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Research Article

Energy-Efficient TDMA based Clustering Scheme for WSN

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Abstract: Wireless Sensor Networks (WSNs) are broadly deployed for civil and military purposes. WSN is a sensor network used to monitor physical and environmental conditions of a system such as a temperature, sound, and pressure. Sensors collect the data and send it to the desired destination such as base station. It consists of tiny nodes having very limited energy; once this energy ends then the node dies. Energy consumption is a major issue in these sensor networks. Hence, the focus of this research is to make these sensors cheap and energy-efficient. In order to gain optimized results, hundreds and thousands of nodes are deployed. To make the system more energy efficient, different routing techniques are used. In this paper, a new Efficient Time Division Multiple Access (TDMA)-based Clustering (ETC) Scheme for WSNs has been introduced which is more energy efficient than other schemes. ETC scheme uses clustering and TDMA by using hierarchy. In this hierarchy, nodes are divided into three levels, lower level nodes, medium level nodes and high energy nodes. Simulation results show that ETC has high energy efficiency, higher throughput and lower end-to-end delay. ETC results have been compared with existing schemes like Modified Low-Energy Adaptive Clusturing Hierarchy (MODLEACH) and Low-Energy Adaptive Clusturing Hierarchy (LEACH)-CCH. ETC showed better results than these schemes. ETC was 2.13% better than Low-Energy Adaptive Clusturing Hierarchy -CCH and Modified Low-Energy Adaptive Clusturing Hierarchy in case of throughput analysis. ETC had less energy consumption than Low-Energy Adaptive Clusturing Hierarchy-CCH and Modified Low-Energy Adaptive Clusturing Hierarchy. ETC showed $2.29*10^4$ joules of average energy consumption which was far better than Low-Energy Adaptive Clusturing Hierarchy-CCH which showed$1.16*10^5$ joules and Modified Low-Energy Adaptive Clusturing Hierarchywhich was $3.63*10^4$ joules. In the end-to-end delay, ETC show much better results as compared to Low-Energy Adaptive Clusturing Hierarchy-CCH and Modified Low-Energy Adaptive Clusturing Hierarchy. ETC showed $4.94*10^4$ seconds of an end-to-end delay which was far better than Low-Energy Adaptive Clusturing Hierarchy-CCH which shows $9*10^4$ seconds and Modified Low-Energy Adaptive Clusturing Hierarchy which was $6.66*10^4$ seconds. It is shown from the results that ETC has high stability period and higher throughput.

Keywords: WSN, ETC, LEACH-CCH, MODLEACH

1. INTRODUCTION

Wireless Sensor Networks (WSNs) consist of small tiny nodes also known as sensor nodes. These sensors are used to monitor physical and environmental conditions of a system such as a temperature, sound, and pressure etc. Hundreds and thousands of these small size nodes are deployed in the region of interest to sense an environment. These low-cost, low-power and multifunctional nodes sense the data from the environment and transmit the desired data to the sink node or base station [1, 2]. They have the ability to sense the data and process the desired data. Sensors sense the data from the environment and send it to the sink node or base station [3, 4]. Energy consumption during sensing and transmission of data is very high. So, to reduce this energy consumption efficient schemes are used [3, 4].

In order to avoid the problem of energy consumption and to achieve network scalability

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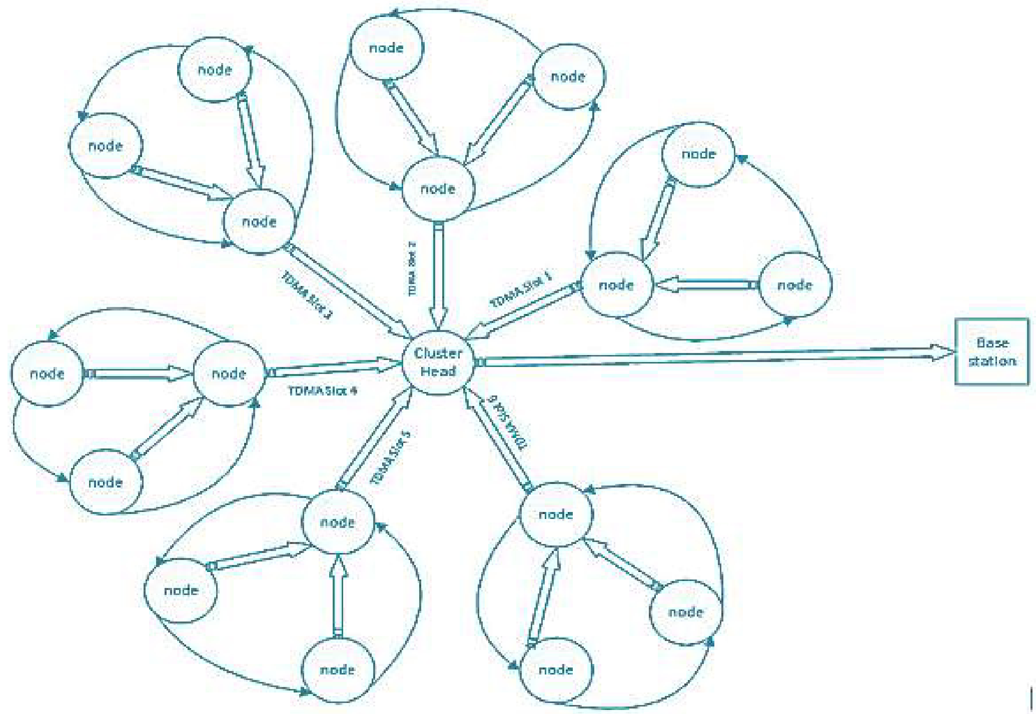

Fig. 1. Clustering in Wireless Sensor Networks (WSN)

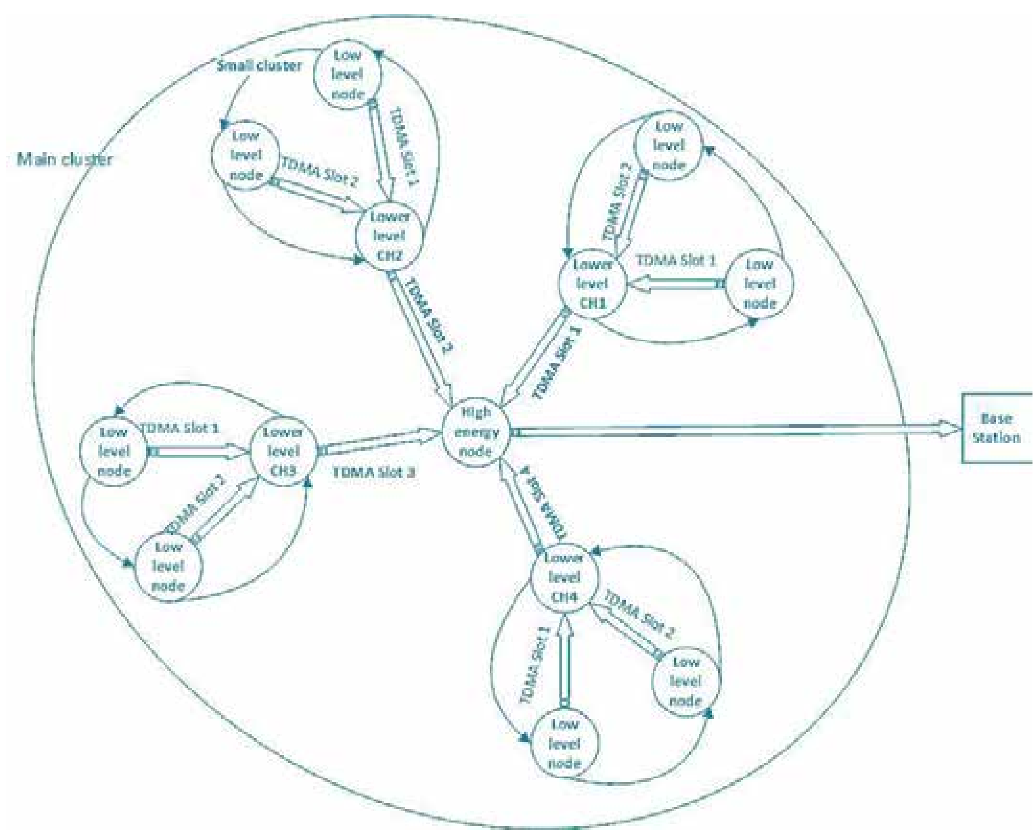

Fig. 2. TDMA based hierarchical clustering.

clustering technique are used. Clustering is also used because if all the nodes send their own data directly to the base station this will consume most of the energy of every node. The nodes which are far away from the base station require more energy to transmit which will result in the drainage of battery [4, 5]. The cluster chooses a leader known as CH. The CH may be randomly chosen through election or on the bases of the amount of the energy remaining in any node. The nodes which have higher energy are chosen as a CH [4, 5].

As shown in Figure 1, by making clusters only a few nodes communicate directly with the base station. This decreases energy consumption of other nodes. Clusters are made according to the nearest node. The node which requires less energy to transmit the data to the CH is taken in to cluster as a member. These nodes then send their data to the desired CH, not to the base station. CH makes a TDMA schedule for each node so they can send their data on their prescribed time and then remains OFF.

This scheduling helps nodes to save their energy and hence the lifetime of the system increases. This scheduling technique also helps to limit redundancy in coverage and prevent medium access collision [4, 5]. These CHs are randomly chosen for the short period of time and then the new CH is chosen. In this way, the whole energy load is distributed among all the nodes and hence the lifetime of the system increases eventually.

When CH receives data from all nodes, then data aggregation is done by the CH in order to decrease the number of packets. After this data is sent to the base station from where this data is sent to the end user. In data aggregation, the whole information is combined together which CH has received from all the nodes then the extra information is removed by enhancing the common signal and removing the noise. After data aggregation, all the information is sent to the base station. The following are the key features of network clustering:

- Load balancing
- Fault-tolerance
- Increased connectivity and reduced delay
- Minimal cluster count
- Maximal network longevity [5]

A number of simple clustering, clustering with TDMA and non-clustering schemes have been proposed which are summarized in Table 1.

2. PRPOSED SCHEME

We proposed an Energy Efficient TDMA based Clustering (ETC) Scheme for WSN which uses hierarchy (Figure 2). In this hierarchy three level nodes are used; Lower Level Nodes, Medium Level Nodes and High Energy Nodes. Low-level nodes are nodes within a small cluster of radius r equal to 1meter. They are always more than one node. Medium level nodes also called as low-level CH are elected on the basis of their residual energy. If two nodes have the same residual energy, then it should check the minimum distance between the main CH and nodes. The node which has less distance from the main CH is chosen as a medium level node or low-level CH. After selection of Low-level CH, the TDMA schedule is made for rest of the nodes and nodes send their data according to the TDMA schedule. The data which is collected from low-level nodes is sent to the high energy nodes or main CH through TDMA scheduling and main CH aggregates the data and sends it to the base station. In this hierarchy, load balancing on each node is used due to which network lifetime will be increased and energy consumption will be low. Flow Chart of TDMA base Hierarchical Clustering is shown in Figure 3.

2.1. First Order Radio Model

The advantage of the protocol depends on the radio characteristics like energy loss during transmission and receiving of data. LEACH assume a simple model that the radio dissipation is E_{elec} = 50 nJ/bit to run the transmitter or receiver circuitry and $\in_{amp} = 100$ pJ/bit/m for the transmit amplifier. This would help to achieve an acceptable $\frac{E_b}{N_o}$ (Figure 4 and Table 2). In radio design these parameters are better than other state-of-the-art design parameters [1].

In this model, it is assumed that the r^2 energy loss is due to channel transmission. In order to transmit k-bit message at a distance d, then radio expansion is:

$$E_{Tx}(\text{k, d}) = E_{Tx-elec}(k) + E_{Tx-amp}(\text{k, d})$$

$$E_{Tx}(\text{k, d}) = E_{elec} * \text{k} + \in_{amp} * \text{k} * d^2 \quad (1)$$

Table 1. Routing Schemes for Wireless Sensor Networks (WSN)

Scheme Name	Parameters addressed	Methodology	Limitations
LEACH [1]	Energy efficiency	Clustering	Low stability time for 1st node
Improved LEACH [2]	Energy efficiency and energy conservation	Clustering	Does not concentrate on end to end delay
CBDR [3]	End to end delay, delivery ratio of data	Clustering	Have additional overheads and contains extra information for each node
REAC-IN [4]	Selection of CH and node isolation	Clustering	Limited energy efficiency
Energy Efficient Clustering [5]	Uniform energy dissipation, end to end delay	Clustering	Limited for single WSN
Multi-Hop LEACH Protocol [6]	Energy Efficiency. CH election	Clustering	Limited network scalability
MODLEACH [7]	CH formation, throughput, and energy efficiency	Clustering and TDMA	Calculation of routing load, CH replacement issue
H-LEACH [8]	Threshold and average energy dissipation	Clustering and TDMA	Assigning of TDMA slot is not efficient
Energy-aware Routing Protocol [9]	Network scalability, energy efficiency, CH formation	Clustering	Have more average energy dissipation
LEACH-CCH [10]	Network throughput and energy efficiency	Clustering and TDMA	Forming clusters based on predicting future node, limited radio transmission capability
Modified LEACH [11]	Energy efficiency	Clustering and TDMA	For lager network areas Modified LEACH is not much more efficient
TFM Tree Approach [12]	Energy efficiency and energy conservation	TDMA in tree-based approach	Extra information of each node is taken. Allocation of slots is not good
Hybrid MAC Algorithm [13]	Collision avoidance and reduction in allocation of slots	MAC base TDMA	End to end Delay is more
Multi-Channel TDMA Scheduling (MDT) [14]	On time packet delivery and end to end delay	Mathematical modeling using TDMA	Dedicated time slots and extra time slots consumes a lot of energy
TDMA Scheduling for Multi-Hop WSN [15]	Interference avoidance, end to end delay	Tree-based Mathematical modeling in TDMA	Does not guarantee short time scheduling
EETS [16]	Time synchronization and node synchronization	TDMA base mathematical modeling	Extra overhead problem
BS-MAC [17]	Packet delays, overhead reduction	Mathematical modeling using TDMA	Interference is more
IDeg-LO and IDeg-ReLO base TDMA Scheduling [18]	Latency and end to end delay	TDMA	Uses single metric which causes problem in case of interference
TDMA Time Synchronization Protocol for WSN [19]	Synchronization errors, latency, and bandwidth utilization	TDMA	Have more energy dissipation
TDMA MAC slot allocation [20]	Data collision and transmission delay	TDMA with Modeling	High latency
Packets Distribution in a Tree-Based Topology [21]	Packets distribution	Tree base	Tree base topology in which each node communicates with the sink node which consumes a lot of energy
Energy efficient mobile sink path strategy [22]	Latency and data aggregation	Mathematical modeling	Extra overhead information
Algorithm for the Maximum-lifetime Data Aggregation Tree Problem in WSN [23]	Transmission power and data aggregation	Tree base	Load balancing is not good
EERC-MAC [24]	Throughput and energy efficiency	Tree base modeling	For smaller network
TST Algorithm [25]	Optimization of path length, energy and computation costs in multicast of WSNs	Tree base	Only for static networks. Does not provide backup routing path

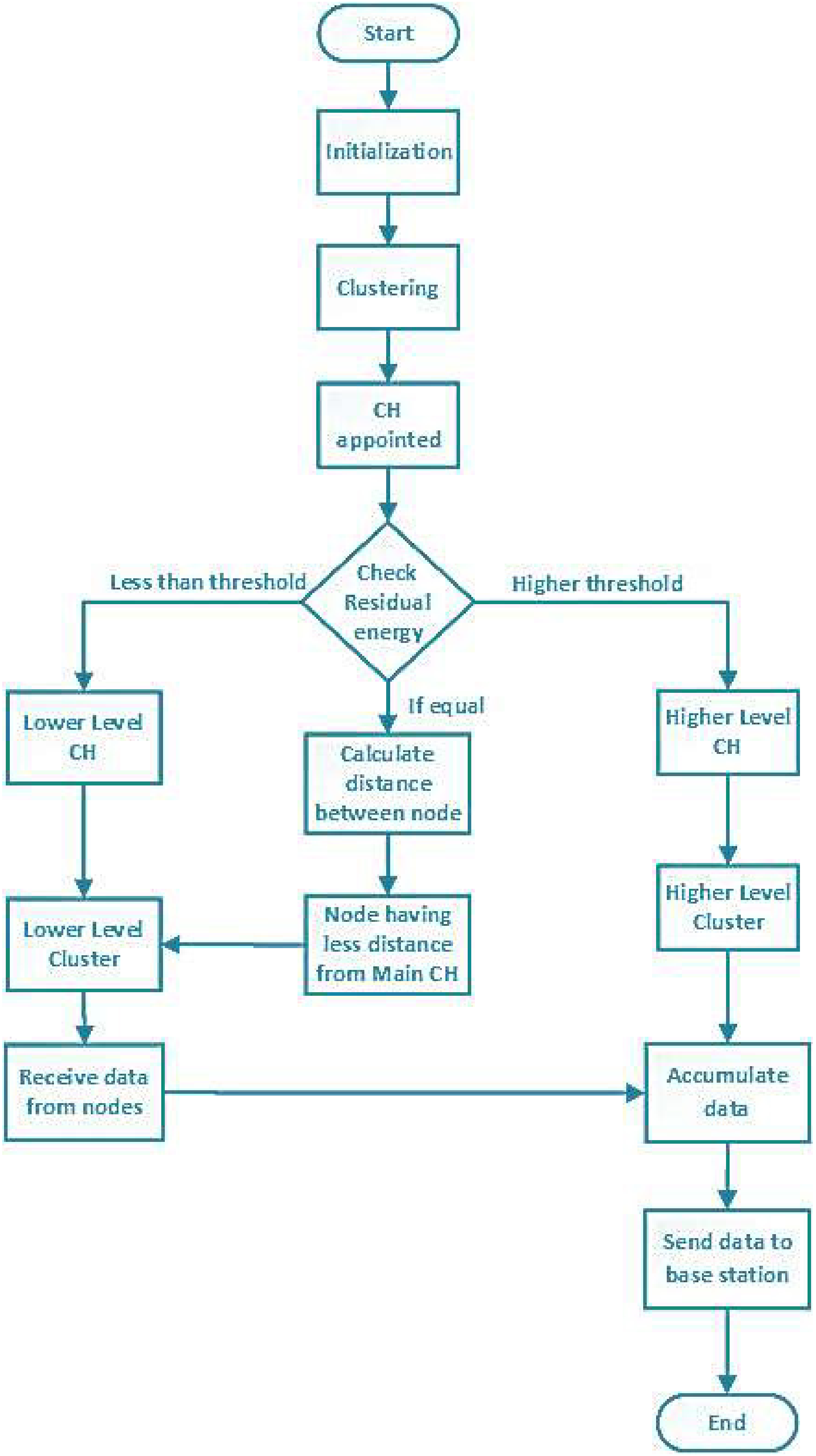

Fig. 3. Flow chart of TDMA based hierarchical clustering.

Table 2. Radio characteristics

Scheme Name	Parameters addressed
Transmitter Electronics ($E_{Tx\text{-}elec}$) Receiver Electronics ($E_{Rx\text{-}elec}$) $E_{Tx\text{-}elec} = E_{Rx\text{-}elec} = E_{elec}$	50 nJ/bit
Transmit Amplifier (E_{amp})	100 pJ/bit/m

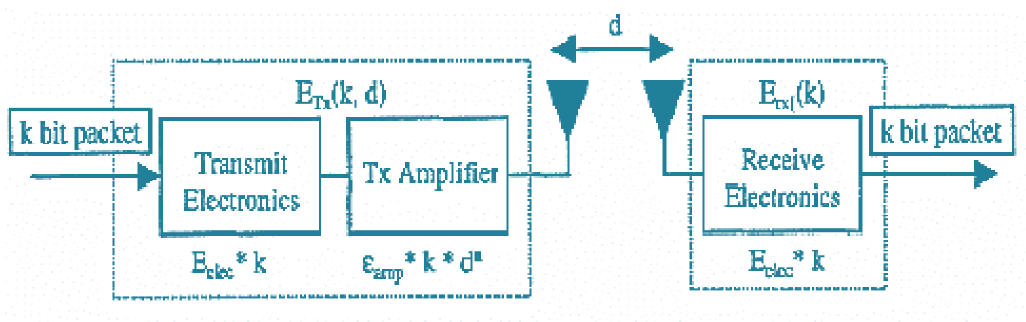

Fig. 4. First order radio model [1]

To receive a message, the equation we have is [1]:

$$E_{Rx}(\text{k}) = E_{Rx-elec}(\text{k})$$

$$E_{Rx}(\text{k}) = E_{elec} * \text{k} \quad (2)$$

Receiving of the message for the above values of the parameter is not low cost. So, the protocol must decrease the number of operations for the transmission and receiving, and also decrease the distance for transmission of data [1].

An assumption is made that all the nodes require the same amount of energy to transmit the data from node A to node B or vice versa for the given SNR (Signal to Noise Ratio). Such a system is called asymmetric system or channel. The assumption is also made that all the nodes have always a data to send and that they send the data at a constant rate [1].

In the minimum energy routing protocol, the data is sent through intermediate nodes. These nodes act as routers. Different schemes use different methods to choose the routes through which data is being transmitted from source to destination. To determine these routes, some protocol considers the transmit energy and some neglects the dissipation of energy. If the intermediate nodes are chosen, then their transmit amplifier energy will be minimum [1].

$$E_{Tx}\ (\text{k, d}) = E_{elec} * \text{k} + \epsilon_{amp} * \text{k} * d^2$$

So, to transmit the data from node A to node C if

$$E_{Tx}\ (\text{k, d}=d_{AB}) + E_{Tx}\ (\text{k, d}=d_{BC}) < E_{Tx}\ (\text{k, d}=d_{AC}) \quad (3)$$

$$d_{AB}^2 + d_{BC}^2 < d_{AC}^2 \quad (4)$$

For the ETC routing scheme, data is sent through n low transmits of low energy rather than sending a data directly to the base station in one transmits. The whole transmission is divided into n transmits and n receives. It depends on the radio electronics and transmitter amplifier cost. The total energy of the system is greater in ETC as compared with the direct transmission. Consider a network where the nodes are at an equal distance from each other and are at the distance of r. If the energy expended is k-bit message and is at a distance of nr. So the equation one and two transform as[1]:

$$E_{direct} = E_{Tx}\ (\text{k, d=n* r}) = E_{elec} * \text{k} + \epsilon_{amp} * \text{k} * (nr)^2$$
$$= k(E_{elec} + \epsilon_{amp} * \text{k} * n^2 r^2) \quad (5)$$

Each node sends a message to the near node in ETC routing to send a data to the base station. The node which is at a distance of nr requires n transmission bits for r distance and receives n-1 which is far from the base station [1].

$$E_{MTE} = \text{n} * E_{Tx}\ (\text{k, d=n* r}) + (\text{n-1}) * E_{Rx}(\text{k})$$
$$= n(E_{elec} * \text{k} + \epsilon_{amp} * \text{k} * r^2) + (\text{n-1}) * E_{elec} * \text{k}$$
$$= \text{k}\ ((2\text{n-1})\ E_{elec} + \epsilon_{amp} * nr^2) \quad (6)$$

So ETC routing requires more energy than direct communication.

$$E_{direct} < E_{MTE}$$

$$E_{elec} + \in_{amp}\ n^2r^2 < (2n\text{-}1)\ E_{elec} + \in_{amp} * nr^2)$$

$$\frac{E_{elec}}{\in_{amp}} > \frac{r^2 n}{2} \quad (7)$$

2.2. Cluster Formation

In ETC, scheme selection of CH is improved. Residual energy is the main part of this scheme. CH is chosen on the bases of residual energy and the distance between the node and base station in case of the two nodes having the same energy. Each node has the same probability of being chosen as CH for the first round. But after the first round, residual energy is to be considered. The nodes which have higher residual energy is taken as CH [2]. The selection of CH also depends on the threshold value which can be measured as

$$T_r(n) = \frac{P}{1-P*(r mod \frac{1}{P})} [\delta P + (1\text{-}\delta P) \frac{E_{residual}}{E_o}] \text{ if } n \in C$$

$$T_r(n) = 0 \qquad \text{otherwise} \quad (8)$$

Where P stands for the nodes which can be chosen as CHs and is the residual energy of the node and E_o is initial energy of the node before transmission. δ is the continuous number of rounds. After the cluster formation, the CH is chosen based the residual energy of the node and the distance between the base station and the node. The value of the λ plays an important and vital role in choosing of CH, where λ is [2]

$$\lambda = \frac{E_{residual}}{d_{toBS}} \quad (9)$$

Where is the distance between the CH and the base station. λ is calculated between all the CHs. The node which has the higher value of lambda is chosen as CH [2].

In this work, hierarchical clustering routing is used which means that after every round new clusters are made and new CHs are chosen. The new CHs after every round helps us to balance the energy load among all the nodes equally. This helps us in load management. A number of nodes are chosen after every round as CH. The threshold value is used for the deciding of selection of CHs in each round [2]. This threshold value is calculated as:

$$T_r(S_{(nrm)}) = \{\frac{P}{1-P_{nrm}*(r mod \frac{1}{P_{nrm}})} \text{ if } S\ \varepsilon\ G$$

$$T_r(S_{(nrm)}) = \{\ 0 \qquad \text{otherwise} \quad (10)$$

Where r is the number of current rounds and G is the number of nodes that have not been chosen as CH, for the $\frac{1}{P_{opt}}$ rounds.

2.2.1 For maximum number of CHs

The first order leach model is used for receiving energy expense E_{Rx} (l) and the transmission energy expanse E_{Tx} (l, d) of 1-bit message between two nodes and d is the distance between two nodes [2]. The mathematical equation is:

$$E_{Tx}(l, d) = \{\ l * E_{elec} + E_{fs} * d^2 * l \qquad \text{if } d \le d_o$$

$$E_{Tx}(l, d) = \{\ E_{elec} * l + E_{amp} * d^4 * l \ \text{ if } d \ge d_o \quad (11)$$

$$E_{Rx}(l) = l * E_{elec} \quad (12)$$

Where E_{elec} is the energy of the each bit dissipated during the transmission and gathering of data from source to destination. For the distance between transmitter and receiver there are two types of models used, namely the two ray model and the free space model. The threshold distance do can be calculated by the following equation [2]:

$$d_o = \sqrt{\frac{E_{fs}}{E_{amp}}} \quad (13)$$

If d < d_o, free space model is used otherwise two ray model is used. In order to find the ideal number of cluster, the following formula is used:

$$k_{opt} = \sqrt{\frac{n}{2\pi}} \cdot \sqrt{\frac{E_{fs}}{E_{amp}}} \cdot \frac{M}{d^2} \quad (14)$$

The ideal probability of a node to be selected as CH is calculated as [2]:

$$P_{opt} = \frac{k_{opt}}{n} \quad (15)$$

Initially, the energy of the normal nodes and advanced nodes is calculated as [2]:

$$E_1 = E_o(1 + a) \quad (16)$$

Where is the energy of the normal nodes and is the energy of advance nodes.

$$E_t = n.E_o(1\text{-P-k}) + \text{n. P }.E_o(1-a) \quad (17)$$

$$E_t = n.E_o(1\text{+a}) \quad (18)$$

This protocol is used to the likelihood of a node to be selected as CH in the current round. This weight is equal to the initial energy of the node. The node which is turned into CH once is heterogeneous. The probability of normal and advanced node into CH is calculated as[2]:

$$P_{nrm} = \frac{P_{opt}}{1+P.a} \quad (19)$$

$$P_{adv} = \frac{P_{opt}}{1+P.a+(1+a)} \quad (20)$$

3. RESULTS AND DISCUSSIONS

This environment is simulated and the field has been taken as (300,300). The deployment of the sink is at the center of the field which is (150,150). The initial energy of each node is taken as Eo=0.9. The nodes are divided into 3 categories, some nodes are taken as advance nodes, some are medium energy nodes and some are normal nodes. Simulations are conducted and then analysis of the performance of the different protocols has been compared with each other. Proposed protocol ETC is compared with LEACH-CCH and MODLEACH. The aim of this comparison and evaluation is to observe the different effect of different scenarios on the proposed protocol ETC with LEACH-CCH and MODLEACH. The different parameters used for simulating results are shown in Table 3.

3.1. Throughput Analysis

Throughput is a number of packets delivered successfully to the base station. As shown in Figure 5 and Table 4, ETC has achieved greater throughput than LEACH-CCH and MODLEACH because lower nodes send their data to medium nodes and medium nodes send their data to the main CH or high energy nodes. TDMA scheme is used for sending data which helps us to achieve higher throughput. A result of each protocol is shown in Table 4 which shows that packet delivery ratio of ETC is showing much better results as compared to LEACH-CCH and MODLEACH. At 500 rounds, all are delivering 100% packet delivery. But at 1500 round ETC shows 95% packet delivery, LEACH-CCH has 18% and NODLEACH has 79% packet delivery. At 2000 round ETC shows 64% of packet delivery which is far better than LEACH-CCH which is 9% and MODLEACH which is 44%. This is the result at the ideal position of our sink at x=150, y=150. According to Table 4 ETC is 2.13% better than the LEACH-CCH and MODLEACH is 1% and 1.9% respectively.

3.2. Stability Period Analysis

As shown in Figure 6 and Table 5, the stability period of ETC is much more than LEACH-CCH

Table 3. Simulation parameters

Area of deployment	**(x*y)**	**(300*300)**
Initial energy	Eo	0.9 J
Sink location	(x, y)	(150,150)
No of nodes	N	100
Probability of making CH	P	0.1
Maximum No rounds	Rmax	10000
Percentage of normal nodes	M	0.3
Alpha times advance nodes having great energy than normal nodes	A	3
Transmission energy	E_{tx}	50 n J
Receiving energy	E_{rx}	50 n J
Free space energy	E_{fs}	10 p J
Amplification energy	E_{mp}	0.0013 p J
Data aggregation energy	E_{DA}	5 n J

Table 4. Packet delivery ratio vs rounds. For the position of sink at x=150, y=150

Protocol	Rounds 500	1000	1500	2000	2500	3000	Average	Ratio
MODLEACH	100	100	79	44	31	30	64	1.9
LEACH-CCH	100	60	18	9	8	7	33.6	1
ETC	100	100	95	64	39	32	71.6	2.13

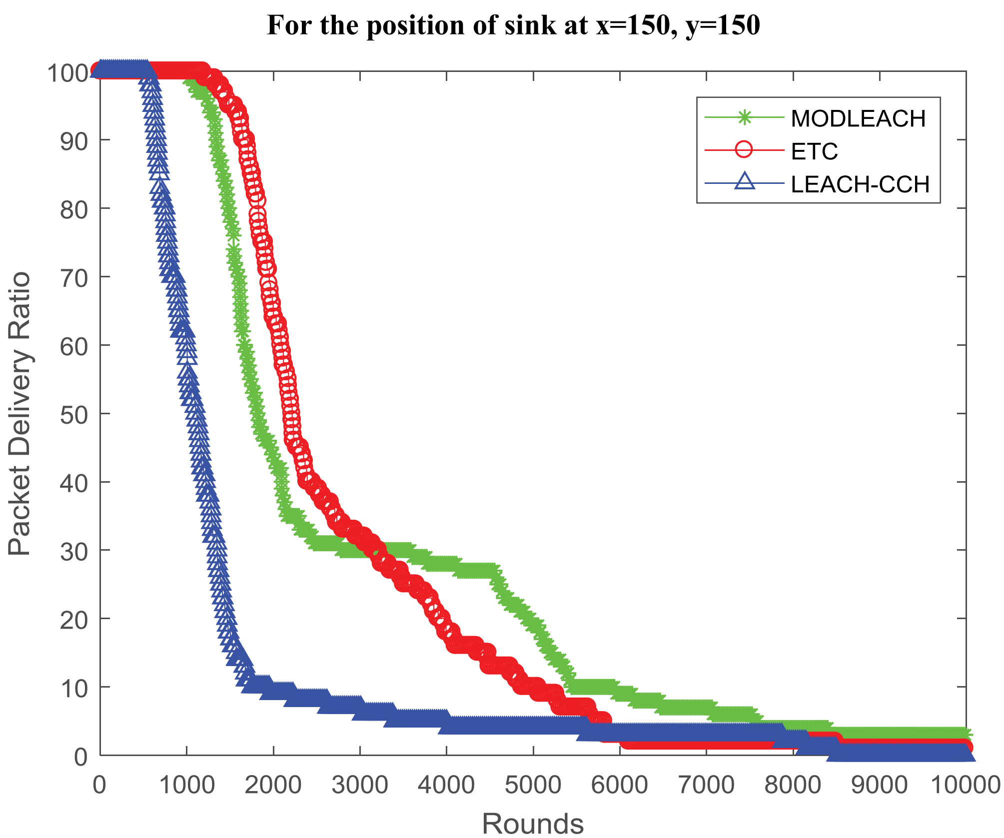

Fig. 5. Packet delivery ratio vs rounds

and MODLEACH. The reason is that data is transmitted through intermediate nodes. Level of nodes is divided into 3 levels like lower level nodes, medium level nodes and high energy nodes. So, data is sent only when needed. The simulation shows the number of nodes that are dead during transmission. If a node dies early it means that our protocol will work only for short period of time. A result of each protocol is shown in Table 5 which shows the number of dead nodes. Table 5 shows that ETC is showing much better results as compared to LEACH-CCH and MODLEACH. At 2000 round, ETC shows 32% of its nodes are dead which is far better than LEACH-CCH which shows 90% of dead nodes and MODLEACH which shows 63% of dead node. This is the result at the ideal position of our sink at x=150, y=150. But at 4000 round, these values change whereby, ETC shows 79% of its nodes are dead, LEACH-CCH shows 97% of dead nodes and MODLEACHshows72% of dead node.

3.3. Energy Efficiency Analysis

Energy efficiency of the system is how much the system is using energy for sending and receiving data. This energy consumption shows how much energy efficient is the protocol. Energy consumption, measured in joules is energy consumed or used during transmission of data it is always. There are 2 types of energies like initial energy and advance energy. Initial energy is 0.9 all the nodes have provided the same initial energy. The normal nodes are less energy as compared to advanced nodes. Advance nodes have greater energy which is a=3. A result of each protocol is

Table 5. Packet delivery ratio vs rounds. For the position of sink at x=150, y=150

Protocol	Rounds 2000	4000	6000	8000	10000	Average	Ratio
MODLEACH	63	72	91	97	98	84.5	1.04
LEACH-CCH	90	97	99	100	100	97.2	1.2
ETC	32	79	96	98	99	80.8	1

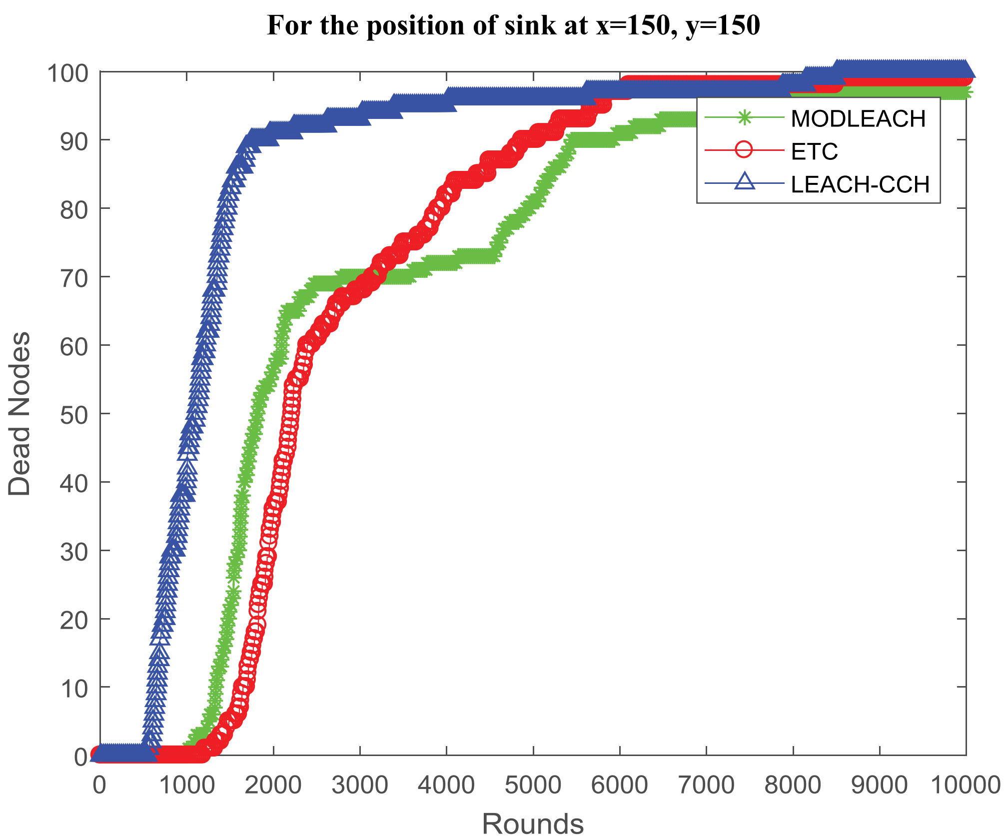

Fig. 6. Dead node vs rounds.

shown in Figure 7 and Table 6 which shows that average energy consumption in joules. Table 6 shows that ETC is showing much better results as compared to LEACH-CCH and MODLEACH. At 2000 round ETC shows $2.29*10^4$ joules of average energy consumption which is far better than LEACH-CCH which shows $1.16*10^5$ joules and MODLEACH which is $3.63*10^4$ joules. This is the result at the ideal position of our sink at x=150, y=150. But at 4000 round, these value change ETC shows $3.69*10^4$ joules of average energy consumption which is far better than LEACH-CCH which shows$1.32*10^5$ joules and MODLEACH which shows $5.06*10^4$ joules. As average energy consumption of ETC is less then LEACH-CCH and MODLEACH so the ETC is more energy efficient than all other protocols.

3.4. End to End Delay

End to end delay shows that how much time it takes to deliver the packets to the destination. Less the delay more efficient will be the protocol. For the ideal position of the sink at x=150, y=150,a result of each protocol is shown in Figure 8 and Table 7 which represent send to end delay. Table 7 shows that ETC is showing much better results as compared to LEACH-CCH and MODLEACH. ETC shows 49.4 milliseconds of end to end delay which is far better than LEACH-CCH which shows 90 milliseconds and MODLEACH which is $6.66*10^4$ seconds of end to end delay.

Table 6. Average energy consumption vs rounds. For the values of x=150, y=150

Protocol	Rounds 2000	4000	6000	8000	10000	Average	Ratio
MODLEACH	3.63	5.06	5.95	6.34	6.66	5.5	1.41
LEACH-CCH	11.6	13.2	13.5	13.6	13.7	13.1	3.3
ETC	2.29	3.69	4.35	4.67	4.93	3.9	1

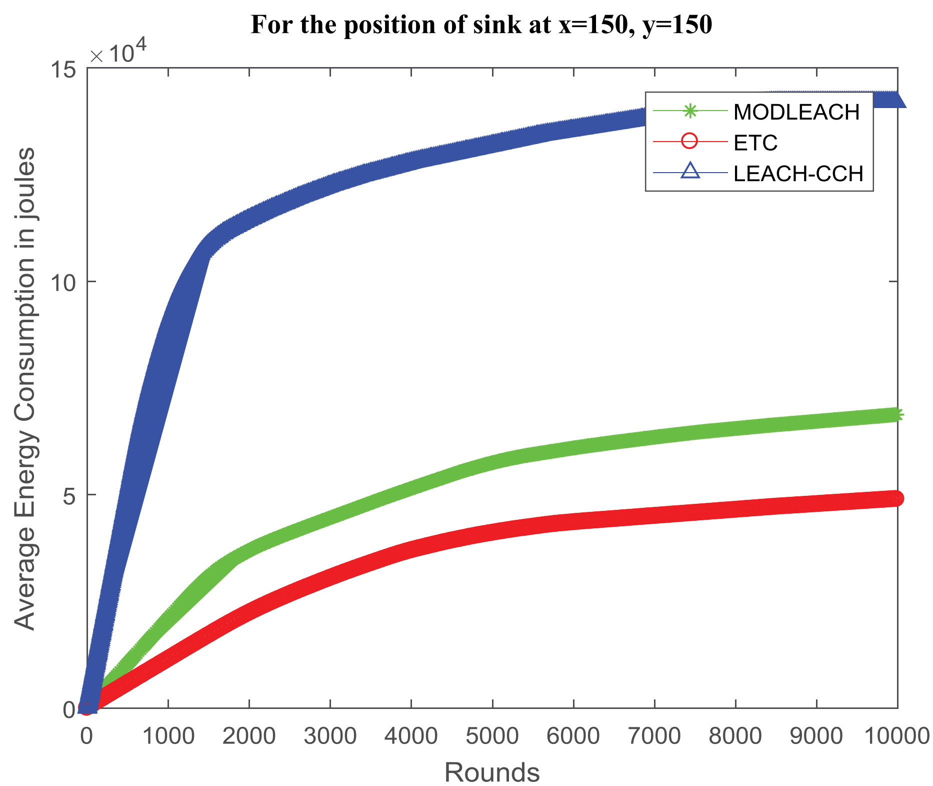

Fig. 7. Average energy consumption vs rounds.

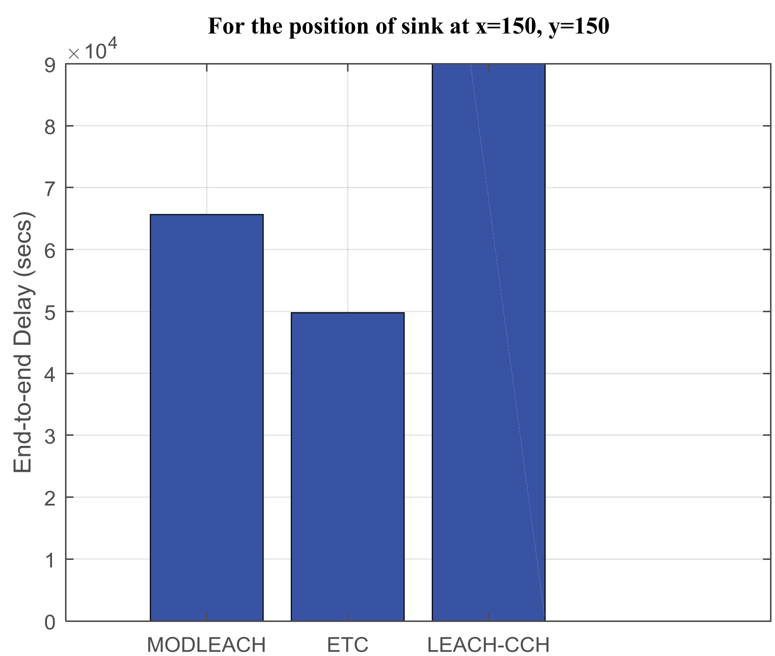

Fig. 8. End to end Delay.

Table 7. End to end Delay in seconds. For the position of sink at x=150, y=150

Protocol	Values
MODLEACH	66.6 msec
LEACH-CCH	90 msec
ETC	49.4 msec

4. CONCLUSION

An interest-based buffer management scheme is proposed in throw-boxes to increase the performance of the network. When the throw-box is full, we delete the data with high diffusion level instead of deleting the data with less popularity. The proposed scheme has good energy efficiency as compared to other routing protocols. This hybrid approach increases the delivery probability of the network by also delivering the data with less popularity. The overall average latency and overhead ratio are also decreased with this buffer management policy, and we also double-checked and prevented some critical data discrepancies. In future research, this buffer management scheme can be compared with other buffer management policies.

5. REFERENCES

1. Kaur, J, G. S. Gaba, R. Miglani & R. Pasricha. Energy efficient and reliable WSN based on improved Leach-R clustering techniques. *Indian Journal of Science and Technology* 16:1–6 (2015).
2. Imran & D. Singh. Energy-balance node-selection algorithm for heterogeneous wireless sensor networks.*Wiley ETRI Journal* 40:604–612 (2018).
3. Varma, GNS. Abhishek, G. A. K. Reddy, Y. R. Theja & T. A. kumar. Cluster Based multipath Dynamic Routing (CBDR) protocol for wireless sensor networks. *Indian Journal of Science and Technology* 8:17–22 (2015).
4. Leu, J.S, T. Chiang, Min-Chieh Yu & K. W. Su. Energy efficient clustering scheme for prolonging the lifetime of wireless sensor network with isolated nodes. *IEEE Communications Letters* 19:259–262 (2015).
5. Samantaray, A, G. Devi & R. S. Bal. The Energy Efficiency Clustering in Wireless Sensor Network. *Journal of Network Communications and Emerging Technologies* (JNCET) 6:86–92 (2016).
6. Sony, Chinchu T., C. P. Sangeetha & C. D. Suriyakala. Multi-hop LEACH protocol with modified cluster head selection and TDMA schedule for wireless sensor networks. *IEEE Global Conference on Communication Technologies* (GCCT),Thuckalay, India:539–543 (2015).
7. Mahmood, D, N. Javaid, S. Mahmood, S. Qureshi, A. M. Memon& T. Zaman. MODLEACH: a variant of LEACH for WSNs. *IEEE Eighth International Conference onBroadband and Wireless Computing, Communication and Applications* (BWCCA), Compiegne, France: 158 –163 (2013).
8. Razaque, A, S. Mudigulam, K. Gavini, F. Amsaad, M. A. Qader & G. S. Krishna. H-LEACH: Hybrid-low energy adaptive clustering hierarchy for wireless sensor networks. *IEEE Long Island Systems, Applications and Technology Conference* (LISAT), Farmingdale, NY, USA:1–4 (2016).
9. Goyal, R, S. Gupta& P. Khatri. Energy aware routing protocol over leach on wireless sensor network.*International Conference on Computing, Communication and Automation* (ICCCA), Noida, India:699–703 (2016).
10. Corn, J. & J. W. Bruce. Clustering algorithm for improved network lifetime of mobile wireless sensor networks.*IEEEInternational Conference on*, *Computing, Networking and Communications* (ICNC), Santa Clara, CA, USA: 1063–1067 (2017).
11. Sony, C.T., C. P. Sangeetha, & C. D. Suriyakala. Multi-hop LEACH protocol with modified cluster head selection and TDMA schedule for wireless sensor networks.*IEEE Global Conference on Communication Technologies* (GCCT), Thuckalay, India:539–543 (2015).
12. Bakshi, M., B. Jaumard, M. Kaddour & L. Narayanan. On TDMA scheduling in wireless sensor networks. *IEEE Canadian Conference on Electrical and Computer Engineering* (CCECE), Vancouver, BC, Canada:1–6 (2016).
13. Saraereh, O.A., I. Khan & B. M. Lee. An Efficient Neighbor Discovery Scheme for Mobile WSN. *IEEE Access* 7:4843-4855 (2018).
14. Lee, J, W. Jeong & B. C. Choi. A multi-channel timeslot scheduling algorithm for link recovery in wireless multi-hop sensor networks. In *IEEE2016 International Conference on Information and Communication Technology Convergence* (ICTC), Jeju, South Korea:871–876 (2016).
15. Sasaki, M, T. Furuta, U. K. A. I. Takamori & F. Ishizaki. TDMA scheduling problem avoiding interference in multi-hop wireless sensor networks. *Journal of Advanced Mechanical Design, Systems, and Manufacturing* 3:1–10 (2016).
16. Khedo, K. Kumar & D. Lobin. EETS: An Energy-Efficient Time Synchronization Algorithm for Wireless Sensor Networks. *International Journal of Advanced Research in Computer Science* 1:1–8 (2017).
17. Alvi, A. Naseem, S. H. Bouk, S. H. Ahmed, M. A.

Yaqub, N. Javaid & D. Kim. Enhanced TDMA based MAC protocol for adaptive data control in wireless sensor networks. *Journal of Communications and Networks* 17:247–255 (2015).

18. Louail, L, & V. Felea. Routing-aware TDMA scheduling for wireless sensor networks. *12th Annual Conference onWireless On-demand Network Systems and Services* (WONS), Cortina d'Ampezzo, Italy:1–8 (2016).
19. Lennvall, T, J. Å. berg, E. Hansen & K. Yu. A new wireless sensor network TDMA timing synchronization protocol.*IEEE 14th International Conference onIndustrial Informatics* (INDIN), Poitiers, France:606–611 (2016).
20. Chang, C. Lung & K. Y. Ho. Slot assignment for TDMA MAC in industrial wireless sensor network. *IEEE/ACIS 15th International Conference onComputer and Information Science* (ICIS), Okayama, Japan:1–5 (2016).
21. Akpakwu, G. A., Hancke G. P. & A. Mahfouz. Packets distribution in a tree-based topology Wireless Sensor Networks. *IEEE 14th International Conference on Industrial Informatics* (INDIN), Poitiers, France:1181–1184 (2016).
22. H. Salarian, K. W. Chin & F. Naghdy. Energy Efficient Mobile Sink Path Strategy for Wireless Sensor Network. *IEEE Transactions on Vehicular Technology*63:2407–2419 (2014).
23. Lin, H. Chun & W. Y. Chen. An Approximation Algorithm for the Maximum-lifetime Data Aggregation Tree Problem in Wireless Sensor Networks. *IEEE Transactions on Wireless Communications* 6:3787–3798 (2017).
24. Khalil, M. Ibrahim, M. A. Hossain, M. J. Haque & M. N. Hasan. EERC-MAC: Energy efficient Receiver Centric MAC protocol for Wireless Sensor network. *IEEE International Conference on*, *Imaging, Vision & Pattern Recognition* (icIVPR):1–5 (2017).
25. Gong, H, L. Fu, X. Fu, L. Zhao, K. Wang & X. Wang. Distributed Multicast Tree Construction in Wireless Sensor Networks. *IEEE Transactions on Information Theory* 63:280–296 (2017).