# IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE TO IMPROVE THE LIFETIME OF WIRELESS SENSOR NETWORK (AIWSN)

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## ABSTRACT

Artificial intelligence play vital role in the field of technology where computational output has to be more defined. It includes application of fuzzy logic, neural network and genetic algorithm. Neural, fuzzy have redundant real time applications in various fields. Wireless sensor network is one such field where artificial intelligence is implemented to improve the lifetime of the network as it is the key research challenge. In this paper an algorithm is designed to have an energy aware network implemented with kohenan self organizing map and fuzzy logic that leads to reduced energy consumption by a factor of 33.325 and 10 respectively on comparison with classical routing algorithms.

**Keywords:** wireless sensor network, fuzzy logic, neural network, power consumption

## I. INTRODUCTION

Recent advances in wireless communication and micro - electro - mechanical Systems (MEMS) have lead to the development of implementation of low-cost, low Power, multifunctional sensor nodes.[1][2] Sensor network have a large number of unattended, self-organized micro sensors, of size of the order of a cubic centimeter, scattered in an area for a specific application. Each micro sensor is capable of sensing data from the environment, performing simple computations and transmitting this data over wireless medium either directly to command centre or through some cluster head, commonly known as gateway. [3] Though it has some similarities with ad-hoc networks it differs due to their more severe energy constraints, much larger density of sensor nodes, lower cost and usually static nature of nodes. Sensor Networks are designed for information gathering, rather than distributed computing. An important challenge in the design of wireless and mobile systems is that two key resources communication bandwidth and energy are significantly more limited than in a wired network environment. These restrictions require innovative communication techniques to increase the amount of bandwidth per user and innovative design techniques and protocols to use available energy efficiently.

Artificial intelligence is one of the best suitable techniques for reduced energy consumption. Fuzzy logic methods always provides best outcome for a network with uncertainties. Estimation of cost metric considering various parameters can be done efficiently using this method. Updating of neighbor table and route can be selected efficiently with the help of fuzzy logic concepts. Artificial neural network is best compatible with wireless sensor network with neurons as sensors and connections as radio link for information processing.[5]

## II. RELATED WORK

The routing protocols play a vital role in the life time of the sensor networks. Various routing protocol based on fuzzy logic system and the other techniques are discussed in this section. Mohammad Zeynali et al [6] proposes a novel tree based routing protocol (TBRB) based on clustering techniques. The author proposes a fuzzy based technique for cluster head selection. Based on the distance between two nodes and residual energy of each node at the end of each transmission a fuzzy election number FEN is allotted and based on the priority of the FEN cluster head is selected. Zohre. Arabi et al [7] proposes a Hybrid Energy Efficient Routing using a Fuzzy Method in Wireless Sensor Networks (HERF), in which the protocol switches between two algorithms EF-Tree (Earliest-First Tree) and SID (Source-Initiated Dissemination) based on fuzzy logic systems and selects a cluster head. This protocol makes use of node energy, node concentration and node centrality as the linguistic variables. Based on fuzzy “IF THEN rule” cluster heads are selected. Mahmood R. Minhas et al [8] his work claims that the routing path among the multi objective path is established based on fuzzy membership function residual energy. In this protocol when routing request is sent first it calculates the residual energy of the fuzzy membership function,

secondly the residual energy using the fuzzy membership function around the edges and finally based on Dijkstra's shortest path algorithm the transmission takes place.

Shu-Yin Chiang et al [9] proposed an algorithm called Routing Analysis Using Fuzzy Logic Systems in wireless sensor network for forwarding the packets to the destination. In this protocol residual energy, distance from node, Traffic Load and distance from shortest path are taken as linguistic variables. Qilian Liang et al [9] proposed a protocol based on Energy and Mobility Aware Geographical Multipath Routing for Wireless Sensor Networks in which proper selection of neighbor based on fuzzy linguistic variables is done. The major linguistic variables taken in to account are energy, mobility and distance. Hee Wan Kim et al [10] proposes a protocol in which using the fuzzy logic concepts, a fitness level is determined. On the basis of fitness level the protocol switches between various existing protocols for the selection of route. Tarique Haider et al [11] also suggested a fuzzy model for the computation of neighbor node.

Apart from the fuzzy based protocol the other traditional protocols also work towards energy. Flooding and gossiping are the very traditional ways of transmitting data to the destination. LEACH Krishnamachari B and Orid F [12] follow a hierarchical based cluster formation technique and also proposes a method for the selection of proper cluster heads. GEAR Yan Yu et al [13] protocol says that the entire network is divided in to partitions and within partitions, flooding technique is adopted. Geographic adaptive fidelity GAF Y. Xu et al [14] is an energy-aware location-based routing algorithm designed primarily for mobile ad hoc networks, but may be applicable to sensor networks as well. GAF conserves energy by turning off unnecessary nodes in the network without affecting the level of routing fidelity. It forms a virtual grid for the covered area. Sudir .G et all [15] suggested The sensor data is classified using ART1 Neural Network Model. Wireless sensor network populates distributed nodes. The cooperative routing protocol is designed for communication in a distributed environment. The classified sensor data is communicated over the network using two different cases of routing: cooperative routing and diffusion routing. Ptolemy-II-Visual Sense is used for modeling and simulation of the sensor network. Lifetime improvement of the WSN is compared with and without classification using cooperative routing and diffusion routing. Sang Hoon Chi et al propose a new data propagation method in which the data transmission area is limited according to a threshold value for reducing the energy consumption in the network. The fuzzy rule based system is exploited to determine the threshold value by considering the energy and density of all the deployed nodes.

Younis et al. [16] have proposed a different hierarchical routing algorithm based on three tier architecture. Sensors are grouped into clusters prior to network operation. The algorithm employs cluster heads, namely gateways, which are less energy constrained than sensors and assumed to know the location of sensor nodes. Different neural network algorithms have been implemented in detection of route, cluster formation and cluster head selection. Table 1 shows different algorithms and its application in wireless sensor network.[4]

**Table 1. Implementation of ANN algorithm in WSN source [4]**

| S. No | Application of ANN in WSN | Algorithm Implemented |
|---|---|---|
| 1. | Energy efficient path discovery | Self Organizing Map, Back Propagation |
| 2. | Cluster head selection | Self Organizing Map |
| 3. | Data aggregation/ fusion | Self Organizing Map, Back Propagation |
| 4. | Data association | Hopfield |
| 5. | Mobile data association | Competitive Hopfield |
| 6. | Context /Data classification | Self Organizing Map |
| 7. | Data prediction | Back Propagation |

This paper focuses on energy aware protocol using fuzzy and neural techniques. Consumption of energy for entire network is analyzed and proved to be energy efficient when compared with existing protocol.

## III. PROPOSED PROTOCOL (AIWSN)

This paper proposes two protocol one with fuzzy based routing protocol and second formation of clusters

and selection cluster heads using self organizing map input neurons.

*A Proposed System Model*

Figure 1 clearly shows the methodology implemented for improving the life time. Network with sensor nodes are established and implemented with Kohenan self organizing map (SOM). SOM forms clusters and selects its cluster heads. Route is established by using shortest path algorithm between selected cluster heads.

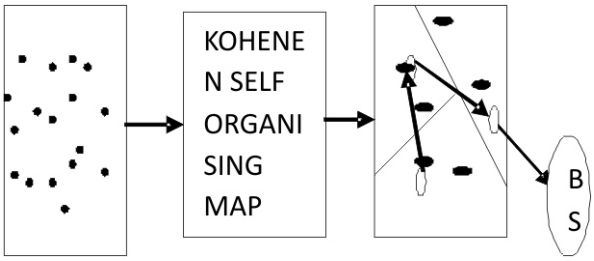


Fig. 1. System model for AIWSN

In the SOM implemented two vectors are taken as inputs. One the distance between two consecutive nodes and the other residual energy of two nodes. Based on the input vectors clusters are formed and cluster head is selected for each clusters. Information is transferred to the base station by existing shortest path route. Localized communication are implemented as per the available cluster based routing protocol. Every twenty five nodes will form a cluster. Protocol is framed in such a way that for hundred nodes four clusters will be formed.

*B. Architecture of SOM*

Architecture of SOM for proposed protocol is given in figure 2.

Figure 2 architecture of SOM in AIWSN

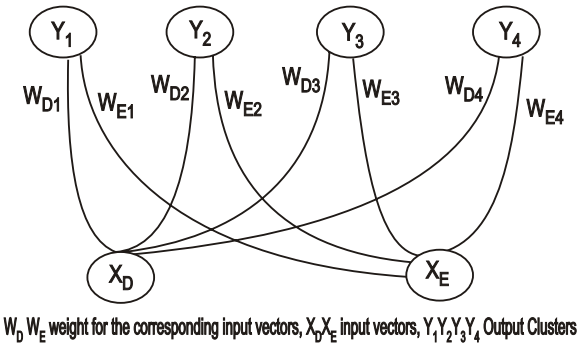


Fig. 2 Architecture of SOM

The network is trained using the following steps

Fund the index using

$$D_{(j)} = \int_{i=1}^{n} \left( W_{i3} - X_1 \right)^2 \quad \text{such that} \quad D_{(j)} \text{ is} \quad \ldots (1)$$

minimum.

Updating of weights are done using

$$W_{ij}(\text{new}) = W_{ij}(\text{old}) + \alpha \left( X_i - W_{ij}(\text{old}) \right) \quad \ldots (2)$$

## IV. ENT PROTOCOL

Classical routing protocol implements different methodologies and estimates various metrics to update neighbor table. Though much efficient work has been implemented consumption of energy is high. Power consumption is reduced on computation of neighbors based on fuzzy logic concepts. This paper focuses on computation of neighbors based on fuzzy logic conditions.. Source node is assigned a transmission range of 50 meter radius.

It selects neighbors within this transmission range. Neighbors selected by source are first level neighbors. Consecutive neighbors for first level neighbors are selected and so on. Selection of neighbors is done till destination node is reached.

**Table 2. Membership Function for Neighbor Node Computation**

| Membership Function / Inputs | Very Small | Small | Medium | High | Very High |
|---|---|---|---|---|---|
| Energy (J) | 0.0-1 | 0.5-2.0 | 1.5-3 | 2.5-4 | 3.5-5 |
| Queue Length (Packets) | 00-15 | 10-25 | 20-35 | 30-45 | 40-55 |
| Distance (m) | 0-10 | 5-20 | 15-30 | 25-40 | 35-50 |

Once all possible neighbors are computed neighbor table is updated. The parameters considered for computation of neighbors are distance between two consecutive nodes, queue size between each link and residual energy of each node. On Fuzzification and defuzzification process neighbors are selected. Table 2 and 3 provides membership functions, their values and some sample fuzzification rules.

**Table 3. Fuzzy rule matrix for selection of neighbors (only few samples)**

| Rule No | Energy | Queue Size | Distance | Selection |
|---|---|---|---|---|
| R1 | VS | VS | VS | REJECT |
| R2 | H | VS | M | SELECT |
| R3 | M | M | VH | REJECT |
| R4 | H | M | M | SELECT |
| R5 | S | VS | VS | REJECT |
| R6 | VH | VH | VH | SELECT |
| R7 | VS | M | VS | REJECT |

**Table 4. Fuzzy rule matrix for selection of route (only few samples)**

| Rule No | Energy | Queue Size | Distance | Selection |
|---|---|---|---|---|
| R1 | VS | VS | VS | REJECT |
| 2 | H | VS | M | SELECT |
| R3 | M | M | VH | REJECT |
| R4 | H | M | M | REJECT |
| R5 | S | VS | VS | REJECT |
| R6 | VH | VH | VH | REJECT |
| R7 | VS | M | VS | REJECT |

VS -Very small, S- Small, M- Medium, H-High, VH-Very high

Of possible routes one best route is selected based on linguistic variable. Table 4 and 5 gives the details of membership functions and sample rules.

Fuzzy Logic is used in this work as main implementation of perceptive reasoning. Fuzzy Logic provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, or missing input information. It imitates the logic of human thought, which is much less rigid than the calculations computers generally perform.

**Table 5. Membership Function – route selection**

| Membership Function/Inputs | Very Small | Small | Medium | High | Very High |
|---|---|---|---|---|---|
| Energy (J) | 0.0-1 | 0.5-2.0 | 1.5-3 | 2.5-4 | 3.5-5 |
| Hop count | 0-2 | 1-3 | 2-4 | 3-5 | 4-6 |
| Distance(m) | 0-10 | 5-20 | 15-30 | 25-40 | 35 – 50 |

Fuzzy Logic offers several unique features that make it a particularly good alternative for many control problems. It is inherently robust since it does not require precise, noise-free inputs and can be programmed to fail safely. The output control is a smooth control function despite a wide range of input variations. Since the Fuzzy Logic processing is done using user defined rules governing the target control system, it can be modified and tweaked easily to improve or drastically alter system performance. Fuzzy Logic deals with the analysis of information by using fuzzy sets, each of which may represent a linguistic term like “Warm”, “High” etc. Fuzzy sets are described by the range of real values over which the set is mapped, called domain, and the membership function. A membership function assigns a truth value between 0 and 1 to each point in the fuzzy set’s domain. Depending upon the shape of the membership function, various types of fuzzy sets can be used such as triangular, beta, PI, Gaussian; sigmoid etc. Fuzzy Logic incorporates a simple, rule-based IF X AND Y THEN Z approach to solving a control problem rather than attempting to model a system mathematically. The FL model is empirically-based, relying on an operator’s experience rather than their technical understanding of the system.

*A. Estimation of Degree of Membership*

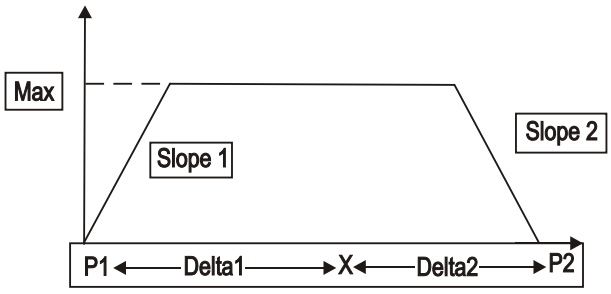


Fig. 3. Fuzzification plot

Source Neural Networks, Fuzzy Logic, Genetic Algorithm Synthesis and Applications By S. Rajasekaran et al

From the figure 3

Delta 1 $= X - P1$ and Delta 2 $= P2 - X$ ... (3)

If (Delta 1 <= 0) or (Delta 2 <= 0), then Degree of Membership (DOM) $= 0$ Else

DOM = min (Delta 1 + slope 1) ... (4)
(Delta 2, Slope 2)

*B. Estimation of Defuzzified Output*

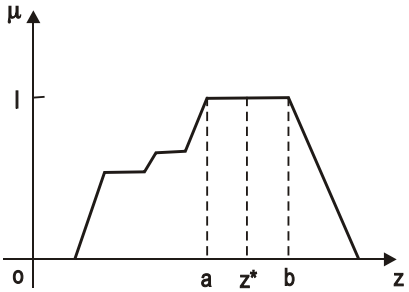


Fig. 4. illustration of MOM

The defuzzification method used for finding out the crisp values is the mean of maxima method..

$$a + b/2 = Z^* \quad \text{... (5)}$$

Equation 5 determines the defuzzified output.

## V. SIMULATION RESULTS AND DISCUSSION

The simulations are performed using the network simulator ns2 .The system requirements are Pentium 4 with a version of LINUX (Red Hat / Fedora) as the operating system. The version of ns2-29 [20] is taken as simulator. The patch files for implementing the LEACH protocol is attached with the network simulator. The network is simulated with the initial parameters given in the table 5.

**Table 5. Simulation parameters**

| Simulation Parameters | |
|---|---|
| Nodes | 100 – 200 |
| Mobility | All nodes are mobile nodes with 10 m/s speed |
| Initial Energy | 2800 J |
| Transmission Power | 97.2 mw |
| Receiving Power | 97.2 mw |
| Propagation Model | Two Ray Ground |
| Topology | Grid |
| Learning rate | 0.6 |

From figure 5 - 6 shows the results of simulation. The protocol has been run in the simulation platform for 25 iterations. The parameters taken for analysis are energy consumed by the entire network to reach the destination from source. Average lifetime of the network. When two AA batteries are connected for single node, each node will have an initial energy of 2800 joules henceforth initial energy of each node is taken as 2800 J. Simulation results are run for both static and mobile nodes with a mobility speed of 10 m/s.

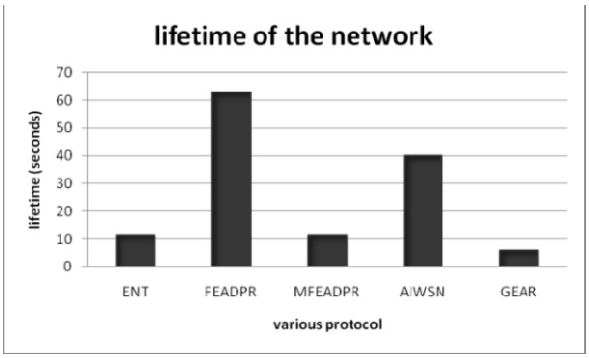


Fig. 5. life time of the network

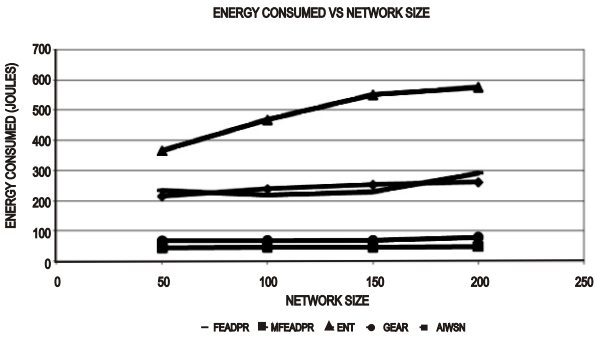


Fig. 6. Energy consumed by the network

In **F**uzzy based **E**nergy **A**ware **D**ynamic **P**ath **R**oute for wireless sensor network - **FEADPR** neighbor table is updated with only two linguistic variables distance between two consecutive nodes and residual energy of nodes at the end of each transmission. **M**odified **F**uzzy based **E**nergy **A**ware **D**ynamic **P**ath **R**oute for wireless sensor network – **MFEADPR** one more linguistic variable queue length is added up as in FEADPR the PDR obtained is only an average value of 44.520 % which is not efficient. **E**nergy **A**ware dynamic path route with improved **T**hroughput – **ENT** **r**oute is also established based on fuzzification. Table 5 clearly shows the energy consumed and average life time of the entire network for different protocols.

AIWSN Artificial Intelligence for Wireless Sensor Network is implemented for dynamic cluster heads using neural network SOM protocol. Results are also compared with existing protocol GEAR.

**Table 5. Energy consumed by network for different protocol**

| Protocol | Energy Consumed (J) | Life time (sec) |
|---|---|---|
| FEADPR | 45.663 | 61.3187 |
| MFEADPR | 242.18075 | 11.56 |
| ENT | 243.3625 | 11.505 |
| AIWSN | 70.3255 | 39.99 |
| GEAR | 470.4365 | 5.95 |

Table 6 clearly shows the variation in energy consumption with respect to different protocol for mobile nodes and static nodes respectively. Of the fuzzy based protocol FEADPR consumes very less energy when compared to other two fuzzy based routing protocols. MFEADPR and ENT consume more power due packet overhead. Though energy consumption increases in fuzzy based routing protocol, when compared with existing classical routing protocol GEAR power consumption is reduced to a minimum of 48.62 % and hence fuzzy based routing protocol is energy efficient. In FEADPR protocol the entire network exist for an average of 62 seconds. Whereas other two fuzzy based protocol the life time of the entire network is 11 seconds. Life time of the network is defined as the time at which the first node dies out of its energy in seconds. AIWSN protocol consumes an average power of 70.3255 joules which is lesser than the existing protocol GEAR and fuzzy based routing protocol MFEADPR and ENT. But when compared to FEADPR, AIWSN power consumption increases by 50 %.

**Table 6. Variation of savings of energy in percentage**

| Mobile nodes | FEADPR | MFEADPR | ENT | AIWSN | GEAR |
|---|---|---|---|---|---|
| **FEADPR** | – | Decreases by 81.14 | Decreases by 81.23 | Decreases by 50 | Decreases by 90.29 |
| **MFEADPR** | Increases by 81.14 | – | Increases by 48 | Increases by 70 | Decreases by 48.51 |
| **ENT** | Increases by 81.23 | Decreases by | – | Increases by 71 | Decreases by 48.26 |
| **AIWSN** | Decreases by 50% | Decreases by 70 | Decreases by 71.11 | – | Decreases by 85.10 |

## VI. CONCLUSION

Hence on comparing the fuzzy and neural based protocol, fuzzy based routing FEADPR gives better performance when the linguistic variables are minimum. Cluster based neural network AIWSN protocol performs better with MFEADPR and ENT than FEADPR. AIWSN protocol could be made to perform better by using integral technique of fuzzy and neural and proper optimization.

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