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The Terminal System Design based on hybrid RFID-GPS in Vehicular communications

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ABSTRACT: *In this paper, vehicle terminal system is proposed to realize continuous monitoring and tracking the location of cargos or goods loaded on board for digital logistics. The embedded design of the terminal system is combines both the RFID with GPS technologies. The ultra-low power 16-bit RISC microcontroller is used as the central control unit considering both small size and high efficiency. The vehicle terminal system can give the automatic identification of cargos loaded, the real-time vehicle location, the data and voice communication, and continuous monitoring. The results specify that the combination of RFID and GPS can provide the reliability of the system, which further improve the accuracy and efficiency of digital logistics management.*

Keywords: *digital Logistics; vehicular communications; RFID; GPS; vehicle terminal system*

I. INTRODUCTION

In recent years, the RFID (Radio Frequency Identification) technology is known for real-time identification and tracking. Because of its accurate and fast identification, RFID is used extensively to improve the logistics management, supply chain operation and asset tracking. The GPS (Global Positioning System) is the most popular technology to acquire the position information in outdoor environments. Always GPS is used for tracking of vehicles over a wide geographic area. With simultaneous data received from four satellites and ideal conditions and minimal Ionosphere, users can calculate an object's location including mainly latitude, longitude, and altitude. The powerful combination of information and intelligent technologies will advance the supply chain monitoring and management capabilities from the origin to final destination. There have been some related works that are focused on the integration of RFID and GPS in certain fields. A hybrid RFID-GPS system was explored and tested in, which allowed for the real-time location of human resources both indoors and outdoors. In, an embedded pedestrian navigation system comprising a self-contained sensor, the GPS and an active RFID tag system was presented, and a method of complementary compensation algorithm for the GPS/RFID localization was proposed. From we find a new integrated solution, which makes the cargos and container monitored and located through moving RFID and GPS equipment. Using both RFID and DGPS technique, solved the limitations of existing yield mapping systems for manual fresh fruit harvesting, which was also tested in the field. In a stray prevention system that integrated RFID, GPS, GSM, and GIS technologies was constructed for elderly patients without interfering their activities of daily livings. In mobile supply chain management, it is also very necessary to propose an advanced, flexible, intelligent and ultra-low-power vehicle terminal system to ensure logistics goods and transport vehicles against damage, loss or theft. Cooperating with the remote monitoring centre, the mobile vehicles and cargos loaded can be localized quickly, which will improve management visibility and centralized control energetically. The main components of the terminal system are composed of the ultra-low power 16-bit MCU LPC 2148, the acquisition unit of RFID tags information, the receiver module of GPS information, the GSM wireless communication module, and the temperature sensor. The RFID-GPS-based tracking vehicle terminal system can provide identify, monitor, track, localize and manage key mobile supply chain assets, even though in the hard environmental conditions. Moreover, the system can perform real-time stock checks, locate missing stock soon, position drivers quickly and protect drivers from danger in case of emergency. Experimental results show that the vehicle terminal device can distinguish correctly RFID tags and receive accurately GPS information. The RFID tags information and the GPS data can be processed in time. The processing results can be transmitted to the logistics monitoring center via the GSM mobile networks. The performances indicate that the system can improve the real-time management of movable supply chains. The organization of this paper is as follows. Section II depicts an overall framework of the vehicle terminal system. In section III, the system architecture and prototype design are presented. Section IV describes the prototype system test and evaluation. Finally, conclusive remarks are made in Section V.

II. OVERVIEW OF THE SYSTEM FRAMEWORK

II.1 System Description

During logistics management, one of the constant challenges is to ensure the celerity, accuracy, security and safety of consignment. When cargos or goods are loaded in vehicles, Transport Company should know immediately a detailed product description, which will act as the identification information of different cargos or goods. During the transportation, the logistics management center need to know whether the products are security and safety, whether the products are damaged or stolen, and what is the real-time geographic position of the vehicle. When the vehicle arrives at the destination, transport company should know how many and what kind of products should be unloaded. Thus the logistics management center has to monitor more closely the supply chain using the real-time automatic visibility afforded by expert and advanced technologies such as RFID and GPS. RFID technology is stable and evolving, and it cannot be easily replicated. Therefore, RFID is becoming increasingly available in variety of fields, including manufacture, transportation, warehousing, distribution, retail, healthcare, and security. RFID systems play a key role in managing updates of stocks, transportation and logistics of the product, which enables counterfeit identification, parcel tracking, shipment monitoring and tracing, access controlling, and so on. A typical RFID system consists of a reader, tags, antennas and a connection to database management system. The reader can receive the information (a unique ID) of tags in the available range of the reader. Using the merit of accurate and fast identification and tag reading from a greater distance, all kinds of related messages can be received by the RFID reader when the tagged products are loaded or unloaded. Hence RFID can improve movable asset management accuracy and efficiency. GPS technology has provided major breakthroughs in transportation fleet management (vehicle tracking, speed, waiting time, etc.). Through GPS, the object position coordinates and the time of the determination, which is related to a value referred to as clock bias, can be obtained by picking up signals from four satellites and measure the time. So GPS is used extensively to trace, locate and navigate. Considering the advantages of RFID and GPS, we proposed to design and develop a hybrid RFID/GPS vehicle terminal system for mobile supply chain assets tracking and monitoring.

II.2 Overall System Framework

To solve accurate consignment and realize real-time monitoring service in the transport management, the overall framework of the digital logistics management system can be proposed as figure 1. Working in coordination, the system can implement corresponding function to track goods and vehicle movement in real time. Once the position and the product ID information are captured through GPS and RFID, the vehicle terminal can send the messages to the logistics monitoring center through GSM/GPRS base stations.

The system operating procedures consist of three basic stages. Firstly, when the products leave the warehouse and are handed over to transport company, the product identification data can be found by the RFID reader. Meanwhile, the product's departure and arrival information can be automatically registered as well. The transporting information of goods is sent to transport company momentarily. Then, the GPS module achieves the message (latitude, longitude, and altitude) of vehicle position; RFID reader detects whether a product data is changed. Both the product information and the combined GPS position information are sent in real time. Once the information is inconsistent with the present manifest, the vehicle terminal system raises the alarm to ask for help towards the logistics monitoring center. Finally, when the vehicle gets to the destination and the goods are unloaded, the information database is updated immediately.

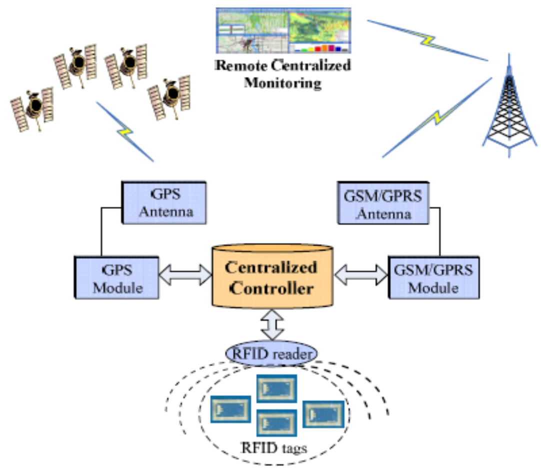

Figure 1. The overall system framework.

III. System Structure and Prototype Design

III.1 Analysis of hardware Structure

The hardware structure of the vehicle terminal system is depicted as Fig. 2. The main components are described as follows.

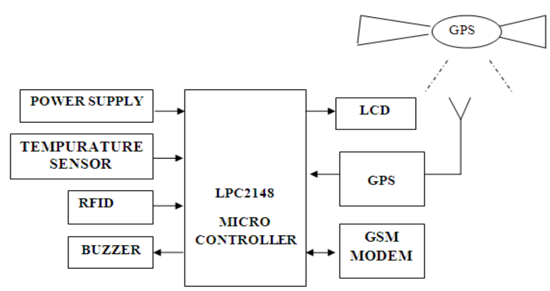

Figure 2. Block diagram of the vehicle terminal system.

III.1.1 Micro controller: The LPC2148 micro controllers is based on a 32-bit/16-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30% with minimal performance penalty. Due to their tiny size and low power consumption, LPC2146/48 are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to I2C-bus and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers suitable for industrial control and medical systems.

III.1.2 RFID reader Module: This is used to automatically identify the products tagged within the communication range of the reader, which will be able to provide the accurate consignments and real-time automatically manifest, and improve movable asset management accuracy and efficiency.

III.1.3 GPS Module: It is used to provide satellite localization information to trace and locate the vehicle of transportation, such as WGS84 coordinates (latitude, longitude and altitude), time, speed, and direction.

III.1.4 GSM Module: It provides a communication channel to transmit product tag messages, geography location messages or emergency rescue messages, and receives commands from the transport company or the remote monitor center.

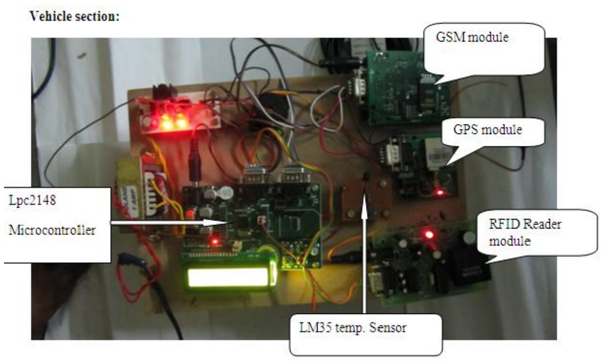

Figure 3. Prototype of the vehicle terminal system.

III.2 Building the Prototype System

As is depicted in Fig. 3, the vehicle terminal prototype system consists of a low-power microcontroller, a RFID reader, GPS module, a GSM module, power management, and other interface circuits. The LPC 2148 micro controller is chosen as the centralized control unit due to its ultra-low power.

The MCU power consumption of active mode is 280μA and only 1.6μA in standby mode. The RFID reader of the vehicle terminal is performed by a TI TRF7960 13.56MHz RFID reader, which supports the ISO 14443A/B, ISO 15693, ISO 18000-3 standards, and TI's Tag-It RFID protocol. The GPS and GSM functions of the vehicle terminals are performed by a FALCOM JP7-T GPS receiver module and a Siemens TC35-i GSM module. JP7-T is a standard receiver using the L1 band and C/A coding by stand alone positioning with 12 channels, 10m position accuracy, 0.1m/s velocity accuracy and its power consumption is 200mW in continues mode. Working in coordination, the vehicle terminal system provides the ability to capture and trace supply chain assets movement in real time. The system supports combined RFID and GPS message reporting. We can also create custom rules associated with products or vehicles passing into or out of the zone that may trigger further actions or messages.

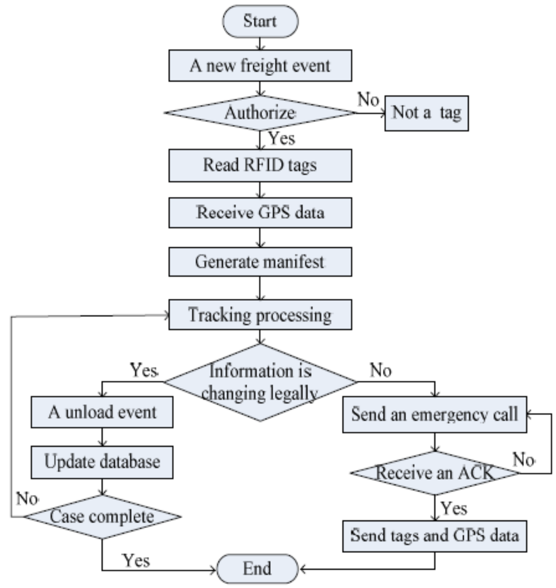

Figure 4. The operation flow of the vehicle terminal system.

III.3 System operation flow

The vehicle terminal system operation flow is depicted as Fig.4. Once a new freight event occurs, the RFID reader will continuously read RFID tags. Then the data combined with GPS position are sent to the remote monitor center for further processing through GSM communication module. Meanwhile a real-time automatic manifest is generated, including data from RFID tags with a unique ID which describes a tagged product's manufacturer, type, and serial number. When a legal unload event happens, related database will be updated. If a transportation case is completed, the system will enter standby mode and wait for a next freight event.

Whenever an abnormal situation happens, the vehicle Terminal system will immediately send out a message Containing the product's status and GPS information to the remote monitor center. After the monitor center receives the data packet, it will manage or convert the longitude and latitude coordinates, and combine this location with other basic information such as product characteristics, type, material, shape and size to generate the complete information needed for search and assistance tasks.

IV. EXPERIMENTS AND RELATED RESULTS

We have conducted related experiments and evaluations in a simulation transportation scene. The vehicle terminal system was mounted at an automobile carrier. Each product has a fixed RFID tag working at 13.56MHz band, which supports ISO15693 protocol and provides 9600bps communication link. When the products tagged enter the operational zone of the RFID reader, each of unique ID is acquired. Meanwhile, the reader can get the detected time of the product tagged. One of the experiment results is shown in Fig. 5.

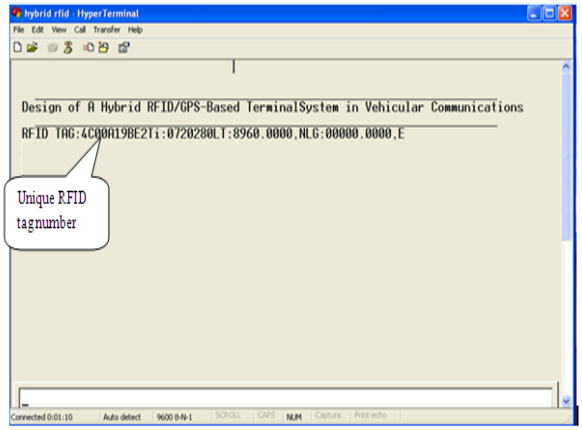

Figure 5. RFID Testing Experiment.

During the experiment run, the GPS module receives the longitude, latitude values which will give the real-time location message from different satellites shown in figure 6.

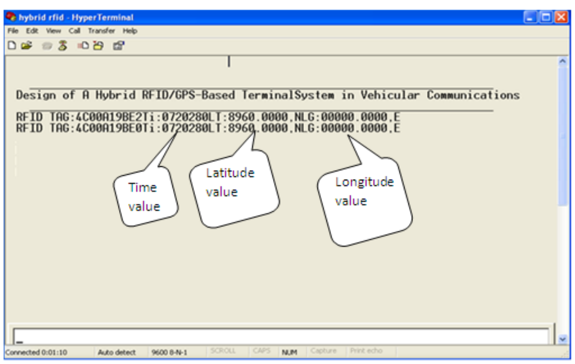

Figure 6. Locating the longitude & latitude values.

Fig.7 shows that when the temperature exceeds more than 50°C then the message "fire accident occurred" is sent to the control section.

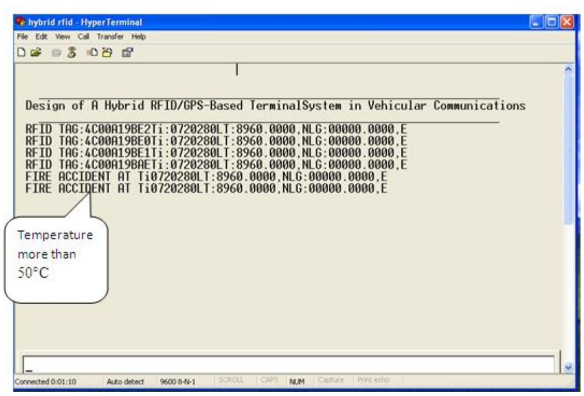

Figure 7. The message when temperature more than 50°C.

V. CONCLUSIONS

A new solution that integrates RFID identifying and GPS tracking is proposed and implemented, which can enhance automatic management, information security, real-time trace and location, and anti-theft in digital logistics management. Experimental results show that the vehicle terminal system can identify quickly mobile supply chain assets, trace and locate mobile equipment in real time, reduce loss and theft and enhance management control as well. Soon the system will be further improved through the integration with GIS technology, which will enhance the visibility of the supply chain. It is conceivable that this research will bring more efficient and intelligent logistic transportation.

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