

DESIGN OF A HYBRID RFID/GPS-BASED SYSTEM FOR DIGITAL LOGISTICS

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ABSTRACT

In this contribution, a novel vehicle terminal system is proposed to realize continuous monitoring and precise localization of cargos loaded on board for digital logistics. The integrated hardware and software design of the terminal system is presented, which combines RFID with GPS technologies based on embedded systems. We use the ultra-low power LPC2148 microcontroller as the central control unit considering both small size and high efficiency. The intelligent vehicle terminal system can provide mainly the automatic identification of cargos loaded, the real-time vehicle localization, the data and voice communication, and remote centralized monitoring as well. Experimental results indicate that the integration of RFID and GPS can enhance the reliability of the system, which further improve the accuracy and efficiency of digital logistics management.

I INTRODUCTION

In recent years, the RFID (Radio Frequency Identification) is known as a ubiquitous technology used in real-time tracking. [1]. Because of its accurate and fast identification, RFID is applied extensively to improve the logistics management, supply chain operation and asset tracking. The GPS (Global Positioning System) is the most promising technology to acquire the position information in outdoor environments [4]. Always GPS is chosen for tracking of vehicles, assets and staff 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 [2]. 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 RFIDGPS system was explored and tested in [3], which allowed for the real-time location of human resources both indoors and outdoors. In [4], 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 as well. From [5] 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, [6] solved the limitations of

existing yield mapping systems for manual fresh fruit harvesting, which was also tested in the field. In [7], 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.

In this contribution, a novel vehicle terminal system was proposed, and the hardware and software system was implemented and tested. The main components of the terminal system are composed of the ultra-low power LPC2148 MCU, the acquisition unit of RFID tags information, the receiver module of GPS information, the GSM wireless communication module, and the human machine interface. The RFID/GPS-based seamless end-to-end tracking vehicle terminal system can provide identify, monitor, track, localize and manage key mobile supply chain assets, even though in the harshest 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

A. System Description

During logistics management, one of the constant challenges is to ensure the celerity, accuracy, security and safety of consignment. When cargos are loaded in vehicles, Transport Company should know immediately a detailed product description, which will act as the identification information of different cargos. 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.) [2]. 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.

B. 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.

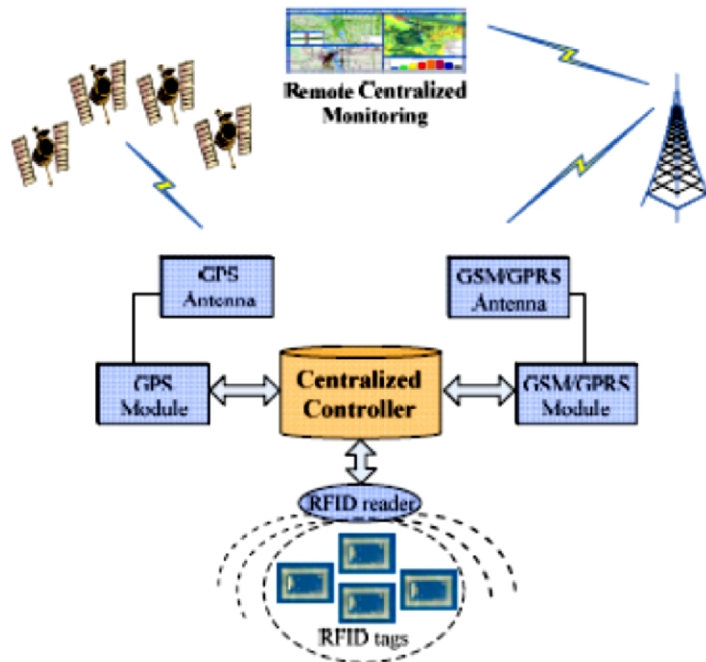


Fig. 1. The overall system framework.

III SYSTEM STRUCTURE AND PROTOTYPE DESIGN

A. Analysis of hardware Structure

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

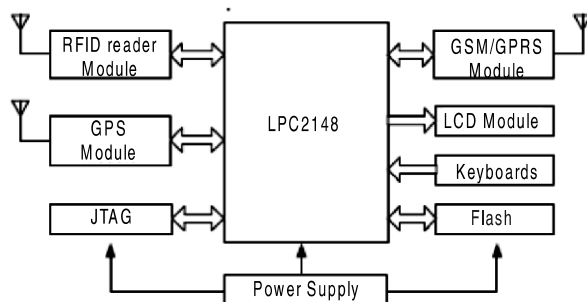


Fig. 2. Block diagram of the vehicle terminal system.

A.1. Microcontroller: The microcontroller LPC2148 performs signal analysis, command execution, and logical judgment. One of the most important logical judgments is determination of a theft event. LPC2148 first records the original manifest and original GPS coordinates and then updates them every preset-time. Once an invalid unloaded authorization is detected, the monitoring system raises the alarm. Then the system will report the detailed product description and current location to the monitoring center.

A.2. RFID reader Module: This is used to automatically identify the products tagged within the communication range of associated with products or vehicles passing into or out of the the reader, which will be able to provide the accurate zone that may trigger further actions or messages. Consignments and real-time automatically manifest, and improve movable asset management accuracy and efficiency.

A.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.

A.4. GSM/GPRS 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.

A.5. Human Machine Interface: This interface consists of a LCD Module and a 4'4 keyboard matrix, which provide a convenient channel to enable human and machine intercommunicate. The LCD display indicates the current operating status of the vehicle terminal.

B. Building the Prototype System

As is depicted in Fig. 3, the vehicle terminal prototype system consists of a low-power

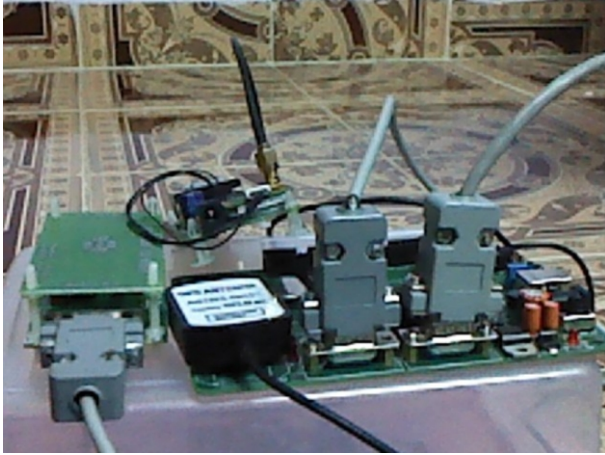


Fig. 3. Prototype of the vehicle terminal system.

microcontroller, a RFID reader, GPS module, a GSM module, power management, and other interface circuits. LPC2148 is chosen as the centralized control unit due to its ultra-low power. The MCU power consumption of active mode is 280mA and only 1.6mA in standby mode. LPC2148 has five optimized low power modes which enable minimize the system power consumption.

The RFID reader of the vehicle terminal is performed by a EDK125 KHz 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 terminal are performed by a IWAVE GPS receiver module. IWAVE is a standard receiver using the L1 band and C/A coding by stand alone positioning with 12 channels, 10 m position accuracy, 0.1 m/s velocity accuracy and its power consumption is 200 mW 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.

C. 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

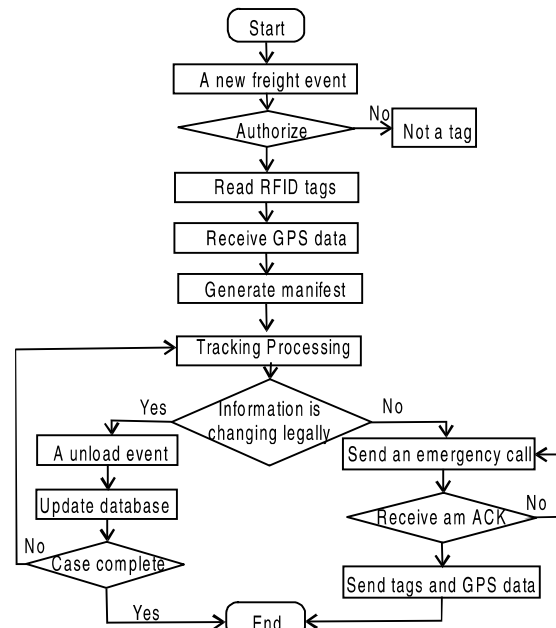


Fig. 4. The operation flow of the vehicle terminal system.

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 of products was affixed a RFID tag working at 125 KHz band, which supports ISO15693 protocol and provides 9600 bps communication link. When the products tagged enter the operational zone of the RFID reader, each of unique ID is acquired.

