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A Monitoring Method of Network Power Consumption Information Based on SNMP

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***Abstract*—In order to realize the real-time collection of network information, to achieve energy saving and fault monitoring, it puts forward a method of monitoring the power consumption information based on the network data analysis. The method can use SNMP and MIB to collect the power information of the power equipment in different networks, including the CPU occupancy rate, physical and virtual memory usage. It use BP neural network to train the data and get the real-time electricity information of equipment. System operation results show that the method can collect the running data of the equipment in real time, and effectively obtain the information of the power consumption of the equipment. It gets the estimated data with high accuracy and can meet the requirements of the use of electricity information collection.**

Keywords- power information collection system; SNMP; BP neural network; MIB

I. INTRODUCTION

The development of Internet and information industry makes more electric equipment to access network, which makes it possible to access the operating data of electrical equipment and then analysis the user's electricity consumption behavior through the network. Through the analysis of network data to get the device power consumption and real-time power can not only avoid metering device using frequently, but also can break the geographical restrictions, get the electric energy information through the network node anywhere. Accessing the power information of electrical equipment real-time can effectively control the equipment, timely closing high-power electrical appliances or appropriate to reduce the no-load power consumption of device, which can effectively reduce the waste of electric energy. By using the collected data, we can find and remove the fault of equipment nodes in time.

At present, the network monitoring using SNMP protocol and MIB is relatively mature, but the research using the collected data to monitor the electricity information is rare. Literature[1] analysis the electricity status of equipment through the operation data using, but it can only get the electricity status of several different electric equipment and can't get a better power curve and energy curve fitting. It shows that the model error is larger.

The information acquisition system uses SNMP as the communication protocol, and the two sides of the communication are the request and the provider of the data. The data collector is also the main control unit of the system, and the data provider is the node of each power equipment. The data provider sends a request to the provider in a round robin manner. The provider extracts the data from the MIB database and forward it to the provider.

Now almost all of the electricity information collection based on data analysis is established by means of linear equation, but the equipment operation data and electric energy is not a simple linear relationship, and the BP neural network can well fit the non-linear relation. Therefore, the system will use BP neural network with model L2 regularization to train the data such as CPU utilization, memory usage of electric equipment accessing form requester. Finally, the power and power information of the equipment is obtained, and the data is displayed in a visual way.

II. DATA ACQUISITION MODE

A. System Structure

Figure 1 shows the system is composed of the main control collector, SNMP proxy gateway and network device node, and so on. Different network devices are located on the different branches of the MIB tree. The SNMP proxy gateway is based on the OID number of the device to query the information of the network equipment, and it can get the data from the MIB of the device and send the data to the master control collector. Network nodes can be a variety of electrical appliances, including computers, servers, network printers, large switches and smart TV and other network equipment.

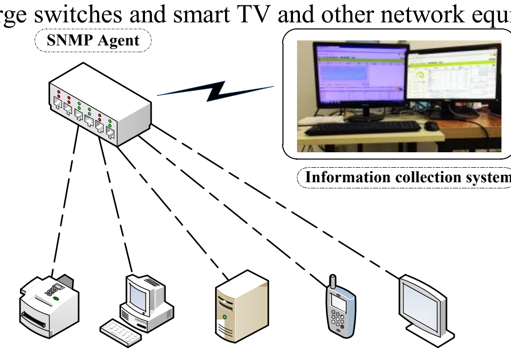

Figure 1. Diagram of system overall structure.

System collect data of heterogeneous through the MIB and SNMP, mainly including CPU usage, physical memory usage, virtual memory usage, disk data throughput, etc. The system has the characteristics of high compatibility, high real-time performance and high security. It can collect the data of the

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network equipment of different manufacturers or operating systems in real time.

Using the latest B/S architecture model, it can be in any place for the collection and management of information, and reduce the maintenance of the client. By way of training network station to get data from a database agent MIB, and the data stored in MySQL database. As shown in Figure 2, the main control collector is the core of the entire system, running on Manager SNMP, Trap Receiver SNMP and Web servers, and it also connects the browser and database. The SNMP manager and Trap Receiver SNMP are responsible for the request and receive data, Web server is to provide data and graphics to the browser display, and the database is used for data storage.

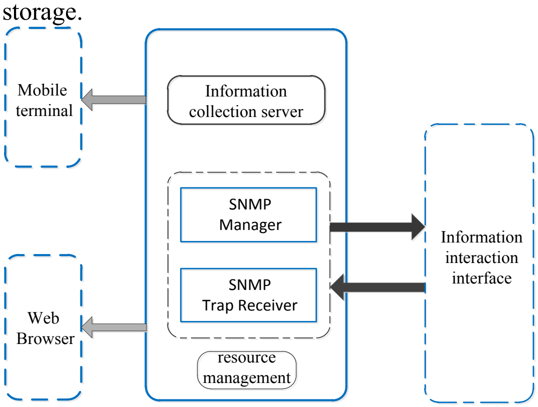

Figure 2. Internal structure of the main collection server.

The SNMP based on connectionless UDP protocol [3], the system will collect data from MIB stored in the MySQL database, so the managers can view the collected data at any time. System can also provide backup capabilities, it will be back to the local database backup to a certain period of time to the cloud.

B. *SNMP Protocol*

The data acquisition system uses the simple network management protocol SNMP, which is one of the application layer protocols in the TCP/IP protocol cluster. Transport layer can use a variety of different protocols, so it can be compatible with a variety of network. Its basic idea is to provide a unified interface and protocol for different types of equipment, different manufacturers of equipment, as well as different types of equipment. This way allows the server to use a unified management method for network equipment management [2]. The server can manage the network equipment in different regions through the network. It is the heterogeneous network management characteristics of SNMP that enables the collection system to collect the data of different network devices at the same time.

SNMP has a very strong ease of use and scalability. They all have SNMP of the available components of the current mainstream operating system. Not only that, a lot of networking equipment with the SNMP module, and the latest version of the SNMPv3 provides the latest security mechanisms [2], so that information interaction more secure.

Mode of SNMP is to specify the device to get data through the administrator. So the SNMP provides three kinds of data operation mode, which are Get, Set and Trap and among them, Get is to get the information of network equipment, Set is the configuration of equipment parameters, and the role of Trap is to obtain important information of the equipment.

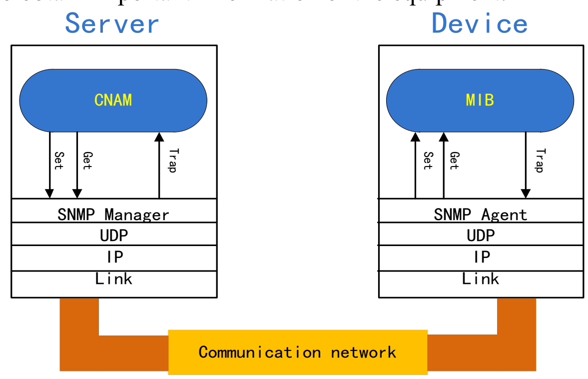

Figure 3. Hierarchical graph of SNMP communication protocol

Figure 3 is the communication hierarchy of the server and the device. The communication between the server and the device needs to be followed by application layer, transport layer and data link layer. Management station and the agent side are unified through the MIB interface. They have already implemented the corresponding MIB objects. This allows the two sides can identify each other's data, and thus achieve the transmission of data. When the management station wants to get the data in MIB, it first submitted to the agent, the agent to identify their identity and the data submitted to the management station [3].

C. *Management Information Base*

Management Information Base defines the devices and properties that can access the network, and points out the variables that are maintained by the network element. Each network node device is uniquely specified by the object identifier OID. MIB uses and domain name system DNS similar tree structure, its root in the top, and the root has not been named. SNMP protocol to access the device in the network and get his data through the tree directory node [5]. As shown in Figure 4, the manager requests data from the proxy, the proxy receives the request and responds to it. The agent obtains data from MIB according to OID and returns it to the network station [4].

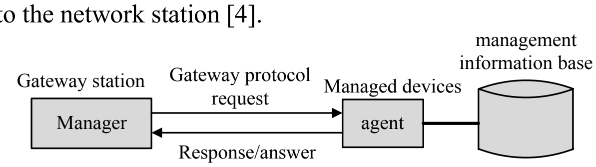

Figure 4. Relationship between management station and agent

The definition of MIB is not related to the specific network management protocol so it can enhance the versatility of MIB. As long as the device contains the SNMP agent software, it will be able to ensure that the software is still in compliance with this standard when the new MIB project is defined. This breaks the software version of the restrictions, so users can use the same network management client software to manage multiple network devices with different versions of MIB.

The manager obtains the data from the MIB through the proxy mainly includes the following 5 basic operations:

1）Get Request: Extract one or more parameter values from the agent process.

2）Get Next Request: The next parameter value is obtained from the proxy process with the current parameter value.

3）Set Request: Set one or more parameter values for the agent process.

4）Get Response: Returns one or more parameter values.

5）Trap: The agent process of message is sent out, and the management process is informed that some things happen.

Search for data in the MIB management information base on data read and write operations can be achieved through these 5 steps.

TABLE I. PERCENTAGE OF OCCUPANCY DATA COLLECTED BY MIB

	Processer 1	Processer 2	Processer 3	Processer 4	Physical memory	Virtual memory
1	9%	11%	8%	2%	61%	56%
2	5%	7%	6%	1%	54%	55%
3	13%	9%	7%	3%	65%	69%

Table I is the percentage of occupancy data collected by MIB, including the occupancy rate of four processors, as well as physical memory and virtual memory occupancy rate.

III. BP NEURAL NETWORK MODEL

A. Power Prediction Process

In order to achieve the fitting of the nonlinear correlation between the data and the electrical information, BP neural network is used to create the model. BP neural network is a multilayer feed forward neural network which is trained by the error back propagation algorithm, and it can store a large amount of input output mode mapping relation. The learning rule uses the steepest descent method, which adjusts the weights and thresholds of the network by the way of back propagation, which enables the network to obtain the least square error [7]. As shown in Figure 5, there is an input layer and one hidden layers, each layer of neurons and the next layer of neurons are connected, with no connection between the same layers of neurons.

The training process of BP neural network is mainly divided into two stages: the first stage is the forward propagation of the signal, it will be transmitted from the input layer to the output layer through the middle of the hidden layer. The second stage is the reverse transmission of the error: it will be transmitted from the output layer to the input layer in the middle will go through the hidden layer. It will then adjust the implicit weights and bias in the training process of [6]. Three layer BP neural network structure is used to be L2 regularization, the parameters of the model are set as follows: training times 1000, training target 1.0e-006 and learning efficiency 0.01. The input end includes 6 sets of data, which have four groups of processor occupancy rate as well as physical and virtual memory occupancy rate, the output is the power of the device.

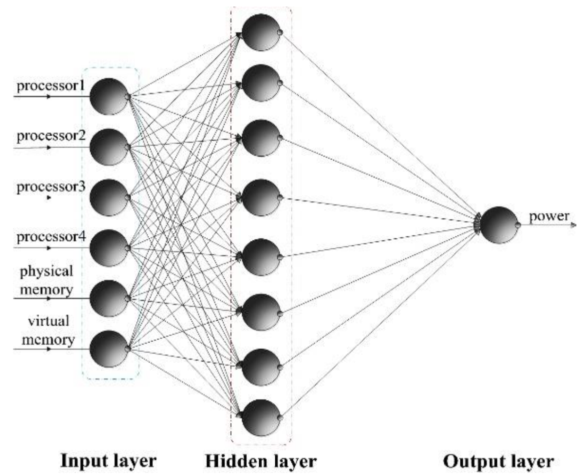

Figure 5. Hierarchical structure of neural network

The number of nodes in the input layer is 6, the number of nodes in the hidden layer is 8 and the number of nodes in the output layer is 1.The weight of the input layer to the hidden layer is ω_{ij}, the weight of the hidden layer to the output layer is ω_{jk}, The input layer to the hidden layer of paranoia is a_j, the hidden layer to the output layer of paranoia is b_k, The form of its incentive function is as follows: The input of neuron of a hidden layer or output layer is processed by a common activation function, which is a sigmoid function, defined as follows:

$$g(x) = \frac{1}{1+e^{-x}} \quad (1)$$

The output of the hidden layer is represented as H_j

$$H_j = g\left(\sum_{i=1}^{n} \omega_{ij}x_i + a_j\right) \quad (2)$$

The output of the output layer

$$O_k = \sum_{j=1}^{l} H_j\omega_{jk} + b_k \quad (3)$$

Error calculation formula

$$E = \frac{1}{2}\sum_{k=1}^{m}(Y_k - O_k)^2 \quad (4)$$

Where Y_k is expected to output, I =1•••n, j=1•••l, k=1••• m in the upper.

It adjusts the value of the weight w_{ij} according to the error. Finally get better training results and meet the requirements of our error. Its learning efficiency is set to 0.01. When the learning rate is large, the training convergence is fast, but it is easy to fall into the local optimal solution. If the learning rate is relatively small, the convergence rate is slow, but it can gradually approach the global optimal solution.

B. Solve the Neural Network over Fitting

BP neural network algorithm is easy to fall into the local minimum and the convergence of the data of the problem in the iterative process. This leads to the overall level of the error is relatively large, which will produce a phenomenon of fitting. Too much training data or excessive training will lead to the phenomenon of fitting. The two solution is to increase the training data or reduce the size of the network, but this will weaken the ability to predict the network. The best way is to use the weight decay (L2) solution, in which some additional regularization term is added in the cost function. The cost function of regularization is as follows

$$C = C_0 + \frac{\lambda}{2n}\sum_{\omega}\omega^2 \tag{5}$$

Where C_0 represents the original cost function, the original cost function, one of the following is the L2 regularization term, n is the training set sample size and w is the parameters， λ is a regular term coefficient which can balance the proportion of regular items and C_0 items. The role of regularization is to allow the network to learn a smaller weight, while in other ways it will maintain the same, regularization is a way to compromise the consideration of the small weight and minimize the cost function.

IV. SIMULATION AND ANALYSIS

A. System Simulation

In order to show the validity of the network model, the simulation is carry out on the MATLAB2012 platform, and the BP neural network model is construct by using the MATLAB neural network toolbox [6].

The running data of the equipment is collected by the network information collection system based on SNMP, and the real mark power data is collected by the Billion electric energy information collection platform. Data is derived from 5 different models and configurations of the computer in the laboratory, which contains high configuration and low configuration, desktop and no desktop computers. The system automatically collects information once every 1 minutes, it collects a total of 5000 sets of data were collected and randomly selected from the 2000 sets of data for training.

The input of BP neural network consists of the CPU, the physical and virtual memory and the output of the network device. In this paper, the 3000 sets of data at different time of different models are input and trained by the model. The model input layer contains 6 nodes, 8 nodes and the output layer is a node. Transfer function of each layer using the Tansig function, the training function using the traingdx algorithm.

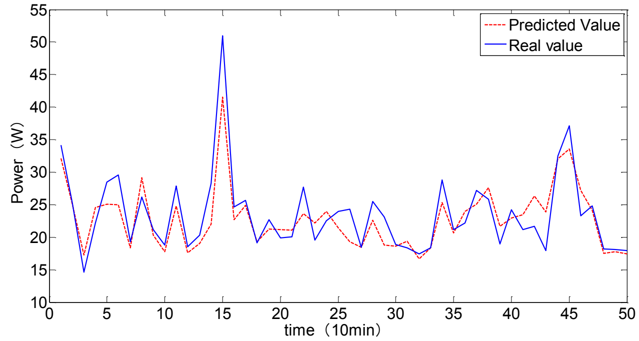

Figure 6. The true value and the predictive value of the power

Through Figure 6 can be seen that the power range of the computer is between 20-60w, the time interval is 10 minutes. The BP neural network model can be used to reflect the trend and the rule of the power change of the equipment very well and there is no over fitting. The error between predictive value and true value is small, and the system model can meet the requirement of power forecast.

Because the external interference factors are more, so there is a certain error between the real-time power estimation and real power data. But the error of this kind of error is instantaneous, which includes the positive and negative errors. The positive and negative errors of this kind of power can cancel each other when we monitor the electrical power of the equipment, so the power error will decrease obviously. As follows, we monitor the power data of the equipment using hours as the unit。

Figure 7 shows that due to electric energy is the product of power and time in a period of time, so there will be no rapid change in the monitoring and estimation of electrical energy. The solid line represents the true value of the dotted line represents the predicted value of electric energy. Its whole trend is relatively flat, which shows that the error is very small, the system is very good for the prediction of electric power.

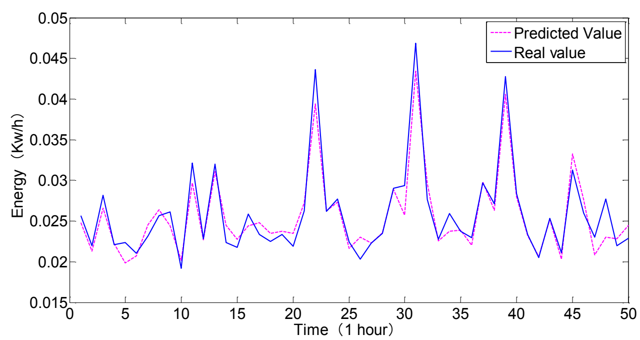

Figure 7. The true value and predictive value of electric energy

B. Error Analysis

Fig. 8 is the comparison of power error and power error. The error of power is relatively fast, and the average relative error is about 7.5%. The relative fluctuation of electric energy error is relatively flat, and the average relative error is less than 4.5%. The dotted line represents the predicted power value, the solid line represents the electric energy of predictive value. This shows that the use of this method to collect and estimate the power and electric energy can achieve very good results.

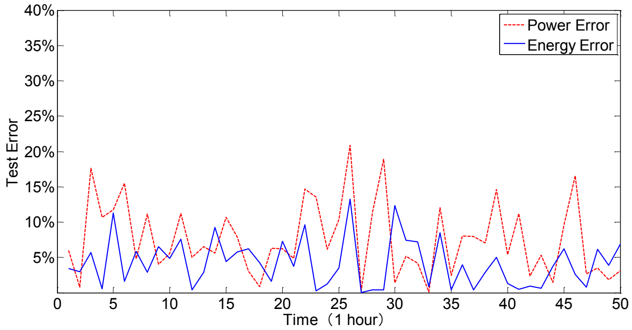

Figure 8. Comparison of the relative error of power and electric energy

In order to verify whether the system is applicable to other network equipment and its estimation error is within acceptable range. The system uses 5 different models and different configurations of the computer for data collection and simulation results. These include high configuration and low configuration computers, desktop computers and laptops.

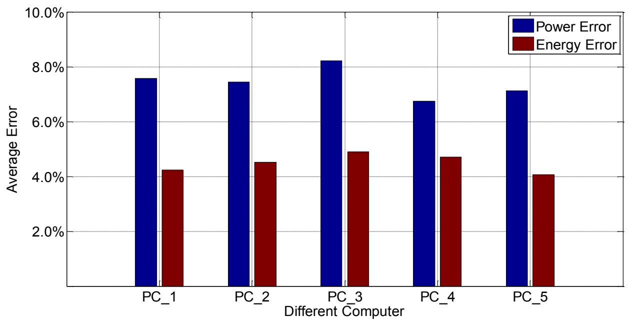

Figure 9. Comparison of different models of computer error

Figure 9 shows that the maximum draw error of 5 computer power is 8.6%, the minimum is 6.3%. The average relative error of electric energy is relatively small, the maximum is 4.5% and the minimum is 3.6%. It can be seen that, although the variety and configuration of the computer is not the same, their average relative error can meet our requirements and application requirements of the electrical information acquisition of equipment. Therefore, the prediction performance of the BP neural network model is effective. This method can be used to accurately collect the power information of network equipment in accordance with our requirements.

V. CONCLUSION

This method uses SNMP and MIB to collect data. It uses the regularized BP neural network to carry out the training of the data. At last, it gets the information of the network equipment, and the data error of the power and the electric energy are all within the acceptable range. The system is applicable to different types of different types of equipment, so its portability and compatibility are relatively strong. This is an extension of the power monitoring and practice in the development of the Internet of things environment. It will have a very good application prospects in the development trend of intelligent and network of power system.

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REFERENCES

[1] S. Izumi et al., "G-MIB: Green-oriented Management Information Base and its standardization in IETF," 2013 IEEE 2nd Global Conference on Consumer Electronics (GCCE), Tokyo, 2013, pp. 21-22.

[2] K. Bharadwaj, S. Flores, J. Rodriguez, L. Long and G. E. Marai, "Developing a Scalable SNMP Monitor," 2016 IEEE International Parallel and Distributed Processing Symposium Workshops (IPDPSW), Chicago, IL, 2016, pp. 1043-1047.

[3] A. Affandi, D. Riyanto, I. Pratomo and G. Kusrahardjo, "Design and implementation fast response system monitoring server using Simple Network Management Protocol (SNMP)," Intelligent Technology and Its Applications (ISITIA), 2015 International Seminar on, Surabaya, 2015, pp. 385-390.

[4] Z. q. Wang, Y. Wang and G. q. Shao, "Research and Design of Network Servers Monitoring System Based on SNMP," Education Technology and Computer Science, 2009. ETCS '09. First International Workshop on, Wuhan, Hubei, 2009, pp. 857-860.

[5] S. Shahid, K. R. Narumanchi and D. Gurkan, "Plug-in electric vehicle battery sensor interface in Smart Grid network for electricity billing," Sensors Applications Symposium (SAS), 2012 IEEE, Brescia, 2012, pp. 1-4.

[6] Yujing Sun et al., "Research on short-term module temperature prediction model based on BP neural network for photovoltaic power forecasting," 2015 IEEE Power & Energy Society General Meeting, Denver, CO, 2015, pp. 1-5.

[7] J. Li and J. Mao, "Ultra-short-term wind power prediction using BP neural network," 2014 9th IEEE Conference on Industrial Electronics and Applications, Hangzhou, 2014, pp. 2001-2006.