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Design of Real-Time Monitoring System on Raw Milk Transport Process

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Abstract

With a purpose to guarantee the quality safety of raw milk during the transport process, based on the internet of things, this paper made the raw milk transport process as the research objective. As the key technologies like GPS, GPRS and RFID were applied and STM32F103 Singlechip was adopted to fulfill the hardware design of system. Real-time collection and storage of the information on transport vehicle location and milk box temperature as well as real-time monitoring on raw milk transport process could be conducted to achieve the visualization of the whole process from livestock farm/milk station to processing factory, thus the transparency of raw milk in transportation could be ensured, which provided guarantees for raw milk quality and safety and was of great significance for the healthy development of the dairy products- business in our country.

Keywords*: GPS; GPRS; temperature; real-time monitoring*

1. Introduction

Dairy products are important components of the modernized agriculture. With the improvement of the people's living quality, the demand on dairy products is increasingly getting intense. However, the quality security events of dairy products of "melamine" and "substandard milk powder" took place frequently [1]. The analysis of quality security events of dairy products from 1999 to 2014 shows that, pollution of milk resources causing dairy products quality security issue accounts for 68%, excessive heavy metal content 18%, quality defects 14%. The above data reflects the imperfection of quality security monitoring system of raw milk [1]. During the producing process of dairy products, the premise of guaranteeing the quality is the quality and security of raw milk, the supervision of real-time position information and temperature during the raw milk transport is the prerequisite condition of the quality and security of the raw milk.

In recent years, the quality security of dairy products has been an issue getting concerned. Scholars at home and abroad and the enterprises have involved in corresponding research on the security monitoring on the transport process of raw milk. In Sweden, the governments stipulate that the alarming devices must be installed on milk tanker and these devices can display and record the temperature and rinsing procedure of milk tanker [2-4]. Domestically, Changqing Zhao, *et al.* designed, researched and developed the temperature monitoring and pre-warning system of food cold chain delivery, which could realize the real-time supervision and pre-warning of the transport process [5]. The related technology can be applied into the transport process monitoring system of raw milk, so as to realize the visualized monitoring on the delivering process of raw milk, completely position and monitor the raw milk transport, guarantee the quality of raw milk and improve the dairy products safety. Thus, the setting up of the real-time

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monitoring system of raw materials transport process is of great significance of diary product quality security guarantee.

2. Materials and Methods

2.1. Acquisition of Longitude, Latitude and Temperature during Transport Process of Raw Milk

The research selected and used the key technology of GPS, GPRS and RFID to realize the acquisition of longitude, latitude and temperature for the transport process of raw materials. Real-time monitoring system GPS vehicles means putting GPS receiver on the mobile vehicles. Adopt wireless communication technology to transmit the received dynamic-target data to the monitoring center on real-time level. Monitoring center will receive and process the target data of GPS real-time delivery. Finally, these data will be real-time displayed on the map of monitoring system [6]. The premise and foundation of real-time monitoring of ram milk transport is the obtaining of vehicle location, with severe demand on real-time feature and successive positioning [7-8]. Thus, GPS technology is applied to the transport process of raw milk to endow diary producer to watch the real-time position information of vehicles. However, GPS also suffers from its weaknesses. It can only provide the related information of position. Neither can it recognize and monitor the terminal of milk vehicle, nor it complete the real-time communication. It does not meet the actual application. Thus the design in this paper proposes the combination of GPS technology, GPRS technology and RFID technology, so as to solve this issue better.

GPRS is another load-bearing form on the basis of the global mobile communication system. GPRS delivers data in the way of Packet and charges fees on the basis of data quantities of communication, with lower price and the highest data delivery rate 171.2kb/s [6]. Meanwhile, it allows users to send and receive data under the terminal to terminal grouping mode, but not benefiting the network resources of circuit exchange mode [9-10]. RFID (Radio Frequency Identification, RFID) is a noncontact automatic recognizing technology. In order to realize the purpose of recognizing the delivered data, it adopts the radio-frequency signal through space coupling to realize noncontact information delivery. RFID technology has the advantages of recognizing technology, large data capacity, long using-span, high safety performance and real-time communication [11-12]. Thus during the raw milk transport, adopt RFID technology in the real-time monitoring system. Install electronic tag on the external package of milk box of delivery vehicles. Combine the real-time monitoring system of GPRS and GPS technology and the completed raw milk transport. Then it can realize the visualized management of the whole transport process from livestock farm to the processing plant.

During the hardware design of raw milk transport, the micro controller selected single chip of data selection module is the STM32F103 chip of ARM Cortex-M3 system "enhancement mode' series. STM32 not only solves the instruction and performance issue of 16-digit single chip, but also resolves the issue of high cost and high energy consumption of 32-bit processer. Sensors shall be taken as DS18B20 digital temperature sensor. The sensor instruments shall have the advantages of special single-line interface way, small fixed temperature difference (0.5 ℃), with the advantages of wear-resisting, small volumes and convenient to use. While connecting target data, the network of sensor adopts star topology structure. The collection end assumes the role of coordinator and setting up network. While issuing the request of joining the network, it can join only by verification. The lower computer target data of the system sends modules by selecting SIM508 modules. Not

only does the module have small volume and low cost, but also very suitable for the GPS terminal design. GPS module shall use the high-performance GPS chipset, supporting the satellite positioning and the positioning based on mobile communication network [13]. Real-time monitoring system can implement continuous monitoring on raw milk delivery vehicle taking second as the time unit, so as to realize the real-time monitoring and punctual warning on vehicles and milk box temperature.

2.2. Overall Framework Design of Raw Milk Transport

Real-time monitoring system of raw milk transport analyzes the overall framework from three levels, target information collection, target data processing, and target data service. Target information collection level mainly includes the key factor elements screening influencing raw milk quality security, that is, the obtaining of the raw milk temperature and position information, providing data support for real-time monitoring of raw milk. Target data processing layer mainly uses information coding technology, information collection, information exchange and digitalized technology to send the information of raw milk transport to the database of server terminal. Target data service level provides quality security information inquiry service by taking network platform as the supervisor, milk station/ farming and consumers, so as to adopt real-time monitoring on the raw milk transport and temperature. The overall framework design of real-time monitoring system raw milk transport refers to Figure 1.

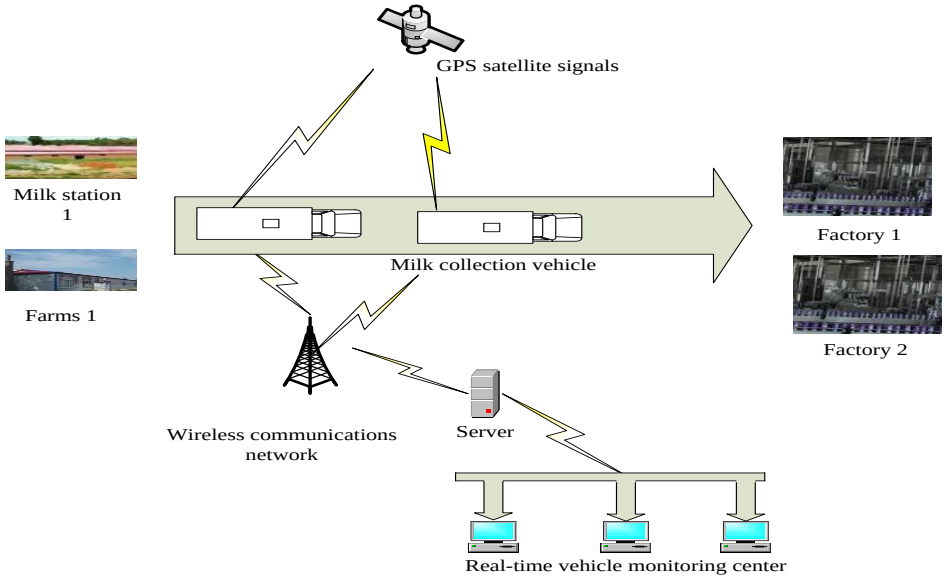

Figure 1. Overall Framework Design

2.3. Software Design at Monitoring Center and Design of Data Communication Protocol

Transport process real-time monitoring management platform is mainly consisted of background software and front-end Web inquiry system. Background software receives the target data packet from vehicle terminal, interprets the target information of GPS longitude, latitude and temperature contained in data packet and deposits them in the database. The design of data frame in data packet is as shown in Table 1.

Table 1. Data Frame Format Design

Detail	Byte	Contents	Data
Header	1	02	02
	2	00	00
	3	18	0x18
Length	4	0x0F	0x0F
Mark	5	0xD3	0xD3
Data	6	Collector	0x54
	7	Version number	0x11
	8	Device ID	0x01
	9	Temperature	Low eight
	10		High eight
	11	Longitude	Low eight
	12		High eight
	13	Latitude	Low eight
	14		High eight
	15	Upper temperature limit	00
	16	Lower temperature limit	00
	17	Uploaded time	3
Check	18	FCS	

Software functional structure refers to Figure 2. In order to provide convenience for the monitoring personnel to monitor the real-time transport process of milk vehicle, the management platform, through analysis of the target data, analyzes and displays the data and stores the completed data into the data base through analysis. Monitors can check the temperature of milk box in the transport process through this system. Once the temperature data exceeds the set threshold value (0-4℃) [14-15], the system would give off alarming to the temperature. The monitor may notify the vehicles person in the charge in time to check the abnormal reasons of temperature and avoid the person in charge not to detect the quality issues of raw milk.

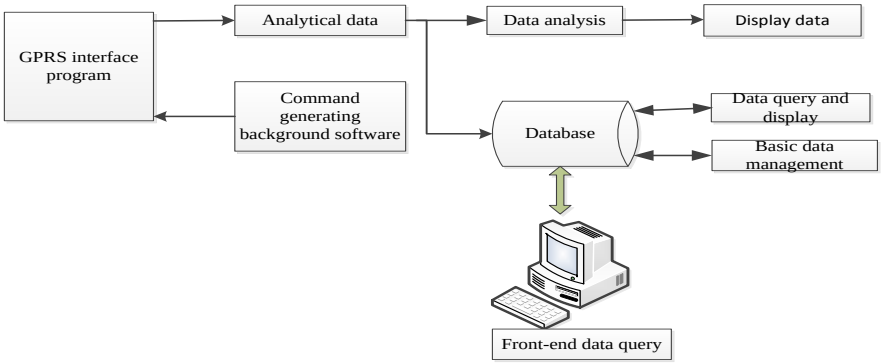

Figure 2. Software Function Structure of Real-Time Monitoring Management Platform

3. Results

3.1. Test of Data Receiving of Servers

In order to test the feasibility of raw milk transport location and temperature information, this paper selected TCP/UDP SocketTool debugging tool V2.3 to test the data receiving condition of the system. SocketTool simulates the data format as required by data agreement and then deliver data to the server. The server terminal receives the milk lorry location and temperature information and stores the target data into the database. The results of target data storage is as shown in Table 2.

Table 2. Database Successfully Received Target Data

Temperature	Longitude	Latitude	Data-sending Time	Equipment NO.	Equipment ID
2.42	126.50499068772643	45.81449106713669	2014-10-12	2	a42e99a3-a447-46c4-a6f6-48778b5690d2
2.21	126.50626568772644	45.81445306714878	2014-10-12	2	e94bd197-dbe2-4a5a-a4ed-6d4d4b3296ac
3.20	126.50711068772644	45.81446606719965	2014-10-12	2	93dff621-2ba8-4141-b464-6c0d8145efc1
2.30	126.50772168772644	45.81441506712589	2014-10-12	2	3a0fe05f-d591-43cb-9e08-4843de05d256
3.24	126.50820668772644	45.81465406713256	2014-10-12	2	71116d27-5259-479a-bd97-bf38c9d4d060
2.34	126.51014901772643	45.81479924574587	2014-10-12	2	dbc7e28e-63ba-4cd6-8819-c001df752713
2.53	126.51313101772644	45.81469824579856	2014-10-12	2	4437d145-480c-4299-920c-d3c75409951c
2.42	126.51535901772644	45.81472324574452	2014-10-12	2	40da9772-da10-4b12-97f5-897a38220f86
2.21	126.52086981142644	45.81473547401235	2014-10-12	2	2597dfef-eb62-4779-bbf8-3d97852ad8ab
3.20	126.52086981142644	45.81473547401478	2014-10-12	2	f7ec4d47-81d6-4058-b935-7002b7b6f237
2.30	126.52658281142644	45.81453447393652	2014-10-12	2	27792d06-d24d-4f46-944c-aaa3d887a1e6
3.24	126.52888316282645	45.81464878785841	2014-10-12	2	feea01af-35ce-4ae2-8adf-7a9af2031ec4
2.34	126.53154216283644	45.81464878784512	2014-10-12	2	cd8c4883-0464-4415-a18c-9f8629492942
2.53	126.53416516282644	45.81472378784784	2014-10-12	2	25380584-ea17-4859-968a-c939fb0a5c17
2.42	126.53693216283244	45.81467378784851	2014-10-12	2	e67688cb-856f-4e2b-b1d8-611ff93046b1
2.21	126.53941512472645	45.81458585803685	2014-10-12	2	4c505dc1-6540-4928-83f5-ed853a1dae49
3.20	126.54203812472645	45.81461185802893	2014-10-12	2	6549b517-83af-4bdf-9001-7ef77409756a
2.30	126.54494812472645	45.81461185807147	2014-10-12	2	942d2197-22bd-46a1-87fc-f74935b7e014
3.24	126.54922152442644	45.81457559462587	2014-10-12	2	75136f72-a901-4018-b925-b5645f9f36a0
2.34	126.55216852442643	45.81467559461485	2014-10-12	2	22c356aa-bac6-4ff1-bafd-f4f9ca7641f3
2.53	126.55202452442644	45.81718859464875	2014-10-12	2	94fdf404-aacf-478e-8479-24a8022d7895
2.42	126.55137242092644	45.81955094927812	2014-10-12	2	55ab0c2a-7cf8-416f-a683-038b3cb170e8
2.21	126.55000742092643	45.82231494924587	2014-10-12	2	5a0ddb3a-0006-4413-93cd-5a728c0d9e45
3.20	126.54964742092643	45.82354594921234	2014-10-12	2	a0b2aac4-888c-4186-a3fe-598fe3855850
2.30	126.54988142092644	45.82370894922581	2014-10-12	2	1de9237a-480b-4802-b531-850e29a6d54f
2.21	126.55007842092644	45.82377194921489	2014-10-12	2	9a5b7556-eb45-4b08-a263-62e8d25b51ed
3.20	126.55072542092644	45.82397294924562	2014-10-12	2	f581de74-b5cf-4be5-820e-03fcd17dcb94

The test result indicates that the vehicle terminal has successfully received the longitude and latitude information by GPS satellite signals and the vehicle terminal target data has been sent to server terminal in real-time through GPRS. The server terminal then adopts Socket technology to store the received target data into the database.

3.2. Vehicle Track Test

Log in the monitoring website. By looking up the received simulated target data, we will find the movement track of transport vehicle and get the movement track diagram as shown in Figure

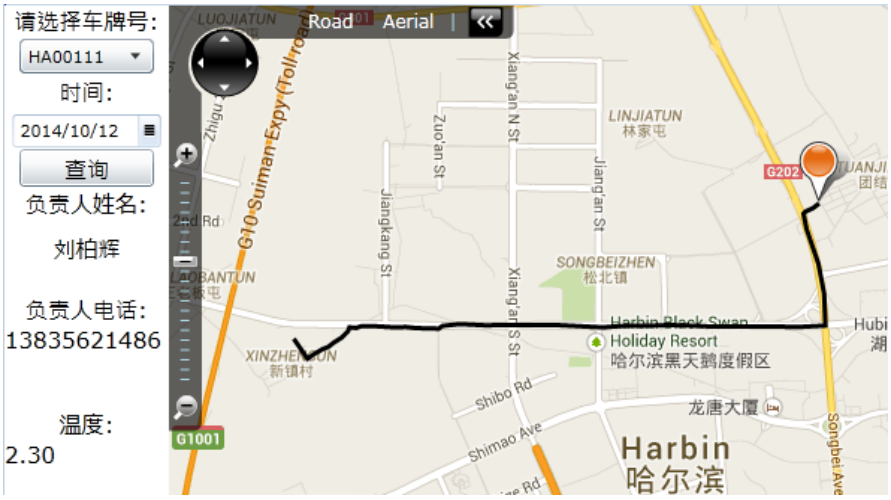

Figure 3. Vehicle Transport Track

The folding line as shown in the figure indicates the vehicle transport track drawn according to the target data received from the server terminal at an interval of 5 seconds. The location of arrow means the real-time of location of the transport vehicle. Current users can select license plate number of vehicle and data to search the transport route map of the milk transport vehicle in some day. The system will draw the vehicle transport track according to original data stored in the database.

3.3. Test of Temperature Alarm

Temperature is the key control point for raw milk during the whole transport process. If the temperature changes, the quality of raw milk will change as well. This will result in the loss of raw milk. When the temperature exceeds the threshold value in the transport process, the monitor will see the red sign in the map. Simultaneously, the basic information will show a red alarm for the over temperature (Figure 4). For abnormal temperature, the location system will retain the abnormal trace. (Figure 5)

Figure 4. Temperature Alarm in Transport Process Figure 5 the Abnormal in Transport Process

4. Discussion

4.1. Longitude, Latitude and Temperature Transmission

Raw milk transport process real-time monitoring system is mainly designed to conduct real-time monitoring on the transport process of raw milk and temperature of milk box. Due to the limit of the small volume of a single data transmission and higher demand on

the reliability of data transmission as well as restriction on the packet loss and disorder probability, the TCP/IP is selected for data transmission. TCP also provides the reliable and connection-oriented service, which enables that all information packets applicable to the protocol are confirmed in order. Besides, the virtual circuit is established and the connection is set up by three-way handshake, which guarantees the target data under monitoring of GPS can be feed back to the real-time connected server in a timely and reliable way. The research should consider the mobility of the transport vehicle and how to deliver the real-time data to the monitoring center. When transmitting the data, the milk vehicle packages the collected target data based on TCP/IP and then sends the packaged data to the nearest BBS. The BBS communicates with SGSN; Secondly, GGSN receives the target data sent by GPRS. After GGSN treats the data package, such data will be delivered to Internet [16].

4.2. Data Receiving

Data receiving involves the target data receiving in monitoring center and server terminal. The monitoring center receives target data package. The information will contain the longitude and latitude and temperature of milk transport vehicle. The monitoring center receives and store target data to get the information about location of transport vehicle and milk box temperature and then packages the data and delivers it to the server terminal. The milk transport vehicle sends the target information to the server terminal through GPRS network and Internet [17]. The server terminal will store the target data. After obtaining the target data and receiving the data package, the corresponding data processing procedures according to different types of data package. The monitoring center can raise a request and invoke sending process for report information capsulation, and then invokes sending function to transmit it.

4.3. Software Overall Design

The function of software overall design mainly refers to four parts including target data reading, basic information management, real-time monitoring function and system maintenance. Raw milk transport process real-time monitoring system adopts Windows 7 OS, with Web server using IIS6.0 and client application program applying Microsoft Visual Studio.Net which is a target-oriented visual programming tool and competent in database management. The server database adopts multi-user and large-scale RDBM system: Microsoft SQL Server 2008 well matches Net, featuring reliability, high-efficiency and intelligence. The software design uses B/S framework and avoids the client deployment, maintenance and update problems usually occurred in the traditional framework. The real-time monitoring system is majorly used to receive the target data from different raw milk transport vehicle and then stores the target data into the database of server. Meanwhile, real-time server needs to build a web site so as to provide convenience for users and administrators to browse and access the real-time monitoring server online and get the location information of transport vehicle, milk box temperature information and drivers' information, thus the system and website might be maintenance and managed. The dairy producer can see the condition of raw milk in the transport process to assure the relative safety of raw milk during the transport process. This system not only realizes the visual monitoring of raw milk during the transport process but also resolve the previous problem in locking the accurate location of transport vehicle.

5. Conclusion

In order to assure the quality safety of raw milk in the transport process, this paper has completed the design of real-time monitoring system on the raw milk transport process based on the GPS, GPRS and RFID technologies and fulfilled the whole-process

monitoring on the raw milk transport and temperature from livestock farm to processing plant, thus the quality safety of dairy products and the work efficiency of food administration and supervision department have been improved. These research methods lay a good foundation for the further research on ensuring the quality safety of raw milk in the transport process and are of significant practical value.

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