Energy Efficient Wireless Sensor Network Model for Safety Monitoring in Underground Coal Mining

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Abstract: - In the present day, because of global warming and climate change, there are complicated conditions in the coal mine area. To reduce costs and improve productivity by product quality in the coal mine area, which reduces the efforts of the younger generation. This paper presents a model of a wireless sensor network (WSN) can alert mine people when hazardous levels of gases are sensed, such as methane and carbon monoxide that may cause outbursts or poisoning of workers. WSNs must be designed to cover all productive mining areas all over a specified time horizon, consequently, which comprises a balance between the cost of installation (i.e., sensors) and operation (i.e., energy consumption). Though most literature on node deployment for WSNs in mines motivations on single objective functions, we propose a novel two-fold approach that allows users to address both the cost of installation and the WSN lifetime.

Keywords: *wireless sensor network, Coal mine, Sensor node, network life time*

I. INTRODUCTION

Underground mining, production process and explosive gases affect the miners for instance; the extraction may produce colorless and odourless gases such as, for example Methane, caused by unstained gases such as carbon. These are hydrogen oxide and sulphide, explosion and Monitoring the air quality in different mine locations is key to generate alarms and prevent accidents and emergencies such as explosions, conflagrations and poisoning of workers.

In Wireless Sensor Networks (WSN) for monitoring mines contribute to the safety of employees. WSN can detect the presence of dangerous gases and supplies early warning. A WSN must monitor all the working areas for as long possible time at a minimum cost. However, the lifetime maximization and cost minimization are conflicting objectives. It is important to define a strategy that allows finding a balance between these two factors

Another important task is that to balance the cost and lifetime of a WSN to monitor gases Underground mine, we answer the following questions: (i) how many nodes must be deployed to guarantee a given lifetime at minimum cost (ii) how much can the WSN lifetime be extended by optimizing the configuration of the same number of nodes defined in that solution.

The remaining paper is organized as follows: Section II Summarizes current solutions for WSM planning and there are limited restrictions, and our solution promotes. Section III provides our approach to mine control WSN to protect air quality. Section IV offers a proposal Part V is the best way to ensure an app in our previous study process. Finally, Section VI provides context and future ideas for work.

II. RELATED WORK

To the best of our knowledge, few approaches have been proposed to support the design of WSNs to monitor underground mines.

Jiang and others. [1] and Wang and others. [2] Indicate a two-dimensional modelling strategy for running nodes in the mining tunnel. The controlled distribution method increases the useful life of the network in which the function of the sensor nodes sends data to other nodes.

Zhou and his collaborators [3] proposed a technique used to design the 3D model nodes of a mining tunnel. They provide detailed discussion on the coverage area, such as coverage area, detection capability, and redundancy. This technique is a controlled implementation method for increasing network efficiency with nodes in the role of sensors

In previous work [4], Jou and his collaborators proposed programming strategies and data fusion technologies to maintain balance between power overheads, network efficiency, and accuracy of WSN. Its node character sensor with random distribution of string topology nodes.

The related work focuses on a tunnel modelling Moreover; they have the same optimization goal. In the unlike these techniques, we are interested in checking the process of implementing WSN's sensor nodes Mine, different optimization goals are taken into account. These are Limitations to prohibit the use of these methods Where and where to place different galleries There are more concerns for shareholders.

III. NETWORK MODELING

We are interested in the design and analysis of WSN Any sensor nodes are implemented in various tunnels of mines Unlike other systems, we do not plan a model A tunnel but not all sections and intersections In this section, using our proposal is displayed to the mines model

A graphical representation.

Network Representation

Underground coal mines are many pitheads Or intercept major tunnels and tunnels horizontally Where different points, expect a mesh shape. The tunnels in the mine are narrow, but usually long,. Depending on the general structure of coal mines, we suggest it Mine from a guided graph, where vertices represent the potential locations of network sensors on the layout of the mine. Vertices correspond to tunnel intersections, pithead(s), and work fronts, whereas edges capture whether there is line of-sight between pairs of nodes, as well as their corresponding distance in meters. Sensors may be located on a subset of the vertices according to the considered optimization objectives.

. To illustrate our approach, suppose we are modelling a small coal underground mine, like the one depicted in Figure 1a. The graph is created taking in to account the geographical distribution of the elements in the mine. Figure 1b shows the corresponding diagram. It comprises 11 nodes and 22 edges. Besides, the edges have an attribute that represents the distance between the connecting nodes. For instance, the edge that goes from the node N1 to N11 has a range of 110 meters, (N1, N11) = 110. Note that edges are created between all pairs of vertices with direct line-of-sight; for instance, (N2, N3), (N3, N4), and (N2, N4) are all created, thus, enabling different possible connectivity configurations depending on the nodes that end up being deployed.

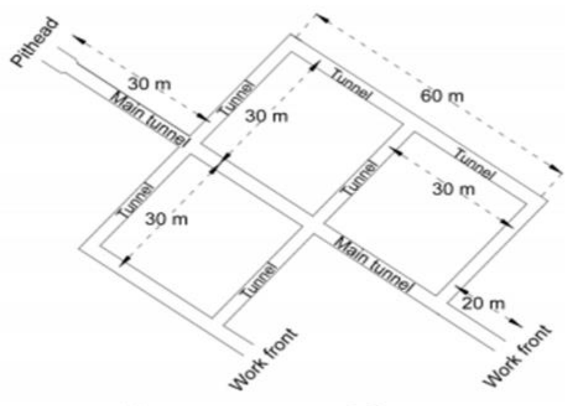

Figure 1(a) Layout of small mine in india.

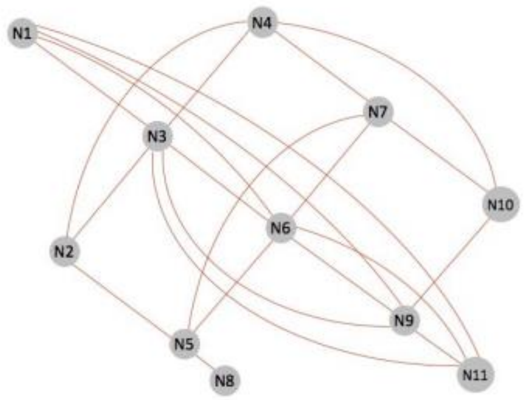

Figure 1(b) Graphbased representation of the above mine

B. Energy Consumption Model

When a WSN node is no longer having battery, this is probably the case Or all sensor data base station node did not reach. In this The paper is thought to be equal to the life of WSN

The first node does not have a battery anymore Common cases can be taken into account in our centers. Why minimizing the power consumption of the node increases Life of WSN In this sense, energy consumption The following model is an important thing to solve this problem

The power consumption of the node depends on three processes: Collection, information and data processing [5] below the process of using more energy In three studies, energy consumption due to acquisition and data processing is constantly and the same for all nodes since our nodes focuses on minimizing the energy utilization of the model due to communication between nodes

In [6], the simplest example of wireless power consumption in Communication has been proposed. Both transmitter and receiver consume energy in the communication process. For the transmitter, the energy consumption is given by Equation 1; if the distance is less than a threshold, the free space model is used; otherwise the multi-path model is applied

$$E_{TX}(k,d) = \begin{cases} k * E_{elec} + k * E_{fs} * d_{i,j}^{2}, d_{i,j} < d_o(Freespace) \\ k * E_{elec} + k * E_{mp} * d_{i,j}^{4}, d_{i,j} \geq d_o(Multi-path) \end{cases} \quad (1)$$

In Equation 1, *d* is the distance between the transmitter and the receiver, *k* is the number of bits of the data packet sent, d_0 is the crossover distance, E_{elec} is the transmission and reception energy per bit, E_f s is the energy dissipated in the transmission by the amplifier in the free space model, and E_{mp} is the dissipated energy in the transmission by the amplifier in the multi-path model. In addition, the energy consumed by the receiver is given by:

$$E_{RX}(k) = k * E_{elec} \quad (2)$$

Therefore, power consumption in a node i that receives a data packet, and sends it to a node j is:

$$E(k,d) = \begin{cases} k * E_{elec} + k * E_{elec} + k * E_{fs} * d_{i,j}^{2}, d_{i,j} < d_o \\ k * E_{elec} + k * E_{elec} + k * E_{mp} * d_{i,j}^{4}, d_{i,j} \geq d_o \end{cases} \quad (3)$$

IV. OPTIMIZATION MODEL

Network costs are directly related to the number of sensor nodes used. Deploying few sensor nodes Reduces execution cost, but can reduce life expectancy. As our proposed optimization model which gets least number of nodes and its location with some constraints and improve the network life time, we The purpose of the agreement is to find the name below Nodes and the most effective ways to meet With many obstacles and more living conditions. Assume that WSN consist of two nods, all nodes have power consumption due to acquisition, data processing and communication.

Table 1.Notation for the optimization model:

Parameter	Purpose
A	Set of edges
k	Number of nodes determined in the first stage
α	Binary parameter equal to "0" for the first stage and equal to "1" for the second stage
E_p	Energy consumed by data processing in a node
E_a	Energy consumed by data acquisition in a node
$E^{(t)}_{ij}$	Transmission energy (sending from node i to j)
$E^{(r)}_{ij}$	Reception energy (sending from node i to j)
N	Set of nodes
O ⊆ N	Set of mandatory nodes
S	Set containing the base station node
$D_{i,j}$	Distance between nodes i and j

A. Binary decision variable

Here we represents binary decision variables i.e X_i , here the value of 1 indicates sensor node located at node , if I value "0" otherwise. Binary decision variable y_{ij} takes the amount of 1 when xi and xj are both equal to 1; 0 otherwise. Note that yij = 1 indicates that nodes i and j can communicate since they are both installed and have direct line-of-sight. Decision variable W_{ij} accounts for the number of packets that pass from node i to node j. Decision variable z represents the maximum power consumption among all nodes in the network. Variable z will be useful when maximizing lifetime since such objective is equivalent to minimizing the maximum use (i.e., extending the life of the first node to run out of battery).

B. Optimization Model

the main objective of the optimization model is constructed for two cases i.e 1. Reduce the deployment cost and second one is improving network life time. A natural approach for this problem would be a multiobjective or multi-criteria optimization strategy. Two optimization steps are based on customization activity limits line: In the first stage, the user specifies the desired lifetime of the network (which results from the time horizon of mining activities), and the optimization model provides the least cost solution that satisfies such lifetime. In the second stage, the optimization model is re-run in order to produce a new network configuration that maximizes lifetime without exceeding the number of nodes obtained in the first stage. Therefore, the model is able to inform about the minimum number of nodes necessary to achieve a certain lifetime, and then provide a network configuration for maximum lifetime with the same number of nodes. Here we projected some of the operational constraints.

1. Fixed sensors at specific nodes: it is mandatory to monitor the concentration levels of gases in certain areas of the mine Connectivity constraints: the constraint defined by specific nodes i.e i and j can only communicate if they are both deployed and arc (i, j) ∈ A, meaning they have direct line-of-sight.

2. Mandatory sensors at specific nodes: in maximum states, it is required to observer the attention levels of gases in certain areas of the mine.

3. Connectivity constraints: the constraint defined by Equations 3 and 4 specifies that nodes i and j can only communicate if they are both deployed and arc (i, j) ∈ A, meaning they have direct line-of-sight.

$$y_{ij} + 1 \geq x_i + x_j, \forall (i,j) \in A \qquad \text{--------------- (3)}$$

$$y_{ij} \leq \frac{x_i + x_j}{2}, \forall (i,j) \in A \qquad \text{----------------------- (4)}$$

3) Flow conservation constraint:

The role of sensor and node base station are responsible for data collecting information from the sensors, and it also provide navigation details how the data propagates from sensor nodes and base station.

$$\sum_{j:(i,j)\in A} w_{i,j} - \sum_{j:(j,i)\in A} w_{j,i} = 1, \forall i \in O \qquad \text{------ (5)}$$

Above shown equation (5) maintains flow conversation at each node.

$$\sum_{j:(i,j)\in A} w_{i,j} - \sum_{j:(j,i)\in A} w_{j,i} = -\sum_{l\in O} x_l - 1, \forall i \in S \qquad \text{- (6)}$$

Equation number (6) provides information regarding base station node receives as many packets as there are sensors. It confirms the all data packets from all other nodes.

$$\sum_{j:(i,j)\in A} w_{i,j} - \sum_{j:(j,i)\in A} w_{j,i} = x_i, \forall i \in N | i \notin O, i \notin S \qquad \text{-- (7)}$$

Equation number (7) states for non-mandatory nodes, which reveals the number of packets they receives is equal to number of packets they send.

Lifetime Constraint:

the constraint in Equation 8 is deeply in the stage-1 of the proposed approach, and conditions that each sensor node must not exceed the capacity of its battery, where $\boldsymbol{m}$ is the number of gas measurements to be made, and depends on the monitoring frequency $\boldsymbol{\varphi}$. In the second stage, constraints 9 makes variable ***z*** capture the maximum energy consumption among all nodes, thus, allowing to determine the maximum lifetime of the WSN.

$$(E_p + E_a + \sum_{j:(i,j)\in A} E_i^t w_{ij} - \sum_{j:(j,i)\in A} E_i^r w_{ji}) * m \leq \beta, \forall i \in N$$ ---(8)

$$(E_p + E_a + \sum_{j:(ij)\in A} E_i^t w_{ij} - \sum_{j:(j,i)\in A} E_i^r w_{ji}) \leq z, \forall i \in N$$ -----(9)

Finally, according to the proposed methods, when the number of deployed nodes of the WSN is increased, it is also possible to increase the lifetime. This occurs because the amount of data packets sent by the nodes is scattered in a balanced way, dropping the power depletion in the nodes by transmission and response of data. In addition, when deploying new nodes in the mine, the spaces of data transmission between nodes are reduced, and the consumed energy losses

V.CONCLUSION:

In this paper we have been presented an optimization methodology for the deployment of Wireless Sensor Networks (WSN) to observe the gases in underground coal mining. The approach addresses two objectives: reducing deployment costs and increasing WSN lifetime. In order to come across the needs of final users (coal miners), a two-stage optimization approach is followed, instead of a less intuitive multi-objective approach. In the first stage, users provide a minimum desired lifetime according to the mining schedule, with which the deployment costs are optimized, achieving a WSN design with the minimum number of nodes required to fulfil users' desired lifetime. In the second stage, the network pattern is optimized, thus, re-arranging nodes to extend lifetime as much as possible.

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