
Research on Clustering Protocols Based on Event-Driven

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Abstract

In order to ensure the safety production in coal face, we need to monitor face working conditions and environment information; this paper presents a kind of clustering routing algorithm which is based on event-driven. Under normal circumstances, we improve LEACH protocol to monitor the information on the face; in an emergency, cluster head nodes in the event area will be selected based on events the degree of irritation the node residual energy and the power transmission level. The simulation results show that the agreement can quickly build a temporary path for effective data fusion, and can prolong the network lifetime.

Keywords: Working face, LEACH event driven, Stimulated degree, Power level

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1. Instruction

In recent years, the wireless sensor network used in underground has become a reality. Coal mining face as the first line production, its environment is complicated, its geological conditions are harsh, and it is in dynamic mining [1]. So it brings a lot of uncertainty factors to the wireless sensor network of the coal mining face, such as the gas explosion and fire emergency occurs frequently, and it brings great threat of safety production in coal mine [6]. Therefore, we need to create a temporary link structure of the incident, promptly informed of the information in the event area, and provide data to support post-disaster relief work.

Recently, extensive research efforts have been dedicated to the establishment of Routing transport mechanism in Wireless Sensor Networks at home and abroad. One typical protocol is TEEN [2], which needs to Cluster the entire network and build the paths in advance. When event occurs, the whole network will reclassify the clusters and update routings by considering the attributes like incident location [4, 5], severity, the influence scope. Therefore, this paper will present a new clustering routing algorithm which is based on event-driven [6]. The main idea of this algorithm is using the improved LEACH protocol to monitor the environmental information and mining information under normal circumstances, while under the emergency situations [7, 8], nodes will be triggered when the detection data overrun, then the nodes in the event area will select the cluster head according to the stimulus level and the remainder energy. Afterwards, the new algorithm will determine the best cluster radius by the power transmission level and design a suitable routing algorithm which is based on event-driven.

2. Improved Algorithm Under Normal Circumstances

Under normal circumstances, we only need to get the information of coal face working environment and mining situation periodically, then transmitting it to the sink node [9]. The sink node will pass the information to the Underground backbone through the explosion-proof industrial Ethernet switch, at last the information will arrive the dispatch center of the Inoue [4]. Generally, the transmission doesn't demand stringent real-time and priority, so we can use the clustering method. As proposed later in this paper, we will improve the typical clustering protocol LEACH to design a routing protocol which can be used in the long and narrow space of coal face working environment.

A typical long and narrow space is generally 2-5m wide, 2-5 meters high and about 100-200 meters in length. Coal working face is a limited space of semi-coal rock and semi-metallic non-uniform heterogeneous, which is arranged by the bracket, miner, scraper conveyors, and other large metal equipment, coal, rock and other media. Therefore, the wireless sensor network in the coal face is different from that in the open ground. In this paper, we will take the node remaining energy and the number of times for a node to be the cluster head node into account. To meet the long and narrow space, we adopt the multi-hop ways to transmit information, and pre-delineated the size of the cluster beforehand in order to avoid the network discontinuity caused by overloading near the sink node cluster head.

2.1. Network Partitioning

To avoid nodes take place premature death caused by the network "rod cone" data flow, we will use a non-uniform clustering method of the balanced energy consumption to divide the coal face wireless sensor networks. As illustrated in Figure 1, the coal face is divided into N regions $A_1, A_2, A_3 \dots A_N$, and the corresponding length are $L_1, L_2, L_3 \dots L_N$.

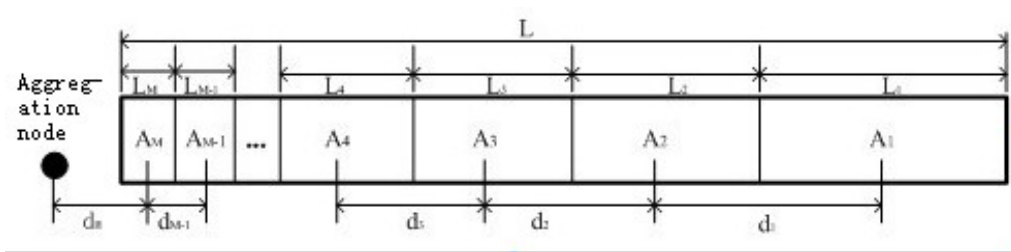


Figure 1. The Division of Working Face Wireless Sensor Network

We assume that the nodes are uniformly distributed in the monitoring area in t time and the amount of data generated by each node is k . During the time, the consumed energy in the region A_i is consists of three parts: receiving data from the region A_{i-1} , forwarding data from the region A_{i-1} , and sending the data of local area. Namely, the formula (1):

$$E_i = (E_{elec} \times k \times \frac{\sum_{j=1}^{i-1} L_j}{L}) + (E_{elec} \times k \times \frac{\sum_{j=1}^i L_j}{L}) + (E_{fs} \times k \times \frac{\sum_{j=1}^i L_j}{L} \times d_i) \tag{1}$$

Based on the balanced energy consumption between region A_i and A_{i-1} , we can get the equation $E_i = E_{i+1}$, then the partition iterative formula can be Calculated as formula (2) :

$$L_{i+2} = 2 \times \left(\frac{\sum_{j=1}^i L_j \times \left(\frac{L_i + L_{i+1}}{2} \right)^2 - \frac{E_{elec} \times (L_i + L_{i+1})}{E_{fs}}}{\sum_{j=1}^{i+1} L_j} \right)^{\frac{1}{2}} - L_{i+1} \tag{2}$$

Simultaneously, A_1 should be as large as possible to ensure the least network partition. Then, $r_c = L_1 + L_2$ should be guaranteed, and we can calculate the length of each zone by it.

2.2. Selection Of The Cluster Head

It is necessary to take full account of the remaining energy, the average remaining energy and the number of times for a node to be the cluster head in each Partition to select the cluster head. Here we use the weighted clustering method to select the cluster head. In region A_m , the formula (3) as follows is used to calculate the node weights:

$$W_i = \omega_1 \frac{E_0 - E_{(i)res}}{\overline{E_{A_m}}} + \omega_2 \frac{r_{(i)dan}}{r_{total}} \quad (3)$$

$$\overline{E_{A_m}} = \frac{\sum_{i=1}^{i=n} E_{(i)res}}{n} \quad (4)$$

where ω_1 and ω_2 are non-negative weights factor and meet the equation $\omega_1 + \omega_2 = 1$. The value of ω_1 and ω_2 can be adjusted according to the focus of the cluster head. E_0 is the initial energy of node; $E_{(i)res}$ is the current remaining energy of a round node; $\overline{E_{A_m}}$ is the average residual energy of nodes in the region A_m which can be calculated by the formula (4); r_{dan} is the number of times for a node to be the cluster head, while the network cycles is denoted by r_{total} . In the formula (4), n is the total number of rounds in the partition A_m . Nodes in the network calculate its weights according to equation (3), and the minimum node will serve as a cluster head in the current round.

When cluster heads have been selected, they will suspended to collect data, and they are mainly responsible for collecting the information, transmitting data in the cluster to reduce the traffic load. The cluster head broadcasts the news of the cluster head and establish a TDMA slot table, Cluster members will send their own message to the cluster head, which includes its residual energy. Consequently, The cluster head and its members can communicate with each other, and the cluster heads communicate through multi-hop link, then transmit the data to the sink node.

3. Routing Algorithm under Emergency Situations

Emergency situation require a higher real-time information, so we should create a temporary link, it will transmitted the perceived information with the fastest speed to Inoue, provide the basis for post-disaster relief work, shorten rescue time, reduce losses. Therefore, we will be considering the node's residual energy consumption, the incident area and stimulated level, after considering these factors, we should design the routing algorithm which accommodate of the face of unexpected circumstances. In order to facilitate the description of the event, we need for a simple parameter setting, node-aware information for the detection value D, the private threshold (Individual Threshed, referred to as the IT), When the node detection value of D over their own IT, indicating that the event occurs, the node is triggered. Meanwhile we will introduce the stimulus intensity (Excited Intensity is referred to as EI) to indicate the size of the node suffered stimulation, the absolute of the value of the detection value of the difference to a private threshold ($EI = |D - IT|$), characterized by severity of the incident.

3.1. Algorithm

When emergency events occur at some point, the detection value of the nodes within the event area will be more than IT, event LAN is triggered. And then it will select cluster head according to the event of incident severity, node residual energy and location within the region, bear the tasks of data collection and integration within clusters.

Node is triggered, at the same time, the built-in timer of node will be activated to start timing, the timing T_i decided by the node in the current residual energy and suffered stimulate strength, and it is inversely proportional to them. That means that the greater of node's residual energy, the stronger are stimulated, the greater the probability of being cluster head, T_i the shorter of T_i . Formula (5) to calculate T_i :

$$T_i = \frac{\alpha}{E_{(i)res}} + \frac{\beta}{EI} \quad i = 1, 2, 3 \dots N \quad (5)$$

Among them, α , β is the node energy coefficients and the stimulus intensity coefficient, which can be set according to the historical data monitored by incident, also be set by the dynamically demand. When the timing reached to T_i , the node is included in the scope of the prospective cluster head.

To ensure the energy consumption of the event within the region is quite, we need to optimize the number of cluster head and the number of cluster members. Clustering stage of the cluster head, we use different transmit power, establish the power gradient of the cluster head and cluster members, and select the appropriate radiation power to ensure low energy consumption and better connectivity.

Sensor nodes designed by Crossbow company, with the power control function, it can adjust the size of the transmit power. In this algorithm, we will assume that the node has four transmit power (level1 - level4), when the nodes become quasi-cluster head, the node will broadcasting quasi-cluster head message by four-power broadcasting, and establish the power

level with other nodes that time has not reached T_i . Assume quasi-cluster head broadcasting with power of level1- level4, the number of nodes within a certain range is 1, 2, 3, and 4, easy to know that $1 < 2 < 3 < 4$. To find the optimal number of clusters and number of cluster members, we conducted the following simulation. Prospective cluster broadcast messages with power of level4, after node in the event area clusters, the average power consumption of the remaining number of a single node and network as a comparison object to find the best members of the number of.

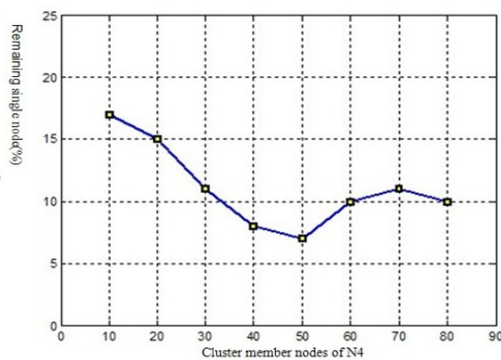


Figure 2. Changes of Remaining a Single Node with the Cluster Radius

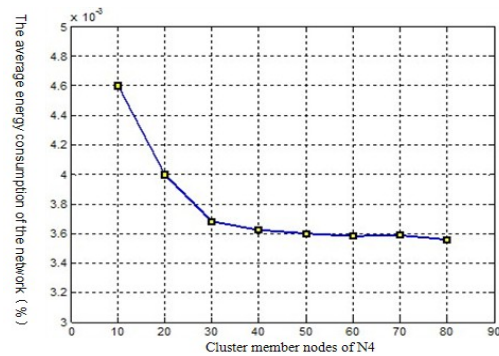


Figure 3. Changes of Average Energy Consumption of Network with the Cluster Radius

It can be seen from Figure 2, when the cluster member nodes accounted for 40% -50% of n_4 , the number of remaining cluster node is least and sub-clusters cover the highest. In Figure 3, when the number of cluster members accounted for 30% of n_4 , the average energy consumption of the network increases significantly lower with the cluster radius. But expanded to greater than 30% of n_4 , the average energy consumption of the network tend to balance. Through the above simulation, in order to use less cluster head and to achieve the equilibrium

of the network energy consumption, we choose the optimal solution of members of the cluster nodes is 50% of n_4

The cluster head has adopted level 4 launch power to radio news, when the nodes around it receive the node's information, they will record of the power grade with the cluster head, and its information will be feedback to cluster head. The nodes around to the node information, will record of the head with a prospective power grade, and its information feedback to prospective cluster head. If the cluster head is allowed to radio news in level 1 power grade, not the discovery has not triggered node events that the node is located in the border area events; if it is found that the members of the other in the ensemble, explain two cluster too close.

After a cluster, the cluster head in the events areas will collect nodes information, simple fusion, and set the highest priority for data transmission, then it will sent the data to the nearest cluster head, the cluster head of the news will stop the current task, and forward information to gathering node along the path, but they only forward events area information, no include fusion information of cluster head in normal area.

3.2. Algorithm Simulation

To indicate the effect of improved agreement, we will use MATLAB to simulate this agreement and TEEN agreement which for testing emergency event, the simulation content mainly includes data transmission delay, data quantity received by gathering node and the number of cluster in event areas. In the agreement, the parameters involved in $IT = 20, BT = 5, \alpha = 1, \beta = 1$.

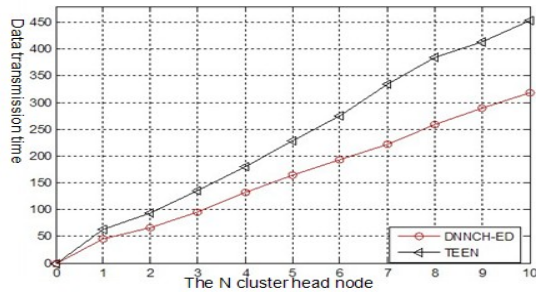


Figure 4. Data Transmission Delay

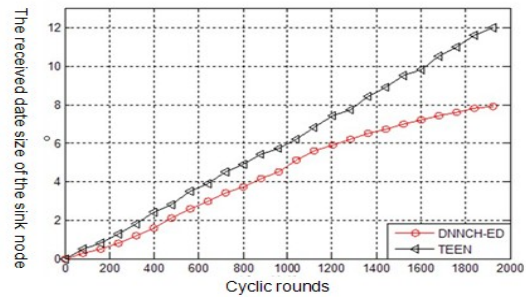


Figure 5. The Revolution Between Time and the Data Quantity Received by Gathering Node

Figure 4 shows that the transmission time of improved agreement is significantly shorter than TEEN agreement. The most important reason is that TEEN agreement didn't consider data correlation, events nodes in the area may be divided into several clusters, what maybe go against data fusion, and after a cluster, the cluster head still need monitoring local information while delivering information, and as data gradually accumulate, increase of data transmission, and increases the network time delay, at last cause the longer time delay from the event area information to the convergence node.

Figure 5 shows in the same cycle count wheel, the improved protocol received little data, the main reason is that in the events area, the clumps of improved agreement can ensure fusion processing of relevant data, reduce data redundancy, and avoid the similar data is divided into several cluster. But when an event occurs in TEEN agreement, a data acquisition is needed for a network, and then increases the amount of data which has nothing to do.

Figure 6 shows that with the expansion of events regional, the number of cluster head of TEEN agreement is rising, and the number of cluster head of DNNCH-ED agreement change gently. This is because in DNNCH-ED agreement the area clustering only related with events strength and the clustering radius, clumping less; And with the expansion of the scale of TEEN agreement, a cluster path increased, the number of cluster head increases.

From Figure 7 we can see that, in the same cycle wheel number, the energy consumption of DNNCH-ED is smaller than the TEEN agreement, the life cycle is also relatively long. And in

the process of data transmission, the improved agreement can transfer information directly, reduce the consumption of data transmission.

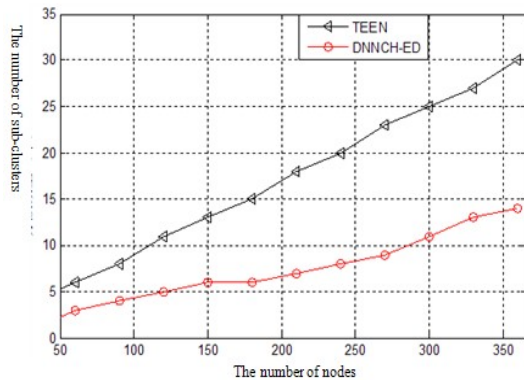


Figure 6. The Revolution Between Scale of the Network and the Number of Cluster Head

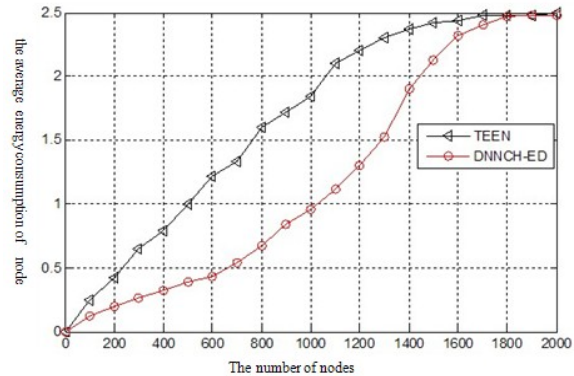


Figure 7. The Average Energy Consumption of Network Node

4. Conclusion

This article proposed a clumps and routing algorithms based on event driven in view of the special environment on coal mining face, and verify the algorithm through the simulation. In normal circumstances, it can adapt to the long and narrow work space, avoid tapered data flow, prolong the network life. In an emergency, it can build a transmission lines and gathering node communication which have the highest priority, the shortest time delay.

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