Energy-hole reduction scheme in Wireless sensor network

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Abstract—**In wireless sensor network, so many sensors are present and these sensors are arranged in different-different topology. Some sensors are arranged in flat topology. WSN have sensor nodes and sink node. Sensor which are near to sink need more energy than in compare of sensors that are far away from the sink and as energy exhausted, these sensor node get die and energy hole is established near the sink. So that other sensor can not transfer their data to the sink node and network arrangement get disconnected. By this even if so many sensors still have a lot energy but they cant be used because network get disconnected. So by energy hole, network lifetime get reduced and network lifetime is a crucial issue for WSN. Because energy of sensor nodes are limited. Sensor nodes are powered by batteries and these battery powered sensor collect the information from the environment and send this collected information to sink node. For the network lifetime improvement and to balance the energy consumption we have to find the solution for energy hole problem. Many researches are trying to eliminate this problem but 100 % elimination is not possible. This is inevitable but we can minimize it to some extent. So many methods and techniques developed and tried to minimize this energy hole. Since the energy resources (battery) limited in sensor network, proper selection of clustering method, proper selection of routing is very important to improve the efficiency and lifetime of network. Here, we will discuss some method that try to eliminate the problem and to enhance the lifetime of network.**

***Index Terms*— WSN, Energy hole problem, Energy-efficiency.**

I. Introduction

WSN is typically collection of small , energy limited, low power devices that communicate with each other using a network. Wireless sensor network are kind of ad-hoc network because in this network, sensors are not connected in predefined way but they connect with each other instantaneously and form a network. WSN created by nodes as name indicate wireless sensor network in which so many sensor are connected with each other wirelessly. Each sensor node have internally so many components like: radio transceiver, an antenna for transmitting and receiving signal. Microcontroller device, an electronic device which works as a mind of the sensor. A battery which works as energy resource. Sensor node might vary from a match box down to the size of little pearl. The cost also can vary according to the complexity of its design.

Energy hole problem: In wireless sensor network, so many sensors are present and these sensors are arranged in different-different topology. Some sensor are arranged in at topology. WSN have sensor nodes and link node. Sensor that are close to sink utilize more energy than the sensors that are far from the sink and as energy depleted, these sensor node get exhausted and energy gap is made close to the sink.so that other sensor can't exchange their information to the sink and system get disconnected. By this even if so many sensors still have a lot energy but they can not be used because network get disconnected. So by energy hole [3], network lifetime get reduced and network lifetime is a crucial issue for WSN. Because energy of sensor nodes are limited. Sensor nodes are powered by batteries and these battery powered sensor nodes collect the information from the environment and send this collected information to the sink node. For the network lifetime improvement [4] and to balance the energy consumption we have to find the solution for energy hole problem many researches are trying to eliminate this problem but 100 % elimination is not possible. This is inevitable but we can minimize it to some extent. So many methods and techniques developed and tried to minimize this energy hole. Since the energy resources (battery) limited in sensor network, proper selection of clustering method, proper selection of routing is very important to improve the efficiency and lifetime of network. Here, we will discuss some method that try to eliminate the problem and to enhance the lifetime of network.

Energy hole problem(EHP) occure because of :

- Unbalanced energy utilization
- some nodes deplete their energy more quickly because they have more work to do.

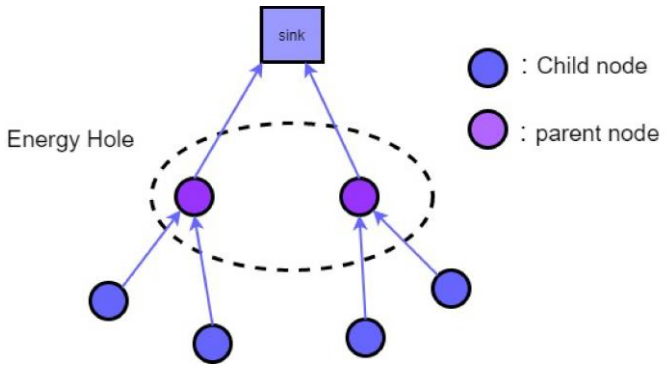

Figure 1: energy hole event

- Node nearer the sink have to take more traffic load.
- Sensor that are closer to sink consume their energy more rapidly and finally network partition take place.

In this paper, we also talk about two trigger-based protocol that are energy-efficient and that guarantee the network link for periodic data collection applications. These conventions OHCR(On-Hole Children Reconnection) and OHA (On-Hole Alert) take care of any directing gap issue in the point of neighborhood and global data, separately.

They suit on all the topology development calculations and system offices of single way coordinates with single setup stage. They handle the untimely end of system lifetime in such systems; particularly, when the BS is a long way from the ROI. Also, they maintain a strategic distance from the persistent dynamic topology arrangement, dis-similar to other dynamic directing conventions. These protocol progressively reconnect the detached node at whatever point a steering gap happens with negligible system setup overhead. The primary commitments of these protocol can be summarized in two points. To begin with, they safeguard the stability time-period, while expanding the system lifetime of the topology development calculation. Second, they restrain the trade-off among availability and system overhead by limiting the energy consumption in topology reorganization while looking after network.

Since in wireless sensor network(WSN), sensor have limited energy because they are powered by battery. As they are deployed in very complex environment so that human intervention is not possible there. So their energy must be used as efficiently as possible. But in WSN, sometime because of unbalanced energy distribution, some sensor nodes exhaust much faster compare to other nodes. So a energy gap is developed in between the network and network get disconnected and network failure occurs. This problem is known as Energy hole problem. So to avoid this or to deal with this problem we discuss here several techniques that helps to minimize it and increase the network lifetime. So for improvement of network lifetime reduction of energy hole problem is essential thus we choose this problem as research topic.

II. LITERATURE REVIEW

The nodes which are near the sink will encounter with energy drop by increasing the traffic of sensor nodes. When these nodes don't work well, network will be out of work. This process will cause early death. Although energy remains in some sensors, the network will not work well. [3]. In [5] in order to solve the problem of energy hole, distribution of more nodes had been used near the sink. In [6] in order to solve the problem of hole energy two nodes with more energy have been placed in the middle of network. The nodes which are near the sink will send the data directly to the sink after clustering. The nodes which are happened far from the sink will be sent to these two nodes. Since the energy of these two nodes is high then because these two nodes act as a bond don't fail and the network doesn't fail. Near nodes since are located in radio range, they will not consume extra energy. Thus energy hole will be prevented in network.

In [6] design of Alternating transmission between one hop and multi hops is proposed. In [8] for solving the energy hole problem, the consumption of energy in cluster and head clusters was at least. In this method the clusters are not equal and the distribution of nodes is not equal in the network. Algorithm ECHERP is the other method which this protocol by using of multi levels and dividing the levels into two parts and by clustering will send information by routing to the base station and in the next steps, the base station by using Gauss elimination algorithm in order to minimize the energy consumption in network. The problem of this method is relying on the base station to choose the head cluster [9], [11].

HRTBR model [10] creates a circular network and performs as a tree synthetic routing. According to the tree routing with Es threshold and middle ring, controls communication methods among nodes. Simulation results show that effective routing algorithm is for prevention of energy hole.

III. PROPOSED METHOD

A. Problem definition and assumption

Because of energy hole issue, around 90% energy of the single way with single arrangement stage network remained unused while the system lifetime ends untimely [2]. This energy-gap issue is more likely on account of far BS area from ROI. We accentuate the issue by dealing with the energy-hole issue in Degree Constrained Tree (DCT) demonstrating the impact of the quantity of child node on the system life- time. The model we used for our study follow the energy model. In this manner, the transmitter disseminates energy to process the radio circuit and the power enhancer, and the recipient scatters energy to run the radio gadgets. For the tests portrayed here,
both the free space (d^2 power loss) and the multipath fading (d^4 power loss) channel
models were utilized, which is depending upon the separation between the transmitter
and recipient. Power control can be utilized to reduce this loss by correctly setting the
power amplifier. If the separation distance is not as much as threshold $d_o = \sqrt{€_{fs}/€_{mp}}$,the free space (fs) model is utilized otherwise the multipath (mp) model is utilized. In this way, the energy consumed in transmitting and getting 1 – bit message through separation distance d are appeared in Eqs. (1) and (2):

$E_{TX}(l,d) = E_{TX\text{-}elec}(l) + E_{TX\text{-}amp}(l,d)$… at transmitter side[1]
$E_{Rx}(l; d) = E_{RX\text{-}elec}(l) = E_{elec}(l)$ .....at receiver side [2]

Utilizing the information gathering process, every node gets and send one in every round. The electronic energy, E_{elec} relies upon elements, for example, the digital coding, filtering, modulation, and spreading of the message, though the power amplifier energy, $€_{fs}(d^2)$ or $€_{mp}(d^4)$, relies upon the separation distance to the collector and the satisfactory bit error rate. Thus

$$E_{TX}(l,d) = \begin{cases} lE_{elec} + l\epsilon_{fs}d^2 & \text{if } d < d_o \\ lE_{elec} + l\epsilon_{mp}d^4 & \text{otherwise} \end{cases} \quad (1)$$

To understand the methodology, firstly we should know about some basic definition that have been used in this methodology.

- **Def.1:** Round I= Time required to complete single cluster design and data collection process from all of the sensor in the monitoring area.
- **Def.2:** Stability period (Rs)= Total rounds till the very first node get die.
- **Def.3:** Network lifetime (Rn) = Maximum life of the network, the network can be die if connection with base station is lost.
- **Def.4:** Relay node (rn)= Sensor nodes, who have the responsibility to connect Region Of Interest with Base Station.
- **Def.5:** Breakdown Energy (Eb)= Average amount of energy at which network ends. As the no. of child node increases, the network lifetime get decreases and breakdown energy increases upto a certain no. of children node and after that they will become constant.
- **Def.6:** Parent hole= When a parent node's energy get exhausted it disconnected with its child node and parent hole occure.
- **Def.7:** Pendant hole= When a node have no children and if its energy get disconnect from the network this case is pendant hole.

B. Methodology:

OHCR (On-Hold Children Reconnection) and OHA (On-Hold Alert) Protocol: There are two proposed energy proficient directing convention for handling the routing gap issue. These conventions are On-Hole Children Reconnection (OHCR) with nearby nature and On-Hole Alert (OHA) with worldwide nature. The amusement comes to fruition showed that the proposed conventions beat the present ones in regards to framework lifetime, hub incident rate, and framework overhead. The two conventions are reviewed on both Degree Constrained Tree (DCT) and Shortest Path Tree (SPT) to give around half to 75% extension in compose lifetime over the present vitality effective directing conventions; like UCCGRA and NEECP. Besides, applying OHCR and OHA to any framework topology doesn't impact its soundness period, since these conventions are initiated by directing hole event. The inconvenient end of framework lifetime is a standout amongst the most widely recognized issue in single way associates with single framework setup organize. This finish of framework lifetime is an eventual outcome of losing association of a couple of hubs with the BS in view of energy exhaustion of the arbiter node. This issue is more probable when the partition between the ROI and the BS is particularly. In this way, the hubs who are in charge of ROI to BS transmission get depleted before different hubs. In this manner, the ROI is segregated from the BS not withstanding the way that the typical framework vitality is for the most part high.at in the first place, we examine two energy effective steering convention that

certification network for occasional information gathering applications. Conventions that are OHCR(On-Hole Children Reconnection) and OHA(On-Hole Alert) deals with energy gap issue in setting of global and neighborhood data. They handle the troublesome end of framework lifetime in such systems; especially, when the BS is far from the ROI. Additionally, they evade the consistent dynamic topology course of action, not in any way like other dynamic directing conventions. These traditions logically reconnect the isolated hub at whatever point a coordinating hole occurs with insignificant system setup overhead. The essential duties of these conventions can be compacted in two core interests. In any case, they spare the dependability time period, while extending the framework lifetime of the topology improvement calculation. Second, they kept the exchange off among availability and framework overhead by restricting the vitality devoured in topology redesign while taking care of system.

Some notations is also used in the methodology that are:

- S= Total no. of sensors in Region Of Interest.
- S(i).C= Set of i^{th} sensor's children.
- S(i).E= Energy of i^{th} sensor.
- S(i).D=Distance between parent node and child node who is farthest from the parent node.
- jReq=Joining request.
- Ack= Joint acknowledgment.

As shown in figure:2 first of all, there is well established set-up where Base station, parent node, pendant node, child node are present. With the time, energy of the parent node(1) get decreases slowly. When the energy = Breakdown energy than sensor node:1 multicast a Breakdown packet to its child node to inform that it is going to die. After receiving the jReq if any of the node is ready to be their parent will send an acknowledgment message to them. if more than two nodes are ready to be their parent than the node who transmit acknowledgment message first, be the orphan child's parent. If there is no node in the Range Of orphan node than it transmit its data directly to the Base Station.

We can explain it by the help of flow chart also for the easiness of the process to understand. In the first flow chart the process of Breakdown multicast is explained that when $E < E_b$ then parent node multicast Breakdown message and get die. As shown in the figure:3, in the second flow chart, process after multicast BD packet is explained where orphan node try to search for their new parent node by sending jReq.

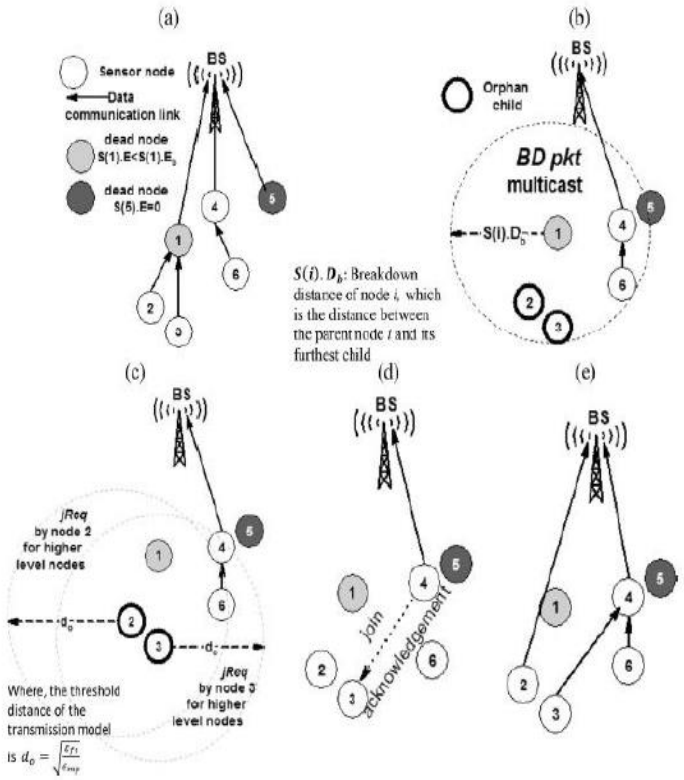

Figure:2 Procedure of OHCR protocol

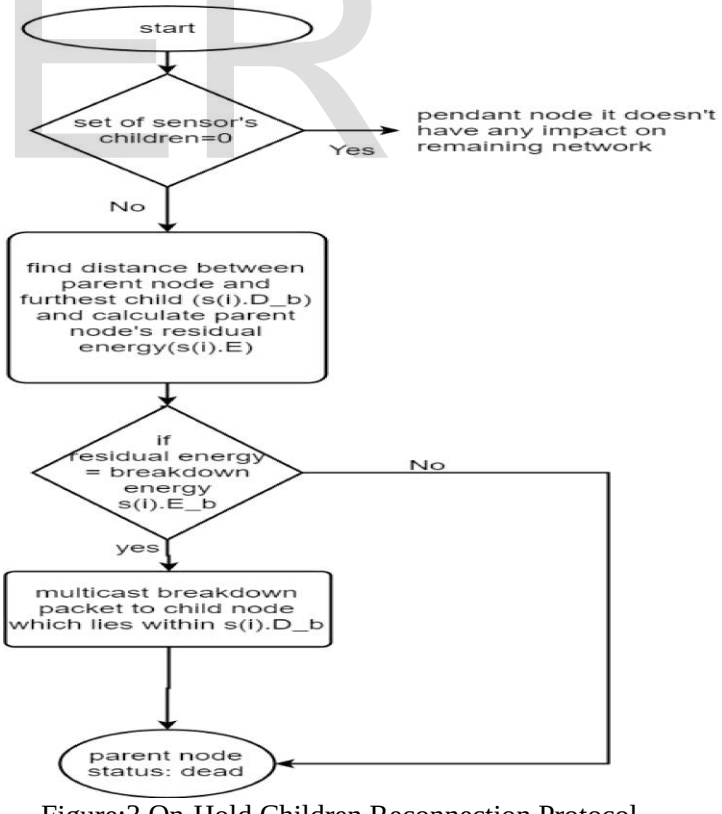

Figure:3 On-Hold Children Reconnection Protocol

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IV. Result

The proposed protocol has been simulated in Matlab software. Protocols have been compared by dependent parameters involving data, delivery rate, remaining energy average of nodes, the number of lost packets, the average of data delivery latency, the average of nodes queue length and the average of remaining energy of the first layer nodes. Simulation is done in 5000 rounds. Initial energy of the nodes is considered 1 J. Because the buffer nodes involve one buffer for its package and one buffer for received packets from another nodes. The sum of these buffers is considered 225.

A. The average of nodes' queue length:

The effect of packet production rate on the average of nodes queue length has been shown in Fig. 5. One of the most important features of determining the network traffic is the average of available packets' queue length in buffer of nodes.

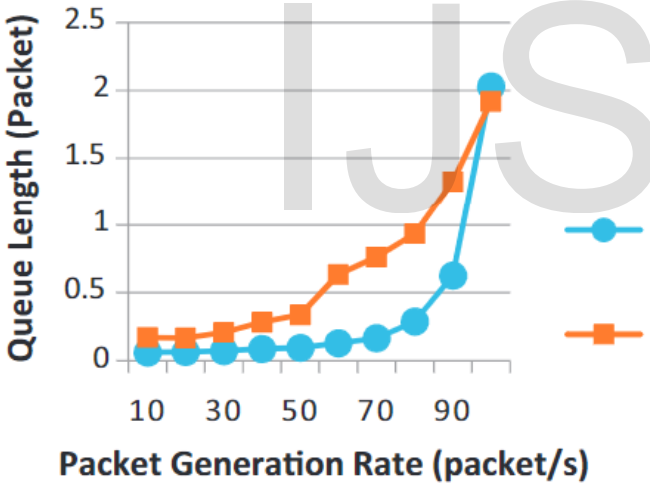

Figure:5 The effect of packet production rate on the average of nodes queue length.

B. Data delivery rate:

The effect of packet production rate in the source on data delivery rate in the sink node has been shown in Fig.6. Simulation results show that data delivery rate in proposed protocol is more than protocol HRTBR because (1) consumed energy of nodes is less in presented protocol and much protocol data are routed have sent to the sink by middle nodes of network, (2) energy consumed by the first layer nodes is less in presented protocol so much data transferred by other layer nodes to this layer are not sent to sink with minimum amount of lost packets. As it can be observed in simulation results, when package production rate increases in the network, data delivery rate reduces in both protocols. Nodes are used to transfer packets due to increasing the network traffic and consumed energy.

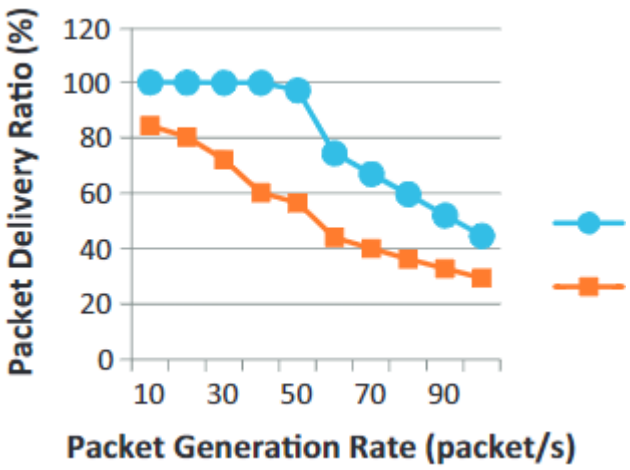

Figure:6 The effect of packet production rate on data delivery rate.

V. Conclusion

The untimely death of system lifetime having more chance in such checking applications, particularly when the Base Station is a long way from the Region Of Interest. The system structure is shaped of a solitary way between each source node and its goal, and with single arrangement stage. In like manner, we presented two answers for this sort of systems to keep up network while maintaining a strategic distance from the expansion in overhead offered by powerful steering conventions. The two arrangements are On Hold Children Reconnection and On Hold Alert conventions that are described by high adjust capacity to application necessities with neighborhood and global nature, separately. On Hold Children Reconnection and On Hold Alert are better connected on trees with as restricted requirements as conceivable to give the best outcomes as far as system life, energy overload, and rate of node misfortune. The neighborhood idea of On Hold Children Reconnection influences it to work the best as far as vitality overhead particularly on low confinement topology, as SPT, so the reconnection succeeds inevitably, not at all like DCT. Consequently, OHCR-SPT accomplishes the most noteworthy extension in organize lifetime and least system overhead.

- OHCR(on hold children reconnection)protocol and OHA(on hold alert) protocol gives better result when they applied on trees in terms of network life, energy overload and node loss rate.

- Using OHCR (on hole children reconnection algorithm),it can enhance the network lifetime. The network lifetime of single setup phase tree can be extended upto 3-5 times.
- Using anyone of OHCR or OHR provide network firmness upto 25% and 52% more than their other competitive energy efficient protocols.
- Proposed protocol minimized the network overhead to be less than 10% .

VI. REFERENCES

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