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Retraction

Retracted: Development and Application of Smart Home Energy Management System Based on Wireless Network Technology

Wireless Communications and Mobile Computing

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] J. Wu, "Development and Application of Smart Home Energy Management System Based on Wireless Network Technology," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 2449418, 8 pages, 2022.

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Research Article

Development and Application of Smart Home Energy Management System Based on Wireless Network Technology

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In order to solve the problem of integration of home energy management system and wireless network technology, the author proposes the development and application of a smart home energy management system based on wireless network technology. Divide the NB-IoT into different simulation levels, simulate the physical layer of the NB-IoT, and according to the household energy conservation rules, calculate the household energy distribution parameters, convert the intelligent control signal into a signal constellation point, calculate the deviation value of the control command corresponding to the energy equipment, build an intelligent control simulation algorithm, and finally complete the simulation of the intelligent control system. Experimental results show the following: The simulation method in the intelligent home language input terminal control system is based on the Internet of Things, the average time of simulating the test point of energy equipment is about 4.9 s, the required simulation time is long, and in the intelligent control system of the mobile road tunnel lighting vehicle, the simulation time required by the designed simulation method is about 6.8 s, and the simulation time is the longest. The average time of the method proposed by the author to simulate the energy distribution instruction is about 3.3 s. *Conclusion*. The application prospect of a smart home energy management system based on wireless network technology is very broad.

1. Introduction

With the gradual improvement of basic conditions such as home network and mobile Internet, especially the rapid development of information communication technology, computer technology, and control technology, a large number of intelligent electronic products have appeared, which has brought convenience to people's daily life [1]. At the same time, it also affects the home, including work and rest habits and work behavior. The information Internet era consists of web Internet and mobile Internet; nowadays, it has transitioned to a leap-forward development in the era of the Internet of Things [2]. With the popularization of the concept of a smart home, the development of the Internet of Things, the maturity of cloud computing, and the continuous progress of artificial intelligence technology, at the same time, the irreversible trend of smart homes in the future smart home industry has emerged [3].

The basic standards for preliminary preparation are relatively complete, the main equipment products and service standards are almost covered, the standard technology level is steadily increasing, the standard application scope is constantly expanding, and it is a good situation to keep pace with the international advanced standard level [4]. The issuance of this guide may open up a huge multitrillion smart home market. The smart home energy center utilizes smart collection devices installed at the energy end of residential users, such as metered distribution boxes, smart sockets, smart meters, and water meters, using the Internet of Things technology to upload data in real time [5]. The smart home energy center management and control system stores and analyzes data, realizes the intelligentization of users' energy use, and achieves the goals of energy conservation, emission reduction, and smart home [6]. The popularization and networking of smart products in the home can help residents better manage and control home equipment, and at the same time, they can fully grasp the details of the composition of household electricity consumption, understand the electricity consumption data and operation status of electrical equipment at home, and guide residents to use electricity

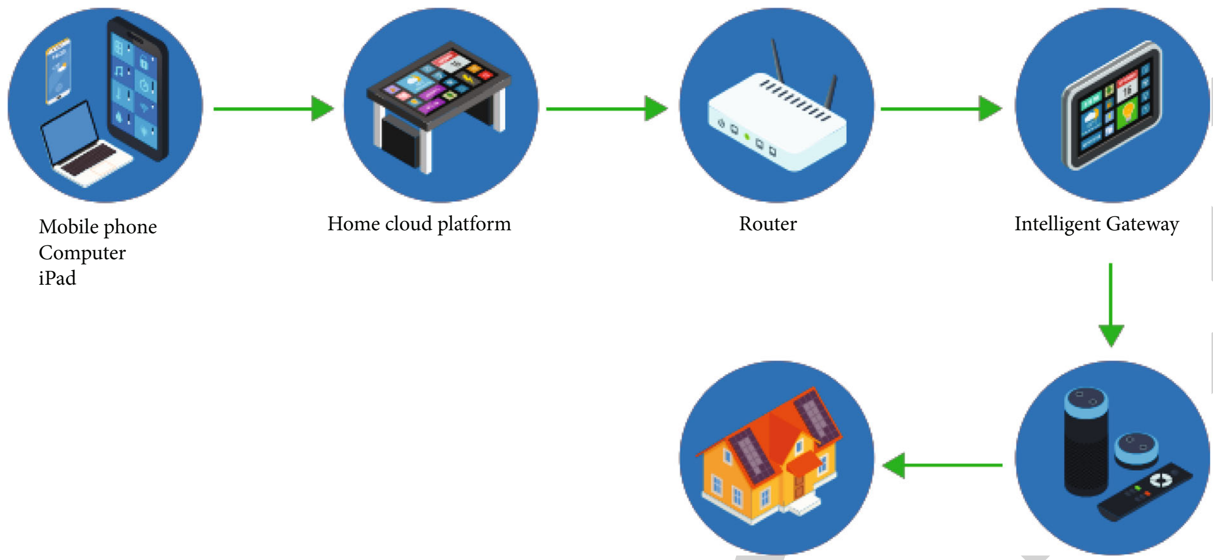

FIGURE 1: Smart home energy management with wireless network technology.

scientifically and save electricity. The design of the smart home energy center management system is based on the Internet of Things technology. This system takes the energy management of households as the research object and uses intelligent devices to connect with the system. Relying on the Internet of Things technology, the information flow and service flow of large bucket smart home devices constitute an efficient smart home energy center [7]. It can optimize and simplify the energy management of residents and provide a comfortable, convenient, and healthy living space.

Home energy management is becoming increasingly important due to the increase in home energy consumption, as well as emerging technologies in the smart grid residential sector, advanced metering infrastructure, smart meters, and demand response programs; in addition, as other smart home appliances using IoT technology, devices including air conditioners, washing machines, and refrigerators are being deployed to provide more advanced functions to serve residents; developing smarter systems, namely, home energy management systems (HEMS), becomes necessary for residents [8], as shown in Figure 1.

2. Literature Review

NB-IoT is an important branch of the Internet of Everything, which is constructed from cellular networks [9]. Under the bandwidth value of 180 kHz, it can be directly deployed in the local area network to realize the smooth upgrade of the Internet of Things. This kind of Internet of Things is suitable for the transmission process of difficult locations, long transmission time, and small amount of data; it can run wide-area technology in a virtual manner anywhere; it is possible to establish a connection on the mobile network in a simple and efficient way and process the bidirectional data generated by the Internet of Things safely and reliably. The home energy intelligent control system takes household appliances and home appliances as the main control objects; with the participation of wiring technology and network communication technology, it can enhance the intelligence of family schedule affairs and enhance the utilization rate of energy [10]. With the support of narrowband Internet of Things technology and the simulation of the home energy intelligent control system, according to the parameters of the control system obtained from the simulation, the operating parameters of the intelligent control system can be adjusted to maintain the comfort of the home environment [11].

On the simulated intelligent control system, the research at home and abroad has reached a high level; Zhang and Zhi proposed a smart home language input control system based on the Internet of Things, the home perception data is collected through the laser sensor module in the perception layer, and the user's voice commands are input into the terminal APP through the ZigBee wireless data transmission module and the cloud recognition module [12], which is transmitted to the network layer. The feature parameters of smart home language signals are extracted by Mel frequency cepstral coefficients, and the feature parameters of language signals are converted into language signal feature vectors by the DTW algorithm, language syllables are recognized, and matching control commands are implemented to complete smart home voice control. Yun and Leng proposed an intelligent control system for road tunnel lighting [13]. Through the wide-area integration of the Internet of Things, the group control of LED lights is realized based on the air light lighting technology. Through group control of LED lights, tunnel lighting can be divided into several lighting segments. When a vehicle is detected by a surveillance camera, the corresponding LED group can be adjusted to the required brightness based on environmental conditions and traffic information. Considering the role of household energy, a variety of strongly coupled simulation processes are derived from the design.

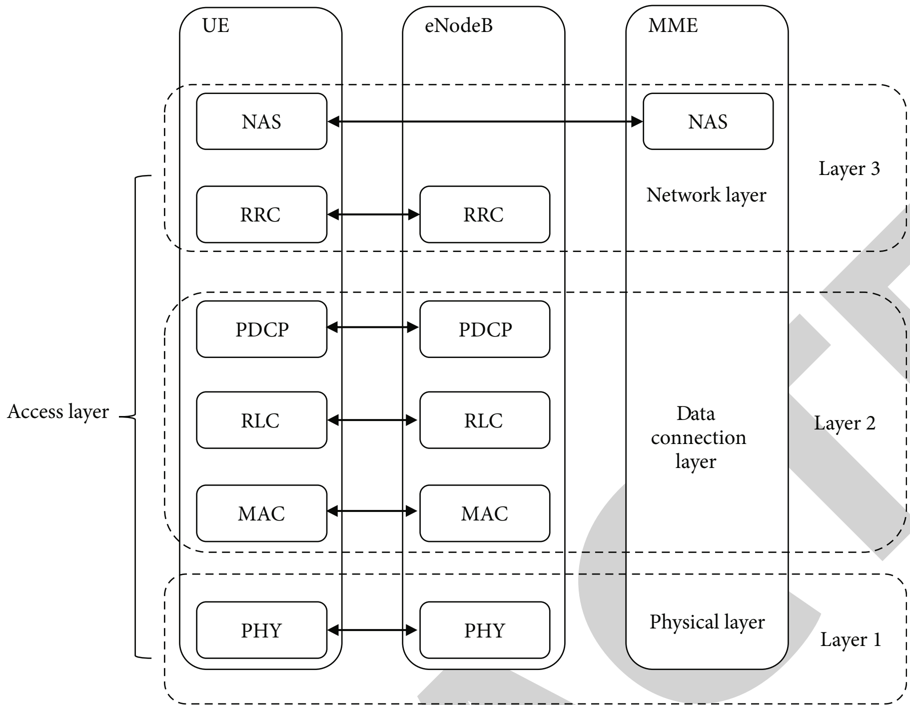

FIGURE 2: The constructed simulation structure.

Based on previous research, the author proposes a home energy intelligent control system based on the narrowband Internet of Things, and the effectiveness of the proposed method is verified by simulation.

3. Methods

3.1. Simulation of Home Energy Intelligent Control System Based on NB-IoT

3.1.1. Simulation of NB-IoT Physical Layer. The narrowband IoT physical layer supports the intelligent control system, using LTE carrier resource blocks for deployment, and there is a fixed value of bandwidth at the GSM frequency band, so when simulating the physical layer of the narrowband Internet of Things, the physical layer is divided into three layers, corresponding to the access layer of the intelligent control system, forming the simulation structure shown in Figure 2.

Under the simulation structure shown in Figure 2, set the channel grid value of NB-IoT to 120 kHz, use a specific resource block in the IoT as the anchor carrier, set the time-frequency resource to 6RB, use a length of 1024 for the system frame, and simulate the format of the signal sent by the intelligent control system; in order to control the signal range of the simulated intelligent system, the superframe signal index range set by the control simulation is 0 to 512, and the subframe length in a system frame is set to 5 ms [14]. In order to simulate the signal synchronization process of the physical layer of the intelligent control system, the transmission direction of the channel is set as downlink and uplink in the constructed simulation structure, and the NPUSCH and NPRACH physical channels are set in the uplink direction, which is responsible for simulating the data transmission process of the control signal command [15]. The downlink transmission direction sets NPBCH, NPDCCH, and NPDSCH physical channels, fixes the subframe format of the analog control signal, schedules the control information generated by the control system, and simulates the energy response process.

Under the control of the two signal transmission directions, a narrowband signal simulation and reconciliation process is constructed, and the simulation generation sequence of the narrowband signal is defined; the sequence can be expressed as

$$r(m) = \frac{1}{\sqrt{2}}(1 - 2c(2m)) + j\frac{1}{\sqrt{2}}(1 - 2c(2m + 1)). \quad (1)$$

In formula (1), m represents the random signal sequence parameter, c represents the simulated signal parameter, and j represents the signal initialization parameter. Random initialization processes the above signal simulation sequence, and the processing process can be expressed as

$$c_{\text{init}} = \frac{(n_s + 1) + l + 1}{N_f^e + N_{cp}}. \quad (2)$$

In formula (2), n_s represents the time slot number in a simulated system frame, l represents the symbol index value in the time slot, $N^e{}_f$ represents the narrowband position parameter, and N_{cp} represents the system bandwidth value in the frequency domain. After designing the simulated NB-IoT physical layer, the distribution parameters of home energy are calculated.

3.1.2. Calculate Home Energy Distribution Parameters. When the intelligent control system distributes household energy, according to the time-varying characteristics of the indoor environment, build a mathematical model to trace the energy distribution process [16]. According to the law of conservation of energy, the change in energy distributed by the intelligent control system is equal to the energy difference between the inflow and outflow of the control system; the calculation formula (3) can be expressed as

$$C\frac{d(T_i - T_0)}{dt} = Q_i - HA(T_i - T_0). \quad (3)$$

Among them, C represents the indoor change parameter, T_0 represents the original indoor temperature, T_i represents the temperature after energy distribution, H represents the energy heat transfer coefficient, Q_i represents the heat generated by the energy, and A represents the heat transfer area of the energy. The left side of the above equation (3) is taken as the energy change in unit time, the right side of the equation is taken as the energy value controlled by the intelligent control system, and the processing of the above energy identity is a mathematical model for controlling the energy process, which can be expressed as

$$HA(T_i) + C\frac{d(T_i)}{dt} = Q_i + HA(T_0). \quad (4)$$

In the above expression, the meaning of each parameter remains unchanged. When the intelligent control system is in a stable operation state, the value of $d(T_i)/dt$ is zero, the household energy is in the process of distribution, and the distribution process can be expressed as

$$g(s) = \frac{K}{Ts + 1}. \quad (5)$$

Among them, K represents the proportional coefficient of energy distribution, T represents the time factor, and s represents the distribution time. The numerical change of energy distribution at this time is shown in Figure 3.

Under the energy distribution process shown in Figure 3, according to the above numerical values, the energy during household energy distribution will be delayed by the external environment during the transmission process, so when calculating the energy distribution parameters and adding a lag link in the energy distribution process, the lag link can be expressed as

$$d = \frac{Z}{Ts + 1} e^{-T^x}. \quad (6)$$

In formula (6), Z represents the gain coefficient, τ represents the pure lag time, and other parameters remain unchanged. Under the control of this lag link, the above calculation formulas (5) and (6) are processed discretely, and formula (7) can be calculated by assigning parameters:

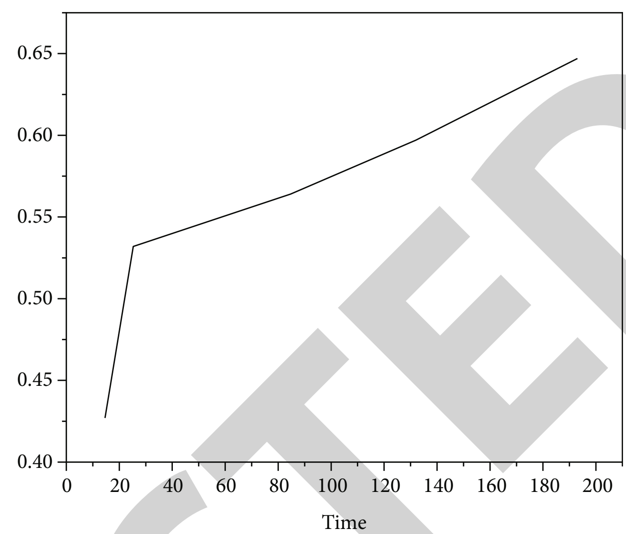

Figure 3: Energy distribution process.

$$\lambda = \frac{y(k-1)}{u(k-1)}. \quad (7)$$

In formula (7), $y(k)$ represents the energy proportional function and $u(k)$ represents the energy distribution function. The parameters calculated by the above calculation formula are used as energy distribution parameters, and under the control of the parameters, an intelligent control simulation algorithm is constructed.

3.1.3. Building Intelligent Control Simulation Algorithms. In the process of decoding control commands, the narrowband Internet of Things is affected by channel fading, and the position of control data to control energy equipment will have a certain deviation; therefore, when building an intelligent control simulation algorithm, set the signal-to-noise ratio value in the channel to zero and convert intelligent control signals into signal constellation points [17]. After the data of the control system is debugged and processed by QPSK, the Euclidean distance of the actual modulation symbol position is used as the weighting coefficient of the simulation algorithm, and the data of one cycle is combined in the simulation and can be expressed as

$$r[i] = \sum_{n=1}^{Z} w_n \times r_n[i], i = 1, 2, \cdots, N. \quad (8)$$

In the above calculation formula (8), Z represents the number of instructions transmitted repeatedly in a repetition period, w_n represents the subframe weighting coefficient in a repetition period n, and N represents the RE value occupied by the transmission data carried by the control channel on the subframe. The deviation generated by the control command in the energy equipment can be expressed as

Table 1: Simulation platform component parameters.

Serial number	Name	Parameter
1	Emulated platform operating system	Windows 7
2	Simulation development language	C language
3	Simulation interface and program running environment	VisualC++6.0
4	FOM/SOM development tools	Omdt 13v5
5	HLA operation support software	VR-Link software
6	Simulate and debug LAN configuration	DHCP, DNC
7	Operational support system of HLA	MAK RTI

Table 2: Multiband NB-IoT (LTE Cat NB2) module parameters.

Serial number	Parameter name	Parameter
1	LTE bands	3, 5, 8
2	3GPP release baseline	13
3	Configurable voltage domain	3.3 V
4	Configurable object	Dynamic LWM2 M
5	Supported embedded protocols	CoAP/DTLS
6	FOTA	Compliant with CTCC/CMCC

$$\bar{\gamma}_n = \frac{1}{L}\sum_{i=1}^{N} \|s_n[i], s_0[i]\|_2. \quad (9)$$

In formula (9), L represents the command modulation data quantity of the control system, $s_n[i]$ represents the modulation data, and $s_0[i]$ represents the initial modulation control data. Considering the deviation generated by the energy control, the intelligent control algorithm finally constructed can be expressed as

$$e_x = \frac{1/\gamma_n}{\sqrt{\sum_{n=1}^{z} (1/\gamma_n)^2}}. \quad (10)$$

After considering the deviation generated by the intelligent system during the operation process, the deviation is simulated and processed into the intelligent control algorithm, and the above processing is combined, and finally, the simulation of the home energy intelligent control system based on the narrowband Internet of Things is completed.

3.2. Simulation Test. In order to verify the effectiveness of the designed home energy intelligent control system based on the narrowband Internet of Things, a simulation comparison experiment was designed [18].

3.2.1. Environment Deployment. The components shown in the parameters in Table 1 are prepared, a simulation platform environment was built, and the price parameters are shown in Table 1.

Under the control of the component parameters shown in Table 2, a multiband NB-IoT (LTE Cat NB2) module supporting narrowband IoT is prepared; the relevant parameters are shown in Table 2.

Under the control of the above simulation platform components, an intelligent control system development middleware VR-Link is constructed; under the control of the supported embedded protocol, the running state of the transportation energy intelligent control system is continuously simulated, with the participation of the simulated local area network, which continuously sends control information to other applications of home energy and creates a simulation task in the prepared simulation platform [19].

The above simulation tasks are simulated by using the intelligent home language input terminal control system based on the Internet of Things, the intelligent control system of mobile road tunnel lighting vehicles, and the simulation method designed by the author, and the performance of the three simulation methods is compared [20].

4. Results and Discussion

Based on the above experimental preparations, the equipment that debugs the energy demand in the simulation platform is in the energy waiting state, and ten energy statistics time points are set; taking the energy utilization rate of the actual household energy control system as the comparison standard, the final utilization rate results of the three simulation methods are shown in Table 3.

As can be seen from the experimental results in Table 3, taking a household energy consumption location as the statistical object and taking the measured data as the comparison standard, under the control of three simulation intelligent system methods, the simulation method in the intelligent home language input terminal control system is based on the Internet of Things; the obtained energy utilization value is smaller than the measured data, the energy utilization value obtained by the simulation method in the

Table 3: Energy utilization values obtained by three simulation methods.

Test time point	Actual data	Energy utilization value (%) Intelligent home language input terminal control system based on Internet of Things	Mobile road tunnel lighting vehicle intelligent control system	The author's method
Time point 1	0.369	0.206	0.535	0.347
Time point 2	0.396	0.274	0.516	0.335
Time point 3	0.373	0.262	0.415	0.408
Time point 4	0.365	0.213	0.431	0.346
Time point 5	0.329	0.237	0.515	0.404
Time point 6	0.397	0.239	0.467	0.342
Time point 7	0.381	0.286	0.416	0.448
Time point 8	0.386	0.298	0.471	0.408
Time point 9	0.323	0.222	0.402	0.319
Time point 10	0.358	0.286	0.494	0.398

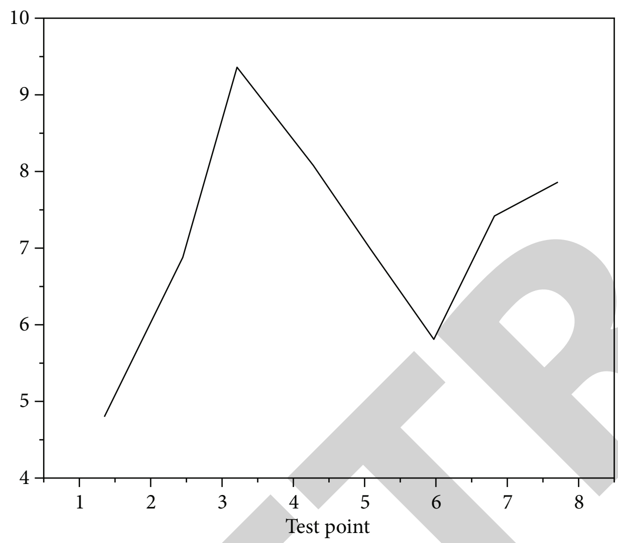

Figure 4: Comparison of energy blockage rates obtained by three simulation methods.

intelligent control system of the mobile road tunnel lighting vehicle is much larger than the measured data, and the energy utilization value obtained by the proposed method is not much different from the measured data; the simulation effect of the simulation method designed by the author is optimal.

Keeping the above environment unchanged, 8 household energy consumption points are set; under the action of the intelligent control system, three simulation methods are used to simulate the working process of the control system, and three simulation methods are used to simulate the same control instructions and energy value; by constructing the calculation formula of energy blockage rate, the calculation formula can be expressed as

$$D = \frac{w - w_s}{w} \times 100\%. \quad (11)$$

Among them, w represents the actual energy value dispatched by the control system and w_s represents the actual energy consumption value. Taking the measured blockage rate of energy equipment as a comparison index, the final energy blockage rate results obtained by the three simulation methods are shown in Figure 4.

It can be seen from Table 4 that when the three simulation methods simulate the energy intelligent control system, the simulation results show that the energy blockage rate generated by the control system is different; according to the numerical results in Table 4, the simulation method in the intelligent home language input terminal control system is based on the Internet of Things, the energy blockage rate value obtained by the simulation is smaller than the measured data, there is a certain deviation in the simulation process, the energy blockage value obtained by the simulation method in the intelligent control system of the mobile road tunnel lighting vehicle is much larger than the measured value, and the effect of the simulated energy control system is not good; the proposed method is not much different from the measured energy blockage rate; compared with the simulation methods in the two literatures, the simulation effect of this simulation method is better.

In the above experimental environment, at the set energy test point, three simulation methods are controlled to simulate the energy distribution control instructions in the intelligent control system at the same time, and the household energy starts working as the end point of time statistics; the actual simulation time results of the three simulation methods are shown in Table 5.

As can be seen from the simulation time results in Table 5, three simulation methods are controlled to simulate the energy distribution process; according to the statistical results, the average time of the simulation method in the intelligent home language input terminal control system based on the Internet of Things to simulate the energy equipment test point is about 4.9 s, the required simulation time is long, and the simulation time required by the simulation method designed in the intelligent control system of the mobile road tunnel lighting vehicle is about 6.8 s; simulation takes the longest time. The average time of the proposed method to simulate the energy distribution command is about 3.3 s; compared with the simulation

Table 4: Energy blockage rate obtained by three simulation methods.

Energy equipment test point	Actual data	Energy blockage rate (%) Intelligent home language input terminal control system based on Internet of Things	Mobile road tunnel lighting vehicle intelligent control system	The author's method
Test point 1	8.3	5.1	13.3	9.2
Test point 2	9.7	6.5	13.1	9.3
Test point 3	9.8	6.9	14.7	9.1
Test point 4	8.2	7.2	14.3	8.6
Test point 5	9.8	6.5	13.3	9.1
Test point 6	8.5	5.5	14.8	9.2
Test point 7	8.5	6.3	14.2	9.3
Test point 8	9.5	6.5	14.9	9.3

Table 5: Simulation time of three simulation methods.

Energy equipment test point	Simulation time (s) Intelligent home language input terminal control system based on Internet of Things	Mobile road tunnel lighting vehicle intelligent control system	The author's method
Test point 1	5.5	6.2	2.5
Test point 2	5.3	7.8	3.8
Test point 3	4.2	6.1	3.4
Test point 4	4.9	6.7	3.9
Test point 5	4.5	7.6	3.9
Test point 6	5.2	6.8	3.5
Test point 7	4.7	6.4	2.9
Test point 8	5.5	7.1	3.2

methods in the two literatures, the simulation method designed by the author requires the shortest simulation time.

5. Conclusion

The author proposes the development and application of a smart home energy management system based on wireless network technology; the home energy intelligent control system supported by the narrowband Internet of Things is the most common technology combination method at present; simulating the intelligent control system supported by this technology, it can improve the time-consuming control of traditional home energy intelligent control system and defects with large control deviations. From the experimental data, it can be seen that the average time of the simulation method in the intelligent home language input terminal control system based on the Internet of Things to simulate the energy equipment test point is about 4.9 s, the simulation time required is long, and the simulation method designed in the intelligent control system of the mobile road tunnel lighting vehicle requires a simulation time of about 6.8 s; simulation takes the longest time. The average time of the method proposed by the author to simulate the energy distribution instruction is about 3.3 s, which provides a certain theoretical basis for simulating the intelligent control system in the future.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that they have no conflicts of interest.

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