# "Evaluate the Performance of Energy Efficient Routing Method Based On Forward Aware Factor for WSNs"

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**Abstract: Due to the limited energy of sensor nodes, it is important to use routing protocol for WSNs so that data can be easily transmitted from sensor nodes to the base station. A forward-aware factor is discussed in this paper. In FAF, the next-hop node is selected according to the awareness of link weight and forward energy density. In the experiments, FAF is compared with LEACH and results show that FAF performs better than LEACH and increases the efficiency of network lifetime in WSN.The FAF protocol shows an increase in the lifetime by 19% over the basic LEACH**

**Keywords— Routing in wireless sensor networks,FAF,LEACH,WSN.**

## I. INTRODUCTION

Wireless sensor networks[1] is widely considered as one of the most important technologies.In Wireless sensor network, sensor nodes are used for gathering data and transmitting to sink but sensor nodes has limited energy and communication ability.So, it is important to design a routing protocol for WSNs so that sensing data can be transmitted efficiently.it balances the energy consumption and increases the network lifetime.Routing protocols are used for finding and keeping the routes in the network.

## II.ROUTING PROTOCOLS IN WSN

A wireless sensor networks[1] is a self-organization wireless network system consist of sensors nodes with limited energy. They are used to monitor the sensing field and collect information from physical or environmental condition and to cooperatively pass the collected data through the network to a main location [12]. Due to the limited energy and communication ability of sensor nodes, it is important to design a network topology, routing algorithm and protocol for large-scale wsn communication system. energy consumption is an important factor in system designs of WSNs. Traditionally, there are two approaches to accomplish the data collection task: direct communication, and multihop forwarding. in one hop wireless communication, the sensor nodes upload data directly to the sink, which may result in long communication distances and degrade the energy efficiency of sensor nodes. on the other hand, in multihop[4] forwarding, data are transferred from the nodes to the sink through multiple relays, and thus communication distance is reduced[7]. however, since nodes closer to the sink have a much heavier forwarding load, their energy may be depleted rapidly, which degrades the network performance.

## III RELATED WORK

### *3.1 LEACH PROTOCOL*

Low energy adaptive clustering hierarchical protocol [12] is self-organizing clustering protocol. The protocol is divided into two phases:-

- Setup phase
- Steady-state phase

The protocol is divided into a setup phase and steady phase,In setup phase the clusters are organized themselves and in steady-state phase data are transferred from the nodes to the cluster head and on to the sink [5].

- *Setup Phase*

In the setup phase, each node choose a random number between 0 and 1,if this number is less than a certain threshold T(n),the node will act as the cluster head.The non cluster head node chooses the cluster head with greater signal strength and join the cluster, and after the formation of cluster and cluster head node, cluster head node receives data from all of the cluster members and transmits data to the sink.The threshold value [14] is calculated based on an equation that incorporates the desired percentage to become a cluster-head, the current round, and the set of nodes that have not been selected as a cluster-head in the last (1/P) rounds, denoted by G. It is given by:

$$T(n) = \begin{cases} \dfrac{p}{1 - p \; mod \left[\frac{1}{p}\right]} & n \in G \\ 0 & otherwise \end{cases}$$

where G is the set of nodes that are involved in the CH election.

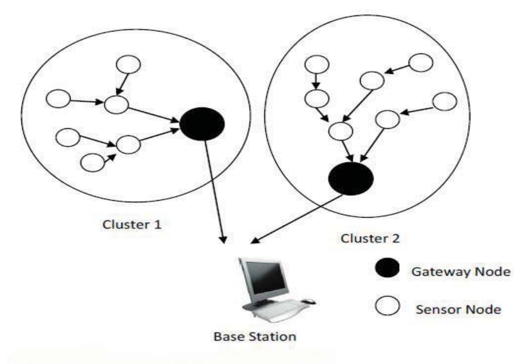



Figure 1 working of LEACH [12]

- *Steady Phase*

During the steady state phase, the sensor nodes can begin sensing and transmitting data to the cluster-heads. The cluster-head node, after receiving all the data, aggregates it before sending it to the base-station. After a certain time, the network goes back into the setup phase again and enters another round of selecting new CH.

*3.2 FORWARD AWARE FACTOR*

In forward aware factor[2] ,we measure the forward transmission area, by defining forward energy density,which constitutes forward-aware factor with link weight that balancing the energy consumption and increases the network lifetime.

*A. Network Model*

As shown in Fig. 2, suppose sensor nodes are randomly dis- tributed in a W*H rectangular sensing field.Data are sent to the regional central node(cluster head),then transferred to the sink node(Sink).The descriptions and definitions are as follows.

1) All sensor nodes are isomorphic, and they have limited capabilities to compute, communicate and store data. The set of sensor nodes is defined as V= $(v_1, v_2, \cdots, v_N)$ and the total number of nodes are i={1,2,3......N}.Here, i is the identifier for a node.

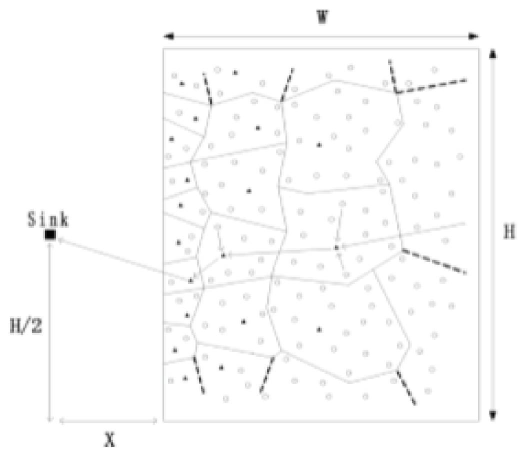



Figure 2 Distribution of sink and sensor nodes[2]

2) The energy of sensor nodes is limited,and the initial energy is **E.**However, the energy of the sink node can be added. Locations of nodes and Sink do not change after being constant and a node cannot obtain the absolute position depend on its own location device.

3) Nodes transmission power changes according to the distance to its receiver.The sink node can broadcast message to all sensor nodes which is in the sensing area. The distance between the source and receiver can be computed based on the received signal strength. central nodes are not selected at the beginning, on the contrary, they spring up during the topology evolution.Importance nodes have more connections,whose degree and intensity are significantly more than neighbor nodes.

The energy spent for sending a l-bit packet over distance d[2] is

$$E_{Tx}(l,d) = E_{Tx-\text{elec}}(l) + E_{Tx-\text{amp}}(l,d) = \begin{cases} lE_{\text{elec}} + l\varepsilon_{fs}d^2, & d < d_0 \\ lE_{\text{elec}} + l\varepsilon_{mp}d^4, & d \geq d_0 \end{cases}$$

Where

$$d_0 = \sqrt{\frac{\varepsilon_{fs}^2}{\varepsilon_{mp}}}$$

When the data transmission distance is larger than threshold , the energy consumption would rise sharply, so the maximum communication radius of common sensor nodes is set to $d_0$ .

As time goes on,the amount of data becomes larger with the increase of nodes.when *d(i,j)* is long, the data transmission tends to choose a short-distance link. In same way , when is *d(i,j)* large, the communication link is busy,the data transmission choose low-load link firstly.Energy plays a key role in edge weight,

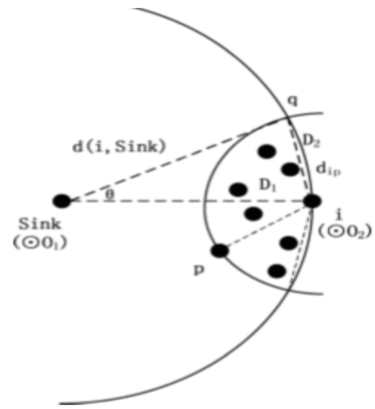



Fig 3 forward transmission area[2]

*B. Establishment of the Model [2]*

The forward transmission area[2] of node is shown in above figure . Fig 3 shows that a circle $0_1$ with Sink as the center and *d(i,sink)* as the radius,there is another circle $0_2$ with *i* as the center and $d_{ip}$ as radius[2].

$$\mathrm{FTA}(i) = \odot O_1 \cap \odot O_2$$
$$d_{ip} = \max(d_{ij}), j \in N'(i)$$

where *N (i)* is the set of nodes that have communication link with node *i*. $N^1(i)$ is the set of nodes of that have an edge with node ,and is the distance of node *i*and node *j* .

Fig 3 shows that, in WSN[11] clustered hierarchical routing protocols, sometimes nodes of a cluster are closer to the sink than the cluster head is,but it should transmit data to the head node. it must result in a waste of energy.

This paper shows routing protocol that uses forward transmission area according to the position of sink and the final data flow direction., the arc of circle $0_1$ ruled out the possibility of node *i'*s backward transmission,which ensure that there will be no loops. $0_2$ contains all of the nodes that directly connected with node . As an area that satisfy the two requirements, Forward transmission area (FTA) contains all possible nodes under topology and routing algorithm of this paper .

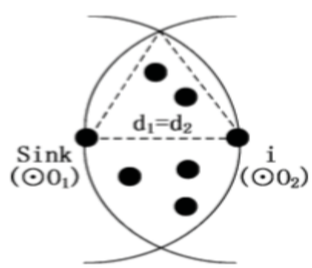



Fig 4 showing minimum FAF[2]

*C. Design of the FAF-*

FAF is used for the large-scale WSN for static data collection and event detection. firstly takes the FED of all of the possible next-hop nodes into account, which means the ability to transmit data. The second term considers the weight of transmit link, which can be used to choose the next-hop node directly.

The routing algorithm can be divided into seven stages as follows.

1) Determine *FTA(i)* and all of the possible next-hop nodes of node *i*. First, take $d_0$ the communication radius, de termine the set of all of the nodes that have edges with *i*. Select the nodes that closer to Sink than *i* does, which constitute the set of all of the possible next-hop nodes and the furthest node determine *FTA(i)*.

2) Determine *FTA(j)* and each possible next-hop node.Determine *FTA(j)* as we determined .Plug the furthest distance between j and sink nodes in FTA.
3) Calculate *FED(j)* of each possible next-hop node and get *FED(j)* .

*FED(i,t)* is calculated as-

----j

$$\mathrm{FED}(i,t) = \frac{\sum_{j \in FTA(i)} E_j(t)}{S_{\mathrm{FTA}}(i)}$$

where is $E_j(t)$ the energy value of node *j* at time *t*

4) Calculate the weight of edges between *i* and each nodes.
5) use the parameters of 3) and 4) and calculate FAF of each possible transmit link. Choose the next-hop node according to

$$j = \max_j[\mathrm{FAF}(ij)]$$

6) If there is no node closer to Sink than i in $N^1(i)$, directly compare FAF of all of the nodes in $N^1(i)$and choose the next-hop node . If there is no node in $N^1(i)$,*i* will increase the transmit power to get a longer radius than $d_0$ until connected with another node,or will abandon the packet.
7) If Sink is among the forward transmit nodes, i will transmit data directly to Sink and accomplish the procedure.

## IV. SIMULATION AND RESULTS

To evaluate the execution of Forward Aware Factor based wireless sensor network, we use MATLAB to simulate the protocol. ere both LEACH and FAF protocol are simulated and compared with respect to the two parameters

- $R_{FND}$ (First node dead)
- $R_{LND}$ (Last node dead)

Where $R_{FND}$ is the round in which first node dies and $R_{LND}$ is the round in which all nodes are dead.The comparison results drawn are detailed in table 2.The parameters being taken for the simulation are given in table 1.

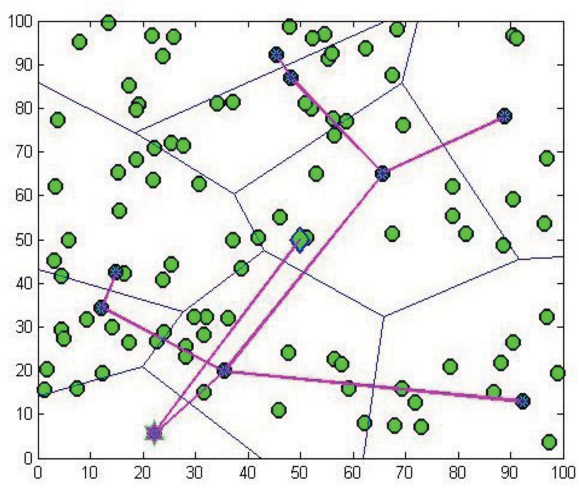



Figure 5 Showing forward aware factor performance

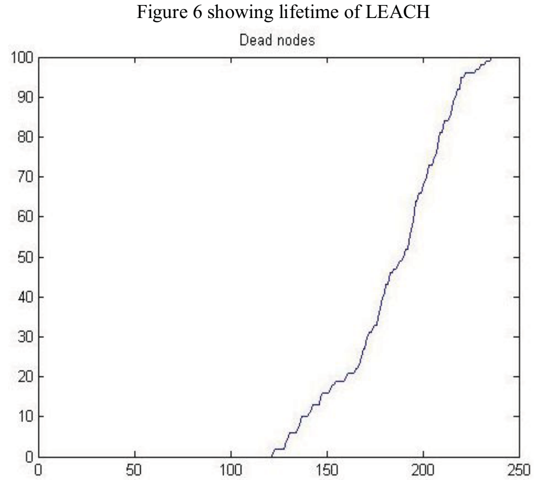
The comparison of both the protocols shows that the FAF protocol increases the lifetime of the network. The total number of rounds in which the FAF based network executes completely is 273 as compared to 230 of LEACH protocols.The FAF protocol shows an increase in the lifetime by 19% over the basic LEACH.

| **Parameter** | **Value** |
|---|---|
| Network size | 100x100 |
| No. of nodes | 100 |
| Sink location | (50,0) |
| Initial Energy, $E_o$ | 0.1J |
| $E_{mp}$ | 0.0013pJ/bit/m4 |
| $E_{elec}$ | 50nJ |
| $E_{fs}$ | 10pJ/bit/m2 |

Table 1-Simulation Parameters

After the execution of the both the protocols the resultant graphs of the number of dead nodes with respect to number of rounds(network lifetime) are given in figure 6 and figure 7.

Figure 6 showing lifetime of LEACH



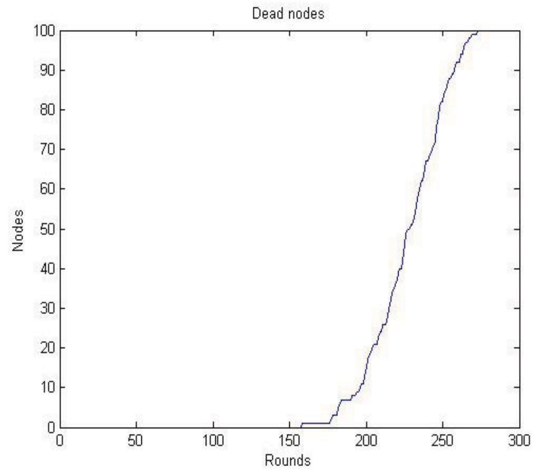



figure7 Showing network lifetime of FAF

In case of both the protocols we have taken 2 values of initial energy ($E_o$) as 0.01J and 0.1J.

The comparison is as follows:

**CASE 1-** Initial Energy, $E_o$= 0.01J

| | LEACH | FAF |
|---|---|---|
| $R_{FD}$ | 4 | 40 |
| $R_{LD}$ | 38 | 81 |

Table 2- Result when Eo= 0.01J

**CASE 2-** Initial Energy, $E_o$= 0.1J

| | LEACH | FAF |
|---|---|---|
| $R_{FD}$ | 120 | 176 |
| $R_{LD}$ | 230 | 273 |

Table 4- Result when Eo= 0.1

## V. CONCLUSION

Wireless sensor network, sensor nodes has limited energy and communication ability.so it is important to design routing protocol in WSN. In this paper working of forward aware factor is explained with simulation result and result is compared with LEACH .The FAF protocol shows an increase in the lifetime by 19% over the basic LEACH.To further increase the performance of WSN we can also use the concept of data aggregation that will minimize the energy dissipation of the nodes. The aggregation can further be inter-cluster or intra- cluster to extend the lifetime.

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