A Minimum Spanning Tree-based Energy Efficient Clustering in WSNs for Smart Cities

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***Abstract*— Over recent decades, both scientific and commercial societies have been seeing the progress of wireless sensor networks (WSNs). Clustering is the most common form of growing WSN lifetime. The optimal no. of cluster heads (CHs) & structure of clusters are the main problems in clustering techniques. The paper focuses on an efficient CH preference mechanism that rotates CH between nodes amid a greater energy level than others. OrigINAl energy, residuAl energy As well**

As the optimum vAlue of CHs Are Assumed to be used by the Algo for the choice of next cAtegory of IoT-cApAble network cluster heAds including ecosystem control, sMArt cities, or devices. The upDAted version of K-medium Algo k-meAns++ displAys stronger perforMAnce thAn R-LEACH protocol SiMULAtion AnAlysis. MeAnwhile, A minimum spAnning tree nAmed BellMAnford Algo is Also constructed to estAblish the connection between the nodes for finding the shortest And secure pAth for DAtA trAnsmission hence resulting in FAster DAtA sending And receiving process.

Keywords— WSN, IoT, CH selection (CHS), ResiduAl energy (RE), Lifetime, Energy-efficient (EE).

I. INTRODUCTION

The IoT is a system of interrelated autonomous items, wireless sensors, or individuals that can exchange data independently through the network. Varied studies forecast a massive IoT demand from 157B dollars in 2016 to 457B dollars by 2020. Types of applications using the internet of things technologies include transport and distribution, smart machines, smart supply chains, and smart towns, electric vehicles, the automotive economy, or smart retail. [1].

Wireless sensor networks (WSNs), which serves as the digital skin or introduces virtual layers where real-world knowledge can be interpreted by the computer machine, is of significant importance to achieving the IoT dream. WSNs consist of sensors that can gather environmental data independently.

WSNs are ad hoc technology for network surveillance in military applications that appear more than 20 years ago[2]. WSNs frequently comprise huge no. of sensor nodes or actuators (in short nodes describe) that are mainly resource-constricted but may also link to other network nodes for data transmission. In addition to its potential roles as relay or data fusion nodes, the primary role of every node is to track the atmosphere through on-board sensors. The router to transmit neighbor data to sink or Base station (BS) may be applied by each node. BS(s) are applied to process data nearby or to send data to remote machines through the network gateway.

Sensors can create a vast amount of data & have heterogeneous capabilities including computing capacity, memory, and connectivity. If all nodes are identical, for example, they have the same equipment or the same rate of transmission; the WSNs are referred to as homogenous. A non-homogeneous WSN is considered heterogeneous. Devices are usually operated by batteries; it is therefore very necessary to capture WSN data in an energy-efficient manner. Figure 1 illustrates how sensor nodes are installed in a wireless network [3].

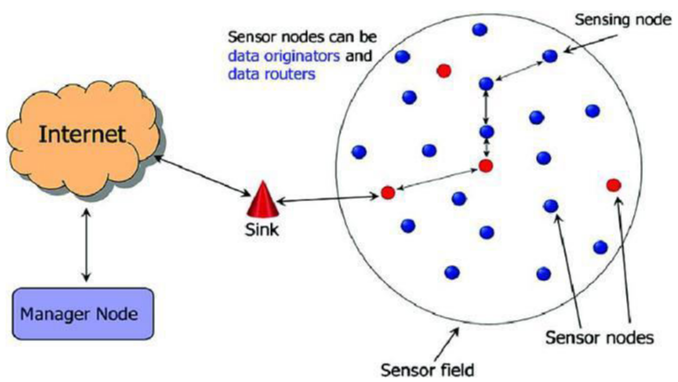

Figure 1. Architecture of WSN

Clustering has been suggested by the scientific district to collect data from WSN and is one of the energy-efficient alternatives. It creates a variety of clusters. There are a variety

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of nodes with participants CH in every cluster. It gathers data as of its participants (communication inside cluster). To order to send data to unify BS CHs collaborate CHs).

II. LITERATURE REVIEW

The LEACH [4] is revolutionary routing protocols (RPs) that brought the concept of clustering in WSN. LEACH is the best way to do so. In comparison to other clustering protocols, LEACH uses the probabilistic method using residual power for cluster preference. Both cluster heads may interact explicitly with BS, i.e. there is no multi-hop contact. When a node is selected as CH, in the next election of a cluster, it cannot assume the same position. LEACH proposes a regular CH rotation and grouping of data at each CH.

The clustering protocol HEED [5] creates the same size clusters i.e. that have the same size range. The HEED algo consists of (1) clustering & (2) network processing. through clustering time, CHs are the rest of energy & the nodes of members enter the nearest CH.1 Data messages are forwarded by members to the BS during the network service process. Overtime is replicated in the clustering and network processes stages. HEED typically stops CHs from being two nodes within the same transmission spectrum.

The sensor nodes near the BS, as described in [6], deplete their power faster in respect of distant nodes. This topic is recognized as the question in the hot spot. Indeed CHs near BS have advanced intercluster communicative (explicitly, relay traffic among CHs) when all CH's have the same amount of inter-traffic average contact (i.e. traffic within a cluster).

DWEHC is an EE distributed clustering protocol (DWEHC)[7] for WSNs focused on equivalent size clustering. The multi-hop transfer in the clusters optimizes intra-cluster connectivity. DWEHC is performed independently by all sensor nodes to assess if it is a CHs or a node. The forming step of DWEHC is focused on the topology of HEEDs. The resultant configuration of the clusters is compatible and increases network operation.

One of the early solutions for WSNs is the EE Unequal Clustering (EEUC) algo [8]. EEUC is focused on assumption that while CH exists in places far from BS, a broader classification will be used, a greater community size should be used, whereas regions nearer to BS should be occupied by a large number of minor clusters. This strategy would decrease the transparency pressure on CHs close BS and the energy trouble or the issue of the hot spot.

Unequal HEED clustering algos[9] is a clustering technique unprecedented by WSNs. The concept of the EEUC protocol is introduced into the HEED by UHEED to create clusters of unequal scale. Based on the distance from the BS scale of a cluster CH. difference between CH & BS, larger their strategic power. It means that clusters further from BS have a smaller range than clusters near to BS. UHEED eliminates the issue of hot spots & boosts network longevity relative to HEED & LEACH.

Rotated Unequal HEED [10] utilizes a non-equal-size clustering strategy, which not only fixes the question of a hot spot but also increases the longevity of the network. The RUHEED comprises three steps involving the choosing of CH, design of clusters, & rotation of CH. HEED is applied to prioritize CHs depended on their excess energy & contact prices. To create unprecedented clusters, the EEUC concept that is focused on BS-SN distance is applied. New CH chooses the nodes with the lowest energy at the CH rotation stage and designates this explicitly as the next head of the cluster.

ER-HEED[11] is an improved HEED efficiency clustering protocol by incorporating the CH position turning within the clusters. ER-HEED consists of 3 stages: CHS, HEED cluster formation as well as CH rotation. Like RUHEED, CHs designate following CHs with the highest energy residual. principle of CH selection reduces the amount of cluster election results within member nodes. Just when one sensor node absorbs its energy can HEED CH be selected absolutely.

DEEC (distributed EE clustering algo for heterogeneous WSNs) [12] is a protocol of the same scale. DEEC CHS is based on the assumption that a mixture of residual sensor node energy as well as total network energy is calculated. The CH feature rotates among sensor nodes because of its residual energy. The energy use is consistent across the network. Cluster heads would most definitely be chosen as sensor nodes with the lowest residual and lowest initial energy.

III. RESEARCH METHODOLOGY

Two methods, the free space interface ef d2 as well as the multipath fading, were used for energy consumption analysis emd4 pattern. The distance among the transmitter & receiver is base on all types. the figure displays the radio energy model.

2. Then the radio uses a k- packet to relay it at distance d:

(,) = _ ( ) + _ (,)

*+**2

*

+**4

() = _ () = k*

E_{TX}: energy usage needed for the transfer of packages. E_{elec}: is electronic energy that relies on filtering, digital coding modulation, or signal amplification.

E_{RX}: energy usage needed for the reception of packets. d0: is equivalent to the multipath fading sequence square root of the EDA separating the free space model.

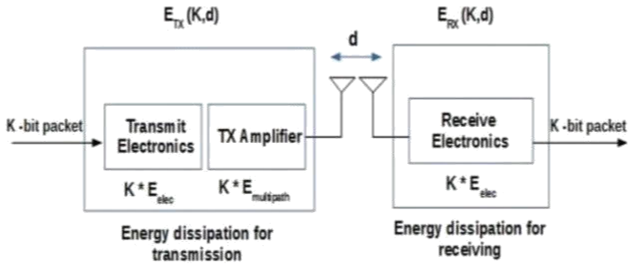

Figure 2 Radio Model

PROBLEM FORMULATION

Three specific problems may be outlined in the disadvantages of the LEACH system. The first problem is CH's inaccurate decision. The second issue has emerged since the sensor nodes within each cluster are unequally distributed. For smaller clusters, the energy usage of the sensor nodes is lower than that of a wide cluster. Since the majority of data is sent by the nodes in smaller clusters. In the constant state process, the third problem formalized. Within the growing cluster, all sensor nodes are sent continuously. The transfer has been carried out even though the sensed data is not modified. The three problems are why inefficient energy consumption has fallen. This decrease limits the life of the network.

PROPOSED APPROACH

In the proposed work, we have used a new clustering algo for overcoming the limitations of R-LEACH algo. The new clustering algo is the modification of K-means algo which is hence named K-means++. Further, we have decided a strategy for the cluster head (CH) selection process and later the CH nodes are connected by a minimum spanning tree namely BellmanFord tree algo.

For the k-means clustering algo, k-means++ is an algo for the discovery of the first values (or seeds). The NP-hard k-mean problem is an approximation algo — a way to avoid often weak clustering by standard k-mean algo.

The idea behind this approach is that it is good to spread the k initial Cluster Center (CC): the first CC is selected by random from clustered data points, after which the remaining data points are selected in a probability proportional (PP) to its square distance from most similar cluster centers.

The following is K-Means++ algo:

Step 1 Select a center consistently between the data points. **Step 2** Compute the distance from x to the closest core for every database point x, compute D(x),.
Step 3 Should select a new data point randomly as core by the weighted distribution of probabilities where an item is select by PP to D(x)2.
Step 4 Replicate steps 2 & 3 to pick k centers.
Step 5 That now initial centers, continue with regular clustering by k-means.

Cluster head selection is min distance from sink node & cluster center or higher residual energy. A node having min distance from sink node & cluster center & higher maximum residual energy is considered as CH of the cluster. Later minimum spanning tree is formed for establishing the shortest path between the cluster heads for transmitting data.

Bellmanford Algo: Negative weight edges can at first seem needless, but may clarify other phenomena. Negative weight edges can establish negative weight loops i.e. a loop that reduces the cumulative distance by returning to the same location in figure 3.

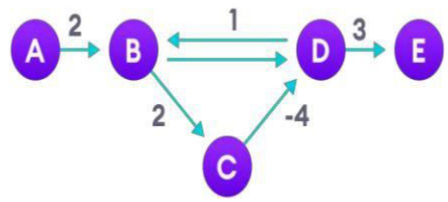

Figure 3: Negative weight cycle

Such a loop can't be identified by other shortest path Algos because they will go through a negative weight process and minimize the path length.

By overestimating the direction from the beginning vertex to all other vertices, the Bellman-Ford algo functions. This then relaxes these calculations iteratively by discovering different forms which are shorter than the already overestimated conduct. This will guarantee that outcome is optimized on all vertices repeatedly.

Step 1 function bellmanFord(G, S)
Step 2 for each vertex V in G
Step 3 distance[V] <- infinite
Step 4 previous[V] <- NULL
Step 5 distance[S] <- 0
Step 6 for each vertex V in G
Step 7 for each edge (U,V) in G
Step 8 tempDistance <- distance[U] + edge_weight(U, V)
Step 9 if tempDistance < distance[V]
Step 10 distance[V] <- tempDistance
Step 11 previous[V] <- U
Step 12 for each edge (U,V) in G
Step 13 If distance[U] + edge_weight(U, V) < distance[V}
Step 14 Error: Negative Cycle Exists return distance[], previous[]

IV. RESULTS ILLUSTRATIONS

Table 1 defines network parameters for the MATLAB simulation of the network model.
The scale of the package is 4000 bits. As seen in Figure, 100 nodes are arbitrarily distributed by BS at the center of the network area. 5.

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Network diameter	100 meters$_2$
Total no. of nodes (n)	100 nodes
Total network energy (E_0)	0.5 J
Energy dissipation: receiving (E_{amp})	0.0013 pJ/bit/m$_4$
Energy dissipation: free space model (E_{fs})	10 pJ/bit/m$_2$
Energy dissipation: power amplifier (E_{amp})	100 pJ/bit/m$_2$
Energy dissipation: aggregation (E_{DA})	5 nJ/bit

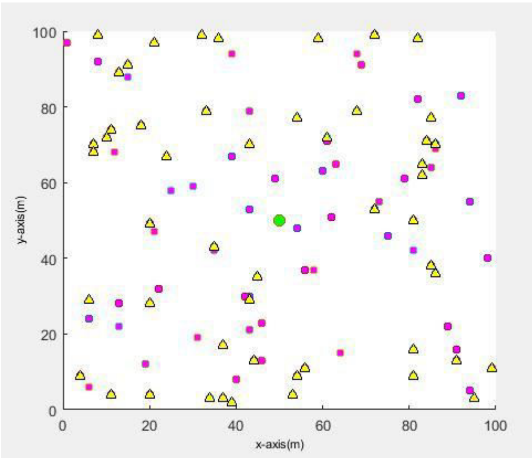

Figure 4. Node deployment

The simulation outcome in Fig.5 & 6 shows network life for both LEACH & K-means++ algos.

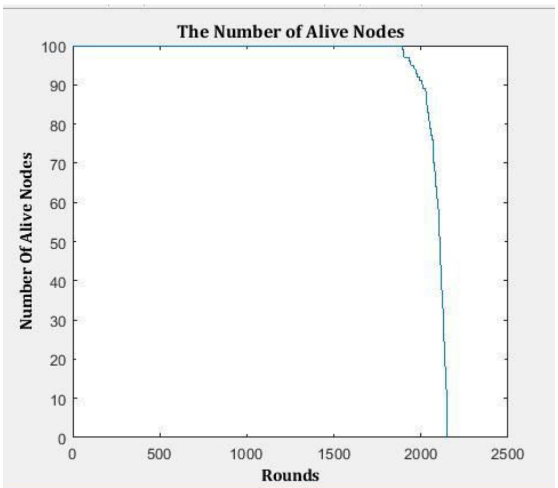

Figure 5 Network lifetime of R-LEACH

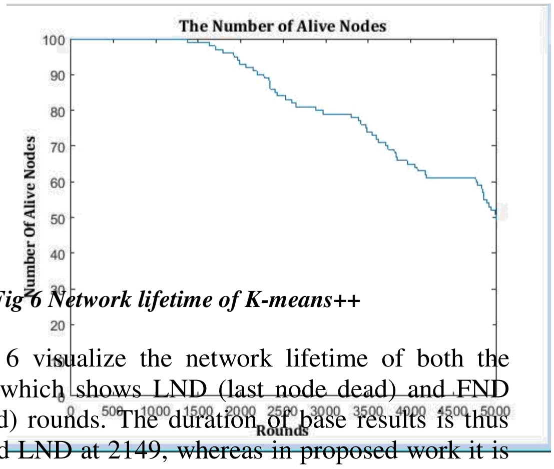

Fig 6 Network lifetime of K-means++

Figures 5 and 6 visualize the network lifetime of both the research work which shows LND (last node dead) and FND (first node dead) rounds. The duration of base results is thus FND at 189 and LND at 2149, whereas in proposed work it is improved with the improvement in the dead node time of nodes. K-means++ has the first node dead at 1370 and last node dead at 5000

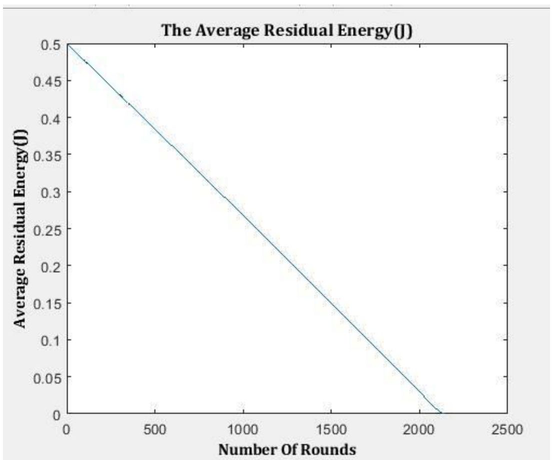

Fig 7 RE of R-LEACH

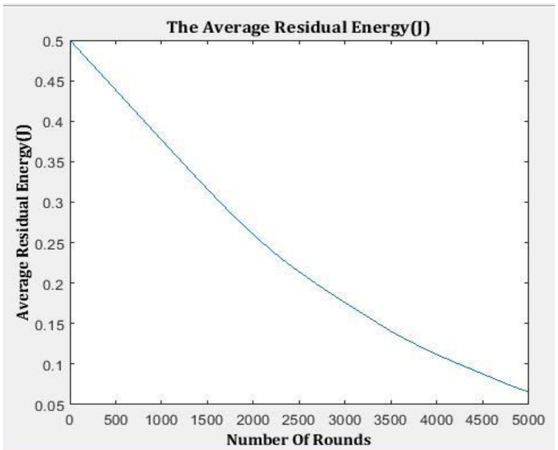

Fig 7 RE of K-means++

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The below figure is the schematic view of tree construction using the Bellmanford algorithm where the sink node is connected with the cluster head node and has constructed a connection with each cluster for the faster routing process.

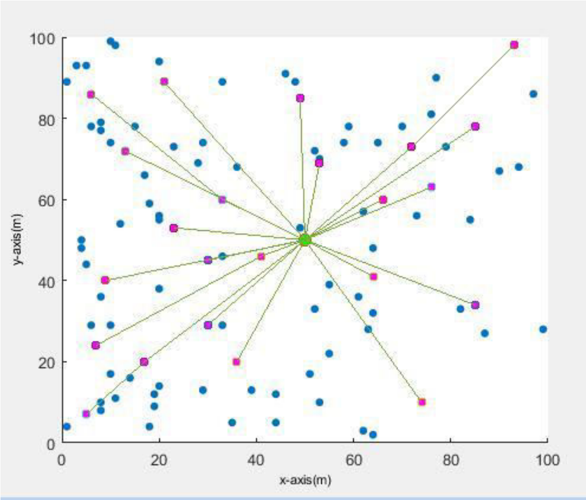

Fig 8 Tree construction using Bellmanford algorithm

R-LEACH consumes residual energy faster than K-means++. As the capacity for KM++ is gradually declining, there are still more rounds of network life. This paper proposes an updated CH selection algo to prolong a network existence by monitoring the energy dissipation of the network. In situations including environmental surveillance, the improved routing mechanism is easily accessible through IoT, because the protocol offers stronger outcomes inhomogeneous networks than LEACH. The findings of the simulation indicate increased network efficiency for metrics like residual electricity, packets sent to BS, output & lifespan. research currently underway may be expanded by exploring more CH selection parameters in the network of mobile nodes that regularly shift location. The theoretical concept may be evaluated for a WSN dependent IoT framework in different practical scenarios.

V. CONCLUSION

Since the design of every WSN routing protocol is limited to various major restrictions, energy or lifetime are very relevant. The target was achieved. It is challenging to use an energy effective routing method to uniformly spread the load throughout the system. From the above results visualizations, we can conclude how the new approach of clustering discovered in this work is more efficient, less time consuming, more power-saving, and having a large duration of network lifetime.

The Bellmanford algorithm established a tree that has evolved new clustering criteria through which we can easily do the routing process and also our data remain secure with this process of clustering. In the future, we can go for a fuzzy-based clustering using a minimum spanning tree.

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