

# Indoor Environment Remote Monitoring System Based on NB-IOT

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**Abstract.** Aiming at the importance attached to the indoor environment, design and development of the indoor environment monitoring system based on NB-IOT and sensor technology. The real-time system by a plurality of sensor nodes collect indoor environment parameters, ZigBee embedded transmitted over the network to the gateway, and then use the NB-IoT uploaded to the service center stores the data; APP monitoring indoor environment using a mobile phone. Users can view the indoor environment in real time and historical data track through remote terminals. Experiments show that the system can achieve real-time monitoring of the indoor environment. The system is stable, low-cost, low-power, easy to operate to meet the design requirements.

## 1. Introduction

Most people spend more than eighty-five percent of their time indoors. Indoor environment is directly related to human health, severe thermal environment will affect people's work status. In recent years, the introduction of modern office equipment due to the popularity of modern building air conditioning systems, as well as improve the tightness of the building, not the indoor harmful gas emissions, the amount of carbon dioxide rise, leading to "Air conditioning disease", "room syndrome." As people focus on the indoor environment, more and more research on indoor environmental monitoring international environmental issue has become one of the most concern.

Due to small size, low-cost and intelligent sensors, intelligent indoor environment monitoring possible, become a hot technology smart home. The development of intelligent home and abroad earlier, late twentieth century, Western countries established indoor air quality monitoring center for indoor air data detection government. Most researchers in the past used traditional GPRS technology to achieve remote monitoring. The system realizes the early warning and forecast of indoor environmental disasters by analyzing and processing the collected data, and transmits data through the NB-IOT network. Compared to traditional GPRS technology, NB-IOT has wide coverage, connect multiple, low-rate, low cost, low power consumption, excellent architectural features.

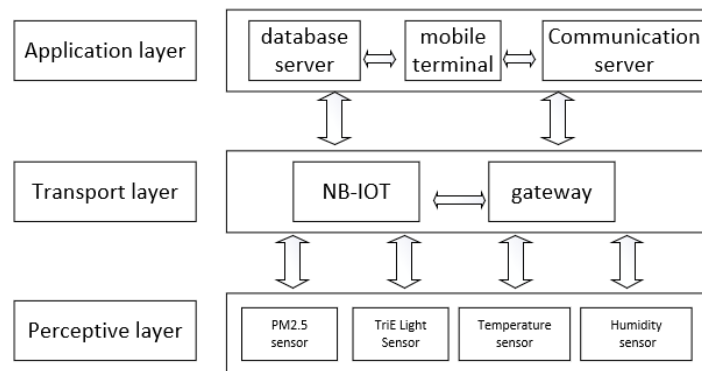
In this design, the authors began to try to replace the conventional GPRS network with NB-IOT technology. The use of technology is now mature to 4 m × 6 meters in an office as a test subject, under the NB-IOT technical support, design a remote monitoring system for the indoor environment.



## 2. System design

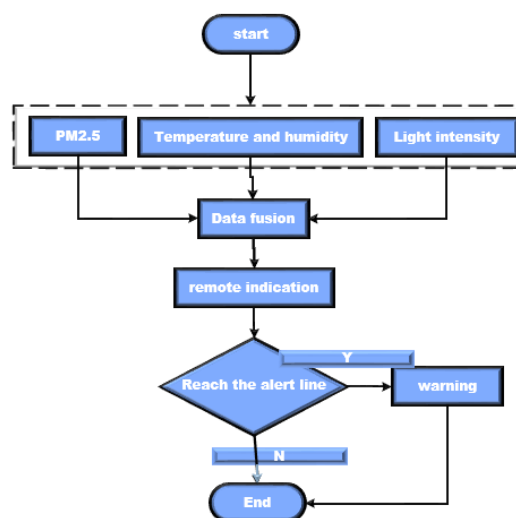
### 2.1. System architecture design

The system is modular, structured design. Specifically divided into an application layer, transport layer, a node layer. Node layer comprising: a light sensor, a temperature sensor, a dust sensor module. Transport layer is a link to the upper application and sensors and control equipment hub key, the embedded gateway, ZigBee networking and NB-IoT module. The master node is responsible for routing and transmission of the data stream, ZigBee collected by the water quality parameters measured by the sensor 485, the summary to the embedded gateway. On the one hand connected via a Zigbee network nodes each sensor acts as coordinator, on the other hand by the remote terminal NB-IOT; Android application layer of the mobile terminal, communications servers, and database servers. The database server is mainly responsible for keeping the indoor environment parameters embedded gateway uploaded communications server is mainly responsible for building embedded gateways and bridges Android mobile side, so communicate with each other; Andrews mobile terminal connect to the database server via HTTPS protocol, retrieval of data in the database Show it.



**Figure 1.** Two or more references.

The parameters of indoor environment are collected by the sensor nodes distributed in the room, and the collected data is sent to the embedded gateway via Zigbee network. After data fusion, the data is forwarded to the database server through NB-IOT network, and the alarm value is displayed, recorded and set by row data.



**Figure 2.** System flow chart.

## 2.2. NB-IOT Technology Introduction

NB-IoT is an emerging technology in the Internet of Things that supports low-power devices in the WAN cellular data connection, also known as low-power wide area network (LPWAN). NB-IoT support long standby time, the network connection demanding efficient connection device. It is said that NB-IoT device battery life can be increased by at least 10 years, while providing a very comprehensive coverage of indoor cellular data connection.

With regard to the development of Internet of things standards, HUAWEI has been the first to push forward. In May 2014, Huawei proposed NB M2M, a narrowband technology; in May 2015, NB-CIoT was formed by merging NB OFDMA; in July, NB-LTE and NB-CIoT were further merged to form NB-IOT; NB-IOT standards are expected to appear in 3GPP R13 and freeze in June 2016.

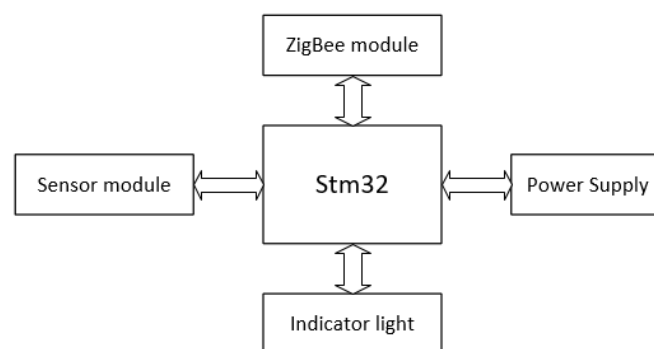
Prior to this, Huawei has focused more on building NB-IOT ecosystems than Ericsson, Nokia and Intel-driven NB-LTE, including Qualcomm, Vodafone, Deutsche Telecom, China Mobile, China Unicom, Bell and other mainstream operators, chipmakers and equipment system industry chains upstream and downstream.

## 3. System hardware design

### 3.1. Information Collection Node

The system sensor nodes using a common design, integration and mcu zigbee module. CC2530 infinite serial communication module based Zigbee2007 / PRO protocol the CC2530. Embedded Processor Module with the present design uses a microcontroller STM32F103VFT6 STMicroelectronics STM32 series.

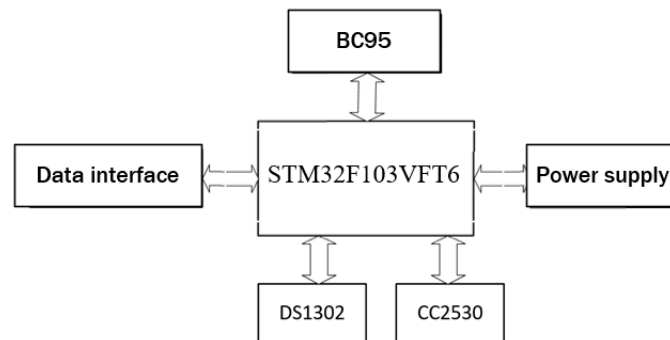
The battery module uses the Nanfu LR6-12B fifth battery. Since the sensor node is powered by a common fifth battery, the STM32 and CC2530 chip sleep states are set for long-term use. When the data acquisition and STM32 wake, wake-up data transmission module. 15ms delay, until the data transfer is completed, the data transfer module will be switched to the sleep mode again. If 30s is used as the sampling interval, the author can roughly calculate the single-section Nanfu LR6-12B battery for more than 60 days.



**Figure 3.** Node schematic.

### 3.2. Embedded Gateway

The module includes a ZigBee module, NB-IOT module, the microcontroller module, clock module, power module. The MCU module uses STM32F103VFT6 micro-control, and the clock module uses DS1302 clock chip. The ZigBee module uses CC2530 as the network coordinator to complete the information circulation of each node. The cellular network module uses the BC95 chip to replace the traditional GPRS module for data forwarding between the MCU and the communication server and database server. NB-IOT based network services, implemented by TCP / IP protocol with the AT command and remote messaging terminal; wherein BC95 chip also supports multiple IP connections, the connection may be implemented with a plurality of servers.



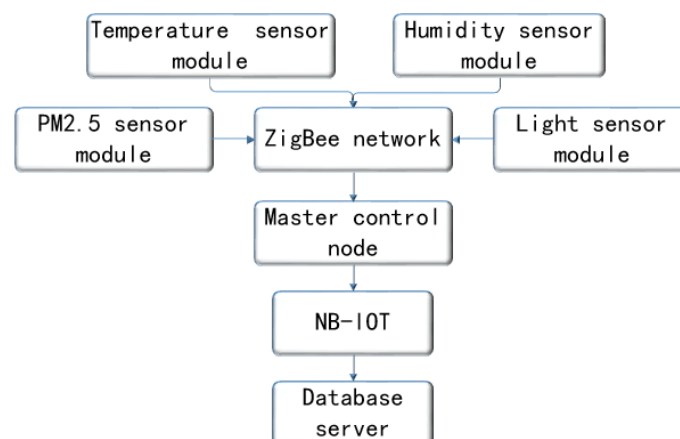
**Figure 4.** Embedded gateway schematic.

## 4. System software part design

### 4.1. Transport layer design

The mobile client presents data in the form of remote handheld terminal software. By software installed on Android phones, the system functionality enables remote monitoring of key parameters of indoor air quality, recording, alarm and control decisions related equipment and other functions. Using the display, automatic control and timing control data of the mobile APP, it is convenient for the user to grasp the indoor environment anytime and anywhere. The client server communication using the XMPP protocol connection, and send instructions to the communication line through the gateway server embedded. The gateway replies to the current water quality data information to the client. The client uses the post method in the AFNetworking framework to retrieve historical parameters such as temperature, humidity, pm2.5, and light intensity from the database server, and can display historical data through a line graph.

In order to facilitate the query of historical data. Database using open-source database MySQL, indoor air quality parameter data can be stored in the database, you can use SQL language and writing fast access to data. The software also plots and presents data curves for different environmental information.



**Figure 5.** Network structure diagram.

### 4.2. Mobile terminal APP design

Mobile client display data in the form of hand-held remote terminal software. By software installed on Android phones, the system functionality enables remote monitoring of key parameters of indoor air quality, recording, alarm and control decisions related equipment and other functions. Mobile display of APP, automatic control, timing control data, user grasp the indoor environment anytime and

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#### *4.3. Embedded Software Design*

The embedded gateway consists of devices such as the NB-IoT module and the embedded ARM board. The main gateway is to collect water quality data and upload the database, complete remote control. ARM board ZigBee wireless sensor network acquired by the sensor data, using the HTTP protocol to upload data data service center, stored in mysql.

(1) Listening: accept the data query, device control and other commands sent by the Android mobile terminal, and return the result to the client after making the corresponding operation.

(2) Disconnection reconnection: detect the long link between the embedded device and the server. If the device connection is interrupted, re-establish a connection with the server to ensure that the embedded device is always online.

(3) Timing: Use the clock module to detect whether the device operation time set by the user matches. If the time matches, the corresponding action is performed.

(4) Data upload: The data is collected every 0.5 minutes, and after analysis and filtering, it is uploaded to the database server for storage.

#### *4.4. Server design*

According to the press service center is divided into functional modules communications server and a database server. The two servers are designed separately and independently, so that the database service and the communication service do not interfere with each other. Communications Server uses the open source instant messaging system openFire, Tencent be deployed on a cloud server, client and embedded gateway to achieve the establishment of indirect communication, maintain a long link, transferring control commands and real-time data information between each other. The database server provides an interface for query and storage. It is responsible for saving all data uploaded by the embedded gateway. It is easy to use and use the Mysql relational database. Written in Java Webservice, Tencent will publish it on the cloud server, embedded gateway the collected data is uploaded to the server via HTTP protocol, save in Mysql database for mobile end view digital or chart type of real-time data and history data. The two servers are independent of each other and do not affect each other.

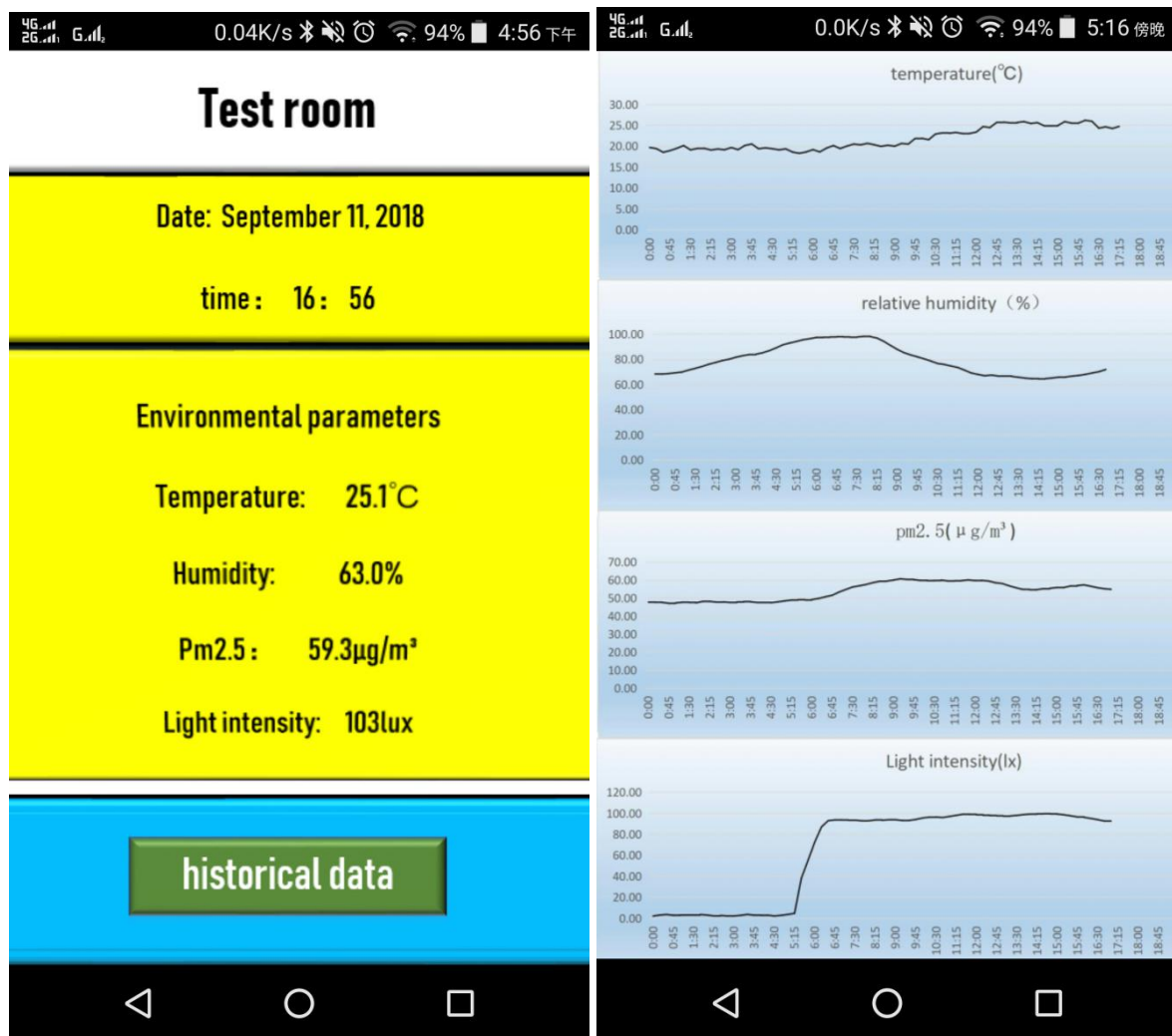
### **5. System test**

#### *5.1. Packet Loss Rate Test*

To verify the stability and reliability of the system, test the packet loss rate of NB-IoT. The system uses TCP / IP protocol, after three-way handshake to establish a connection, reducing the system loss rate, to ensure the integrity of data uploaded to the server. Five tests, the average transmit each packet to the server 388 through the NB-IoT network, each server module receives an average of 379.8 packets from NB-IoT, and the test results are averaged less than 1% loss ratio, to meet the system stability sexual requirements.

#### *5.2. Remote monitoring experiment*

The experiment was carried out in an office building in Shushan District, Hefei, Anhui, China. The remote monitoring system designed above was used for the test. The real-time display data and the data curve in the database were shown in Figure 6.



**Figure 6.** Android mobile app test interface diagram.

## 6. Epilogue

In order to realize the remote monitoring of indoor environmental information, a monitoring system is built based on NB-IOT network. Real time remote monitoring of indoor environment is realized through advanced NB-IOT technology. A real-time display on the phone shows that when the air quality is abnormal, the mobile phone will remind the user. Experiments show that the system meets the design requirements, realizes real-time remote monitoring of light intensity, air environment data, historical data query, warning output and other functions.

Compared with the subject that our research group did half a year ago, this paper studies and uses the latest Internet of Things technology in line with the development trend of the Internet of Things. The remote monitoring system has good compatibility with the expansion of the system, which can further cooperate with controllable refrigeration and heating devices to build indoor thermal comfort environment intelligent regulation system; with air purification devices or ventilation settings to build intelligent air cleanliness regulation system; can also be matched with simple electric hydraulic devices to achieve intelligent curtain, Smart door. NB-IoT technology will have a place in the field of environmental remote monitoring by virtue of its characteristics and advantages.

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