Research on Routing Algorithm of Smart Grid Atmospheric Optical Communication Network in Cloud Computing Environment

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Abstract. With regard to improving the transmission rate of the smart grid atmospheric optical communication network and reducing the output error code and reality, a calculation method of the smart grid atmospheric optical communication network routing based on the operation and calculation of hybrid particle swarm optimization is studied. The link structure model of the smart grid atmospheric optical communication network is established, and the network routing nodes are explored to achieve the dynamic neighborhood and node location of the optical communication network routing. Through practice, improving the transmission rate of the optical communication network of the smart electrical network and reducing the network output timeliness and error codes can be solved by the routing calculation method.

Keywords: Cloud Computing, Smart Grid, Optical Communication Network, Routing

1. Introduction
Smart Grid is a safe, reliable, economical and efficient new power network based on high-speed, broadband, and large-capacity communication networks, comprehensively using advanced information processing technology [1,2]. The smart grid system uses a large number of advanced micro sensors, and forms a wireless sensor network through independent sensors [3,4]. This network overcomes the limitations of the traditional wireless point-to-point transmission mode. The nodes adopt self-organizing technology, Ways such as multi-hop relay realize long-distance and energy-saving data transmission. The new wireless transmission network composed of sensors has multiple expandable functions and strong applicability [5,6]. At the same time, the wireless sensor network can effectively monitor the operating status of local power networks, which effectively improves the grid data in traditional power companies. The security level in the direction of transmission and information management and control [7,8]. Combined with the future development trend of communication technology, wireless sensor systems have a wide range of applications in the transmission, transformation, distribution, and utilization of the power grid [9]. At present, the routing algorithms of smart grid atmospheric optical communication network in cloud computing environment mainly include LEACH clustering algorithm, adaptive equalization algorithm, channel conflict avoidance routing algorithm and ring routing algorithm, etc. The routing protocol optimization design is realized...
through routing detection algorithm. Optimize the deployment and positioning of the nodes of the smart grid atmospheric optical communication network, improve the stability of the network output and have a better smart grid energy-saving path planning effect [10]. Through the channel equalization design of the smart electrical network optical communication network, routing optimization detection is realized Harmony networking design improves the global connectivity of the network and the probability of accurate transmission and reception. However, this method is susceptible to interference from neighboring nodes in node deployment and routing design, and is prone to routing conflicts, leading to increased output error and nonlinear distortion.

In response to the above problems, this paper proposes a smart grid atmospheric optical communication network routing algorithm based on hybrid particle swarm optimization in a cloud computing environment. First, build the link structure model of the smart grid atmospheric optical communication network, analyze the fitness of the network routing nodes, and then perform the linear combination design of the network routing nodes, combined with the hybrid particle swarm distribution method, perform optimal routing distribution search, and realize optical communication Network routing dynamic neighborhood decision and node location adaptive update. Finally, the simulation design of the routing algorithm is carried out, and the validity conclusion is drawn.

2. System networking scheme and sensor function module

The smart grid sensor wireless backhaul system to be completed in the project is shown in Figure 1. The bottom layer of the system realizes the collection and monitoring of environmental parameters (such as temperature, humidity, hazardous gas detection and other business data) of the energy storage hydropower plant building through a variety of sensor nodes.

![Figure 1. Smart grid wireless sensor backhaul system networking scheme](image)

The basic data collection task of the system is realized through the sensor collector device and the high-speed wireless gateway (CPE) module, through the CPE access to the TD-LTE wireless private network, and the power plant sensor monitoring network management platform to achieve data interaction; adopted in the plan The electric power TD-LTE wireless private network can realize the high-speed broadband channel for data transmission; at the same time, the application layer conducts centralized management of the system through the integrated information management platform, and the system parameter management can be viewed and unified in the central computer room located in
the office building of the power plant. Operation and maintenance. The real-time data monitoring, return and monitoring functions of the power plant plant realized by the wireless sensor return system can effectively improve the efficiency of the system function and greatly improve the systemic risk prevention and control capabilities of the plant. At the same time, this solution can effectively meet the needs of future big data collection and Analyze the required infrastructure requirements to greatly improve the overall operation and maintenance capabilities of the electromechanical equipment of the hydropower plant, as well as the level of refined management of personnel.

3. Network model analysis and node fitness calculation

3.1. Smart grid atmospheric optical communication network link structure model

In order to realize the smart grid atmospheric optical communication network routing design under the cloud computing environment, it is necessary to first build the link structure model of the smart grid atmospheric optical communication network. According to the adaptability of the network routing nodes, the network link structure model is mainly divided into four layers. The network structure is shown in Figure 2.

![Network Structure Diagram](image)

**Figure 2.** Smart grid atmospheric optical communication network link topology

According to the initial network topology shown in Figure 2, the random link networking analysis is carried out. It is assumed that the edge vector of the smart grid atmospheric optical communication network is \( \text{Li}_{i=1, 2, \ldots, \text{CL}} \), and the directed graph \( G \) is used. \( \{V, E\} \) represents the topology of the network, where \( V \) is the edge set of the smart grid, and \( E \) is the sink node set of the grid. The position update formula of the network routing node is obtained as shown in the following formula:

\[
\begin{align*}
\text{v}^{k+1}_{id} &= \omega \cdot \text{v}^k_{id} + c_1 \cdot \text{rand} \left( \text{p}_{id} - \text{x}^k_{id} \right) + c_2 \cdot \text{rand} \left( \text{p}_{gd} - \text{x}^k_{id} \right) \\
\text{x}^{k+1}_{id} &= \text{x}^k_{id} + \text{v}^{k+1}_{id}
\end{align*}
\]

(1)

(2)

Among them, \( k \) is the number of iterations for routing node optimization, \( c_1 \) and \( c_2 \) are learning factors, \( \text{rand}() \) is a random number uniformly distributed between \([0, 1]\), and \( \omega \) is the inertia weight of the smart grid network topology. Consider The energy balance of the network uses the linear decrement method for adaptive weighting of the network link layer [8], where the value of \( \omega \) is:
\[
\omega = \omega_{\text{max}} - t \frac{\omega_{\text{max}} - \omega_{\text{min}}}{T_{\text{max}}}
\]  

(3)

Among them, \(\omega_{\text{max}}\) and \(\omega_{\text{min}}\) are the upper and lower limits of the inertia weight of the distributed routing, \(T_{\text{max}}\) is the maximum number of iterations of the fixed path transmission, and \(t\) is the current number of iterations of the algorithm. The gateway GW (Gateway) is initialized, and the topological radius of the routing conflict node is calculated as:

\[
SL_i = \begin{cases} 
L_i & \text{if } i = 1 \\
\text{New}^i & \text{otherwise} 
\end{cases}
\]  

(4)

Among them, \(\text{New}^i = (e_{i1}, e_{i2}, \cdots, e_{iD})\) represents the robust coefficient of the cloud computing node. The node link matrix \(S_{\text{N} \times \text{L}}\) and the conflicting signal are linearly weighted, and the communication load of the computing node is:

\[
B_{\text{N} \times \text{L}} = S_{\text{N} \times \text{L}} \cdot T_{\text{L} \times \text{L}}
\]  

(5)

Within the constraint range \((x, x(k))\) allocated by the network manager, the correlation coefficient of the smart grid atmospheric optical communication network is \(i, j\), and the load of each link is marked to obtain the output power load of the corresponding sink node for:

\[
D_{\text{node}}(i) = \frac{N'_{\text{node}}(i)}{N_{\text{node}}} \quad 1 \leq i \leq N_{\text{node}}
\]  

(6)

Note the node communication frequency matrix \(F_{\text{N} \times 1}\), in the cloud computing environment, compare the robustness state characteristic parameters of neighboring nodes, and carry out the optimal networking design of the smart grid atmospheric optical communication network link structure.

3.2. Node fitness calculation

Based on the link topology design and network link analysis of the smart grid atmospheric optical communication network, the node fitness is calculated, and the hybrid particle swarm optimization method is used to adapt the node adaptation of the smart grid atmospheric optical communication through the optimization of the node fitness. In the process of particle swarm evolution, the pheromone update of each particle depends on the current fitness value of the particle. The fitness value of the current root node of the smart grid atmospheric optical communication network is selected and the rapid simulated annealing algorithm -VFSA) performs pheromone update, the update rules are as follows:

\[
l_i(k) = (1 - \rho)l_i(k - 1) + \gamma f(x_i(k))
\]  

(7)

Among them: \(\rho\) is the balance coefficient of the candidate cluster heads of the smart grid atmospheric optical communication network, and \(\gamma\) represents the fitness extraction ratio. Use \(P_{ij}(k)\) to represent the probability of the data sent by the i-th routing node to its neighbor set at time k, which is calculated by the following formula:

\[
P_{ij}(k) = \frac{(l_i(k) - l_j(k))\eta_{ij}(k)}{\sum_{j \in N_i(k)} (l_i(k) - l_j(k))\eta_{ij}(k)}
\]  

(8)
Where \( j \in \text{Ni}(k), \ Ni(k) = \{ x_j(k) - x_i(k) < r_d(k) \} \); \( n_{ij}(k) \) is the distance from the multi-hop route between clusters to the base station, which represents the smart grid atmospheric light The degree of enlightenment from node i to node j in the communication network.

In the node location update stage, the particle swarm algorithm is used to calculate the fitness to obtain the optimal repair weight probability \( P_{ij}^{opt}(k) \) of the i-th particle for route repair. During the evolution of the particle swarm, the step size \( s \) is adjusted, and the candidate node enters the sleep state calculate the position of the i-th particle training node at time \( k+1 \) according to the following formula:

\[
x_i(k+1) = x_i(k) + s \left( \frac{x_j(k) - x_i(k)}{x_j(k) - x_i(k)} \right)
\]

(9)

Among them: \( \tilde{x} \) represents the norm of \( \tilde{x} \). The output power of the power grid is modulated according to the energy \( E \) of the cluster head, \( r_s(k) \) is used to represent the cluster head perception range of the power grid node, \( r_s(k) \) is the probability that the i-th node at time \( k \) receives CompeteHeadMsg, and \( 0 < r_s(k) < r_i \), the following formula is used for adaptive iteration and node Campaign adjustment:

\[
r_i(k+1) = \min \left[ r_s, \max \left\{ 0, r_i(k) + \beta \left( N_i(k) \right) \right\} \right]
\]

(10)

Among them: \( \beta \) represents the neighborhood change rate of the cluster head, and \( N_i \) represents the remaining energy of the smart grid. The fitness of neighbor nodes is calculated through local information, and the network routing optimization deployment and vulnerability repair design are realized according to the fitness calculation.

4. Simulation test and result analysis

In order to verify the application performance of this method in the routing design of smart grid atmospheric optical communication network, simulation test analysis is carried out. The experiment is established in the OMNet++ cloud computing environment. The routing algorithm design is implemented by programming with Matlab7 simulation tool. Smart grid atmospheric optical communication The information coverage radius of a single routing node of the network is 12m, the probability of collision at the node PC is 0.21, the initial position of the sink node is \((0.25,0.25)\), the output power of the grid node is 1200W, and the grid output bandwidth is \( T_s = N_f T_f \), where \( N_f = 25 \), \( T_f = 200ns \), \( T_c = 3ns \), the number of mixed particle swarms is 1024, and the selection range of disturbance coefficient is \( 0.2 \leq K \leq 0.35 \).

According to the above simulation environment and parameter settings, the output state measurement values of the smart grid atmospheric optical communication network system under different disturbance coefficients are obtained. Until the loop termination condition is met, the iteration is completed, and the optimization design of the routing algorithm of the smart grid atmospheric optical communication network is realized. Analyzing the results of Figure 3, we know that the method in this paper is used for routing design. As the disturbance coefficient \( K \) decreases, the output state information parameters of the power grid are closer to the true value, and the optimal power transmission is realized. Different methods are used to measure the smart electrical network. The transmission error of the optical communication network, the comparison result is shown in Figure 3.

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Analyzing the simulation results, it is concluded that the method of this paper is used to design the network routing, the transmission error is the smallest, and the stability of the network is improved. Table 1 shows the bit error rate and experimental comparison of different methods for network routing design. Analysis of the results of Table 1 shows that using the method in this paper for routing design, the output error of the network is low, and the delay of grid data transmission is small, improve the real-time performance of grid dispatching and distribution.

**Table 1.** Comparison of bit error rate and transmission delay

| Method                        | Bit error rate | Delay/ms |
|-------------------------------|----------------|----------|
| Method of this article        | 0.0044         | 2.14     |
| Particle filter               | 0.0547         | 3.36     |
| Ring routing                  | 0.1026         | 4.06     |
| Linear weighting              | 0.1929         | 2.86     |
| Minimum mean square error     | 0.0833         | 3.87     |

### 5. Conclusion

This paper studies the optimal design of optical communication network routing for smart grids, and proposes a smart grid atmospheric optical communication network routing algorithm based on hybrid particle swarm optimization in a cloud computing environment to achieve dynamic neighborhood decision-making and node location for optical communication network routing Adaptive update. The research results show that the use of the routing algorithm can improve the transmission accuracy of the optical communication network of the smart electrical network, reduce the network output delay and error code, and improve the real-time and accuracy of the output distribution of the power grid under the cloud computing environment.

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