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Research of Smart Payment System of Power Grid Using Strongly Sub-feasible SQP Algorithm

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Abstract. **With the continuous development and perfection of "Internet + Electricity", the regional grid operation has gradually realized the Internet-based automation. In order to improve the smart level of regional grid operation, this paper analyzes the status quo of power grid terminal in Fujian local power (group) company, and introduces the strongly sub-feasible sequence quadratic programming (SQP). The smart payment system based on strongly sub-feasible SQP algorithm is described by its structure, function and implementation process. Through the information technology to improve the efficiency of the service, so that payment staff and smart terminal of self-service payment system has been information between the interactive mode, the actual operation effect is good**.

1 Introduction

In the increasingly developed modern information technology, It is the inevitable choice of power supply enterprises to deepen and enhance the level of smart management of power grids for electricity customers to provide better service by information technology means.In china there are six types of electric payment terminal: lobby-style self-service terminal; through the wall-type self-service terminal; through the wall self-service terminal; POS terminal; financial institutions self-service terminal; third party terminal. In the above-mentioned various power payment terminals, the wall-mounted self-service terminal, the POS terminal, the financial institution self-service terminal, the third party terminal can only complete the payment function, the lobby type self-service terminal and the wall-type self-service terminal can complete the payment function To provide historical power tariff detailed inquiries.If 24-hour self-service business hall installed through the wall-type self-service terminal expands its function, it will also display the message of power outage, install the voice and video system can provide remote assistance services. There are different needs on the location choice for the power companies, the financial institutions and the third-party agents. Power companies want to provide customers with more options to facilitate the nearest customer payment, to minimize the customer non-malicious arrears caused by power outages, and to speed up the recovery of electricity fee .

The main problems of current payment terminal: the table after the opening of the network layout issues; own network terminal deployment planning issues; power payment terminal installation and commissioning work; power self-service payment terminal business status monitoring issues; power self-service payment terminal Equipment operation monitoring problem; some payment terminal customers can not get invoice and payment success message. In this paper, we propose a grid payment system based on strong and feasible SQP algorithm, which is based on Qt, Oracle software, and so on. In this paper, we propose a scheme of power payment system based on strong and feasible SQP algorithm. With the interactive functions, the developed system has a very good versatility and achieve good results in practical operation.

2 Mathematical Model of Smart Payment System for Power Grid

The payment terminal is the core component of the smart grid operation system. The user can judge whether the payment is made by checking the electricity bill and the personal account balance. At the same time, the payment method is provided, which includes the artificial electricity fee, the online payment and the bank direct deductions and other ways, and the system will be based on the user to set the reminder function for self-service payment management. For the optimal solution of the multiobjective nonlinear problem, the self-service payment system model is as follows.

Assuming that λ is the user's monthly electricity bill, θ is the electricity owed by the user, μ is the account balance of the user, ξ is the upper limit of the electricity charge for the user to forcibly.

$$\xi=\Sigma M_{i=1}\varphi_i\lambda_i\,,\ \varphi_i=\begin{cases}1/\theta_i & \theta_i\neq 0\\ 0 & \theta_i=0\end{cases} \quad (1)$$

On behalf of the calculation of the weight, its value depends on the amount of electricity owed by the user, M refers the number of months, generally 12 months. According to the system requirements, It is necessary to meet the following constraints in order to use the self-service payment function:

$$\lambda+\theta\geq\xi \quad (2)$$

$$\theta+\varphi\leq\mu \quad (3)$$

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For manual payment, you need to manually control the user according to individual needs and also need to use remote data access technology for data update operation.

3 The Principle of SQP Algorithm

The SQP (sequence quadratic programming) algorithm is one of the most effective algorithms to solve the nonlinear constrained optimization. The feasible SQP algorithm is one of the most important algorithms. The SQP (sequence quadratic programming) algorithm is one of the most effective algorithms for solving nonlinear constrained optimization. Because it can produce feasible iterative point sequence, It has a very important practical application in engineering design and real-time control.

Strongly feasible SQP algorithm principle General inequality constraint optimization problem can be expressed as:

$$\begin{cases} Min f(x) & (1) \\ s.t. g_j(x) \le 0, j \in I = 1,2,\dots,n \end{cases}$$

f(x) is the objective function; x is the design variable; I is the subscript set; g_j (x) is the constraint function; *j* is the number of the constraint function. The kth iteration point $x^k \in Rn$ is defined as follows.

$$\begin{cases} \Gamma(x^k) = \{j \in I: g_j(x) \le 0\} & (2) \\ I^+(x^k) = \{j \in I: g_j(x) > 0\} \\ \varphi(x) = max \{0, g_j(x), j \in I\} & (3) \end{cases}$$

The inequality constraint optimization problem (1) can be solved by solving the quadratic programming problem of the following formula (4), and finally the main search direction d_0^k is obtained.

$$\begin{cases} Min \nabla f(x^k)^T d + \frac{1}{2} d^T B^k d \\ s.t. g_j(x^k) + \nabla g_j(x^k)^T d \le 0, j \in (I^k)^- & (4) \\ s.t. g_j(x^k) + \nabla g_j(x^k)^T d \le \varphi_k, j \in (I^k)^+ \end{cases}$$

Where $B^k \in Rn \times n$ is the approximation of the Hessen matrix of the Lagrangian function at x^k. Since the formula (4) has a feasible solution d = 0, d_0^k is its optimal solution, but not necessarily a feasible solution direction, the algorithm uses the generalized projection technique to obtain the new improved display correction direction d^k, and give the new Of the high-order display correction direction ~ d^k, the specific formula can be seen in details in the reference.

The iterative formula for the design variables is:

$$x^{k+1} = x^k + \lambda^k d^k + (\lambda^k)^2 \tilde{d}^k \quad (5)$$

The step length λ^k is found by constructing a new Armijio curve. When $(d_0^k, \varphi_k) = (0,0)$, x^k is the optimal solution of equation (1).

The strong and feasible SQP algorithm can first ensure that the algorithm has been subjected to finite iteration, the iterative point falls into the feasible domain, and then automatically becomes a feasible SQP algorithm, and thus overcome a strong assumption (that is, the maximum constraint violation function is the higher order of QP subproblems.) Second, the strict complementary conditions are removed, which greatly reduces the amount of computation. Finally, the algorithm has global and superlinear convergence. The preliminary numerical experiments show that the algorithm is stable and effective.

4 Design of Smart Payment System for Power Grid and Realization of Main Function

Power grid intelligent payment system in the overall design of the modular structure of the system, divided into six modules: manual payment module, bank card payment module, file and electricity tariff query module, electricity invoice and electricity bill printing module.

4.1 Manual Payment Module

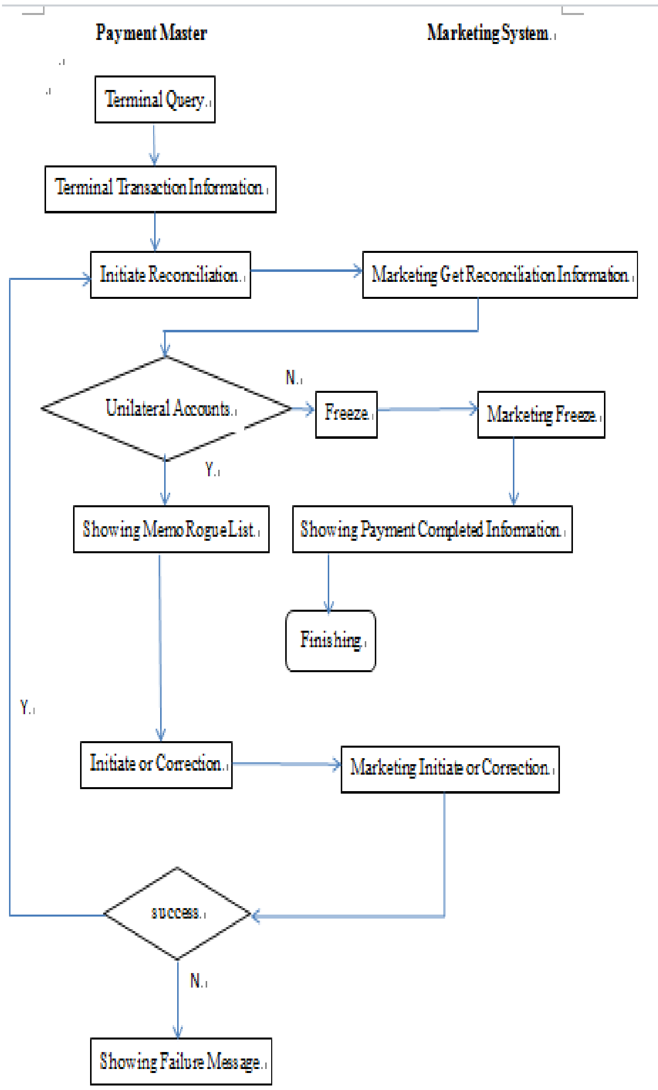

Fig 1 Artificial solution flow chart

Manual payment is to provide the administrator to use the function when payment cannot be solved because of the network or machine failure at the terminal .As the process shown in Figure 1, the module consists of pay the main station and marketing system 2 parts. This function is only open to the administrator, the administrator can enter the wenbrowser interface in the main station and input the needed terminal number of payment, SG186 account, find out the current records of the unpayment at the corresponding terminal, and show detailed transaction records and the total amount ,the total number of pen.

As shown in Figure 2 , in order to solve the problem at payment terminal which is because of network barrier at the time of the boot ,but the consumers due to the terminal fault, the boot module function at payment terminal is added.

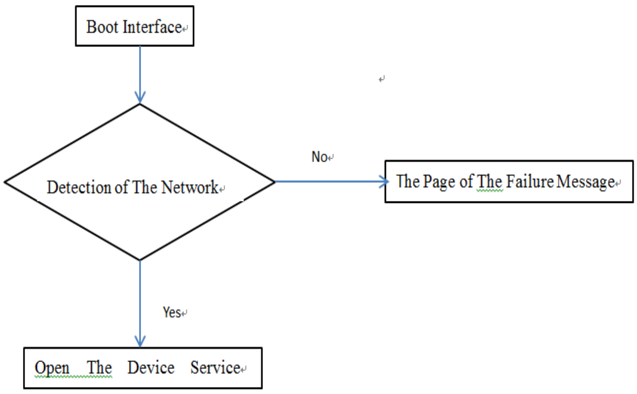

Fig 2 Payment terminal flow chart

Terminal start when the first start a QT prepared by the client program, the interface shows "is initializing the payment process", this procedure is to pay the main station system network check, if the network is smooth, then start the device service program by the device service program to start Firefox. If the network does not work, the page prompts "power network interruption, please contact the network administrator to view the network connection status".

This boot interface displays the "restart", "shutdown" button, after the firefox browser is opened, the boot interface is set at the end, while adding a button "restart the payment process", click this button to restart the device service process, After the firefox runs into fault,the user will see the boot interface, and click "restart the payment process" to restart the program.

4.2 Bank Card Payment Modul

The bank card payment module mainly implements the bank card payment function, and the terminal directly communicates with the CUP system to complete the data interaction and the interactive data is 8583 packets. Bank card payment authority is for electricity customers. The basic processes : Enter the number -> Show under the charge information -> Enter the amount of payment -> Insert the bank card -> enter the bank card password -> payment success.

4.3 File and Electricity Tariff Query Module

(1) file query module, enter the user account number, you can query the file information. The basic processes : Enter the number and password -> Show file information. The file information mainly includes the customer's basic information (customer number, account name, contact person, contact telephone number, document name, document number, payment method, withholding bank, bank account number), customer electricity information (electrical address, copy number , Power supply units, industry classification, measurement methods, voltage levels, electricity categories, user classification, contract capacity, production frequency, into the line) data.

(2) power tariff query module mainly through the user input power account number, customers can query their own nearly a year of electricity consumption information, this authority is for electricity customers, The basic processes : enter the number and password -> show the month Electricity situation -> click on the specific month to check the power situation. File query module constraints for the electricity situation A page shows 6 months, you can click on the previous page or next page to see the last 6 months or the next 6 months. The electricity situation includes: meter reading detail (meter date, the type of display, magnification, last month only, this month only), electricity price details (electricity price unit price, power billing power, electricity tariff) Rate details (to adjust the amount of electricity, adjust the coefficient, the power factor to adjust the electricity), if the user has the corresponding details , it will show, Otherwise no show.

4.4 Electricity Bill and Electricity Bill Print Module

(1) electricity invoice module provides the effective fee vouchers for the electricity customers. After the customer payment is successful, the self-service payment window prompts to print the invoice.

(2) The tariff list print module is to enter the user's account number, select the year to be printed, the list printing, the basic process input number and password -> select the year to print -> to print. The tariff list print module constraint allows customers to print only once for a month (such as 201701) during the user's login session, but also allows the user to print the list for the month after the next login.

5 System Operation Example Analysis

In the current Jinjiang power payment system, for example, when the power grid intelligent payment system is running, the operator firstly judges whether the network terminal is operating normally. It is necessary to add a judge, when the user input SG186 account, you need to join the terminal number to make judgments.if the customers input SG186 account which does not correspond to the machine's terminal number, it will show: the SG186 account and the terminal does not

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match. The administrator can initiate the reconciliation function manually and can initiate a freeze operation if there is no unilateral account. As shown in Figure 3, if there is a one-sided account can be judged by the system program out of the single-sided account to fill or red positive action. After the manual payment is completed, the administrator also needs to contact the operating room counter in time to solve the situation, and inform the amount of money and the number of pen to facilitate the opening of the money box to check the amount.

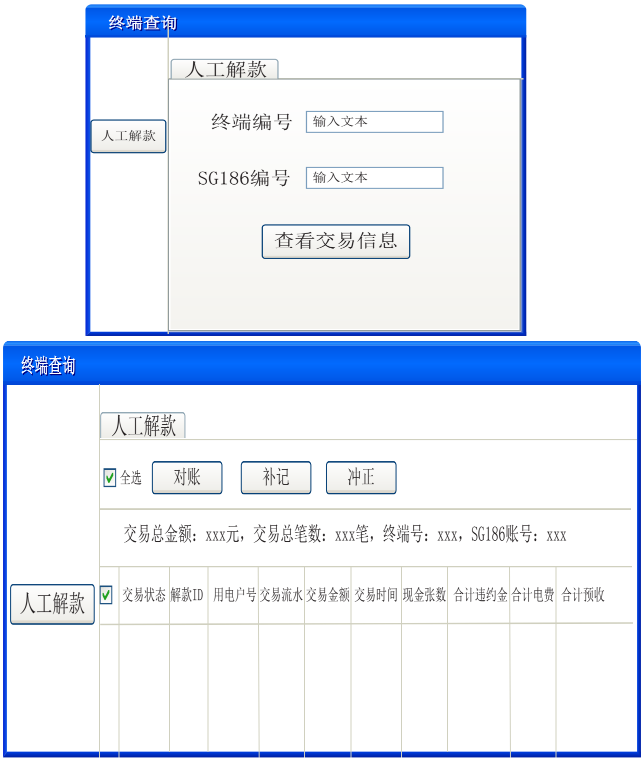

Fig 3 Terminal query and terminal list

After successfully registering the payment terminal, it displays the main interface function area of the system. As shown in the figure, there are six parts: cash payment fee, bank card payment fee, electricity bill invoice printing, electricity bill printing, file inquiry and electricity tariff query.

Fig 4 The main interface of grid smart payment system

Power customers choose electricity tariff query function, enter the electricity account number, the system shows the arrears of information, and prompted the amount required to pay. The system prompts the customer to pay the bank card, after entering the bank card password, the terminal automatically networked bank deductions.

As shown in Figure 5, payment system prompts that customers pay successfully, invoices can be printed. If the power customers forget the user number, as shown in Figure 6 , log on the payment system by swiping the account holder's ID card. In this case, the data obtained from the intelligent payment system of the power grid is consistent with the actual on-site payment data, and the reliability of each module is verified.

Fig5 Payment Successful to print Invoice

Fig 6 Login mode of ID card

6 Conclusions

The intelligent payment system of power grid mainly focuses on the existing problems of self-service terminal of power payment. It is more convenient and quick to pay electricity and improve the application level of power payment terminal. It adopts the power grid intelligent payment system architecture based on strong and feasible SQP algorithm, Armi jio curve search and two new display correction directions with the same inverse matrix structure, which reduces the computational complexity and ensures the validity of the data. Qt, Oracle software's powerful interactive function has developed a complete application system.

Power grid intelligent payment system is one of the key technologies of smart grid development, and is the cornerstone of achieving the smart grid "informatization, digitization, automatization, interactivity". The system has a good versatility and good results in operation. It has a wide range of development prospects in practical engineering applications. The upgrading and updating of the system equipment are to be in further and deep discussion.

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