are transmitted into the inner network.

C. Database Development

The center database, which takes Windows NT Server, Oracle software and VB.NET as the developing tools and introduces the N-tier Architecture and the reusable component technology, is the core of the whole monitoring management. Database mainly stores basic data about vehicles, vehicle-mounted termination and users, as well as historical data and operation record. It mainly contains the following data: user information, register information of all registered vehicles, driver information, different function and feature of vehicles, historical record of vehicles curves, record of orders sent by monitoring center, etc.

III. MAJOR FUNCTIONS OF THE SYSTEM

Since the exhibition system is an inserted sub-system of gateway electric power meters device status management system developed by Chongqing Electric Science Research Institution, users can practice monitoring and management on on-site measurement vehicles by logging in the gateway electric power meters device status management system. The login interface of the platform is eye-attracting, well humanized, and easily used. Moreover, information of electric power vehicles will be updated on the satellite map of Chongqing every 5 minutes, which makes the system more real-time, and more accurate.

A. Vehicle tracking and locating

The system is able to precisely locate all vehicles of electric units, accurate current location of vehicles will be displayed in real time on satellite map by matching with

GIS information provided by Google map, the flow chart is given as follows. Monitoring information involves license plate number, accurate location of vehicles (current longitude and altitude), and organization that vehicles belongs to, vehicle type, vehicle function and driver code of vehicles. Monitoring information will be available for consulting, and can be directly obtained on the map, as showed in the Fig. 3.

B. Consulting nearby vehicles

It is necessary to assign the nearest on-site measurement vehicles to the site to handle the problem when faults or meter mistakes happen on one meter device. In order to make it possible for coordinators in production and coordination units to find 3 nearest vehicles to the site, Dijkstra algorithm is selected to calculate the shortest path.

The Dijkstra algorithm is a typical single-source shortest path algorithm, which is available for calculating the shortest path from one joint to all the other joints. The feature of the algorithm is that it starts from the staring point and expand to outer layers until to the termination. Steps of the algorithm are as followings:

(1) At the beginning, suppose S={V0}, T={other end}. If $<V_0,V_i>$ exists, then $d(V_0,V_i)$ is expressed as $d(V_0,V_i)$'s weight on arc. If $<V_0,V_i>$ doest not exist, then $d(V_0,V_i)$ is expressed as infinite.

(2) Select an end W with its distance the minimum value and not included in S, and add into S.

(3) Adjust distances between ends in S: if the added W is expressed as the middle end, then distance from V_0 to V_i shall be shortened, then the distance shall be adjusted.

Repeat step 2 and step 3 above until two ends is involved in S, i.e. $W= V_i$.

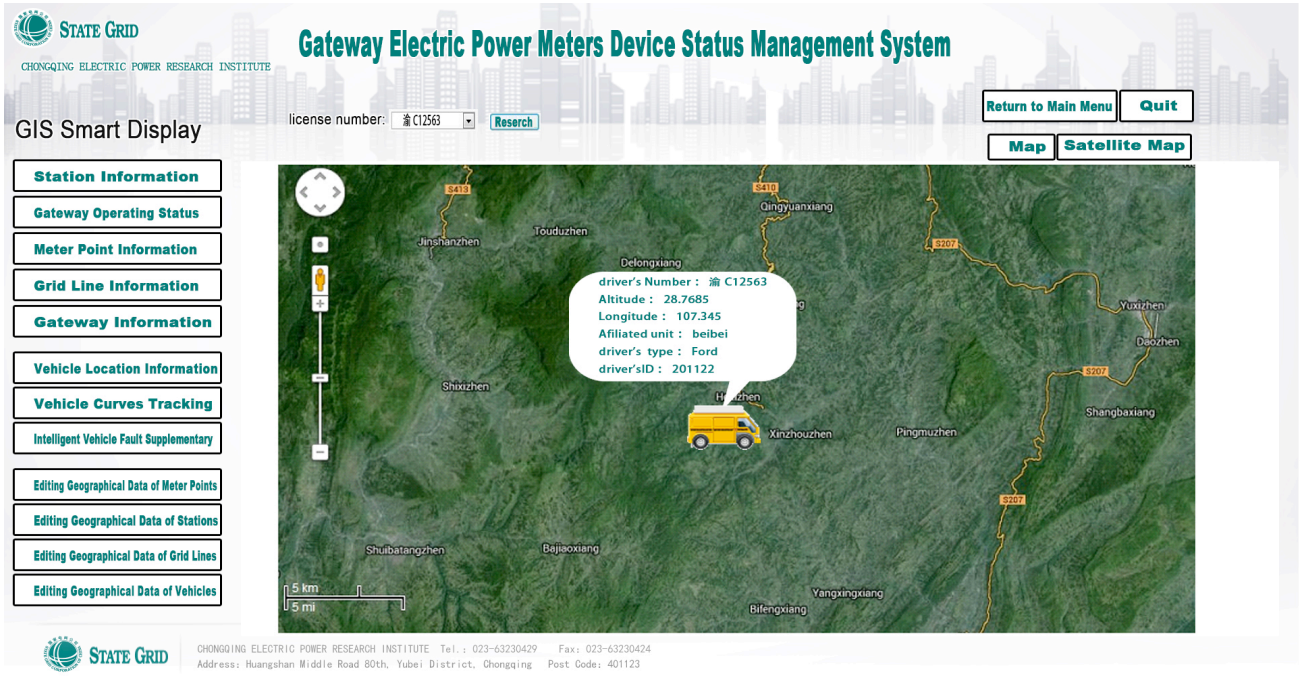

Figure 3. Vehicle tracking interface

Figure 4 is the flowchart of the algorithm. By consulting three nearest vehicles to the incident site with Dijkstra algorithm, coordinators in production coordination departments will be able to inform on-site measurement vehicles to head for the broken-down part to perform repair by making calls or sending short messages, which considerably improved efficiency of production coordination, shortened required time for handling faults and mistakes on measurement devices as well as decreased loss caused by unexpected faults on measurement device, and ensured the accuracy of measurement. Consulting results of the shortest path on the interface are showed in Fig. 5 (Appendix).

C. Real-Time record of vehicle's status

In order to ensure if the vehicle has already reached the destination, the on-site operation coordination personnel can track through the system and display the license plate number of the vehicle, current location (longitude and altitude), route (curve) from the starting point to the destination and driving time. On-site coordination personnel can easily read driving status of every vehicle on the map.

In addition, the system is also available for intelligent coordination management on moving vehicles, limiting accessible areas and automatic over-speed warning. The results of vehicle route tracking are shown in Fig. 6 (Appendix).

IV. CONCLUSIONS

A kind of smart exhibition system of engineering vehicles based on the GIS/GPS technique was established in the paper. The system is mainly consisted with three parts, which are the vehicle-mounted terminal, server software platform and monitoring center. Windows NT Server was used as the operational system platform; Oracle database management system and VB.NET system were used as the development tools. The system applies the n-tier architecture and reusable accessory technique, and can exhibit real time vehicle information and fault information by integrating GPS and GIS techniques.

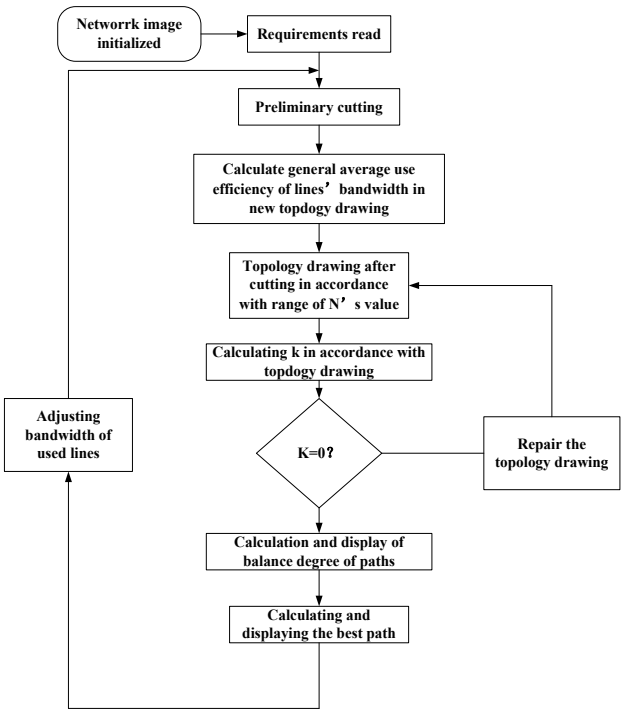

Figure 4. Dijkstra algorithm flowchart

The system is available to real-time monitoring on power vehicles, intelligent coordination and management, accessible area limitation, automatic over-speed warning, and will automatically highlight three vehicles which are nearest to the incident site on the electric power GIS map when faults happen on certain measurement device, which will significantly facilitate the on-site operation and management. The system will considerably promote electric power management and reaction ability of measurement departments to unexpected electric accidents.

Trial operation of the system in Chongqing electric power corporation indicated that it can be realized that by using this system, the developing applications has no relationship with the practical platforms, and the interaction between isomerous databases becomes more simple.

Compared with the existing management systems, this system is mainly based on the practical requirements of the electric power companies, and it contains more advantages in stable operation, compiling, transplanting, friendly user interfaces, and better development prospects as well.

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AUTHORS

Chao Tang is an associate professor in College of Engineering and Technology, Southwest University, 400715, China. His main research interest lies in the on-line monitoring and fault diagnosis of power equipment. (e-mail: tangchao_1981@163.com).

Jufang Xie* is an associate professor in College of Engineering and Technology, Southwest University, 400715, China. Her main research interest lies in the analysis of power system. (*corresponding author, e-mail: 41847130@qq.com).

Yiyi Zhang is a lecture in College of Electrical Engineering, Guangxi University, 530300, China. His main research interest lies in the on-line monitoring and fault diagnosis of power equipment. (e-mail: zdsizyy@126.com).

Dong Hu is a lecturer in College of Engineering and Technology, Southwest University, 400715, China. His main research interest is the on-line monitoring of power equipments. (e-mail: 28471290@qq.com).

Jiao Li is a lecturer in University Library, Southwest University, 400715, China. Her main research interest lies is on-line monitoring of power equipment. (e-mail: 25075697@qq.com).

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APPENDIX

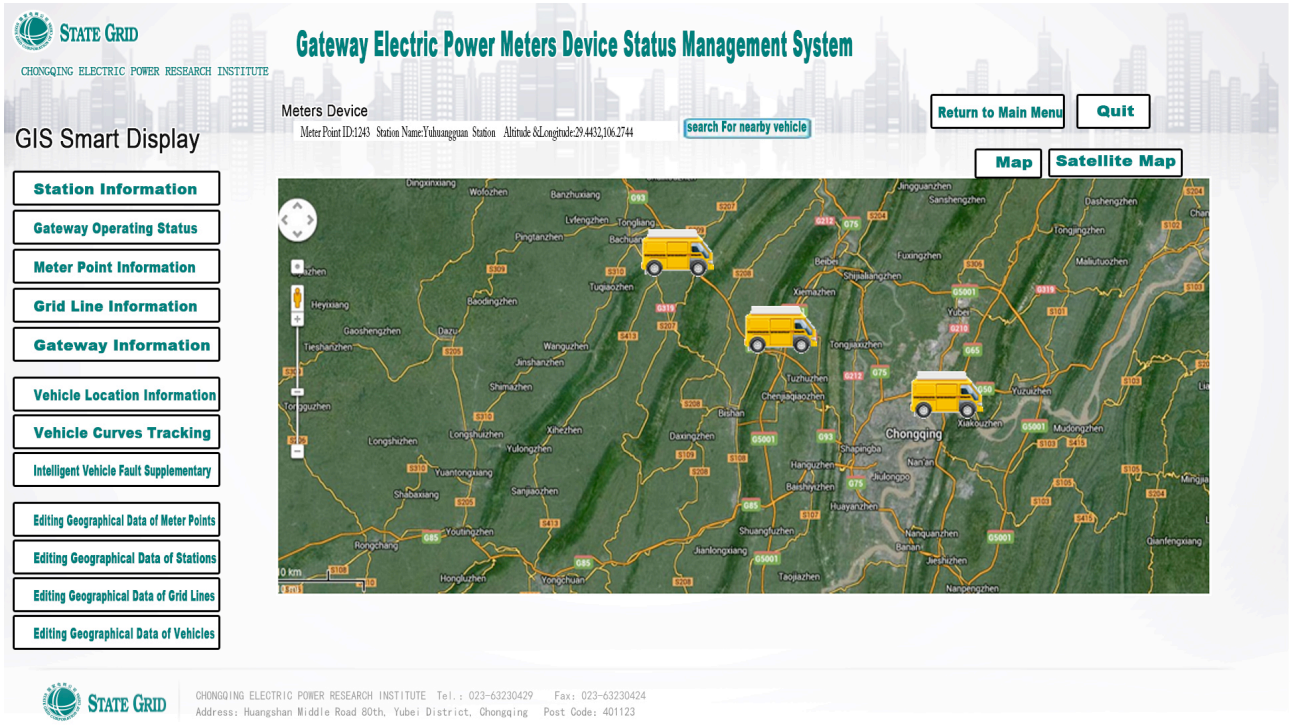

Figure 5. Interface of vehicle nearby searching

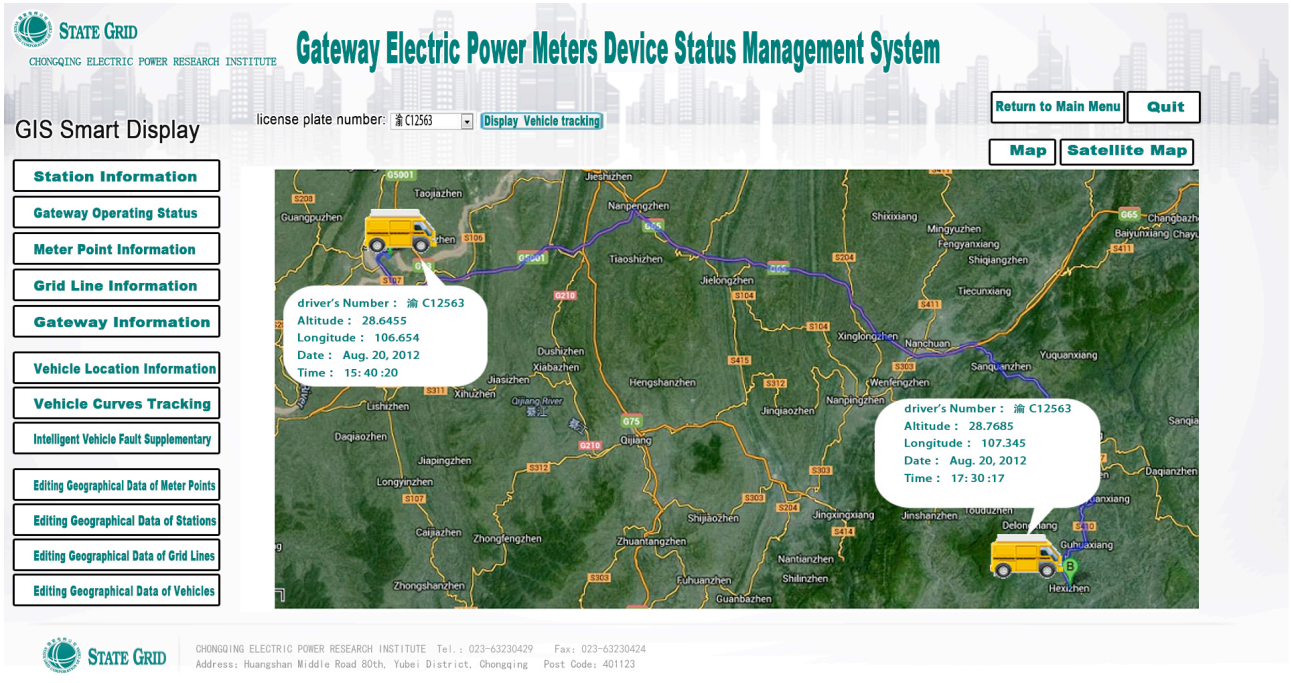

Figure 6 Interface of vehicle curves tracking