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CDARGA: Cluster-Based Data Aggregation with Genetic Routing Algorithm in Wireless Sensor Networks

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Abstract*: In the wireless sensor networks (WSNs), the upholding the energy and routing formation at every sensor node is the major issues. The distance from base station and internal node mainly has imbalanced in the energy consumption during transformation of the data. To reduce the energy upholding and the data aggregation routing issues in Centralized Clustering-Task Scheduling for wireless sensor networks (WSNs), this paper focuses on a Cluster-Based Data Aggregation Routing with Genetic search Algorithm (CDARGA) , which reduces the energy consumption in a hyper round model. The proposed data aggregation routing protocol using the Genetic Algorithm (GA) estimates the fitness function using the three key parameters distance, energy, and Hyper round policy. The proposed methods were compared with RP-MAC and the experimental result shows that the proposed protocol is superior to RP-MAC protocol and the proposed algorithm improves the network lifetime which can used in real time application.

Keywords: Centralized Clustering, Data Aggregation, Genetic Algorithm, Hyper round policy.

I. INTRODUCTION

A Wireless Sensor Network (WSN) is a cluster of sensor with small, lightweight, low computational capacity sensor nodes [1]. WSNs can be installed in uphold of a selection of different applications such as examining environmental occurrence (e.g., the stage of air pollution, weather monitoring). The information gathered from every sensor nodes is forwarded to a base-station for additional processing. The power conservation is significant measure for WSN design, as WSNs are classically positioned to isolated locations or more huge regions. In any case, restoring exhausted batteries for huge amount of nodes or still an incomplete rest of hard-to-access nodes is typically not a feasible option.

WSN nodes are little, battery controlled and low-cost. The essential problems in WSN are energy utilization among all nodes. The elongated distance among sensor nodes, need the extra energy to utilize it. Consequently to expand the duration of WSN, there are numerous research studies on communication distance of the sensor nodes.

The more advance that is cluster-based networks are an important for atmosphere monitoring. To utilize each sensor nodes in cluster based network, it decreases communication distance for huge amount of sensor nodes, challenging only little nodes to broadcast long distances, e.g., Base Station (BS). A cluster-based procedure splits the network into a quantity of clusters. Every cluster has a Cluster Heads (CHs) with the intention of gathers data as of all associate nodes in its cluster.

These CHs aggregate the accumulated data and transmit it to the BS. This approach strongly decreases the message rate of the sensor nodes so that the duration of the network really expands. The major issues with WSN are that is needed to boost the duration of network. Commonly, duration of network is distinct as the time when the primary node is unsuccessful to transmit the packets or messages to the base station. This problem can be determined by executing data aggregation method as it reduces data traffic and additional saves energy by merging numerous incoming packets into a particular packet whenever the sensed information are extremely correlated [2]. Many researchers have been accepted out to additional level network lifetime.

In data aggregation the sensor network is frequently supposed as repeal multicast tree. During this process, sink request the sensor nodes to details ambient provision of occurrence. In this procedure, normally the information that is coming from numerous sensor nodes are aggregated, in such that the similar attribute of occurrence once it attain the equivalent routing node on mode back to sink.

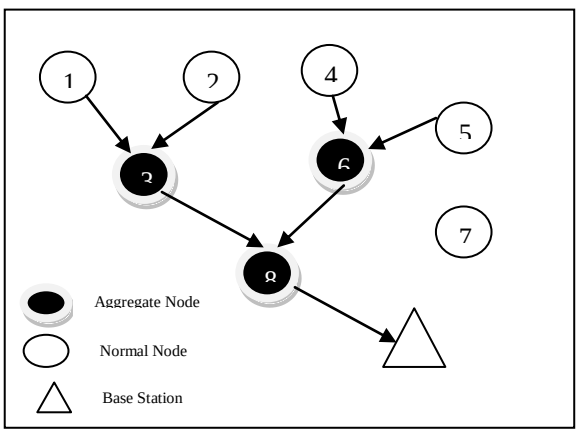

Fig. 1: An example of data aggregation

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II. PROCEDURE FOR PAPER SUBMISSION

In figure 1. illustrates 8 sensor nodes and one Base station is deployed in a centralized WSN. At first, sensor node '3' combined the message from both '1' and '2' sensor nodes. In the similar approach node '6' aggregates data as of '4' and '5' sensor nodes. According to [3], data aggregation is perceived as the rest of computerized techniques of joining the packet information's which arrives from a number of sensor nodes into rest of significant data. In other manner this procedure is also called as data synthesis. Based on this point, 8th node collects messages from 3rd and 6th nodes and lastly transmits the message (data) to Base Station node.

Most of the researchers discussed about an energy efficient routing protocols with data aggregation, geographic information, clustering approach etc and many research papers shows the effectiveness of a Genetic Algorithm (GA) based approach in sensor networks [4 – 7]. Here, this paper present an enhanced hierarchical based routing is an element of the cluster-based data aggregation routing using genetic algorithm evaluates the fitness function schedules clustering-task to extend the network lifetime and reduce energy consumption.

Section I contains the introduction of clustering, data aggregation and Genetic algorithm. Section II contains the brief review on previous work on data aggregation and genetic algorithm. Section III contains the proposed methodology. Section IV contains the Performance Evaluation Section using NS2 Simulator. Section V contains the Result. Section VI concludes the paper.

II. RELATED WORK

(*Maraiya* **et.al., 2011 [8])** discussed about a WSN is a source restriction network, in which every sensor nodes have incomplete resources. To arrange an accumulate resources and data, energy should be cumulative, and evade quantity of traffic in the network. The objective of data aggregation is that removes unnecessary data communication and improved the life occasion of energy in WSN. Data aggregation procedure has to be completed with the assist of effective clustering method connected to clustering for data aggregation called "Efficient cluster head selection scheme for data aggregation in wireless sensor network" (ECHSSDA), also they evaluated the system to the LEACH clustering algorithm.

(*Babie. S, Ad Khadim***, 2012 [9]**) discussed a routing protocols in Wireless Sensor Networks (WSN) have been considerably examined by researchers. The majority reviewed subject have focused on examining the special routing methods that have been projected for WSN and categorizing them based on the network's and protocol's function also a essential problem in the aim of WSN is to exploit the lifetimes typically when they contain an incomplete and non-replacement energy supply. The authors developed the network duration, calculating of power utilization and energy-efficient communication methods by every sensor are essential. The authors proposed a novel technique for the routing problem by using genetic method for WSNs. Their idea is to exploit the network lifetime by progressing proficient routing methods.

(*S. Mottaghi and M. R. Zahabi*, **2015 [10]**) discussed a wireless sensor networks are collected of a huge amount of not reusable wireless sensors that gather packets about neighboring position and broadcast them to the last client. Since these sensors not having a rechargeable batteries, amplifying the duration is significant and different techniques have been projected to boost the duration of the sensor nodes in the network. Mainly these techniques are projected on routing or clustering algorithms. The Low Energy Adaptive Clustering Hierarchy (LEACH) algorithm is a proficient clustering technique where nodes inside a cluster transmit the packets to a local CH. Several researchers suggested a Mobile Sink (MS) as a system to decrease energy utilization and a Rendezvous Node (RN) to perform as a accumulate point for the MS. The authors proposed method that joins the exploit of the LEACH clustering algorithm, MS and RP.

(*Shivkumaret.al.*, **2016 [11]**) discussed an optimized battery control, energy efficient routing procedures should be employed such as General Self-Organized Tree-Based Energy-Balance routing protocol (GSTEB), Hybrid Energy-Efficient, Distributed clustering approach (HEED) and Power Efficient Gathering in Sensor Information Systems (PEGASIS). GSTEB can be utilized to decrease energy utilization. It builds a routing tree for every round. BS distributes a root node and distributes message about position responsiveness to every sensor nodes and it routinely classifies nodes when any node in tree has small battery influence. This procedure extend network lifetime. Between these procedures GSTEB presented packet delivery ratio, high throughput, and having longer battery utilization compared to PEGASIS and HEED. The drawback of GSTEB is that the average packet drop is slightly high with value of time. So GSTEB is customized with clustering mechanism to decrease packet dropping.

(*S. Ghosh, W. Bengal*, **2016 [12]**) presented an enhanced version of PEGASIS (E-PEGASIS) which conquers the disadvantages and is energy efficient. The model consequences specified that E-PEGASIS expands the WSN duration (lifetime) in evaluation to PEGASIS, Binary PEGASIS and LBEERA alongside with significant decrease in packet delay. The outcomes are showed to be statistically considerable.

(*N. R. Roy and P. Chandra*, **2019 [13]**) presented an Energy Efficient Data Aggregation method for Clustered Wireless Sensor Network (EEDAC-WSN). It decreases intra-cluster connections through permitting cluster member nodes to transmit tiny scaled control messages pursued by comparatively complete messages from nodes chosen by the CH node. They proposed work can united with several clustering method, they had used it with LEACH for the function of simulation. The outcomes attained are considerable in terms of network constancy phase and duration.

(*Kowsalya. R, and B. Rosiline Jeetha*, **2019 [14]**) stated that "Wireless sensor networks (WSN) consist of massive amount of sensor nodes. These little and tiny cost sensor nodes are prearranged in observing area of interest.

Because sensors performed numerous functions such as data gathering and data broadcast cost in energy reduction, these effects the network lifetime. The authors presented a brief survey on minimizing energy dissipation and exploiting a network lifetime is with the essential concerns when intending applications and procedures for sensor networks. Clustering has been recognized to be energy-efficient in sensor networks because data routing and relaying are only functioned by cluster heads. The authors presented a different distributed clustering algorithms based on Dynamic Hyper round policy (DHRP) methods of new Distributed Clustering Algorithm, HEF clustering, DERC, LCM, EDIT, I-LEACH and DHRP for large-scale WSNs to optimally establish the Energy-efficiency and Scheduling".

(*Kowsalya. R, and B. Rosiline Jeetha*, **2019 [15]**) proposed centralized cluster based cluster-head selection is a major issue in presented representative clustering process such as M-LEACH and SEDC, cluster heads are chosen with a optional likelihood in a distributed approach. So, there are huge deviations of the amount of clusters and size for each cluster at each round throughout network lifetime. In order to overcome issues of difficult cluster-head selection and great energy consumption in Centralized Clustering-Task Scheduling for wireless sensor networks (WSNs) they presented a Modified Centralized Cluster-Head Selection (MCCHS) algorithm based on Simple Energy-efficient Data Collecting (SEDC) protocol was projected. The authors presented a MCCHS algorithm in static manner selection algorithm for cluster head selection technique using NS (Network Simulator) 2.34 Framework. This technique leads to improved CH strength, reduction in the quantity of clusters in the network, and improving the energy efficiency.

III. PROPOSED METHODOLOGY

The proposed method of cluster-based data aggregation routing using genetic algorithm (CDARGA) is executed through a clustering framework which aims to gathering data energy efficiently to enhance network life. The figure 2 describes the proposed method flow process.

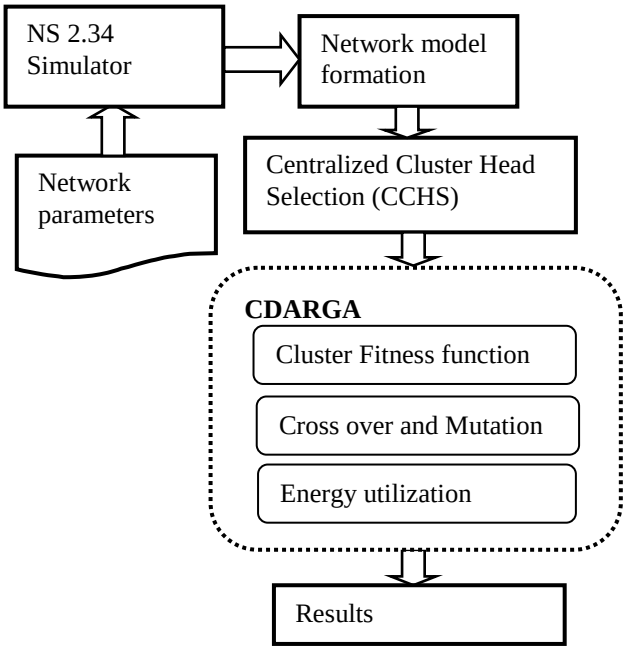

Fig. 2: Proposed Flow Diagram

A. Network Model Formation

In network model formation procedure is assessed in graph based neighbor distance method was already presented by (Kowsalya. R, and B. Rosiline Jeetha, 2019). In this model, the system will described a network with the following assumptions:

- In network model, sensor nodes are located within a simulation area with corresponding radius *R*.
- This model is defined where every sensor nodes are controlled by CH node.
- The networks comprise the intra and inter cluster communication.
- The packet communication is executed through CH.
- All sensor nodes positions and directions are dynamic but CH is stable.

B. Centralized Cluster Head Selection (CCHS)

The cluster head selection based on Simple Energy-efficient Data Collecting in centralized clustering-task scheduling in WSN technique was already presented by (Kowsalya. R, and B. Rosiline Jeetha, 2019). In this procedure, centralized CH selection technique involves pursued by basic of BS. The BS decides the CH on the source of unstable parameters such as node type, hop count, residual energy, and least distance from the BS, etc. In centralized manner, CH is static for the entire network lifetime. In figure. 3 shows the simulation result of CH formation.

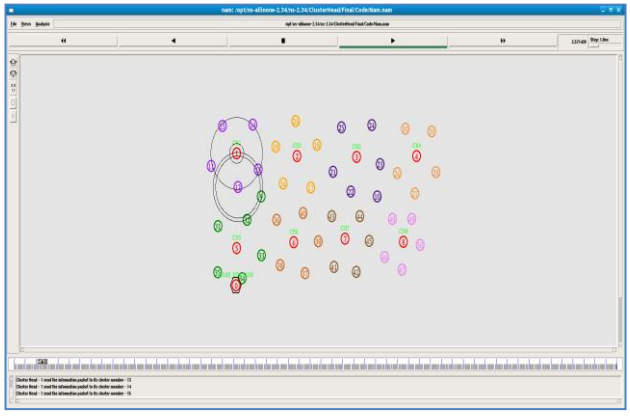

Fig. 3: Cluster Head Assignment

C. Cluster-Based Based Data Aggregation Algorithm

Cluster based data aggregation is distinct as the procedure of shortening and joining sensor data in order to decrease the quantity of data or message communication in the sensor network. With the plan of decreasing power utilization, data aggregation is the inclusive procedure of collecting and routing information during a multi-hop network and developing a data at middle nodes. It efforts to gather the most significant data from the sensors nodes and make it obtainable to the Base Station in an energy efficient method with minimum data latency and least possible bandwidth.

The proposed Centralized approach with cluster based data aggregation method of sensor nodes send data to a suitable Cluster Head. These data are combined by the central node (Cluster header) to decrease the redundancy.

A Cluster Head is chosen in every cluster among different sensor nodes or Cluster Members (CMs). The nodes chosen as a Cluster Heads are dependable for the aggregation method of data received from CM and then broadcast the result to the Base Station. Lastly base station is acknowledged the data from cluster heads, in order to decrease the communication time here the proposed technique is eliminate the redundant data from the overall data and then send to the base station.

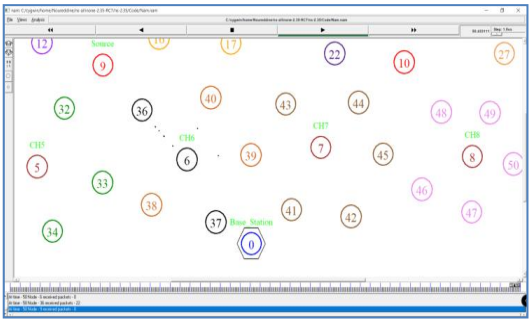

Fig. 4: Data Aggregation

Algorithm 1: Cluster based Data Aggregation

Initialize: Network Size *N*, Preferred Node *P*, Single hop neighbor N_p, Action node *A*, Connected Nodes *m*, Cluster Weight W_{CH}, W_{DCH} denotes dynamic threshold of W_{CH}.

Process

Step 1: Initialize *W*←0; set←0;

Step 2: do

set ← set + P_i;

Ne_set ← Ne_set + P_i + N_{pi} // Neighbor Set

//P_i preferred single of its actions and denoted as P_j

//Automatically P_j is actived, set P_i to P_j

until (Ne_*set* ≠ N && *P_i as possible actions*)

Step 3: set ← set + P_i; // *Updated Initial and Neighbor set*

Ne_set ← Ne_set + P_i + N_{pi}

Step 4: if (*Ne_set* = N) **then**

CH gathered information

Else if (*Ne_set* < N) **then**

Exploring on *set* and in order to discover the node that has 2 hop neighbor which are not covered in *Ne_set*

End if

Step 5: Repeat process step 2.

Step 6: Calculate the average weight of connected CH and denote it W_{CH}.

Step 7: If ($W_{CH} < W_{DCH}$) **Then**

Return the selected actions of the activated automatically along the CH.

Else

Remove selected actions of the activated automatically along the CH.

End if

Step 8: $m \leftarrow m+1, _{CH} \longleftarrow [(m\text{-}1)\ W_{DCH} + W_{CH}] / m$

Step 9: until (m >= MaxIteration || stopping criteria threshold)

Step 10: end

D. Cluster-Based Routing using Genetic Algorithm

In normal energy controlled wireless sensor networks is huge dimension, it is extremely hard for the sensors to transmit data directly to the BS. In these conditions the sensors can broadcast the packets to neighboring aggregator or cluster and then to BS. So in this network, all sensor nodes are structured in the form of clusters. At this time cluster members (CM) sensors broadcast the packets or messages to CH and there by this CH combined all the data received from CM and then broadcast the concise data to BS. The CH can correspond with the BS either through stretched range communications or multi-hoping throughout further CH's. Thus this procedure outcomes are saving the energy and primarily useful for energy-constrained sensors.

In this proposed method, the data routing process in cluster based centralized hyper round policy is done with genetic search technique has been proposed to discover an appropriate pathway for a sensor node to transmit the packets to the BS. In general, Genetic Algorithm (GA) has been demonstrated tentatively and empirically to be a strong search method. Particularly, cluster based routing optimization system plans that every sensor node must discover a promising path to transmit the data to the BS. The main objective of GA is to exploration the inclusive near-finest resolutions by frequently manipulative the fitness function using examination and utilization techniques. GA is stimulated by the bio-inspired procedures of initialization, assessment, selection, crossover, mutation, and replacement as depicted in Figure. 5.

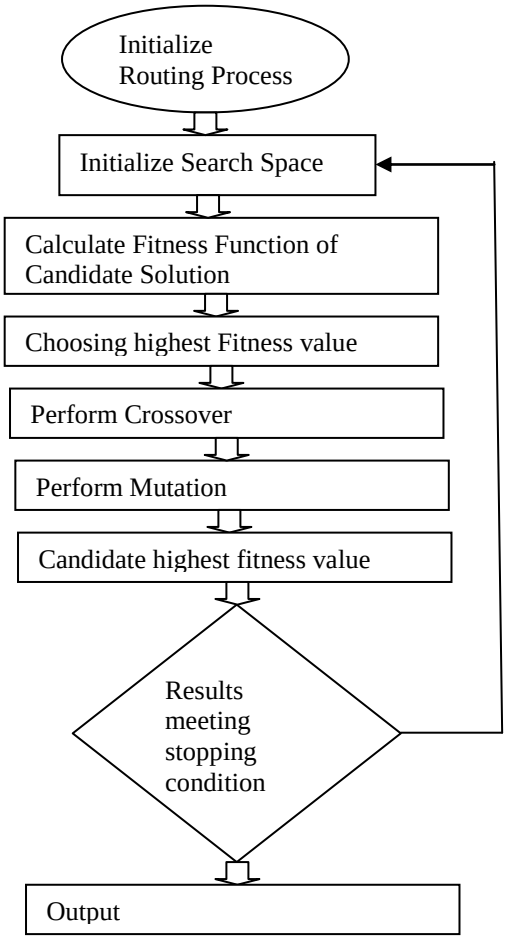

Fig. 5. Genetic Algorithm process flow diagram

The proposed CDARGA performs the following steps,

- **Population:** Signifies that a route from origin node to target node
- **Child:** involves a neighbouring sensor node equivalent to a CM
- **Chromosome:** involves a absolute route from origin to BS
- **Gene:** Correspond to a neighbouring nodes
- **Chromosome configuration:** Be inclined to the whole promising route from origin node to target node.
- **Crossover:** It is a genetic operator that creates 2 novel child chromosomes from 2 parent chromosome.
- **Mutation:** It is to stop diminishing every solution in population into a narrow optimum of resolved issue. This modifies every path of the novel child chromosome with a possibility called alteration rate.

Algorithm 2: CDARGA

Initialize: Number of Sensor nodes; Current residual energy $E_{g;}$ Distance D_t; $CH_{cur} \leftarrow 0$; $HR \leftarrow$ Hyper round;

Process

Step 1: Calculate fitness function using initial energy and distance method by,

$$Energy\ (E_g) = \frac{E_{SN}}{E_{TE}} \quad eqn.(1)$$

$$Distance\ (D_t) = \frac{d_{sch}}{d_{chbs}} \quad eqn.(2)$$

$$E_{HR} = Eg_{group+}N_{HR} \times Eg_{stable} + Eg_{CSP} \quad eqn.(3)$$

$$Fintness\ (F) = E_g + D_t + E_{HR} \quad eqn.(4)$$

Where, D_t is the distance, E_g is the rate of the energy, d_{sh} is the distance of origin sensor node to CH and d_{chbs} is the distance of CH to BS, E_{SN} is the energy of every sensor node and E_{TE} is the whole remaining energy of all sensor nodes within the cluster, *CSP* Clustering-task Scheduling Packer .

Step 2: Apply the routing process of the network to generate the primary gene population

Step 3: In every iteration calculate the fitness value. The amount the paths or links in rising categorize based on the rate of fitness function.

Step 4: If $F \leq 0.8$ **then**

Stop

Else

Utilize Lower amount links to create novel neighboring CM nodes

End

Step 5: For 1: *M* times **Do**

Choose CH

Select path to Source (origin) to BS

Perform mutation probability

End

Step 6: Discover the possible path otherwise go to Step 1

Step 7: end

IV. PERFORMANCE EVALUTION

The performance evaluation illustrates the different constraints and new set up of the proposed algorithm. The proposed method is performed in NS2.34 framework using Fedora operating system based PC with 3.20 GHz, Intel Core i5 processor and 8 GB RAM. The parameter surroundings of the wireless sensor network are as illustrated in Table 1.

Table 1: Simulation Parameters

PARAMETER	VALUE
Number of Sensor Nodes	2-50 in steps of 10
Simulation Area	1000 × 1000 m
Number of Cluster Head	8
Initial Energy	100 Joules
Node Energy	100 Joules
Number of Packets	400

The energy of a node is inspired due to Energy Transmission (ET), Energy Reception (ER), and Event Sensing (ES). Thus common Energy Utilization (EU) of a network is expressed as follows,

$$EU = \sum_{k=1}^{m} \frac{N_j[E_T + E_R + E_S]}{m} \quad eqn.(5)$$

Here $[E_T + E_R + E_S]$ represents energy utilization of 'j^{th}' node (Ni) in the network with 'n' number of nodes.

V. RESULT

The Figure.6 shows that the proposed CDARGA algorithm along with hyper round policy performs low energy consumption when compared with existing Ring partitioned based MAC (RP-MAC) protocol (*Movva Pavani and Polipalli Trinatha Rao*, **2019**) methods. The X axis represents number of nodes and Y axis represents the energy consumption.

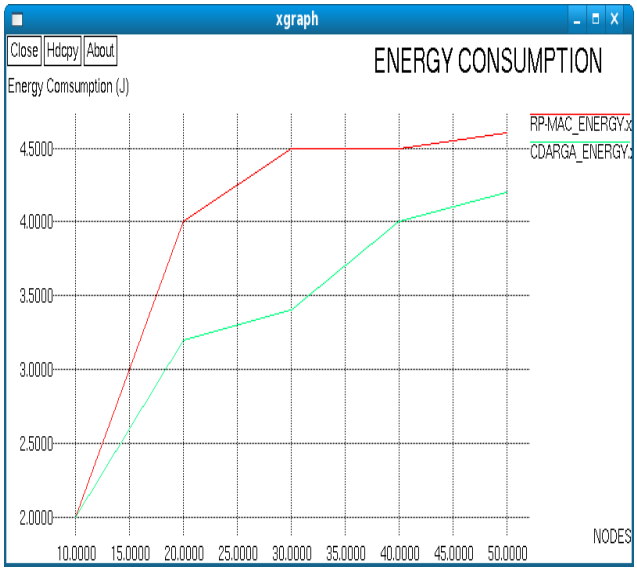

Fig. 6: Energy consumption.

The throughput of the network is given in the figure 7. It shows that the proposed CDARGA algorithm performance is High than the existing RP-MAC (*Movva Pavani and Polipalli Trinatha Rao*, **2019**) method.

The graph represents the performance of network, the *Y* axis contains the average throughput and the *X* axis contains the number of nodes in network experimentations.

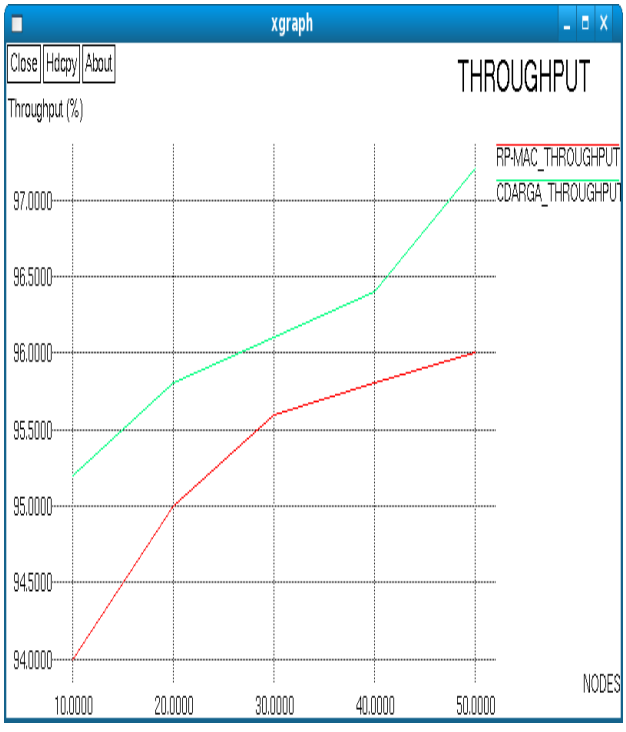

Fig. 7: Analysis on Throughput

VI. CONCLUSION

In the proposed paper analyzed the Cluster-Based Data Aggregation Routing with Genetic Algorithm (CDARGA) with Energy Consumption in a hyper round concept. The Genetic Algorithm is a heuristic routing algorithm resolves several optimization issues in transferring the data. With choosing an appropriate fitness function, CH is selected in every round. Every CH transmits a packet to the nearest Cluster Head in a sequence method to calculate a proper pathway to achieve at the Base Station as well as internal clustering of cluster members. The cluster overhead reduction was achieved by the data aggregation which could prolong the energy of the sensor. The simulation model results confirm that the proposed CDARGA algorithm executes better than RP-MAC protocol and continues as longer network lifetime.

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