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High performance of Cluster-Based Strategy for reducing Delays in Wireless Sensor Networks

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Abstract: ***In Wireless Sensor Network (WSNs), nodes are interlinked that establish communication wirelessly for data collection in the surrounding environment. It regards as a structured and heterogeneous network where the sensor nodes have some energy which is power by external sources and it is constructed using a collection of several tiny sensor nodes. In WSN, all sensor nodes are powered by battery in which a very small battery is placed over the sensor nodes, which is normally not simple to replace by which communication could be interrupted. Thus, energy efficiency and hence transmission delay is a major need in WSNs to make interrupt free communication in wireless manner. In presented approach, cluster-based routing protocol named as Low Energy Adaptive Clustering Hierarchy (LEACH) is utilized to find the path that consumed minimum energy and helpful to reduce the transmission delay. For this purpose, K-means with Artificial Neural Network (ANN) is integrated. Here, the ANN approach is utilized with the aim to minimize the transmission delay in the network. The performance evaluation of presented approach is done on the basis of QoS parameters such as Throughput, Packet Delivery Ratio (PDR), Transmission Delay and Energy Consumption, etc. The significant amount of improvement has been observed in terms of considered parameter. Both PDR and throughput using ANN has been observed as 7% and 22% respectively. The reduction in delay and energy consumption is decreased by the amount of35% and 4% respectively. So, it has been examined that by using ANN classifier, the presented work performs better.***

Keywords: Wireless Sensor Network, Low Energy Adaptive Clustering Hierarchy, Artificial Neural Network, K-means, Transmission Delay

1. Introduction

Recently, in sensor network technology, the development in sensor or mobile nodes becomes expensive. Therefore, the researchers all across the world tries to reduce the cost of these sensor nodes that finds application in different fields such as environmental monitoring, agriculture, structure monitoring etc [1]. The area where these nodes are deployed is known as Wireless Sensor Network (WSN). The area, which is monitored by these sensor nodes, is known as Region of Interest (ROI). The information is collected by these nodes and sends to the Base Station (BS) either directly or through multiple communication nodes [2]. The general structure of WSN is shown in Figure 1.1.

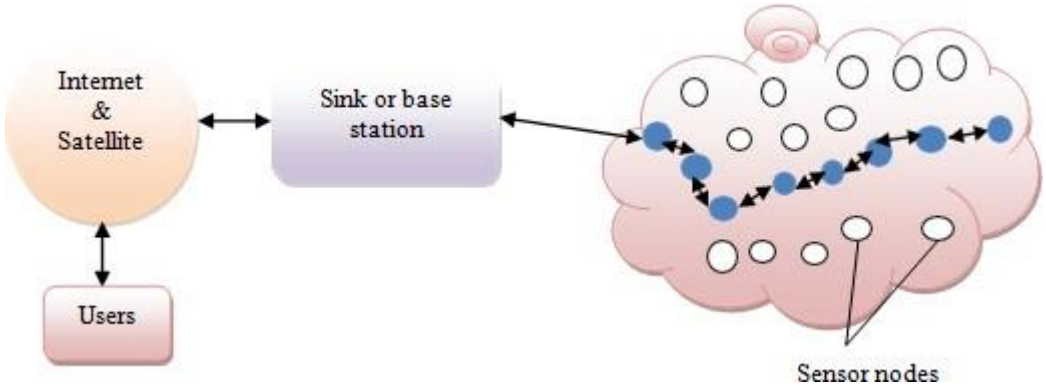

Figure 1.1: General structure of WSN [3]

The mobile nodes comprised of four units (i) sensing, (ii) treatment, (iii) wireless transmission and (iv) power unit that include batteries. Among all, battery is the most important unit of the system. These nodes are powered with very small amount of energy, memory, communication range, processing capacity etc [4]. As these nodes are deployed in remote area therefore, it is very difficult to replace or charge their batteries. Due to this, energy saving becomes one of the important issue for WSN. Exiting researchers have followed a number of techniques or design different algorithms to save energy including, routing protocols, optimization algorithm, data aggregation techniques etc [5].

In the existing work, a number of routing protocols have been proposed to deliver the collected data from the source node to the sink node. In most of literature, hierarchical clustering approach is used. One of the most famous hierarchical clustering approaches is named as "Low Energy Adaptive Clustering Hierarchical (LEACH)" protocol that will be described in detail in subsequently section. Various modified LEACH protocols

Named as DMR (**Alnawafa and Marghescu 2018) [6],** MH-LEACH (**Neto et al.2014) [7],** EMODLEACH (**Singh, and Nayak 2015) [8],** MHT-LEACH (**Alnawafa and Marghescu 2016) [9]**, enhanced LEACH (**Salem and Shudifat 2019) [10],** O-LEACH (**El Aalaoui, and Hajraoui 2020) [11]** etc.

$$T(n) = \frac{P_b}{1 - P_b(q \bmod P_b^{-1})} \forall n \epsilon Grp$$
$$T(n) = 0$$

In this research, we have proposed a new improved K-mean based LEACH protocol by integrating the concept of Artificial Intelligence technology. By considering collision time, delay, energy consumption metrics, the energy consumption of the network is minimized and hence prolong the lifetime of the network.

2. Leach (Low Energy Adaptive Clustering Hierarchy)

LEACH is a hierarchical clustering routing protocol used to prolong the lifetime of the WSN. It is based on randomized rotation of the CHs to distribute the energy load among the sensor nodes evenly in the entire network. Each node elects itself as a CH based on a probabilistic scheme and broadcasts its availability to all the sensor nodes present in the area. The received signal strength is the prime parameter for determining the communication distance between the nodes. The CH performs aggregation of the packets received from all the nodes present in their cluster. Also, all the nodes get a chance to become the CH to balance the overall energy consumption across the network. Although the complexity of LEACH is low, the algorithm is not energy efficient due to irregular distribution of the CHs [12-13].

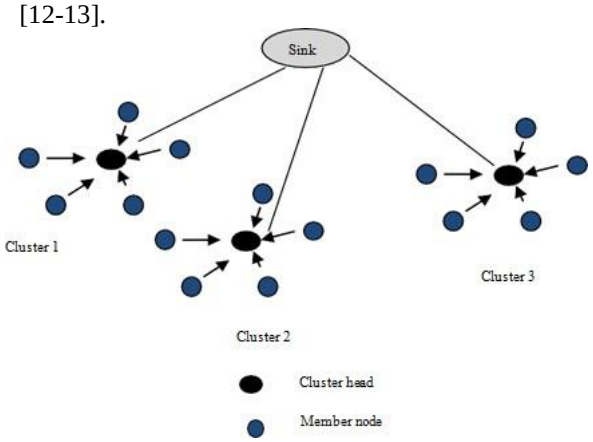

Figure 2.1: LEACH in WSN [14]

Using LEACH protocol, the entire network is split into multiple clusters as shown in Figure 2.1. Each cluster comprises a master node known as cluster head (CH). As indicated by the black circle. CH is the head of the cluster that takes action such as to which node or cluster, the received data is forwarded. The other nodes except Ch nodes are known as member of cluster. The route formation using LEACH is performed into two steps as discussed below [14].

i. Setup phase

The foremost step is to select an appropriate CH with higher energy. This is performed by selecting a number between 0 and 1. Then compare the selected number with the following formula.

Here, n is a random number [0 and 1]

$Pb \rightarrow$ is the probability of cluster head
Grp is the group of nodes that were not clustered heads in the previous rounds
$T(n) \rightarrow$ is the threshold value

The node with smaller T (n) is selected as CH for the current round.

ii. Steady State Phase

At this stage, data is sent to the base station with minimal overhead. Similarly, the time required for the setup phase is greater than the time required for the steady-state phase

3. Related Work

Sasikumar, P., & Khara, S. (2012) implemented both centralized and distributed k-means clustering algorithm in network simulator. K-means is a prototype-based algorithm that alternates between two major steps, assigning observations to clusters and computing cluster centres until a stopping criterion is satisfied [15]. **Azad, P., & Sharma, V. (2013)** provided a fuzzy decision-making approach to select the cluster heads. Using three parameters, including residual energy, number of neighbours and distance from the base station of the nodes, the Fuzzy multiple attribute decision-making (MADM) method has been used for selection of CHs. Its obtained findings indicated that efficacy of this scheme has higher in terms of network enhancement in network lifetime as compare to distributed hierarchical agglomerative clustering (DHAC) protocol in homogeneous environment. With the aim to optimize the number of cluster or cluster heads they have considered three criteria comprises of residual energy distance of the nodes from base station along with number of neighbour nodes [16]. **Ghasemzadeh et al. (2014)** have selected CH using Bayesian network model. Using parameters, such as distance to the base station, remaining energy, and density has been considered as main working attributes. Dynamic partitioning methods and greedy mechanisms have been used to evenly distribute CH, which leads to an increase innetwork life [17]. **Echoukairi, et al. (2017)** introduced a new hierarchical routing protocol based on the centralized grouping approach is defined by wireless sensor

networks inspired by the k-means method to organize sensor networks into groups and obtain a better performance parameter. The goal of this contribution is to improve the LEACH-C protocol grouping method by applying the k- means algorithm to generate a new group scheme and thus extend the existence of the sensor network [18]. **Lehsaini, M., &Benmahdi, M. B. (2018)** suggested two routing schemes based on clusters. The first has based on an approach to K-means and the second on an improved version of the approach to K-means. The latter produces balanced clusters, which allow the load to be distributed equally between the heads of the clusters [19]. **Kovendan et al. (2018)** have explored ANN as a best route selection approach that consumes less energy. The performance parameters such as throughout, PDR and energy consumption of about 50%, 0.55, and 300 mJ respectively have been obtained. By changing the current LEACH protocol to achieve energy efficiency to ensure the effective use of accessible power resources in WSN, a systematic integrated ANN method is proposed to determine the range parameters for selecting CHs [20]. **Sarkar and Murugan (2019)** have used Firefly as an optimization approach to select the best CH among the available one. The best CH is one that consumesminimum energy for data transmission with minimum delay. The Ch having minimum distance from the BS is selected for data transmission [21]. **Mohanty et al. (2020)** have presented a distributed data mining approach based on deep learning technique to obtained balance between the balanced load and energy consumed by then in WSN. The network consists of RNN and LSTM and hence given the named as RNN-LSTM model to split the entire network into multiple zones. The test results prove that thetime taken by the proposed model is less with reduced signaling overhead [22]. **Bhola et al. (2020)** have presented an energy efficient routing protocol using LEACH along with Genetic Algorithm (GA). Using LEACH protocol, the sensor nodes are grouped into clusters, each cluster has its own cluster Head (CH). The collected data using CH is send to the sink node. Here, the role of GA is to find an optimal route bases on fitness function. The simulations have been performed in MATLAB, with the energy reduction up to 17.39% has been obtained compared to existing work [23].

4.Proposed Work

A network of 1000×1000 (length* height) was prepared that consists of n number of nodes ranges from 10 to 100. Each node is labeled by unique name (N1…. . Nn), where n is the number of nodes deployed in the network. Including n number of nodes two additional nodes the source and the destination node are also deployed.

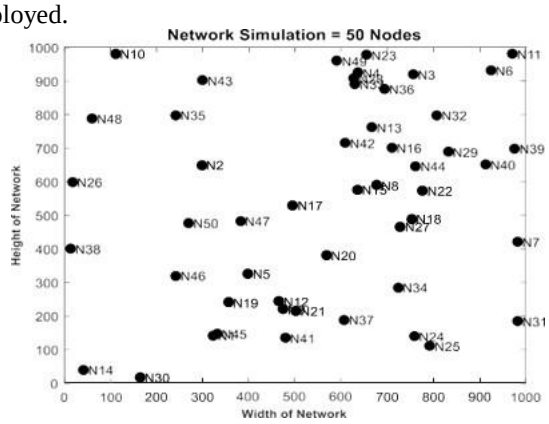

Figure 4.1: Deployed n number of nodes

Define the coverage area for each sensor nodes which helps to establish the route from source to destination node for communication. Discover Route from source to destination node via cluster head nodes using improved LEACH with K-means routing mechanism for the communication in WSN and calculate performance parameters of network.

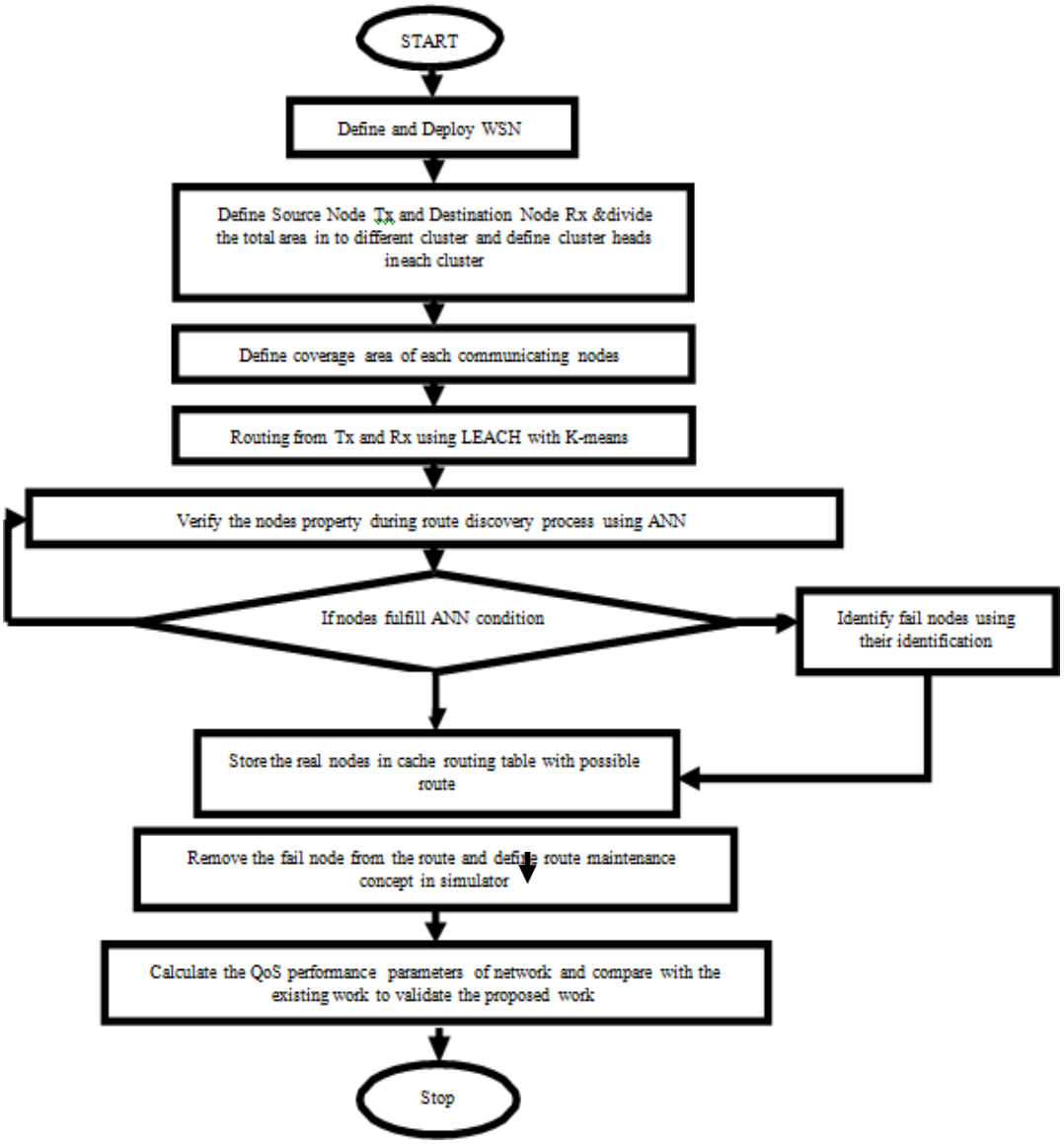

Figure 4.2: Proposed work

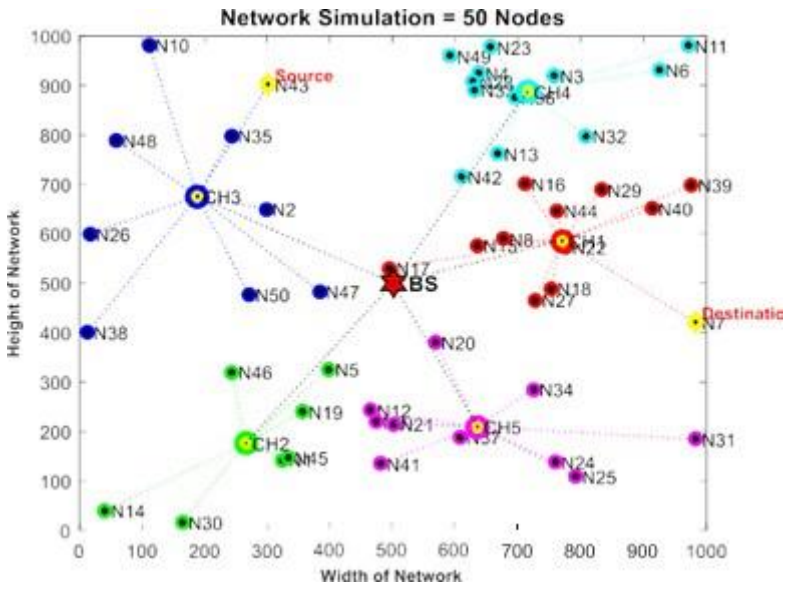

Figure 4.3: Network with identified source and destination

As depicted in figure 4.3, five cluster head by which 50 numbers of nodes divided into five different clusters. In which first cluster (CH1), second cluster (CH2), third cluster (CH3), fourth cluster (CH4) and fifth cluster (CH5) is represented by the, red, green, dark blue, sky blue and pink color, respectively. The decided cluster head (CH) for every cluster, such as CH1, CH2, CH3, CH4 and CH5 are denoted as centered yellow-color with different outlines for different groups. The deployed node of one cluster is denoted with red, green, sky blue and dark blue outlined. All deployed nodes first send all information to CH. The collected information from CH is then forwarded to BS then send to destination node. If performance of network is degraded, then the concept of artificial intelligence is used to detect the fail/dead sensor nodes in network. Identify nodes in discovered route and detect the fail/dead/attacker's sensor nodes which are not able to communicate with another node and produce a transmission delay within the route using the ANN as an artificial intelligence algorithm. At last of simulation, the performance parameters of proposed work will be calculated and compare with exiting work in terms of Transmission Delay, Packet Delivery Ratio, Energy Consumption, Throughput etc.

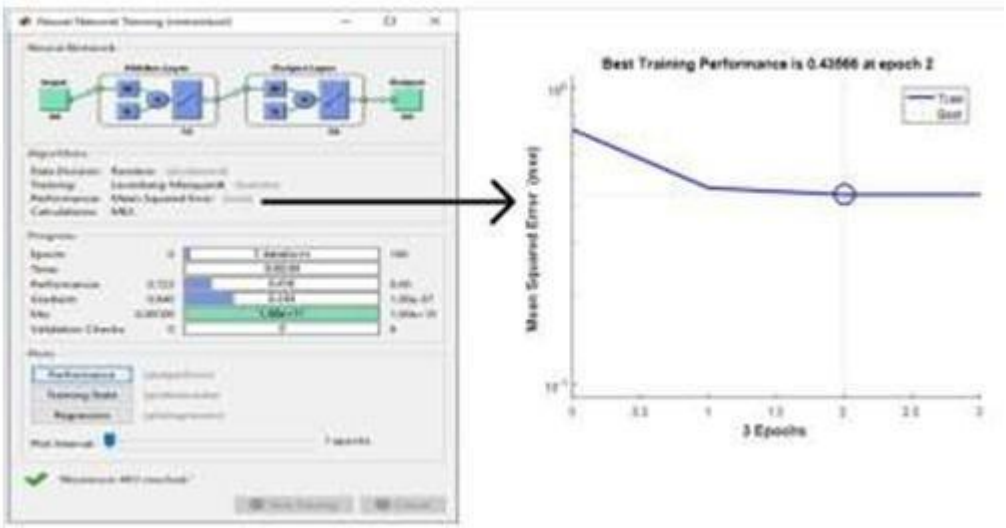

Figure 4.4: ANN training with MSE performance

The ANN performance is depicted graphically, as shown in figure 4.4, and the training of ANN is completed for two iterations. As per the above graph, it is observed that here, the two distinct lines are represented through blue dashed and dotted lines, which signifies the training and best value of ANN correspondingly. In this case, the best deal is achieved at the second iteration with lower MSE and better training of ANN.

5. Result and Analysis

The key objective of this research is to minimize the transmission delay using the LEACH with K-means in WSN using the concept of ANN as an artificial intelligence technique and maximize the lifetime of the network. To achieve this, cluster-based energy efficient routing techniques such as LEACH are analysed. In which the sink node elects the cluster head and next heads based on the residual energy and partitions the network into clusters. The performance of the presented approach is determined here. In this section given the performance analysis of the presented work by using the sensor nodes on the simulator network in MATLAB.

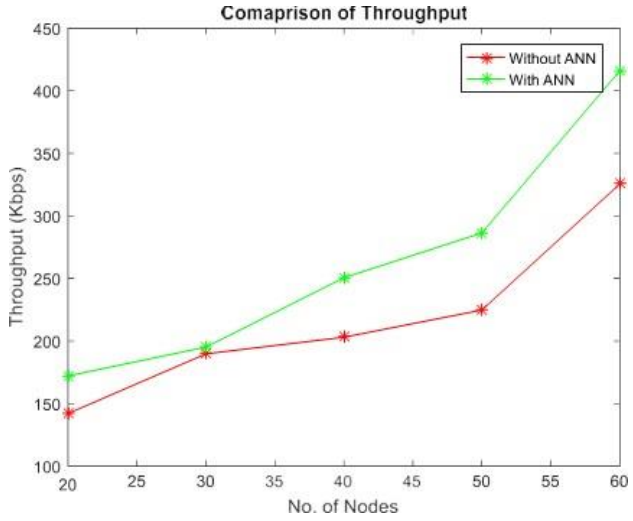

Figure 5.1: Throughput

Figure 5.1 represents the computed parameter named throughput without and with utilizing ANN. Throughput are increased after applying ANN. As per above depiction in figure5.1, the proposed work's throughput is improved as the rounds increase. Along X-axis and Y-axis depicts the throughput and number of nodes correspondingly. The average throughput value obtained without using ANN is 211.6 and with ANN is 258.8 respectively, so the percentage increment is 22%.

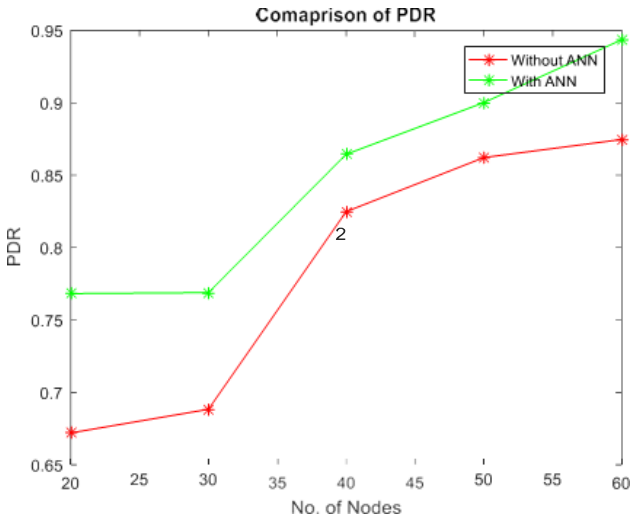

Figure 5.2: PDR

Figure 5.2 shows the PDR of proposed work; by using the ANN, PDR is enhanced. The parameter throughput and number of nodes are plotted along X-axis and Y-axis, respectively. The average PDR without using ANN and using ANN is 78% and 85%, so the percentage increase is 7% by utilizing ANN.

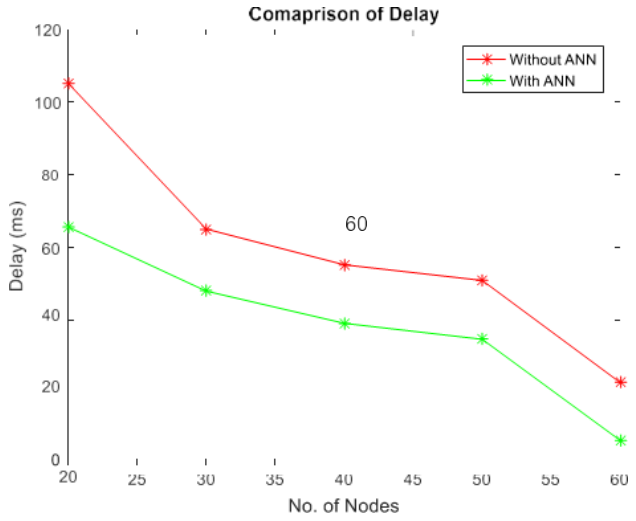

Figure 5.3: Delay

Figure 5.3 shows the delay (ms) without using ANN and by using ANN. After utilizing the ANN, the delay is reduced. The corresponding average value of delay in ms without using ANN and with using ANN is 64.9ms and 41.6ms, so the percentage reduction in the delay is 35%.

Figure 5.4 shows the energy consumption of proposed work; by using the ANN consumed energy is reduced. The parameter energy consumption and number of nodes are plotted along X-axis and Y-axis, respectively. The average energy consumption without using ANN and with using ANN is 3.38 mJ and 2.72 mJ, so the percentage reduction is approximately 4% by utilizing ANN.

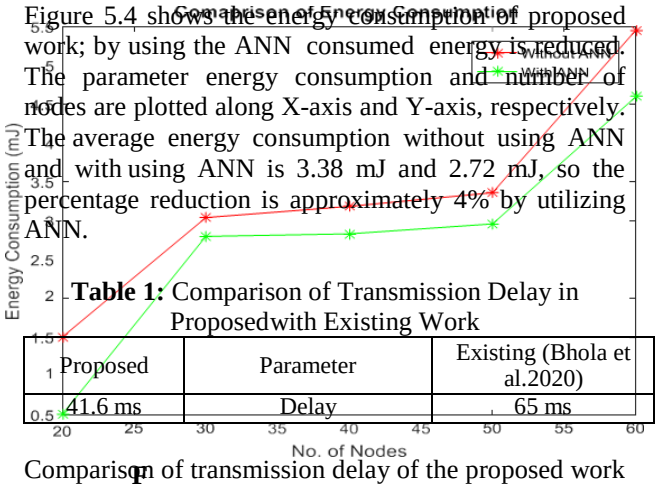

Table 1: Comparison of Transmission Delay in Proposedwith Existing Work

Proposed	Parameter	Existing (Bhola et al.2020)
41.6 ms	Delay	65 ms

Comparison of transmission delay of the proposed work with the existing research Bhola et al. (2020) has been depicted in Figure 5.5. From Figure 5.5, it is clearly observed that delay of the proposed work is less compared to the existing work. In exiting work, data transmission has been performed using LEACH with genetic algorithm. In recent work, to increase the speed of data transmission and to minimize delay, K-means with ANN approach has been introduced. Here, ANN helps to find the failure node and hence minimized the delay. Also K-means helps to find appropriate CH node, which also helps nodes to boosting the data speed.

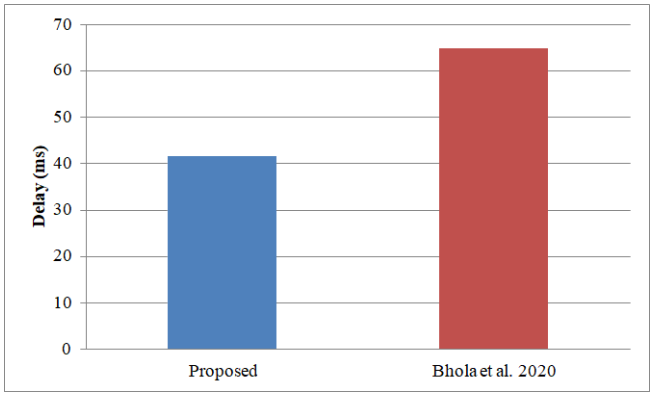

Figure 5.5: Comparison of Delay

6. Conclusion

This work focuses on the delay minimization routing mechanism using the LEACH with K-means in WSN using the concept of ANN as an artificial intelligence technique to utilize the ANN approach with the aim to minimize the transmission delay in the network. To examine the designed WSN model, hybridization of designed routing protocol along with classifiers is proposed. The performance evaluation of presented approach is done on the basis of the following parameters such as; Throughput, Packet Delivery Ratio (PDR), Transmission Delay and Energy Consumption. The significant amount of improvement has been observed in terms of considered parameter in which both PDR and throughput is increased by 7%

and 22%by using ANN. The reduction has also been observed in delay and energy consumption, which is observed as 35% and 4% respectively. So, it has to be concluded that by using ANNclassifier, this presented work performs better.

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