Optimization Algorithm of Transmission Delay in Power Network Based on Spatio-temporal Data Compression

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Abstract. Conventional power network transmission delay optimization algorithm mainly uses RTT substream congestion window to adjust the network throughput, which is easily affected by the dynamic distribution characteristics of transmission cost function, resulting in poor performance of power network transmission algorithm. Therefore, it is necessary to design a new power network transmission delay optimization algorithm based on spatio-temporal data compression. That is, the scheduling delay information of power network is divided, and the transmission delay optimization model of power network is constructed by using spatio-temporal data compression, thus the transmission delay optimization algorithm of power network is generated. The experimental results show that the designed optimization algorithm of spatio-temporal data compression delay in power network transmission has good performance, reliability and certain application value, and has made certain contributions to improving the transmission performance of power network.

Keywords: Spatio-temporal data compression; Electricity; Network; Transmission; Delay; Optimization; Algorithm

1. Introduction

The construction of power Internet of Things promotes the development of power network transmission. The power Internet of Things includes four layers[1-3]: perception layer, network layer, platform layer and application layer. In the sensing layer, the operating state of power equipment, meteorological environment, user information and other data are comprehensively acquired by miniaturized and intelligent sensors[4-6] and transmitted to the local data center through the transmission path. In the local data center, the data will be localized by the edge computing module. The network layer is responsible for the wide-area business information transmission between local data centers and between the perception layer and the platform. As a management link, the platform layer is responsible for the unified access management of the business data stream of the electric power Internet of Things and the efficient processing of business information[7-10]. The application layer feeds back the adjustment information downward and outputs the value information externally, so as to support the internal and external business such as planning and construction, production and operation, operation and management, and customer service.

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The core of power network transmission is data transmission network. In the power Internet of Things, the data transmission network not only provides a safe and efficient transmission channel for all kinds of collected power-related data to help calculation and analysis, but also provides a real-time and reliable bearer [11-13] for releasing control and maintenance information, and also provides a bridge for sharing all kinds of integrated power data information internally and externally. Therefore, it is of great significance to optimize the transmission delay of power network. The transmission delay of power network may lead to abnormal real-time monitoring and management needs of power system, which is not conducive to the security and stability of power system. Therefore, it is necessary to optimize the transmission delay of power network and improve the response speed of power system . In addition, the optimization of transmission delay of power network is also beneficial to improve the scalability of power system. With the continuous development of power system, the demand for data transmission volume and speed is also increasing. Optimizing transmission delay can meet this growing demand and realize more efficient data transmission. According to the characteristics of power network transmission, researchers have designed several conventional power network transmission delay optimization algorithms, including the power network transmission delay optimization algorithm based on wireless sensor and the power network transmission delay optimization algorithm considering multi-path transmission of network information. However, most conventional transmission delay optimization algorithms mainly use RTT substream congestion window to adjust the network throughput, which is easily affected by the dynamic allocation characteristics of transmission cost function, resulting in poor performance of the algorithm. Therefore, this paper designs a new transmission delay optimization algorithm for power network based on spatio-temporal data compression.

2. Optimal design of transmission delay optimization algorithm for power network based on spatio-temporal data compression

2.1 Division of power network scheduling delay information

In the process of power network transmission, it is necessary to quickly judge the delay information, reasonably allocate the delay processing tasks, and effectively control the scheduling delay time. Therefore, the power network transmission delay optimization algorithm designed in this paper first divides the delay information, and can first draw the simulation structure diagram of network scheduling transmission, as shown in Figure 1 below.

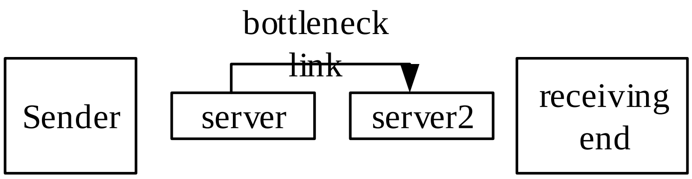

Fig. 1. Simulation structure of power network transmission scheduling.

As can be seen from fig. 1, according to the above power network transmission scheduling simulation structure, the relationship between scheduling delay and communication quality can be adjusted , and the network transmission task allocation formula at this time is shown in the following equation (1).

$$DT(i,j) = TA + DA + FE + TR + ET \tag{1}$$

In the formula (1), TA represents the storage time of network transmission tasks, DA represents the channel jump time, FE represents the minimum time for data transmission, TR represents the minimum time for the transmission task to run storage, ET represents the total execution time of transmission task decomposition, matrix decomposition can be performed according to the above-mentioned network transmission task allocation relationship, and the optimal transmission mapping can be obtained by using the reaction energy function. In the process of actual power network transmission, the problem of abnormal probability distribution is easy to occur due to the influence of node jump. To solve this problem, this paper calculates the continuous transmission time of power network T_f , as shown in the following equation (2).

$$T_f = \frac{T_x\left[F(t)\right]}{L} \tag{2}$$

In the formula (2), T_x represent a transmission time interval of a network node, $F(t)$ represents the critical value of transmission cycle constraint, L represents the number of transmission tasks, the control parameters of network transmission nodes can be quickly determined according to the above-mentioned continuous transmission time of power network, and the delay information of power network transmission scheduling can be effectively divided, which lays the foundation for subsequent delay optimization.

2.2 Based on spatio-temporal data compression, the transmission delay optimization model of power network is constructed

Spatio-temporal data compression can play an important role in transmission delay optimization of power network. It can reduce the volume and transmission amount of data, improve the efficiency of data transmission, and thus optimize the transmission delay. Besides, it can also improve the efficiency of data synchronization and calibration with the help of the temporal and spatial correlation of data . Therefore, this paper constructs the transmission delay optimization model of power network based on spatio-temporal data compression technology, as shown in Figure 2 below.

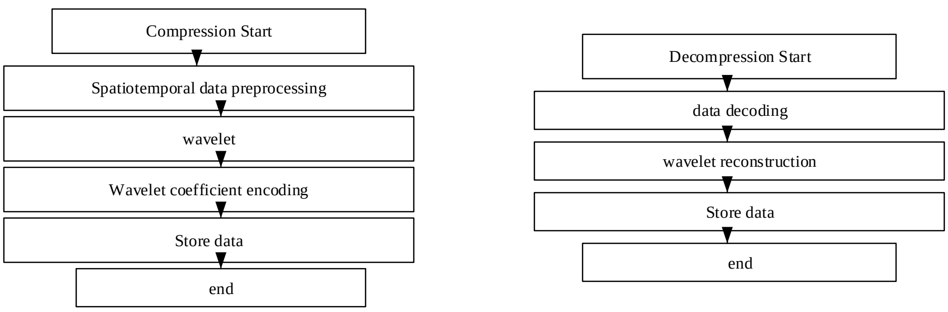

Fig. 2. Optimization model of transmission delay of spatio-temporal data compression in power network.

As can be seen from Figure 2, the above model has several important steps in the process of network transmission delay optimization. First, it is necessary to consider the time-space correlation of power network data to carry out time-space correlation and generate time-space transform coding; Secondly, according to the transmission characteristics of power network, the variation law of transmission delay is analyzed; Thirdly, the data is preprocessed to remove noise and redundant information. This can improve the effect of data compression and reduce the transmission burden; Fourthly, the preprocessed power network data is compressed by using the selected data compression algorithm and spatio-temporal data model. The compressed data can be transmitted through the power network; Fifth, at the receiving end, the received compressed data is decompressed and post-processed as needed. This can include decoding, filtering, interpolation and other operations to restore the temporal and spatial distribution and characteristics of the original data; Sixth, the power network topology, node performance, communication protocol and other factors are considered to select the best transmission path. Using the above-mentioned power network transmission delay optimization model, the power transmission delay parameters can be optimized and the comprehensive performance of the transmission delay optimization algorithm can be improved.

2.3 Generation of power network transmission delay optimization algorithm

According to the above-mentioned transmission delay model of power network, an effective transmission delay optimization algorithm of power network can be generated, which has several main generation steps. First, data link is generated and the connection relationship of each node is established. Secondly, data transmission is performed, and the leader nodes are randomly counted ; Third, control the token and optimize the network chain structure; Finally, the energy resource consumption of the sensing node is reduced, and the network transmission delay is reduced. At this time, the sending and receiving threshold of the sensing node is calculated, as shown in the following equation(3).

$$d_0 = \sqrt{E_{amp} \setminus E_{bmp}} \tag{3}$$

In the formula (3), E_{amp} represents the energy consumption of spatial model transmission, E_{bmp} represents the transmission energy consumption of multipath attenuation model. At this time, the transmission data of each node is fused to process the consumed energy $E_A(k)$, as shown in the following equation (4).

$$E_A(k) = E_D k \tag{4}$$

In the formula (4), E_D represents the wireless transmission line for sending and receiving energy, k represents the length of bytes sent, and the level of nodes in the transmission area will constantly change dynamically, so each node can be regarded as a subtree, and the radiation range of nodes can be adjusted, and the network transmission distance $T_W(d)$ at this time is shown in the following equation (5).

$$T_W(d) = \frac{1}{d_{bs}} + random(0, c) \tag{5}$$

In the formula (5), d_{bs} represents the node connection distance, $random(0,c)$ represents the optimal connection range, according to the above-mentioned node transmission distance, the node-level optimal connection can be established, and the transmission delay optimization algorithm W_{ij} of power network is generated based on this is shown in the following (6).

$$W_{ij} = \alpha W(E) + (1-\alpha)W_D \tag{6}$$

In the formula (6), α represents the node transfer connection energy weights, $W(E)$ represents the residual energy parameter, W_D represents the convergence coefficient of the transmission base station, the power network transmission delay optimization algorithm generated above can prevent nodes from executing invalid transmission instructions, improve the transmission efficiency of power network transmission nodes to the greatest extent, and ensure the reliability of transmission.

3. Experiment

In order to verify the comprehensive performance of the designed power transmission network delay optimization algorithm based on spatio-temporal data compression, this paper configures a basic experimental environment, and compares it with the power transmission network delay optimization algorithm based on wireless sensor and the power transmission network delay optimization algorithm considering multi-path transmission of network information, and carries out experiments as follows.

3.1 Experimental preparation

According to the performance verification requirements of power network transmission delay optimization algorithm, this paper selects MATLAB software to develop experimental environment, and carries out power network transmission simulation experiment in MATLAB R2016A version. Firstly, it is necessary to assume the transmission areas set by different network nodes. At this time, the initialization schematic diagram of each node is shown in Figure 3 below.

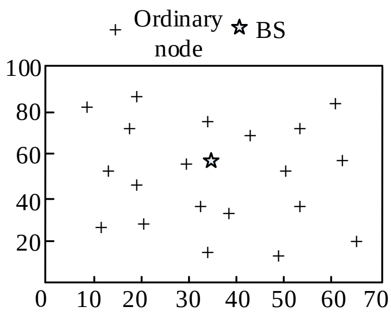

Fig. 3. schematic diagram of network transmission node initialization.

As can be seen from Figure 3, after the labeling and placement of the above-mentioned network transmission nodes are completed, the topology structure required by the experiment can be formed according to the distribution and connection of the nodes to ensure the transmission state of each node. The experimental simulation network parameters set at this time are shown in Table 1 below.

Table 1. Experimental Simulation Network Parameters.

Parameter	Numerical value
Area size	100m×100m
node number	100
BS position coordinates	(50,50)
Wireless transceiver circuit energy consumption	50*10-9nJ/bit
Free space model amplifier energy consumption	10*10-12pJ/bit/m2
Multipath attenuation model amplifier energy consumption	13*10-16pJ/bit/m4
Energy consumption per unit length data fusion	5*10-9nJ/bit
initial energy	1J
Length	2000/bit
parameter	describe
sens	Induction radius
DisNode(i,j)	Distance between power network transmission nodes
degree(i)	Power network transmission node level
change(i,j)	Exchange information of power network transmission nodes
parent(i)	Parent node of power network transmission
liveN	Number of surviving power network transmission nodes
weight(i,j)	Power Network Transmission Node Weights
link(i,j)	Determine whether there is a connection between two power network transmission nodes
energy(i)	Node Energy
live(i)	Power network transmission node status

As can be seen from Table 1, according to the above-mentioned experimental simulation network parameters, we can generate operational pseudocode, generate an effective experimental fusion tree structure, and then select an effective parent node by using the time sequence changes of nodes to establish a network transmission connection. After the above experiments are completed, the subsequent experimental results of performance verification of transmission delay optimization algorithm in power network can be obtained.

3.2 Experimental results and discussion

According to the above experimental preparation, the performance verification of power network transmission delay optimization algorithm can be carried out. In order to ensure the effect of performance verification, this paper starts from three aspects: transmission time, reception time and residual energy consumption of nodes. Among them, the smaller the transmission time and reception time, the better the performance of power network transmission delay optimization algorithm, and the higher the residual energy consumption of nodes. At this time, the power transmission network delay optimization algorithm based on spatio-temporal data compression, power transmission network delay optimization algorithm based on wireless sensor and power transmission network delay optimization algorithm considering multi-path transmission of network information designed in this paper are used for transmission respectively. The experimental results are shown in Table 2 below.

Table 2. Experimental results.

Data sending/ feedback receiving bytes (kbit)	The delay optimization algorithm for power transmission network based on spatiotemporal data compression designed in this article		Optimization Algorithm for Transmission Delay in Power Networks Based on Wireless Sensing		Optimization Algorithm for Power Network Transmission Delay Considering Multipath Transmission of Network Information	
	Data transmission time (ms)	Data receiving time (ms)	Data transmission time (ms)	Data receiving time (ms)	Data transmission time (ms)	Data receiving time (ms)
5	10.474	11.058	21.485	21.482	21.584	24.485
10	11.555	11.244	22.142	22.473	25.243	25.368
15	11.644	11.425	23.358	23.846	26.985	26.257
20	12.222	12.112	24.245	35.857	32.987	27.486
25	12.461	12.336	25.358	36.473	35.246	32.237
30	12.693	12.589	26.638	38.185	38.286	36.148
35	13.255	13.255	31.742	39.753	39.876	37.265
40	13.388	13.844	32.745	42.856	45.842	38.855
45	14.446	13.967	35.573	45.286	46.874	39.374
50	14.659	14.535	36.846	46.986	47.576	42.573
55	14.824	14.982	37.854	47.853	48.778	43.986
60	14.934	15.594	38.276	49.742	51.274	44.854
65	15.555	15.866	42.584	52.746	52.862	49.276
70	16.464	16.486	44.445	53.856	53.753	55.784
75	17.892	17.348	46.386	55.987	55.845	56.276
80	18.386	18.957	49.985	58.356	69.576	57.283
Data volume (GB)	The delay optimization algorithm for power transmission network based on spatiotemporal data compression designed in this article		Optimization Algorithm for Transmission Delay in Power Networks Based on Wireless Sensing		Optimization Algorithm for Power Network Transmission Delay Considering Multipath Transmission of Network Information	
	A-B	B-A	A-B	B-A	A-B	B-A
50	1288.5	1454.5	452.5	557.4	455.5	655.5
100	1654.2	1523.3	474.3	545.5	424.1	634.4
150	1523.3	1598.6	424.6	528.2	558.2	662.3
200	1586.6	1575.2	539.2	436.6	443.3	523.6
250	1698.5	1624.4	484.4	562.3	585.6	559.8
300	1687.8	1636.2	558.8	488.5	438.9	642.5
350	1627.4	1584.8	427.5	554.8	554.5	538.7
400	1638.5	1666.4	633.6	448.4	548.4	665.8
450	1647.2	1785.5	655.2	476.5	525.6	596.2
500	1524.3	1841.6	658.7	628.6	536.8	558.3
550	1687.6	1727.3	672.5	544.9	669.4	584.8
600	1541.9	1738.8	564.6	455.5	698.5	642.8
750	1654.5	1749.5	488.9	583.6	456.2	524.4
800	1725.7	1752.4	646.8	434.4	583.3	536.2
950	1838.8	1774.8	576.5	668.2	442.6	558.3
1000	1865.5	1827.2	452.6	695.4	585.8	685.6

As can be seen from Table 2, the transmission time and reception time of the power transmission network delay optimization algorithm designed in this paper are relatively short, and the node residual energy consumption is high; the transmission delay optimization algorithm based on wireless sensor and the transmission delay optimization algorithm considering multi-path transmission of network information are relatively long, and the node residual energy consumption is low. The above experimental results show that the delay optimization algorithm of power transmission network designed in this paper has good performance, reliability and certain application value.

4. Conclusion

Power network transmission is a very important part of power system, which mainly involves data collection, transmission, processing and application. In recent years, with the rapid development of technologies such as big data, artificial intelligence, intelligent perception, Internet of Things and wireless communication, power network transmission is also undergoing major changes. Transmission delay optimization of power network is of great significance to improve the response speed, data integrity and scalability of power system. The transmission delay of power network can be optimized by upgrading communication equipment technology, adopting high-speed and stable communication protocols and hardware equipment, adopting data compression technology and data type optimization technology to reduce data transmission, improving communication speed and optimizing network topology and node layout. The conventional transmission delay optimization algorithm of power network has poor performance and can not meet the current transmission requirements of power network, so this paper designs a new transmission delay optimization algorithm of power network based on spatio-temporal data compression. The experimental results show that the designed transmission delay optimization algorithm of power network has good performance, reliability and certain application value, and has made certain contributions to improving the transmission reliability of power network.

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