Research on Power Consumption Control Method of Online Teaching Terminal Based on IEEE 802.11

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Abstract. The online teaching terminal of Internet of things platform has a huge amount of information transmission, and power consumption has become one of the important factors restricting the development of mobile Internet of things teaching platform. In order to ensure the good operation of online teaching terminal, a power consumption control method of online teaching terminal based on IEEE802.11 is proposed. Collect power consumption characteristic data, optimize the power control protocol of online teaching terminal according to different application scenarios of mobile Internet of things platform, reduce the average power consumption of online teaching terminal without changing the hardware of mobile network and online teaching terminal, so as to achieve the low-power operation state of online teaching terminal of mobile Internet of things platform.

Keywords: IEEE802.11 · Internet of things platform · Online teaching terminal · Power consumption control

1 Introduction

With the continuous expansion of the application scale of the online teaching platform of the Internet of Things, the power consumption of the online teaching terminal of the platform of the Internet of Things is getting higher and higher. The low-power design of the online teaching terminal of the Internet of Things platform is a research hotspot. The online teaching terminal node of the Internet of Things platform contains high-performance modules, such as baseband processing, signal processing and RF power control, etc., with high power consumption. In the operation process, the online teaching terminal nodes of the Internet of Things platform drive multiple online teaching terminals of the Internet of Things platform, collect and transmit the data of the online teaching terminal of the Internet of Things platform, process and analyze the data, fix the wireless digital baseband, network formation, and drive the RADIO frequency to send information, which all need to consume a large amount of current [1].

The current power consumption control technology has limited power, so it is difficult to make the online teaching terminal node of Internet of Things platform work for a long time. Internet online teaching platform terminal nodes need to work continuously for

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one year and do not need to change, power consumption in recent years, the node online teaching terminal of the low power design is very important, most of the time, only the Internet of things platform online teaching terminal and its drive peripheral equipment to keep working, and the central processor and some high-performance power control module in the idle state [2]. Therefore, only a small part of the online teaching terminal nodes of the Internet of Things platform need to keep working during most of the time. If most of the other idle modules can be shut down or turned off, the dynamic and static power consumption of the Internet of Things platform will be significantly reduced.

In the traditional online teaching terminal power control method of the Internet of Things platform, all terminals control their working state accordingly according to the sequence information. In order to reduce the collision probability of the competing channel, the response competition window is introduced. When there is no data grouping in an access point (AP), the AP broadcasts the GAS frame and activates the idle timer. All terminals go to sleep until the idle timer expires [3]. However, the method neglects the collection of power characteristic data, which leads to a large error in power control.

For this reason, an IoT terminal power control method based on IEEE802.11 is proposed. According to the different application scenarios of the mobile Internet of Things, the terminal power control protocol is optimized, and the average power consumption of the terminal is reduced without changing the mobile network and terminal hardware, so as to improve the service time of the terminal power consumption of the mobile Internet of Things.

2 Power Consumption Control Method of Online Teaching Terminal of Internet of Things Platform

2.1 Power Characteristic Data Acquisition

Most of the online teaching terminal data of the Internet of Things platform are stored in the acquisition and sensing layer, and the information is transmitted to the network transport layer. Although the equipment can be maintained to work all the time in the power consumption life cycle of the online teaching terminal of the Internet of Things platform, the defects are obvious at the same time. The charging controller of the online teaching terminal equipment of the Internet of Things platform takes up the investment cost, and the installation is complicated, which requires a special bracket to fix the solar power consumption board, and the power consumption is also limited by charging times. Generally, the charging period is about 400 to 600 cycles, and it needs to be replaced after running for about 2 years [3]. With the development of modern technology, more and more low-power Internet of Things platforms are launched, and the power control technology is becoming more and more mature, which makes the power consumption capacity of the same information storage capacity gradually increase. The wireless channel of the online teaching terminal of the Internet of Things platform refers to the propagation path of the electromagnetic wave signal of the online teaching terminal of the Internet of Things platform between the transmitting end and the receiving end. A linear band-pass model is used to describe the wireless channel to construct the structure of the online teaching terminal of the Internet of Things platform, as shown in the Fig. 1.

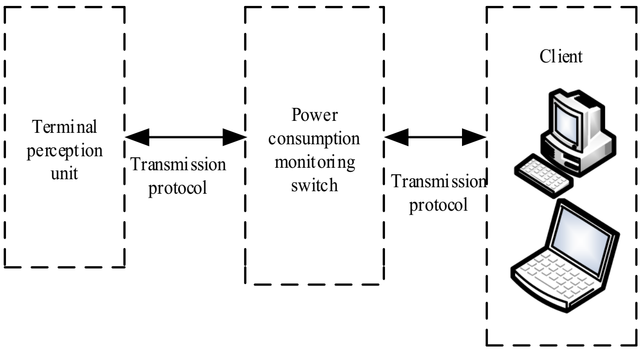

Fig. 1. Internet of things platform online teaching terminal wireless channel structure composition

Internet of Things platform online teaching terminal data acquisition telemetry Online teaching terminal should realize the data acquisition of various online teaching terminals on the site of Internet of Things platform. Acquisition signals can be divided into three types: analog signals, digital signals and Internet of Things platform interface signals. Among them, the analog quantity is mainly 4–20 mA current or 0–5 V voltage, the digital quantity signal is mainly switching quantity and pulse quantity signal, and the interface signal of the Internet of Things platform is mainly RS232 and RS485 interface. The wireless Internet of things platform of data acquisition and telemetry online teaching terminal adopts GPRS mode. Using the SIM900A Platform module of the Internet of Things, the establishment of the platform link of the Internet of Things and the sending and receiving of data are completed through AT instruction [4]. The principle of the multi-channel transmission model under the Internet of Things platform is to determine the information output path according to the stability of the two-party network controlled by power consumption and the processing of the system's online teaching terminal. The subsequent multiplexing key and the process of multiplexing should follow this principle to select the path. Figure 2 shows the multi-channel transmission model under the Internet of Things platform environment.

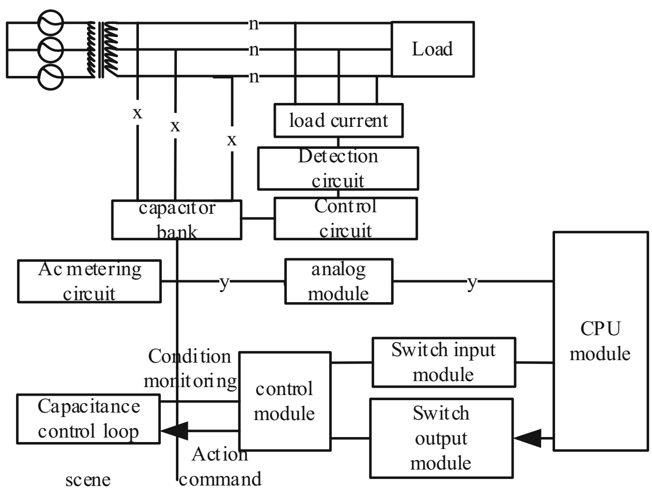

Fig. 2. Power transmission model in the environment of Internet of things

X and Y in the figure are two online teaching terminals of the Internet of Things platform, and there are many information transmission paths of the Internet of Things platform between these two online teaching terminals. N1, N2… Ni + 1 in the figure are intermediate forwarding stations on the paths. If one of the paths is used to transmit information during power consumption control, the attacker can get all the information of power consumption control only by attacking any intermediate forwarding station on this path. If multiple paths are used to transmit information during power consumption control, the attacker must attack at least one station on each path to get some information of power consumption control [5]. The Internet of Things platform manager is the clock of the whole chip and the control center of the Internet of Things platform. Clock gating and power gating of each module in the control chip. Under the control of the Internet of Things platform manager, general peripheral modules can enter three modes: working mode, sleep mode and deep sleep mode. In addition to these three modes, the CPU can also enter the backup mode. In the transmission process of its Internet of Things platform, a series of vector δ of signal components after varying degrees of attenuation h, delay and phase shift arrive at the receiving end due to multipath effect. The discrete time-domain multipath model is described as a linear bandpass filter, and its equivalent baseband pulse effect X is shown in formula.

$$\mathrm{X} = \sum_{l=0}^{N(\mathrm{d,t})-1} \alpha_l(\mathrm{d, t})e^{-j} \cdot (\tau - \tau_l(\mathrm{d, t})) - lh(\mathrm{d, t}, \tau) \tag{1}$$

Where l represents the resolvable path component of the l, N(d, t) is the spacing between the terminals d, the number of resolvable multipath components at observation time t, where $\tau_l(\mathrm{d, t})$ represents the arrival path relative to the first, The arrival delay of path $l.\alpha_1(\mathrm{d, t})\mathrm{e}^{-j}$ is the component of article l when the distance d and the observation time t are measured. The amplitude and phase of the l path component in the delay time $\tau_l(\mathrm{d, t})$. The multipath channel time domain model is constructed under the fixed distance between the transceiver and the wireless power control node. Among them, link loss is not only related to the coverage of wireless power control, but also related to the link budget, which is the most important large-scale fading parameter [6]. A link loss model is proposed for the transmission channel of short-distance wireless power consumption control on the Internet of Things platform in 2.4 GHz. Assume that the distance between the receiver and the transmitter is d, and if the transmitter transmits power $\mathrm{P_t}$, the test gain is known as $\mathrm{G_t}$ and where the gain is included $\mathrm{G_r}$, if the receiving power at the receiving end is p (d), the link loss can be expressed by the following formula.

$$P_t + G_t + G_r = 10n\lg p(d) + \mathrm{X} + lh(\mathrm{d, t}, \tau) \tag{2}$$

Where, n is path loss index.In the application of the Internet of Things platform, especially in the field, the collection points are scattered, many of them are remote, and the network coverage is poor [7].Considering the needs of low power consumption and wide coverage of power consumption control network, GPRS wireless power consumption control network in 4G mode is selected as the information transmission mode of wireless Internet of Things. For broadband power consumption control, negative impulse response can be used to calculate link loss. Then the total received power can be calculated, which can be expressed as the formula:

$$P_r(d,t) = \sum_{l=0}^{M(d,t)-1} \alpha_1^2(d,t)/P_t + G_t + G_r \tag{3}$$

Where, M is the number of multipath components. α_1^2 is shadow fading.

Assuming that a total of K points are tested around the distance d point, the total received power can be expressed as formula:

$$P_{\mathrm{t}}(d,t) = 1/\sum_{K=0}^{K-1} K \sum_{l=0}^{N(d,t)-1} \alpha_1^2(d,t) \tag{4}$$

The algorithm is very important in the software design of the online teaching terminal of the Internet of Things platform. To solve the information problem under normal circumstances, the formula can be used to express:

$$W(a)_{\min} = \sum_{i=1}^{n} \lambda_i [\left(\mathrm{K}_i^t \alpha_1^2\right) + KP_r(d,t)] P_{\mathrm{t}}(d,t) \tag{5}$$

The function of online teaching terminal information collection can be expressed by formula:

$$W(\mathrm{b})_{\min} = \sum_{i=1}^{\mathrm{m}} \lambda_i(-b_i)\mathrm{t} - \delta y\left(\frac{1}{\delta}\sum_{i=1}^{m} k_i b_i\right) \tag{6}$$

Where, $\mathrm{k}_1, \cdots, k_{\mathrm{m}} \in 2^m$ is a vector of m pieces of information; $\lambda_1, \cdots, \lambda_{\mathrm{m}}$ is the amount of information loss; y represents the coefficient of the function; δ stands for conjugate function; b represents the variable of the fault information function.

$t \geq 0$ is the function parameter. Each information variable c_i corresponds to a stored variable. The constraint software function model can be obtained from the above formula:

$$f(a)_{\min} = \|Fa - r\|_3^3 + z\left\|\mathrm{a}\lambda_i\left(\mathrm{c}_i^t a\right)\right\|_2 \tag{7}$$

Where, F belongs to the matrix of n items of fault information; z is the parameter of information constraint.

2.2 Power Consumption Control Algorithm of Online Teaching Terminal of Internet of Things Platform

The low-power design of wireless Internet of Things platform online teaching terminal network software can be divided into different levels according to the network protocol stack, that is, the physical layer, the MAC layer, the network layer and the application layer. The emphasis is on the research, design and implementation of the physical layer and the MAC layer. The online teaching terminal of the Internet of Things platform only performs power control at a fixed time point or specified time point, and does not perform power control at other times [8]. The samples from the established learning and training sample set are input into the neural network structure for learning and training. The process is as follows:

Input fault sample (xi) to the input layer of BP neural network. In the input layer, when the following constraints are satisfied, namely, the formula, output and input into the hidden layer.

$$\mathrm{A} = \sum_{i=1}^{1} \sqrt{\mathrm{BC}} - \frac{\mathrm{d}}{2}\mathrm{e} \tag{8}$$

Where, A is the target output; B and C are the output functions of each neuron between the input layer and the hidden layer; d is the initial value of the weight; e is the threshold. Input the ith neuron from the input layer into the hidden layer according to formula (9) below.

$$u1 = \sum_{i=1}^{N} w \cdot x \tag{9}$$

In the formula, w is the weight. The output result of the hidden layer is as follows:

$$y1 = f\left[\sum_{i=1}^{N} w \cdot x\right] \tag{10}$$

In the formula, f is the number of alternations. Input the output of the hidden layer into the output layer as follows.

$$u2 = \sum_{i=1}^{N} w \cdot y1 \tag{11}$$

Output results of the output layer are obtained:

$$y2 = f\left[\sum_{i=1}^{N} w \cdot y1\right] \tag{12}$$

5) Output layer error g is:

$$g = m - y^2 \tag{13}$$

In the formula, m is the expected output value and $g = m - y^2$ is the actual output value output layer. Judge whether the error value g meets the termination condition. If it meets the termination condition, it ends. If it does not, it needs to carry out back-propagation to adjust the connection weight W between neurons in each layer, so that the weights can be infinitely connected with the expected value after the output of the transfer function. Then the weights of each neuron after the correction of the weights are calculated, and the results are compared with the expected values again When the results meet the conditions, the sample training is finished [9]. According to the working mode, the online teaching terminal of mobile Internet of things platform is divided into three states: null, standby and connected. The main principle of online teaching terminal power control is to make the online teaching terminal as low power consumption as possible. Power optimization is based on the Internet of things platform [10–12]. The three-layer neural network structure, namely neural network, is adopted, as shown in Fig. 3.

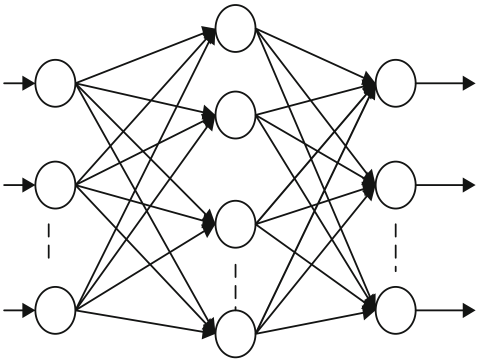

Fig. 3. Control layer structure of neural network

Neural network control operation direction can be divided into two types: forward propagation, that is, fault samples are input into the input layer, and then into the hidden layer. After the hidden layer processing, the final output results are output through the output layer, and each layer of neurons only works on the next layer of neurons; reverse transmission: when the output of the output layer is not accurate, it needs to reverse (output layer → hidden layer → Input layer) modify the connection weight of each layer (which can be modified for many times) to obtain the most accurate fault diagnosis results. Online teaching terminals are in fixed or low mobility application scenarios. Many Internet of things platforms online teaching terminals are in fixed or low-speed mobile application scenarios [13].

2.3 Realization of Power Consumption Control of Online Teaching Terminal on Internet of Things Platform

The protocol stack is initialized; then the idle channel is selected to construct the network environment, and finally the channel is found. If the appropriate channel is found, the coordinator will have the pan identification, which can represent the whole network information monitoring situation. Therefore, it is necessary to select pan identification. If there is information missing at the node, intelligent scanning should be carried out to find out whether there is a coordinator in the surrounding environment, and then the beacon should be monitored within the scanning limit to obtain the relevant information of the coordinator and send a connection request. Finally, the coordinator node is assigned a short address, which contains the new address and the instruction of the successful connection state, so that the information power consumption can be controlled. The specific process is shown in the figure (Fig. 4).

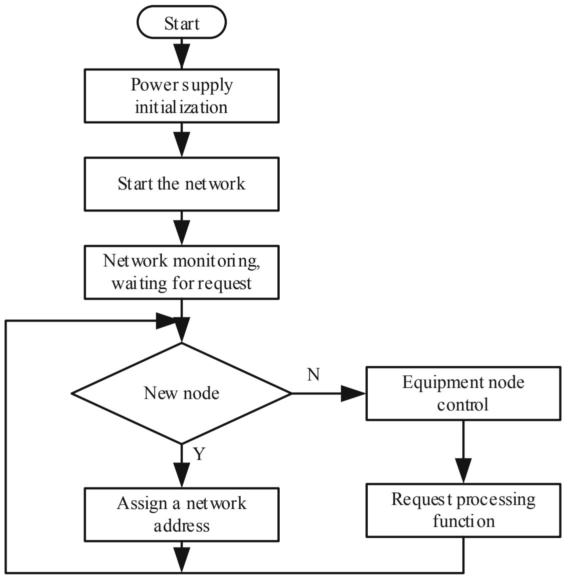

Fig. 4. Power consumsption control flow of online teaching terminal on internet of things platform

As the network master node in the Internet of Things platform environment, the wireless power consumption control technology coordinator node can exchange the old address and the new address in real time. This kind of online teaching terminal does not need to move or only moves at low speed. The principle of power consumption optimization is to reduce the power consumption in low Standby state and Connected state by reducing the mobility management process. The specific implementation method is a protocol optimization process that reduces power consumption and location area update frequency by optimizing periodic location/routing area update process, reducing the number and frequency of service and neighbor cell measurements in Standby state and reducing the number and frequency of service and neighbor cell measurements in Connected state. If T3212 timer is set to 30 min, it takes 250 ms to update the location area or routing area once, that is, every 30 min, which can save the working power consumption of 54 TDMA frames. Optimize the protocol control flow of measurement frequency and cell number to reduce power consumption. After optimization design, if there are 102 TDMA in a paging cycle, it saves 2 TDMA frames for measurement, reception and calculation, and reduces the average standby power consumption. Based on this, the energy consumption control state of the online teaching terminal of the Internet of Things platform is optimized, as shown in Fig. 5:

After building the energy consumption control platform of the online teaching terminal of the Internet of Things platform, the functional optimization is carried out. In the process of functional optimization, it is necessary to verify whether the functions of the

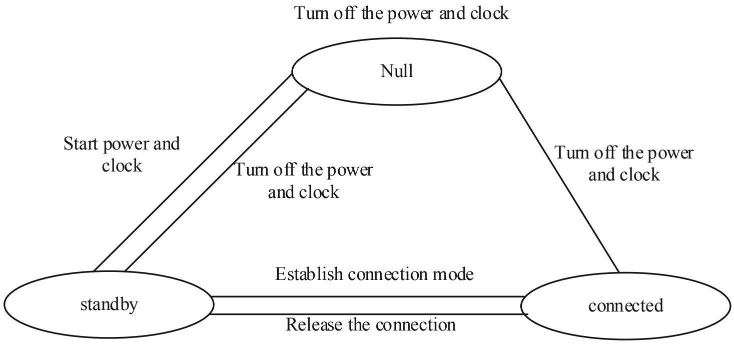

Fig. 5. Energy consumption control status of online teaching terminal of internet of things platform

online teaching terminal of the Internet of Things platform meet the design requirements. The following aspects need to be optimized in functional testing:

1) Whether the receiving module can receive the power consumption data of the online teaching terminal of the Internet of Things platform is verified whether the functions of the Internet of Things platform are normal.
2) Verify whether the platform and data processing function of the Internet of Things are normal through the analysis of the received operation data.
3) Through analysis, the data values of online teaching terminals of the Internet of Things platform are obtained, and compared with the actual output of online teaching terminals of the Internet of Things platform or the simulated value of instruments and meters, to verify whether the data collection function is normal.
4) By setting the time interval of certain timing startup, the observation of equipment operation and data reception is consistent with the set time interval. It can judge whether the response of the online teaching terminal of the Internet of Things is normal.
5) By triggering the associated external triggers, the collection and sending functions of the device are started to check the running state of the device and the condition of the data receiving end.
6) Use serial port to connect with the computer, use the setting software to set the parameters, and verify whether the setting function of the online teaching terminal is normal. At the same time, the setup software is used to read the internal Flash area of the online teaching terminal and check whether the data control function is normal.

Compared with the common online teaching terminals on the Internet of things platform, the power consumption in the non-power control state is reduced from 5 mA to less than 100 A level after optimization. Optimization in two situations: one kind is when the Internet of things online teaching platform terminal peripherals with RTC, RTC power overflow, peripherals to start the iot terminal online teaching platform, hosted network, power control, power control, instructs the peripherals to start the timer values of the next boot, peripherals to close the terminal iot online teaching platform, online teaching terminal in a microampere level of ultra-low power consumption; The other is that when the peripherals of the Internet of Things platform are not equipped with RTC, when the internal RTC power overflow occurs in the online teaching terminal of the Internet of Things platform, the online teaching terminal of the Internet of Things platform is started, the resident network is maintained, other power sources and clocks of the terminals are turned off, and the power consumption is low. Optimize the power control principle of the Internet of Things platform, as shown in Fig. 6:

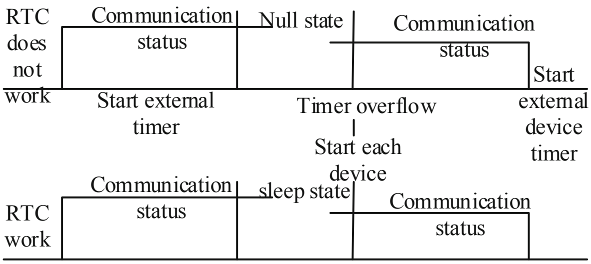

Fig. 6. Power consumption control principle of internet of things platform

Iot online teaching platform terminal nodes on the introduction of the Internet of things platform manager, can according to the Internet of things platform of each module in the idle state, in the wake of time and save the power to make a compromise between, to select the most appropriate for each of the Internet of things platform domain sleep sleep depth, significantly save a iot of online teaching platform terminal node power consumption, but at the cost of the Internet of things platform manager itself in the Internet of things platform, therefore, the Internet of things platform manager's power consumption on a piece of very important in the design of low power consumption. The iot platform manager has one core manager and four APB managers. The entire IOT platform manager is located at SMIC 130 nm. The power consumption of 1.08 V and 32 kHz is shown in Table 1.

Table 1. Power consumption of online teaching terminal module of Internet of Things platform

Submodule	Core Power Manager	Single APB power management	Total power
Dynamic power consumption	0.046	0.008	0.063
Static power consumption	0.678	0.341	1.050
Total power consumption	0.751	0.329	2.034

This paper briefly introduces the requirements, structure, hardware composition and embedded software structure of the data acquisition telemetry online teaching terminal.

This paper introduces the structure of information acquisition and data processing on the platform of Internet of Things, and analyzes the position and function of the online teaching terminal of data acquisition and telemetry in the platform of Internet of Things. The design idea and overall design principle of the data acquisition telemetry online teaching terminal are described from the perspective of the equipment components, and the design framework is given. The definition of software function module and function division of several tasks are given. To realize the research goal of effectively controlling the power consumption of online teaching terminals on the Internet of Things platform.

3 Analysis of Experimental Results

In order to verify the power consumption control method of Internet of things platform online teaching terminal based on IEEE802.11, MATLAB software is used to fit the test data according to logarithmic distance path loss model and improved model. The experimental simulation platform of Internet of things platform is constructed in matlab7.0 environment. The network simulator is used as information transmission simulator, and C++ language is used as network protocol Results: the standardized experimental platform tools are shown in Table 2.

Table 2. Experimental tool parameters

Type	Tool name
Development system	Windows 2013
Development platform	ASP.NET + IIS5.0
Data access	Data access class library set (ADO.NET)
Using tools	Photoshop, Dreamwever
Programming languages	SQL, HTML
Database server	SQL Server 2014

The log distance path loss model parameters of the scene under different operating frequencies are shown in Table 3, and the modified model parameters are shown in Table 3.

Table 3. Improving model parameters

Frequency	Path loss index	Attenuation factor
Power index	2405	2480
The path loss index	70.26	72.16
Long distance transfer factor	2153	2100
Short distance transmission factor	−9.45	−8.95

In order to better reflect the accuracy of the power control method of the online teaching terminal of the Internet of things platform based on IEEE802.11, this paper compared the traditional control method and added gupl model to verify the three parameter models, and compared the root mean square error (RMSE). If the root mean square error is smaller, the accuracy of the corresponding model will be higher, and the more accurate description of the Internet of things platform will be Wireless transmission channel characteristics. Among them, the measured values are measured in the experimental environment, and the predicted values are predicted in the experimental environment when the predicted values are different models.

$$RMSE = \sqrt{\frac{\sum_{n=1}^{N} |f(n) - f'(n)|^2}{n}} \tag{14}$$

The specific experimental results of the root mean square error of the traditional method and the proposed method are as follows (Fig. 7):

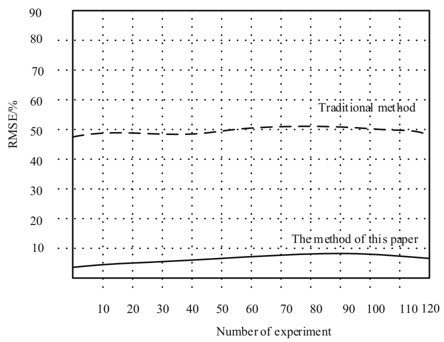

Fig. 7. Comparison of experimental detection results

According to the experimental results in the figure above, compared with the traditional method, the proposed online teaching terminal power control method has a lower root mean square error. In 120 experimental iterations, its mean square error has been less than 10%, while the traditional method has a root mean square error of about 50%. The above data show that the proposed method is more applicable.

The measured data are exported, and the mean value is calculated according to the sequence of distance, and the mean value of path loss measurement is plotted. With the help of the improved model, the mean value of the measured data was fitted, and the fitting curve of the improved model was drawn. As shown in the figure. It can be seen from the figure that the improved model can better predict the path loss at three measurement frequencies (Fig. 8).

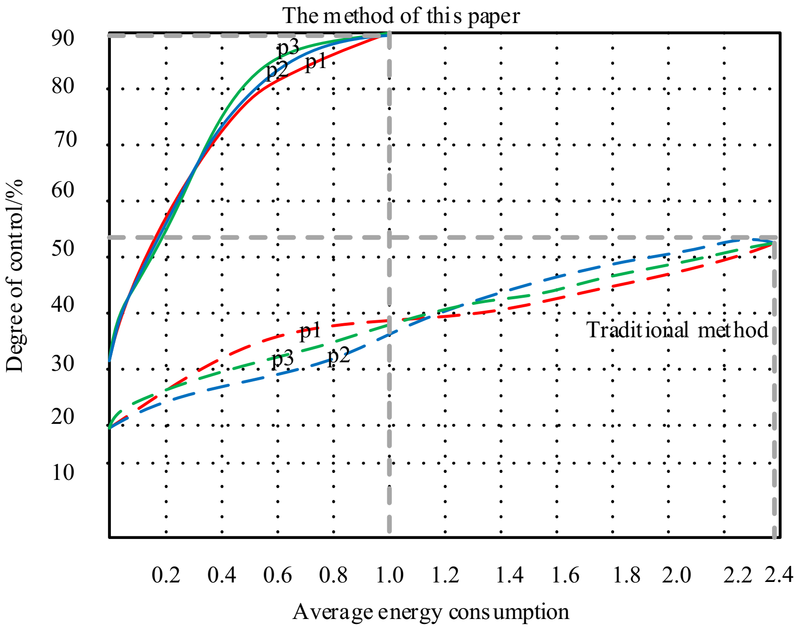

Fig. 8. Compare the test results

Based on the above figure, compared with the traditional control methods, the proposed power consumption control method of the Internet of things platform online teaching terminal based on IEEE802.11 in the actual application process, the control accuracy is obviously better than the traditional method, and the power consumption is relatively lower, which fully meets the research requirements.

4 Conclusion

In side don't need to modify the network control protocol (TCP) power consumption and terminal side equipment under the premise of online teaching based on Internet of things platform online teaching business application characteristics of the dynamic optimization process and parameters, terminal power consumption control agreement to make the Internet of things platform terminal in the connection state of online teaching have significantly lower power consumption, and decrease the cost of the Internet of things platform online teaching the use of the terminal.

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