Dust monitoring and processing system based on WiFi Mesh network distributed backup routing algorithm

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Abstract. This paper proposes a dust monitoring and processing system using WiFi Mesh network distributed backup routing algorithm. The system is based on WiFi Mesh technology to realize real-time dust data monitoring and dust processing, and transmit the data to MCU and cloud. Users can access the cloud through mobile devices to obtain dust concentration data in the industrial environment. The system uses WiFi Mesh network distributed backup routing algorithm to improve the self-healing of the network system and the stability of the overall system.

Keywords: WiFi Mesh network, dust monitoring and processing, dust concentration

1. Introduction
With the rapid development of modern industry, productive dust has become a major hidden danger to industrial safety. Dust reduces product quality and machine accuracy, and brings great harm to the health of workers in dusty environments. The Chinese government has promulgated a series of regulations such as "Decision on Preventing Silica Dust Hazard in Factory and Mining Enterprises" to reduce the hazard of dust. A variety of dust monitoring instruments have been developed at home and abroad, such as dust samplers, direct-reading dust meters, dust concentration sensors, etc., but each has disadvantages such as increased accuracy and reduced dust concentration and higher working environment requirements. The core idea of the distributed backup algorithm of WiFi Mesh network proposed in this paper is extended based on the routing algorithm of HWMP routing protocol, and the backup routing function is proposed and developed to realize the multi-path routing protocol. Combining the WiFi Mesh network distributed backup algorithm with the dust monitoring system can improve link self-healing and reliability, significantly increase throughput, reduce time delay, and improve the efficiency of dust processing. At present, there are problems in the field of industrial dust monitoring and processing systems, such as unstable throughput, large environmental constraints and easy damage. The dust monitoring and processing system based on the WiFi Mesh network distributed backup routing algorithm proposed in this paper solves the above problems.

2. System structure
The dust monitoring and processing system proposed in this paper consists of three subsystems: dust monitoring system, dust processing system, real-time data monitoring, and control system. The dust monitoring system is composed of multiple intelligent dust sensors distributed in nodes. The intelligent dust sensor is composed of a sensor, a microprocessor, and a communication terminal. The
function of the dust monitoring system is to monitor the real-time dust concentration in the industrial environment and transmit the data to the MCU and the cloud. The dust processing system is composed of multiple intelligent dust processing devices distributed in nodes. The intelligent dust processing device is composed of a dust collector, a microprocessor, and a communication terminal. The function of the dust treatment system is to process dust and reduce the dust concentration in the industrial environment to a safe range. The real-time data monitoring and control system is composed of personal devices, communication terminals and cloud platforms. Its function is to upload the monitored dust concentration data to personal devices in real time to realize the user's monitoring of dust concentration, and at the same time receive control commands from mobile devices and operate instructions Released to the dust treatment system [1].

3. Application of WiFi Mesh network distributed backup routing algorithm in this system

3.1. Establishment of WiFi Mesh network node in this system

Figure 1. Dust monitoring and processing system structure

Figure 2. Dust monitoring and processing system WiFi Mesh node network
WiFi Mesh is a network protocol based on WiFi protocol. WiFi Mesh allows multiple devices distributed in a huge indoor or outdoor physical area to be interconnected under a single WLAN. These devices constitute the nodes of the WiFi Mesh network. There are five types of nodes in this system:

1. **Root node**: The root node of the communication terminal, the top node of the WiFi Mesh network tree topology, is the only interface between the WiFi Mesh network and the external IP network, and connects the cloud platform and personal devices through a router. The root node of the communication terminal acts as a gateway to forward external data packets, that is, to forward real-time dust concentration data to personal devices and to deliver dust processing instructions issued by users to the WiFi Mesh network.

2. **Parent node**: includes the intelligent dust sensor parent node and the intelligent dust collector parent node. These two types of nodes are the intermediate nodes of this WiFi Mesh network, and their functions are to receive, send, and transmit dust real-time data packets from the root node, leaf nodes and parent nodes.

3. **Leaf node**: Including intelligent dust collector leaf node and intelligent dust sensor leaf node. These two types of nodes only receive and send dust real-time data packets, and do not transmit data [2].

3.2. **The working principle of the WiFi Mesh network distributed backup algorithm in this system**

3.2.1. **WiFi Mesh network distributed backup algorithm module**

![WiFi Mesh network distributed backup algorithm module]

The distributed backup routing scheme of WiFi Mesh network in this system includes four modules [3].

1. **Route establishment module**: This module is modified based on the original HWMP routing protocol route establishment process, and backs up the root route and local route in the original protocol.

2. **Route maintenance module**: This module is responsible for monitoring and maintaining the life cycle of each link in the network.

3. **Data transmission module**: This module reasonably selects the routing path or backup routing path when sending data in the network.

4. **Route self-healing module**: This module is the first to use the backup path to rebuild the data path when the link node fails. If the main path and backup path from the current node to the root node fail during the route reconstruction process, find the nearest neighbor nodes that can communicate with the root node to rebuild the data path, bypass the failed link, and make the route reconstruction more efficient improve.

3.2.2. **The routing path establishment of the distributed backup algorithm of the WiFi Mesh network**

The distributed backup routing path in the WiFi Mesh network includes the main routing path and the backup routing path. The establishment of the main route path is to establish a tree route from the
MAP node to the root node in the WiFi Mesh network. First, the root node Root initiates a RANN broadcast message. After receiving the message, the MAP node determines whether the MAC address of the node has been added to the address list of the RANN data frame. If it has been added, the data frame is discarded; if not, it will be Write your own MAC address into the list of RANN data frames and modify the local backup routing path information. Write the address information of the current node into the RANN message, and record the path to the root node.

Figure 4. Routing path establishment of distributed backup algorithm in WiFi Mesh network

3.2.3. Routing path selection of WiFi Mesh network distributed backup algorithm in data transmission. When dust data is sent to the destination node, first find the corresponding main path in the local main path routing table, if found, send it according to the main path; if not found, search for the local backup path, if find the backup path, then press the backup path send. If neither the primary path nor the backup path is found or has failed, the root path routing table is searched, and the source node sends the data to the root node. The root node continues to forward data frames to the real destination node. When none of the above paths are found, the source node rebuilds the two links to the destination node and does not want to cross paths, and the establishment process is as described above. After receiving the dust data message, the intermediate node determines whether the path is the main path or the backup path according to the flag in the message. If it is the main path, a bidirectional route is established in the main path routing table according to the address information and the source address and destination address in the message.
4. Experimental result
In the experimental simulation system structure, first power on to detect the establishment time of the WiFi Mesh network system.
Table 1. Distribution network time detection

| Node Type    | Time Spent (ms) |
|--------------|-----------------|
| Root Node    | 8.14            |
| Parent Node  | 4.69            |
| Chile Node   | 3.94            |

From the above table, it takes 8.14ms to establish a root note, 4.69ms to establish a parent node, and 3.94ms to establish a child node. It can be seen that the WiFi Mesh network configuration only takes a very short time to complete.

In order to test the fault tolerance and high efficiency of this system, one node is randomly damaged and the link fails. The time for rebuilding the data transmission link for multiple tests is shown in the following table:

Table 2. Comparison of the reconstruction time of the basic algorithm and the reconstruction time of the algorithm when the node is damaged

| Numble | Original (ms) | Backup (ms) |
|--------|---------------|-------------|
| 1      | 6.98          | 1.01        |
| 2      | 6.15          | 1.05        |
| 3      | 5.42          | 1.03        |
| 4      | 7.01          | 1.00        |
| 5      | 6.17          | 1.01        |
| 6 (mean)| 6.35         | 1.02        |

It can be seen from the table that the average reconstruction time of the backup algorithm is 1.02ms, and the average reconstruction time of the basic algorithm is 6.35ms. The reconstruction time of the backup algorithm is reduced by 83.94% compared with the basic case. It can be seen that the system is damaged in the node when a link fails, it takes less time to rebuild the link by using the backup algorithm, which significantly improves the efficiency of the system.

5. Conclusion
The industrial dust monitoring and processing system based on WiFi Mesh distributed backup routing algorithm proposed in this paper has been tested by experiments to improve system self-healing and improve system processing efficiency. Applying WiFi Mesh technology to the process of industrial dust monitoring and processing can overcome the instability and low fault tolerance of traditional sensors. The main path and backup path are enabled through the WiFi Mesh algorithm, which provides a variety of options for data transmission. The routing table is updated in time to delete the invalid path, which improves the utilization of the system's profit space. This system not only meets the actual needs of dust monitoring and processing in industrial production, but also provides development prospects for the application of emerging WiFi Mesh technology.

Acknowledgments
This work is supported by the National innovation and entrepreneurship training program for college students with Grant No. S202010497211.

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