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Research paper

Minimizing the energy consumption of WSN by using modified hybrid energy efficient distributed clustering protocol

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Abstract

Wireless Sensor Networks use batteries for supplying power to the sensor nodes. Batteries are capable of supplying only a limited amount of power. Wireless Sensor Networks are making use of node clustering with the aim of reducing the network power requirements thereby increasing the network lifetime. Various clustering algorithms are being made use of today for the purpose of achieving high energy efficiency. Out of all such protocols the Hybrid Energy-Efficient and Distributed Clustering protocol (HEED) is the most energy-efficient clustering algorithm. In the (HEED) protocol the Cluster Head is selected on the basis of the cost of the route within the cluster as well as the residual energy of the node to be selected. The modified HEED protocol has been proposed in this paper. The network is set up by making use of certain procedures that are similar to those used by the HEED protocol. The network periodically refreshes and updates itself in instances known as rounds. At the start of each network round, the Cluster Heads of all the clusters wait for a certain period of time that is defined by the network to obtain a New Cluster Formation notification from the WSN sink. defined period of time for receiving a re-clustering message from the sink. If such a notification is not received, the same cluster will continue to scan the other nodes within it in order to select a New Cluster Head that is suited to the present network conditions. The performance simulation shows that the proposed protocol outperforms the original protocol with regards to the lifetime of the network. In this paper, the Custer Head is selected by searching the nodes by giving importance to the residual node energy instead of searching the nodes in a random manner. NS2 Software is used to simulate the network performance. The results clearly indicate that the performance of the network has improved in terms of energy efficiency, Quality Of Service and other performance parameters.

Keywords: *Algorithm, Clustering, Cluster Head, HEED, Energy Efficiency, Power Consumption, Wireless Sensor Network, Quality of Service*

1. Introduction

Wireless sensor networks consist of a number of individual sensors that are placed over a decided area for monitoring of parameters such as temperature, humidity, gas concentration, pollutant concentration and many other environment's related parameters. These sensors individually collect all the relevant data and send it to the network sink [1]. Major applications of wireless sensor networks include the monitoring and control of traffic, environment monitoring for industries and health monitoring in hospitals.

The nodes in a WSN have several constraints in terms of the ability to communicate in the network, the computational ability as well as the amount of energy it possesses and makes use of these nodes are many times needed in areas of difficult terrain. In such situations, it becomes very difficult to change the batteries of these nodes or recharging them. In order to overcome the constraints related to power consumption and network lifetime, the clustering method is used as it is the most effective of all the approaches.

The 2nd section talks about Clustering in detail: how the cluster is formed, how the cluster head is selected and how it is re selected. In the 3rd section, the current methods have been discussed. In the 4th section, the proposed method has been discussed. In the 5th section, the settings for the simulations are shown. In the 6th section, the simulation is carried out and results are shown. In the last section conclusion and future considerations are presented.

2. Clustering

A group of sensors forms a cluster. This grouping takes place before the sensors start sending data to the base station. In every cluster, there exists a cluster head, whose purpose is to send the data from all its cluster nodes collectively to the base station. Communication that takes place within the cluster (from the cluster nodes to the cluster head) is known as intra cluster communication as shown in Figure 1. In the multi hop method, the cluster head calculates a route to the base station through which the collected data will be sent. The cluster head also schedules activities so that all the nodes need not be active all the time, thereby reducing the energy usage of the node [2]. One of the earliest methods to form clusters in wireless sensor networks is the Random Competition based Clustering(RCC). In this method the cluster head position is decided by the first node that announces itself as the cluster head. Broadcasting is also a method that can be used for forming clusters. Once the cluster is formed, every cluster must select a cluster head.

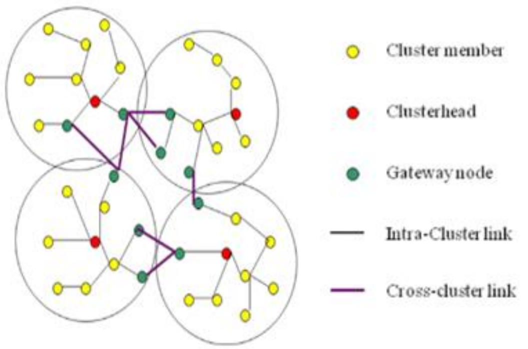

Fig. 1: Intra-cluster and inter-cluster communication in WSN

The cluster head is responsible for combining the data from all the cluster members and then subsequently sending this data to the sink of the network. Since the cluster head has to perform such major tasks in the network compared to other nodes, nodes with higher residual energy are selected as cluster heads. The cluster head will therefore spend more amount of energy in the network to get the jobs done and hence has to be re selected to avoid over consumption of power by one particular node. The re selection of the cluster head will therefore improve the network longevity [3].

In a certain method, the cluster heads are chosen randomly in order to make the selection process easier and less power consuming. Clustering and Cluster Head (CH) rotation were taken into account for theoretical investigation of the parameters for optimal deployment of WSN in view of energy cost and network lifetime [4].

In another method, the cluster head is chosen such that the distances from the nodes in the cluster to the cluster head have the least cost. Whichever the method used, the cluster head has to be re selected periodically for the reasons already mentioned. Dynamic multilevel hierarchical clustering used a state transition pattern for the nodes to make better use of the existing energy of each node with focus on enhancing the network lifetime [5].

Hierarchical approach of mobile agent based layers to optimize load balancing was developed for a large scale network, in view of enhancing energy conservation of nodes [6]. Multi-layer upper Residual Energy based Mobile Agent nodes were modelled as charging Mobile Power Banks (MPB) to avoid premature failure upon request was demonstrated [7] with target detection mechanism.

Hybrid, Energy Efficient, and Distributed clustering protocol is the most effective of clustering protocols available today especially in terms of energy efficiency [8]. The cluster head is selected based on the node residual energy and the communication cost between the cluster head and the other nodes of the cluster. This cluster head selection takes place in 3 steps. The first step known as the initialization step involves all the nodes set the probabilities of them becoming the cluster head. The second step known as the main processing step is where the decision making takes place by comparing the parameters important for the selection of the cluster head. The third step known as the finalization step is where the nodes that have been selected declare themselves as the cluster head to the group.

Re clustering keeps taking place whenever the energy of a particular cluster head is going to drop below a certain value. The problem with this protocol is the fixed periods of time for which re clustering occurs. If the energy of the cluster head falls to zero within that fixed time the network will have problems. The network will have to wait until that re clustering time to resume normal functionality. Re-clustering framework for wireless sensor networks to undergo global re-clustering framework and local delegation for WSNs were proposed so as to enhance the lifetime of the network [9].

3. Methodology Adopted

For analyzing the system there is the network model and the radio model. The network model describes the sensors, their modes of operation which are active mode, idle mode and sleep mode. The radio model describes the communication between the sensor nodes. The following figure shows a first order radio model for the purpose of analysis and understanding.

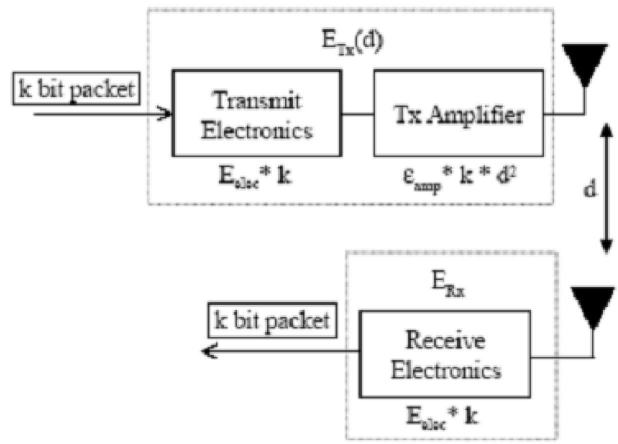

Fig. 2: Radio Model of a Wireless Device

Values for Etx, Eamp, Erx and Eelecare mentioned in table I.

4. Proposed method

The network setup is divided into 3 steps just like in HEED. They are the initialization, main processing and the finalization steps. The first round starts with all clusters selecting their cluster heads using the same procedures of HEED. Each cluster head will then create a schedule which will describe when it will be the turn for a particular node in that cluster to become the cluster head. The schedule will contain this information for all the nodes in that cluster and the cluster head will inform this schedule to all the cluster nodes. In this way the cluster heads keep changing within the same cluster. This keeps happening until the current cluster head's energy goes below a certain threshold value at which point are clustering message is sent to the cluster head. Upon receiving this message, the cluster process goes back to the first step. Again the same process repeats. Formula for calculating the threshold energy is as follows.

$$T.E = k*Eres \quad (1)$$

In this formula, k is an experimentally decided constant between 0 and 1. Eres is the residual energy of the node at the start of the latest round in which re clustering has taken place. Both the existing and proposed systems have been shown in flow chart in Figure 3. In the existing system, the cluster head is selected at random thereby making the process quick and easy. But this randomness leads to drawbacks such as the routing drawbacks as the cluster is not evenly distributed due to random cluster head selection. The method that we have proposed takes residual energy of the nodes into account in order to determine the cluster head. This method has been implemented in single level and multilevel cluster methods.

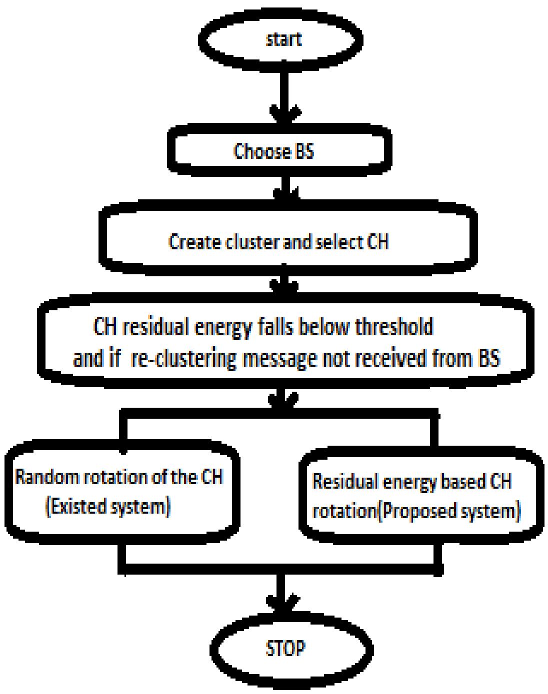

Fig. 3: Flow diagram

Figure 4 shows a single level clustering approach in which all the cluster heads directly connect to the base station. Figure 5 shows a multilevel clustering approach where the lower level cluster heads communicate through the higher level cluster heads. Multilevel approach leads to more efficient energy distribution in the network.
We will be analysing the performance of the proposed method by making use of Quality Of Service parameters such as data rate, jitter and packet delivery ratio in the case of a multilevel system.

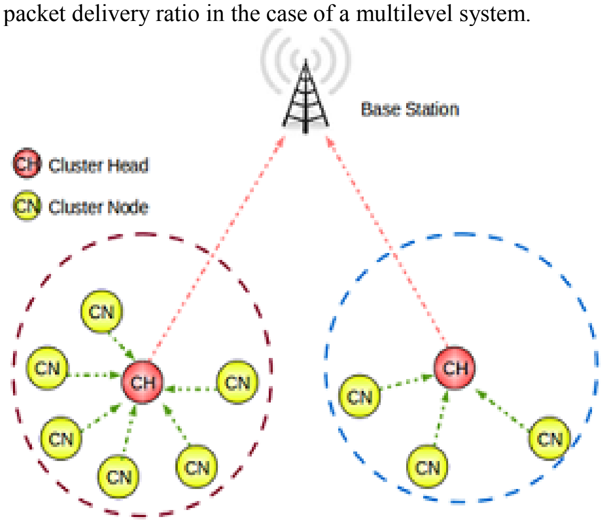

Fig. 4: Single level hierarchical clustering

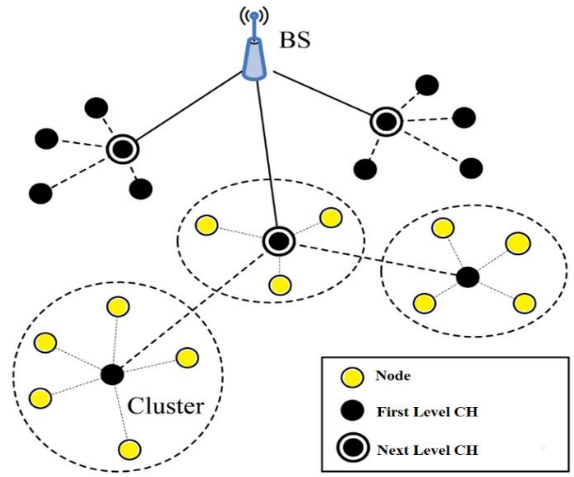

Fig. 5: Multi- level hierarchical clustering.

5. Simulation Settings

The simulation consists of 100 nodes that are uniformly place over the area to be monitored. The base station is located at a faraway distance from the area to be monitored. Signal attenuation is proportional to the square of the distance from the source. For relatively small distances, the attenuation can be considered linearly varying with distance. Practically, several parameters can affect attenuation such as background noise, obstacles along the path, etc. [10]. For the purpose of making the analysis easy, we have assumed an ideal case where attenuation is only a function of distance from the source. Performance evaluation for various routing protocols in a WSN environment could vary with simulation of different parameters under same mobility models as it has significant influence on multihop networks performance [11].

Table 1: Simulation Parameters

Parameters	Value
Deployment Field	1000 x 1000 m
Packet Size	900 bytes
Number of nodes	100
Initial Energy	2.5 j
Application	TCP
Constant C	0 – 1
Deployment Method	Uniform, Random
Eelec	50nJ/bit
efs	10nJ/bit/m2
Efus	5nJ/bit/signal
eamp	0.0013nJ/bit/m4

6. Results and discussions

The simulation results are discussed in this section. The simulation is done for both single level and multilevel methods. In the single level system, we compare the existing and proposed system in terms of energy consumed, packets lost, end to end delay, throughput of the system and the signal strength. Then single and multilevel systems are compared in terms of energy consumption and number of nodes alive. Finally, we use the multilevel approach and compare the existing and proposed system in terms of packet delivery ration, jitter and data rate. Following are the results for the single level approach:

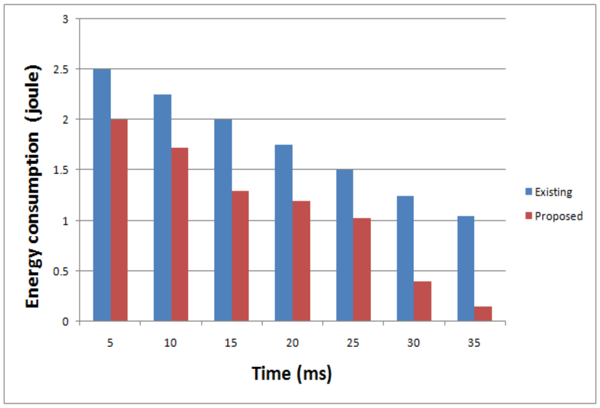

Fig. 6: Time vs Energy consumption in a single-level hierarchical clustering method

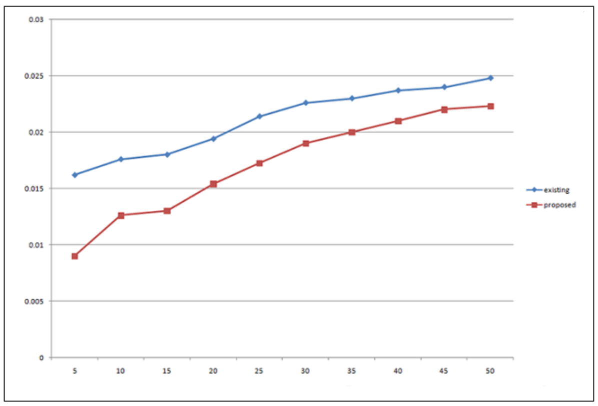

Fig. 7: Time vs End to End delay in a single-level hierarchical clustering method

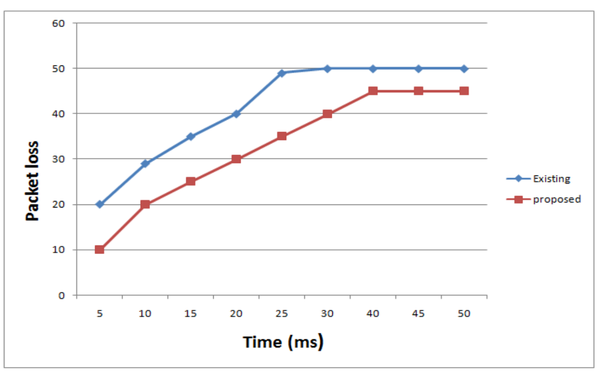

Fig. 8: Time vs Packet loss in a single- level hierarchical clustering method

Figure 6 shows the comparision of the energy consumption of the network. It can be seen that the proposed system offers a greater network lifetime compared to the existing system because of lesser power consumption. Figure 7 shows the end to end delay comparision between the existing and proposed system. The results show lesser delay for the proposed system and it can also be seen that the delay for the proposed system decreases linearly when compared to the existing system. Figure 8 shows the packet loss conparision. The proposed sustem exhibits lesser amount of packet loss than the existing system.

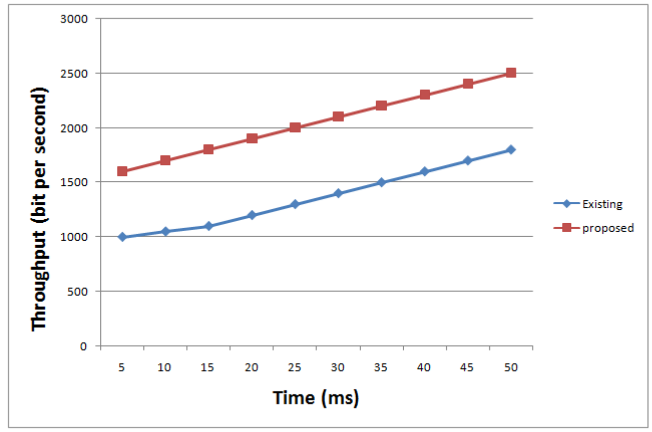

Fig. 9: Time vs Throughput in a single- level hierarchical clustering method

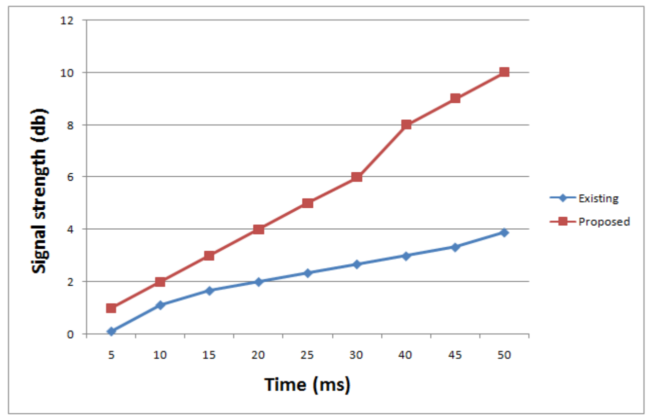

Fig. 10: Time vs Signal strength in a single- level hierarchical clustering method

Figure 9 shows the throughput conparision between the existing and proposed sytems. It can be seen that throuput is better in the proposed system and that it increases linearly compared to the existing system. Figure 10 shows the comparision of signal strength which again shows superiority of the proposed sytem. we present the throughput comparison result for the existing and the proposed system. The result show that the throughput for the proposed system increases linearly when compared to the existing system. Figure 11 shows that multi level systems have better energy efficiency than the single level systems. Figure 12 interprets that the number of nodes alive is greater in multi level systems compared to single level systems indicating lesser chances of network issues and failure.

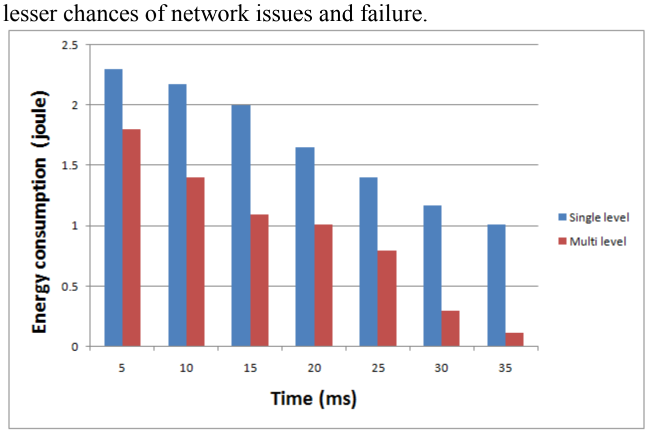

Fig. 11: Time vs Energy consumption comparison for a single and multi-level hierarchical clustering method

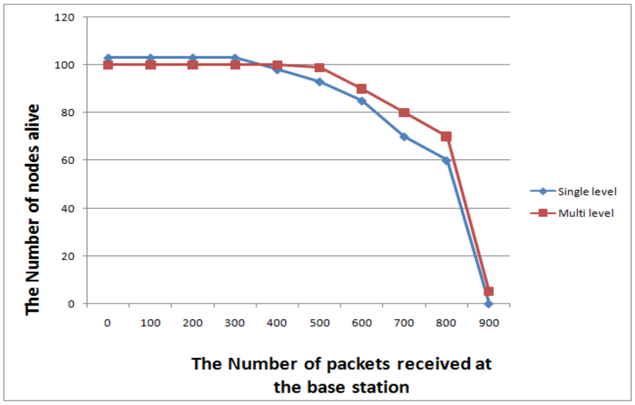

Fig. 12: The number of packets received at the base station vs the Number of nodes alive comparison for a single and multi-level hierarchical clustering method

Now we present the reults obtained wwhen using the multi level approach for the existing and proposed systems.

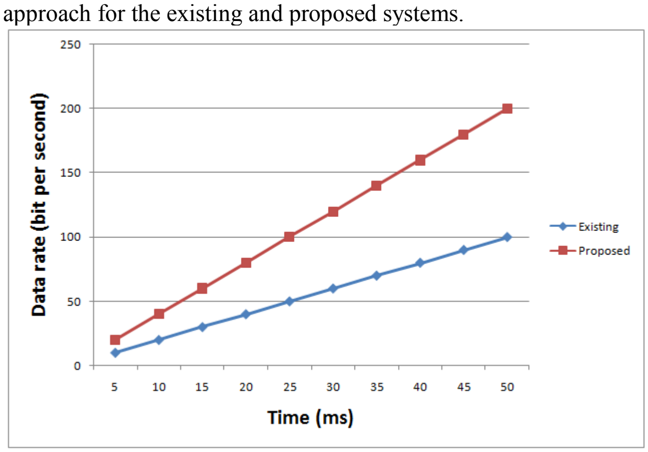

Fig. 13: Time vs Data rate in a multi-level hierarchical clustering method

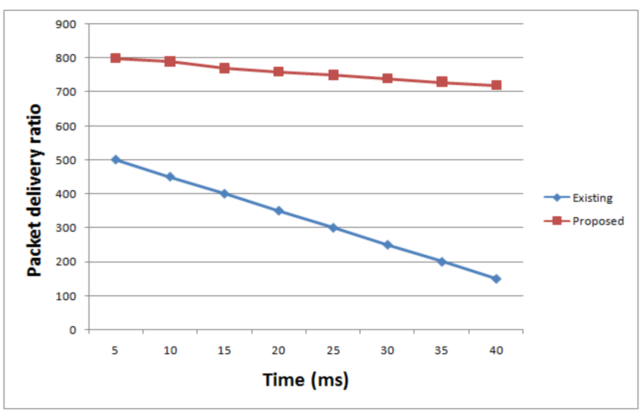

Fig. 14: Time vs Packet delivery ratio in a multi-level hierarchical clustering method

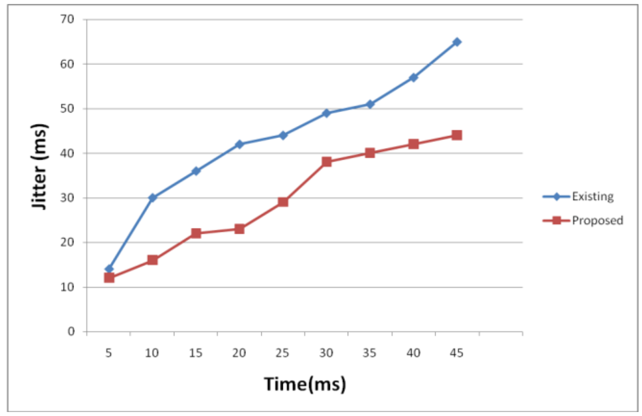

Fig. 15: Time vs Jitter in a multi-level hierarchical clustering method

Figure 13 compares the data rate for the existing and proposed system. It can be seen that the proposed system offers a higher data rate. Figure 14 indicates a better packet delivery ratio for the proposed system indicating that lesser packets are lost when using he proposed algorithm. Finally, Figure 15 compares the network jitter between the existing and proposed systems. It shows that the proposed system results in lesser jitter and better Quality Of Service compared to the existing system.

An autonomous self-healing, fault tolerant system based on FPGA can also be used with the goal of reduced power consumption and faster recovery time [12].

7. Conclusions and future work

In this paper we proposed the selection of the cluster head by taking into account the node residual energies instead of a random selection. We have compared the existing and proposed system in terms of network lifetime and several other QOS parameters. The results clearly show that the proposed system performs better than the existing system. We have applied the method for both the single and multilevel systems successfully. We have also shown that multilevel clusters offer much better performance, quality of service and lesser energy consumption than the single level clusters.

In the future, improved results can be obtained by considering additional parameters such as the degree of the node (level of the node) in the multilevel systems and the strength of the signal. As a future work additional parameters such as the degree of the node (level of the node) in the multilevel systems and the strength of the signal can be considered which can be taken up as a project work for undergraduate courses. Multichannel communication protocols can be used to overcome the effects due to interference. Adaptive learning based algorithms can be developed which can provide effective solutions for energy efficiency and throughput. Inexpensive battery operated sensors can be deployed for monitoring and data aggregation in the field of IoT which can pave new area for researchers.

References

[1] Akkaya, K. and Younis, M., "A survey on routing protocols for wireless sensor networks'' , *Elsevier Ad Hoc Networks*, Vol. 3, No. 3, (2005), pp. 325-349.

[2] Abbasi, A. and Younis, M., "A survey on clustering algorithms for Wireless Sensor Networks", *Computer communications*, Vol. 30, No. 14, (2007), pp. 2826-2841.

[3] Xu, k. and Gerla, M., "A heterogeneous routing protocol based on a new stable clustering scheme'', *Proceedings of IEEE International conference on MILCOM*, Vol. 2, (2002), pp. 838-843.

[4] A. K. Thomas and R. Devanathan, "Energy efficient dynamic multi-level hierarchical clustering technique for network discovery in wireless sensor networks," *Proceedings of 3rd International Congress on Ultra-Modern Telecommunications and Control Systems and Workshops (ICUMT)*, (2011), pp. 1-5.

[5] A. K. Thomas and R. Devanathan, "An Analysis of the Performance of Wireless Sensor Networks, *International Journal of Engineering and Technology (IJET)*, Vol. 7 No. 1, (2015).

[6] Vallikannu R, A.George and S.K.Srivatsa, "A Novel Energy Consumption Model using Residual Energy Based Mobile Agent Selection Scheme (REMA) in MANETs" *Proceedings of 2nd IEEE International Conference on Signal Processing and Integrated Networks (SPIN)*, (2015), pp. 334-339, DOI: 10.1109/SPIN.2015.7095410.

[7] Vallikannu R, A. George and S.K.Srivatsa, "Dynamic and Secure Joint Routing and Charging Scheme with Mobile Power Back Ferry Nodes in Mobile Adhoc Networks", *Indian Journal of Science and Technology*, Vol. 9, No. 33, (2016).

[8] Younis, O., and Fahmy, S., "HEED: a hybrid energy-efficient, distributed clustering approach for Adhoc Sensor Networks" *Transactions on Mobile computing*, Vol. 3, No. 4, (2004), pp. 366-379.

[9] A. K. Thomas and R. Devanathan, "Hybrid Re-Clustering Algorithm for Enhancement of Network Lifetime in Wireless Sensor Networks", *International Review on Computers and Software (I.R.E.CO.S.)*, Vol. 9, No.9 (2014).

[10] Vallikannu R, A. George and S.K.Srivatsa, "Performance Analysis of Autonomous Location Based Energy Efficient ACO Routing Protocol with Dissimilar MANET Mobility Models" *ARPN Journal of Engineering andApplied Sciences*, Vol. 10, No.4, 2015, pp. 1804-1809.

[11] Goyal, A., Vijay, S., Jhariya, D. K., "Simulation, analysis and performance comparison among different routing protocolsfor Wireless Sensor Network using QualNet", *International Journal of Computer Application* , Vol. 52, No.2,(2012), pp. 0975-8887.

[12] D Jose, R Tamilselvan, "Fault Tolerant and Energy Efficient Signal Processing on FPGA Using Evolutionary Techniques" *Computational Intelligence, Cyber Security and Computational Models*, (2016), pp.155-164.

[13] T Pranisha, D Jose, "Area Efficient Cordic FFT Using Error Correction Codes And Parseval Checks For OFDM Systems",*ARPN Journal of Engineering and Applied Sciences*, Vol.11, No. 5, (2016), 3534-3540.