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Life Time Change Dynamics of WSN In Spite of Energy Hole at Sink

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Abstract: Wireless Sensor Network (WSN) has become very important network for sensing surroundings for temperature, humidity, surveillance and so on. Such networks are deployed in strange environments also. The life time of the network depends on the battery power which is limited. Therefore the life time of the network needs to be improved by considering optimizations. Moreover, certain attacks such as energy hole at sink are to be prevented in order to ensure that lifetime of the network is optimized. In this paper we investigate the presence and the effectives of energy hole at sink and characterize it in order to have better understanding of it and take preventive measures. The proposed investigations are made using NS2 simulations. The results reveal the efficiency of the proposed method.

Keywords: energy efficiency, energy hole, network lifetime, routing, Wireless Sensor Network (WSN)

I. INTRODUCTION

Wireless Sensor Network (WSN) is a collection of sensor nodes that are located geographically in a distributed environment. The nodes in the network are capable of performing sensing. Typically they capture data from surroundings and send to base station or sink. The sensor nodes thus play vital role in many real world applications like temperature monitoring, surveillance, home monitoring, and studying wildlife habitat besides serving other civilian and military purposes. A typical WSN appears as shown in Figure 1. The network can be connected to Internet servers and thus people from remote places can view data collected by sensor network. The problem with such devices in WSN is that they have limited energy with batter power. Once energy is completed, a sensor node gets switched off. Thus the lifetime of the network goes down drastically.

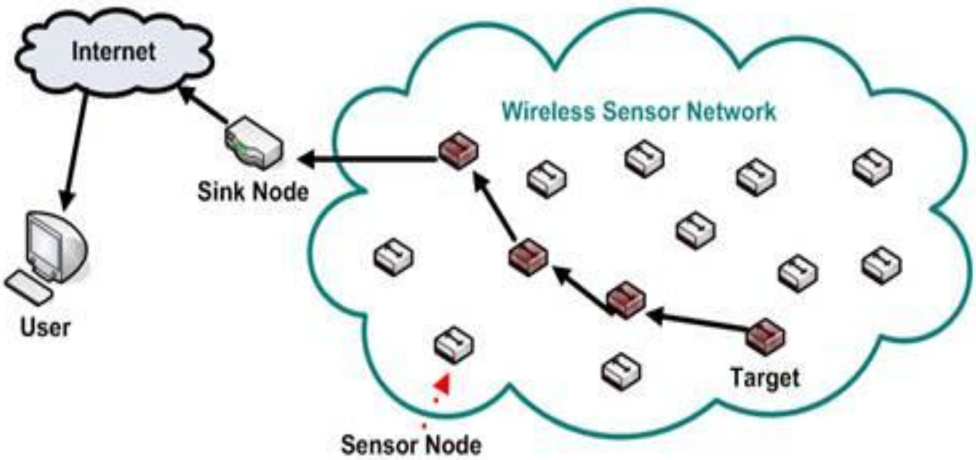

Figure 1: A typical WSN

As shown in Figure 1, the WSN needs to be supported with energy efficient means of communication in order to maximize network lifetime. There are many utilities when network lifetime is monitored and increased. Network lifetime is very important for continued services rendered by deployed WSN. In this context, it is essential to monitor the network for energy efficient approaches and optimizations. In this paper we proposed an analytical model that focuses on estimating network life time and energy efficiency in order to make well informed decisions. We proposed two algorithms towards this end.

We built WSN using NS2 and the proof of the concept is demonstrated. The results revealed that the proposed model is capable of shedding light into the need for evaluating network life time and evolution of

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energy hole. As energy holes drain the energy of WSN, this study assumes siginicance. The remainder of the paper is structured as follows. Section II reviews related works. Section III provides details of the proposed system. Section IV provides experimental results. Section V provides conclusions. It also gives directions for future work.

II. RELATED WORKS

Many energy consumptions models in WSN came into existence for improving energy efficiency [1]. Data gathering networks like WSN consumes energy. However, energy efficiency is very important for energy constrained sensor nodes. Many approaches came into existence to have energy efficiency and improve network life time. Network life time analysis was done by many researchers [2], [3], and [4] where the focus was from network initialization to the time the death of fist node in the network. It is known as first node died time (FNDT). Distributed Energy Balancing Routing (DEBR) is an algorithm proposed in [5] for increasing FNDT. Network life time and cost models are explored in [6] for estimating node dynamics and network longevity. FNDT was explored in [7] in a WSN where clusters are used with spatial correlation. They used routing protocol to improve energy efficiency. The concept of upper bound derivation for FNDT is derived in [8] in cluster based WSN for efficient communications.

In [9] FNDT is highlighted as an important problem that needs to be taken care of for longevity of WSN. It is an important measure of performance of network as well. Annuli-based analytical model was proposed in [10] for finding network life time while aging process was proposed in [11] for the same. The network lifetime is the period between network initialization time and death of any sensor node for the first time. An improved model was proposed in [12] with respect to FNDT and optimal network lifetime. Event driven WSN was studied in [13] and [14] for monitoring entire lifetime of WSN.

Though many approaches came into existence to analyze network lifetime, there are few insights in literature on the energy hole and its effect on the network lifetime. Considering energy hole is very important for the research in WSN for network life longevity as explored in [15] and [16]. Many load balancing techniques are found in [17] for handling energy hole problem in WSN. They also proposed a heuristic algorithm that is distributed in nature. The problem also studied in [18], [19], [20] and [21] and stated that energy hole is located at the sink and energy efficient routing protocols can mitigate the effect of energy hold in order to improve the lifetime of WSN.

III. PROPOSED APPROACH FOR LIFE TIME EVOLUTION

In this paper, we proposed two algorithms for finding network life time and dealing with energy hole. At different stages of network, traffic load, energy consumption and lifetime of sensor are computed. This is done by the algorithm 1.

Input: Network radius R, transmission radius r, node density of the network ρ, and other parameters.

Output: For each stage i and each node j, return the nodal traffic load $P_j^{(i)}$, energy consumption $e_j^{(i)}$, as well as the energy transfer function f and lifetime vector l.

1. According to theorem 1 and 2 we have to calculate traffic load and energy consumption of all nodes at first stage (i=0) like[P_1^0 , P_2^0 , P_3^0, P_j^0 ,..... P_n^0],[e_1^0 , e_2^0 , e_3^0, e_j^0 ,..... e_n^0]

2.then move onto the next stage i.e i=1

3.while(i<n){

calculate life time l^{i-1},ith batch of dead node region [ui, ui + ε].

Calculate traffic load and energy consumption like [P_1^i , P_2^i , P_3^i, P_j^i ,..... P_n^i],[e_1^i , e_2^i , e_3^i, e_j^i ,..... e_n^i]

using theorem 3 and 4.

i++;

}

Algorithm 1. At each network stage determine the traffic load, energy consumption and lifetime of sensor nodes.

Input: Network radius R, transmission radius r, node density of the network ρ, and other parameters.

Output: The energy hole boundary $[d_{s\square ole}, d_{e\square ole}]$ and emerging time $t_{\square}$.

1.Iterate first algorithm until we satisfy the below condition
while(d>=r)
2.At that point we have to calculate the dead region boundary, emerging time.
3. return values.

Algorithm 2. Determining the emerging time and boundary of the energy hole

Algorithm 2 proposed here determines the boundary of the energy hole and emerging time. The algorithm thus helps in energy hole evolution and measuring the dynamics of network life time.

IV. EXPERIMENT RESULTS

We used NS2 simulations to demonstrate proof of the concept. Experiments are made in terms of observations on network lifetime with different network size, transmission radius, number of sensor nodes, with different algorithms.

PARAMETER	SPECIFICATION
Simulation tools used	NS2 Network Simulator (ns-2.35)
Simulation time	10 sec, 20 sec, 30 sec
Number of nodes	10,20,30,40
Transmission range	250m
Maximum speed	0-20 m/sec
Application traffic	CBR [constant bit rate] [20]
Packet size	512bytes
Node mobility model	10 packets/sec
Protocol	AODV
Number of runs	36

Table 1: Shows simulation environment

As shown in Table 1, it is evident that the simulation environment used for experiments is presented. It includes the protocol, simulation time, nodes, NS2 version, packet size and so on.

Network Size	Andt(* 100 rounds)		
	Simulation	Our Analysis	Analysis Of [17]
400	13	10	7
600	14	11	7.5
800	16	12.5	8

Table 2: ANDT with different network size

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As shown in Table 2, it is evident that the network size has its influence on the ANDT. The results show the difference among the analysis of [17], proposed analysis and simulation.

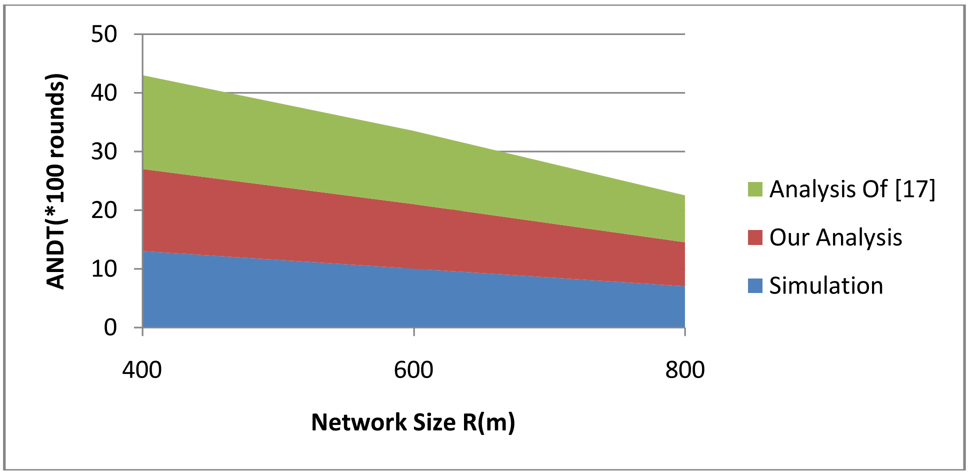

Figure 2: Network size vs. ANDT

As shown in Figure 2, the network size is taken in horizontal axis and ANDT is represented in vertical axis. The results revealed that ANDT has its influence on the size of the network.

Transmission Radius r(m)	50	60	70	80	90	100	110	120	130	140	150	160
Fndt In a	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9
3% Nodes Die In a	0.5	0.6	0.7	0.7	0.7	0.8	0.8	0.9	0.9	1	1	1
Andt In a	1	1.1	1.2	1.5	1.7	1.8	1.7	2.4	2.5	2.3	2	
Fndt In b	1.3	1.5	2	2.3	3	3.5	3.6	4.5	4.5	5	5.3	5

Table 3: Transmission radius and network life time

As shown in Table 3, it is evident that the transmission radius is considered from 50 through 160 incremented by 10. The transmission radius has its impact on the FNDT and ANDT dynamics in WSN.

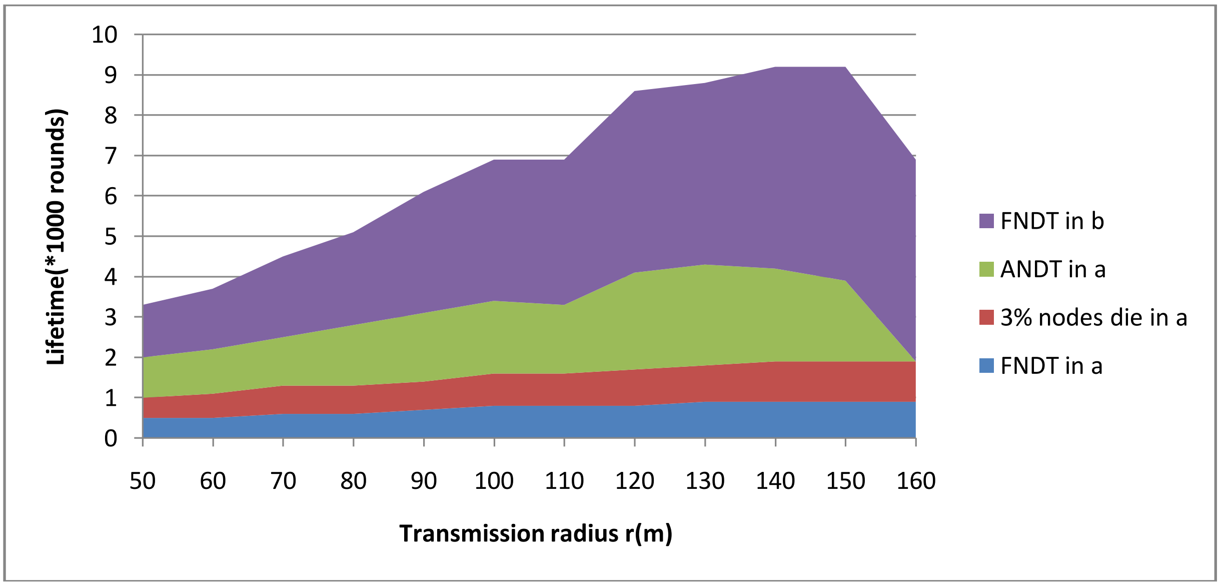

Figure 3: Transmission radius vs. network life time

As shown in Figure 3, it is evident that the network lifetime is measured in terms of FNDT and ANDT. The results revealed that the transmission radius has its impact on the lifetime of the network both with ANDT and FNDT models.

Number Of Sensor Nodes	600	800	1000	1200	1400	1600	1800
Fndt,r=70m	7.6	7.4	7	7.3	7.4	7.3	7.5
Fndt,r=90m	8.5	8.5	8.5	9	8.5	8.7	8.6
Fndt,r=120m	9.5	9.6	9.5	9.5	9.5	9.5	9.5
Andt,r=70m	9.7	10	10	9.7	9.7	9.7	9.7
Andt,r=90m	11	10.6	10.3	10.5	10.3	10.7	10.7
Andt,r=120m	12	12	12	11.6	11.8	11.5	11.5

Table 4: Number of sensor nodes vs. network life time

As shown in Figure 4, the experiments are made with different number of nodes. For each experiment the details of ANDT and FNDT are recorded.

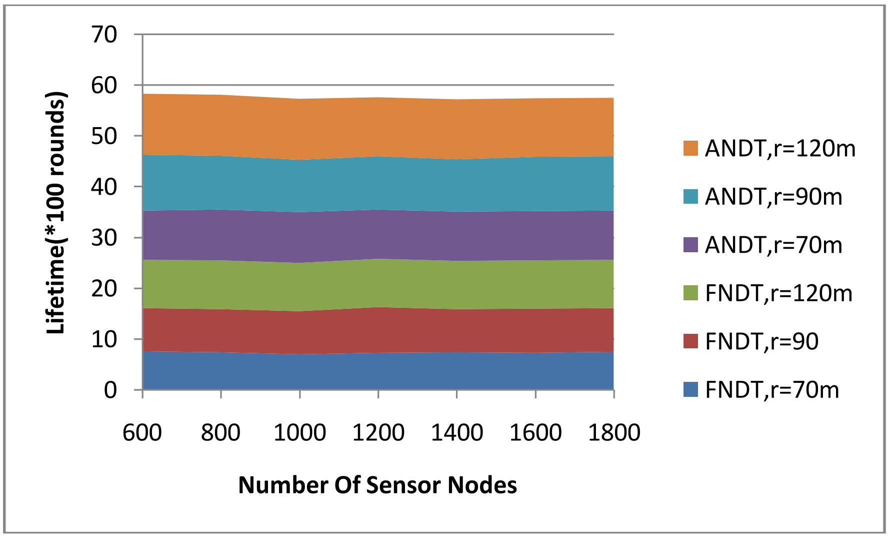

Figure 4: Number of sensor nodes vs. ANDT and FNDT

As presented in Figure 4, the results revealed that the number of sensor nodes have their impact on the network life time both in terms of ANDT and FNDT.

Network SizeR(m)	Andt(* 1000 rounds)		
	GGR	DEBR	DCFR
200	3.9	4.4	4.6
300	2.5	3	3.3
400	1.5	2.3	2.6
500	1	1.7	2

Table 5: Network size vs. ANDT

As shown in Table 5, the results of different mechanisms like GGR, DEBR and DCFR are presented in terms of ANDT in the presence of different network sizes.

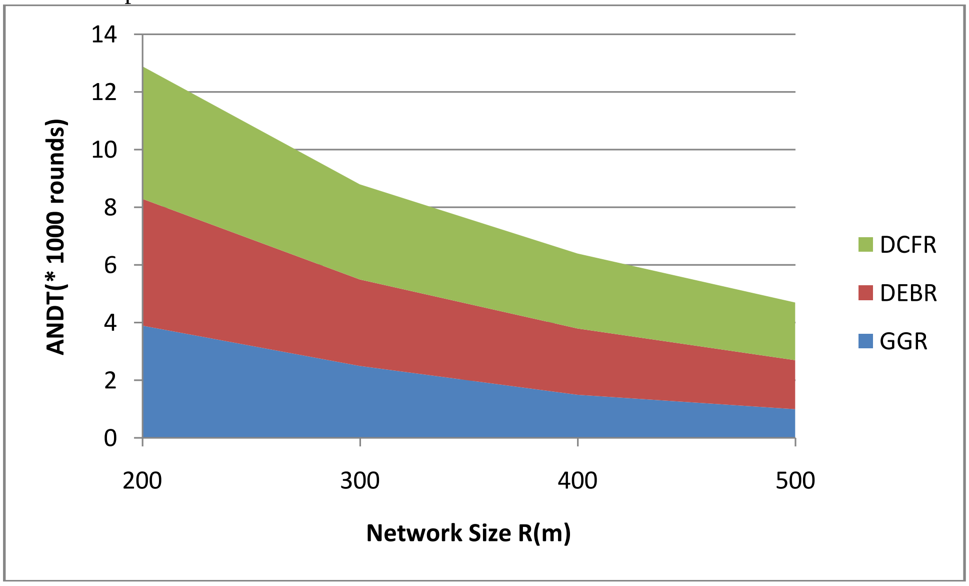

Figure 5: Network size vs. ANDT for different approaches

As shown in Figure 5, it is evident that different network sizes are considered and ANDT is plotted for different algorithms like DCFR, DEBR and GGR.

Number Of Sensor Nodes	600	800	1000	1200	1400
GGR	15	16	17	18	19
DEBR	25	27	28	29	30

Table 6: Number of sensor nodes vs. GGR and DEBR performance with ANDT

As shown in Table 6, it is evident that the number of sensor nodes has its influence on ANDT with different algorithms such as GGR and DEBR.

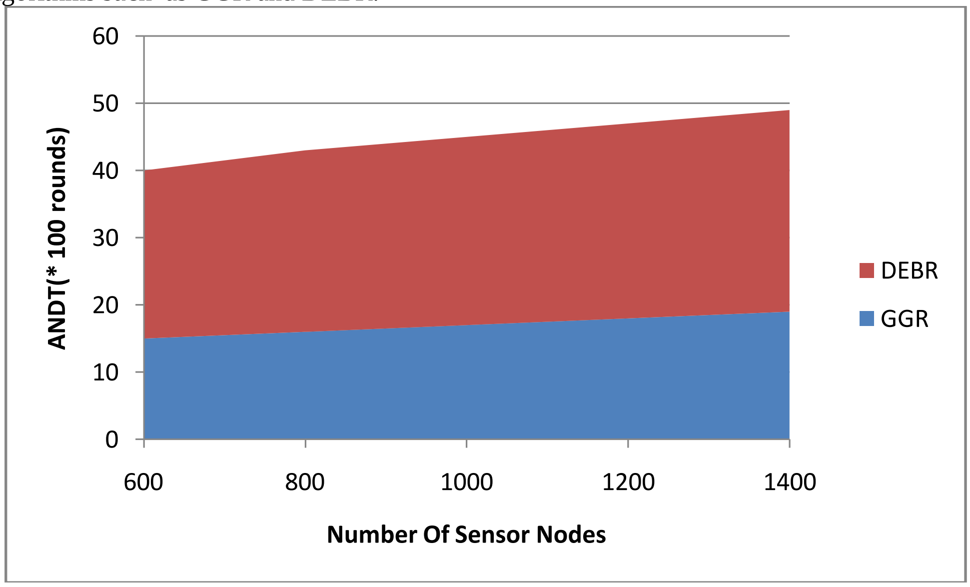

Figure 6: Number of sensor nodes vs. ANDT

As shown in Figure 6, the number of sensor nodes is presented in horizontal axis while the vertical axis shows ANDT measure. The results reveal that DEBR showed more ANDT when compared with that of GGR.

V. CONCLUSION

We studied WSN with energy hole problem at sink. We understood that such attack drains energy of the network and ensures that the life time of the network is reduced drastically. The lifetime dynamics of the network are investigated in this paper. We also considered the presence of dead nodes and their percentage besides characterizing the energy whole at sink in WSN. We proposed a methodology that is used to investigate the problem using NS2 simulations. The experimental results reveal the significance of the proposed method and its ability to reduce error rate. In future we intend to improve our method with a hybrid approach.

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An acknowledgement section may be presented after the conclusion, if desired.(8)

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