

Optimization of Wireless Sensor Networks using Artificial Intelligence and Ant Colony Optimization to Increase Network Lifetime and to Minimize Energy of Network

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Abstract— Energy consumption, network lifetime and packet loss are the major concerns in wireless sensor network. So for minimizing the energy of network and increasing the network lifetime, the ant colony optimization algorithm is proposed. Firstly, all the stages of Wireless sensor network such as node placement, network coverage, clustering and data aggregation and routing are optimized by the Genetic algorithm. Secondly, the proposed algorithm focuses on two parameters i.e. energy consumption and network lifetime. In Ant swarm algorithm, EAAR (Energy-aware ant-based routing) and ANTHOCNET (Adaptive nature-inspired algorithm for routing in mobile ad-hoc networks) protocols are used to minimize the energy of overall network and to follow the shortest path to reach the destination. These protocols are also used to find the number of dead nodes due to which packet loss and network lifetime improves. Lastly, APTEEN protocol with threshold energy finds the number of dead nodes by draining threshold energy to 50% and with maximum energy cluster head is selected. Results of EAAR, ANTHOCNET, APTEEN and proposed protocol (APTEEN with threshold energy) are analyzed in which proposed algorithm shows better results than APTEEN protocol where energy consumption is reduced from 90% to 60%.

Key words: Wireless Sensor Networks, Artificial Intelligence, EAAR (Energy-aware ant-based routing), ANTHOCNET

I. INTRODUCTION

A wireless sensor network is the network of sensor node without wired communication between the nodes. A wireless sensor network (WSN) typically consists of a sink node sometimes referred to as a base station and a leaf node says small sensor node. The base station is assumed to be secure with unlimited available energy while the leaf nodes are assumed to be unsecured with limited available energy. The sensor nodes including cluster node, leaf node monitor a geographical area and capture data say Sensory information. The Same information is communicated to the sink node through secure wireless mesh networks. To conserve energy this information is aggregated at intermediate sensor nodes say cluster head by applying a suitable aggregation function collected data across from the whole network. The intention behind aggregation is to reduce the amount of network traffic which helps to decrease energy consumption on sensor nodes. Providing security to aggregate data in wireless sensor networks is known as secure data aggregation in WSN. The wireless sensor networks stages such as node placement, network coverage, clustering, data aggregation and routing by using a genetic algorithm can be optimized. And by using ant

colony optimization these stages gives optimized results with efficiency, accuracy, and speed. In Ant colony optimization, this ant swarm algorithm used for optimization of wireless sensor networks. And EAAR protocol is used to maximize the network lifetime and for data routing in WSN. Also, modified APTEEN gives the number of dead nodes by threshold energy drained to 50%.

Wireless sensor networks (WSN), sometimes called wireless sensor and actuator networks (WSAN), are spatially distributed autonomous sensors to watch physical or environmental conditions, like temperature, sound, pressure, etc. and to hand and glove pass their information through the network to the main location. The lot of trendy networks square measure bi-directional, conjointly facultative management of sensing element activity. The event of wireless sensing element networks was actuated by military applications like a parcel of land surveillance; these days such networks square measure utilized in several industrial and shopper applications, like process observance and management, machine health observance, and so on.

Wireless sensors are of low cost, so in many applications, they are not tampering resistant. It is composed of small, low cost, low power nodes. It is used for transferring data to the destination sink node without tampering. It is used to increase Packet Delivery Ratio (PDR) for real-time applications. It also decreases extra computation overhead for efficiency. In the wired network that- it has high costs for the communication between networks. The motivation from above concern is that the Wireless Sensor networks- kill the high cost of the wired network. Optimization of various stages of WSN can be easily optimized from artificial intelligence techniques.

II. LITERATURE SURVEY

A literature survey or a literature review in a project is that section which shows the sundry analyses and research made in the field of your interest and the results already published, taking into account the various parameters of the project and the extent of the project.

A.H. Mohamed, K.H. Marzouk in 2015 focuses on energy consumption in WSN. The author introduces a new system that uses a genetic algorithm (GA) for optimizing the node deployment, node locations and dividing the sensor nodes into two form of operation that can minimize the energy consumption of the WSN. Recommended system has been applied for a simulated WSN used in the radiation discovering sites as proof of concept in industry standard [1]. The energy consumption is the major concern in WSN so to minimize the energy of network [6-7] explains about optimizing the energy consumption and the energy-efficient coverage in WSN by using the Genetic algorithm. All the

issues of coverage, connectivity, and energy consumption are solved in [6-7]. But at the lower bound the performance is not optimal. Authors Mohammed Abo-Zahhad et al. [8] explains about network lifetime and stable period of WSN. GAEEP protocol is used to increase the reliability of clustering process. It is difficult to recharge the batteries due to network lifetime cannot be achieved.

Sneha More, et al. [3] focuses on optimization of WSN stages and also the energy consumption parameter. The author explains about the artificial intelligence techniques which optimizes the stages of WSN and for more accuracy APTEEN protocol is used. Ajit A. Chavan, et al. [4] focuses on energy consumption and throughput of the network. COAPs and COAPs+RPK protocols are used to compare energy and throughput due to which energy consumption of nodes, memory requirement, network response and authentication interoperability is efficient. Mininath Nighot et al. [5] explain about the GDCP protocol in which energy efficient routing is achieved using local communication among sensor nodes. The simulated results show the overall energy of network that is improved. This technique cannot be worked in a mobile sensor network.

Sohail Jabbar, et al. [9] focuses on the energy consumption of WSN. EASARA (Energy-aware simple Ant routing algorithm) improves the route discovery procedure and mainly concentrate on energy efficient forwarding node and route selection so that the network lifetime can be increased. In M2M, IOT, Cyber physical systems this technique is not used so encryption method can be used. Authors Gurjeet Singh, Er. Karandeep Singh [10] explains about the modified APTEEN routing protocol. A modified clustering technique is introduced with a variable value of threshold energy for nodes to aggregate and transmit data is utilized. The variable value withal modifies the cluster head selection, where energy utilization is improved. The improvement in energy efficiency and lifetime comes at the cost of an increase in complexity of the protocol. This protocol cannot use in mobility.

Arati Manjeshwar, et al. [11] gives a detailed explanation of the APTEEN protocol. In APTEEN (Adaptive Periodic Threshold-sensitive Energy Efficient Sensor Network Protocol), when best features of both proactive and reactive networks combine then it provides periodic data collection as well as near real-time warnings about critical events. This protocol is mainly used for energy consumption of network. Charles E. Perkins, et al. [12] explains about Ad-hoc On-Demand Distance Vector Routing (AODV), a novel algorithm for the operation of such ad-hoc networks. Each Mobile Host operates as a specialized router, and routes are obtained as needed (i.e., on-demand) with little or no reliance on periodic advertisements [12]. Our incipient routing algorithm is quite opportune for a dynamic self-starting network, as required by users wishing to utilize ad-hoc networks. AODV provides loop-free routes even while rehabilitating broken links. A route to a destination may be returned by any intermediate node [12]. Link breakages are reported immediately, and routes are expeditiously re-established. Dormant routes are expeditiously aged out of the system because they are more liable to go stale. This technique

cannot work in various interconnection topologies with fixed networks.

III. PROBLEM DEFINITION

To optimize the stages of wireless sensor networks i.e. node placement, network coverage, clustering, data aggregation and routing using a genetic algorithm for grid architecture and to overcome its limits the ant colony optimization algorithm is proposed. ACO can be worked on grid architecture for the balancing energy consumption and the proposed protocol is used to maximize network lifetime.

IV. SYSTEM ARCHITECTURE

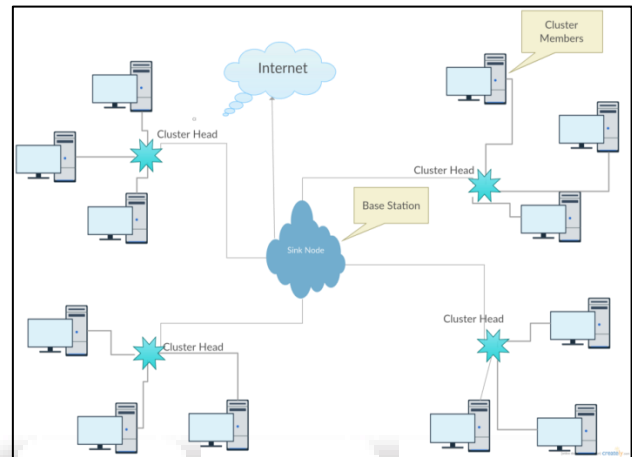


Fig. 1: System Architecture

The above system architecture i.e. Fig.1 describes the whole system which includes the 5 stages of WSN i.e. node placement, network coverage, clustering, data aggregation and routing. In above diagram, the main communication is going to start from the sink node i.e. Base Station (BS). Using this base station, the further communication is going to obtain in between the cluster heads and cluster members. Cluster members send data to the cluster head (CH) and one CH will send to another and finally, by following the shortest path or routing protocol, data is received by the base station. In node placement, the nodes are optimized easily because the nodes are placed as particles. In clustering, the cluster heads are used to optimize and to send the data to sink node i.e. base station, who behaves as the coverage of the network, and with the help of cluster members the broadcasting is done easily, the clustering can be achieved by APTEEN protocol. The data aggregation can be used to load balance, passing message from one node to other by using the genetic algorithm. And the last stage i.e. routing can be obtained in the data aggregation stage where we need to send the data in the minimum distance.

A. APTEEN Protocol

The APTEEN (Adaptive periodic threshold sensitive energy efficient sensor network) protocol is the most advantageous protocol to form the clustering with the help of cluster heads. A responsive network protocol called APTEEN is Adaptive periodic threshold sensitive energy efficient sensor network protocol. Hybrid Networks join the best components of proactive and reactive networks while minimizing their disadvantages. Nodes in such a network transmit information periodically at moderately longer

intervals while in the meantime transmitting information when the detected esteem goes past its threshold. In this manner, the sensor energy is utilized effectively by decreasing the number of transmissions of noncritical information.

The client can change the periodicity, the threshold value(s) and the parameter to be detected in various regions. This network can copy either the proactive or the reactive network by reasonably changing the periodicity or threshold values. Along these lines, this network can be utilized as a part of an application by appropriately setting the different parameters. In any case, this adaptability and flexibility increase the complexity at the sensor. Here a new protocol APTEEN (Adaptive Periodic Threshold-sensitive Energy Efficient sensor Network Protocol) is presented for hybrid networks. There are applications in which the client needs time basic information furthermore needs to inquire the system for examination of conditions other than gathering time basic information. As it were, the client may require a system that response quickly to time basic circumstances and gives a general picture of the network at periodic intervals, with the goal that it can answer examination inquiries.

APTEEN can consolidate the best components of proactive and reactive networks while minimizing their restrictions to make another type of network called a hybrid network. In this network, the nodes not just send data periodically; they additionally react to sudden changes in attribute values. Along these lines, it acts as a proactive protocol and additionally reactive protocol.

B. System overview

The following Five steps which show us actual network creation and network optimization in the Genetic algorithm:-

1) Node Placement

Node placement is the placement of the node in the network to ensure that system keeps running with the most noteworthy practical execution, the nodes are situated on the grounds organizes as shown in Fig.1.

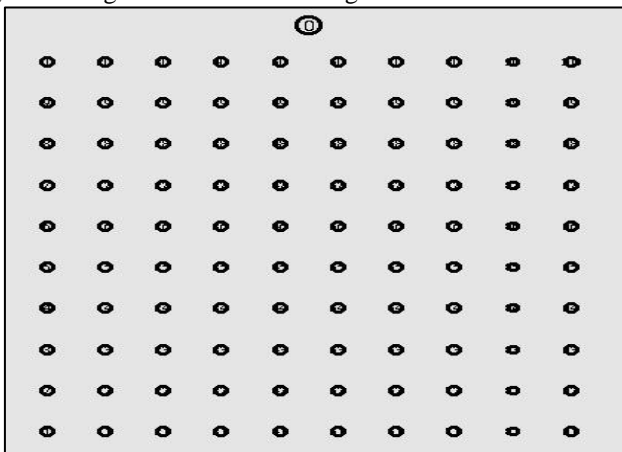


Fig. 2: Node Placement

2) Network Coverage

Network Coverage is the term particularly inferred for keeping up and measuring the physical areas of networks. Really Network Coverage intends to associate the network indiscriminately and exactly so all network siblings get associated with Sink node say base station for network message correspondence as shown in Fig.3.

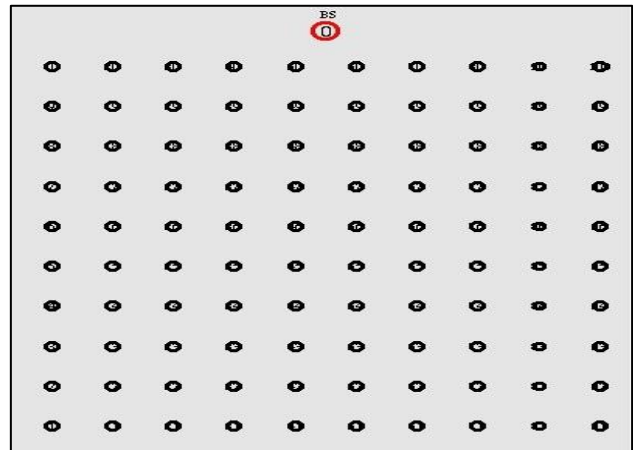


Fig. 3: Network Coverage

3) Clustering

For making the networks very load balance clustering come into the picture. By utilizing fitness function, the clustering can be accomplished. Clustering is the stage in which packet forwarding problems are easily solved. When packet forwarding method is used, the time, energy, delay, and packet delivery ratio entities are more so to avoid these problems clustering is proposed as shown in Fig.4.

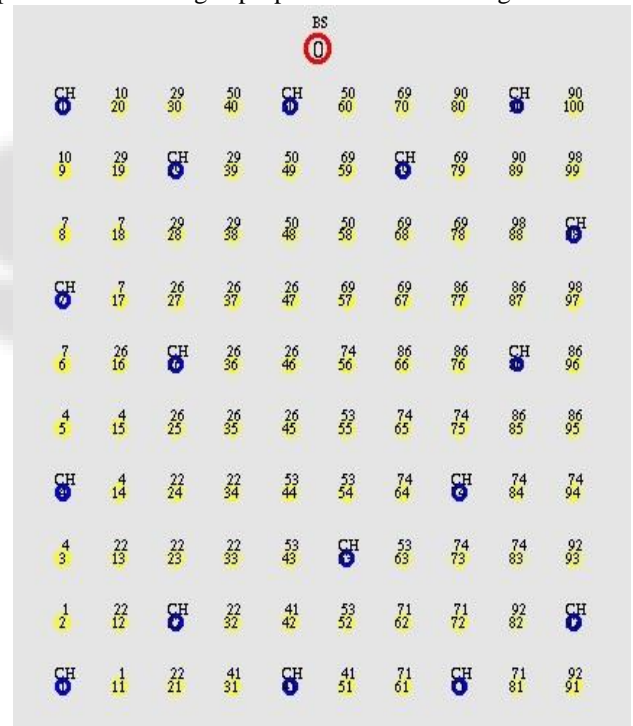


Fig. 4: Clustering

4) Data aggregation

Data Aggregation makes it simple to gather every single sensible data from all networks including all clusters and his cluster member. Data Aggregation certifications to convey exact information to sink node say base station. Another pour stance is to dole out or choose load to the node in the network as shown in Fig.5. Additionally, help GA to make the load balance network.

5) Routing

At long last from fitness function, routing protocol takes some parameter to pick the optimum route to travel to every part of the entire WSN. Regularly routing fitness function consider three conditions of energy they are called

- 1) Low communication range
 - 2) Middle communication range
 - 3) High communication range
- Using above range routing algorithm decide the route to travel toward sink node.

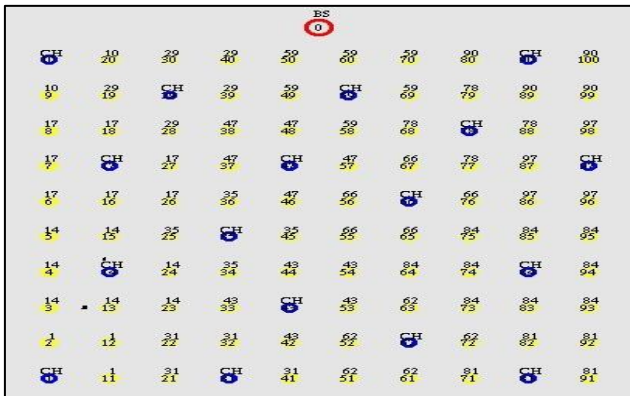


Fig. 5: Data aggregation and routing

Hence, these are the stages of wireless sensor network which can be optimized by using the ant colony optimization.

V. PROPOSED WORK

The stages of wireless sensor networks such as node placement, network coverage, clustering, data aggregation and routing can be optimized by proposed work i.e. Ant colony optimization algorithm. Whereas balancing of energy consumption and increasing the network lifetime can be achieved by using ACO and EAAR protocol.

An ant colony optimization algorithm gives us objectives:-

- For data aggregation and routing of the network where EAAR protocol used for routing.
- To balance the energy consumption and to increase the network lifetime.

Ant colony optimization (ACO) is a population-predicated meta-heuristic that can be acclimated to find approximate solutions to arduous optimization problems.

In ACO, a set of software agents called artificial ants search for good solutions to a given optimization problem. To apply ACO, the optimization problem is transformed into the quandary of finding the best path on a weighted graph. The solution construction process is stochastic and is partial by a pheromone model, that is, a set of parameters associated with graph components (either nodes or edges) whose values are modified at run time by the ants.

The ACO meta-heuristic is:-

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Set parameters, initialize pheromone trails
    SCHEDULE_ACTIVITIES
        ConstructAntSolutions
        DaemonActions {optional}
        UpdatePheromones
    END_SCHEDULE_ACTIVITIES
    
```

a) Ant Colony Optimization Algorithm:-

Step 1: Initialize

 Pheromone trail

Step 2: Iteration

 Repeat for each ant

 Solution construction using pheromone trail

 Update the pheromone trail

- b) Until stopping criteria
- Algorithm EAAR [2]

Input:

The following blank tables of all nodes are input:

- 1) The neighbor table: A table containing all nodes in the neighborhood of a node.
- 2) Seen table: A table containing all packets received by a node and their paths.
- 3) Routing table: A table containing next hop to transfer packets.

 Initial pheromone for all nodes = 0.

Output:

Updated tables with all the values required to transmit data.

Pheromone value for selected nodes.

Steps:

- 1) Broadcast all the request packets and initialize a "seen" set S of every node as NULL.
- 2) On receiving any route request:
 - for all routes Ri in S of node check:
 - if the route traveled by the request is not a super set of the Ri
 - if the route is a subset of Ri OR the hop count is less than 1.5 times the highest in the set S:
 - add a route in set S and rebroadcast it.
 - else
 - discard it
- 3) On reaching the destination, the route request is converted to the route reply, the path traveled is returned to, and the pheromone PH in the routing table of each node of the path is added.

$$PH = MBR/HOPS$$
- 4) 4. When the source receives the first reply, the delay of the first packet is made 5 times in order to receive more packets and the routing table is updated.
- 5) 5. Data transmission is initiated with each packet, selecting next hop with probability Pnd from all available, by taking the pheromone values from routing table.
- 6) 6. On each transmission, the pheromone is reinforced and others are evaporated.
- 7) 7. On link failure, Step 1 is repeated from the node that has data to send, but no neighbors available.

VI. OWN CONTRIBUTION

In APTEEN, find the number of dead nodes when one node's energy becomes zero. And this would be compared with own work is contributed in:

Set the threshold energy to 50% that will check the dead nodes when one node's energy becomes zero. This method would be compared with the simple APTEEN protocol with various parameters that can be shown by the graph.

A. Proposed Algorithm:

- 1) Initialize all the variables and threshold energy=50.00 Joules
- 2) Calculate the energy of all the nodes which is in the range and also its neighbor nodes.
- 3) Compare one node's energy (val) with neighbor node's energy (nb_val)

- if val is greater than nb_val then select val.
- 4) Now compare this val and threshold energy, if that val is less than threshold energy then select val as a cluster head.
- 5) Now check cluster head is present in neighboring hops, if not then exit
- 6) Else send cluster head to announce message.

In APTEEN protocol, node's energy is not setting to zero due to which the dead nodes cannot be obtained by which packet loss was more. So to overcome this problem, this proposed protocol is obtained. In this proposed protocol, dynamic cluster head selection becomes easy by setting threshold energy to 50 Joules. And to calculate number of dead nodes also becomes easy by which the packet loss and network lifetime is improved. This proposed protocol is 90% better than APTEEN protocol.

VII. RESULTS ANALYSIS

Comparison of APTEEN, proposed protocol, EAAR and ANTHOCET protocols has been shown by the graph in NS2. The graphs are of the number of dead nodes, energy consumed per delivery packets, the number of packets dropped, dead nodes received packets, the number of packets delivered. The comparison shows us that EAAR protocol is the most appropriate technique used for optimization as well as the enhancement of network lifetime.

Fig.6 shows graph of a number of dead nodes, in which there are less number of dead nodes in EAAR protocol and more number of dead nodes in proposed protocol due to which network lifetime can be calculated. Number of dead nodes=one node's energy is zero

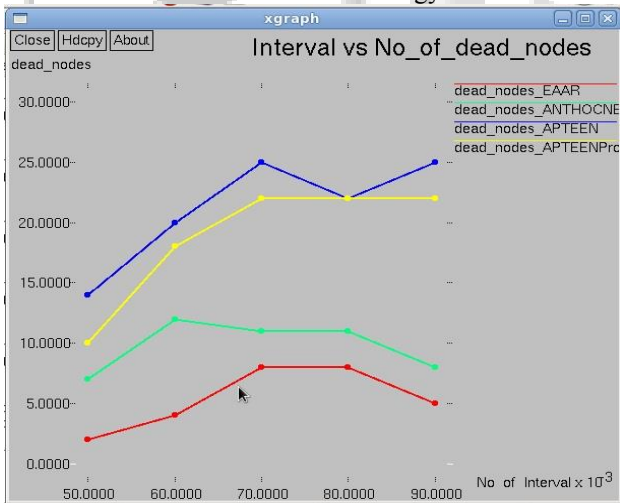


Fig. 6: Number of dead nodes

In Fig.7, energy consumed per delivered packets of all the protocols are compared, in which maximum energy is consumed in APTEEN and minimum energy is consumed in EAAR protocol.

The energy consumed per delivered packets can be calculated by using the below formula:-

$$\text{Energy consumed} = \text{Total energy/nodes}$$

$$\text{Energy consumed per delivered packets} = \text{Energy consumed/received packets}$$

Where number of delivered packets (recv) is calculated if-

$$\text{recv} == 0 \text{ then } 1 \text{ else } \text{recv}$$

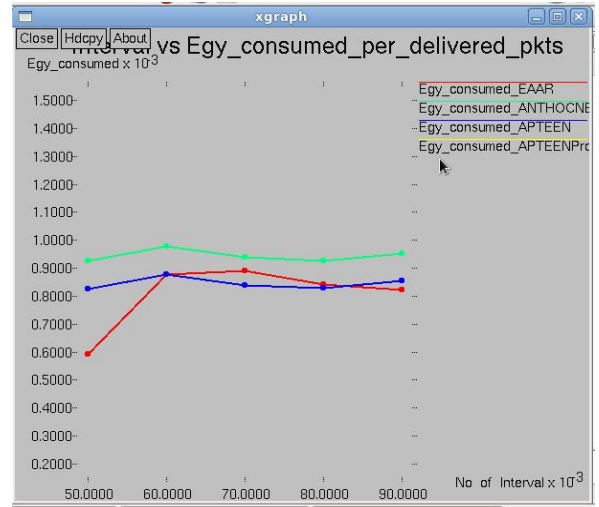


Fig. 7: Energy consumed per delivered packets

Fig.8 shows graph of a number of packets dropped. A maximum number of packets are dropped in APTEEN protocol, then less in proposed protocol and minimum packets are dropped in EAAR protocol.

$$\text{No. of packets dropped} = \text{send} - \text{recv}$$

Where, send is calculated from the trace file of the network.

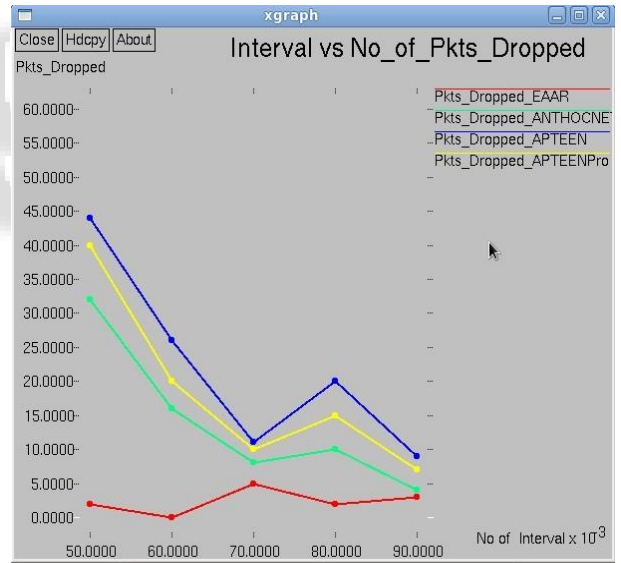


Fig. 8: Number of packets dropped

Dead node received packets graph is shown in Fig.9. Here, maximum dead node packets are received in APTEEN and minimum dead nodes are received in EAAR protocol.

Dead nodes received packets is calculated from trace file of the network.

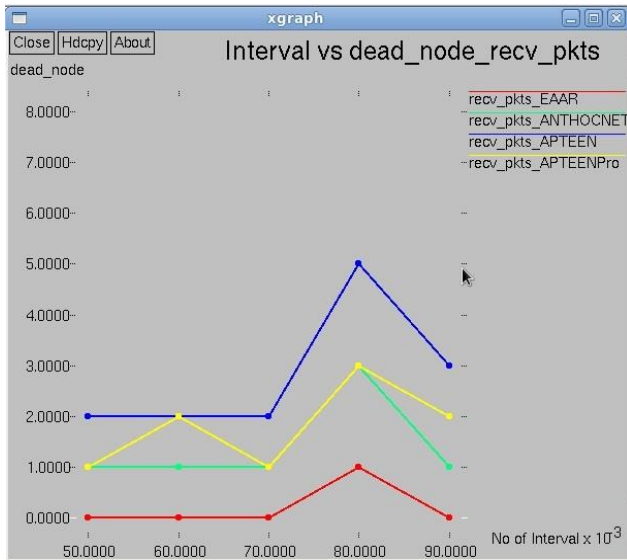


Fig. 9: Dead node received packets

In Fig.10, a number of packets delivered in all the protocols are compared. A maximum number of packets are delivered in EAAR protocol and minimum packets are delivered in APTEEN protocol.

Number of delivered packets (rcv) is calculated if-
 $rcv == 0$ then 1 else rcv

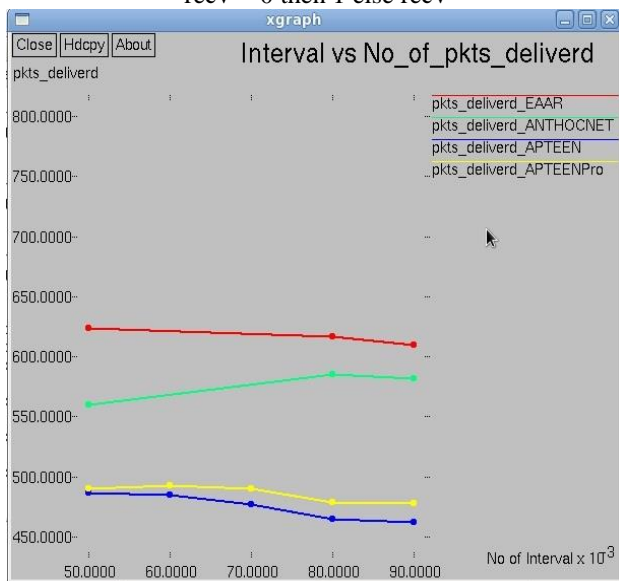


Fig. 10: Number of packets delivered

These above results are used to optimize the stages of Wireless sensor networks. It is used to balance the energy consumption. It is also used to increase the network lifetime. The EAAR protocol is used to select the cluster head and to send data to the base station in minimum time by following the routing mechanism. APTEEN with threshold energy increases the network lifetime.

VIII. CONCLUSION AND FUTURE SCOPE

The proposed protocol (APTEEN with threshold energy) improves the packet loss and network lifetime which is compared with APTEEN protocol. To get more than 90% network lifetime, EAAR protocol is implemented and it shows better results than APTEEN protocol. Also, all the stages of the Wireless sensor network are optimized using the Genetic algorithm. The main concern of minimizing

energy and network lifetime has been solved by using two protocols, for minimizing energy-EAAR protocol is proposed and for network lifetime- proposed protocol is obtained. These results give 80-90% accuracy as compared with the existing system.

In the future, this technique can work on the security of sending and receiving the nodes to the base station where data can be sent in encryption format and receive in decryption format.

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