Research on Multithreaded Data Scheduling Control Method for Power Communication Based on Wireless Sensor

Zhou Qian[1](✉) and Zhao Bing[2]

[1] Guizhou Power Grid Corporation, Guiyang 550002, China
[2] Elites Partners Corporation, Beijing 100027, China

Abstract. The traditional power communication scheduling control method has the problem of low utilization of network bandwidth. Therefore, a multi thread data scheduling control method of power communication based on wireless sensor is proposed. According to the path of multiple nodes in the communication system, a multi-threaded scheduler is designed to realize the network bandwidth prediction of the power communication system; the parameters of the controlled object are taken as the input variables of the controller, and the power communication dispatching control is realized through the Ryu controller to realize the feedback control and multi-threaded data dispatching control. The results show that the designed data scheduling control method has high utilization rate of network bandwidth and can adapt to the environment with different interference. The control method effectively improves the security of power communication data.

Keywords: Wireless sensor · Power communication · Multithreading · Data scheduling

1 Introduction

With the continuous progress of modern science and the rapid development of economy, smart distribution networks are getting more and more attention, and smart distribution networks are the development trend of future power grids. The intelligent distribution network integrates a variety of advanced technologies, such as data communication technology, new energy technology, sensor technology, power system technology etc. [1]. In this way, the self-healing, interactivity and security of intelligent distribution network can be improved. In order to improve the reliability, real-time performance of the power supply system, the efficiency of power energy utilization and reduce the impact on the environment, the mutual flow of information flow and power flow between power supply and power consumption equipment can be realized [2]. The power grid in the traditional sense refers to the one-way power distribution system, which cannot meet the needs of distributed power in the power grid, while the smart distribution network can meet and apply to various new energy sources. Therefore, the research of smart distribution network has become a hot topic in today's society [3].

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WSNs has become an important development direction in the field of intelligent distribution network data communication. At home and abroad, the research on the operational reliability, accuracy, integrity and maximum delay time of WSNs data transmission in intelligent distribution network is in the initial stage. The key point is to ensure the reliability and real-time performance of WSNs data transmission, meet the requirements of power industry distribution network data communication specification, with guaranteed QoS index, which is the practical application of intelligent distribution network data transmission WSNs One of the basic research problems [4].

At present, many algorithms and corresponding improvement measures have been proposed for WSNs to achieve high-efficiency power communication under the condition of limited network resources. A neural network dynamic model for detecting links between nodes is studied. The model uses the nonlinear model and state of the network topology as the input of the neuron network to realize multi-threaded data scheduling control and improve the reliability of power communication. In addition, a data-driven dynamic algorithm is proposed. According to the historical information of mobile nodes, the algorithm dynamically predicts the location of mobile nodes, and uses the routing decision-making method based on geographic information to realize the control optimization of multi-threaded data scheduling. In the above methods, different methods are used to study multi-threaded data scheduling control, but there is nothing to do with a large number of network interference nodes in power communication. These interference nodes occupy too much network bandwidth resources in the scheduling, and compete with many thread characters for network resources. A serious threat to the security of power communication. Relevant scholars have made some progress in this field. Liu Wenjing et al. Proposed the optimal dispatching method of hydro thermal power system based on super efficiency DEA benefit evaluation [5]. The particle swarm optimization algorithm was used for multi-objective optimization of power system data dispatching, the data envelopment analysis algorithm was used for data dispatching classification of power system, and the decision-making unit and benefit evaluation method were designed. This method can effectively improve the system security, but the network bandwidth utilization is not high. Duan yanru et al. Proposed the power dispatching automation and control method based on Smart Grid [6], constructed the optimal control model of power dispatching, estimated the state of power dispatching system, and adjusted it into the optimal load. This method can effectively improve the data regulation time, but the utilization rate of network bandwidth is poor.

Therefore, a multi-threaded data scheduling control method based on wireless sensor for power communication is proposed. According to the path of multiple nodes in the communication system, a multi-threaded scheduler is designed to realize the network bandwidth prediction of power communication system; the power communication scheduling control is realized through Ryu controller to realize feedback control and multi-threaded data scheduling control. The effectiveness of this method is verified by experiments, and the security of power communication data is effectively improved.

2 Wireless Sensor-Based Power Communication Multithread Data Scheduling Control Method

2.1 Multithreading Data Design

In the power communication using wireless sensor network, due to the deployment of wireless sensors, there are multiple network nodes with different functions in the network. These network nodes will generate multiple scheduling tasks at the same time during data scheduling, showing multi-threaded The task mode seriously affects work efficiency and safety [7–9]. Therefore, before control, a data scheduler for multi-threading is designed as an aid to the controller.

A scheduler is introduced into the original data scheduling control structure, which is used to adjust the sampling period of each control loop in real time, so as to ensure the smooth transmission and timely update of the data information of each loop [10, 11]. Among them, the measured bandwidth value, the bandwidth setting value and the error of each loop are all working parameters required when the node is scheduled for real-time operation in the sampling period. The basic structure diagram of the scheduler is shown in Fig. 1.

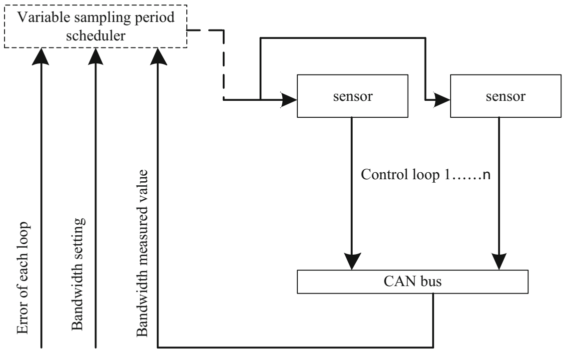


Fig. 1. Scheduler structure diagram

The workflow of scheduling design is mainly divided into three parts: network bandwidth prediction, network bandwidth configuration and sampling period calculation. In the first part, network bandwidth prediction is based on the difference between the current measured network bandwidth value and the original network bandwidth setting value, and then through proportional control to re predict the next network bandwidth value. Here, the predicted new network bandwidth value is the total bandwidth value; In the second part, the network bandwidth configuration is based on the new network bandwidth value predicted in the previous step and the data transmission error value of each loop, and at the same time, according to the importance of each control loop established long ago (weight coefficient value), to configure each in real time The network bandwidth value of the loop; In the last part, the sampling period of each task loop is calculated by the ratio of the data transmission time of the loop network to the network bandwidth allocation value. The calculation of the sampling period needs to be based on the network bandwidth value and the data transmission time of each loop, so as to realize the real-time and effective adjustment of the multi-path sampling period.

It should be explained here that the network used in the variable sampling cycle scheduling design is the CAN bus. The CAN bus is different from other methods in that each message has a priority, that is, it has a priority nature. When multiple nodes access the network at the same time It can be used to judge the order of nodes visiting the communication network. Moreover, the data transmission of sampling can bus has many advantages, such as strong real-time, high reliability and strong anti-interference. When the network load increases, the priority control provided by the CAN bus will significantly improve the working efficiency of the network nodes.

2.2 Forecast Network Bandwidth

The prediction of network bandwidth reflects whether the limited capacity provided by communication network is effectively utilized. The concept of network bandwidth is similar to that of drainage pipeline. The larger the bandwidth is, the greater the cross-sectional area of drainage pipeline is, and the drainage capacity per unit time is stronger. In the power communication multi-threaded data scheduling control method, the network bandwidth prediction process adopts a proportional control method to predict the new network bandwidth value at the next moment. Suppose that the preset value of network bandwidth is R_1 and the real-time measurement value of network bandwidth is R_2, the difference between the actual value and the preset value of network bandwidth can be obtained:

$$E_0 = R_1 - R_2 \tag{1}$$

Calculate the adjustment increment of network bandwidth through proportional control strategy:

$$\Delta\hat{R}(k+1) = \mu(E_0) \tag{2}$$

Formula: E_0 is the difference between the actual value of network bandwidth and the preset value, μ is the proportional adjustment gain, k is the time, and $\Delta\hat{R}(k+1)$ is the proportional adjustment amount of network bandwidth. The predicted network bandwidth is as follows:

$$\hat{R}(k+1) = R(k) + \Delta\hat{R}(k+1) \tag{3}$$

There is a difference between the measured network bandwidth and the predicted network bandwidth. Suppose the ratio between the two is $\bar{w}(k+1)$, Then there is:

$$\bar{w}(k+1) = \frac{\Delta R(k+1)}{\Delta\hat{R}(k+1)} \tag{4}$$

among: $\bar{w}(k+1) \in (0, \bar{w}_{\max}]$. The measured network bandwidth is:

$$R(k+1) = R(k) + \Delta R(k+1) \tag{5}$$

By substituting formula 4 into formula 5, the following results are obtained:

$$R(k+1) = R(k) + \bar{w}(k+1)\Delta\hat{R}(k+1) \tag{6}$$

Use the set value R_2 to subtract the left and right sides at the same time, then:

$$R_1 - R(k+1) = R_2 - R(k) - \bar{w}(k+1)\Delta\hat{R}(k+1) \tag{7}$$

Substituting Formula 1 into formula 7, we get the following results:

$$E(k+1) = E(k) - \bar{w}(k+1)\mu E(k) \tag{8}$$

Simplify to get:

$$E(k+1) = E(k)[1 - \bar{w}(k+1)\mu] \tag{9}$$

Record it as:

$$\varphi(k+1) = 1 - \bar{w}(k+1)\mu \tag{10}$$

Then there are:

$$E(k+1) = \varphi(k+1)E(k) \tag{11}$$

For the designed controller, if the proportional gain satisfies:

$$0 < \mu < \frac{2}{\bar{w}_{\max}} \tag{12}$$

Then the feedback control described in formula 10 is exponentially convergent, that is, the network bandwidth can make the exponential convergence reach the desired value, so the feedback scheduler is schedulable. Expand formula 11 to get:

$$E(k+1) = \varphi(k+1)\varphi(k)\ldots\ldots\varphi(1)E(0) \tag{13}$$

According to the matrix theory, we can see that:

$$\begin{cases} |E(k+1)| = |\varphi(k+1)\varphi(k)\ldots\ldots\varphi(1)E(0)| \\ |E(k+1)| \leq |\varphi(k+1) \times \varphi(k) \times \ldots\ldots \times \varphi(1) \times E(0)| \end{cases} \tag{14}$$

Given $|1 - \bar{w}_{\max}\mu| < 1$, we can know from Eq. 10:

$$|\varphi(k+1)| \geq |1 - \bar{w}_{\max}\mu| \tag{15}$$

Combining formula 14 and formula 15, we can get the following results

$$|1 - \bar{w}_{\max}\mu| \leq |\varphi(k+1)| \leq 1 \tag{16}$$

For any value of k, there is always a scalar χ, $0 < \chi < 1$ that makes $|\varphi(k+1)| \leq \chi$ true. Substituting it into Eq. 14, there are:

$$|E(k+1)| \leq \chi^k |E(0)| < |E(0)| \tag{17}$$

Therefore, once the schedulability lemma is satisfied, the network bandwidth value can gradually converge to the desired target ideal value. Under the condition of satisfying the expected objective ideal value, the control strategy is optimized to realize the multi-threaded data scheduling control of power communication.

2.3 Controller Design

According to the predicted network bandwidth, the range of controlled value variable is set. Communication rate: Divide the communication rate from l0 kbps to 250 kbps into 5 levels, respectively: low: l0 kbps–20 kbps, low: 20 kbps–40 kbps, medium: 40 kbps–80 kbps, high: 80 kbps–160 kbps, high: 160 kbps–240 kbps. Transmission power: the transmission power is divided into 5 levels from lodb to 22 dB, which are low, low, medium, high and high from low to high. Backoff strategy: the backoff strategy is divided into two aspects: the backoff time from 10 to 30 symbols is divided into 5 levels, from low to high are low, low, medium, high and high; the maximum number of backoff is divided into 5 levels from 5 to 15 times, and from low to high are low, low, medium, high and high. After setting the value range of the parameter controlled value variable, design the controller.

In the control method, the Ryu controller is used as the nerve center. The basic components of Ryu controller are the basis of its development and application. Ryu controller contains many components and libraries. It uses python programming language to develop applications. Users can develop their own applications by modifying the functions of each component.

Among the many components, the app component is used to manage the written application; the base component is used to load the application, which contains an app_manager.py file, which is one of the necessary import files when developing an application One; The controller component contains a series of important files that handle switch connections, such as events.py, of p_handle.py, controller.py These are the key documents; The lib component defines many basic data structures and some commonly used network protocols; the of proto component contains files that support various versions of the OpenFlow protocol. It mainly contains two types of files, one is the data structure definition of the protocol, and the other is the protocol analysis. The above components are the key parts of the development controller. In addition, other components also play different roles. In general, Ryu is rich in component types, which is enough to construct multi-threaded data scheduling controller in wireless sensor networks.

The natural advantage of this controller is the separation of control and forwarding, and centralized control is realized by the control plane. Therefore, it is essential for each controller to have a data flow monitoring function. In addition to physical resource information, the network information that can be counted by data flow monitoring also includes information such as logical links, and the same is true for flow information. In the actual monitoring process, the main statistics are the switch port rate information, the number of flows, etc., and the remaining bandwidth of the link and the size of the flow can be calculated based on the statistics of the port information. Using the obtained statistical information enables the controller to better perform data scheduling.

In the process of traffic monitoring, Ryu completes the statistics of port information and flow information through two important messages: of port state request and offpf1owstaterequest. This is the request sent by the controller to obtain the information of the switch. In addition, the controller establishes an event handle of the event handling type on the response information of the switch to receive statistics messages of the flow or port that the switch responds. In a complete topology, the statistical information of switch port mainly includes the number of received packets, the number of received bytes, the number of received errors and so on. Similarly, the statistical information of convection also includes various information, such as the length and duration of the flow. After mastering the multi thread data of power communication and matching with the predicted network bandwidth data, the multi thread data scheduling control of power communication can be realized.

3 Experimental Research on Multithreaded Data Scheduling Control Method for Power Communication

3.1 Experiment Setup

In the experiment, the simulation model required for the experiment is built, and the content of the construction is consistent with the general framework established by the original variable sampling cycle scheduling system. The internal transmission dead zone of the sensor and the controller is set up, as shown in Fig. 2.

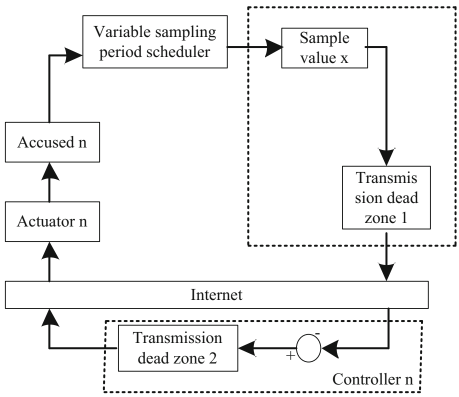


Fig. 2. Structure diagram based on dead time scheduling

Among them: x is the sampling value of the sensor node, r is the given input value of the controller node, and the deviation value e is the difference between the sensor sampling value and the reference input value, that is, the deviation signal of the system in the controller node. The transmission dead zone 1 is set in the sensor node and 2 is set in the controller node. The sensor node is time driven, and the controller node and actuator node are event driven. When the sensor node does not send packets, the controller node and actuator node will not be triggered to execute.

Two new dead zone scheduling strategies are adopted, and the dead zone is set in the sensor node and the controller node at the same time to realize the two-way setting of the forward path and the feedback channel. In the sensor node, compare the difference between the previous sampled signal value and the current sampled signal with the set dead zone threshold, and determine whether the sensor node sends a data packet according to the comparison result; In the controller node, combined with the idea of human simulated intelligent control, the network is scheduled according to the system deviation value. The human simulated intelligent control can maximize the intuitive reasoning of all parameters and feature information in the control process, and implement effective control effect. The six schemes are shown in Table 1.

Table 1. Parameters setting of dead time implementation

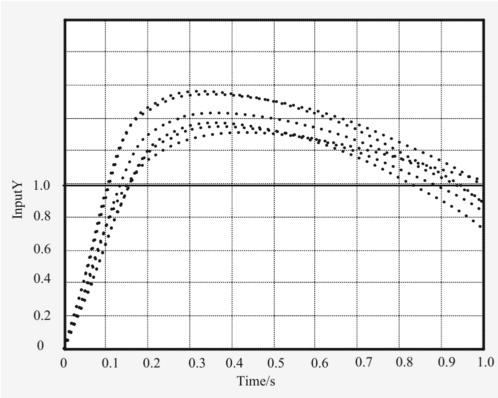
Programme	Sensor node	Controller node	Probability value
	Parameter setting of deadband threshold	The output value is in the steady-state range	
One	0.045	(±5%– ±10%)	0.85
Two	0.045		0.75
Three	0.035		0.85
Four	0.055		0.85
Five	0.035		0.90
Six	0.035		0.75

The implementation parameters of six different schemes are fine tuned in different directions. Two points should be noted here. First of all, the increase of dead time threshold in sensor node will limit the node packet, and the difference between the sample values before and after the sensor node is maintained at a small value, which is often not very large. Due to the use of unit step signal, the increase of dead time threshold of sensor node will compress the packet space; at the same time, the probability of controller node is reduced It is also equivalent to restraining the contract to a certain extent. In general, the simulation experiments of the six different schemes are essentially to verify the effectiveness of fine-tuning parameters under different restrictions on outsourcing.

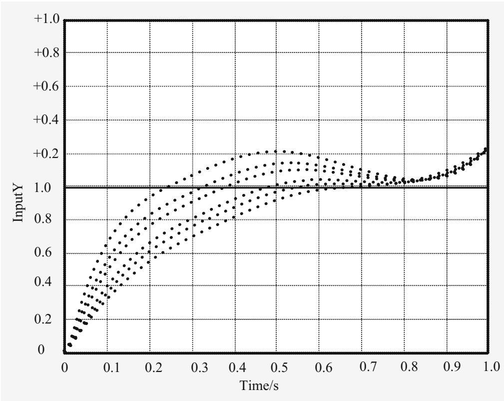
3.2 Adaptability Experiment and Analysis

On the basis of verifying the effectiveness of the control method, the above experimental plan refers to the traditional neural network-based control method and the data-driven control method, and conducts adaptive experiments under the same experimental conditions to verify that the control method faces data flow. Whether real-time changes can ensure a high level of network bandwidth utilization. Use third-party software to monitor data scheduling control and output experimental results. The specific content is shown in Fig. 3.

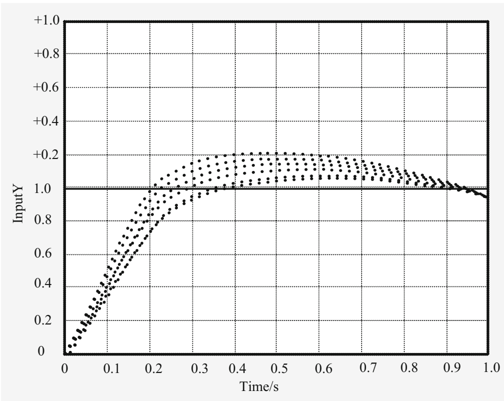
Compare and observe the results in the figure, the solid line in the figure represents the input value, and the dashed line represents the response curve under different scenarios. From the experimental results, it can be seen that the difference between the neural network control method and the input value is relatively large, and the overshoot of the response curve increases obviously, and then decreases gradually; the overshoot of the



(a) Experimental results of control method based on Neural Network



(b) Experimental results of data driven control method



(c) Experimental results of control method based on wireless sensing

Fig. 3. Adaptability test results of different control methods

response curve of the control method based on data-driven increases obviously, and it is always in the state of increase in the follow-up; the response curve of the control method based on wireless sensor is more close to the input value, and the response curve is more close to the input value The increase of overshoot is not obvious. In summary, the designed wireless sensing-based power communication multi-threaded data scheduling control method is more adaptable under different conditions.

3.3 Experiment and Analysis of Network Bandwidth Utilization

Based on the above experimental results, the network bandwidth utilization rates of different control methods under different schemes are calculated, and the calculation results are shown in Table 2.

Table 2. Calculation results of network bandwidth utilization of different control methods

	Control method based on neural network	Data-driven control method	Control method based on wireless sensor
Option 1	54.6%	42.8%	85.2%
Option 2	52.3%	59.6%	89.6%
Option 3	49.2%	57.2%	87.2%
Option 4	48.5%	47.6%	86.4%
Option 5	51.6%	43.2%	90.6%
Option 6	49.7%	41.3%	88.4%

It can be seen from the data in the table that compared with the traditional two control methods, the designed control method based on wireless sensing has higher network bandwidth utilization. Combining the above-mentioned adaptability experiment results, it can be seen that the designed power based on wireless sensing The communication multi-threaded data scheduling control method has stronger performance and better security.

4 Conclusion

In recent years, the application of wireless sensor network technology to power grid communication has attracted the attention of the industry. This article takes the power communication multi-threaded data as the research goal, and based on relevant literature materials, designs the power communication multi-threaded data scheduling control based on wireless sensing Methods, and after the control method design is completed, design a number of comparative experiments. The experimental results verify the effectiveness and safety of the proposed control method. However, only the stability of the controlled object is considered in the study. For dynamic changes, how to adapt to the drastic changes of the environment and have high-throughput is worth further study.

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