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An ACO Improved Approach for Critical Node Tracking in WSN

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Abstract: A wireless sensor network is composed by hundreds or thousands of small compact devices, called sensor nodes, equipped with sensors (e.g. acoustic, seismic or image), that are densely deployed in a large geographical area. One of the most effective sensor network type is critical sensor network. In such kind of network, some nodes are connected to environment called critical sensor nodes and some nodes are defined as normal sensor nodes. Complete system depends on the critical nodes. Because of this, it is required that the critical nodes are always in processing situation. To analyze whether these nodes are working or not it is required to monitor these nodes regularly. In this paper, an approach is defined to analyze these critical nodes. This research paper defines an approach to resolve number of associated problem in such critical node network.

Keyword: *sensor network, critical nodes, ACO, network lifetime.*

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I. INTRODUCTION

Wireless Sensor network is most adaptive communication network that is used in many applications and organizations. These networks are defined by using the tiny sensor nodes where each node is defined under energy definition. The sensor network is connected with outer network by the help of base station. The base station is defined at specific distance location. All the network nodes transfer the collected information to base station and base station broadcast this information over the web. These networks are defined under some architecture so that effective will be drawn over the network. The parameters in sensor network are defined under memory, time, power and bandwidth parameters. The objective of the communication architecture is to achieve the effective communication and to improve the performance of the network[1][2]. These networks are defined so that effective data gathering over the network will be performed. One of the challenging tasks in such network is the effective deployment of nodes over the network. These sensor nodes are defined with energy specification. While defining these network types, the protocol specification is required[13].

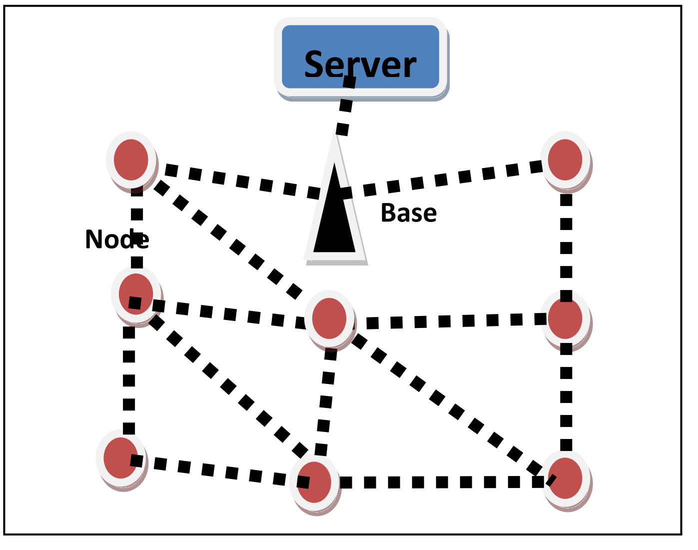

Figure 1: Wireless Sensor Network

As shown in figure 1, Senor Network is defined with 3 main components:

- Node itself that sense the environment or the resource
- Another component is process component to perform the communication
- Communication components are responsible for the information exchange.

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The constraints of sensor network include the memory, computing power, energy etc. To perform the communication over the network, one of common adaptive approach is aggregation.

II. RELATED WORK

Wireless sensor networks (WSNs) are the products which integrate sensor techniques, embedded techniques, and distributed information processing and communication techniques. The appearance of the wireless sensor network is a revolution in information sensing and detection. Although there have been significant improvements in processor design and computing, advances in battery technology still lag behind, making energy resource considerations the fundamental challenge in wireless sensor networks. Consequently, there have been active research efforts on performance limits of wireless sensor networks. These performance limits include, among others, network capacity and network lifetime. In Year 2007, Liangjie He performed a work," Implementation and Emulation of Distributed Clustering Protocols for Wireless Sensor Networks". In this paper, Author study the implementation of distributed clustering protocols in WSNs. Presented results demonstrate the working of clustering algorithms in practical small scale networked sensor systems. It also confirms the superior performance of the HEED algorithm over HIDCA in terms of power consumption and network lifetime[3]. In Year 2008, Sangbo Seo performed a work," A New Energy Efficient Data Transmission Method for Wireless Sensor Networks". In this paper, Author apply a hexagon tessellation with an ideal cell size to deploy the sensor nodes for two-dimensional UWSN. Upon this setting, Author propose an enhanced hybrid transmission method that considers load balancing of data transmission in two-dimensional UWSN[2]. In Year 2011, Diba Mirza performed a work," Real-time Collaborative Tracking for Networked Systems". Localization is a crucial requirement for mobile systems. Real-time position information is needed for control and navigation of vehicles, in early warning systems and for certain routing protocols. Author proposes a low overhead scheme for real-time and distributed tracking. Presented proposed technique can strategically trade off localization accuracy and energy consumption[1]. In Year 2012, Vikram P. Munishwar [9]performed a work," Node Criticality Management for Mobile Attentions in Visual Sensor Networks". In this paper, Author proposes several policies for automatic control of the cameras with a goal of Node Criticality maximization for mobile Attentions.

III. PROPOSED APPROACH

A. The present work is about to provide the solution to the Critical Node Analysis problem.

Critical Node Analysis problem: The issue of maximizing network lifetime while taking into account the limited power supply is called Critical Node Analysis Problem.

In this work we have defined a random topology with n number of nodes distributed over the network. M numbers of Criticals are defined randomly. The work is to define the cover nodes that can monitor or cover these Critical nodes. Cover nodes are the group of nodes that can collectively cover the Critical nodes hence called coverset. In a sensor network, there are number of possible coversets, the work is to identify these cover-sets and use them effectively so that the Critical nodes will be monitored regularly as well as the network life will be improved. Once the cover sets are generated, the next requirement is to track the position of the Criticals and respectively particular Critical cover set activated. To track the Criticals, the ACO based approach is suggested in this section. According to this approach, the ants will be spreaded over the network that will be sensing the current position of the Criticals and activate the relative coverset.

The presented work is divided in two main phases.

Eligibility criteria for the node to be the member of coverset: A node can be the member of coverset and will cover the Critical node if it satisfies the following criteria:

(i) *Sensing Range*

The sensing range is defined in terms of the actual communication distance for that the communication is possible with extra energy loss. A node can monitor a Critical present within the sensing range. It is the first and the most required eligibility criteria. A sensor node can cover more than one Critical covers if they are present within the same sensing range. To define the sensing range we have define some fixed value for each node.

(ii) *Energy Vector*

The second parameter for deciding the coverset eligibility for a node is the energy of the node. Each node is defined with some initial energy. If a low energy node will be included in the cover set, it will die soon and the coverset will not me more beneficial after that. So that we have defined some energy threshold value to decide the node node eligibility. If the node is having the energy more than the 50% of initial energy then only it can become the part of the node. A low energy node cannot be a member to the cover node.

(iii) Load

Each node defined in a real scenario has to participate in the communication, But as the communication over that node is increased or the load over that node is increased it require more energy for the communication. The load over a node can be increased in case of multi-hop communication over that node or to handle the orphan nodes. In this work, we have defined only a normal node without any extra load is only eligible to be the member of coverset. To identify the load we have define some random load value on each node. If the load is lesser than the .5 than the node will taken as the eligible to that node.

Based on these all vectors, the cover nodes will be defined. As the cover nodes setup the next phase is to identify the Critical nodes in range with each sensor node. Once we get all the eligible nodes to be the cover node members. The next work is to generate the coverset. A coverset will be defined under the following constraint:

- A cover set will contain k number of sensor nodes so that all m number of Criticals will be covered.
- A sensor node can be the part of any number of coversets.

After generating the coversets we get k number of coversets that individually cover the Critical nodes. At a particular instance of time, only one cover node will be active. Each cover node will be activated for the fix time interval. As all cover nodes are having equal weightage, they will be activated in the same sequence in which they are generated. As a cover node gets activated, it starts losing some energy for each node. Each coveset consumes same amount of energy.

In this presented work, the second decision criteria is about to decide which coverset will be activated. To perform this decision the following critieria is defined.

(i) Coverset Energy

A Coverset will be activated, if the overall energy of the nodes is higher than the defined threshold value. Let for any ith coverset we have m number of sensor nodes then the energy required by the cover is

$$\sum_{j=1}^{m} S(i,j).Energy > EnergyThreshold$$

B. ALGORITHM:

The approach defined above is briefly expressed through the algorithms given below:

```
CriticalNodeAnalysis(Sensor,Critical,N,M)
/*Sensor is the array to represent N normal sensor node with energy specification,
 Critical is the the list of M critical nodes */
{
   1.  For i=1 to N
       [Process All Sensor Nodes]
       {
   2.  Sensor(i).Position=Random; /* Place the Node at random Position*/
   3.  Sensor(i).Energy=Random; /* Specify the Energy vector for each sensor node*/
   4.  Sensor(i).Fault=Random;/*Set the fault ratio for each sensor node*/
       }
   5.  For i=1 to M
       [Process all critical Nodes]
       {
   6.  Critical(i).Pos=Random;/* Specifiy Critical Nodes at Random Position*/
       }
   7.  for r=1 to ITERATIONS_Max
       [Process the critical Node Analysis for Defined Number of Iterations]
       {
   8.  For i=1 to N
       [Process All Nodes]
       {
   9.  For j=1 to M
       [Process all Critical Nodes]
       {
   10. Dist=Sensor(i).Pos-Critical(j).Pos
       [Estimate the distance between the sensor node and critical node]
   11. If (Dist<=SensingRange)
       {
   12. GenerateCoverset(k,Sensor(i));
       [Add Node to Coverset]
       }}}
   13. Set Cover(k).SetActive=True;
   14. Path=GetACOPath(Sensor,N)
       [Generate the ACO Path over the Node]
   15. For i=1 to Length(Cover(k))
       {
       Sensor(Cover(k,i)).Energy=Sensor(Cover(k,i)).Energy-EnergyLoss;
       }
   16. Estimate Network Life
Estimate Fault Analysis
       }}
```

Figure 2. Critical node analysis algorithm

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GetACOPath (Sensor, N)
/*Obtain the ACO Path for Critical Node Tracking using Sensor Node]
{
1. Distribute M Ants over the Network at Random Position
2. Set ACOPath=[]
3. For r=1 to MAX_ROUNDS
   [Process Number of Rounds for Ant based Node Tracking]
   {
4. For i=1 to M
   [Process M Ants]
   {
5. Identify the High Energy Neighbor Node Analysis under the Pheromone Based Analysis]
6. Identify the Efffective High Energy Neighbor Node to Include as the effective Path Node
7. ACOPath.Add(EffectiveSensor)
   [Include the effective Neighbor as the path member]
8. Update Node Position and ANT position
   }
   Return ACOPAth
}

Figure 3: ACO path generation algorithm

IV. RESULTS & DISCUSSION

In this section, we present the performance results of the simulation experiments using MATLAB. The various simulation parameters which are considered for network establishment are given below:

Parameters	Specifications
Area	500×500
Sensors	30
Attentions	3
Base Station	(450,400)
Energy of each Sensor	0.5 J
Sensing Model	Binary
Sensing Range	150m

Table 1: Simulation parameters for the network establishment

Network life analysis is done in terms of alive nodes & dead nodes. Here figure 4 is showing the alive node analysis in case of existing and proposed approach. Here x axis represents the number of nodes and y axis represents the alive nodes. As shown in the figure, initially all nodes are alive. But as the communication is performed, the nodes starts loosing the energy. The figure shows that the presented work has improved the network life.

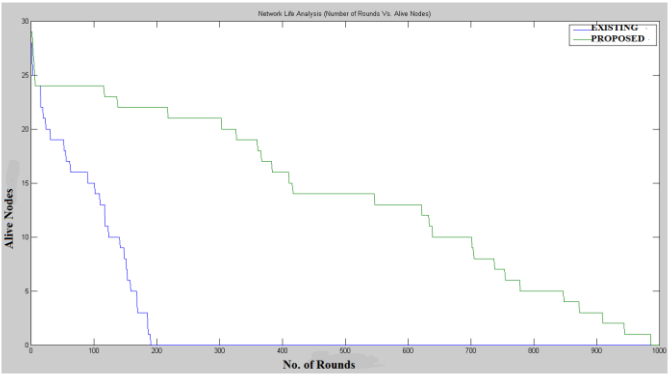

Figure 4: Alive Node Analysis (Existing Vs. Proposed)

Figure 5 is showing the dead node analysis in case of proposed approach. Here x axis represents the number of nodes and y axis represents the dead nodes. As shown in the figure, initially all nodes are alive. But as the communication is performed, the nodes starts loosing the energy. The figure shows that the presented work has improved the network life.

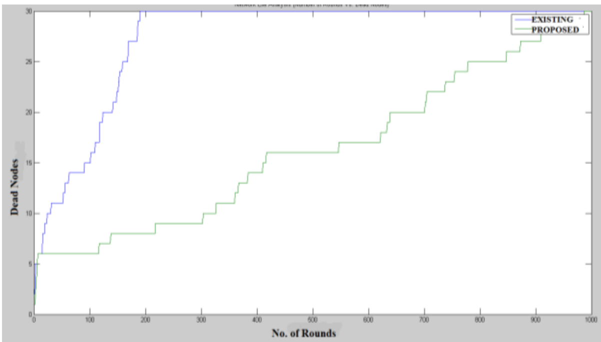

Figure 5: Dead Node Analysis (Existing Vs. proposed)

Finally figure 6 shows failure probability analysis. It can be seen that the presented work has improved the network life as failure probability is reduced to a greater extend.

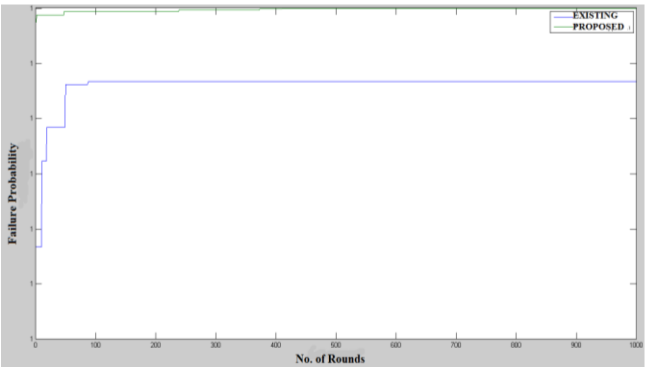

Figure 6: Failure Probability Analysis (Existing Vs. proposed)

V. CONCLUSION

One of the most effective sensor network type is critical sensor network. In such kind of network, some nodes are connected to environment called critical sensor nodes and some nodes are defined as normal sensor nodes. To improve the effectiveness and reliability of network, it is required to monitor these critical nodes regularly. To monitor these cover nodes, the coversets are generated. In this work, a multiple parameters based approach is defined for coverset generation. The parameters considered in this work are energy, load, failure probability and coverage range parameters. The node tracking of moving critical nodes is here defined using ACO approach. The analysis results show that the work has improved the network life as well as reduced the failure probability.

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