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Optimization of Energy Dissipation in Direct-Diffusion Two-Level Low Energy Adaptive Clustering Hierarchy Routing Protocol

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Abstract: Wireless Sensor Network (WSN) comprises various sensors. They sense data based on various physical phenomena parameters and transmit the same to base station by forwarding data though intermediate nodes which also behave like relaying nodes in route. However there are some resource constraints attached to them like energy and memory which attract all attention towards an energy efficient routing protocol. There exist numerous such protocols and the most prominent and effective one is Low Energy Adaptive Clustering Hierarchy (LEACH) routing protocol and its family. The lifetime of nodes and network depends on routing protocol. This paper covers some protocols under LEACH family like TL-LEACH, M-LEACH, DD-LEACH and DD-TL-LEACH. Finally, proposed work enhances the DD-TL-LEACH protocol in terms of energy by considering three major parameters size of packets, energy, and distance between node and BS.

Keywords: *WSN, LEACH, DD-LEACH, TL-LEACH, M-LEACH, DD-TL-LEACH, routing protocol.*

1. INTRODUCTION

Wireless Sensor Network (WSN) is collection of base station and multiple nodes which are deployed to collect different types of data[1]. These nodes consists various modules like sensors, memory, micro-controller,processing module, antenna, battery, etc. Major component is sensor which collectsdata like temperature, pressure, beat rate, pulse, humidity, etc.[1, 2]. These nodes face some serious issues like resource and energy constraints due to size and their deployment conditions[24].There are many deployment areas of WSN, wherever wired network is not possible due to unusual conditions like hostile environment, physical situation, and emergencies[25]. Some of the major deployment areas and reasons are healthcare, forest fire detection, troops tracking, border monitoring, rescue operations, etc. Nodes are situated in such locations over a specific area which may or not be accessed physically post-deployment to replace any internal modules and it is the biggest hurdle in the way of WSN. Hence, it needs some energy efficient mechanism for data transmission which can dissipate low energy and solve the problem efficiently and effectively[3]. One of the biggest aspects where we can optimize the energy dissipation is routing because it covers a lot of processing like route selection, routing table maintenance, route agreement[7], etc. Although there are some very good and effective techniqueswhich aggregate sensed data after

collection and forward the same to Base Station (BS) which is connected to internet which provides data to intended user[10]. One of the most prominent and efficient one among such routing protocols is Low Energy Adaptive Clustering Hierarchy (LEACH)[4, 5]. It divides the deployment area in various clusters having some nodes and every cluster is handled by one supreme node known as Cluster Head (CH). CH is elected and all other nodes in that cluster forwarddata to it. Finally, CH forwards data to BS and communication completes[6].

2. LITERATURE REVIEW

Nodes are scattered in deployment area and they need to forward data to BS. It is almost not possible to transmit data by any particular node to BS directly because of limited transmission range. There are various routing methods which come underthree different categories Direct Transmission (DT), Minimum Transmission Energy (MTE) and Low Energy Adaptive Clustering Hierarchy (LEACH)[12, 13]. DT group focuses on direct transmission of data from node to BS whereas MTE is a flat based topology where a chain is created from sending node to BS, involving various intermediate nodes[9]. However, other variants of MTE create four other types of topologies chain, area, tree and grid. Chain-based topology forms a chain from sending node to BS whereas in area-based topology deployment area is divided in small areas and every area has an area head to communicate further with any other area head or BS. Tree-based topology uses hierarchical structure to reach BS[8] and Grid-based divides the area in grids and communication takes place with the help of interaction among them[23].

LEACH is an energy efficient routing protocol which creates multiple clusters based on number of nodes and distance to BS[11]. Every cluster has its own Cluster Head (CH) and it is selected based on two parameters as energy of the node and previous status of cluster head candidature. Node which has been selected previouslyas CH, it cannot be CH again for any. Moreover, all other nodes within a single cluster forward data to CH and it forwards to BS. WSN has attracted researchers in recent years due to unique features and usability, resulting in development of various protocols. However LEACH remains in focus due to its energy efficient feature andnumerous variants of LEACH have been proposed. All of them are bundled under a single umbrella known as LEACH family. This group covers Two-Level LEACH (TL-LEACH), Multi-hop LEACH (M-LEACH), Direct-Diffusion LEACH (DD-LEACH), Direct-Diffusion Two-Level LEACH (DD-TL-LEACH) and others[25].

2.1. TL-LEACH

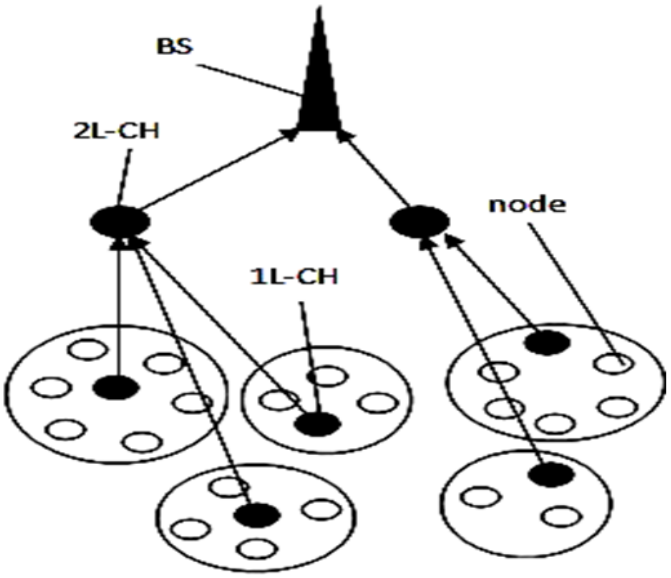

Figure 1: TL-Leach

The first advancement of core LEACH protocol is TL-LEACH. LEACH transmits the sensed data directly to CH and it forwards further to BS[14]. There are possibilities that BS may be situated beyond the transmission range of CH and this is the reason behind the development of TL-LEACH as in Figure 1. There are two-levels of CHs as First-Level and Second-Level CH (1L-CH, 2L-CH). 1L-CH is almost similar to CH in core LEACH. They are present inside their clusters whereas 2L-CHs are other nodes which are deployed between BS and boundary of cluster. They are not a member of any cluster and are used for second layer data transmission. Hence, nodes transmit data to their 1L-CH and then it forwards that to the nearest 2L-CH which forwards to BS. 1L-CHs of all clusters have to maintain the details of all 2L-CHs and based on those details nearest 2L-CH is selected[21]. The major benefit of this protocol is escalation of data transmission failure between CH and BS due to distance.

2.2. M-LEACH

The second advancement in LEACH is M-LEACH. TL-LEACH has one issue in case of flat architecture where all nodes are arranged sequentially with increasing distance from BS as in Figure 2, 2L-CHs are far away from transmission range of 1L-CH. Solution of this problem came out with another version of LEACH as M-LEACH[15, 16].

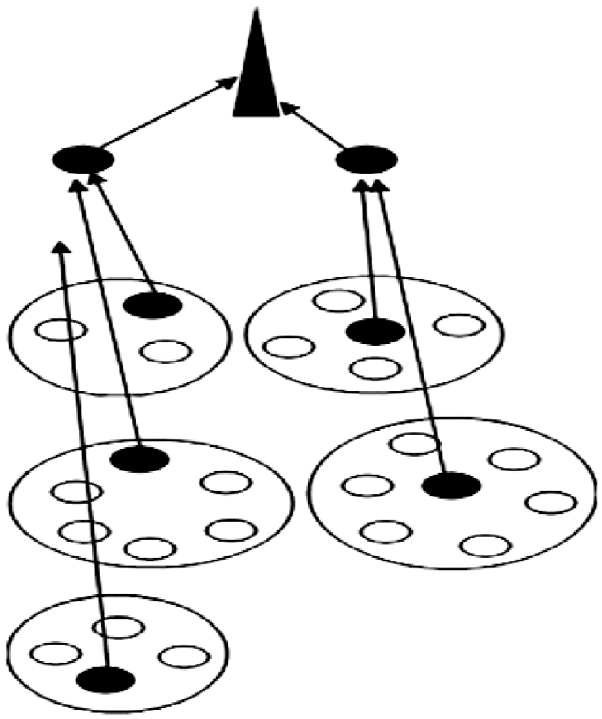

Figure 2: Limitation of TL-LEACH

It creates clusters with CHs like core LEACH but difference is in data transmission process as in Figure 3. Node transmits data to its CH and it forwards to CH of any other cluster which is nearby to BS and must be available within its transmission range.Single transmission processmay involve various CHs of different clusters on its way from source node to BS and that is why it is named as Multi-hop LEACH[20].

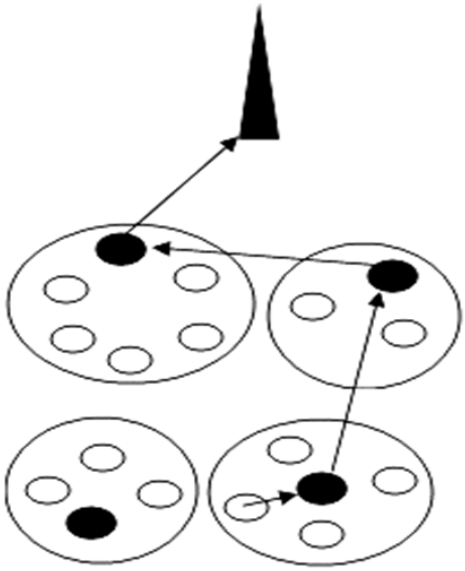

Figure 3: M-LEACH

2.3. DD-LEACH

Direct-Diffusion LEACH, as name suggests, it is combination of two routing techniques Direct-Diffusion and LEACH as in Figure 4. Motivational aspect behind development of this protocol is limitation of M-LEACH[22]. Numerous CHs were involved in data transmission in M-LEACH and sometimes it causes loop which results as data transmission failure. DD-LEACH resolved it and proposed that data is aggregated by CH up to first level and then Direct Diffusion technique is applied for further transmission to BS. CHs are virtually grouped under a cluster near BS and interaction takes place among each other for any further transmission to BS[17]. It proves itself as more energy efficient because no any CHscommunicate directly to BS and all of them have equal energy dissipation rather than load on a single CH only.

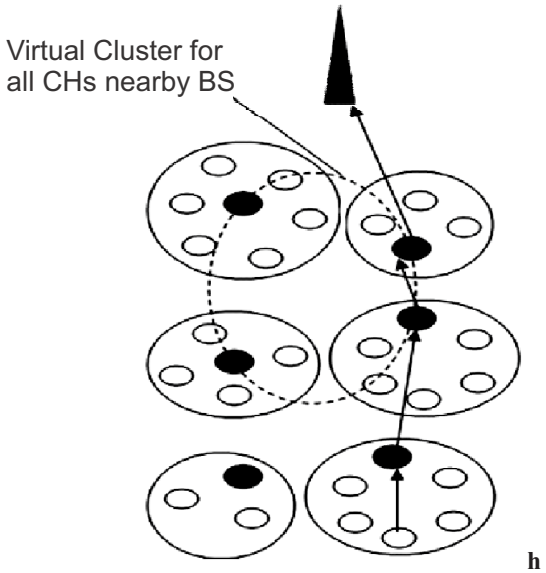

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Figure 4: DD-LEACH

2.4. DD-TL-LEACH

DD-TL-LEACH is a multi-level hierarchical data-centric routing model. It is a combination of TL-LEACH and DD-LEACH as in Figure 5. Clusters are formed at first level without CHs. All 1L-CHs are grouped in different clusters which operate at second level[19].

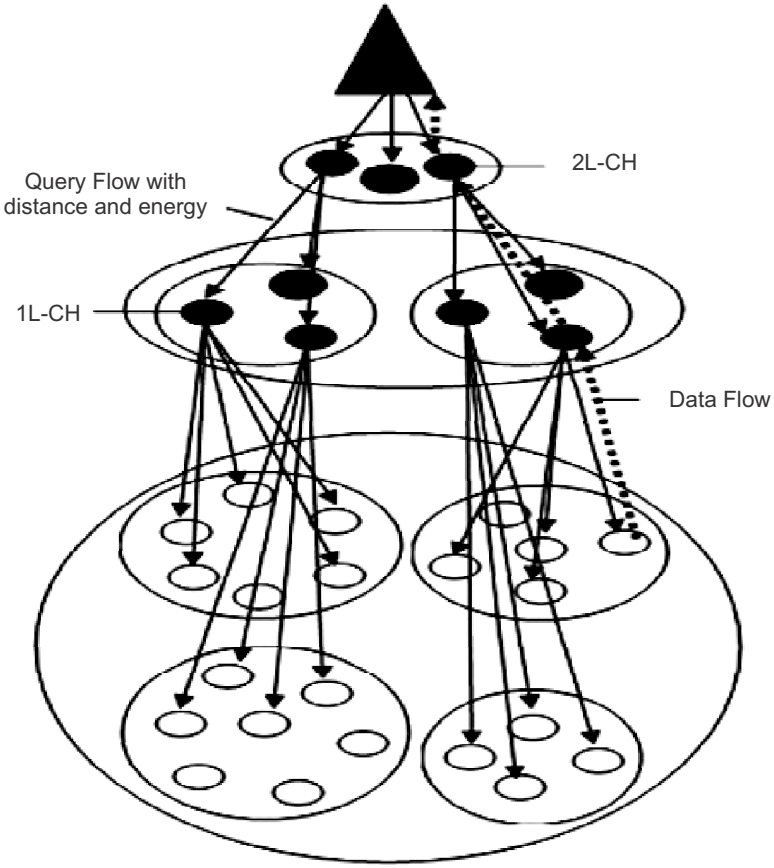

Figure 5: DD-TL-LEACH

Finally, 2L-CHs are grouped to form another cluster at third level. Overall, the deployment area is divided in three levels. Nodes transmit data to the nearest 1L-CH and it forwards to 2L-CH. Finally 2L-CH forwards data to BS by using direct diffusion technique[18].

3. PROPOSED SCHEME

Existing DD-TL-LEACH does not consider the distance between 2L-CH and BS and number and size of sent packets. However, energy dissipation of node is similar regardless of distance from the BS because of 1L-CH is not fixed in this technique. The nearest one is selected for aggregating and forwarding data. Apart from that number and size of packets affect overall energy dissipationdrastically due to reserved energy and distance because the nearest either 1L-CH or 2L-CH to BS will face more load of data transmission than any other nodes. We have proposed an energy efficient scheme which will resolve this issue. Proposed algorithm considers three parameters as number and size of packets, energy and distance. Rather than sending a large packet, it is observed that sending multiple chunks of that packet is a good solution in terms of energy and number of dead nodes. Proposed scheme considers two types of flows as query and data flow. Query flow covers all those three parameters to determine the nearest node, suitable chunk of data and available energy.

Pseudo-code of the proposed energy efficient algorithm is as follows:

number of nodes (*n*)

Query flow process and data transmission

if(2L-CH(*i*)==TRUE) then //*i* is any node as 2L-CH

BS to 2L-CH(query(distance,enrgy)) //BS sends the query to 2L-CH about distance and energy

if(1L-CH(*j*)==TRUE) then // *j* is any node as 1L-CH

2L-CH to 1L-CH(query(distance,energy)) //2L-CH sends the query to 1L-CH about distance and query

if(node[*k*]==sensed_data) then

node to 1L-CH(sensed_data) //Node wills send the data to 1L-CH which is nearest and energy; energy is considered because, it will determine about total number and size of packets that can be handled

aggregate(sensed_data) //Sensed data is received and aggregated by 1L-CH

1L-CH to 2L-CH(sensed_data,energy,distance) //Transmits aggregated data with its energy and distance

aggregate(sensed_data) //Sensed data is received and aggregated by 2L-CH

2L-CH to BS(sensed_data,distance) //Transmits aggregated data with distance which is used by BS to determine the future 2L-CH cluster formation

else sleep-state

end

4. SIMULATION RESULTS

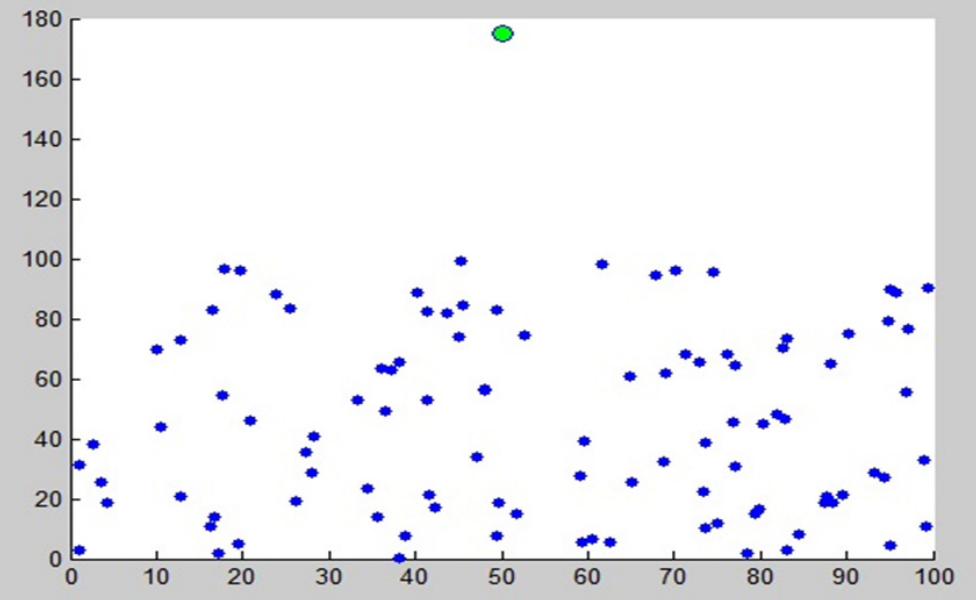

Figure 6: Yard with 100 nodes

Proposed technique uses distance parameter for selecting CH for any data transmission from second level to third level. This balances the energy among CHs which are scattered around the BS. It uses the basic LEACH protocol as underlying protocol. Proposed work is simulated on MATLAB and results are compared with existing technique and we found it better in terms of energy efficiency. We have used three parameters as number and size of packets, sum of energy and number of dead nodesto compare the simulation results.Figure 6showsyard where 100 nodes are deployed in a 100 by 100 planes and CH isdeployed at 50 and 175.Figure

7displays the results of number of packets sent to BS in 100 and 1000 rounds. Total number of packets sent to BS reached to approx 2900 in 100 rounds whereas it reached to approx 16000 in 1000 rounds when packet size is of 6400 bits in both cases.Last part of the figure displays that it hiked drastically and reached to 3*10000 in same 1000 rounds but packet size in this case is of only 100 bits.

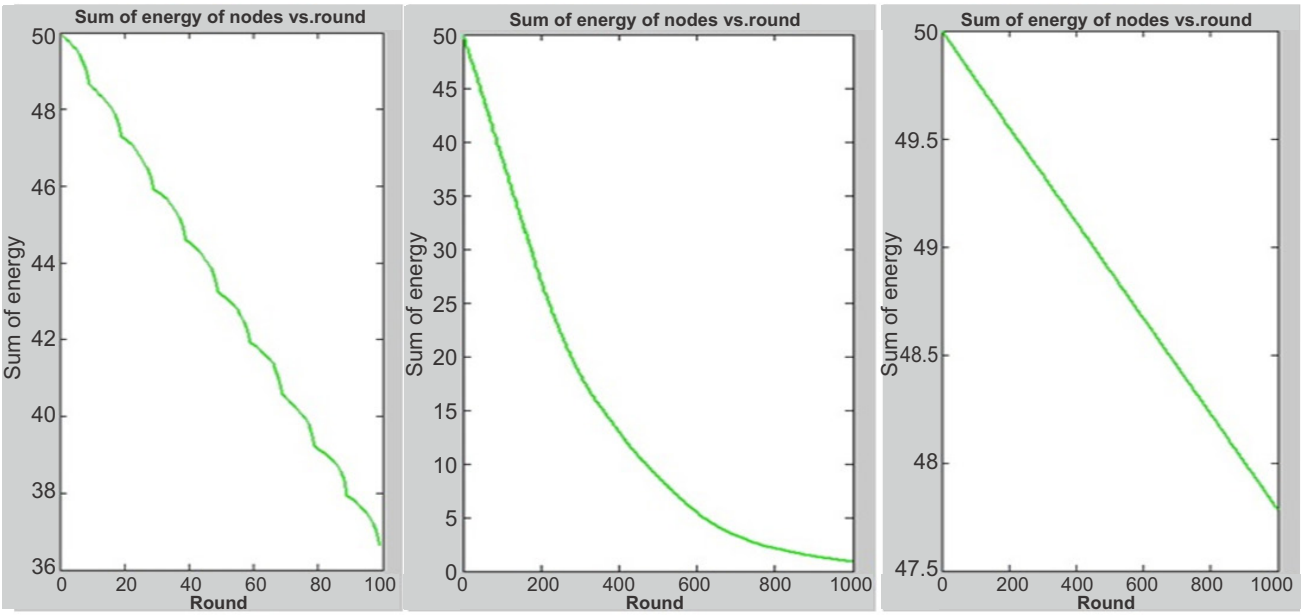

Figure 7: Number of packets sent to BS

Figure 8reveals results of total energy of all nodes against each round. Total energy decreased from 50 to 36.5 in 100 rounds whereas it decreased to 1 in 1000 rounds when packet size is of 6400 bits. Considerable improvement is witnessed in third result where it decreased from 50 to 47.25 only in 1000 rounds when packet size is 100 bits. This is even better than 100 rounds which prove its energy efficiency.

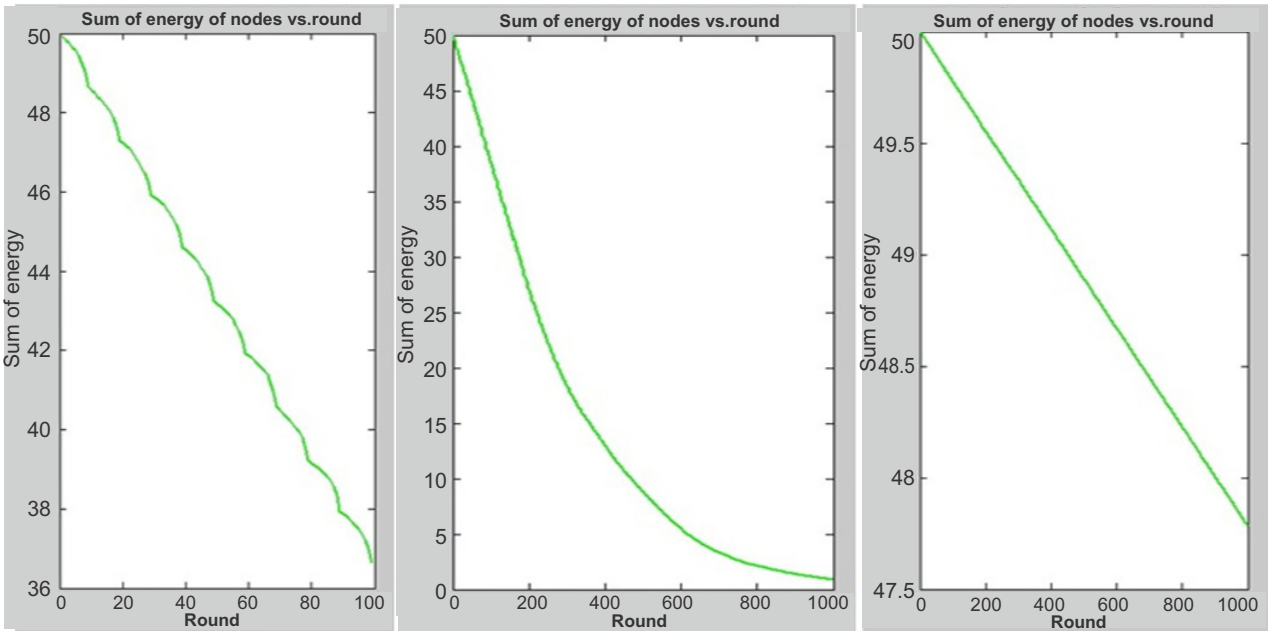

Figure 8:Total energy of nodes against each round

Similarly according to energy dissipation in each round, Figure 9shows total number of dead nodes in all three cases.

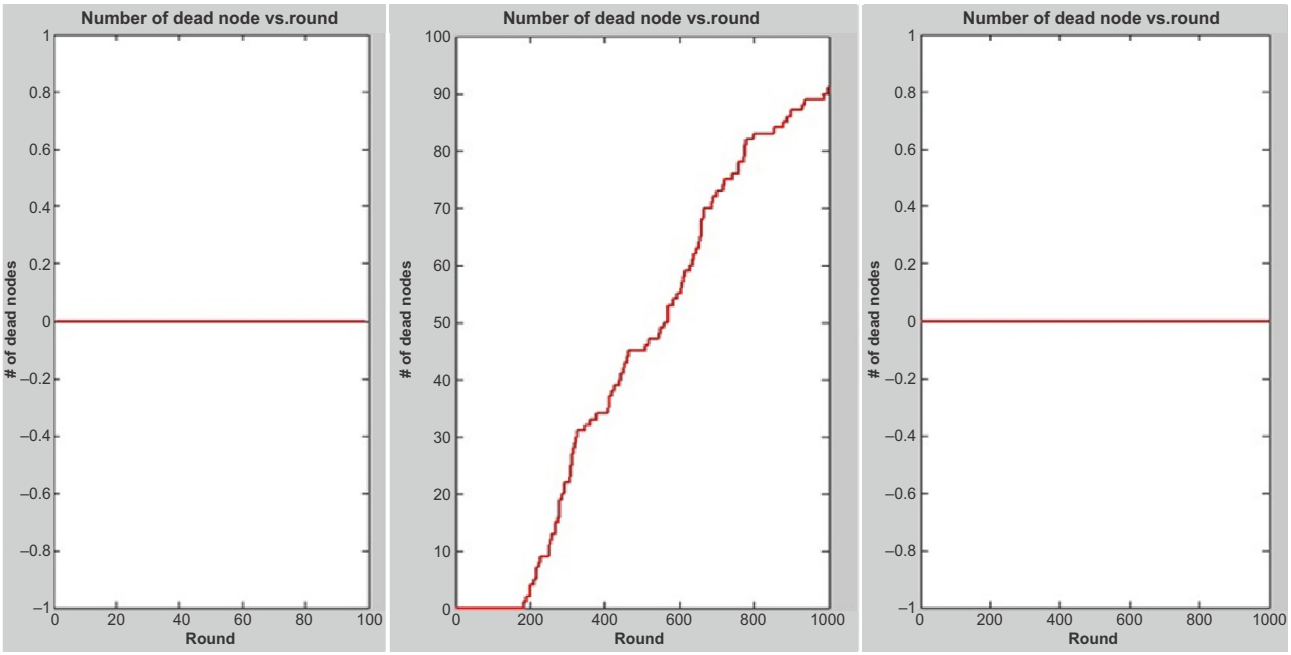

Figure 9: Total dead nodes against each round

5. CONCLUSION

As energy efficiency of DD-TL-LEACH has been improved in this proposed paper and results have been compared with TL-LEACH, M-LEACH, DD-LEACH and existing DD-TL-LEACH also. Analysis of simulation results have cleared that rather than using big size of packet it is better to use small data chunks. Energy efficiency is based on distance, size and number of sent packets. Moreover, number of dead nodes also decreases due to better energy efficiency.It has also been observed that total energy of nodes is even more after going through more rounds, only due to size of packets. Finally, this proposed work shows optimized simulation results considering three parametersof DD-TL-LEACH.

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