Study of Intelligent Express Box based on NB-IoT

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Abstract. In order to solve the problem of inconvenience of delivery and delivery of express delivery in today's society, this paper puts forward the design of intelligent express box system, which has the functions of positioning, intelligent lock, real-time monitoring, logistics tracking and so on. Location is realized by NB-IoT enhanced positioning mode, namely OTDOA positioning, which facilitates users to quickly find the required express box. Intelligent lock is implemented by STM32 and NB-IoT communication module. When the password matches, the NB-IoT communication module receives the unlock command from the cloud platform, and the unlock is controlled by STM32. During the user's use of a smart express box, owning the ownership of the express box, the logistics status and the switch status of the lock can be monitored in real time on the APP. "Intelligent Express Box" is a new way of delivery, dedicated to providing more convenience for the masses.

Keywords: Express box; NB-IoT; OTDOA positioning; STM32.

1. Introduction

There are three main ways to send and receive express mail. One is to send to a fixed express site, which is not enough to save manpower and time. Second, the appointment of express delivery personnel for a certain period of time to send and receive, express delivery personnel can not accurately in your spare time to carry out "door-to-door service". Thirdly, express delivery is delivered in the form of "Hive Box" in the adjacent express cabinet sites. The express cabinet covers a small area and is not efficient enough. Therefore, the solution of "express box" is put forward.

"Express box" uses NB-Iot technology to achieve positioning [1], intelligent lock and other functions. Express box is made of portable materials and easy to transport. It can be put into large-scale delivery under the permission of regulations, such as school dormitories, etc. Compared with "Hive Box" Express cabinet, it covers a wider area. When users need to send express, they can choose express box to put items nearby. Staff can collect them in time according to positioning information. Before that, intelligent lock ensures its security; when users need to pick up express delivery, users can choose the staff to deliver goods to their door or put them in a certain place according to their needs, and users will receive the corresponding positioning information and pick-up password in the client.

The positioning of express box needs to be realized by wireless positioning, and the higher precision positioning algorithms such as AOA positioning method need special antenna array to measure the angle of arrival of signals, TOA positioning method requires higher synchronization between base stations. TDOA positioning method estimates the target position by measuring the delay difference between the signals reaching multiple receivers, which improves the accuracy and reduces the synchronization between base stations. NB-IoT is a wise choice because of its OTDOA [2] enhancement in 3GPP version R14 and its location by measuring the time difference of arrival of downstream signals from multiple base stations.

In the aspect of intelligent lock, NB-IoT technology also has unique advantages[3], such as no gateway or routing to reduce costs, no distribution network, reduce the intermediate link of the network, thus reducing the link attacked by the network, directly connecting to the telecommunication base station, signal stability, ultra-low power consumption (which can guarantee the battery life of more than five years), unlocking information monitoring at any time. In contrast, Bluetooth locks are difficult to connect to the network directly, cannot get the real-time status of locks, and the battery life is only a few months.

2. Location and Intelligent Lock

2.1 Positioning Principle

Express box uses OTDOA (Observed Time Difference of Arrival) technology [4]to realize positioning. Its implementation follows the E-UTRAN [5] positioning architecture and protocol. It uses terminal equipment to measure the time difference of arrival of reference signals from different base stations and coordinates of base stations to determine the terminal position. Generally, at least three base stations need to be measured. The baser stations are measured, the higher the measurement accuracy is, and the better the positioning and tracking performance is.

Location measurements of three base stations are shown in Figure 1. A, B and C are base stations, assuming coordinates are (x_a,y_a),(x_b,y_b),(x_c,y_c), respectively. D are terminals, coordinates are (x_d, y_d), base station coordinates are known fixed data. The signal propagates in the form of electromagnetic wave in the air, so the transmission speed can be approximately equal to the speed of light C. Taking base stations A and B as examples, the time difference is ΔT_{AB} by comparing the time interval between the signal transmitting time of base stations A and B and the signal receiving time of the terminal, or ΔT_{AB} can also be obtained by the coordinates of base stations and the signal transmission rate. The formulas are as follows,

$$\Delta T_{AB}=\frac{\sqrt{(x_d-x_b)^2+(y_d-y_b)^2}-\sqrt{(x_d-x_a)^2+(y_d-y_a)^2}}{c}$$

The terminal coordinates (x_d, y_d) can be calculated by the time difference of arrival of multiple base station signals, such as ΔT_{BC}, so as to realize the location of express box.

$$\Delta T_{BC}=\frac{\sqrt{(x_d-x_c)^2+(y_d-y_c)^2}-\sqrt{(x_d-x_b)^2+(y_d-y_b)^2}}{c}$$

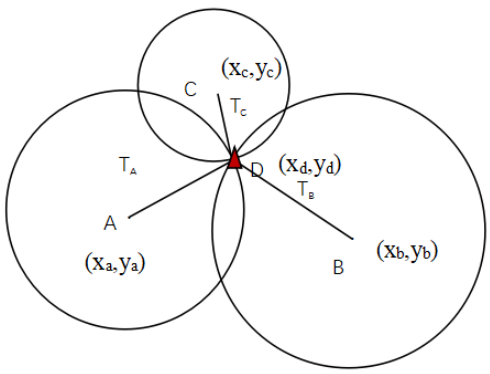


Fig. 1 OTDOA location principle

2.2 Realization of Location and Intelligent Lock

The new version of NB-IoT protocol specifies that the base station uses a new dedicated positioning reference signal NB-IoT NPRS (Narrowband Positioning Reference Signal), which is specially used for the terminal to measure the base station signal. NB-IoT is deployed independently or with protection band[7]. Because of the high NPRS density of these two deployment modes, this will improve the accuracy of measurement.

The hardware circuit of the terminal is composed of STM32[8], NB-IoT module and key module. STM32 controls each module to coordinate work and transmits and receives serial data through AT instructions. Key module detects user key data, NB-IoT module realizes data reporting and receiving commands from cloud platform, collects time information returned by base station, sends time information to Ocean Connect cloud service platform through COAP protocol, parses it into JSON format data and calculates and processes it to get location information. Cloud platform connects

server, HTTP protocol realizes communication between mobile APP and server, sends control information and location information to module according to API provided by server.

When using smart lock, STM32 will report the collected data of key module to cloud platform through NB-IoT module after the user enters and confirms the unlock password for express delivery and the pick-up password for receiving express delivery. The cloud platform transmits data to the user server, checks whether the password matches, and sends other data to the user APP for relevant prompts. If the password matches, the unlock command is issued through the cloud platform.

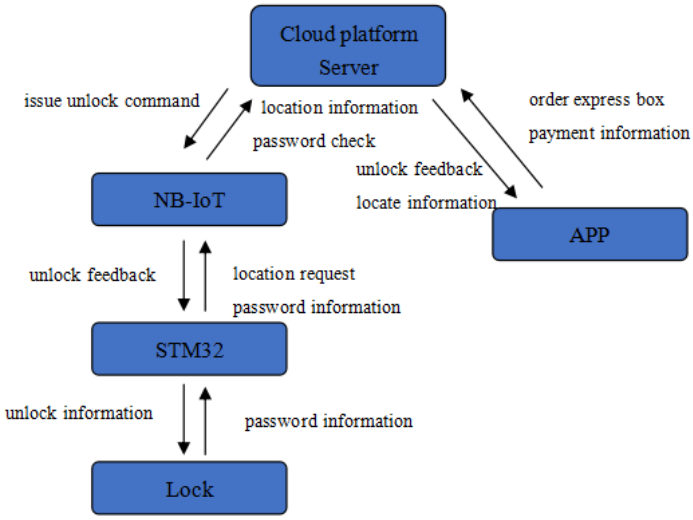


Fig 2. Express Box Workflow

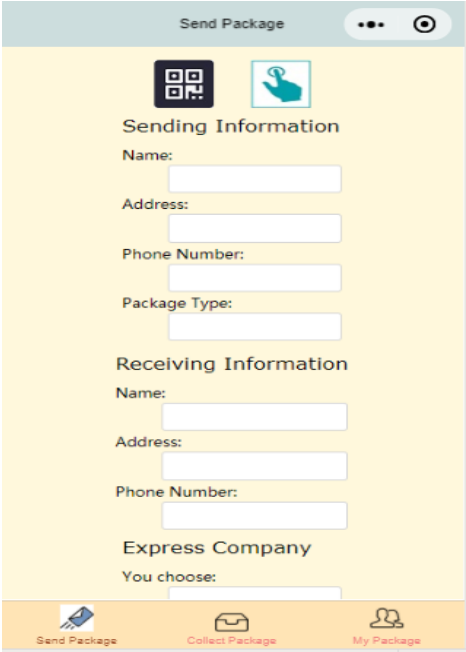
3. APP

The APP is mainly divided into three parts, including "send package", "collect package" and "my package".

"Send package" section has two major functions, one is to apply for the express box, the user can apply for delivery box door-to-door, in this function, the user needs to provide the delivery address, time and size of the express box; The second is to receive the express box. After finding the appropriate express box, the user can scan the QR code on the box body or manually input the number of the express box to enter the mailing page and fill in the information such as the sender, the mailing address, the sender's contact information, the type of items to be mailed, the recipient, the recipient's address, the contact information of the recipient and the selected express company.

In the "collect package" section, the user scans the box body two-dimensional code or manually enters the express box number into the pick-up. The user needs to fill in the pick-up password. If the password matches correctly, the password lock opens automatically. If the password does not match, the sender will be notified. If the three password inputs do not match, the new pick-up password information will be sent to the receiver.

There are two main parts in the "my package" section. The first part is "the package I sent". After the express company checks the security of the package and weighs it, the notice of freight payment will pop up to the user. Second, "the package I collect ", users can track the status of express delivery logistics by inputting order number or checking information without knowing the order number. In the delivery stage, the system will confirm the location and time of the express box (which can be set in advance) with users. After the placement is completed, the system will push the delivery password information.



4. Summary

Intelligent express box breaks the traditional way of express delivery. And on the premise of guaranteeing its function and performance, we will speed up the research and development speed, make it enter the market as soon as possible, and provide convenience for the masses. Although the research and development process cannot be smooth, we will continue to study and improve.

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