Research on New Generation of Power Line Carrier Communication Trusted Networking Algorithm

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ABSTRACT: With the safe and stable operation of the new generation of power line carrier communication, it is of great significance to the rapid development of smart power grid. However, due to its own physical characteristics and the impact of the external environment, communication cables usually have some security risks, such as aging, damage, theft. In this paper, a new generation of power line carrier communication trusted access network is studied. In this paper, the current situation of the new generation of power line carrier trusted access and network requirements are analyzed, then the principle and characteristics of basic ant colony algorithm are briefly introduced, then the characteristics of power line carrier communication system network and network requirements are analyzed, the improved ant colony algorithm is applied to network optimization of the new generation of PLC communication system. The algorithm makes the power line carrier communication system have certain destruction resistance and recombination ability when the network state changes, it can guarantee the reliable operation of power network communication system.

1. Introduction

Power line carrier communication (PLC) is a power system communication with transmission lines as the carrier signal transmission medium. Because the transmission line structure is very strong, there will be at least three conductors, so that the power line can not only serve as the carrier of the power line, but also serve as the medium for the carrier signal, which not only saves cost but also has high reliability. Many countries in the world have invested a lot of manpower and material resources to carry out research, experiment and industrialization, so carrier communication has received extensive attention.

The current grid development mode is a power transmission and information processing system of integrated network architecture, from a certain extent, the grid is the double carrier of electricity and PLC signal transmission, on the basis of the existing communication and sensing technology, through the power line to power grid operation and maintenance to provide reliable, timely, actionable information. At the same time, the application of power line carrier communication technology to the laid power cable avoids the rebuilding of new lines, greatly saves the cost and improves the use efficiency of the power system. For some complex and dangerous environments, a large amount of human and material resources are also avoided. In addition, the network environment and equipment
state information can also be sensed through PLC signal and power line channel, thus, it can realize the perception of power grid operation state, the all-round protection of power grid operation equipment and the intelligent diagnosis, it can realize the purpose of detecting the safety of power network and making the power system run efficiently. As an important part of the development of intelligent power network system, the power line carrier communication technology has been widely concerned and is one of the most important frontier technologies at home and abroad.

2. A new generation of power line carrier trusted access to the status quo
At present, China is in a new era of stable people's livelihood and rapid economic development, and the safe operation of power grid is of great significance to maintain this situation. Therefore, the reliable and stable operation of the new generation of power line carrier communication directly affects the communication security of power grid. But the existing communication cable due to its own physical characteristics and the impact of the external environment, there are usually some security risks, such as aging, damage, theft, which directly cause PLC communication failure. Therefore, this paper studies the trusted access of new-generation power line carrier communication. Once the original network topology changes due to fault or other problems, it should be possible to find another communication path for the fault line as soon as possible, so as to realize the reorganization of network topology and establish a new routing table.

3. Demand analysis of new generation PLC trusted networking
The networking algorithm adopted by the new generation OF PLC network should be able to meet the following requirements:

(1) The primary goal of using the improved networking algorithm for networking operation is to establish the routing table of each slave station in the master station, so as to facilitate the master station to obtain the best path to a certain slave station.

(2) When the original network topology changes due to fault or other problems, it should be possible to find another path for communication for the fault line as soon as possible, so as to realize the reorganization of network topology and establish a new routing table.

(3) When the system network is communicating, it shall ensure that only one communication node in the current region sends data at any time. Considering the blind structure characteristics of the system network, only the master station keeps the routing table of the site, and each slave station only knows the communication path to the master station and the information of the nearby stations that can be directly communicated.

(4) Can realize the communication to the designated site and plug and play site. All sites in the network should have their own physical ID to distinguish them. The communication process between slave station and master station is the same. Once the network structure changes, the normal communication can be resumed only by adding or deleting the corresponding nodes.

4. A new generation of PLC trusted networking algorithm based on ant colony algorithm
Ant colony algorithm was born in the early 1990s. It was first proposed by Italian scholar Marco Dorigo and others as a random search algorithm based on the observation of ant foraging behavior. As a kind of social insect, ant can show highly structured and autonomous behavior, which has aroused great research interest of scholars. After more than 20 years of development, ant colony algorithm has been widely used in a variety of combinatorial optimization problems, such as travel agent problem, workshop scheduling, line distribution, etc., and has also been applied in low-voltage distribution network networking and street lamp monitoring, all of which have achieved good results. Therefore, the new generation OF PLC trusted access system based on ant colony algorithm designed in this paper will be improved on the basis of ant colony algorithm.

In this section, the principle and characteristics of ant colony algorithm are briefly introduced, and the network topology of cable anti-theft system is analyzed. Then, the improved ant colony algorithm is
applied to network simulation. Finally, the simulation results are obtained and the performance of the algorithm is compared and analyzed.

4.1. Principle and Characteristics of ant colony algorithm

Ant colony algorithm (ACO) is an optimization algorithm inspired by the behavior of ants searching for food in nature. In nature, the ants' final foraging route is always approximated by a line connecting the nest to the food source. Through observation and research, it is found that the ants' initial foraging route is not the final straight line, but the shortest route to the food source obtained through the interaction of the colony during foraging and constant adjustment of the searching route. Communication between colonies depends on pheromones released by ants as they search for a path. The more ants pass along the same path, the higher the pheromone concentration. Conversely, if a line is too long and fewer ants pass by, pheromones in the line will gradually evaporate, leaving subsequent ants looking for food only with a lower probability of choosing this route.

Ant colony algorithm is obtained by theorizing the actual foraging behavior of ants. The algorithm guides the ant's optimization behavior by heuristic information and changes of pheromones, and gets the optimal solution after several iterations. Similar to actual foraging behavior, when an ant passes through a path, the pheromone concentration on that path increases, making it more attractive to subsequent ants. At the same time, the pheromones on the path will continue to evaporate at a certain rate, which is a good way to prevent the search from stopping prematurely.

The change of pheromone concentration in this algorithm combines both positive feedback and negative feedback, and the release and volatilization of pheromone directly guide the behavior of "ants", so as to obtain the continuous optimization of path solution, so that the result finally converges to the optimal solution.

As an optimization algorithm derived from bionics, ant colony algorithm has the following characteristics:

① A combination of positive and negative feedback;
② Distributed computing;
③ Self-organization and systematicness.

4.2. New generation PLC trusted networking algorithm

This paper takes the "hop count" required from the master node to the target slave node as the optimization goal, and the "communication distance" as the constraint condition. "Hop count" in this article refers to the number of times that data needs to be forwarded when sent from the master node to the target slave node. For example, if two nodes can communicate directly, the number of hops when sending data between the two is 0; if one is required The relay node can reach the target node only after forwarding, and the hop count is 1. "Communication distance" in this article refers to the number of nodes crossed by two nodes that can communicate directly plus one.

The number of "ants" in the algorithm should be selected according to the complexity of the network, considering that the length of each branch is very limited, and in actual situations, the number of slave stations under each master station is mostly (30, 40), so we choose 10 ants per batch. When the global pheromone is updated, refer to the update rules of the maximum and minimum ant colony algorithm to limit the size of the pheromone and set the upper and lower limits of the value to prevent the algorithm from prematurely stagnating and falling into the local optimum. Since the cable anti-theft system only needs to establish a route from the master node to each slave node when it is networked, artificial ants are placed in the master node. Every time an iteration is completed, the global pheromone is updated according to formula (1):

$$\tau_{ij}(t + 1) = p\tau_{ij}(t) + \Delta\tau^{\text{best}_{ij}}$$

Among them: it is the volatilization coefficient of the global pheromone in the current iteration; is the pheromone increment on the optimal path obtained in the current iteration, which can be obtained according to formula (2):
Δτ_{best}^{ij} = \begin{cases} K \cdot (L_{ib})^{-p}, & L_{ib} \in \text{best} \\ 0, & \text{else} \end{cases}

Among them: represents the optimal solution in the current iteration, K is the coefficient, and the choice of it and the value of p will affect the growth rate of the pheromone during the iteration of the optimal path. In the process of the algorithm, only the pheromone increase processing is performed on the optimal path obtained from the iteration, and the pheromone on other paths is volatilized. This can make the search process more instructive, so that the ant search can focus on the iterative optimal around the path.

5. Summary
The article analyzes the current status and networking requirements of the new generation of power line carrier trusted access first, and then briefly introduces the principles and characteristics of the basic ant colony algorithm, and then analyzes the characteristics and networking requirements of the power line carrier communication system. The improved ant colony algorithm optimizes the networking of the new generation PLC communication system. When the original network topology changes due to fault or other problems, the algorithm should be able to find another communication path for the fault line as soon as possible, realize the reorganization of network topology, and establish a new routing table, so as to better protect the grid communication reliable operation of the system.

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