ENERGY OPTIMIZATION IN WIRELESS SENSOR NETWORKS

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of
Technology in
Electronics & Communication

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CANDIDATE DECLARATION

I hereby declare that the work presented in this report entitled "ENERGY OPTIMIZATION IN WIRELESS SENSOR NETWORKS", submitted towards fulfillment of BACHELOR'S THESIS report of Bachelor of Technology in Electronics & Communication at Indian Institute of Information Technology Allahabad, is an authenticated record of our original work carried out under the guidance of Dr. Suneel Yadav. Due acknowledgements have been made in the text to all other material used. The project was done in full compliance with the requirements and constraints of the prescribed curriculum.

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CERTIFICATE FROM SUPERVISOR

This is to certify that the statement made by the candidate is correct to the best of my knowledge and belief. The project titled “ENERGY OPTIMIZATION IN WIRELESS SENSOR NETWORKS” is a record of candidates’ work carried out by him under my guidance and supervision. I do hereby recommend that it should be accepted in the fulfillment of the requirements of the Bachelor’s thesis at IIIT Allahabad.

Dr. Suneel Yadav

CERTIFICATE OF APPROVAL

The forgoing thesis is hereby approved as a creditable study carried out in the area of Electronics and presented in a manner satisfactory to warrant its acceptance as a pre-requisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein, but approve the thesis only for the purpose for which it is submitted.

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ABSTRACT

In today's world, as the technology rapidly improves, data is the new gold for research and analysis purpose.
This data in Internet of Things (IoT) is captured by sensors (nodes). These nodes together form Wireless Sensor Network (WSN) and give the data received to server/base station (BS).
It becomes important how these sensor nodes work and communicate among themselves to maximize the data collection i.e. network lifetime. LEACH (Low Energy Adaptive Clustered Hierarchy) was one of the first methods in this area to improve the First Node Dead (FND) time enhancement. Other modifications of LEACH soon followed to further improve it and various other mathematical models were inscribed in it like Grey Wolf Based Optimized Clustering (GWBOC) to improve network lifetime.
The proposed method's main focus is to improve the FND over existing methods by using Fuzzy Logic (FL). Cluster head selection is done using fitness function involving several parameters like distance of node to base station and total number of alive nodes remaining. It is followed by cluster formation using fuzzy logic. It is then compared to LEACH method and GWBOC method for various parameters.

CONTENTS

INTRODUCTION

Many sensor nodes together constitute a WSN where they wirelessly communicate with each other. The data collected from these sensors is relayed to base station/server. The processing of sensing and communicating data dissipates energy which impacts the energy level of nodes and subsequently the WSN. The lesser the energy dissipation, the better is the network lifetime of WSN.WSN form a major part of IoT which eventually will be used in building smart cities for future using thousands of nodes for collecting information throughout the city.

These nodes have limited battery power which is a constraint and challenge in this field. Various algorithms and techniques are developed to find the solution of increasing the network lifetime.

LEACH protocol was the first clustering algorithm with a major breakthrough in WSN. In this nodes are divided into cluster with each cluster headed by cluster head having many cluster members. The cluster members collect information and relay it to its corresponding cluster head and then CH transmits the information to base station/server.

LEACH has 2 phases – setup phase and steady phase.

In setup phase cluster head are formed and nodes join it form a cluster and become its cluster member. In steady phase, data is transmitted from cluster member to its cluster head and cluster heads transmits data collected to sink/base station. LEACH used Time Division Multiple Access(TDMA) for transmitting data from node to cluster head making sure no collision takes place at receiver.

Earlier cluster members chose their cluster head depending solely on the energy level of node wishing to be cluster head. Later energy level was replaced by function value depending on various parameters like distance of node to cluster head, total remaining of alive nodes, maximum energy of alive node. And further limiting of number of cluster heads to a certain extent e.g. 5%, 10%, 15%.

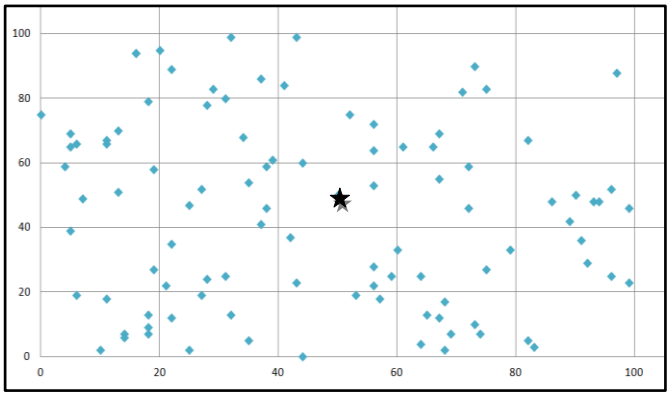
Grey Wolf Based Optimized Clustering mathematical model is being used for extending network lifetime. It mainly focuses on extended Last Node Dead (LND) and not for FND. Fuzzy Logic model is used and found to be optimal for extending First Node Dead (FND).

PROBLEM STATEMENT

The problem statement of project is energy optimization in WSN which is achieved by maximizing the First Node Dead (FND) rounds for Wireless Sensor Networks in IoT. Different mathematical tools/models will be applied to existing techniques to improve energy optimization

METHODOLOGY

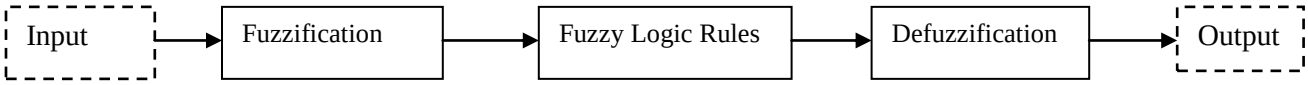
We consider 100m x100m grid with 100 nodes randomly distributed. The sink/base station is positioned at (50, 50) to which all cluster heads will send data. Initially each node has energy of 1J and is assigned type 'N' normal.
The distribution of nodes is shown in the figure given below.



Random Distribution of points in grid

Fuzzy Model

Boolean methods have only 0 and 1 as output. Sometimes Boolean does not define true state of variable. When various parameters are in consideration, then it's better to have a value which defines the true value in respect of all the parameters. We give various inputs and fuzzy logic gives a single output. Fuzzy logic is used in cluster formation in proposed method with fitness value and distance of cluster member to its cluster head as its parameter.
The proposed method takes distance to cluster head and fitness value as inputs and gives the output which is used in cluster formation and helps make node a decision to which cluster head it should join to form cluster.



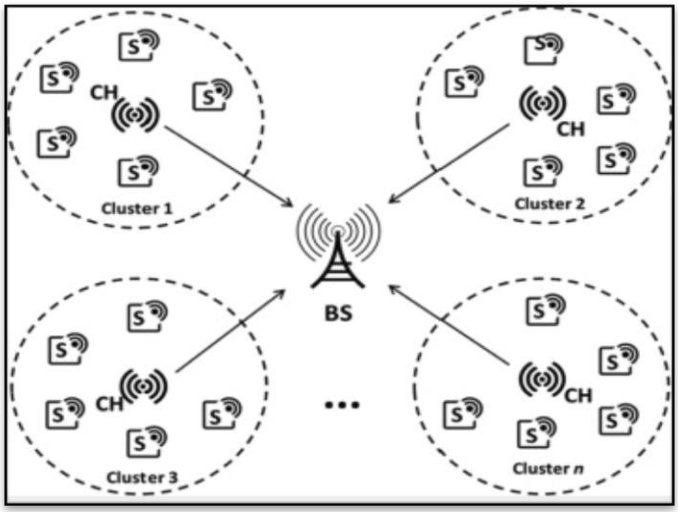
Generalized Fuzzy Logic System

Fuzzy Rules involved in proposed method

Distance to cluster head	**Fitness**	**Feasibility**
Less	Weak	Decent
Less	Decent	Powerful
Less	Strong	Massive Powerful
Moderate	Weak	Decent Low
Moderate	Decent	Decent Powerful
Moderate	Strong	Quite Powerful
Far	Weak	Massive Low
Far	Decent	Quite Low
Far	Strong	Low

Fitness of a node is defined by a weighted function F = w1*f1 + w2*f2 + w3*f3 + w4*f4 + w5*f5.
The parameters involved in this equation are-

1) Residual energy: It is the main factor in FND calculation. It is the remaining energy of node. The more the residual energy, the better is chance of node becoming cluster head. For better FND, the weight of residual energy is set to be greater than equal to 50%.(w1=0.5)
2) Node degree: It is the number of nodes in the vicinity of node. More are the nodes nearer, better is chance of becoming cluster head.(w2=0.2)
3) Average intra-cluster distance: Lesser the intra cluster distance, better is chance of node becoming cluster head.(w3=0.1)
4) Distance from base station: Less is the distance, less energy is consumed to communicate to base station, better is chance of node becoming cluster head.(w4=0.1)
5) Balancing factor: If some nodes have high remaining energy compared to other nodes, the others would not get chance to become cluster head. Here balancing factor comes in play to make sure others too are cluster head in some epoch.(w5=0.1)



Communication in system by CH and nodes

Algorithm 1: For cluster heads (CH) selection

1) For each of the 100 nodes whose energy level > 0, their fitness value is calculated.
2) We assign a specific number of nodes to be selected at cluster heads, for maximum FND it is found at 10%.
3) We assign a communication radius Rc = 25 units.
4) Each node will broadcast a message in its Rc vicinity asking for fitness levels.
5) If any neighbour has fitness value than its own fitness value, then that node cannot become a cluster head (CH).If all neighbouring nodes satisfy this condition, then it becomes a CH.
6) Add all cluster head in a list which will be used later and their type it changed to 'CH' from 'N'.

Algorithm 2: For cluster members (CM) selection

1) Loop through each node with type = 'N' and energy level > 0.
2) Initially take cluster head index as -1, it will store the index of CH which will eventually be its CH and a value chance as 0, it will store the chances of a CH to be node's only CH. The CH with more chance will have higher value.
3) Loop through all the CH stored in the list.
4) If chance of that CH is more than maximum value, update the chance value that store the current index for CH selection.
5) This chance value uses fitness value of CH as well as Fuzzy Logic.

Parameters deciding energy consumption in nodes

- Etx – Transmission energy from node to cluster head
- Efs – Free space energy between nodes
- Eamp – Amplification Energy
- Erx – Energy to receive information
- Eda – Data aggregation energy

Simulation Parameter	Value
Number of nodes (N)	100
Grid Size	100x100
Location of Base Station	(50,50)
Initial energy of nodes	1J
Data Packet Size (t)	4000 bits
Cluster head percentage selection (p)	10%
Surrounding radius for cluster head(Rc)	25 units

Formulas used:-

D = distance of CH to sink at (50, 50)
$d0 = (Efs/Eamp)^{1/2}$

Energy spent while cluster formation

$E_{node} = (Etx*t) + (Efs*t*D^2)$, if $D < d0$

$E_{node} = (Etx*t) + (Eamp*t*D^4)$, if $D \geq d0$

$E_{CH} = (Erx + Eda)*t$

Energy spent while CH transmits data to sink/base station

$E = (Etx*t) + (Efs*t*D^2)$, if $D < d0$

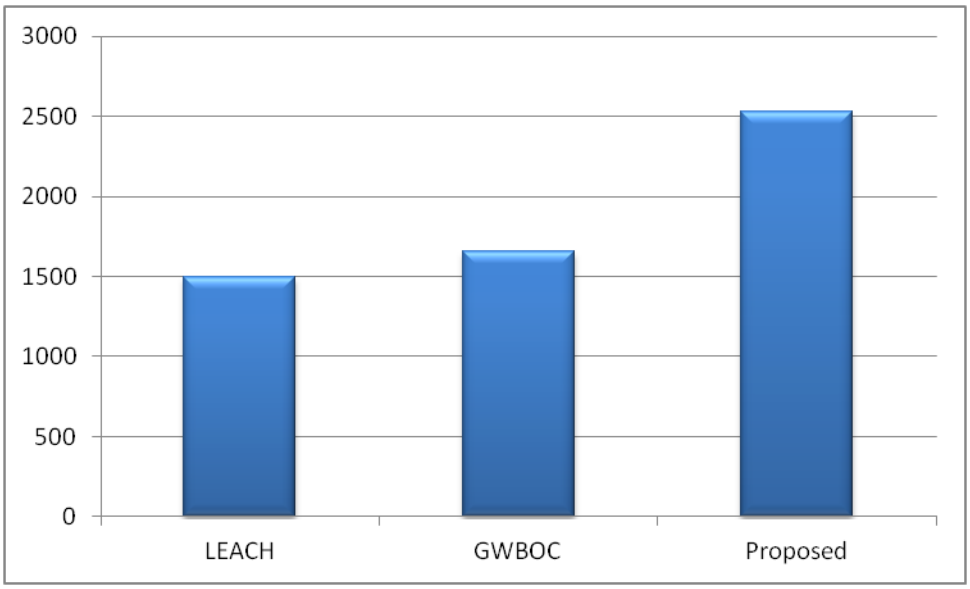
$E = (Etx*t) + (Eamp*t*D^4)$, if $D \geq d0$

RESULT

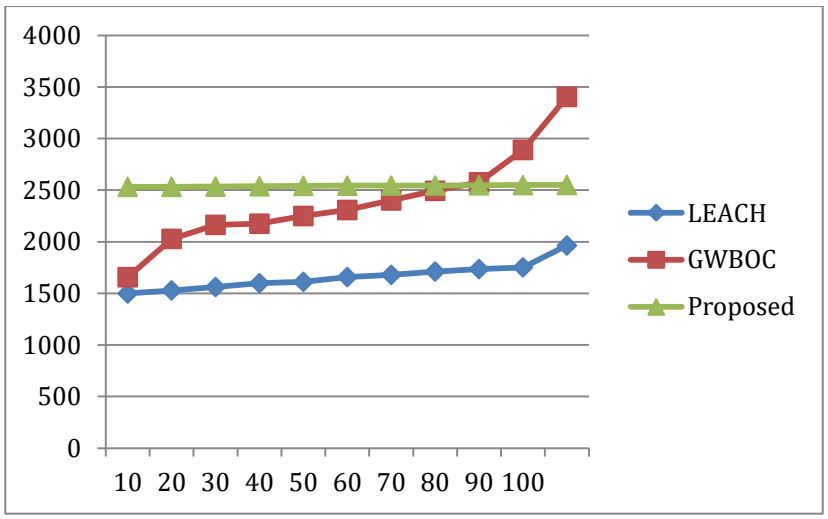
TABLE - Network Lifetime Comparison

Approach	LEACH	GWBOC	Proposed
FND	1499	1657	2532
HND	1702	2309	2544
LND	1964	3404	2551

With this proposed method, FND was improved by 68.91% and 52.8% compared to LEACH and GWBOC methods respectively.

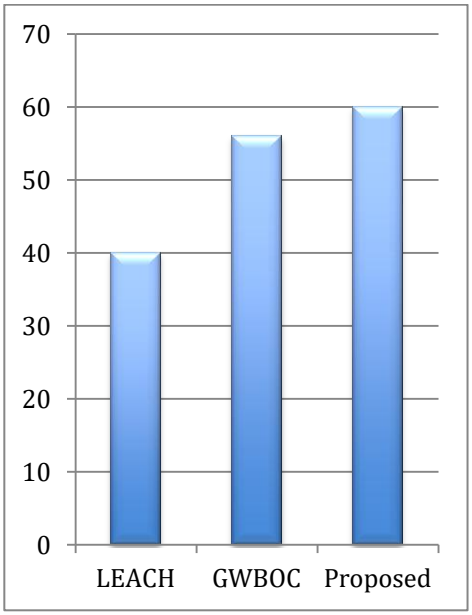


FND Comparison

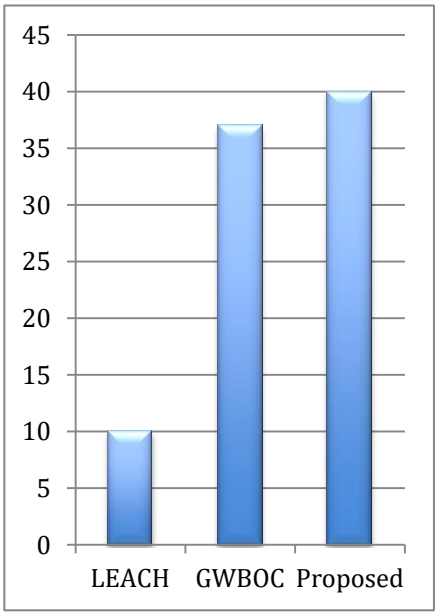


Number of dead nodes at subsequent rounds

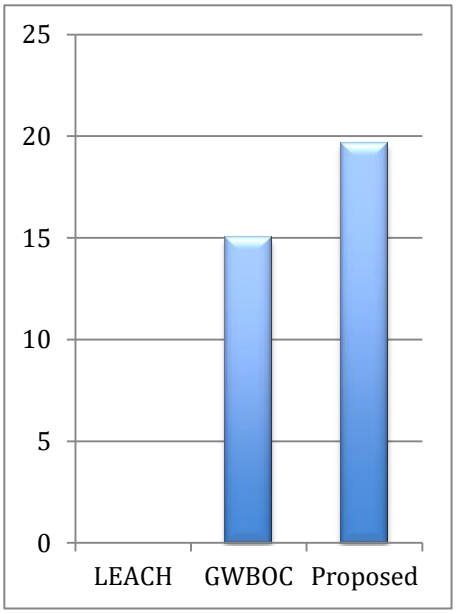
Energy left at:-



a) 1000th round



b) 1500th round



c) 2000th round

CONCLUSION

Keeping in mind the daily advancement in technology and rapid growth of use of sensors in all sectors, it becomes important to improve network lifetime. Whenever a node in network dies (battery is down to 0%), it cannot take measurements from its surrounding and makes depletion in the network and affects the overall system. The proposed method improves existing techniques like LEACH method for First Node Dead (FND) using Fuzzy Logic for cluster formation. Network lifetime of the proposed method is also improved apart from FND too. For GWBOC, it improves the FND as it was observed that GWBOC is primarily used for network lifetime enhancement only. This algorithm can be further improved for Half Node Dead (HND) and Last Node Dead (LND).

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