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Optimizing Industrial Production Lines through 4G DTU and Cloud-Based Remote Monitoring and Control Systems

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Abstract:

To achieve digitization in various industrial settings, a Data Transmission Unit (DTU) presents an effective solution for data acquisition and transmission. Utilizing a cloud platform enables real-time remote monitoring and control. In this study, the entire system is designed using 4G DTU and China Mobile's OneNET platform. Serial communication is employed between the production line and the DTU. A mobile application is developed to facilitate remote monitoring and control. This system is applicable to production lines equipped with serial ports, enabling rapid and straightforward digitization and networking.

Keywords:

4G DTU, OneNET cloud platform, remote monitoring, remote control.

1. Introduction

With the rapid development of intelligent manufacturing, production lines have been constantly upgrading[1]. But in practice, there are still some problems. At present, the automation is still inefficiency in the primary production and processing stage[2]. Most of the management and control rely on artificial. Intelligent control technology is not mature. Equipment status, personnel operation and production process cannot be real-time and accurate transmitted, which leads to various complicated and error prone production problems, low personnel efficiency and insufficient centralized control rate. Therefore, the production lines need to be further optimized. The data of production line can effectively improve the above problems. The digitalization of production line is one of the most effective methods[3].

Real-time data acquisition and transmission is essential for the digitalization. Wired transmission is the commonly used method in industrial environment. The cost is high and the cabling is inconvenient. Wireless data transmission is more potential[4]. Considering the complex industrial environment and many interference factors, wireless data transmission faces greater challenges. High packet loss rate and large interference are the biggest problems restricting the usage of traditional WiFi, 2.4G[5] and other wireless technologies in industrial environment. New generation NB-IOT technology has the shortage of small data transmission[6]. The applications are also limited. In order to solve the above problems, 4G DTU(data transfer unit), cloud system and sensors are used to monitor various production processes, which is easier to implement without reconstructing the production line compared to other methods. The DTU can transfers serial data to carrier network through RS232 / RS485. 4G is one of the most commonly used technologies of DTU[6]. The maximum downlink speed can reach to 150Mbps, and the maximum uplink speed can reach to 50Mbps. The speed property is enough for most applications. Movable 4G DTU can break the limitation of time and space, compared with the traditional network. The system is easy to configure. The whole communication link can be checked clearly. It has different built-in working modes, such as transparent transmission, HTTP and etc. In order to further improve the utilization of mobile network, multi-channel TCP / UDP connections are available. Cloud system is used to monitor the status and operate the production line remotely.

Using the data, real-time and visual monitoring and intelligent control of equipment can be achieved. The system is significant to solve the problems in the practical application of enterprise production line, and improve the product quality and economic benefits of enterprises.

Generally speaking, the overall solution using 4G DTU and cloud platform has great potential in the development process of industry 4.0. Most researches focus on the short distance wireless communication in LAN. The work on how to upgrade the production lines using WAN technologies is limited. So, a remote monitoring system based on DTU and cloud platform is designed in this paper. Through the cloud platform, the collected information can be monitored and remote control can also be realized.

2. Hardware Structure Design

2.1. Overall Design

The specific design is provided in Figure 1.

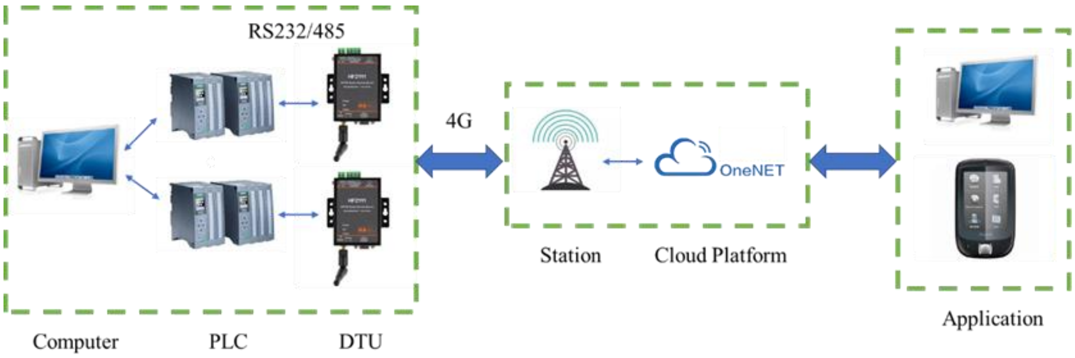

Figure 1. System structure diagram

The system includes three parts: data acquisition and transmission part, data storage part, remote monitoring and control terminal.

In industrial site, the production line is usually controlled by PLC. The data acquisition and transmission part includes computer, PLC and DTU. Computer is used to design the function of the production line. It can be realized through PLC. The data collected by PLC can be sent to DTU through serial port. When DTU receives the remote control command from cloud platform, the data is also sent to PLC through serial port. The collected data is stored in OneNET cloud platform through 4G module. TCP transparent transmission protocol is used to transmit the data. Users can remotely monitor information or send control commands by creating desktop or mobile applications.

2.2. DTU Design

DTU is the core component of data acquisition and transmission part. The system consists of Cortex-M3 microcontroller, 4G communication module, flash, serial port and so on. The hardware structure of the system is shown in Figure 2. In this system, ARM Cortex-M3 with the frequency 96MHz is used as MCU. HF-GL40 4G modem is selected as the communication module. After power on, MCU is connected with 4G communication module through RS232 serial port. Initialization of 4G module is finished by MCU through data receiving and sending. Meanwhile, flash memory GD25Q16CSIG and MCU conduct bidirectional data exchange. When the wireless DTU terminal is abnormal, watchdog will intelligently wake up the software or restart the hardware to ensure the smooth wireless networking and keep wireless data transmission in real time, which has great advantages in industrial applications.

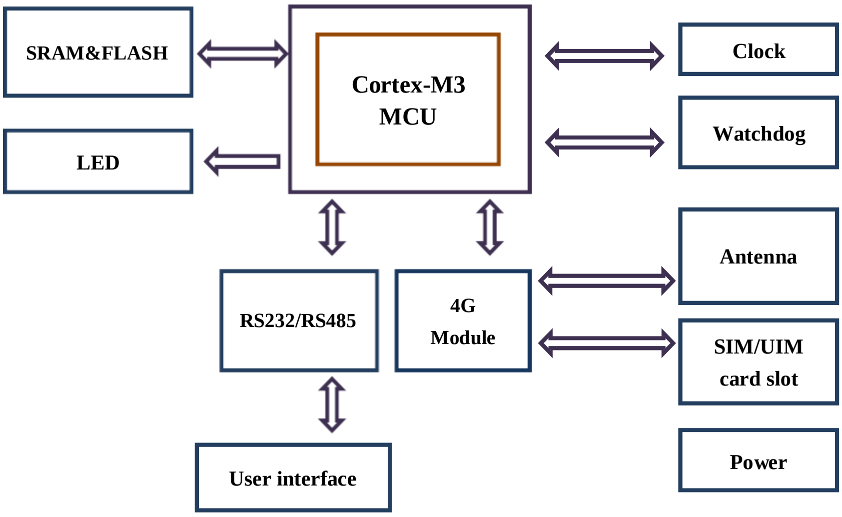

Figure 2. Structure diagram of DTU

2.3. DTU Configuration

Before connecting the cloud platform, parameters of DTU must be configured. The configuration follows the procedure below.

Firstly, open the serial port operator to select the device, and then open the serial port according to the current device serial port parameters to read the parameters.

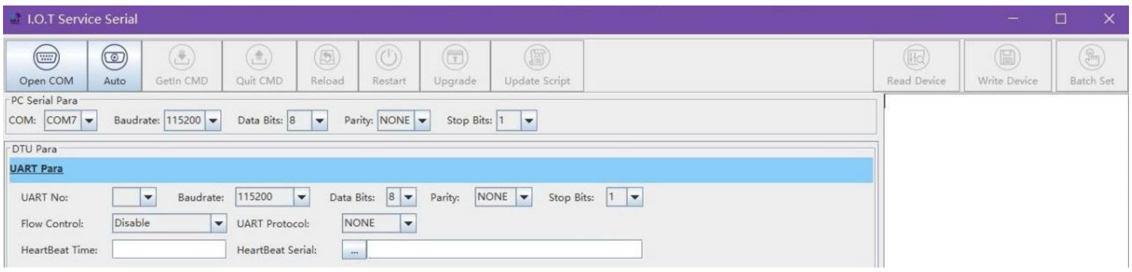

Figure 3. Interface of DTU configuration software

After pressing the "Read" button, the working status of the current module will be displayed. The parameters can be modified. Here, the following parameters are used. The DTU supports multiple access network protocols. TCP transparent transmission is selected for this study. Since DTU is used as client and cloud platform as server, TCP-client is selected. Server address and port can be found from the development document. Server address is 183.230.40.40 and port is 1811. The connection mode is always, which means long connection. Disconnection time and heartbeat time are not specially set. Generally, the heartbeat is used to maintain a long network connection and send heartbeat packets at intervals to inform the platform that it is still active. Registration package mode is the login message, which can be sent when the connection is successful, and the message content is * $PID # $auth_ INFO#$PARSER_ Name *, which is consistent with the information provided by cloud platform. After the parameter configuration is completed, click write parameter and wait for the write to complete.

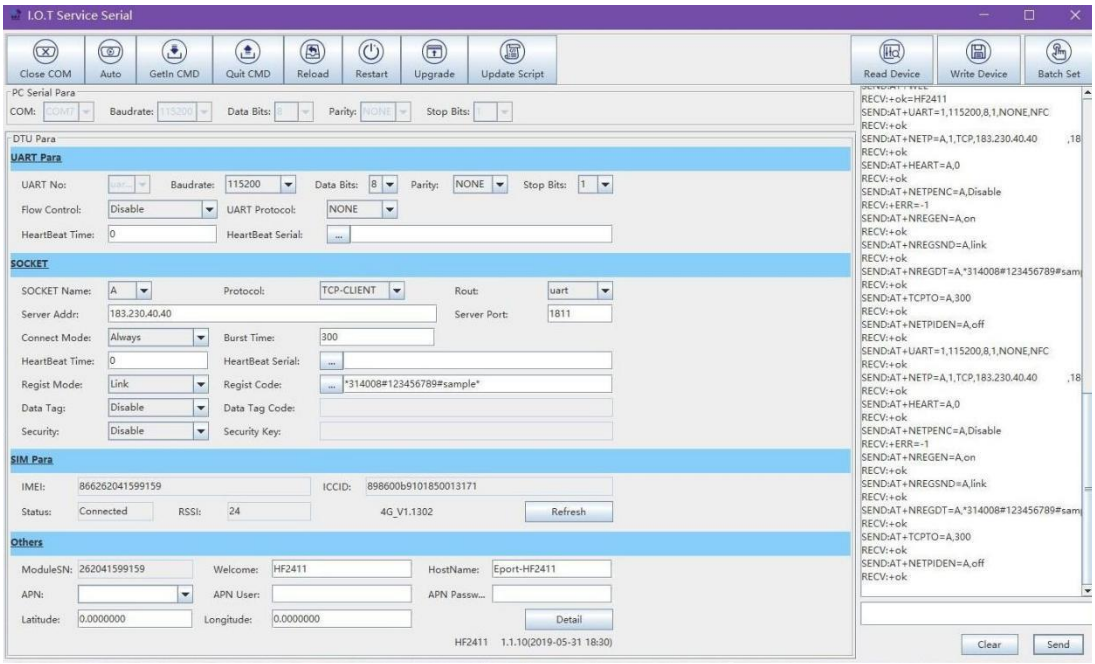

Figure 4. Parameter configuration

3. TCP Transparent Transmission

Onenet platform provides TCP transparent transmission protocol. This protocol aims to weaken the modification made by terminal test software to adapt to the protocol as far as possible. The cloud platform is responsible for resolving the protocol, which is more convenient for different terminals. It provides the feasibility for any protocol device to access to OneNET. If the device is connected to OneNET through TCP connection, data interaction can be carried out between the device and OneNET after successful authentication. Different from HTTP or MQTT, which has strict format requirements for uploading data, TCP transparent transmission protocol uses user-defined scripts uploaded by users to realize the parsing and sending data to the device. This protocol is flexible. The high flexibility of TCP transparent transmission determines that it is not constrained. It is mainly applicable to user-defined protocols. It can complete the interaction of any protocol according to the script defined by itself. The script canbe modified and uploaded at any time. The protocol supports one connection to transmit data from multiple devices. In a centralized manner, data from multiple devices can be uploaded and distributed. It has a wide range of applications in the field of intelligent meters, such as intelligent meters, intelligent water meters.

User-defined protocols are usually written in Lua scripts. It usually includes three parts. First of all, analyze the information uploaded by the underlying device to the platform is the most important function of the protocol. Secondly, the platform can send instructions to the bottom layer. What's more, some supporting parts are also necessary.

3.1. Analyze the Uploading Information

Taking the cloud platform sends "received" to DTU after receiving data as an example, the codeis as follows.

```
function    device_data_analyze(dev)
    local t = {} --define data-flow
    local a = 0
    local    s    =    dev:size()    --    Get    uploading    data    length
    add_val(t,"ds_id",a,dev:bytes(1,s)) -- Add to the data-flow "ds_id"
```

```
    dev:response()        -- Send response
    dev:send("received") -- Send "received"
    return s,to_json(t) --Save data
end
```

3.2. Send Instructions

Taking the cloud platform sends “hello” to DTU from cloud platform every ten seconds as an example, the code is as follows.

```
function device_timer_init(dev)
    dev:timeout(3)            -- Response timeout 3 seconds
    dev:add(10,"ds_test","hello")  -- Send a packet of data every 10 seconds, the content is
“hello”
```

4. Application Design

For OneNET cloud platform, convenient application design is one of the advantages. Using the RESTful API, the relevant application is developed according to the related hardware equipment and uploaded data. The website provides convenient application editor, which can develop application quickly. After completing the system design, a web version of the application is designed. After the application is published, a web address will be generated. Through this application, the data uploaded by DTU can be visualized clearly by logging in to the website. Commands can be sent to DTU using the application. The interface of the application is shown as following.

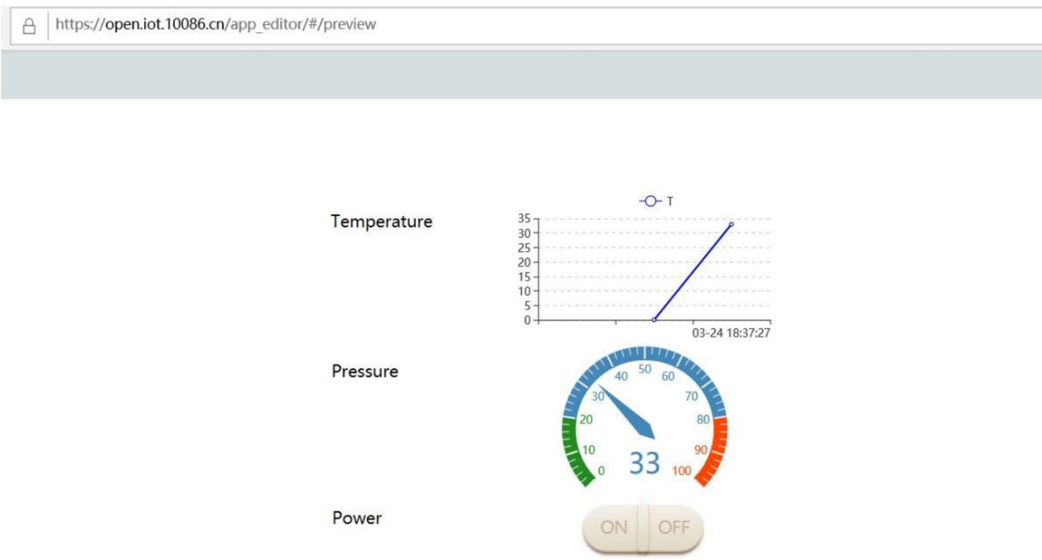

Figure 5. Interface of the application

5. Conclusions

Using 4G DTU and OneNET cloud platform, digitization can be realized conveniently. TCP transparent transmission protocol is used to analysis the information between cloud platform and DTU. A web application is designed to monitor the information collecting from DTU. Command is also can be sent from website to DTU. Compared with other technologies, there is no need for large-scale transformation of the existing production line using this system, which is suitable for promotion.

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