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[Singh * *et al.*, 7(4): April, 2018]
IC™ Value: 3.00

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

ANALYSIS OF "A CLUSTERING BASED NETWORK PROTOCOL IN UNDERCOVER MINING DOMAIN"

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DOI: Will get Assigned by IJESRT Team

ABSTRACT

Scientific study has labored on routing issues for adhoc-networks, VANET's, and Wireless Sensor Networks in an old scenario; recently there have been unsuccessful trend towards the investigation on underground wireless networks and proposals for design and development for Wireless Uncover Sensor Networks. The work highlights the thought of wireless underground sensor network inside coal mine environment, its application and various protocols relevant to underground coal mine environment are actually studied. Little doubt, the WUSN have their share of challenges along with the researchers have just started.

The work is focused on lowering the power consumption in undercover wireless sensor networks in the minings. LEACH (Low-Energy Adaptive Clustering Hierarchy), was extended to support non-uniform cluster size for underground coal mine environment. The method of high energy node is introduced and by putting on the non-uniform clustering a rise in stability factor of network by about 30 % is achieved

Keywords: Undercover Mines, Clustering, Networks.

I. INTRODUCTION

India is one of the major coal powers in the world. Coal resources play a very important role in India's economic security. Coal is the prime resource of energy in India. 55% of the current total commercial need is met by coal in India. 60% of the total electricity is produced by coal in India. So coal mining industry has become a pillar of Indian economic growth. But, these resources come at an extremely huge price of human lives. The following table depicts the same.

Table 1: Statistics of coal mine injury

Type Of Injury	Value
Fatal Accidents	73
Fatalities	94
Serious Accidents	354
Serious Injuries	364
Fatality Rate/M.TE. Of Production	0.28
Fatality Rate/3,00,000 MANSHIFTS	0.27
Serious Injury Rate/M.TE.	1.08
Serious Injury Rate/3,00,000 MANSHIFTS	1.06

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Impact Factor: 5.164
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Safety in coal mine is of paramount importance. So, proper monitoring of coal mine environment is necessary to avoid the accident in the coal mine. More than 50 % of injury is caused by gas explosion and fire. Early detection of fire and the proper monitoring of gas in the environment can change this statistics in a positive way. Environmental regions to monitor in the underground mines are narrow tunnels which are hundreds to thousands meter long as shown in figure 1

Figure 1: Internal view of coal mine

II. MATERIALS AND METHODS

Problem Statement

The wireless network has taken the users by storm, it is just the ease of use, anytime anywhere connectivity that fascinates the user. Wireless networks have been classified as MANETs (mobile ad-hoc networks), VANETs (vehicular ad-hoc networks), WSN.

The WSNs have further been classified as underground WSNs and underwater WSNs. The underground uses of WSNs are important to various activities such as mining. The researcher have proposed several routing protocol to be used in underground WSN environment, but to design and develop an energy efficient routing protocol is still a challenge.

One of the most commonly popular energy efficient protocols for routing in an open WSN is LEACH (Low Energy Adaptive Clustering Hierarchy), which can be extended in an underground coal mine environment. The following hurdles are required to be dealt:

Unbalanced cluster size

Optimal path problem
Node utilization, and
Data Aggregation

Unbalanced cluster size

LEACH protocol selects the cluster head on the random basis with a certain probability. There is no parameter for coverage density of a cluster. So it is not determined the number of nodes in a particular cluster.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

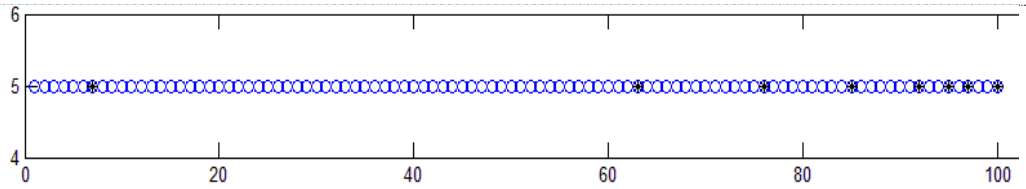


Figure 2: Unbalanced cluster

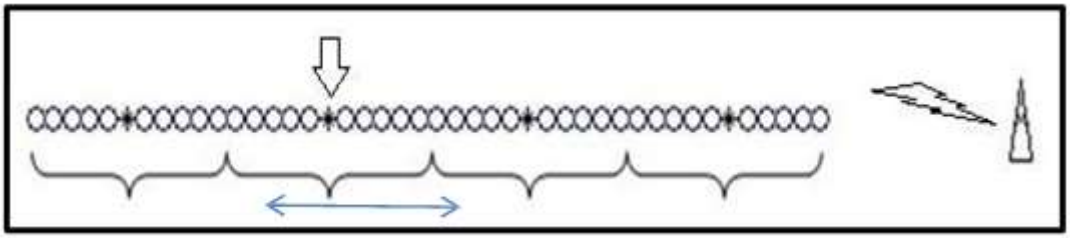
Number of member nodes can be large in some clusters. As we can see in the figure 2, the number of nodes in the left-most cluster is significantly higher than the nodes in other clusters. It has been analysed that receiving data is not a low cost operation. So it may drain more energy of that cluster head and may die early or it can be concluded that the load balancing is not proper.

In this section, a solution to the above identified problem has been proposed. The most popular and energy efficient protocol LEACH has been extended to apply it into the underground coal mine environment. The monitoring area of coal mine environment is long narrow tunnels and it can be monitor by the linear arrangement of nodes. A modification of LEACH protocol, CUG-LEACH is being introduced in this report.
CUG-LEACH is an energy efficient, adaptive clustering based protocol for underground mine environment that uses a linear arrangement of nodes as shown in figure. As discussed previously, in section 3, being a cluster head, it would drain the energy of the node. From the equation 3 and 4 it has been concluded that centre node is more suitable for the cluster head as it would save energy due to lesser effective distance. If the protocol decides the centre node as a cluster head in each round, then it will die very quickly. So the centre node should be a high energy node. CUG-LEACH introduces the concept of advance node (high energy node) to use as a cluster head and it should be placed in the centre of the cluster. Protocol categorizes the sensor node according to the energy consumption. Normal nodes or low energy nodes are used for the low energy transmission and the advanced nodes or high energy nodes are used for the high energy transmission. Protocol gives an architecture in which each cluster contains a single advance node and other nodes are normal node. The advance node will take the responsibility as a cluster head. All the other node of that cluster will send the data to that advance node and advance node will aggregate that data and will send to the base station.

The above figure presents an example of the network. This network contains four clusters, each having ten normal nodes represented by circle and an advance node represented by a star. The base station is away from sensor network. The protocol places the advance node in the centre of the each cluster to minimize the energy dissipation. In this arrangement of nodes, the load distribution would be according to the type of node.

In CUG-LEACH nodes are organized into clusters with one advance node in each cluster, which will act as the cluster head. This node is responsible to perform local compression and to send the aggregated message to base station. Optimal number of advance node or number of cluster and the size of cluster will depend upon the ratio of energy of normal node and energy of advanced node, area of monitoring as advance node has to survive until the last member node of its cluster is alive. The position of advance node is fixed at the time of deployment.

So to initiate the data processing, first the entire advance node broadcast a message that that they are clusters heads. Now the normal node will decide that in which cluster they want to join. The normal node will decide the cluster with the minimum distance. Minimum distance can be found by any ways such that they can check and compare the frequency of cluster head broadcast message. The all the normal will send a reply message to that particular advance node. This is the process of cluster formation.



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As the location of node is fixed and is known at the time of deployment, we can use static cluster but it will decrease the reliability of network and can affect the quality of monitoring. The protocol is using a high energy node so the advance node will alive till the last. But suppose an advance node died by any other reason like physical damage, and then the whole monitoring area will be dead, even all other normal node is alive. So that reason would be out of coverage. To make the cluster formation static, it will be a bottleneck. Static cluster is showing a single point of failure. It is shown in figure 4. If the cluster head which is marked by arrow would be fail then the whole cluster will die.

CUG-LEACH protocol does not use static clustering. It is an adaptive protocol, by broadcasting the cluster head message by the advance node will prove that this advance node is alive and if in any case the node is dead then the whole cluster will not be dead. The normal node will select any other cluster head. Definitely, a load will increase at that node but the monitoring of that area will not be dead. So the performance of protocol will degrade very gradually and it is only in term of life time.

Once the cluster is decided, the protocol will work as LEACH protocol. Advance node will create a time slot for normal node. It will save the energy of normal node as the radio component of the node will be turned off except during its transmission time. After collecting the data from its entire cluster member, the advance node will perform local compression and then transmit the compressed data to the base station.
As discussed earlier in, that the cluster head to base station communication is a high energy communication. So the cluster head which are far away from base station will die soon comparatively with the cluster head which are near to the base station. Figure 3 is showing the energy consumption of the cluster head in a randomly selected round. The figure is depicting the variance of energy dissipation the cluster heads on the basis of distance from the base station. So to improve the load balancing concept of non- uniform cluster size has been introduced. It has been observed earlier that receiving a message is not a low cost operation as the protocol using a symmetric communication channel. Load balancing can be achieved by reducing the intra cluster load of the farthest cluster from the base station and increase the intra cluster node of the nearest cluster from the base station.

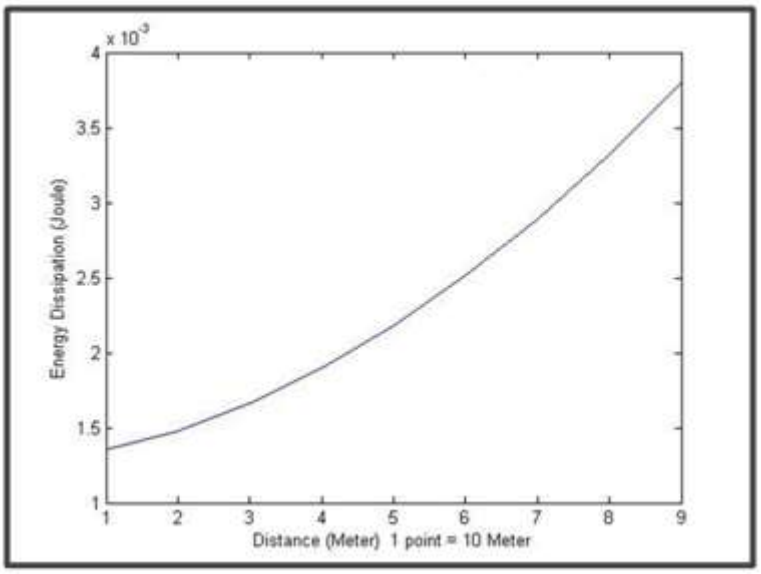

Figure 3: Energy dissipation in cluster head

III. CONCLUSION

The wireless sensor network is an emerging technology. It is just the ease of use, anytime anywhere connectivity and the flexible structure of WSN that fascinates the user. Wireless networks has been classified as MANETs (Mobile Ad-hoc Network), VANETs (Vehicular Ad-hoc Network), WSNs. The WSNs have further been classified as underground WSNs and underwater WSNs. The underground uses of WSNs are important to various activities such as coal mining.

This report has discussed the applicability of LEACH protocol in underground coal mine environment. LEACH is a popular and energy efficient and cluster based protocol of WSN. The problems in the applicability of LEACH in the harsh underground environment have been identified. In the proposed solution an extended version of LEACH for the mine environment named CUG-LEACH is described.

CUG-LEACH uses the advance node as the cluster head and two new architecture of node deployment introduced. CUG-LEACH with Non-uniform clustering shows a 30 % increase in the stability factor of network life time. That means the whole network will remain alive for 30 % more time steps (rounds).

IV. FUTURE SCOPE

In the current scenario, protocol assumes that the sensor nodes always have data to send and it create a periodic schedule to retrieve that data. In the future direction of research, it can be event driven model. It implies that when a node sense some change in the environment, then only it will send the data.
This CUG-LEACH protocol can be extended for the multi-hop communication for the very long tunnels or it can be used in any liner type sensing environment.

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CITE AN ARTICLE

Singh, I., & Goel, A. (n.d.). ANALYSIS OF "A CLUSTERING BASED NETWORK PROTOCOL IN UNDERCOVER MINING DOMAIN". *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY, 7*(4), 705-710.