Review of Energy Efficient and Network Lifetime Improvement Approaches in Wireless Sensor Networks

Deepak v Biradar[1]
Ph. D Research Scholar , Jain University Bangalore [1,2]

Dr. Nataraj K. R[2]
Professor, ECE,SJBIT

Abstract:

As the technology grows low cost and low power multifunctional sensor nodes have gained more attention in the field of wireless sensor networks (WSN). WSN is used in various applications like battlefield monitoring, detection of Enemy vehicles and environment surveillance. In most of the applications energy consumption is the main constraint, the more amount of time nodes are used in data transmission process they eventually become dead and this becomes very critical for Network to function and destroys Network Lifetime (NL). The paper commences by giving brief overview of various NL maximization techniques and sink relocation plays a vital role in improving NL. The survey is extended by an improvement to existing Sink Relocation techniques in the following manner a) Classification of Neighbour Nodes into Healthy Nodes and Non Healthy Nodes b) Picking the Forward Node which is healthiest and closer to destination c) Trigger the Dead Node Recovery Process at regular intervals. d) Making use of MIMO techniques for data rate improvement.

***Keywords: Wireless Sensor Network*; Energy Dissipation; Residual energy.**

NOMENCLATURE

Name	**Details**
WSN	Wireless Sensor Network
IOT	Internet Of Things
SN	Source Node
DN	Destination Node
LR	Lifetime Ratio
NL	Network Lifetime
CSI	Channel State Information
QoS	Quality Of Service
C	Energy Consumption

I.INTRODUCTION

Wireless Sensor Network history began from early 1980s with the usage of wireless voice network as mentioned by V. Potdar, A. Sharif, and E. Chang [1]. For WSN one of the main limitations is the battery capacity of the nodes. The usage of the WSN over the years has been depicted in the fig1. As shown in the fig1 the WSN are used for wide variety of applications [2] – [6]. The WSNs are used for very wide range of applications.

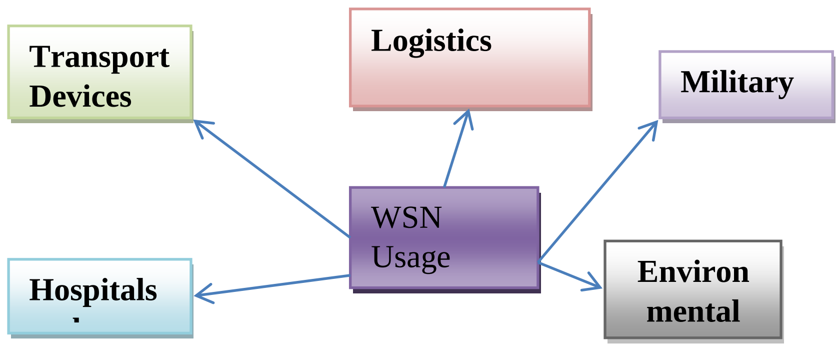

Fig1: Applications of WSNs

The node is a device which has the following characteristics namely Battery, Memory and Antenna. Network is simple terms can be treated as the collection of nodes. The network can be classified into 2 categories Non Hierarchical Network and Hierarchical Network.

Non Hierarchical network is a network in which all the nodes are spread in the single area. The network can be treated as a infrastructure less. The nodes do not have any controlling agent. Hierarchical Network is the network in which the nodes will be spread across multiple areas in the network. Each area will have set of nodes. This set is called by various names like cluster head, zone leader, group head or region head. In this kind of network there are 2 types of communication which are possible one is Inter Cluster and another one is intra cluster communication. For Inter Cluster Communication the communication happens between the nods within the same group or same cluster or same zone.

For Intra Cluster communication the communication will happen between the nodes in one cluster to a node in a different cluster.

Fig3 shows the 4 clusters and each of the clusters has a set of 10 nodes in the network

The Cluster based networks can be future sub divided into 2 sub networks

1) Homogenous Network

2) Non Homogenous Network

Homogenous Network is the network which has similar set of nodes in each of the clusters .Non Homogenous Network is the network which has different set of nodes in each of the clusters.

The Paper is divided into various sections. Section II describes the energy consumption model used in the proposed method. Section III describes how Lifetime Ratio is computed. Section IV provides definition of Network Lifetime Section V provides an overview of Network Lifetime Improvement Measures present in literature. Section VI describes the existing Sink Relocation Algorithm EASR. Section VII describes our contribution towards modification of existing EASR method and finally Section VIII describes the experimental results in which the proposed method is compared several existing methods - EASR, One Step and Stationary algorithm.

II. Energy Consumption Model

This section discusses the energy consumption model [7]-[11] in WSN. Consider that there are two nodes m and n located at a distance of d. Let the number of bits transmitted for the node n be represented by N_b. The node has majorly main components like transmitter component and amplifier component

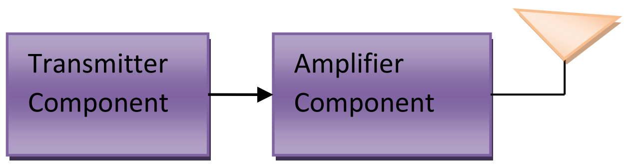

Fig2: Major Energy Dissipation Components

The energy required for transmitting N_b bits is given by the following equation

$$E_{trans}(N_b, d) = N_b * (E_{transmitter} + E_{reciever} * d^n) \quad (1)$$

Where,

$N_b = Number\ of\ bits$

$d = range\ between\ nodes$

$E_{transmitter} = energy\ required\ by\ transmitter\ circuit$

$E_{reciever} = energy\ required\ by\ reciever\ circuit$

$n = a\ constant\ integer$

The energy required by the node receiving the N_b bits is given by

$$E_{reception} = N_b * E_{tranmitter} \quad (2)$$

The total energy consumed for transmitting N_b bits over a distance of d can be given as

$$E_c = E_{trans} + E_{reception}$$
$$E_c = N_b (E_{transmitter} + E_{reciever} * d^n) + N_b * E_{transmitter}$$
$$E_c = N_b E_{transmitter} + N_b E_{reciver} * d^n + N_b * E_{transmitter} \quad (3)$$

W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan in [12] have discussed classical energy consumption model makes use of standard values as given in Table1

Table1: Energy Consumption Values

Mode of Operation of Antenna	Energy Consumption
$E_{transmitter}$	50 nJ/bit
$E_{reciever}$	100 pJ bit/m

The node loses its energy when it is involved in the transmission.
Consider the path which has the nodes which participate in routing

1-->3--->5---->8

Node1 acts like a sender and Node 8 acts like a receiver. Suppose the distance between the nodes 1 and 3 is 40m, number of bits are 100 and n=1. Substituting the standard values from table1 for energy levels and making use of equation1 the following is the energy consumed between Node1 and Node3

$E_c = 100\,(2*50nJ + 40\,pJ*40\,) = 1.3600e\text{-}005$

If the distance between Node3 and Node5 is 50 then the energy consumption can be found as

$E_c = 100\,(2*50nJ + 40\,pJ*50\,) = 1.3600e\text{-}005$

The distance and energy are directly proportional to each other. When the distance increases the energy consumption also increases as shown in the fig3

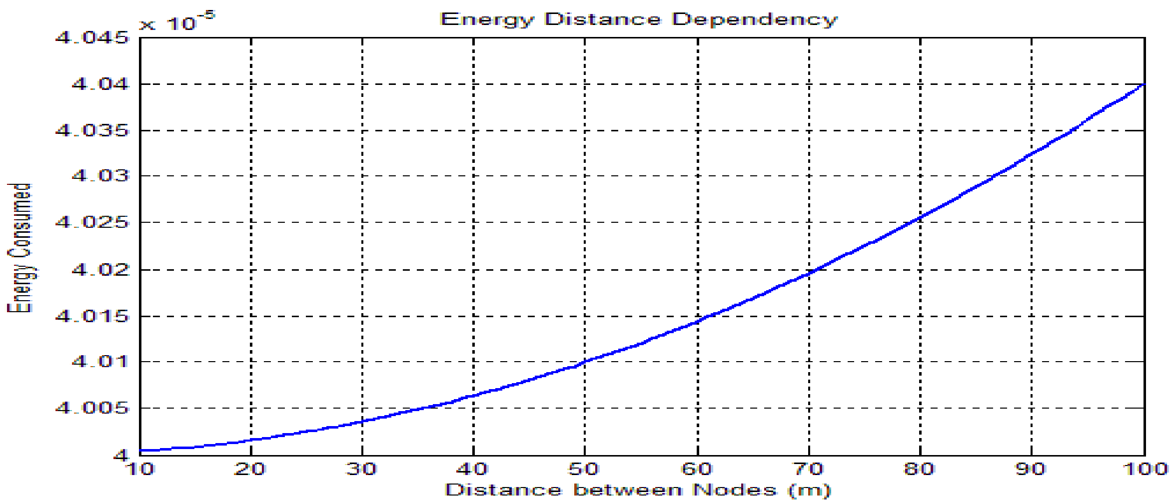

Fig 3: Distance v/s Energy Consumption

As shown in the fig3 as the distance increases the energy consumed also increases. The graph is obtained by varying the distance between 10 to 100 m in increments of 10 m and keeping other values from the standards and substituting in equation3.

III. Lifetime Ratio Computation

Lifetime ratio plays an important role for packets to be propagated in the network. The topology structures like square, linear, triangle and quadrangle topologies have varying definition of network lifetime [13-15]. The lifetime ratio is given by the following equation .

$$LR = \frac{N_a}{N_d} \qquad (4)$$

Where,

$LR = Lifetime\ Ratio$

$N_a = Number\ of\ Alive\ Nodes$

$N_d = Number\ of\ Dead\ Nodes$

The initial value of the battery power is represented by B_I. A node is said to be dead as per the authors S. Anitha, N. Janakiraman in [16] which has residual energy less than $B_I/4$. When the node participates in routing then the energy reduction happens and the updated energy can be computed using

$$U_E = C_E - E_c \qquad (5)$$

Where,

$C_E = current\ energy$

$E_c = energy\ consumption$

Consider that all the nodes have initially the same amount of energy of 5000mJ. Node 1 has participated in routing process and distance between Node1 and Node3 is considered to be 30m.

$$UE_f = CE_f - E_c = 5000 - 1.3600 = 4998.6$$

If the same node is used for a large amount of data transmission repeatedly and the energy of the node reduces by $B_I/4$. In the case of node 1it is 1250. When the nodes repeatedly participate in routing the residual energy level graph can be obtained as in fig 4. Fig 4 shows the functional dependence of number of times node participates in routing versus the remaining energy for the nodes in the network. As seen from the fig the residual energy decreases as the number of times a node participated in routing increases. It is evident from the fig that a point will reach at which the node will become dead.

IV. Definition of Network Lifetime

There are many definitions which exist for Network Lifetime. Few of them have been listed in table2. Dietrich and F. Dressler [17] have said that Network Lifetime is a concept which is important for maintaining either the full functionality of the network or a specific objective which has to be achieved which depends on the application for which WSN is incorporated.

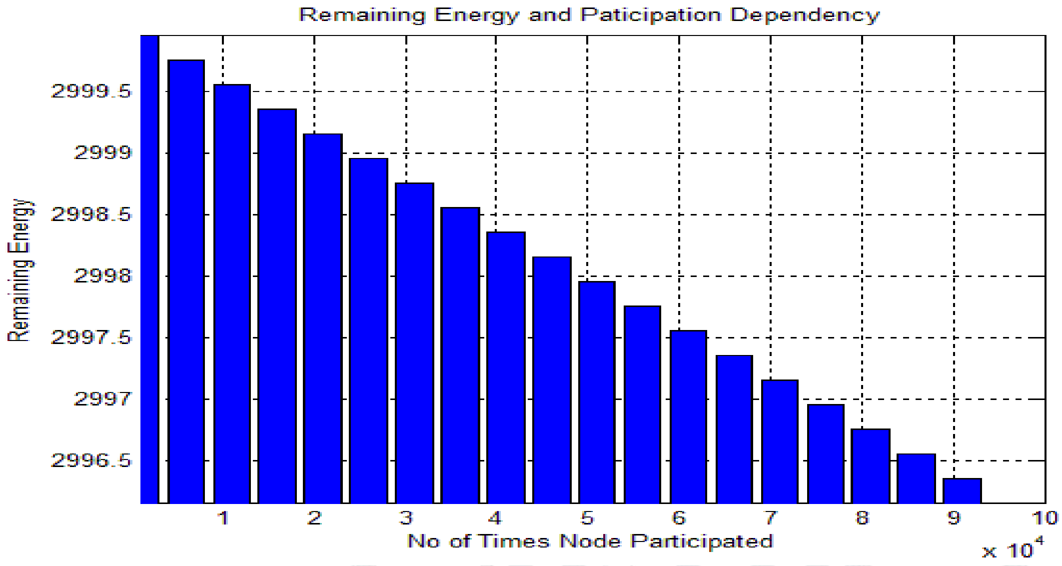

Fig4: Residual Energy and Participations

From the definition of WSN which is a set of nodes in the network and each node is constraint by the battery. The energy depletion happens in a quicker fashion depending on the participation of nodes. NL is defined as the time at which battery of certain number of nodes gets depleted drastically [18]–[20]. Network Lifetime [21]-[23] is also defined as the time at which first dead node occurs in the network.

Network Lifetime Definition
The time beyond which only a certain fraction of operational nodes remains in the network [18-20]
The time at which there is no reasonable event detection ratio [24]
The time at which packet delivery ratio becomes lesser than threshold[25]
The time at which coverage is lost[26]
The time at which any one of the cluster head loses its battery fully [27]
The time until an area is not covered by a single node minimum [28]
The time at which the last data packet is delivered to the sink[17] or when the data collection has failed [29]
The time period over which SNR boundaries are satisfactory as a parameter of QOS constraint [30]

Table2: Network Lifetime Definitions

V**. Network Lifetime Improvement Measures or Techniques or Approaches**

There are many techniques which are responsible for improvement of Network Lifetime. Few of them are listed below – a) Opportunistic transmission and time scheduling b) Energy Harvesting c)Beam forming d) Coverage and Connectivity constraint e) Routing and Clustering techniques f)Data Gathering and g) Resource Allocation

A. Opportunistic transmission and time scheduling

Fading is attenuation of signal time, geographical position, and radio frequency. The sensors gather the information and then they send to controlling station. When the information is send it will be broadcasted to the nodes coming in the path to destination node. The relay nodes must be in sleep mode in order to improve the optimization of lifetime. The channel state information along with residual energy [17] is important factors responsible for improving NL. The sensor nodes which are involved in transmission adjust their power based on remaining energy and CSI as mentioned by *J. Matamoros and C. Antòn-Haro* [31] . D. Wu, Y. Cai, and J. Wang [32] made use of Game theory framework order to select the best transmission scheme which can make the network lifetime maximum. The channel quality is continuously monitored and the transmission is allowed only if the quality exceeds threshold as mentioned by *C. V. Phan, Y. Park, H. Choi* [33]. The scheduling involves two modes one is sleep and another is awake as per J. Kim, X. Lin [34] which improves the NL because this is useful for applications in which the packets arrival is not expected at regular intervals. F. Liu, C.-Y. Tsui, and Y. Zhang [35] have described that In order to handle tele traffic across the network by reducing energy dissipation the sleep scheduling and joint routing algorithm extended the NL by 29% when it is compared with fixed sleep scheduling schemes.

B. Energy Harvesting

The process of devising energy for the nodes depends on thermal, solar power, wind and kinetic energy is called as energy harvesting. G. Martinez, S. Li, [36] describe that the routing decisions that are made depend on energy storage and energy harvesting limits. Battery failures hinder QoS in WSN applications which can be reduced by using energy harvesting techniques from ambient sources by H. Tabassum, E. Hossain [37]. T P. Zhang, G. Xiao [38] make use of method which uses cluster head that is equipped with a solar powered node and also optimal location is found for cluster head which can improve NL. There are various methods presented by Y. He, X. Cheng, W. [39] have presented methods in order to provide the energy harvesting and optimal offline policies. Huseyin Ugur Yildiz [40] describe that the smart grid environment has harsh propagation characteristics with tight energy requirements. Energy harvesting can be used to provide power for nodes by using energy sources like solar or electromagnetic energy. Samuel Perez,[41] produce many use cases for IoT and for few of the cases renewable energy sources can be used in order reduce EC and improve NL. An adaptive extension for adjusting the communication rate as per EH patterns is used. The method is able to avoid power outages. WSN is used in many IoT applications. In order to improve LT it is necessary to reduce the overall energy consumption. Pradip Kumar Sharma [42] describe that EH-WSN model can be used to build smart homes. The data can be transmitted in efficient way by harvesting energy. Greg Jackson, Simona Ciocoiu, Julie A. McCann [43] describe that there are many conventional approaches to improve NL namely adaptive duty cycle, transmission power and data reduction. All these techniques are done with an assumption that energy generation is not controllable in nature. The algorithm makes use of energy generation using solar devices. Eric Schneider, Faouzi Derbel, Florian Strakosch [44] describe that EH can be used when energy source is not available permanently and WSN needs to power continuously. The need of frequent energy source replacement can be reduced by making use of EH. Thien D. Nguyen [45] describe Effective energy-harvesting-aware routing algorithm (EHARA) which improves NL and QoS for various traffic load and energy levels. The NL can be improved by 40% as compared to Energy Harvesting Aware Ad-hoc On-Demand Distance Vector Routing Protocol (AODV-EHA) algorithm.

C. Beam forming

Beam forming [46]-[52] is a process of directly the radiation towards the desired user and then directs side lobes towards interference users. Distributed antenna arrays direct selective beams towards the receiver which can increase the transmission distance. The transmission power can be reduced by nodes because ED is shared among transmitters. The collaborative beam forming by grouping closely located sensors which can reduce traffic load [53] and prevent the data which can be relayed by having critical battery charges. J. Feng, Y.-H. Lu, B [54] describes that the beam forming approach provides reduction in ED and improvement in NL. The optimal solution is proposed which can increase the LT of WSN. Rong Du, Ayça Özçelikkale [55] describes that the LT improvement can be used to maximize the minimum sampling rate of the nodes with the note that energy consumption of node is smaller than energy it receives. The energy beam forming scheme outperforms other beam forming schemes whether optimized routing is used or not. Zhe Wang,Lingjie Duan, Rui Zhang [56] describe that the power supply can be supplied to sensor nodes via electromagnetic waves. The adaptively directional wireless power transfer (AD-WPT) technique makes use of energy beam forming using power beacons (PBs) to maximize average received power. Zhe Wang,Lingjie Duan [57] find the NL maximization along with satisfying QoS requirement is achieved by using energy efficient collaborative scheme which can be used to transmit far away base station.

D. Coverage and Connectivity constraint

The complete coverage for convex region which has adequate connectivity can be obtained by using transmission range which has twice the normal range [58] – [60]. X. Deng, B. Wang [61] describe that when each node is assigned a different task then reliable coverage becomes very important in agriculture applications. The algorithm described provides NL maximization by ensuring reliable coverage. Zhe Wang, Lingjie Duan [62] describe the coverage quality and reliable network connectivity can be capable of maximizing LF of heterogeneous WSNs where large number disjoint subsets of nodes are present. C.-P. Chen, S. Mukhopadhyay [63] performs the traffic balancing to help to provide reliable coverage for the sensing field and also any time connectivity to a base station using NL maximization algorithm. Q. Zhao and M. Gurusamy [36] performs the scheduler approach makes use of active sensors to provide full time coverage of a specific target region for the entire duration and the detection data must be sent to DN with the help of multi hop communication. The NL can be maximized if the coverage of target region and subset of sensors which are coming in between within the subsets. Z. Lu, W. W. Li, and M. Pan [64] proposed that the target spots can be monitored using specific subset of sensors by using sleep mode scheduling which can maximize the NL. Tajudeen O. Olasupo [65] describes the problem of sensing coverage in WSN requires the deep analysis of hierarchical-logic mapping. Saad Talib Hasson [66] has described a method which is used for image processing, classification of terrain with minimum number of nodes and transmission data. The optimization technique can improve weakly connected network topology by placing the sensors in a deterministic manner by using the angle between sensor nodes and neighbouring nodes. The deployment will provide high coverage, good connections, reliability. The optimization will help for several military and civilian applications in WSN IoT.

E. Routing and Clustering techniques

Saad Talib Hasson [67] provides two techniques namely opportunistic routing and energy efficiency which can be used for balancing traffic load distribution and transmission reliability which in turn provides NL maximization. C. Hua and T. Yum [68] describes that Data aggregation reduces the traffic load by avoiding transmission of the redundant data, by reducing power dissipation of nodes which are closer to sink node NL can be maximized. T. Heo, H. Kim [69] describes that the Context prediction and spatial correlation can be used to reduce the amount of data transmission so that NL can be extended. Rui Hou,Liuting He, [70] describe that Underwater acoustic sensor networks (UASNs) makes use of acoustic sensors that use batteries as their power supply. The sensors in under water environments are in very harsh conditions. The battery life can be improved by reducing energy consumption. Energy Balanced unequal layering clustering (EULC) makes use of unequal layering based on node depth and clusters of varying sizes in same layer. The WSN has lot of limitations, one such case of computation capability, energy resources. Bharati Patil,Rutuja Kadam [71] describe Secure and trustable routing technique with utilizing multi data flow topologies (MDT) are used to minimize the energy cost. Optimizing the NL can reduce black hole attacks.

Yu Cao, Linghua Zhang [72] describe that the node energy can be used to elect cluster heads. Greedy routing algorithm can be used to find the route which has the lowest energy consumption. The Stable Election Protocol (SEP) is used to improve Low Energy Adaptive Clustering Hierarchy (LEACH).For clustering routing protocol the cluster heads have high energy consumption rate because they do multi-tasking like data collection, fusion and forward. Xin Feng [73] describes an improved version of k means which make use of data fusion process to improve energy utilization rate. Delay optimization can be achieved using time slot allocation for IoT applications. Dallali Sondes, Hadded Rim [74] describes the Cluster Head Selection Method Multi hop Balanced Clustering (CHSM-MBC) routing protocol makes use of two methods namely k-means clustering, centroid method, score calculation method to select cluster head. CHSM-MBC improves residual energy and improves NL.

E. Data Gathering

Imad El Qachchach [75] describes the routing path contains a set of intermediate nodes. When single or multiple intermediate nodes fail then errors are created and data is lost. Low Rank Parity Check code (LRPC) can be used to correct burst errors and is very efficient with respect to decoding rate and also increases NL. Kun Xie, Lele Wang [76] describe that the Data can be varied in terms of temporal and spatial domains. The analysis on a large set of weather data collected large set of sensors. WSN used for weather monitoring have data which have features like low-rank, temporal stability, and relative rank stability. MC-Weather is a technique which can adapt to sample data from different locations. There are three learning techniques cross sample model, uniform time slot and matrix completion reduces the cost of computation, communication and sensing.

WSN are group of nodes which can transfer data to base station. NL reduces in heavy traffic applications. Kavita R. Kakde ; Mahesh Kadam [77] describe that there are lot of constraints [77] - small memory, limited energy and computation complexity. The tree-cluster data gathering method makes use of tree and zone based protocols to prolong NL, decrease EC.

There are many difficult terrains in which the sensor nodes are unreachable. By increasing use of battery power those areas can be reached which is not a feasible solution to improve NL. Saurav Ghosh, Sanjoy Mondale [78] finds the Fuzzy c means dominating set ant colony optimization (FCM-DS-ACO) algorithm makes use of DS and ACO. The sensors are grouped into dominating set and then chains are formed among DS by making use of ACO. The DS heads are selected based on distance to base station and residual energy. The approach helps in improving NL. The fundamental task of WSN is data gathering. This task has to be done in a time limit and efficient way. The monitoring of the network can be proactive hierarchical data routing protocols. Saurav Ghosh [79] provides E-PEGASIS improves the PEGASIS protocol to make it more energy efficient and improve NL.

The conventional method of data collection involves data forwarding technique in which the data which is collected is forwarded to the base station by a chunk of intermediate nodes. Jianhua Qiao,Xueying Zhang [80] describes that Compressive Data Gathering (CDG) along with even clustering method can be used to balance the overall network energy consumption and prolonging NL. Om Jee Pandey [81] finds the Mobile ubiquitous LAN extensions (MULEs) in order to create an objective function which improves bandwidth and reduces localization error. MULE also computes optimal number of sensors.

H. Yetgin, K. T. K. Cheung [82] provides a method to reduce data transmission and data sampling Compressive Sensing (CS) is awesome approach to prolong NL. There is a variation in sensing data and hence reconstruction accuracy is important, Adaptive Compressive Data Gathering Scheme is used which adaptively adjusts the prediction based on change trend of sensing data. Stage wise Orthogonal Matching Pursuit (StOMP) and Proportional-Integrative-Derivative (PID) is used for achieving reconstruction accuracy.

F. Resource Allocation

There are various constraints like reliability, routing, scheduling, node placement, maximizing throughput and rate adaptation which requires resource allocation.

L. Van Hoesel, T. Nyberg [85] describes that MAC layer sets the sensors in a duplex mode either active or inactive mode so that energy efficient routes are obtained for dynamic topology which is responsible 'for maximizing NL. R. Madan, S. Cui, S. Lall [86] describes that the deep analysis of Link Layer, Routing and MAC Layer can be done using transmitter’s circuit ED in Additive White Gaussian Noise (AWGN) channel. There is multiple hick ups namely power allocation, link scheduling, energy dissipations which can be jointly optimized and cross layer approach can minimize ED which can improve the NL.

Takanobu Otsuka [87] describes that WSN when used in weather applications nodes have the job of detecting the water quality in rivers. The anomaly detection using this sensor will have high power consumption which has to be reduced so that NL can be increased by keeping the nodes switch from active to idle modes at regular intervals.

VI. Sink Relocation Techniques impacting Network Lifetime

This section is responsible for survey on sink relocation algorithms and also simulation of efficient EASR algorithm and comparison of it with stationary and one step algorithms.

Kyriakos Karenos [88] describes the method which makes use of Sink relocation is used in many applications like rescue missions, intrusion detection, smart buildings and rescue missions. The technique is responsible for performing the congestion control because of the sink mobility it will avoid paths which have poor quality and also sends traffic data.

S. Sivakumar [89] finds the holes which generally occur near the destination point because sensors near the controlling station will drain out the energy. Adaptive Tree Based Sink Relocation (ATBR) performs adaptation of residual energy which improves NL.

Jeromina J,K. V. Anusuya [90] describe that WSN are used to sense environment data. WSN can be used to create a matrix which can have parameters like demand of water, pesticides required for such environment. Cluster Formation and Sink Relocation techniques can be used to achieve data aggregation and can provide maximum NL.

A. Keerthika, V. [91] describe the various constraints of WSN network involve restricted memory, transmission range, and high traffic load and energy consumption. The Sink node gets depleted quickly. Hence mobile sink is required which can perform data gathering. Mobile Sink is responsible for transfer of data from sensors to data collection point. VGDG-MA will increase NL, EC, PDR and throughput

S. Anitha, N. Janakiraman [92] describes that NL can be increased by making use of limited power resources; sensor nodes which are closer to sink will consume more energy. By making use of Energy Efficient Sink Relocation (EASR) one can increase NL.

VI. A Stationary Method

A. Chakrabarty [93] find the Stationary algorithm the initiator finds the neighbour nodes. After that picks the node which sends REPLY first and also is towards destination direction? The process is repeated until destination is reached. The nodes closer to the sink will work more in order to relay data for far away nodes. The nodes near sink behave like hotspots.

VI.B One Step Method

Y. Sun, W. Huangfu [94] describes One Step method first computes the position of the destination node. The position can be found out by using total residual energy of sensor nodes. One Step algorithm will move the sink towards the destination no matter how far it is. Sink collects the RE of nodes in range. The node towards destination direction is chosen and then data is given to such forwarding node. Finally a node gets the data which is in the communication range of destination.

VI.C EASR Algorithm

S. Anitha, N. Janakiraman [92] describes EASR algorithm which mainly works on two phases namely classification of nodes and sink relocation. The nodes are classified into 3 kinds namely Healthy Nodes, Super Healthy Nodes and Non Healthy Nodes. If IB_P is defined as the initial battery power. Super Healthy Nodes are the nodes whose battery is in the range of $\frac{IB_p}{2} \le B \le IB_P$. Healthy nodes are the nodes whose battery is in the range of $\frac{IB_P}{3} \le B \le \frac{IB_P}{2}$ and Non Healthy nodes are the nodes whose battery is in the range of $0 \le B \le \frac{IB_P}{2}$. The EASR algorithm determines the location of the destination in terms of direction. The entire area of the sensor is divided in spatial directions and node is moved in forward direction

Algorithm: EASR

Input: source node, destination node, transmission range

Output: Path between sources to destination node with intermediate node shift

Details

1) A set $\{SN, DN\} \in N$ acts as input
2) The entire area is divided into four different sectors $\{S_N, S_S, S_E, S_W\}$
3) Checking whether the sectors have destination, If Yes stop. If no proceed to step4
4) The initiator SN will send the RREQ and then obtain the remaining energy levels of the nodes in the set $\{n1, n2, \ldots\ldots\ldots.nn\}\ ni \varepsilon N$. Find the set of nodes whose energy levels are higher than $B/4$, $B\ in\ initial\ energy$ from the set of nodes $\{n1, n2, \ldots\ldots\ldots.nn\}\ ni \varepsilon N$ with energy levels $el = \{e1, e2, \ldots\ldots\ldots\ldots\ldots\ldots, em\}\ \ each\ ei > B/4$
5) Pick one of the node among super healthy nodes as the next forwarding node. Suppose there are no nodes whose energy lies in healthy or super healthy then the current source node moves towards the destination node with 1 hop distance in appropriate location $S_i\ \varepsilon\ \{S_N, S_S, S_E, S_W\}$

Fig 5: EASR Algorithm

The EASR algorithm can be described as in Fig6. The EASR algorithm is compared with the Stationary and One Step routing algorithms.

VI.D Proposed Algorithm

The Proposed System is obtained by modifying EASR method. The neighbour nodes are classified into healthy nodes or Non-Healthy nodes. If IB_P is defined as the initial battery power then healthy and Non Healthy Nodes. Healthy Nodes represent the node which has energy higher or equal to $IB_p / 4$ and Non- Healthy are those nodes whose energy is less than $IB_p / 4$.The second modification is that in EASR the forward node is chosen as one among the super healthy randomly whereas the proposed method will pick the node which has the highest residual energy among the healthy nodes. At regular intervals after data packets are delivered the genetic algorithm is triggered in order to recover the dead nodes.Fig6 shows proposed method .

Algorithm: Proposed System

Input: source node, destination node, transmission range and Number of Data Packets

Output: Path between sources to destination node with intermediate node shift and recovery of dead nodes

Details

1) A set $\{SN, DN\} \in N$ acts as input

2) The entire area is divided into four different sectors $\{S_N, S_S, S_E, S_W\}$. Checking whether the sectors have destination, If Yes stop. If no the initiator SN will send the RREQ and then obtain the remaining energy levels of the nodes in the set $\{n1, n2, ...nn\}\ ni \varepsilon N$

3) Find the set of nodes whose energy levels are higher than $B/4$, B *in initial energy* from the set of nodes $\{n1, n2, ...nn\}\ ni \varepsilon N$ as $\{n1, n2, ..., nm\}\ ni\ \varepsilon\ N\ \ and\ m < n$ with energy levels

$$el = \{e1, e2, ..., em\}\ ei = energy\ level\ of\ \ a\ node\ i\ each\ ei > B/4$$

4) Find the node which is having the highest remaining energy $RE_{\max} = \max(e1, e2, ...en)$ If all the nodes in the neighbourhood are Non Healthy then the current source node moves towards the destination node with 1 hop distance in appropriate location $S_i\ \varepsilon\ \{S_N, S_S, S_E, S_W\}$

5) The process is repeated until destination is reached.

6) Once the route is obtained using step1 to step9 control mechanism is done and data mechanism triggers in to deliver the data packets . The data packet counter is incremented for each data packet transfer. Once the Data Packets reach a threshold T where T is the half number of data packets to be delivered then step12 onwards execution happens .

Fig8: Proposed Method

VII. Experimental Results of Existing Sink Relocation Methods

This section compares EASR, stationary and one step algorithm. The parameters used for comparison are End to End Delay, Number of Hops, Number of Alive Nodes, Number of Dead Nodes, Lifetime Ratio and Routing Overhead.

Parameter Name	**Parameter Value**
Number of Nodes	100
Energy Required for transmission	20mJ
Energy Required for generation	10mJ
Attenuation factor	0.7
Transmission Range	40m
Initial Battery Power	2000 mJ
Area	100*100 m

Table3: Simulation Set Up

Table 3 shows the simulation set up used for algorithms

A. End to End Delay: End to End Delay is the time taken for the RREQ to go from the source node to destination node and then send back the RRPLY from destination node to source node.

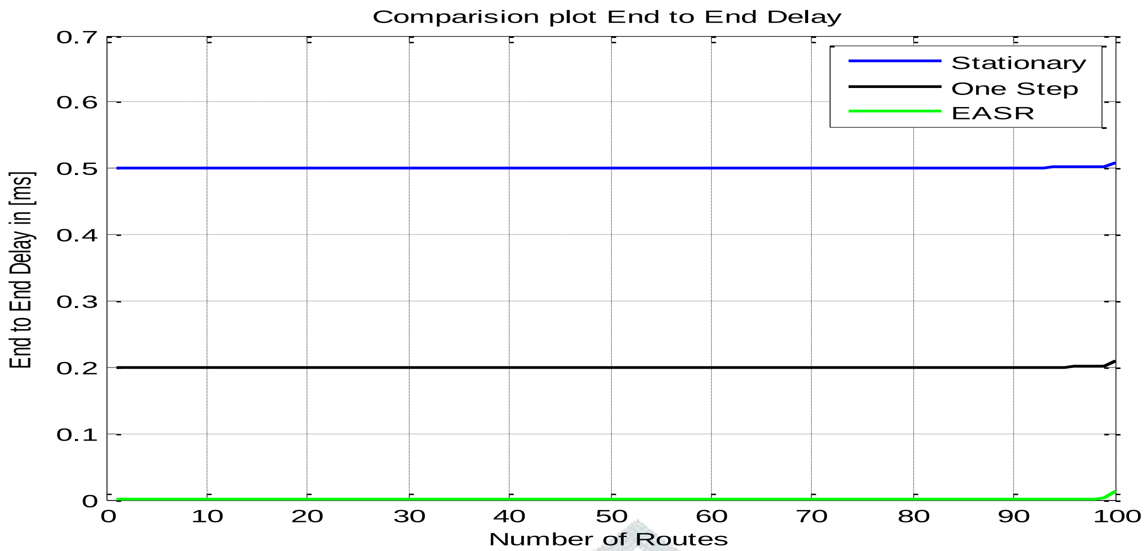

Fig 10: End to End Delay Comparison

Fig 10 shows the comparison of EASR, One Step and Stationary algorithm. As shown in the fig EASR has the lowest delay followed by One Step and Stationary. EASR has the highest delay of 0.013 ms , One Step has the highest delay of 0.21 ms and Stationary algorithm has the delay of 0.509 ms. Hence EASR algorithm behaves in the best way with respect to End to End Delay.

B. Number of Hops

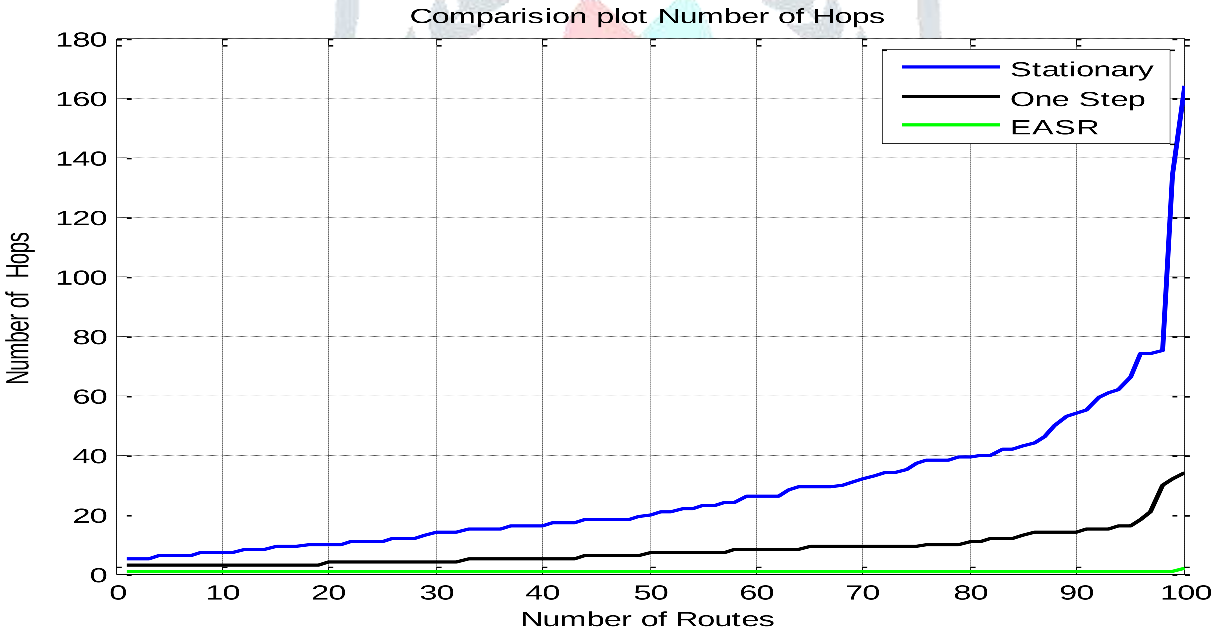

Fig11: Number of Hops Comparison

Fig shows the number of hops comparison between the algorithms. As shown in the fig EASR has the lowest hops as compared to One Step and Stationary algorithm. EASR has the highest hop as 2. One Step has the highest hop as 34 and Stationary has the highest hop as 164. As seen EASR has the lowest number of hops.

C. Number of Alive Nodes : Number of Alive Nodes is defined as the count of set of nodes whose battery level is greater than or equal to B/4 Where B is initial Battery Power

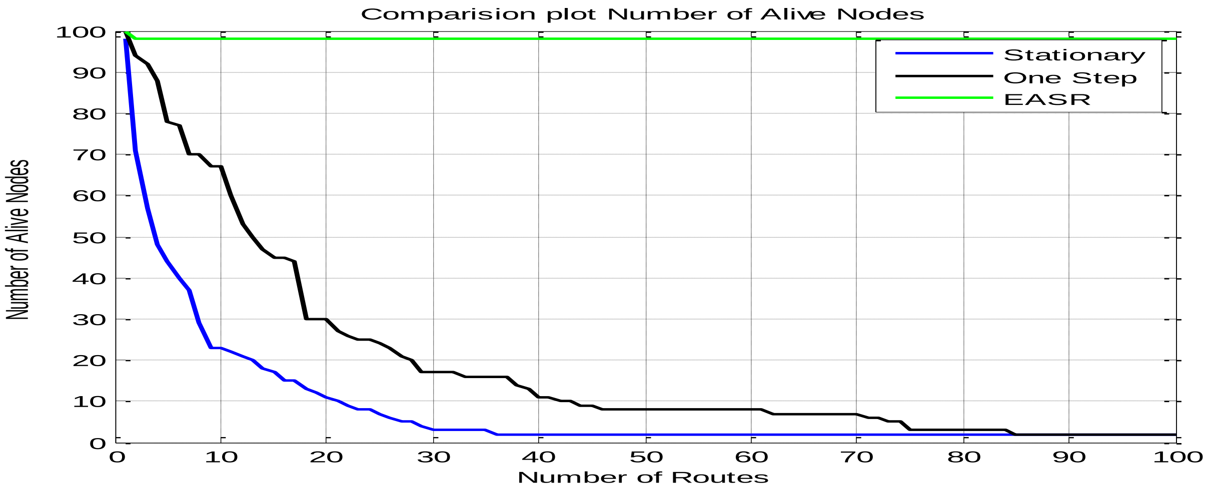

Fig 13: Number of Alive Nodes

Fig 13 shows the Number of Alive Nodes. As shown in the fig EASR algorithm has the highest number of nodes followed by One Step and Stationary algorithm. At the end of 100 iterations EASR algorithm has all the 100 nodes alive followed by One Step which has number of alive nodes as 8 and finally even stationary algorithm has the number of alive nodes as 8 at the end of 100 iterations. As the number of iterations/routes increases the number of alive nodes decreasing is more for stationary followed by one step. Hence EASR is behaving the best for number of alive nodes.

D. Number of Dead Nodes : This is defined as the count of set of nodes whose battery level is less than B/4 Where B is initial Battery Power

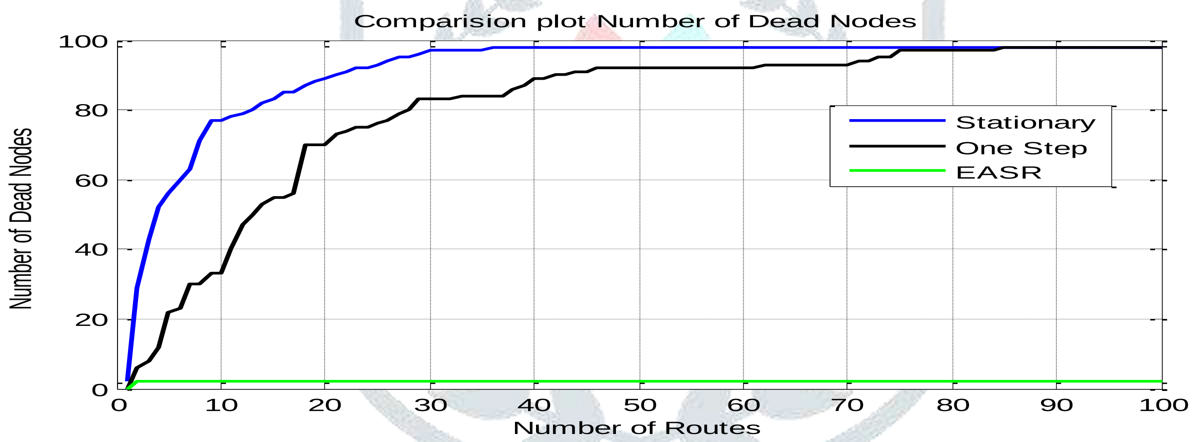

Fig 14: Number of Dead Nodes

Fig 14 shows the Number of Dead Nodes comparison. As shown in the fig none of nodes have become dead for the 100 iterations in case of EASR algorithm. The number of dead nodes is increasing for both One Step and Stationary algorithm. Hence EASR behaves the best with respect to number of dead nodes.

E. Lifetime Ratio: Lifetime ratio is defined as the ratio of Number of Alive nodes to Number of dead nodes. The equation is same as of equation4.

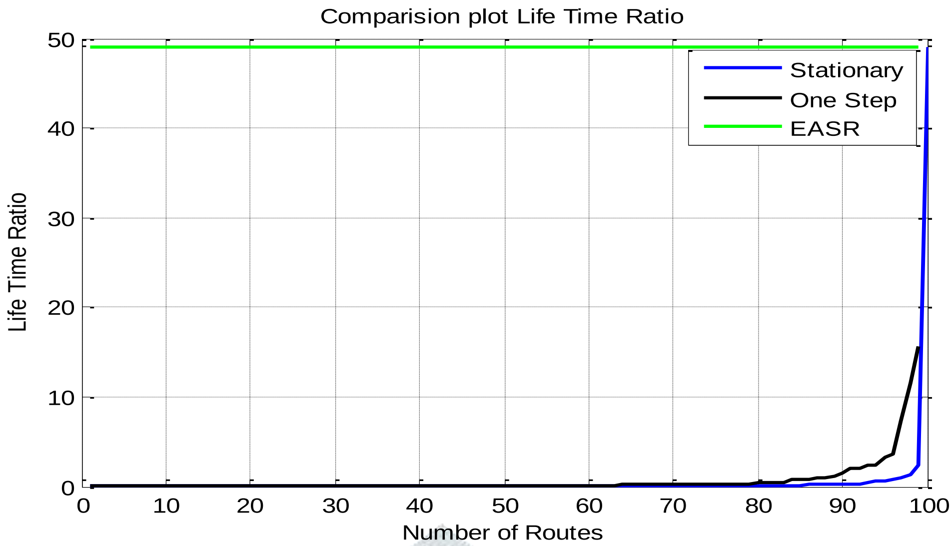

Fig 15: Lifetime Ratio Comparison

Fig 15 shows the Lifetime Ratio Comparison. As shown in the fig EASR has the highest Lifetime Ratio followed by One Step and Stationary algorithm. As shown in the fig EASR has the highest Lifetime ratio followed by One Step and Stationary.

Routing Overhead: The routing overhead is defined as $Routing\ Overhead = \frac{Number\ of\ control\ packets}{Number\ of\ Data\ packets}$

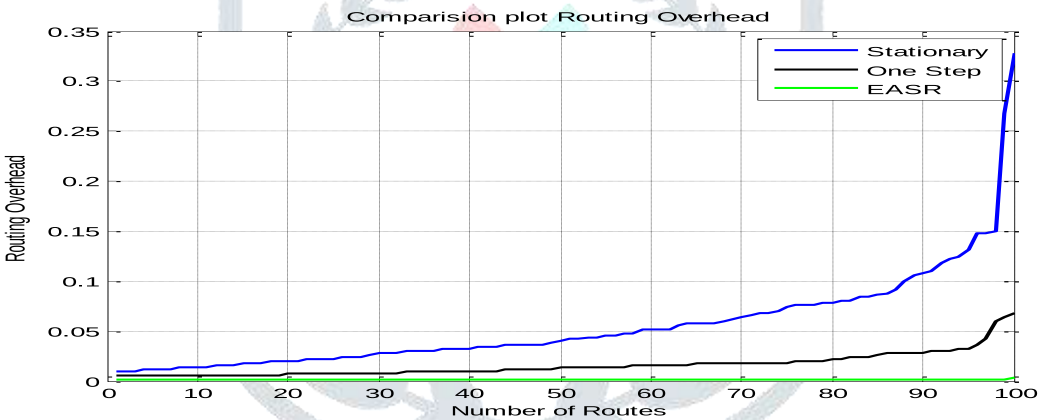

Fig 16: Routing Overhead Comparison

Fig 16 shows the comparison of Routing Overhead for algorithms namely EASR, One Step and Stationary. EASR has the lowest routing overhead between 0.01 to 0.02. The One step algorithm has the overhead in the range of 0.03 and 0.06 and finally Stationary algorithm has the overhead in the range of 0.04 and 0.3. EASR has the lowest routing overhead.

Throughput: Throughput is defined as the Number of data packets which have been received at destination to the unit time required to deliver them. Fig 17 shows the throughput comparison between EASR, One Step and Stationary. EASR has the highest throughput followed by One Step and Stationary.

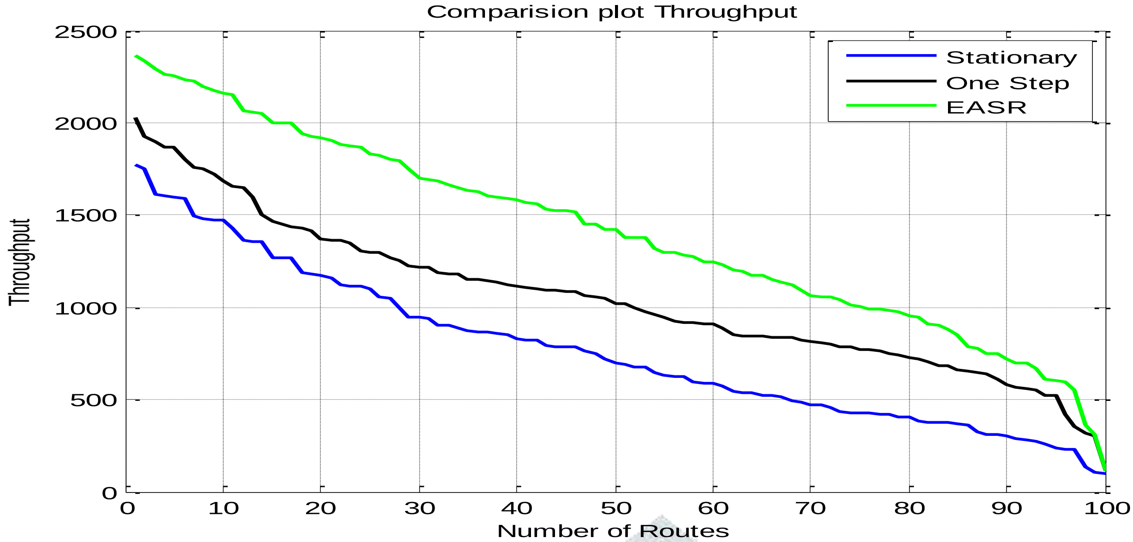

Fig 17: Throughput Comparison

. The summary of sink relocation techniques is described as below

Algorithm	NL Improvement Method	Disadvantage	Optimization Techniques to Improve
Stationary [93]	Multiple routes are found out and then route which has lowest delay is chosen for sending data packets	[1] The nodes closer to the sink will work more in order to relay data for far away nodes. The nodes near sink behave like hotspots and eventually lose more energy. [2] Makes use of Sequential Transmission and standard modulation techniques	One Step Overcomes the disadvantage of Stationary algorithm by determining node position using the residual energy of the nodes in the transmission range and then node which has highest energy is chosen for data transmission
One Step [94]	Residual Energy is computed to pick forwarding node	[1]If all the nodes in the transmission range are having lesser energy then packets are dropped [2] Data Transmission makes use of Sequential technique	EASR algorithm overcomes the disadvantage of One step in case of dead lock by relocating the node towards destination and moving it out of current transmission range
EASR[92]	EASR will divide the nodes into Non-Healthy, Healthy and Super Healthy nodes and then picks the nodes randomly if they exists between Non-Healthy or Super Healthy and if all nodes are Non Healthy then it will move the sink from that range	[1] EASR achieves the optimization only after all nodes are Non Healthy. [2] EASR does not have node recovery process in order to transform the network to have better efficiency as the network is used. [3] Data transmission makes use of sequential technique	[1] The Proposed Method will make use of better classification of neighbour nodes and hence achieve optimization before the deadlock occurs. [2] The Proposed Method makes use of genetic approach to recover few dead nodes [3] The Proposed Method makes use of MIMO technique to achieve high data rate

VIII. CONCLUSION

This paper performs the survey on NL definitions. The paper first presents various applications in which WSN is used. It follows it by various techniques namely Opportunistic transmission and time scheduling ,Energy Harvesting ,Beam forming, Coverage and Connectivity constraint, Routing and Clustering techniques, Data Gathering, Resource Allocation in WSN and the algorithms under each technique whose main aim is to improve NL is also discussed. Sink relocation techniques are also presented. EASR algorithm is mathematically formulated in the form of algorithm. The Proposed method is presented which will provide optimization in terms of reducing the dead lock by picking highest energy node. After multiple iterations of data transmission proposed method applies Genetic to find the subset of the nodes to recover rather than all nodes. Sink Relocation Methods namely EASR, One Step and Stationary are compared with various parameters. The Proposed Method how it overcomes the disadvantages of EASR is discussed. In our Future Work the EASR algorithm will be modified to improve the NL using the techniques of pick one of the highest residual energy nodes before sink relocation triggers, applying the genetic to recover dead nodes at regular intervals, if more than one node has the same and highest energy then node towards destination is selected so that the delay is reduced and MIMO transmission is used to improve throughput

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