New Algorithm for Optimized Cluster Heads with Failure Detection and Failure Recovery to Extend Coverage of Wireless Sensor Network

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Abstract- Wireless sensor network used Clustering techniques to extend the lifetime of the network. LEACH is the one from these clustering techniques to maintain the energy efficiency of sensors. The technique of selecting nodes with highest residual energy as cluster heads with the assumption that energy consumption distribute periodically between the nodes. Cluster heads collect information from the surrounding nodes and send it to the base station. but sometimes if one of this clusters fails it cannot be detected by the cluster heads or BS. Non cluster heads and sub cluster heads still send data to the failed CH in every time slot of a frame allocated to them, hence more energy is consumed. In this paper, we have proposed a new algorithm of fault tolerance to determine the cluster heads failures within a few seconds after the beginning of each round to enhance the lifetime of wireless sensor network.

Index Terms- Fault Tolerant detection, Fault Tolerant recovery, Wireless sensor Networks, Network life time, Cluster head.

I. Introduction

Wireless Sensor Networks deploy a lot of nodes on a wide area to monitor some interesting phenomena, such as traffic surveillance, environment monitoring, health care, wildlife tracking, military sensing, etc. Wireless Sensor Networks consists of many sensors with limited energy. Each node is equipped with unit of sensing to sense the area and cluster head to transmit the information to the base station. Sensor nodes cooperate with each other to perform the functions of sensing data, data transfer and data processing. Hence sensor nodes will consume more energy specifically cluster heads. Hence, may be some cluster heads failure after the beginning of each round. Our proposed algorithm attempts to select cluster heads with fault-tolerant during building a cluster heads of LEACH protocol. We introduce two basic models Fault Tolerant detection and Fault Tolerant recovery. We then modify LEACH to detect the node failure and changed this node by nearest node with highest energy to improve performance of LEACH protocol.

II. Related Work

Having studied widely in fault tolerance the broader context of the distribution of computing [1], but little studies has been done to solve the problem of fault-tolerant clustering in WSN.

[2] deals with fault tolerance in the clustering, but it seems only in heterogeneous sensors, where clustering select the nodes with highest energy as a sink than the ordinary nodes.

We here consider LEACH Protocol and study it in more detail.

In[3] the authors, proposed a novel Fault Tolerant method to select cluster heads in wireless sensor networks. They proposed clustering algorithm to reduce data packets during data aggregation and decreased the cost of wireless communications by reducing the data packets, thereby clustering technology extends lifetime of wireless sensor networks by reducing the energy consumption.

In[4] FEED chooses a supervisor for any cluster node head. This selection causes the entire network to be completely covered until the end of a round, and the network will be fault tolerant. This choice completely covered the whole network till the end of the round. By using this method the single member of clusters is close to zero.

In [5],Lou and Kwon propose Branch routing protocol to improve WSN reliability and security. This proposed builds several trees in directing neighbors sink, which represent branches on the network graph. Each node connects to one branch only, but this node can send data back to the sink of any branch. The main problem of this method is the limited number of paths and the fault tolerance is also limited.

Esseghir et al. [6] optimize the wireless sensor network lifetime under a reliability constraint. They introduce a function that links reliability to the average amount of energy consumed by the network when reporting an event to the base station. By using this function, they showed a successive readings which achieving a reliability.

In [7] Chamam et al. address the problem of maximizing the WSN lifetime under the area coverage constraint. They propose a scheduling mechanism that, for every time slot during the operating period, calculates an optimal covering subset of sensor nodes; only those nodes are activated for the given period and the remaining ones are put to sleep.

Xiong et al. [8] prove that the problem of maximizing the lifetime of a data-gathering sensor network, which is defined as the number of rounds until the first 24 node depletes its energy, is NP-complete. They then formulate it as an integer program to get a suboptimal result. They want to reduce the tremendous computation and storage cost of integer programming.

Heinzelman [9] designed and implemented Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol for WSN. LEACH uses a clustering architecture, Each cluster elects a cluster head. For balancing energy load in the network, LEACH rotates the energy-thirsty function of the cluster head among all the nodes in a cluster. To avoid data transmission collisions, LEACH uses a time division multiple access (TDMA) protocol. The major characteristics of LEACH include localized control for data transfer; randomized, adaptive and self-configured cluster formation; application-specific data processing for data aggregation and low energy media access.

Hasegawa et al. [10] proposes to reduced the energy function of neural network by using a routing reconfiguration method. They was also found that proposed can improve performance of routes to maximize the lifetime of sensor network, without use centralized computing .

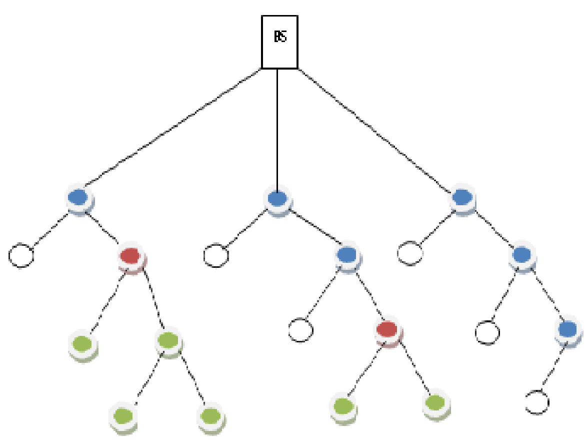
Mak et al. [11] study different WSN protocols based on various WSN lifetime definitions. They classify WSN protocol and different WNS lifetime definitions. With the help of simulation they compare performance of WSN protocols.

III. PROPOSED WORK

We propose a new algorithm to extend the coverage of wireless sensor networks. This proposed work is as follows:

A. Failure Detection

To detect the failure in cluster head, we modify our previous algorithm[12] to select a cluster head. Let t1 represent the time of beginning of round. t1+f represent the beginning time of next round, f represent full time of a single round. In our previous work we have selected three main cluster heads with highest energy, so there are x nodes which are a part of this cluster and sub cluster heads. Each node transmits for s seconds in to the TDMA of this cluster. Then, for each cluster z=f*x/s. represents the transmissions between the nodes and cluster heads in each group. We execute detection through cluster heads selected with z to test transmission of the cluster head. Cluster head sends a small Hello message to all nodes which are ready to receive. If such a transmission is not received, the nodes can advertise that cluster head has failed as
shown in fig 1.



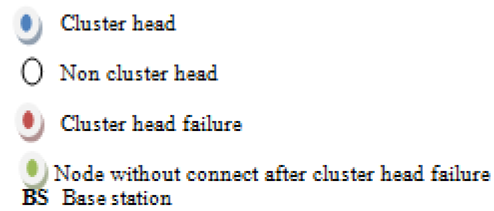


Fig 1: Failure Detection tow cluster heads failure in Cluster Tree of WSN

B. Failure Recovery

After detecting the cluster head failure the failure recovery model tells the value of the position of the [(cluster head failure) +3] to become the new cluster head. Join a position of the [(cluster head failure) +3] to the position of the [(cluster head failure)-3]. Also the non cluster that join before to the failure cluster head, it select by use the (n- (value of the position of the [((cluster head failure) +3)-1) to connect it to the position of the [(cluster head failure)-3] as shown in fig 2.

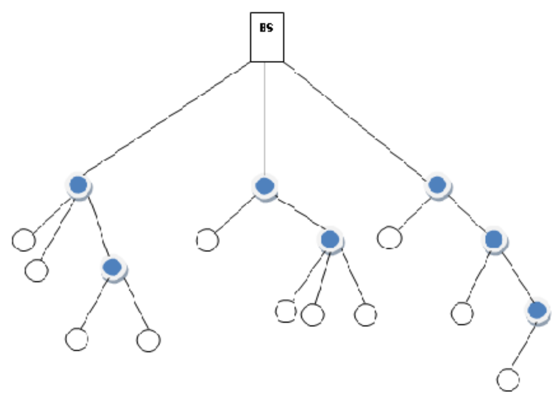


Fig 2: Recovery the cluster heads failure in Cluster Tree of WSN

Pseudo Code of Failure Detection Algorithm:

```
1:  S1←0 and s2←1
2:  Build s (n) array include n nodes and
    Sort it as descending according to
    Residual energy
3:  Build w (n) array to include position of
    S (n) and sort it as descending
    according to s (n)
4:  For every j: 3
5:       Select the three nodes with
         High energy as clusters heads from
         S (n)
6:   For every I: n
7:         For every j: 3
8:       If s (j).E>=0
9:              If w (n-s1)! =w (s2+3)
10:                  Begin
```

```
11:            Select   s (n-s1) to build
               Left branch of the tree
               and select s (s2+3) to
               build right branch of tree
12:            s1←s1+1 and s2←s2+1
13:          End
14:        Else select   s (n-s1)
15:     Else
16:         If ((w (n-s1)! =w (s2+3))&&(
            s(w (s2+3)+3)>0))
17:         Begin
18:         Select s (n-(w (s2+3)-1)) this
            node without a link to the
            cluster head   and select
            S (w (s2+3) +3) this cluster head is
            Failure
19:            s1←s1+1 and s2←s2+1
20:          End
21:        Else select s (n-(w (s2+3)-1)))
           this node without a link to the
           cluster head

22:    End for
23: End for
```

Pseudo Code of Failure Recovery Algorithm:

```
1:  S1←0 and s2←1
2:  Build s (n) array include n nodes and
    Sort it as descending according to
    Residual energy
3:  Build w (n) array include position of
    S (n) and sort it as descending
    according to s (n)
4:  For every j: 3
5:       Select the three nodes with
         High energy as clusters heads from
         S (n)
6:   For every I: n
7:       For every j: 3
8:       If s (j).E>=0
9:           If w (n-s1)! =w (s2+3)
10:             Begin
11:               Select   s (n-s1) to build
                  Left branch of the tree
                  and select s (s2+3) to
                  build right branch of tree
12:               s1←s1+1 and s2←s2+1
13:            End
14:          Else select   s (n-s1)
15:      Else
16:            If ((w (n-s1)! =w (s2+3))&&(
               s(w (s2+3)+3)>0))
17:             Begin
18:               Select s (n-(w (s2+3)-1))
                  To build left branch of
                  the tree      and select
                  S (w (s2+3) +3) to build
                  right branch of tree
19:               s1←s1+1 and s2←s2+1
20:            End
21:          Else select s (n-(w (s2+3)-1))

22:    End for
23: End for
```

IV. SIMULATIONS

The Simulation is implemented in square area of l00m x l00m to deploy the 100 sensors of nodes, this Simulation executed by matlab. To study the performance of the propose fault tolerance models. We implement LEACH and our previous work as described in [12] and then modify this implementation to include fault tolerance models as described in this paper. We simulate the number of rounds as a measure of the lifetime of the network. We compare the number of rounds achieved by LEACH and our previous work with this proposed work. Our proposed make trade-offs in terms of reducing the lifetime caused by the implementation of fault tolerance and achieved with minimal loss in lifetime. Where leach and our previous work do not provide constant coverage during the cluster head failure. proposed work increase the coverage of WSN as shown in fig 3.

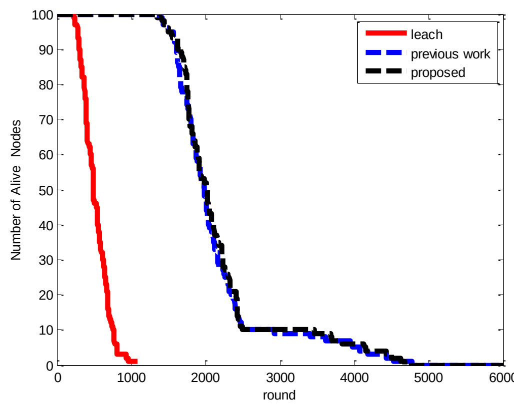


Figure 3. Lifetime measured in rounds

V. COMPARATIVE STUDY

	LEACH	previous work [12]	Proposed
Network lifetime	Good	Very Good	Near to previous work [12]
Fault Detection Capability	No	No	Yes
Fault Recovery Capability	No	No	Yes

VI. CONCLUSION

In this paper, we have studied how to detect and recover failure of the cluster head in wireless sensor networks. From our previous work [12] it is easy to detect the cluster head failure and easy to recover it with this new algorithm. Our proposed Achieved fault tolerance with the minimum loss of lifetime and increase the coverage of wireless sensor networks.

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REFERENCES

[1] G. Gupta and M. Younis. Fault-tolerant clustering of wireless sensor networks. IEEE Wireless Communications and Networking, 2003, pages 1579–1584, 2003.

[2] D. K. Pradhan, editor. Fault-tolerant computer system design.Prentice-Hall, Inc., Upper Saddle River, NJ, USA, 1996.

[3] Hazarath Munaga1, J. V. R. Murthy1 and N. B. Venkateswarlu2" A Fault Tolerant Trajectory Clustering (FTTC) for selecting cluster heads in Wireless Sensor Networks "International Journal of Computational Intelligence Research. ISSN 0974-1259 Vol.4, No.X (2008),

[4] Mohammad Mehrani, Jamshid Shanbehzadeh, Abdolhossein Sarrafzadeh, Seyed Javad Mirabedini" FEED: Fault Tolerant, Energy Efficient, Distributed Clustering for WSN "Global Journal of Computer Science and Technology Volume 11 Issue 2 Version 1.0 February 2011

[5] Y. M. Lu and V. W. S. Wong. An energy-efficient multipath routing protocol for wireless sensor networks. International Journal of Communication Systems, 20(7): 747{766, 2007.

[6] M. Esseghir and H. Perros, "Optimizing the wireless sensor network lifetime under reliability constraint," Proc. IEEE Intl. Conf. on Wireless Days (IFIP), 2008, pp. 1 – 5.

[7] A. Chamam and S. Pierre, "Energy-Efficient State Scheduling for Maximizing Sensor Network Lifetime under Coverage Constraint" Wireless and Mobile Computing ,Networking and Communications, 2007,pp. 63 – 63.

[8] S. Xiong, J. Li and L. Yu, "Maximize the Lifetime of a Data-gathering Wireless Sensor Network," Proc. IEEE Intl. Conf. on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), 2009, p. 1.

[9] W. B. Heinzelman, "Application-Specific Protocol rchitectures for Wireless Networks."Ph.D. Dissertation, Department of Electrical Engineering and Computer Science, MIT, Cambridge, MA, June 2000.

[10] M. Hasegawa, T. Kawamura, H. N. Tran, G. Miyamoto, Y. Murata, H. Harada and S. Kato, "Decentralized optimization of wireless sensor network lifetime based on neural network dynamics," Proc. IEEE Intl. Conf. on Personal, Indoor and Mobile Radio Communications (PIMRC),2008, p. 1.

[11] N. H. Mak and W. K. G. Seah, "How Long is the Lifetime of a Wireless Sensor Network?," Proc. IEEE Intl. Conf. on Advanced Information Networking and Applications (AINA), 2009, p. 763.

[12] Abdo Saif Mohammed, M.N.Shanmukh aswamy "A Novel Algorithm to Select Cluster Heads with Highest and Balanced Energy in Wireless Sensor Networks" International Journal of Computer Applications (0975 – 8887) Volume 54– No.4, September 2012

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