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An Optimized Energy Efficient Clustering and Load Balancing Approach for Multi-Hop Wireless Sensor Network

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ABSTRACT: Wireless sensor network (WSN) includes a package of energy concentrated on the air devices that are interconnected to form a communication system. The performance of the communication system relies based upon the nodes which are operated by battery. The nodes are placed in favorable and hostile environments due to which the lifetime of the network remains fluctuating. Another reason that influences the lifespan of the system model is the rate of data handling that is influenced by the available energy of the nodes. It is proposed an energy-efficient load balancing (EELB) method for harmonizing the advantages of energy efficiency and load handling rate. EELB is specific in handling different traffic rates by measuring the remaining battery power of the nodes to ensure seamless communication and non-overloading energy constraints. It manages the communication of the network by distributing traffic flows predicted on the residual energy and the capacity of the nodes to ensure prolonged link availability. The performance of the proposed methodology is evaluated through simulations graphs using MATLAB and the performance are verified using the criteria: Throughput, Signal received at the base station and the first node dies time.

Keywords: Wireless sensor networks, Energy Efficiency, Clustering, Load Balancing

I. INTRODUCTION

In the pastspans, most of the problems occur within the wired medium of network. Nowadays the wireless medium of network came into existence in order to make the communication a relaxed one. The popular wireless medium of network is Wireless Sensor Network (WSN) [1], as it senses the environmental aspects such as Humidity, Temperature etc., via the sensor nodes. A WSN is a self-organizable network of minor sensor nodes announces within themselves by broadcasting Wireless Sensor nodes are called motes signals, and placement in amount to sense, observe and recognize the physical domain. WSN consist of a many number of sensor nodes, based on the wireless communications each sensor nodes are connected. Every sensor node has the ability of collecting information and transfers it to other nodes [6]. Using the Ethernet network, the data is connected and its information is transferred via multiple nodes with the gateway. The main goals in developing next-generation wireless communication systems are increasing the link throughput (bit rate) and the network capacity [24]. There cognized data by sensor nodes are used as an upcoming reference when there is a necessity to avoid something that goes incorrect in the network. Numerous disputes are related with these sensor nodes such as energy depletion, latency time and overburden of nodes [7]. To conquer these issues efficient clustering routing based protocols are used. WSN sadore excessive usage because of their reduced-cost, limited factor, smooth sensor nodes. They can also be deployed to automate unexciting tasks rather than Nonintervention of Human and hazardous ones of interest, for observing or regulating the region. Sensor nodes has the ability to sense the environment, then the sensed data are moved for processing and the processed data are forwarded to the next nodes, where these all actions are done within the battery of the sensor nodes. To achieve energy efficiency many clustering methods are proposed, HEED is one of the clustering protocols used to achieve energy consumption [10]. There are several characteristic issues such as energy utilization, limited processing capacity, vulnerable atmosphere and the time delay occurs as a maximum with the wireless. Later the sensor nodes are placed in the network, the one with limited energy must wait for the stipulated amount of time without any action [11]. A significant design concern in WSNs is to reduce the consumption of energy by the sustaining external device, internal mechanism and communication protocols. Generally, the wireless sensor networks is sub classified into small networks called cluster. A clustering-based protocol that utilizes randomized rotation of local cluster based station (cluster-heads) to evenly distribute the energy load among the sensors in the network [12]. Every cluster within the monitored area has one efficient node called Cluster Head (CH). Cluster head collects the data from the nodes within the cluster [2]. After this collected data transfer to base station. At the time of data collection and data sending of cluster head there is utilization of node energy. Hence the selection of cluster head after each round is also play important role in the WSN. As transmitting data from the sensor nodes to the base station requires a probabilistic function, in order to make a communication a reliable one. Fuzzy logic is introduced so that the real world entities are maintained. Type 2 Fuzzy Logic (T2FL) is used for the selection of Cluster Head (CH) among the group of clusters [1]. As T2FL is much better situations than the Type 1 Fuzzy Logic (T1FL) in handling the uncertainty. In this paper in addition with the selection of CH using T2FL and unbalanced data are made balanced and then an optimal data reaches the sink node. The outcome of T2FL will be with some traffic and unbalanced data. In order to avoid the traffic, the concept of routing protocol is introduced for finding the suitable path for the transmission of data. For balancing the data, load balancing concept is presented. Load balancing algorithms are separated into static and dynamic load balancing algorithms. Static load balancing algorithms do not base their choice on the recent state of the system, so, there presentation would not be best when compared to the dynamic load balancing algorithms which base their choice on the present state of the system [5]. But dynamic load balancing algorithms deserves more overhead when compared to the static load balancing algorithms. Dynamic policies are further classified into two classes: Centralized and Distributed.

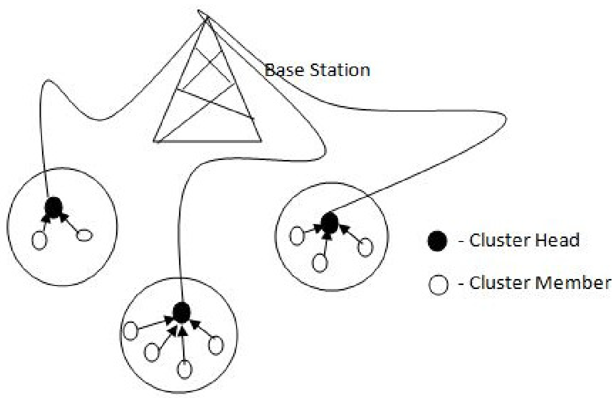

Fig. 1. General Architecture of uneven clustering in WSN.

II. RELATED WORK

The optimal CH is selected by various clustering schemes and after selection of CH the cluster is formed. The nodes are placed in a sensor field, then the CH is selected according to the energy consumed ratio and existing distance factor among the CHs. The methodology applied here is free association model. After clustering is made, the data packets are scheduled and then the transmission stage starts to transmit the data which are sensed by the nodes [1]. The focus of this paper [2] is that, the sorted sensors is made in ascending order on the number of the gateways which is used in allocation of sensors are made in an ascending order, should also being a sorted sensor range. The continuous sorted sensor nodes start for their assignment to the correct gateway. For the presentation of a transmission of packets the Radius Self-adjust Energy-Saving routing protocol (RSES) are involved. In RSES, nodes get minimized as its number of packets radius are made for the sake of reaching the extreme next node before it directs the data to the initial state. The initial work of the On-Demand route discovery is made if in case there is a need for source node to communicate with its neighbor node for that it does not need any routing maintenance table for storing information [3]. In paper [4] the aim is to allocate jobs to the machines, for that information's which are gathered from the algorithm called Greedy Load Balanced Clustering Algorithm (GLBCA), which solve the issues on linear programming problem. By using the Load Balancing clustering problem (LBCP), the ratio of throughput is high when compared to the problems in linear programming. An approach to enhance the network lifespan is introduced in an algorithm named ICLA (Irregular Cellular Learning Automata) based clustering algorithm which can progressively select cluster heads with the high utilization energy and evenhanded number that act together with next nodes happens by the process of learning reinforcement. Henceforth, it has the drawback as it won't measure the effect of unequal distribution of cluster nodes in real systems as a part that may cause unbalanced amount of work carried out by the cluster heads [5].A centralized algorithm named Centralized Energy Efficient Load Balancing Algorithm (CELBA) which reports the disputes of energy utilized of the sensor nodes simultaneously it will balance the load which happened in the cluster heads. In addition to the centralized algorithm further more algorithm needs to balance the network hence for distribution version purpose the Distributed Energy Efficient Load Balancing Algorithm (DELBA) is introduced [6].In order to save the battery from energy draining which occurs in cluster head especially the one that present near the sink node and to perform the user friendly mean the approach called Energy Aware Sleep Scheduling Clustering based Routing scheme(EASSCR) is made for Wireless network and mobile networks. Efficient sensor networks eliminate the requirement of network reconfiguration with respect to sparsity change [13-16]. By using this approach some nodes are laid to sleep for the prolongation of the network lifetime. The three fuzzy descriptors (remaining battery power, distance to base station, and concentration) have been chosen to elect the Cluster Head (CH) and only CHs can deliver the message to the base station [19]. The node with the utilized energy which is high than the estimated average energy is elected as cluster head by the EASSCR and the nodes remaining battery level attains to five percent than its start energy level will send its data straightly to the sink node. It will partly eliminate the node failure at the time when the cluster head gathers the aggregated information from the cluster node and its main aim is to stipulate the prolongation time and reduce the data loss received from the sensor nodes. This is well suited to the environment of the distributed unequal clustering algorithm field because it takes in term of both estimated average energy and the residual energy of nodes. EASSCR works with two techniques to transmit data to sink node (i.e.,) straight transmission of data to the sink node and transmission made with the help of cluster head [7]. Routing always reduces the duration that are sensed by the sensor nodes for finding the optimal path. The selection of optimal path will be based on the two approach (i.e.,) Histogram of energy consumed and the spectral range of sensors fixed. The first method is used to collect the data that are sensed by nodes and the second method is used to aggregate the collected data for the continuous streaming of data in an optimal way. By this the utilization is allocated in a uniform manner so that the flow across the network is reduced [8]. The enhancement of network lifespan is made by the fuzzy logic and tree based routing protocol. The tree based is a general self- deployable based on energy balanced algorithm [9].

III. PROBLEM FORMULATION

In the wireless medium, the data are built from the signal for the transmission purpose. While transmitting data packets from source node to sink node, the sensor nodes which are placed in an un aspirated area plays a vital role. The sensor nodes form the Cluster Head (CH), from which the data are passing to the hops. At the time of transmission, the CH is overloaded with all the burdens and it will be drained as much as soon. Hence replacing the battery in such an unaspirated environment is not that much an easier one so that the CH consuming energy should be minimized. In order to minimize the cluster head prolongation time T2FL is proposed. By T2FL the optimal CH is selected based on the generated rules, as T2FL handles the real world uncertainties than the T1FL [1]. The formation of rules for T2FL is same as in T1FL as the Foot of Certainty (FOU) remains the same. While transmission of packets from source to the final state via CH may result with some delay and loss of packets. To make the delayed packet a reachable one the load balanced techniques is used along with the routing protocol strategy.

IV. PROPOSED SYSTEM

Each and every sensors deployed in the network join with one cluster according to its coverage range. The sensor node is tagged as one of the cluster member. It senses the environmental condition around it particular range and send it to the cluster head. The data that are received from the cluster members are aggregated by cluster head then it is transferred to the next cluster head.

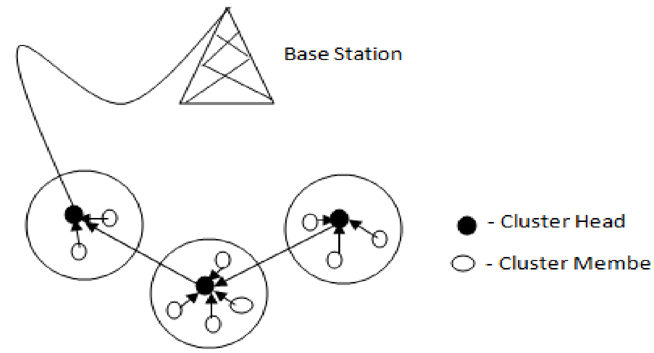

Fig. 2. Proposed model for multi-hop clustering.

A. System model

In the proposed model, CH is selected based on the T2FL by framing the rules for the optimal selection of the CH. Because the T2FL will handle the uncertainties in this real complex world without any intervention [9]. The system model is sub divided into two modules, they are as follows,

(a) Type 2 Fuzzy Logic(T2FL) module

(b) Energy Efficient Load Balancing

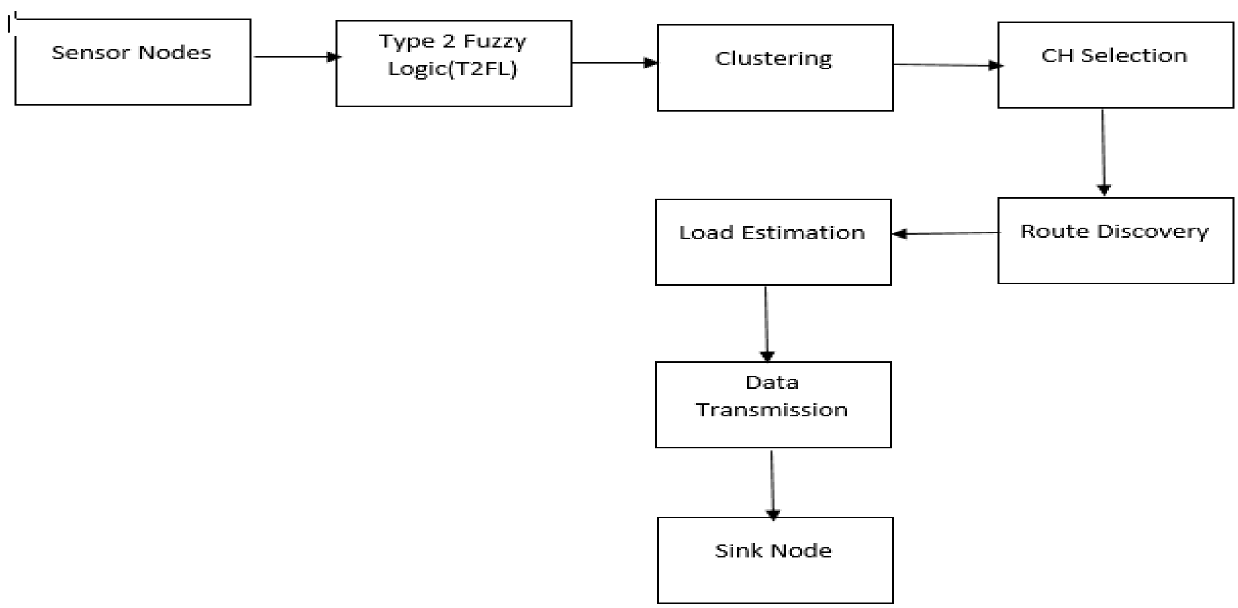

Fig. 3. Proposed Architecture.

The proposed architecture is modeled in a way that the sensor nodes are deployed first as it is the initial step for the process. After the deployment of the nodes, each node must join with one cluster group for that sake the T2FL is used. In our proposed model, there are 27 rules on fuzzy inference system. By T2FL the CH is elected according to the criteria made on the basis of the three fuzzy parameters(i.e.,) A represent remaining battery power, B represents distance to base station [1] and C represents density of node, then D represents the output factor measured. For each of these above mentioned parameters where three inputs are available. The first fuzzy parameter A uses Less, Average and High, the second fuzzy parameter B uses Near, Far and

Farthest and the third one which represents of C uses Low, Medium and High. After considering the fuzzy parameters with the inputs, the output factor is framed as a 7 membership function (i.e.,) Very poor, poor, Below Average, Average, Above Average, Strong and Very Strong. The concentration is made by the use of fuzzy rule model. The T2FL is considered to be the superior one than the T1FL [20]. The method followed at the initial stage is as same as the T1FL, as it also considers the Foot of Uncertainty (FOU).

T2FL = FOU+ Principal Member Function (T1FL) …(1)

The T2FL has the range of FOU which is between 0 to 1, since the fuzzy logic value is meant to range from 0 to 1, the difference among the T1FL and T2FL is that the member function considered if $f°[0,1]$, T1FL ranges from f->0, but T2FL ranges from f->0 to 1. The derivation of output factor is done by given below equation,

$$D = \sum_0^5 RBP + \sum_0^5 DBS + \sum_0^5 Concentration \ldots (2)$$

(a) Type 2 Fuzzy Logic(T2FL) Module

The workflow of the T2FL id depicted as follows,

1) The clusters are assumed to be k over the region M×M, the sensor nodes N are deployed randomly.
2) Based upon the criteria the sensor nodes represented as N are categorized among different layers.
3) Each and every layer is labeled with numbering on the basis of measuring the distance from source to the sink node.

$$d0 = \sqrt{\epsilon fs}/\epsilon mp \ldots (3)$$

ϵfs – Free space energy
ϵmp – Multipath energy

4) At every layer the CH is selected on the basis of T2FL rules.
5) The fuzzy model is applied which is an if-then-else rule format for the selection of CH.
6) The number of optimal CH is elected at each round.
7) The data that are from the top layer reaches from one CH to another CH and finally it reaches to the sink node.
8) The sink node that is a destination node will aggregate all the data from the CH in an efficient manner.

(b) Energy Efficient Load Balancing Modules

The second module of the proposed model is Energy Efficient Load Balancing methodology where the routing protocol happens at its initial stage when the CH transmits its data to the intermediate nodes. The routing algorithm which is applied here is Ad-hoc On Demand Distance Vector (AODV), Simulation results have shown that proposed method protocol achieves lower average delay, more energy savings, and higher delivery ratio than the MCMP protocol [17],[18]. where the shortest path is selected upon the table which carries the ranges among the network. After the stipulated time path is selected for the transmission the data are to be balanced among the node so that the delay of packets is reduced at the time of transmission. The Pseudo code for the energy efficient Load Balancing methodology is as follows:

➢ **Algorithm Steps for Energy Efficient Load Balancing**

Step1: Source discovers the routing path (initial) to the sink based on distance factor. The shortest routing path is selected for transmission.

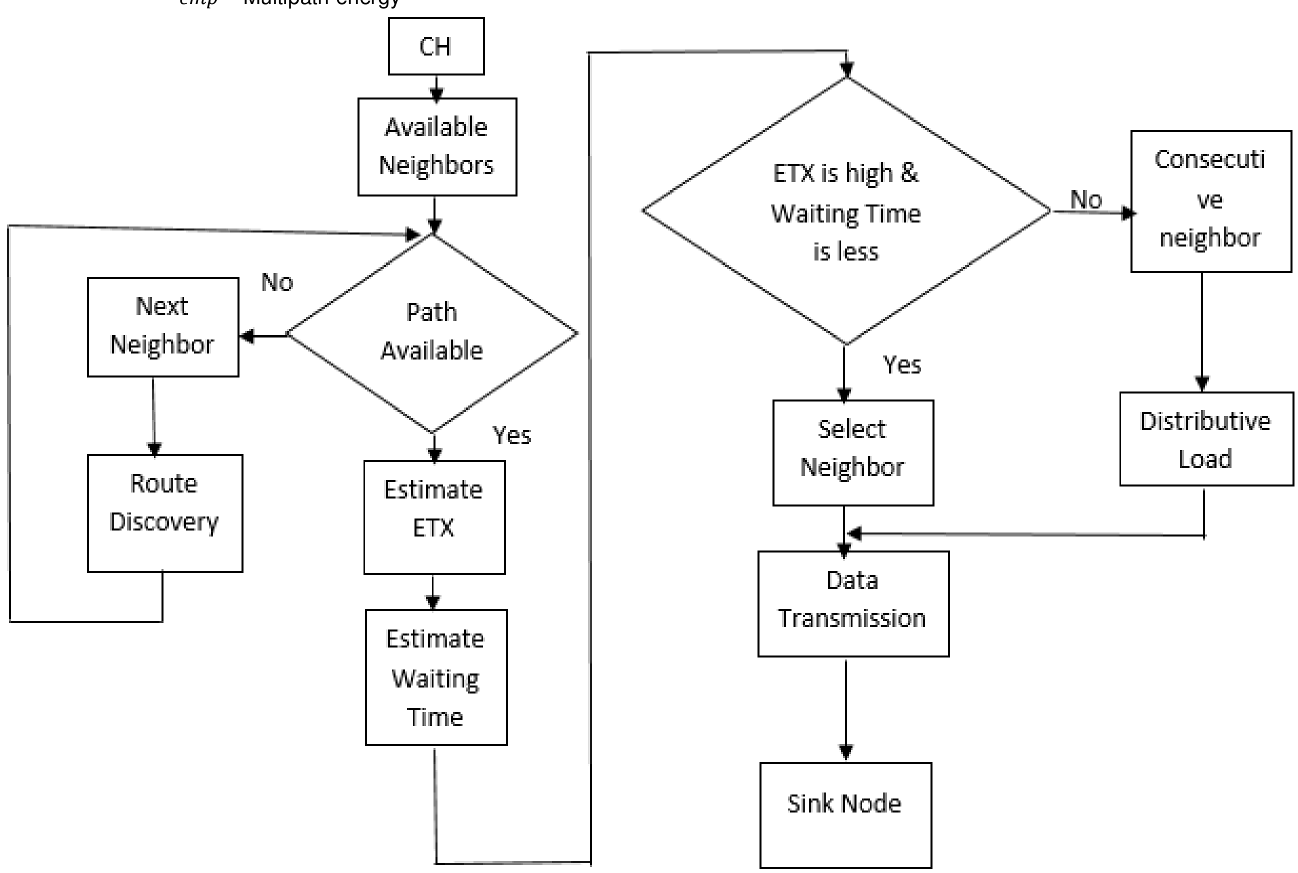

Fig. 4. Sequence of Proposed Model.

Step2: At the final stage of every transfer of packets, the node's remaining energy is updated to the predecessor node.
Step3: If the remaining energy of the node is greater than the threshold, then the node retains its position in the routing path.
Step4: If Step3 fails, then the node is replaced with a next highest remaining energy node to pursue transmission.
Step5: The network traffic is consented with the capacity of the node correlating the remaining energy of the node.
Step6: If the remaining energy of the node is sufficient to transmit the incoming packets, then the data dissemination occurs.
Step7: If Step6 is not satisfied, then the incoming traffic is split into multipath confining to the capacity of the nodes.
Step8: Update the remaining energy of the nodes to verify if it is greater than the threshold.
Step9: If Step3 and 6 fails, then the source initiates a new neighbor discovery.
Step10: Repeat from Step2 for all transmission to the sink until the destination is reached.

V. PERFORMANCE EVALUATION

The proposed model is analyzed and its performance metrics are evaluated in the MATLAB editor with 150 nodes as its network size as mentioned earlier the cluster head is selected according to the rules framed by T2FL for the optimal transmission of packets form initial node to the sink node. The selection of CH is made in such a way that the following three parameters of fuzzy such as remaining battery power, distance to base station and the density of node. The data which are used here is same as I the T1FL, the output factor is validated through the fuzzy inferences rules in the MATLAB editor.

The output factor probability for the CH is derived from the formula mentioned in equation 2.The considered proposed system is an unequal clustering approach with dynamic change of the CH. The cluster formation algorithm makes the cluster split up into eight cluster regions and each CH is dynamically changes as the battery gets drained. By using the MATLAB editor the graph is plotted from Fig.5 to 7. Fig 5 depicts the networks throughput is better in terms of Energy-Efficient Load Balancing(EELB) compared to T2FL.the throughput can be derived from the given below equation 4.

$$Throughput = \frac{size\ of\ packet*delivered\ number\ of\ data\ packets}{Time} \quad \ldots(4)$$

From Fig 6 we tend to know that the performance of the network is predicted by measuring the data signals which are delivered to the sink node successfully as it is one of the major parameter for the network lifespan. Fig 7 shows the First Node Dies in EELB is maximum as compared to the T2FL.

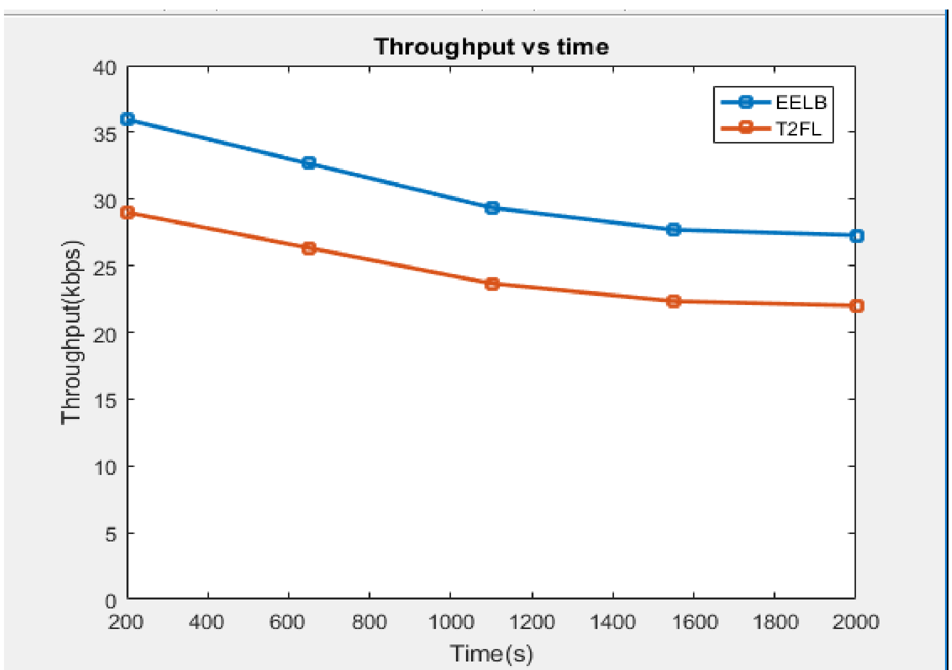

Fig. 5. Throughput vs Time.

Table 1 depict that the performance rate among the T2FL with EELB on the basis of three metric (i.e.,) type-2 ITS'S account for linguistic uncertainties, it should be possible to use our type-2 TSK [21], [22]. Throughput, Data signals to BS and First Node Dies. Hence, it is proved that the simulation result after applying the EELB is in top as compared to the T2FL, which is suitable for the larger applications. The proposed model routing strategy in the larger application is discussed in [23].

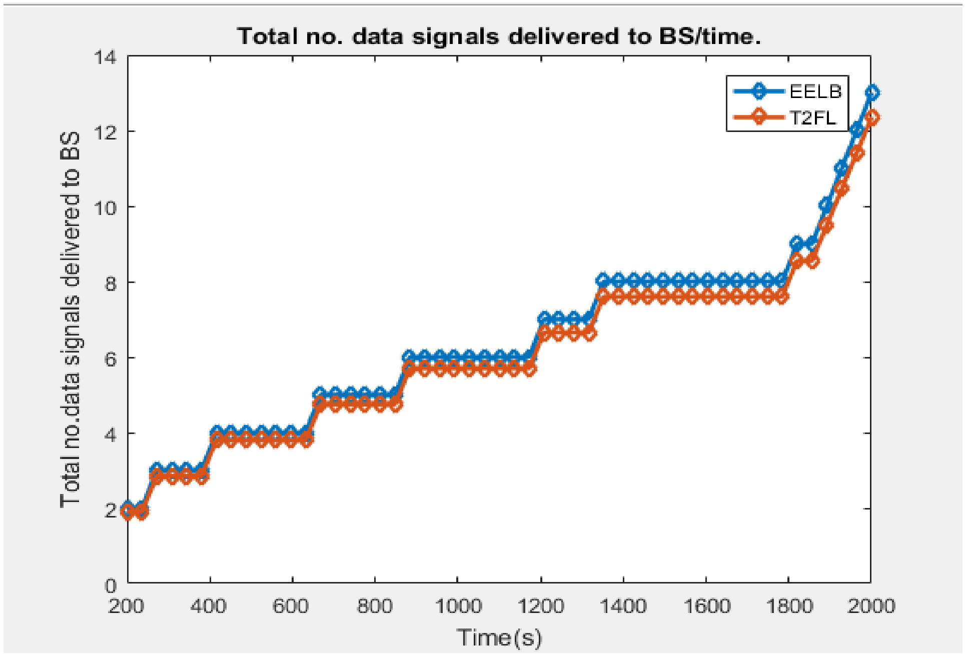

Fig. 6. No. of. Data signals delivered to BS.

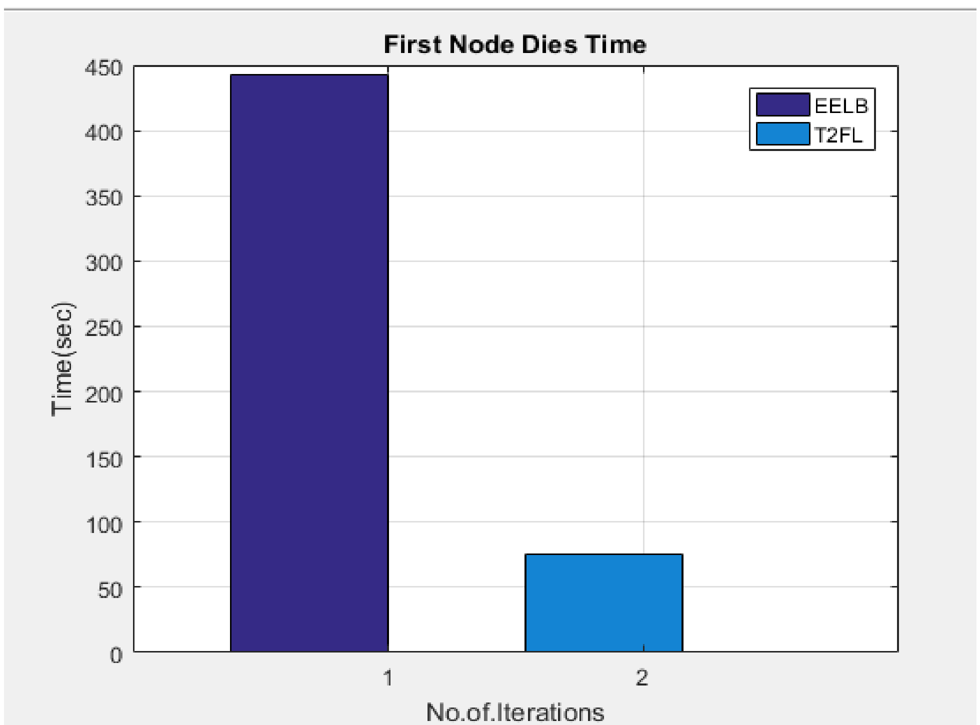

Fig. 7. First Node Dies Time.

Table 1: Comparison of EELB with T2FL.

Metric	T2FL	EELB
Throughput(Kbps)	27.5	32.6
Data Signals to BS	12.5	13
First Node Dies(sec)	80	599

VI. CONCLUSION AND FUTURE WORK

The proposed EELB is effective in adapting the routing paths by selecting nodes based on residual energy and load handling capacity. It balances the data dissemination process based on the available node energy to improve the network throughput. The base is assisted with type-II fuzzy in selecting cluster heads that aids energy conservation besides the distributed energy efficient routing. The achievement of the newly proposed model is compared with the existing type-II fuzzy based clustering for the metrics like Throughput, Signal transmitted to the sink node and first node dies time. In future, the process is planned to be modeled as an opportunistic routing algorithm to enhance the link stability and mediate route recovery of the communicating nodes. This aids swift transmission with distributed energy efficiency.

Conflict of Interest: Nil

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