Research on Train Time Calibration Based on ZigBee

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Abstract

ZigBee Technology, as a wireless transmission technology developed in recent years, has the advantages of low complexity, low power consumption, low cost and so on. Which be widely used in the internet of things and other occasions, this paper will combine ZigBee wireless transmission module and high-precision crystal, proposed a study on the timing of the use of high precision crystal and time servers during travel. When the train stops using the ZigBee wireless module and the station accurate unified clock to school, so as to eliminate the cumulative error of the train clock research. The purpose is to replace the use of GPS signals on the train time calibration method.

Keywords

Time Calibration, ZigBee, Time Server, Crystal Oscillator.

1. Introduction

With the continuous increase of the domestic train speed and the transmission of information within the vehicle, the requirements for time accuracy are also getting higher and higher.All the servers and terminal equipments in the train need unified clock information to ensure the transmission of process data, message data and monitoring data to all the vehicles in a unified time frame. At the same time, the scheduling of trains and need of passengers all require a uniform and accurate time for the train and for the entire railway operating system.At present, trains generally use a time synchronization server with GPS standard time as an information source to calibrate the entire vehicle. This is an intelligent time server that can work independently based on the NTP / SNTP protocol.The time synchronization server transmits the time information in the local area network (LAN). The devices that need time signals in the network (such as computers, controllers, etc.) can be synchronized with the standard clock source through the time alignment software.However, since GPS is developed and maintained by the U.S. Defense Department, once it terminates its time services, it will cause confusion in the operation and management of trains.In view of this situation, this article will propose an improvement of train time calibration.

2. Time synchronization technology

At present, the most common method of time synchronization is to use accurate clock timing. Firstly choose a computer in a network to synchronized with the precise clock. The computer serves as a time server for the entire network, and other devices synchronize time with it.The time server outputs through the network interface. The data format must conform to the time synchronization protocol. All the computers, servers and other devices in the LAN are synchronized with the time server through the network. The time synchronization protocol automatically determines the network delay, compensates the obtained data for time, So that LAN devices' time maintain uniform and precision.PTP is usually used in the localized LAN environment. Its principle is simple, the required computing resources and network resources are few, but it requires that the network environment be stable and secure. PTP was

originally designed for use in distributed measurement and control systems with sub-microsecond accuracy.

The accuracy of the clock synchronization depends directly on the accuracy of the time stamp,it can be obtained from the hardware layer, driver layer, and application layer.The most accurate way is to detect PTP frames at the hardware layer.It is easy to capture and decode the ingress and egress frames as they pass through the media independent interface.The accuracy of this method depends on the timing characteristics of the physical chip.In addition to hardware support, the network driver layer is also a good place to get time-scales.The frame is marked with a time scale before being transmitted to the MAC layer for encapsulation and at the entrance to the network interface, when the adapter is interrupted.The accuracy of this method depends on the interrupt latency and CPU processing power.The application layer time scale is located in the socket interface,due to the stack and load, its accuracy is average.So this paper adopts the time protocol PTP, and detects the PTP frame from the hardware layer.

3. System hardware design

The train's own time synchronization server can ensure that the internal time system of the train still works normally when the external clock source changes,Therefore, this paper presents a comparison of the time signal transmitted by the ZigBee wireless module connected to the station clock source after the train enters the station, and when the train travels between the two stations, it relies on the high Accurate crystal oscillator for the improvement of time source program. Although the on-board crystal oscillator has high precision, it will inevitably cause errors due to the turbulence in the train operation. When the accumulated error is large enough, the operation of the train will be affected. The main purpose of the time-proofing at the platform is to eliminate the cumulative error. The advantage of doing so is that the train can ensure the safe operation even if it does not communicate with the GPS global positioning system.

3.1 crystal oscillator

As a commonly used "clock" device, quartz crystal oscillator is through programming the crystal oscillator’s frequence to achieve timing, The crystal slicing cut with a certain orientation strictly, according to the type can be divided into AT cut, BT cut, FC cut, SC cut, etc., the AT cut and SC cut used widely. According to the frequency characteristics of the crystal classification, quartz crystal oscillator can be divided into: ordinary crystal oscillator (mainly used in less demanding stability occasions), temperature compensation crystal oscillator (according to the resistance value of the crystal to compensate for changes in the frequency deviation, crystal performance can be about 20 times the improvement), temperature control crystal oscillator (crystal and other temperature-sensitive components are installed in a stable structure of the thermostat, the crystal performance of more than 1000 times improvement).Taking into account the temperature,burn-in and other factors, the AT cut-type temperature control crystal oscillator is suitable , In the long time (more than 1000 hours) in the operation of the detection process, the actual error does not exceed 5ns, in full compliance with the error in the train operation process—1ms.

3.2 ZigBee wireless module

Taking into account the actual situation of the station, the hardware environment should be as simple as possible, so the choice of ZigBee wireless communications not only saves wiring costs, but also reduces the workload and improve work efficiency. ZigBee technology is a two-way wireless communication technology with low complexity, low power consumption, low cost, short delay, large network capacity, high reliability and high security. ZigBee technology is a group of wireless communication technologies developed based on the IEEE802.15.4 wireless standard, which for networking, security and application software. As an emerging wireless networking technology, low power (six months to one year of supply from only two cells), low cost (up to five dollars for a typical

ZigBee device) and long-term communication and other advantages make it widely used.ZigBee can work in the 2.4GHz, 868MHz and 915MHz frequency bands, with up to 250kbit/s, 20kbit/s and 40kbit/s transfer rate. Considering that more information data may be transmitted between the train and the platform through the ZigBee in the future, the paper decides to use the 2.4 GHz frequency band, and the transmission rate of 250 kbit/s also ensures the real-time transmission of accurate time data. ZigBee transmission distance due to the size of the transmit power and different, 10mW can generally reach about 100 meters, 100mW can reach 1-2 kilometers, according to the actual range of most stations, it can fully meet the coverage of the entire platform.

ZigBee networks usually have three devices: coordinator, router and endpoint. Network coordinator is the most complex of the three types of equipments, its main function is to establish a network, manage network nodes, storage information of network nodes, as a fully functional device; Router is responsible for add the new ZigBee endpoint, which apply into the network, to Network topology, and then manage the newly added nodes to communicate with other nodes, full-featured devices too; Terminal node does not maintain the network, but it can be easily combined with the routing node to meet the needs of users, it is the reduced function device. ZigBee network mainly has three kinds of networking modes: star, cluster and mesh. This article uses a star network,and the network coordinator and router will be built on the appropriate platform, each vehicle ZigBee wireless module is a terminal node , when the train into the station, the wireless module connected to the network coordinator via the router, so as to obtain accurate time signal on the train clock. In order to ensure the success rate of the school, you can install a redundant router to do the backup. Train can also install multiple wireless modules to ensure the accuracy of data transmission.

4. Train school process

When the train enters the platform at a low speed, the vehicle-mounted ZigBee wireless module connect to the entire wireless communication network via a router. The router continuously sends a time-correction request to the newly added ZigBee wireless module of the network. When the ZigBee wireless module receives the request message, It will send a time-measurement response message to the router and stop responding to the time-measurement request message sent by the router. After detecting the response packet, the router sends the accurate time information to the wireless module sending the packet, after receiving the accurate time information, the wireless module sends the packet with successful timing to the router. On the other hand, if the router waits for a period of time and does not receive a successful message, it will continue to send accurate time information to the ZigBee wireless module. When the router repeatedly sends accurate time information to a certain wireless module unsuccessfully (for example, it sends an accurate packet but does not receive a successful calibration), the module will be skipped and the other modules continue to communicate. As long as a ZigBee wireless module receives accurate time information, the train control network can get that exact time. School only need to be correct once, do not need to repeat.

After obtaining accurate time information, the train control network calibrates the on-board time server and broadcasts the accurate time to all the vehicles through the MVB bus and the WTB bus, until all the devices polled by the bus master successfully receive and send the time calibration. All servers and terminal devices within the whole vehicle receive the message data and update their own clocks during the main bus polling process. After the entire vehicle calibration is completed, the train control network broadcasts "successful school" to the driver and displays the accurate time. However, if all ZigBee wireless modules are unable to receive accurate time information from the ground equipment and can not calibrate each node on the train, the train control network will broadcast a "school-time-failed" message to driver and displays at the relevant position of the driver's cab. Driver need timely adjustment of the school system maintenance. When the train school completed the departure from the station, the time server connected to the AT cut-type thermostatically controlled crystal oscillator for timing, in order to ensure the accuracy of time on the train. When the train school completed the

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5. Conclusion

The time-based system based on ZigBee technology described in this paper can not only make the train get rid of the dependence on GPS in time calibration, but also provide more accurate time signal for high-speed train, which is more conducive to synchronizing the running time and has the advantages of low cost and high feasibility and operability. It provides a time standard for train traffic control, train operation and equipment management, ensures the coordination of communication system and other important control systems, playing an important role in improving the safety and reliability of train operation.

Rsferences

[1] Ni Wenbo, Wang Xuemei. High-speed train network and control technology. Second Edition [M]. Southwest Jiao Tong University Press, 2010.
[2] Li Hui. Based on wireless technology EMU maintenance scheduling system [D]. Dalian Jiaotong University, 2015.
[3] Chang Zhenchen, Niu Detian, Wang Lide, et al.Research status and prospect of train communication network [J] .Electric Power Locomotives and Urban Rail Vehicles, 2005,28 (3): 5-7.
[4] LIU Yu, TANG Tao, LIU Bo, et al. Time-borne system of speeding protective equipment for Beijing subway [J]. Metropolitan Rapid Rail Traffic, 2007, 20 (5): 85-88.
[5] Pu Hongquan, Jia Junying, Zhang Xiaojiao, et al.Review of ZigBee network technology[J]. Application of Computers, 2013,22 (9): 6-11.
[6] Ning Bingwu. Zigbee network networking research and implementation [D]. Dalian University of Technology, 2007.
[7] Chen Chao.Design and realization of high precision clock in smart substation based on GPS [D]. Nanjing University of Science and Technology, 2014.
[8] WANG Deng-yang, YANG Chao.Technology of Time and Space Synchronization of High Speed Integrated Detection [J]. Railway Technical Innovation, 2012 (1): 16-19.
[9] Peng Liyu, Wang Dengyang, Zhang Junsheng.Study on Synchronization of Train Locating Synchronization in Shuo-Huang Railway [J]. Railway Construction, 2017 (2): 129-132.