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ENERGY EFFICIENT HIERARCHICAL AGGLOMERATIVE DATA AGGREGATION IN WIRELESS SENSOR NETWORK

A.VIMALATHITHAN[1] , Dr.A.SURESH[2]

[1]Ph.D Research Scholar, Dept of Computer Science, Periyar University, Salem-636011.

[2]Assistant Professor, Dept of Computer Science, Sona College of Arts and Science, Salem – 636005.

E-mail: [1]a.vimalathithan@gmail.com

ABSTRACT

In wireless sensor networks (WSNs), hierarchical organization structures enjoy the benefit of giving flexible and resource-efficient arrangements. To track down an efficient method for creating clusters, this paper uses a proposed Hierarchical Agglomerative Clustering algorithm by proposing an Energy Efficient Hierarchical Agglomerative Data Aggregation (EEHADA) model. EEHADA model for wireless sensor networks has been proposed. This is an energy-efficient clustering algorithm that utilizes hand-off hubs, variable transmission power, and single message transmission per hub for setting up the group. The problem occurs when sensors transmit data; they use energy in transmission, and uploading the data directly to the sink may require long communication ranges and so degrade the energy of sensors. Indirect communication, in contrast, the data is uploaded to the sink via multiple intermediate sensors, which results in short communication ranges and guarantees the energy efficiency of the sensors. The proposed model is compared with the existing circulated clustering algorithms Drain and HAAS. Simulation results show a significant improvement in the average of the proposed model. The proposed model can be implemented in multi domain in any WSN platform.

Keywords: *Wireless Sensor Network, Energy Efficient Hierarchical Agglomerative Data Aggregation, Clustering Algorithm.*

1. INTRODUCTION

One of the principal difficulties of WSNs is cultivating a convention so much that different erratically conveyed sensor nodes act in a helpful and composed way. While each sensor center point needs to help its utility capacity, the entire organization needs balance in resource assignments. Among many proposed network routing protocols for WSNs, different evened out routing protocols remarkably add to structure adaptability, lifetime, and energy adequacy. Different evened out routing protocols have been proposed with different arrangement goals, clustering norms, and principal presumptions. To our best information, all serial clustering protocols are hierarchical procedures. These protocols first structure the upper level of clusters by picking explicit nodes as CHs and, a while later, bundle different nodes into the relegated group. Various algorithms significantly select CHs and force re-clustering with clear conditions. As a rule, erratic or inefficient selection of CHs achieves low group quality. A couple of algorithms focus on building smoothed out clusters to avoid low bunch quality, requiring comprehensive organization information.

Different progressive procedures have been proposed in WSN to utilize open resources, especially batteries, efficiently. The goal is to get energy capability and expand the network lifetime. In different evened out the routing, clustering is the most extensively used strategy to achieve these targets. Clustering plans by setup clears out the reiteration. Routing in distant sensor networks is more troublesome than remote networks like convenient offhand networks or vehicular exceptionally named networks, as WSN has resource prerequisites. Thus, to address the troubles in WSN, new routing parts are being made, keeping in view the application essentials and the secret organization plan. Due to continuous topological changes in the organization, staying aware of courses is a huge issue, and keeping in mind that perhaps not meticulously dealt with may achieve high energy utilization. Different routing strategies have been introduced to restrict energy utilization and drag out the general organization's lifetime.

This work's major commitment is to outline existing energy-efficient different evened out clustering moves close, and, by network structure, they are requested into bunch-based and matrix-based strategies. The essential spotlight is on bunch advancement, group head selection, group redesign, and bunch head reselection, thinking about energy utilization and its effect on the general organization's lifetime. Besides, the benefits and hindrances are inspected, and an organized blueprint has attracted the interest of both different evened out ways of managing help subject matter experts and experts to pick the most fitting technique considering the application essential. It merits zeroing in here that this work is based solely on progressive energy-efficient clustering protocols.

The group game plan process and the number of clusters are essential for clustering protocols. The clusters should be even, and the number of messages exchanged during the bunch plan should be restricted. The unpredictability of the algorithm should increase straightly as the organization creates. Bunch head selection is another critical test that straightforwardly impacts network execution. The best center should be picked so the organization's dependability period and organization lifetime, as a rule, should be expanded. In most strategies, CH selection relies upon a couple of limits, for instance, energy level and the region of the center. Information all out is performed on the recognized information got by CH from part nodes; keeping that in mind, it is remembered to be an urgent arrangement challenge. It should be considered that the arranged clustering algorithm should have the choice to manage different application essentials, as WSN is application subordinate. Another crucial variable is to guarantee that the arranged algorithm is adequately secure and can be used in applications where information is fragile, for instance, a strategic application or prosperity noticing.

2. EXISTING METHODOLOGY

1. LEACH

Rahmadhani, M. A., (2018) [11] et.al proposed Energy Consumption and Packet Loss Analysis of LEACH Routing Protocol on WSN over DTN. Low Energy Versatile Clustering Hierarchy (LEACH) is one of the clustering steering protocols for Wireless Sensor Networks (WSN). LEACH algorithm is partitioned into the arrangement stage and the steady-state stage. In a bustling organization, LEACH Steering has a high parcel misfortune. We want Defer Lenient Organization (DTN) to tackle the issue. DTN is a high level of engineering that allows communication in outrageous circumstances like a bustling organization. In this examination, LEACH-WSN changes to enhance the organization by adding DTN to LEACH WSN over DTN. The LEACH-WSN change by giving a group layer to keep the data temporarily. Recreation is performed to test the performance of LEACH-WSN over DTN on changes in the number of nodes and support limit. In changing the number of nodes, LEACH-WSN over DTN can further develop performance by diminishing bundle misfortune esteem by half of LEACH-WSN parcel misfortune.

2. Energy and Distance Based Clustering: An Energy Efficient Clustering Method for WSN (EDBC)

Mehdi Saeidmanesh et al. [8] proposed a protocol that considers the residual energy and distance from the base station of each node in the cluster head selection process. In the event that all sensor nodes are conveyed in a large region, a few clusters are a long way from the base station, and others are near the base station. This can prompt an extraordinary distinction in transmission energy dissipations that the nodes use to transmit data to the base station. This creator has separated the entire organization landscape into concentric round segments around the base station. The quantity of group heads in each section is not the same as different segments concerning distance from the base station. The bunch head political decision probability in nearer segments is more than in far off segments, and the number of group heads in these segments is more.

3. A Density and Distance Based Cluster Head Selection Algorithms in Sensor Networks (DDCHS)

Kyounghwa Lee et al. [6] proposed an algorithm to choose the cluster head in light of the thickness and distance of sensor nodes in the sensor network. The cluster region is separated into two opposite widths to get a four-quadrant, then, at that point, in every quadrant, select the following cluster head by the gathering's node thickness and distance from the cluster head. The creator has analyzed LEACH and Notice protocols by working out the energy consumption for communication of once between entire nodes and cluster head by the position of the cluster. This protocol shows preferable execution over LEACH and Regard. It is a unified methodology and requirements the area of every node.

4. Fault Tolerant Energy Efficient Distributed Clustering for WSN (FEED)

M. Mehrani et al. [17] proposed an energy-efficient clustering technique, which selects reasonable cluster heads by utilizing energy, thickness, centrality and the distance between nodes for making a cluster. The creators have taken a boss node for each cluster head which is to be its substitution when the cluster head comes up short. This property causes an expansion in the network lifetime and assists the network with being shortcoming open-minded. It requires the worldwide position of sensor nodes, and message communication is vast in cluster head selection, which is exorbitant and energy consumable separately.

5. HAAS

An, M. K., Cho, H., & Chen, L. (2018). [1] Hierarchical Agglomerative Aggregation Scheduling in Directional Wireless Sensor Networks. The MLAs problem centers on accomplishing information assortment designs that satisfy the two favorable properties: least latency and no effects. Most existing figures explored the problem under the uniform power model with no power control in omnidirectional WSNs. We look at it under a more sensible non-uniform power model with power control in directional WSNs. To the extent that we might be aware, keeping an eye on the MLAS problem in directional WSNs under a non-uniform power model with power control is unprecedented. Unlike existing works that plan nodes considering trees, our proposed booking algorithm does not make trees. Specifically, our algorithms use staggered separation and overcome steps, where a whole network is divided at least once or two more unassuming networks, and the more humble networks are deliberately agglomerated to achieve the two favorable properties. We assess the display of the proposed algorithm to the extent of latency and power level for reenacted networks.

6. Multi-Sensor Data Fusion for Cluster-based Data Aggregation (MSDCA)

Redhu, S., & Hegde, R. M. (2019) [12] proposed Multi-Sensor Data Fusion for Cluster-based Data Aggregation (MSDCA)I n IoT Applications. The clustering of gadgets is critical in improving energy-efficient wireless sensor networks for IoT applications. This paper proposes an intelligent clustering procedure that utilizes the multiple sensor modalities of contraptions to foster an energy-efficient data collection protocol. It packets the contraptions of a network into different clusters using an interweaved resemblance matrix. The proposed method wires sensor modalities like radio, acoustic, and light to gain good resemblance coefficients. The heaps for the blend of different modalities are handled using the showing blunder and inside a conviction stretch. The proposed clustering procedure is made using the Hierarchical Agglomerative Clustering structure. The display of the proposed methodology in cluster-based data total is evaluated for various sensor networks. Experimental results frame the significance of the proposed multi-sensor data-based clustering plan in energy-efficient data collection over IoT networks.

7. Improved Agglomerative Levels K-Means Clustering Algorithm

Jiankun, Y., & Jun, G. (2014). [4] An Improved Agglomerative Levels K-Means Clustering Algorithm. Further created Agglomerative hierarchical clustering algorithm does not need pre-end conditions, yet considering Segment 2 edge regard, by computing conglomeration hierarchical clustering algorithm clusters' distance between any two classes, and differentiated and limit regard chooses if to end the algorithm. Despite the way that, to a certain, it can conquer the absence of existing conglomeration Hierarchical clustering algorithms, its time intricacy of greater fame is at this point not gotten to a higher level. K-implies algorithm is fundamental and efficient, and time intricacy is not high yet needs to pre-set the hidden cluster places and cluster number of clusters. Considering this, solidifying the prevalent Agglomerative hierarchical clustering algorithm and K-implies algorithm, the two reduce the hierarchical clustering algorithm's time intricacy and beats the K-implies algorithm's hidden cluster habitats selection tricky issues.

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8. Emblematic aggregation approximation

Jin, S., Zhang, Z., Chakrabarty, K., & Gu, X. (2019) [5] Hierarchical Symbol-based Health-Status Analysis using Time-Series Data in a Core Router System. To guarantee high dependability and speedy mix-up recovery in business place switch frameworks, a well-being status analyzer is fundamental for screening the different components of focus switches. In any case, ordinary wellbeing analyzers need to store a ton of undeniable data to recognize wellbeing status. The limit essential ends up being prohibitively high when we attempt to do long stretch wellbeing status assessments for innumerable focus switches. We portray the arrangement of a picture based wellbeing status analyzer that at first encodes, as a picture succession, the long perplexing time series accumulated from different focus switches and a while later proposes the picture grouping to do a wellbeing assessment. The emblematic aggregation approximation (SAX), 1d-SAX, moving-typical based design approximation, and non-parametric emblematic approximation depiction methods are executed hierarchically to encode complex time series. Hierarchical Agglomerative Clustering and sequitur rule exposure are completed to learn huge overall and close-by models. Three classification methodologies, including a vector-space model-based approach, are then used to perceive the well-being status of focus switches. Data accumulated from many business place switch frameworks support the proposed well-being status analyzer.[1 – 17]

3. PROPOSED METHODOLOGY

Plan to foster an Energy Efficient Hierarchical Agglomerative Data Aggregation (EEHADA) Component in WSN for expanding the data aggregation exactness and network lifetime. In the EEHADA component, the sensor nodes in WSN are split into structure many clusters utilizing Hierarchical Agglomerative Data Aggregation (HADA) Algorithm. Each cluster has one cluster head and many sensor nodes. The node with higher energy is selected as the cluster head. The cluster head totals the data from all sensor nodes in a cluster. After data aggregation, the cluster head from one cluster sends the gathered data to the cluster on top of the nearby cluster and, lastly, shipped off the sink node (for example, the data aggregator node). This thus assists with lessening the routing time. Exploratory assessment is done on data aggregation precision, energy consumption, and routing time regarding the number of data packets.

Figure 1: Workflow of the proposed method

WSN are split into form many clusters

The proposed Energy Efficient Hierarchical Agglomerative Data Aggregation (EEHADA) model, variable, is a very much distributed clustering algorithm where the sensor nodes are sent haphazardly to detect the objective climate. The nodes are divided into clusters, with each cluster having a CH. The nodes send the information during their Time-Division Multiple Access (TDMA) timeslots to their separate CH, which melds the data to avoid excess information through data aggregation.

Hierarchical Agglomerative Clustering

The hierarchical Agglomerative Clustering algorithm is a conceptually and numerically straightforward clustering method for data examination. It can give excellent portrayals and perceptions of the potential data clustering structures, mainly when genuine hierarchical

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connections exist in the data. We proposed six-step clustering to generate appropriate clusters to apply the Hierarchical Agglomerative Clustering algorithm in WSNs.

Obtain the input dataset

An info data set for Hierarchical Agglomerative Clustering is a component-attribute data matrix. Components are our desired nodes to bunch considering their similarities. Nodes trade Hi messages and acquire neighbor nodes' attributes. Attributes are the properties of the components, like the area of nodes, the RSS, the availability of nodes, or different features. The information data set can be classified into quantitative and subjective data.

Execute the Hierarchical Agglomerative Clustering algorithm

Subsequent to developing the resemblance matrix, the Hierarchical Agglomerative Clustering algorithm over and over distinguishes the minimal coefficient in the resemblance matrix and executes the clustering algorithm to dole out the nodes into a "tree". Each step incorporates consolidating two clusters and updating the resemblance matrix. Updating the resemblance matrix is a significant stage, and different algorithm methods can be taken. There are four principal sorts of the Hierarchical Agglomerative Clustering algorithm methods

Cluster Head Selection

At first, in each cluster, one of the nodes with moderately higher residual energy expects itself as a Temporary Cluster head (TCH). It makes an impression on its part nodes, like this, assembles their residual energy and NID (node personality) during their TDMA timeslots. It contrasts its residual energy and those of cluster nodes' and assumes it finds any node with higher residual energy, and TCH moves its CH job to that specific node. Consequently, CH gets allocated. The CH sends a single message to the part nodes mentioning their residual energies and NIDs. Thus, the nodes send their residual energy and NID to CH during their TDMA timeslot; pointless transmissions are removed, lessening power utilization and delaying the network lifetime.

The clusters are arranged in concentric layers, and the sensor nodes will use messages in the packet and the following equation to calculate the bound B_K of the K^{th} layer, where K=1, 2, L_T.

$$B_k = b_{k-1} + R_{COM\ M}$$

Where b_{K-1} is the average distance between CH and the cluster member in the K-1th layer, L_T is the total number of layers in the cluster. Here b_{K-1} is expressed as,

$$b_{k-1} = \sqrt{\frac{B_{k-1}^2 + B_{K-2}^2}{2}} \quad (4)$$

The cluster members will utilize the received signal strength indicator (RSSI) and the link quality indicator (LQI) of the CH to appraise their distances from CH and works out their separate layers. Variable power can be utilized in this manner for transmitting data from nodes to CH as well as the other way around.

```
Cluster head selection Algorithm
Symbol Definition
ID_n : Node id
CH_id : Cluster ID
R_m : Resemblance Matrix
Min_cof : The minimum coefficient in the R_m
C_m : The number Cluster member in a cluster
Procedure Set up R_m          > information exchange with neighbor
CH_id ← ID_n                  > self forms a singleton clusters
Send hi message to one-hop neighbors
Keep listing to neighbors
Receive hi Message
Establish R_m
End procedure
Procedure Execute EEAHADA
while M_c < Threshold do
If D_n == CH_id . Then.
 M_c minimum value in R_m
CH_M ← CH_ID with M_C
if CH_ID < CH_m then
Send INVITE message to CH_M
end if
end if
  Receiving message
if Received INVITE message then
if CH_M = Sender CH_id, then
send CONFIRM message
CH_id ← Sender CH_id
else
Send REJECT message
end
Procedure MERGE CLUSTERS.
Merge two clusters
Combine neighboring information of two clusters
Update R_m by using chosen method
Broadcast INFORM message
end procedure
```

The cluster head aggregates the data from all sensor nodes in the cluster

A CH will meld all incoming data parcels received from the sensor nodes to avoid redundant data transmission of exceptionally correlated data. The combined data is then sent to hand-off nodes. When a node bites the dust or

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does not send the data during its opening, it is viewed as inaccessible and can be skipped from the data assortment process. The aggregation is performed by spatial connection estimation by estimating the offset between the two sensor readings. On the off chance that the blunder is inside the decent reach, the two readings are correlated.

The collected data is sent to the transfer nodes, which like this course, the data to BS either straightforwardly or by forwarding through other hand-off nodes. Contrasted with the existing algorithms, EEHADA has three distinguishing features. In the first place, in many clustering algorithms, CH forwards the data to BS straightforwardly, which prompts power wastage, yet in EEHADA, CHs does not advance the data to BS. All things being equal, CH forwards data packets to transfer nodes, and these richer-resourced hand-off nodes courses data to BS accordingly, and impressive energy utilization can be decreased. Second, EEHADA utilizes variable transmission power. Nodes closer to CH utilize lesser transmission power, and nodes far away from CH utilize additional power for transmission from nodes to CH or the other way around, which can diminish significant power. Third, CH sends one message for each cluster node; however, many existing algorithms communicate a few messages for cluster setup.

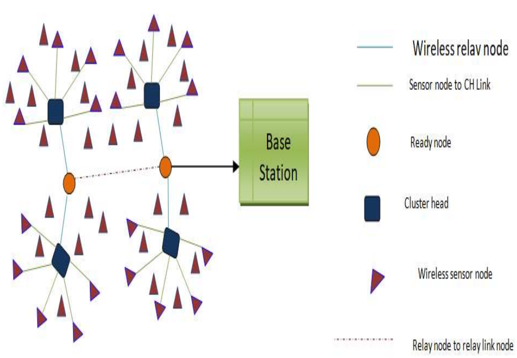

Figure 2: An articulation of the EEHADA clustering algorithm

The functionality of Relay Node:

A transfer node is just a node that is wealthy in resources like batteries, memory, etc. In the proposed algorithm, the transfer nodes perform just the data routing to BS either straightforwardly or forward through other hand-off nodes. In EEHADA, the fundamental truth to be considered is that the transfer nodes closer to BS require more transmission power as they need to advance every one of the data packets from the previous hand-off nodes.

Relay node Algorithm

```
if node is a TCH
send Request for R_E and N_ID to cluster nodes
else if
Wait for request for R_E and N_ID
Else R_E node is highest
Assume CH
Wait for Join request message from CH
end
If Node Have higher R_E
Create TDMA schedule
Scan cluster members (t=0)
Else
Remain as cluster member
Wait for schedule from CH (t=0)
end
If particular nodes timeslot is work
Send data
Aggregate data
Send to reply node
Forward to BS
Else
Go to sleep
end
```

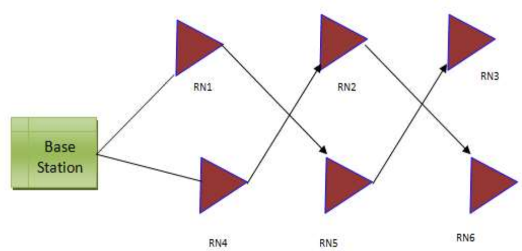

Figure 3: The concept of relay nodes in EEHADA

The power consumption of a relay node is proportional to its location and the number of relay nodes around it. If the power consumption of the sensor node is $(\lambda et + \sigma)$, the relay node density at a distance 'z' meters from BS is given by,

$$p_r(z) = \frac{w(z)}{(\lambda e_t+\sigma)} \qquad (2)$$

where parameter $\rho_r(z)$ is the relay node density at a certain distance 'z' meter from BS, w is the width of the sensing field, e_t is the energy required to transmit unit data, λ is the data gathering rate of each sensor node, and σ is the power consumption of each sensor node spent in sensing. Hence in VEEC, based on $\rho_r(z)$, more relay nodes are placed in the region nearer to BS, and few relay nodes are placed in regions far away from BS.

In EEHADA, the relay nodes are static and forward the data to BS. Each relay node has a similar starting energy and transmission range. The Macintosh protocol places the radio of the relay node in rest mode if it is not the transmitter or collector of the packet. The relay nodes are partitioned into various zones beginning from the BS. The relay nodes in the zone closer to the BS need to relay more packets; thus, more relay nodes must be set closer to the BS. The zone farther from BS requires fewer nodes as there is a requirement for just a little data to be sent. Likewise, the power consumption of the relay nodes closer to BS will be more contrasted with those far away from BS. The BS will occasionally communicate a signal message to the relay nodes. The relay nodes utilize the RSSI and LQI of the reference point message to appraise its distance from BS to maintain the transmission power.

4. Experiment Result

Accuracy

Table 1: Comparison table of Accuracy

Number of packets	LEACH	HAAS	Proposed EEHADA
50	66.94	74.91	87.01
100	69.66	71.77	90.87
150	74.12	67.93	92.48
200	79.09	68.05	95.23
250	86.38	65.39	97.52

Comparison table 1 of Accuracy Values explains the different values of existing LEACH, HAAS, and proposed EEHADA. While comparing the Existing algorithm and the proposed EEHADA provides better results. The existing algorithm values start from 66.94 to 86.38, 65.39 to 74.91, and the proposed EEHADA values start from 87.01 to 97.52. The proposed method provides excellent results.

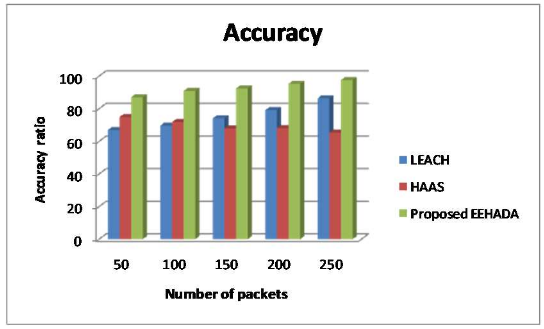

Figure 4: Comparison chart of Accuracy

Figure 4 shows the comparison chart of Accuracy demonstrates the existing LEACH, HAAS, and proposed EEHADA. X axis denotes the number of packets, and the y axis denotes the Accuracy ratio. The proposed EEHADA values are better than the existing algorithm. The existing algorithm values start from 66.94 to 86.38, 65.39 to 74.91, and the proposed EEHADA values start from 87.01 to 97.52. The proposed method provides excellent results.

Routing time

Table 2: Comparison table of Routing time

Number of packets	LEACH	MSDCA	Proposed EEHADA
20	0.625	0.836	0.721
40	0.663	0.874	0.654
60	0.706	0.905	0.598
80	0.728	0.941	0.623
100	0.752	0.962	0.591

Comparison table 2 of Routing time Values explains the different values of existing LEACH, HAAS, and proposed EEHADA. While comparing the Existing algorithm and the proposed EEHADA provides better results. The existing algorithm values start from 0.625 to 0.752, 0.836 to 0.962and the proposed EEHADA values start from0.591 from 0.721. The proposed method provides excellent results.

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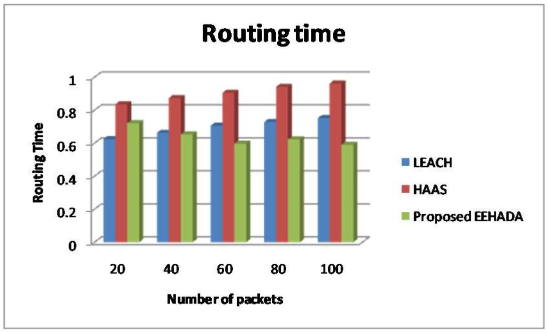

Figure 5: Comparison chart of Routing time

Figure 5 shows the comparison chart of Routing time demonstrates the existing LEACH, HAAS, and proposed EEHADA. The X axis denotes the number of packets, and the y axis denotes the Routing time. The proposed EEHADA values are better than the existing algorithm. The existing algorithm values start from 0.625 to 0.752, 0.591 to 0.721, and proposed EEHADA values start from 0.836 to 0.962. The proposed method provides excellent results.

Energy consumption

$$F - Measure = (2 * Precision * Recall) / (Precision + Recall)$$

Table 3: Comparison table of Energy consumption

Number of packets	LEACH	HAAS	Proposed EEHADA
100	0.98	0.89	0.72
200	0.96	0.85	0.70
300	0.95	0.86	0.67
400	0.93	0.84	0.64
500	0.92	0.82	0.61

Comparison table 3 of Energy consumption Values explains the values of existing LEACH, HAAS, and proposed EEHADA. While comparing the Existing algorithm and the proposed EEHADA provides better results. The existing algorithm values start from 0.82 to 0.89 and 0.61 to 0.72, and the proposed EEHADA values start from 0.92to 0.98. The proposed method provides excellent results.

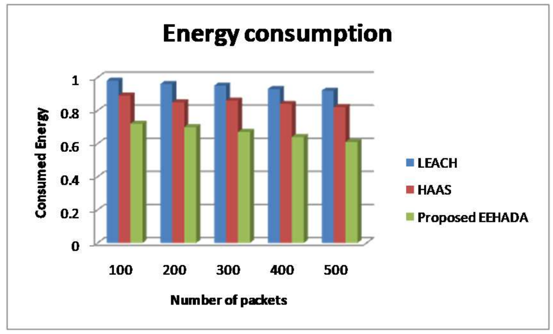

Figure 6: Comparison chart of Energy consumption

Figure 6 shows the comparison chart of Energy consumption demonstrates the existing LEACH, HAAS, and proposed EEHADA. The X axis denotes the number of packets, and y axis denotes the Energy consumption. The proposed EEHADA values are better than the existing algorithm. The existing algorithm values start from 0.82 to 0.89 and 0.61 to 0.72, and the proposed EEHADA values start from 0.92to 0.98. The proposed method provides excellent results.

5. CONCLUSION

The problem with Data aggregation cost and the total link cost is high in existing models the excessive route overlapping problem could cause the transfer of the data along longer paths and an unbalanced data load. Energy Efficient Hierarchical Agglomerative Data Aggregation has been proposed. In Indirect communication, the data is uploaded to the sink via multiple intermediate sensors, which results in short communication ranges and guarantees the energy efficiency of the sensors; for cluster arrangement, variable transmission power, and hand-off nodes, the algorithm EEHADA has been planned to shape efficient clusters in a wireless sensor organization. The algorithm is broken down, the performances are contrasted, and the two existing clustering algorithms Drain and HAAS. It is seen that the proposed appropriated clustering algorithm has shown a lot of progress in communication energy over the two very much assessed algorithms. This research addresses the issues in the existing models. The performance of the proposed algorithm shows a radical improvement in the all-out energy of the wireless sensor system. In any case, the proposed algorithm can enormously minimize the node passing rate and in this way have a drawn-out directing time.

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