



Design of Logistics Information Tracking System for Petrochemical Enterprises Under the Background of Intelligent Logistics

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Abstract. With the gradual expansion of the demand for petroleum and petrochemical products in China, higher requirements have been put forward for the logistics capabilities of corresponding enterprises. The items transported by petrochemical enterprises are corrosive chemicals, therefore there are higher requirements for transportation safety. In order to improve the safety of logistics transportation in petrochemical enterprises, a logistics information tracking system for petrochemical enterprises is designed in the context of smart logistics. Design the system framework structure, mainly including the foundation layer, service layer, system layer, and application layer. In the hardware part of the system, the information collected by temperature and humidity sensors is transmitted through wireless networks. In the system software section, GPS is used to locate the logistics transport vehicles of petrochemical enterprises. Design a logistics information tracking system by combining hardware and software. The experimental results show that the access delay of the designed system is relatively short, with a maximum of 1 s.

Keywords: Smart Logistics · Petrochemical Enterprises · Logistics Information · Tracking System

1 Introduction

Modern logistics, as a derivative of economic development in the Internet era, is rapidly thriving and achieving new breakthroughs and growth through continuous self revolution. Especially in the new era, science and technology are becoming more and more advanced, bringing more possibilities for the intelligent upgrading of China's logistics industry [1]. In the era of information technology, the Internet of Things (IOT) technology is a hot new generation of information technology. Through various physical recognizers, sensors, and positioning systems, combined with monitoring and object interaction, it collects information such as light, heat, and mechanics, and inputs this information into network systems to ensure certain connections between objects and people, and constantly monitors the process of object transfer and movement, At the

same time, it is also identified and managed to a certain extent [2]. In fact, the Internet of Things is a carrier based on many other systems, and it does not exist alone, let alone impossible. The foundation for the existence of the Internet of Things is still the Internet, which is an extension of the Internet. It helps users monitor any item in real-time and exchange information with the parties involved, forming close connections between people and things, as well as between things and things.

The foundation and prerequisite for the existence of smart logistics is the Internet of Things. Smart logistics is the use of the latest information processing technology to centralize information related to logistics, using a central processor to process data, and selecting the optimal solution from all options to assist logistics operations [3]. This approach is both efficient and flexible, meeting people's logistics needs and being able to respond to the ever-changing logistics situation at the fastest speed. Intelligent logistics utilizes intelligent methods to influence the logistics transportation process. Perception technology is a relatively complex technology that requires the perception of multiple basic requirements such as the carrier, flow base, and flow mode of objects in the logistics process, making the logistics operation process more convenient and fast. Real time monitoring of the logistics transportation process, establishing transmission platforms and technical platforms, and realizing the mutual transmission of information between logistics transportation entities, making information exchange more convenient.

With the increasing demand for logistics development from social development, China has launched policies, guidelines, and plans to support the development of smart logistics. The country takes various excellent projects launched by IoT enterprises as demonstration projects, in order to drive other enterprises to deeply explore the field of smart logistics. With the increasing application range of Internet of Things technology, various enterprises and people from all walks of life have an increasing understanding of smart logistics, which has accelerated the development speed of smart logistics and strengthened its foundation [4]. The Internet of Things technology is not only applicable to the logistics field, but can also be applied to medical devices, medical drugs, agricultural and sideline products, food and other fields, helping people track the origin and shipping process of items when shopping. China's smart logistics technology is gradually maturing, with strong policy support and technical support. Many enterprises have established their own intelligent logistics distribution centers to make the logistics operation more intelligent and automated, so that the logistics industry and the production field interact with each other, and realize the overall promotion of the flow of goods, goods and information..

Reference [5] proposes a logistics information tracking system based on the Internet of Things technology. In the hardware part, wireless sensors are designed and Kalman filters are processed. In the software part, GPS logistics information is collected, logistics information is screened, tracking authority of logistics database is identified, Internet of Things tracking model is established and information tracking is carried out. Reference [6] proposes a logistics information tracking system based on blockchain, which takes the blockchain cloud platform as the core of the system application and connects the logistics information management module and information service module respectively in the system. On this basis, the obvious characteristics of logistics users are analyzed, and all data parameters are transferred to the cloud database to facilitate the query of

system application data. The security of relevant logistics information in the system is ensured by the asymmetric information encryption.

Aiming at the particularity of logistics transportation in petrochemical enterprises, a new intelligent logistics information tracking system for petrochemical enterprises is proposed and designed under the background of intelligent logistics.

2 Architecture of Logistics Information Tracking System for Petrochemical Enterprises

The logistics information tracking system focuses on the main supply chain of "production, warehousing, transportation, distribution, and sales", tracking the entire process of goods from production to sales, and even consumption, in order to provide services to different users. Individual users can track and query their purchased products through the logistics information tracking system application, and obtain information for anti-counterfeiting inspection of goods; Suppliers and sellers can adjust their production and sales plans in a timely manner through the logistics information tracking system; Logistics enterprises adjust their warehousing and distribution plans in a timely manner through tracking systems; Government agencies can supervise goods through logistics tracking systems [7–9]. According to the requirements of multiple users and links, a logistics information tracking system model is constructed as shown in Fig. 1. This system adopts a four layer architecture of basic layer, service layer, system layer, and application layer.

The basic layer consists of two parts: a hardware support platform and an EPC network system. The hardware support platform consists of a server system, storage system, and disaster recovery system. The server system mainly provides server operation support for the operation of logistics information tracking systems. The storage system mainly stores various types of data. The disaster recovery system can ensure the integrity of the logistics information tracking system in case of sudden problems. The EPC network system mainly includes three parts: network system, data collection system, and tracking goods [10–13]. The network system is mainly composed of INTERNET, wireless network, GPS, etc. The data collection system consists of electronic tags, readers, PDAs, barcode readers, and other data collection equipment. By establishing the basic layer system, provide the underlying data source for the logistics information tracking system.

The service layer includes directory services, retrieval and tracking services, information distribution services, workflow services, etc. Directory services are used to discover, query, and access RFID related data information; The retrieval service can retrieve all relevant product information based on the EPC code, and organize feedback according to user needs; Tracking service collects all process information of goods throughout their lifecycle, organizes and provides tracking, traceability, anti-counterfeiting and other services; The information distribution service adopts a publish/subscribe method to provide users with product related composite event information; The workflow service system realizes the interaction between service layer, basic layer data source, and application layer users, achieving business automation [14].

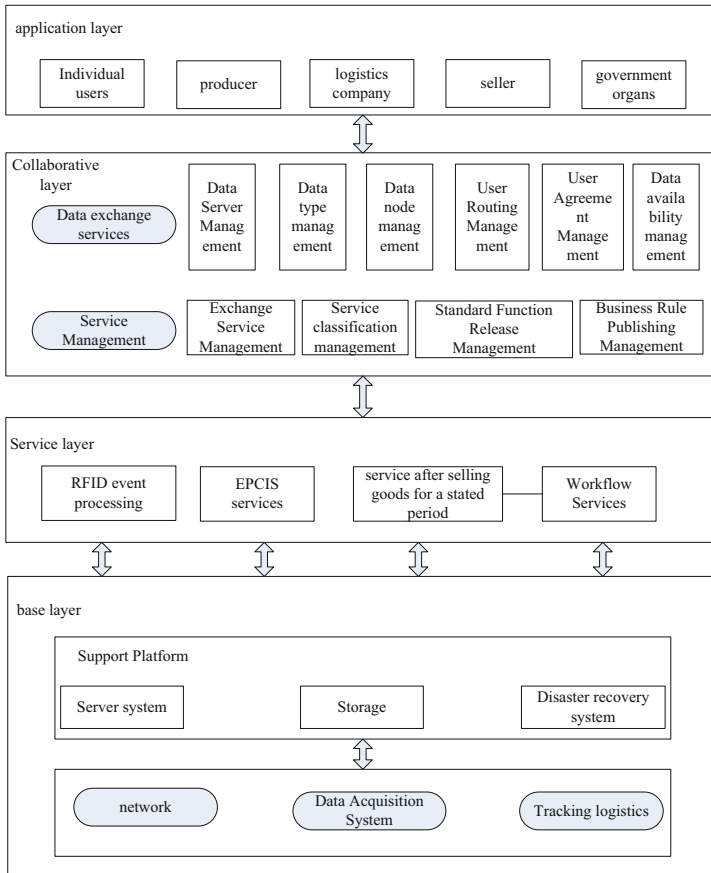


Fig. 1. Architecture of Logistics Information Tracking System

The collaboration layer includes data exchange service management and service management. The establishment of data exchange service management is to unify the basic parameters of each data exchange server for application layer users, manage each data server, data type, data node, user routing, user protocol, data availability, etc., and achieve synchronization of data changes in each data exchange service center. Service management includes exchange service management, service classification management, standard function publishing and management, and business rule publishing and management. Service management provides information service intermediaries for the service layer and application layer.

The application layer is an application system developed for users. Through the application layer, individual users, manufacturers, logistics enterprises, sellers, and government agencies can track and query logistics information. Individual users can track and query their purchased products through the logistics information tracking system application, and obtain information for anti-counterfeiting inspection of goods; Suppliers and sellers can adjust their production and sales plans in a timely manner through the

logistics information tracking system; Logistics enterprises adjust their warehousing and distribution plans in a timely manner through tracking systems; Government agencies can supervise goods through logistics tracking systems [15].

3 System Hardware

The system obtains temperature and humidity information for logistics transportation in petrochemical enterprises through wireless monitoring nodes. Therefore, the accuracy and timeliness of data collection and transmission by these nodes are crucial for enhancing the logistics management level of petrochemical enterprises and ensuring the quality of transportation products. The hardware structure is illustrated in Fig. 2.

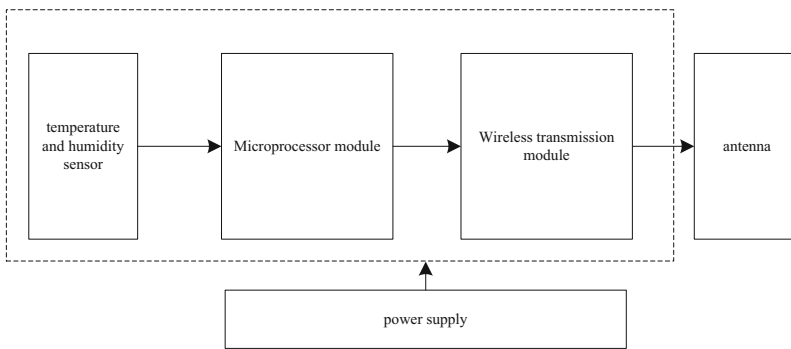


Fig. 2. Hardware Structure

To ensure the stable and reliable operation of the monitoring node, it is recommended to supply the necessary power through a mains transformer since the node is placed inside the transport vehicle.

The temperature and humidity sensor adopts the digital temperature and humidity sensor chip SHT11 from Sensirion, Switzerland. Its characteristic is that the functions of temperature sensing, humidity sensing, signal conversion, A/D conversion, and heater are high-precision integrated into one chip, providing a two wire digital serial interface SCK and DATA, with a simple interface, supporting CRC transmission verification, and high transmission reliability; Programmable adjustment of measurement accuracy with built-in A/D device; High measurement accuracy, providing temperature compensated humidity measurement values and high-quality calculation functions; The packaging size is extremely small, and after measurement and communication, it automatically switches to low-power mode; High reliability, using CMOS technology, the sensing head can be completely immersed in water during measurement; The temperature measurement range is $-40\text{ }^{\circ}\text{C} \sim 128.3\text{ }^{\circ}\text{C}$, and the humidity measurement range is 0–100% RH; SHT11 adopts SMD (LCC) surface mount packaging, with a very simple interface. The pin names and functions are: pin 1 and pin 4- signal ground and power supply, with a working voltage range of 2.4–5.5 V; Pin 2 and Pin 3- Two wire serial digital interface, where DA-TA is the data line and SCK is the clock line; Pin 5- Pin 8- Not connected.

The microprocessor module adopts LM3S811, supporting an ARM Cortex-M3 core with a maximum main frequency of 50 MHz, 64 Kbyte FLASH, 8 Kbyte SRAM, and LQFP-48 packaging. Integrated orthogonal encoder, 4-way 10 bit ADC, PWM with dead band, analog comparator, 3 universal timers, 2-way UART, SPI, I2C bus interfaces, etc. In addition to normal working mode, it also has sleep and deep sleep modes, which is very suitable for low energy applications and fully meets the requirements of Zigbee protocol stack for microprocessors.

The wireless transmission module adopts Chipcon's first CC2420 RF transceiver that meets the 2.4 GHz IEEE802.15.4 standard, which is the first RF device suitable for Zigbee products. It is based on Chipcon's SmartRF 03 technology and is made with a 0.18 μm CMOS process, requiring minimal external components, stable performance, and extremely low power consumption. Adopting O-QPSK debugging method, high reception sensitivity, 4-bus SPI interface, QPL-48 packaging, with an overall size of only 7 mm \times 7 mm, MAC layer hardware can support automatic frame format generation, synchronous insertion and detection, 16bit CRC verification, power detection, and fully automatic MAC layer security protection. The selectivity and sensitivity index of CC2420 exceed the requirements of the IEEE802.15.4 standard, ensuring the effectiveness and reliability of short distance communication. The wireless communication equipment developed using this chip supports a data transmission rate of up to 250 kbps.

The microcontroller LM3S811 communicates with SHT11 through a two wire serial digital interface, and the hardware interface circuit is simple, as shown in Fig. 3.

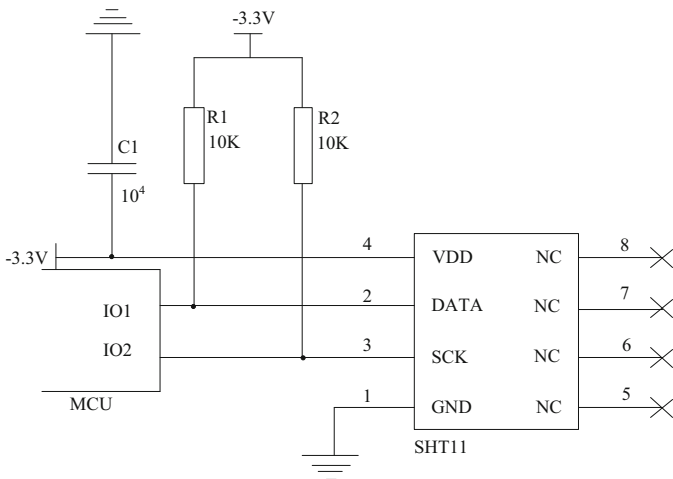


Fig. 3. Hardware Connection Diagram between LM3S811 and SHT11.

The communication protocol is not compatible with the universal I2C bus protocol, so it is necessary to simulate the communication program using a universal microprocessor I/O port. The control of SHT11 by the microprocessor is achieved through five 5-bit command codes, and the meaning of the command codes is shown in Table 1.

Table 1. Command Codecommand

	code
temperature measurement	00011
Humidity measurement	00101
Read Status Register	00111
Write Status Register	00110
Software Reset	11110

LM3S811 After sending the read status register command 0x07 to SHT11, the DATA port of SHT11 transmits temperature and humidity data to LM3S811.

The communication interface connection circuit between the CC2420 RF chip in the wireless transmission module and the microcontroller LM3S811 is shown in Fig. 4.

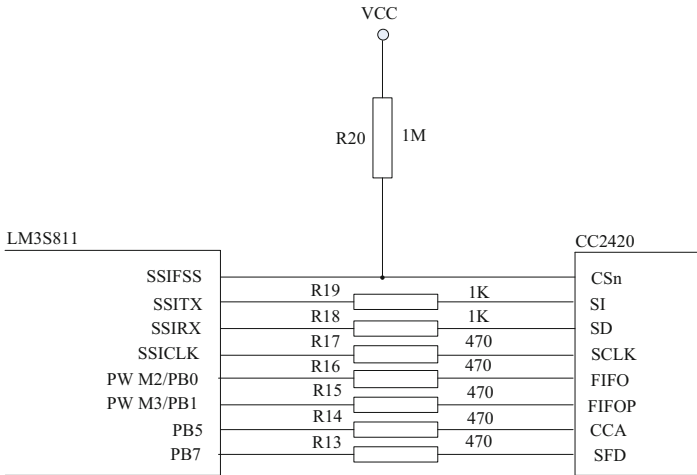


Fig. 4. Hardware Connection Diagram between LM3S811 and CC2420

The four interfaces for CC2420 SPI communication: CSn, SCLK, SI, SO, and LM3S811 SPI communication (SSIFSS, SSICLK, SSITX, SSIRX) correspond one-to-one. The RF chip CC2420 receives and sends data and reads configuration information through these lines controlled by LM3S811. CC2420 operates in slave mode, while LM3S811 operates in master mode.

4 Systems Software

GPS satellite constellation, ground monitoring part and GPS receiver constitute the GPS system, as shown in Fig. 5 below.

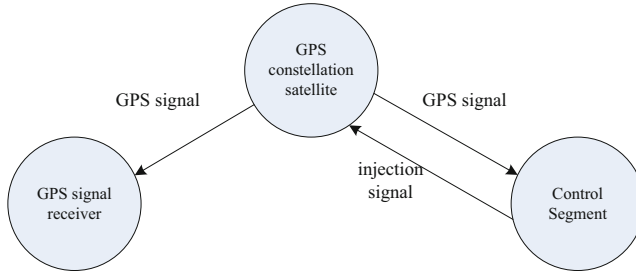


Fig. 5. GPS System Composition

(1) Space Constellation Part.

The space constellation of the Global Positioning System includes a total of 24 satellites, including 3 backup satellites. These 24 satellites are evenly distributed on six orbital planes with an average altitude of approximately 20200 km, and their operation time for one week is approximately 11:58. Each orbit of all satellites is approximately circular, and the maximum eccentricity is about 0.01. In each orbit plane, there are four satellites with an interval of 90° , and their operation period is 12 h. GPS receivers at the same location on Earth display the same satellite distribution pattern every day, with the difference being approximately 4 min earlier in time. So, if conditions permit, each point on Earth can receive signals from at least 4 satellites, and at most 11 satellites, which can meet the needs of positioning and navigation.

(2) Ground monitoring part.

The ground monitoring part of the global positioning system consists of a main control station, three information injection stations, and five monitoring and tracking stations. The main control station, also known as the Joint Space Execution Center (CSOC), is responsible for collecting data from various monitoring stations, generating navigation messages, transmitting them to the injection station, and providing a time reference. In addition, the main control station can also control and manage the work of each monitoring station and injection station. When the satellite deviates, adjustments can be made to ensure the normal operation of the entire system. The job responsibility of the injection station is to inject the prepared navigation messages into the storage space of each satellite, improving the accuracy of the satellite's broadcast signal. Each monitoring station is equipped with dual frequency GPS receivers and high-precision cesium clocks, which can track and measure satellites in real-time and transmit the collected information to the main control station at any time.

(3) Ground receiving equipment.

The GPS satellite constellation and ground monitoring described above are indispensable for the user to carry out positioning and navigation, but positioning and navigation cannot be realized without a receiver. The selection of GPS receivers varies due to different needs and environments, but general GPS receivers include antennas, signal processing units, display devices, recording devices, and power supplies, as shown in Fig. 6.

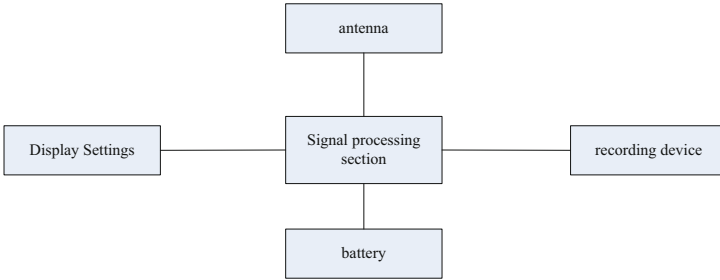


Fig. 6. Basic Structure of GPS Receiver

The principle of GPS positioning is mainly based on geometric and physical principles, utilizing the distribution of space satellites and the distance between satellites and ground points to intersect and determine the specific location of ground points. Assuming that we already know the position of the satellite and can accurately determine the distance between observation point A and the satellite through special measurement methods, we can accurately infer that point A must be located on a sphere centered around this satellite and with the measured distance as the radius. Similarly, if we can also know the distance between point A and any two other satellites, then the position of observation point A must be at the intersection of three spheres.

However, the positioning process for GPS satellites involves measuring three distances simultaneously, as the satellites are distributed beyond 20,200 km. To achieve synchronization and accurate positioning, it is crucial to have a common reference time. According to analytical geometry, GPS positioning necessitates the knowledge of the three-dimensional coordinates of a point and the synchronization of four unknown quantities. Therefore, a minimum of four satellite distances must be measured for precise positioning, as depicted in Fig. 7.

The actual distance R from the satellite to the receiver is calculated by measuring the time Δt from the GPS signal to the receiver. The specific calculation formula is:

$$R = c\Delta t \tag{1}$$

In the formula, c represents the propagation speed of the GPS signal.

Due to the influence of clock difference, the receiver's time V_{t0} and UTC's time V_{ti} may not necessarily be synchronized, i.e. $V_{ti} - V_{t0} \neq 0$. When UTC is fast, then $V_{ti} - V_{t0}$ is positive, otherwise it is negative. Due to the existence of time error $V_{ti} - V_{t0}$, there

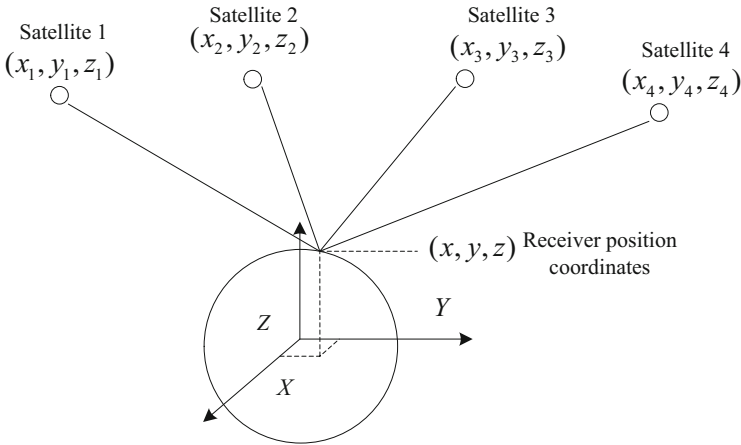


Fig. 7. Receiver position coordinate calculation

is an error in the signal transmission distance. Therefore, the measured distance to the satellite is called pseudo distance ρ , and the calculation formula is as follows:

$$\rho = R + c(V_{ti} - V_{t0}) \quad (2)$$

Calculate the coordinates of the four satellites based on the ephemeris file, and let $(x_i, y_i, z_i) (i = 1, 2, 3, 4)$ represent the spatial indicator coordinate systems of the four satellites at time t . Based on the product of the time Δt of signal transmission and the speed of light, the distance between the satellite and the receiver, known as pseudo distance, can be obtained. Let $\rho_i (i = 1, 2, 3, 4)$ represent the distance between the four satellites and the receiver, and $\Delta t_i (i = 1, 2, 3, 4)$ represent the time it takes for the signals from the four satellites to reach the receiver. At the same time, suppose that $V_{ti} (i = 1, 2, 3, 4)$ represents the satellite clock difference of four satellites respectively, which is provided by the satellite ephemeris, and V_{t0} is the receiver clock difference. The receiver position (x, y, z) can be solved by the following Equation solving, so as to determine the location of the petrochemical enterprise logistics transport vehicle. The specific calculation formula is:

$$\begin{aligned} & \sqrt{(x_1 - x)^2 + (y_1 - y)^2 + (z_1 - z)^2} + c(V_{t1} - V_{t0}) = \rho_1 \\ & \sqrt{(x_2 - x)^2 + (y_2 - y)^2 + (z_2 - z)^2} + c(V_{t2} - V_{t0}) = \rho_2 \\ & \sqrt{(x_3 - x)^2 + (y_3 - y)^2 + (z_3 - z)^2} + c(V_{t3} - V_{t0}) = \rho_3 \\ & \sqrt{(x_4 - x)^2 + (y_4 - y)^2 + (z_4 - z)^2} + c(V_{t4} - V_{t0}) = \rho_4 \end{aligned} \quad (3)$$

5 System Performance Verification

Propose a comparative experiment, using the reference [5] system as a comparative system to compare the tracking performance of this system and the comparative system when facing the same logistics information of petrochemical enterprises.

The performance parameters of the GPS receiver are shown in Table 2.

Table 2. GPS Receiver Performance Parameters

	project	Parameter
Basic performance	Receiver type	50 satellite reception channels, GPS L1 frequency, C/Aa sign or object indicating number; SBAS: WAAS, EGNOS, MSAS, GAGAN
	Start Time	cold start(29s), hot start(1s), Auxiliary start(5-10s)
	Time To First Fix	<1 s
	Maximum update rate	<4 Hz
	positioning accuracy	Auto < 2.5 m, SBAS < 2 m
	timing accuracy	RMS 50ns
	Antenna power supply method	External or Internal VCC-RF
	Antenna status detection	Integrated short circuit detection and antenna shutdown function; Open circuit detection is provided by AADET-N input and external small circuit
	Ultimate operating speed	515 m/s
	Store Wendy	-40~85 °C
	Package Size	17 × 22.4 mm
Electrical performance	working voltage	2.7 V~3.6 V
	consumption	120 mW@3.0 V
	Spare battery	1.3 V~4.8 V, 30 uA
	I/O level	3 V
interface protocol	serial interface	1 UART, 1 I2C USB V2.0 (full speed 12Mbit/s)
	Other interfaces	Full speed 1 time pulse output, 1 external interrupt input, 1 reset pin, 1 configuration pin
	agreement	NMEA, UBX binary system

5.1 System Access Delay

The comparison results of access latency between the two systems are shown in Table 3.

From the system access delay results shown in Table 3, it can be seen that compared to traditional systems, the access delay of this system is significantly shortened, with a maximum of no more than 1 s. Therefore, it indicates that the system in this article has good operational performance and fast access speed. Low access latency is crucial for real-time data acquisition and response. In the field of logistics and transportation, timely access to temperature and humidity data is crucial, as these data play an important role in

Table 3. System Access Delay

Number of experiments	Access latency/s	
	This article system	Traditional systems
1	0.63	5.61
2	0.65	6.64
3	0.69	3.69
4	0.70	5.73
5	0.72	6.85
6	0.74	6.71
7	0.68	5.87
8	0.69	4.85
9	0.80	4.88
10	0.72	4.89

ensuring the quality and safety of goods. This system can efficiently collect, process, and transmit data, ensuring timely access to temperature and humidity information, thereby improving the level of logistics management. In addition, shorter access latency can also improve the user experience. Whether it's internal logistics management personnel, customers or partners, they can quickly obtain the necessary data and make more accurate decisions. This helps to improve the efficiency and smoothness of the entire supply chain process.

In summary, by shortening access latency and achieving faster access speed, the system proposed in this article has good operational performance in the field of logistics and transportation, and can meet the needs of real-time data acquisition and user experience.

5.2 Logistics Information Tracking Effect

Import the logistics information of a certain petrochemical enterprise in the past 10 years into two testing systems, randomly select six logistics information from them, and use two systems to track and set six logistics information in the nearly 2.65TB network data. The basic information of the testing objects is shown in Table 4.

Import all information into the system database and use the logistics information tracking programs of two systems to identify the logistics information in Table 4. In order to make the experimental results more reliable, a total of 10 experiments were conducted. The test results of a random group are shown in Tables 5 and 6.

Table 4. Logistics Information to be Tracked

type of goods	Logistics vehicle number	Order number	Delivery time	Unloading warehouse
A1-15	S1	KBU8546	2012-4-12	C03-1
A3-07	S2	KAU8744	2016-8-7	C02-4
B1-02	S3	KFU0759	2018-7-11	C03-5
F4-13	S4	KDU2434	2010-5-8	C03-3
J2-06	S5	KDU1885	2015-12-25	C02-1
H5-08	S6	KAU579720	2018-9-18	C01-3

Table 5. Tracking results of the system in this article

type of goods	Logistics vehicle number	Order number	Delivery time	Unloading warehouse
A1-15	S1	KBU8546	2012-4-12	C03-1
A3-07	S2	KAU8744	2016-8-7	C02-4
B1-02	S3	KFU0759	2018-7-11	C03-5
F4-13	S4	KDU2434	2010-5-8	C03-3
J2-06	S5	KDU1885	2015-12-25	C02-1
H5-08	S6	KAU579720	2018-9-18	C01-3

Table 6. Tracking Results of Traditional Systems

type of goods	Logistics vehicle number	Order number	Delivery time	Unloading warehouse
A3-07	S2	KAU8744	2016-8-7	C02-4
B1-02	S3	KFU0759	2018-7-11	C03-5
J2-06	S5	KDU1885	2015-12-25	C02-1
H5-08	S6	KAU579720	2018-9-18	C01-3

According to the test results shown in Tables 5 and 6, it can be seen that the system in this paper obtained all the logistics information of the six test objects, while the traditional system did not track the logistics information before 2015, indicating that the performance of the system in this paper is stronger. The system proposed in this article exhibits stronger performance and functionality in obtaining and tracking logistics information, providing enterprises with more comprehensive and accurate logistics data, thereby improving the level and effectiveness of logistics management.

For logistics management, obtaining and tracking complete logistics information is crucial for enterprise decision-making and operation. Through the application of this system, enterprises can have a comprehensive understanding of various links and data in the logistics process, including starting points, transit stations, transportation routes, arrival times, etc. This information helps enterprises to carry out precise logistics planning, optimize transportation routes, improve transportation efficiency, and better respond to potential problems and risks.

6 Conclusion

In this study, a system framework structure was designed to address the logistics information tracking needs of petrochemical enterprises in the context of smart logistics. This framework includes the basic layer, service layer, system layer, and application layer, providing a comprehensive and efficient logistics information management solution for petrochemical enterprises. In the hardware part of the system, a wireless network is introduced to transmit the information collected by temperature and humidity sensors. This enables real-time monitoring and recording of temperature and humidity data during the logistics process, thereby ensuring the quality and safety of goods during transportation. Through wireless network transmission, data can be quickly and accurately obtained and transmitted, improving the efficiency of logistics information collection and transmission. In the system software section, GPS positioning technology is used to track the location of logistics transportation vehicles in petrochemical enterprises. This enables enterprises to real-time grasp the driving situation and location of vehicles, which helps optimize route planning, improve transportation efficiency, and respond to potential problems and risks in a timely manner.

By combining hardware and software, a fully functional, efficient and reliable logistics information tracking system has been successfully designed. This system can help petrochemical enterprises achieve visualization and intelligent management of logistics processes, improve the efficiency and quality of logistics transportation, and reduce costs and risks. In summary, this study provides an effective solution for the design of logistics information tracking systems for petrochemical enterprises in the context of smart logistics. I believe that the application of this system will bring higher logistics management level and competitive advantage to petrochemical enterprises, and contribute to the sustainable development of the industry. In the future, the system will be further optimized and improved to meet constantly changing needs and challenges.

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