Research on Key Technologies of Smart Logistics Dynamic Positioning Based on NB-IOT

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Abstract: This study takes the large-scale freight yard in the free trade zone of Xinjiang and cargo reloading in international railway transit as the prototype scene, and takes NB-IoT network as the core to realize dynamic positioning electronic tags for people, vehicles and containers through Beidou positioning module and RTK technology. Finally, the positioning information will be transmitted to the command center through integrated NB-IoT communication function, and the three-dimensional simulation of the freight yard will be realized by using Three.js to build the intelligent logistics cargo dynamic real-time positioning system with the advantages of low power consumption, low cost, wide and deep coverage, massive connectivity, and precise positioning, so as to realize the role of reducing cost and improving logistics efficiency in intelligent logistics.

1. Introduction

As the economic core area and bridgehead of One Belt And One Road, Xinjiang plays an increasingly prominent role as a logistics center. Smart logistics plays an important role in the construction of bonded zones and logistics ports. It is necessary for smart logistics to improve logistics efficiency and monitor the status of cargo in real time. In addition, there is a very important problem in the process of international railway combined transport, that is, the railway gauge is not consistent between countries, which is a difficult problem and challenge for international intermodal and export transport. At this time, smart logistics, for containers and other large cargo dynamic positioning is particularly important. The research of this paper focuses on the dynamic positioning of large cargo such as containers in Xinjiang bonded area and international railway transshipment.

In June 2017, the General Office of the Ministry of Industry and Information Technology (MIIT) issued the “Notice on Comprehensively Promoting the Construction and Development of the Mobile Internet of Things (NB-IoT)”, which emphasized research on key technologies to enhance NB-IoT service capacity. According to the application requirements of different vertical industries, the key technologies such as positioning function, mobility management, power saving, security mechanism and transmission performance optimization under different application environments and business requirements are studied to ensure that NB-IoT system can provide reliable services for different businesses in different environments. Specifically, it mentioned the development of NB-IoT technology in the field of logistics and transportation to help build a manufacturing powerful country.

Among the widely used types of the Internet, location-based services (LBS) is one of the most potential applications. Most of the Internet of the public service and commercial applications rely on node location information and it is estimated that about 70% of the Internet of things application development depends on directly or benefits from the node location information. Whether provide
reliable terminal positioning function has become an important indicator to determine the standards of different IOT technology.

At present, satellite based positioning system, which is mature in technology and widely used in commercial applications, is not suitable for low-cost IOT application scenarios from the perspective of cost and practicality. The traditional method of using RFID or "barcode + electronic tag" also has the following disadvantages: 1) As RFID or "bar code + electronic tag" generally uses handheld reader or fixed reader, which is limited to read tag information at fixed point; 2) RFID is suitable for short distance identification communication, and it is difficult to deploy and maintain network in a large range; 3) It is difficult to obtain the vertical height information of cargo.

Therefore, it is of great practical significance to study the positioning technology dedicated to the IOT. In the frozen 3GPPR13, there is no technical standard for NB-IoT terminal positioning. In order to further improve the market potential of NB-IoT, terminal positioning technology has become one of the key technologies for the subsequent improvement of NB-IoT system. This paper aims to study the key technology of dynamic positioning by using NB IOT network deployment in several scenarios of intelligent logistics.

2. Research status of NB-IoT application in intelligent logistics at home and abroad

Facing the emerging Internet of Things technology, many scholars have explored the commercial application of NB-IoT.

Sarun Duangsuwan, Aekarong TakarnAlexeyA and other scholars have developed NB-IoT based air pollution detection sensors in smart cities, To monitor air quality, data processing was performed using a network of narrow-band Internet of Things (NB-IoT) modules connected by Arduino Mega 2560 and Respberri Pi 3. S. Petrenko, Sergei A. PetenkoThe and other scholars have studied the equipment control model based on NB-IoT. According to the different characteristics of geography, economy and branches of the Russian Federation, the paper discusses how to create a data center network on a virtualization platform to support the functions of the Internet of things infrastructure, and proposes a comprehensive solution for the interaction of all IIOT / IOT components.

Lin Fang (2017) analyzed coverage enhancement technology of NB-IoT and its application in remote meter reading system[1]. Yuan Shengyong et al. (2016) studied the application of NB-IOT in railway industry, and put forward specific application scenarios of NB-IOT in railway based on the technical characteristics of NB-IoT[2]. Based on the technical characteristics of NB-IoT, Sun Ke (2017) studied the application of NB-IoT in intelligent communities and proposed a NB-IoT intelligent community solution[3]. Shen Zhou et al. (2017) studied the application of NB-IoT in parking and proposed solutions of intelligent parking[4].

However, only one paper entitled "NB-IoT application exploration in logistics industry"[5] by Wang Lei was found in CNKI, and the relevant technology was not studied in this paper. Wan Peng, master of Beijing University of Posts and Telecommunications, wrote his thesis entitled "Research on NB-IoT terminal Positioning Technology", which mainly studied the time delay estimation and positioning algorithm applicable to NB-IoT terminal positioning[6].

To sum up, research on NB-IoT applications and related technologies in intelligent logistics is still in short supply.

3. Introduction to key technologies

3.1. NB-IoT network and its application in intelligent logistics

Low-speed IoT accounts for more than 67% of the whole IoT business. NB-IoT based on cellular network will become the mainstream low-speed IoT technology in the future. Intelligent logistics usually uses trackers with positioning and communication functions, while the data upload frequency of trackers is at the level of minutes or longer, the data volume is small, and the movement rate is not high. NB-IoT requires strong coverage of signal arrival rate and low power consumption, which leads
to power saving. This study will discuss the overall architecture and key technologies of NB-IoT networks, as well as its application in smart logistics.

3.2. Beidou positioning and RTK technology
As for the dynamic positioning technology, the integration module of NB-IoT and Beidou is realized by experiment; At the same time, RTK technology is used to make up for the lack of precision in beidou positioning. By researching the relevant algorithms for RTK positioning, the appropriate algorithm is selected for in-depth research to realize and verify its accuracy and reliability.

In this study, NB-IoT logistics positioning requires rough positioning of containers. The data of tilt angle can be collected, and the corresponding speculation can be made on the angle, such as jitter, tilt Angle, cargo drop, cargo loss can be searched in the platform.

At present, beidou-3 system can provide positioning accuracy of 5-10 meters for users, which can not meet the higher requirements for cargo positioning accuracy. Using RTK positioning technique, one is to solve the defect of the traditional GPS to obtain positioning data delay, the other is to improve the positioning accuracy significantly, and the theoretical accuracy can reach centimeter level. It fully meets the requirements of positioning accuracy in this research scenario. In this paper, through the research of RTK positioning algorithm, select a certain algorithm for in-depth study, to achieve and verify its accuracy and reliability.

3.3. Threejs is used to simulate the goods yard
After integrated NB-IoT communication function transfers positioning information to the charge center, interactive 3D simulation of the field area is needed. Threejs is by far the most popular open source WebGL framework at present. The threejs library can be used to complete the construction and display of freight yard scenes, and JavaScript code can be used to control the scene by mouse, such as moving, panning, zooming and so on.

4. Design scheme and implementation
4.1. System and network architecture
According to the prototype scenario of freight transshipment in Xinjiang free trade zone and international railway, the overall architecture of NB-IoT solution is composed of six parts: industry terminal, NB-IoT module, base station, core network, IoT platform and application server. Its network architecture is as shown in the Figure 1.
(1) NB-IoT module is the core access module of NB technology, such as wireless connection, soft SIM, sensor interface, etc. This study adopts remote BC28 module + STM32 for application development.

The remote NB-IoT module BC28 integrates communication and positioning functions, and can support demodulation algorithms of Beidou, GPS and other multi constellation satellite systems. BC28 has the advantages of ultra-small size, ultra-low power consumption, precise positioning, high integration and strong compatibility. At the same time, BC28 supports low voltage power supply, which is more suitable for NB-IoT positioning application scenario. The model STM32l051c8t6 can be used for MUC. This model is small and flexible, especially suitable for product development, the price is relatively low and can meet the needs of product development.

(2) In terms of base stations, there are two ways: one is to use traditional base stations and then add new units to make it applicable to NB-IoT technology; the other is to build new NB-IoT base stations. The first way can reduce the cost of the site.

In terms of core network, similar to base stations, traditional core network or new IOT exclusive core network can be used. The main technologies include mobility / security / connection management, secure access of terminal without SIM card, terminal energy-saving features, delay insensitive terminal adaptation, congestion control and traffic scheduling, and billing.

From the core network will be connected to IOT platforms, mainly including application-layer protocol stack adaptation, terminal SIM OTA, terminal device and event subscription management, Open API capabilities (industry, developer), OSS/BSS (self-service account opening, billing) and big data analysis.

Finally, to the application server, the terminal that the user can query.

4.2. **Piksi module for quickly obtain the location solution**

The differential GNSS receiver used in this study is Piksi module of Swift Corporation of the United States. The module is a new type of low cost and high precision single-frequency RTK receiver. In the open surrounding environment, the dynamic horizontal positioning accuracy obtained by RTKFixed can be as accurate as 2cm, and the dynamic vertical accuracy is about 4cm-6cm. When the distance between the mobile station and the reference station is increased by 1km, the horizontal and vertical accuracy will be reduced by 1mm and 3mm respectively. It is convenient for users to carry out secondary development. Piksi is a low-cost, high-performance, small shape, low power consumption, and can quickly obtain the location solution, which is very suitable for the scenario of this paper.

4.3. **3D modeling and simulation of Threejs**

In order to display the layout of the freight yard, the placement and flow direction of goods, Threejs is used for 3D modeling and simulation of the freight yard scene. Threejs is an open source 3D engine. As one of the leading WebGL frameworks, Threejs encapsulates the objects commonly used in 3D graphic programming in a simple and intuitive way. It supports interaction and has powerful functions. Because of its ease of use and expansibility, it is sufficient to meet the development requirements of this study.

5. **Conclusion**

This paper takes NB-IoT network as the core, realizes container dynamic positioning through Beidou positioning module and RTK technology, and uses Threejs to realize 3d simulation of the field. It provides the technical thought and basis for the dynamic positioning of intelligent logistics. At the same time, as an important part of xinjiang One Belt And One Road, intelligent logistics is of great significance in solving key technologies related to dynamic positioning of goods.
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References
[1] Lin Fang. (2010) NB IOT Internet of things coverage enhancement technology and its application in remote meter reading system. J. Electronic world, 14: 124-126
[2] Yuan Shengyong, Zhang Xiaojun. (2016) Research on Application of Nb IOT in railway industry. J. Railway communication signal, 12: 63-65
[3] Sun Ke. (2017) Building smart community with Nb IOT technology. J. China new communications, 09: 95-96
[4] Shen Zhou, Huang Zhen, Zhao Rui. (2017) Smart parking: narrow band Internet of things to help [J]. Shanghai informatization, 05: 30-32
[5] Wang Lei.(2018) Application of Nb IOT in logistics industry. J. China Equipment Engineering,01: 206-207
[6] Wan Peng. Research on Nb IOT terminal positioning technology. D. Beijing University of Posts and telecommunications. Beijing.2018.