ISSN 2250-3153

Improving Energy Efficiency using Mobility based Data Compression in LEACH-C for Wireless Sensor Networks

R. Swathi [*], S. Kirubakaran [**], C. Kamalanathan [**]

[*] Department of ECE, Bannari Amman Institute of Technology
[**] Department of ECE, Bannari Amman Institute of Technology

Abstract- A Wireless Sensor Network (WSN) is built from a network of devices referred to as nodes, which can sense the environment and are used to communicate the required information collected from monitored fields. The communication and collection of information is done with the help of wireless links, where each node is linked to one or a number of sensors. The nodes in turn are deployed in large numbers depending upon the application where it is used. In modern days the process is bidirectional where the sensor activity can be monitored. The longevity in network lifetime is necessary as they have limited battery power which is to be used efficiently. This has led to new horizons upon energy saving and reduced power consumption among sensor nodes. Hierarchical cluster-based routing protocols are considered as one of the most efficient routing protocols in wireless sensor networks (WSN) due to its higher energy efficiency, network scalability, and lower data retransmission. An energy efficient hierarchical routing protocol LEACH-EN based on LEACH-C is designed by introducing the concept of dynamic node scenario in LEACH-C where movement of nodes is introduced along with compression of data from each node using LZW compression technique. The energy of nodes by introducing dynamic node concept along with compression seems to be efficient than the energy of nodes in LEACH-C protocol and therefore network longevity can be maintained to a certain extent.

Index Terms- WSN, LEACH, LEACH-C, Network lifetime, LZW compression, Moblity based

I. Introduction

Wireless Sensor Networks are tiny sensor nodes with the main purpose of sensing, computation and communication about physical and environmental activities which in turn is used in wide range of applications such as civilian, healthcare, habitat monitoring etc., in our day to day life. WSNs are battery operated sensing devices where replenishing the batteries is impossible and hence an energy saving method has to be employed to save power.

Routing is an important concept in sensor networks as they deal with the process of data dissemination and data gathering after which the shortest possible and efficient path to reach the destination is chosen. In WSNs routing may be divided into flat routing and hierarchical routing [1]. In flat routing, nodes are similar in carrying out tasks which proves to be a disadvantage when it comes to a larger environment. In flat routing the energy in wasted at times of data processing and thus the limited bandwidth which is allocated has not been used efficiently

In hierarchical routing nodes are dissimilar in the tasks which they carry out. Thus in terms of energy they prove to be efficient when compared to flat routing as they utilize the bandwidth efficiently. [2],[3]. Clustering technique has been introduced in which there is a Cluster Head (CH) and the respective cluster members. Nodes with less energy are chosen as cluster members and that with high energy are chosen are cluster heads which then carry out the sensing process.

The paper is organized as follows: Section II provides an overview of the LEACH and LEACH-C protocol and their comparison. In Section III the problem statement has been discussed . Section IV an overview of LZW data compression technique which is employed based on LEACH-C is given . Mobility based data compression is introduced in Section V. Section V provides the simulation results. Finally we conclude the paper in Section VII.

II. Cluster based routing protocols

CLUSTERING

A WSN consists of hundreds or thousands of nodes deployed based on the application with a centralized Base Station (BS). Clustering based protocols prove to be efficient as these protocols unlike others partition the area into smaller regions. Each region has its Cluster Head (CH) and the cluster members (CM). Hence energy has been efficiently used and does not waste the allocated bandwidth.

Cluster-based routing is mainly two-stage routing method, where the first stage is used to clustering and selecting cluster head for each cluster. Cluster head performs data aggregation and fusion to decrease transmitted packets. The second stage is used to sense and route data, but, most techniques in cluster-based routing focused on the first stage which is “who and when to send or aggregate” the data, channel allocation etc.

LEACH

The LEACH protocol (Low-energy Adaptive Clustering Hierarchy) presented by Heinzelman et al. partitions the nodes into clusters and in each cluster a dedicated node, the cluster head, is responsible for creating and maintaining a TDMA schedule; all the other nodes of a cluster are member nodes. To all member nodes, TDMA slots are assigned, which can be used to exchange data between the member and the cluster head; there is no peer-to-peer communication. With the exception of their time slots, the members can spend their time in sleep state. The cluster head aggregates the data of its members and transmits it to the sink node or to other nodes for further relaying.[4]. Since the sink is often far away, the cluster head must spend significant energy for this transmission.

The protocol is organized in **rounds** and each round is subdivided into a setup phase and a steady-state phase . The **setup phase** starts with the self-election of nodes to cluster heads. In the **advertisement phase**, the cluster heads inform their neighbourhood with an advertisement packet. The cluster heads contend for the medium using a CSMA protocol with no further provision against the hidden-terminal problem[5].. The non cluster head nodes pick the advertisement packet with the strongest received signal strength. In the following cluster-setup phase, the members inform their cluster head ("join"), again using a CSMA protocol. After the cluster setup-phase, the cluster head knows the number of members and their identifiers.

It constructs a TDMA schedule, picks a CDMA code randomly, and broadcasts this information in the broadcast schedule sub-phase. After this, the TDMA steady-state phase begins. Because of collisions of advertisement or join packets, the protocol cannot guarantee that each non cluster head node belongs to a cluster[6]. However, it can guarantee that nodes belong to at most one cluster. The cluster head is switched on during the whole round and the member nodes have to be switched on during the setup phase and occasionally in the steady-state phase, according to their position in the cluster's TDMA schedule. LEACH would not be able to cover large geographical areas of some square miles or more, because a cluster head two miles away from the sink likely does not have enough energy to reach the sink at all, not to mention achieving a low BER.

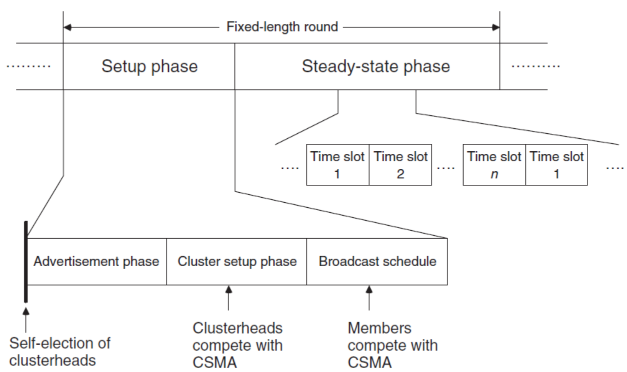


Figure 1. Organization of LEACH

LEACH-C

LEACH-C (LEACH-Centralized), a protocol that uses a centralized clustering algorithm and the same steady-state protocol as LEACH (e.g., nodes send their data to the cluster-head, and the cluster head aggregates the data and sends the aggregate signal to the base station). During the set-up phase of LEACH-C, each node sends information about its current location and energy level to the base station. The base station runs an optimization algorithm to determine the clusters for that round. The clusters formed by the base station will in general be better than those formed using the distributed algorithm[7]..

However, LEACH-C requires that each node transmit information about its location to the base station at the beginning of each round. This information may be obtained by using a global positioning system (GPS) receiver that is activated at the beginning of each round to get the node's current location.

III. PROBLEM STATEMENT

A sensor node is a tiny device that includes three basic components: a sensing subsystem for data acquisition from the physical surrounding environment, a processing subsystem for local data processing and storage, and a wireless communication subsystem for data transmission. In addition, a power source supplies the energy needed by the device to perform the programmed task. This power source often consists of a battery with a limited energy budget. In addition, it could be impossible or inconvenient to recharge the battery, because nodes may be deployed in a hostile or unpractical environment. On the other hand, the sensor network should have a lifetime long enough to fulfil the application requirements. In many cases a lifetime in the order of several months, or even years, may be required. Thus, the design of energy efficient cluster-based is very important to prolong the life time of the sensor node by improvising LEACH-C protocol in terms of transmission of data and also enhancing node movements and positions the energy.

IV. PROPOSED SYSTEM

A. *CLUSTER FORMATION*

During the set-up phase of LEACH-C, each node sends information about its current location and energy level to the base station. The base station runs an optimization algorithm to determine the clusters for that round. The clusters formed by the base station will in general be better than those formed using the distributed algorithm. However, LEACH-C requires that each node transmit information about its location to the base station at the beginning of each round[6],[7]. This information may be obtained by using a global positioning system (GPS) receiver that is activated at the beginning of each round to get the node's current location. The life time of the cluster head is increased due to the randomized rotation of the cluster. Based on the energy level the cluster head is selected. The sensor node with higher energy is converted as the cluster head.

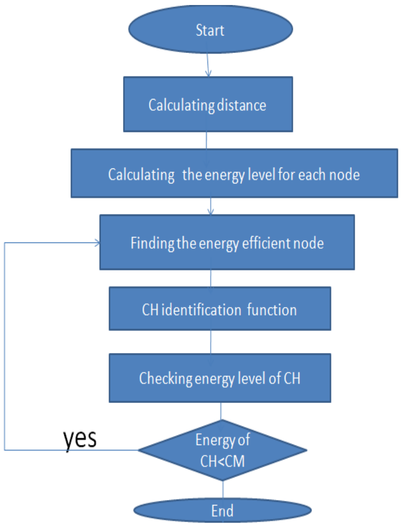


Figure 2. Cluster head selection based on energy level

B. *IMPLEMENTATION OF LZW(LEMPEL-ZIV-WELCH) COMPRESSION IN LEACH-C*

Lempel–Ziv–Welch (LZW) is a universal lossless data compression algorithm . The algorithm is simple to implement, and has the potential for very high throughput in hardware implementations. It was the algorithm of the widely used Unix file compression utility compress, and is used in the GIF image format. A particular LZW compression algorithm takes each input sequence of bits of a given length (for example, 12 bits) and creates an entry in a table (sometimes called a "dictionary" or "codebook") for that particular bit pattern, consisting of the pattern itself and a shorter code.

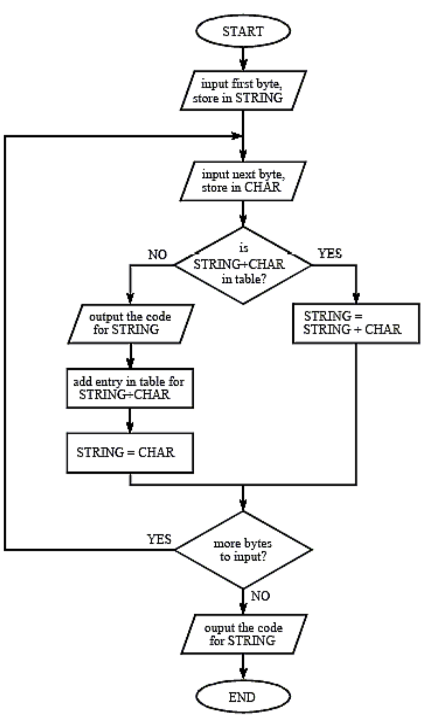


Figure 3. LZW Compression

As input is read, any pattern that has been read before results in the substitution of the shorter code, effectively compressing the total amount of input to something smaller. Unlike earlier approaches, known as LZ77 and LZ78, the LZW algorithm does include the look-up table of codes as part of the compressed file. The decoding program that un-compresses the file is able to build the table itself by using the algorithm as it processes the encoded input.

Encoding

- Initialize the dictionary to contain all strings of length one
- Find the longest string W in the dictionary that matches the current input
- Emit the dictionary index for W to output and remove W from the input
- Add W followed by the next symbol in the input to the dictionary
- Go to Step 2

A dictionary is initialized to contain the single-character strings corresponding to all the possible input characters (and nothing else except the clear and stop codes if they're being used). The algorithm works by scanning through the input string for successively longer substrings until it finds one that is not in the dictionary. When such a string is found, the index for the string without the last character (i.e., the longest substring that *is* in the dictionary) is retrieved from the dictionary and sent to output, and the new string (including the last character) is added to the dictionary with the next available code. The last input character is then used as the next starting point to scan for substrings.

Decoding

The decoding algorithm works by reading a value from the encoded input and outputting the corresponding string from the initialized dictionary. In order to rebuild the dictionary in the same way as it was built during encoding, it also obtains the next value from the input and adds to the dictionary the concatenation of the current string and the first character of the string obtained by decoding the next input value, or the first character of the string just output if the next value cannot be decoded (If the next value is unknown to the decoder, then it must be the value that will be added to the dictionary this iteration, and so its first character must be the same as the first character of the current string being sent to decoded output). The decoder then proceeds to the next input value (which was already read in as the "next value" in the previous pass) and repeats the process until there is no more input, at which point the final input value is decoded without any more additions to the dictionary.

V. MOBILITY BASED DATA COMPRESSION

In LEACH the election and cluster head rotation makes sure that the cluster heads do not die due to prolonged extra work. This is done by the random rotation of the cluster head duty across the nodes in the cluster by considering the energy level of the nodes. In view of mobility centric environment, the election of a cluster or the job rotation of the cluster head on purely energy level with node mobility into consideration. Node movement is introduced randomly along a particular distance covered by the BS. The node with the highest energy and lesser mobility is chosen to be the cluster head. The nodes at first move along a certain distance where during this period of time there may be a change in energy among nodes. The LEACH-C based approach is followed after this where the node with the highest energy is chosen to be the cluster head. Over a period of time this scenario of node position and energy may change and again the threshold value of energy is found out and the CH is chosen. When there is movement among member nodes, there are chances of nodes moving closer to the BS and hence its energy may not change at this distance at any cost.

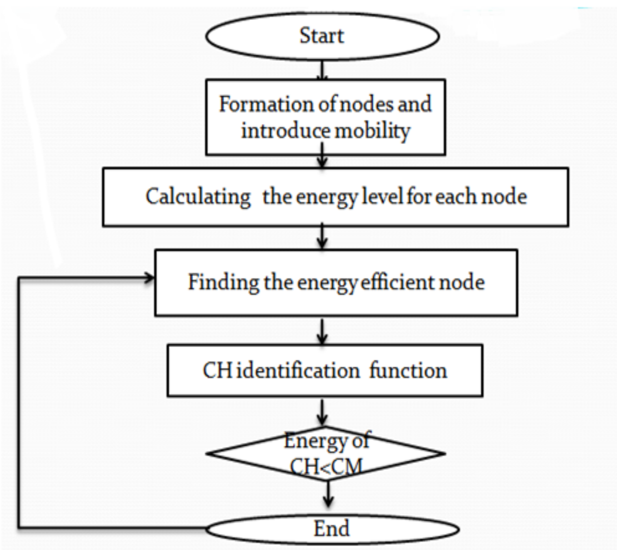


Figure 4. Mobility based technique

In the initial level of cluster, sink or BS that transmit a "Start" message to form cluster in network in its transition range of sensor nodes. This message received by sensors nodes which close to BS.

The nodes are formed and then node movement is introduced. The energy of the nodes is checked and CH is identified. In every cycle the highest energy node is selected as CH. Energy changes when node movement is introduced.

The simulation is carried out using NS-2 tool. The cluster heads are selected based on LEACH-C protocol after which randomized rotation of cluster heads take place. Data compression is done by entering data to nodes. Compression takes place at the respective cluster heads. Decompression is done at the base station.

VI. RESULTS AND DISCUSSION

When mobility of nodes is introduced along with compression in the LEACH-C protocol then the energy of nodes seems to perform well compared to the original LEACH-C protocol.

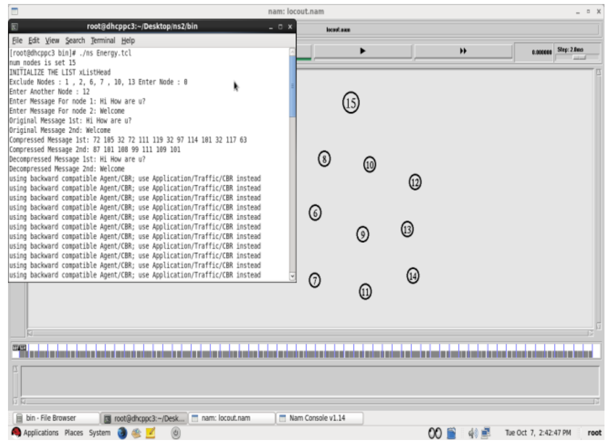
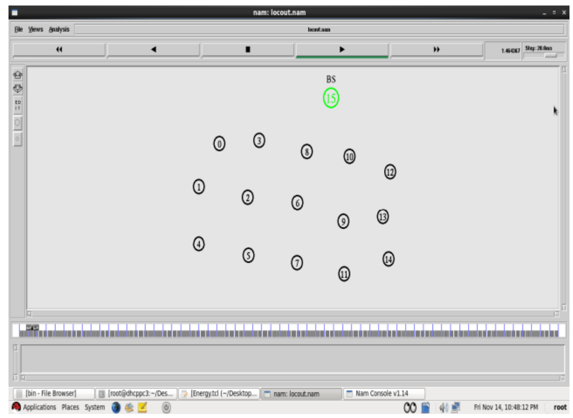
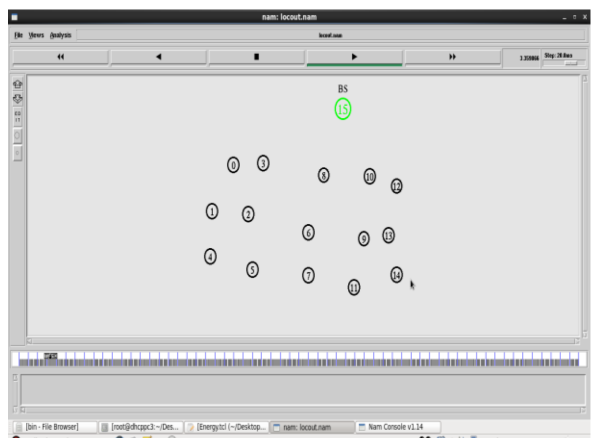


Figure 5. Formation of nodes and data obtained for all nodes





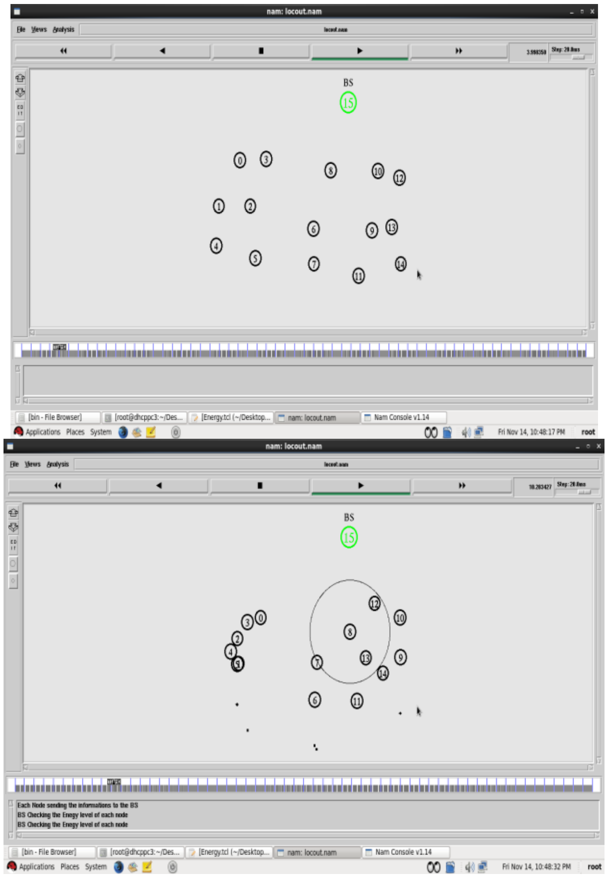
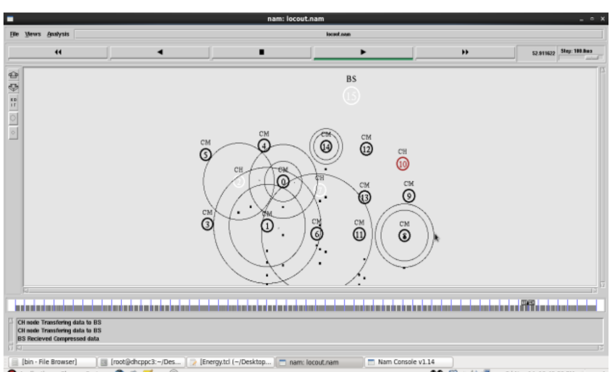


Figure 6, 7, 8, 9 Mobility among member nodes

Figure 6 shows that initially the CH are 1,6,13 and as the compression process goes on depending on the energy the CH changes to 2, 7, 10. In Fig 7,8,9 the CM compresses after which the CH receives this data. The data transmission to the BS is shown and at the BS the decompression of the sent data is done.



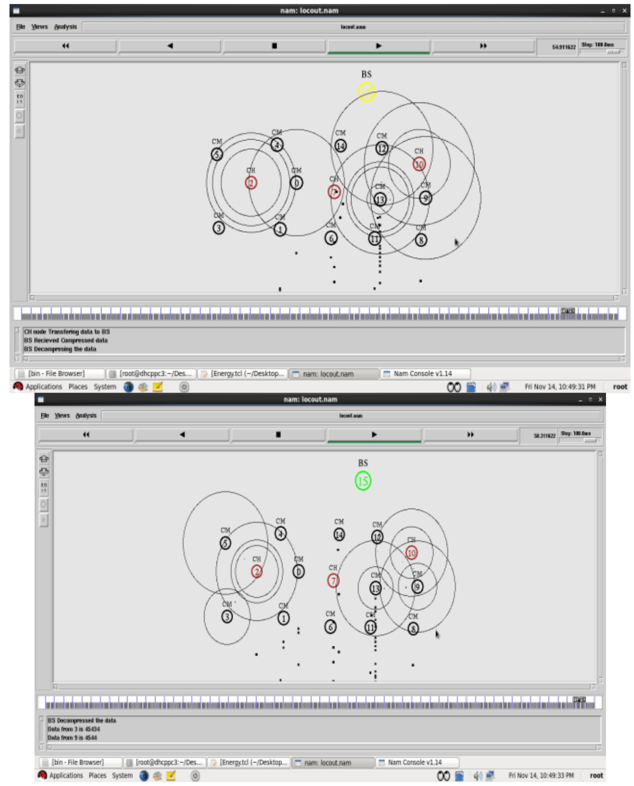


Figure 10, 11, 12 and 13 CM compressing data and sent to CH after which BS decompresses at the receiving end

A. PERFORMANCE OF LEACH AND LEACH-C

The LEACH and LEACH-C performance are conducted on the parameter of the time and energy. The time is given in the x-axis and the energy is given in the y-axis.

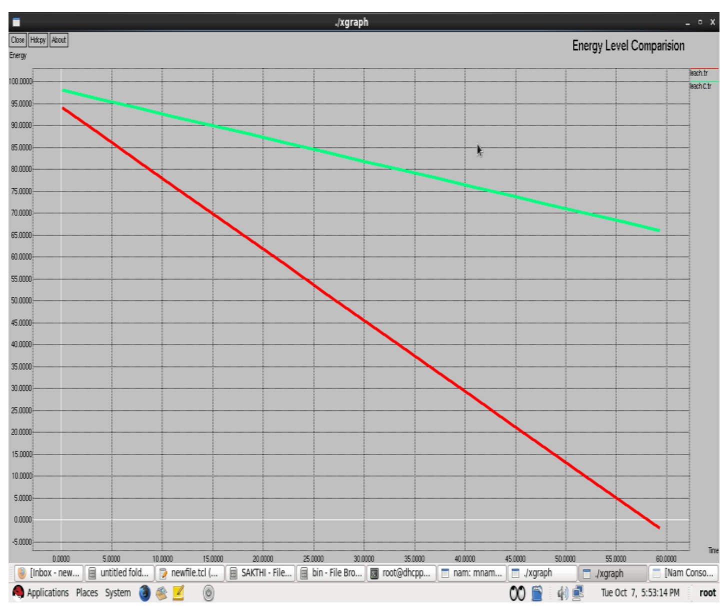


Figure 14. Comparison based on Energy

In the Figure 14. the Energy level of the leach and leach-c protocol as been displayed with respect to time. In the initial state both are at the same energy level. In case of leach they perform a poor clustering set up during a given round thus energy level decreases drastically but in case of the leach-c protocol they perform centralized clustering algorithm and also randomized rotation of the cluster head so energy is reduced gradually. Thus LEACH-C consumes less amount of energy.

B. PERFORMANCE OF COMPRESSED AND UNCOMPRESSED DATA

The time is given in the x-axis and the energy is given in the y-axis. In the Fig 15 the data is transferred without compression it consumes large amount energy but When the data is transferred with compression they consume only less amount of energy

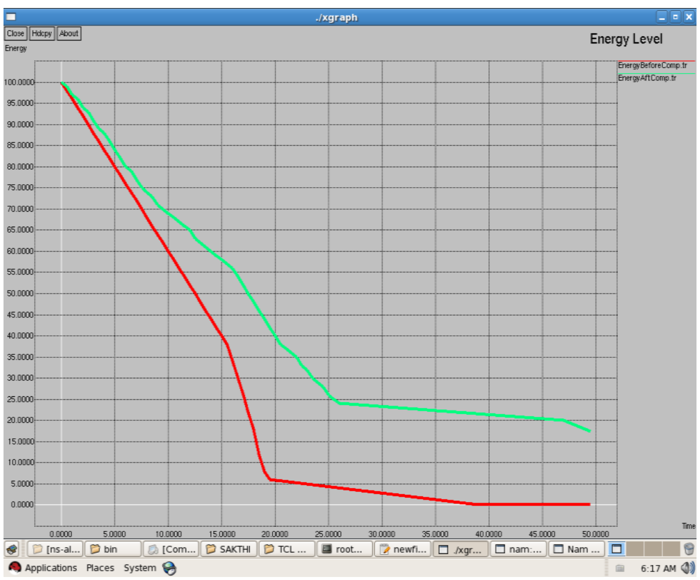


Figure 15. Energy of Compressed and Uncompressed data

C. PERFORMANCE COMPARISON BETWEEN RESIDUAL ENERGY OF NODES

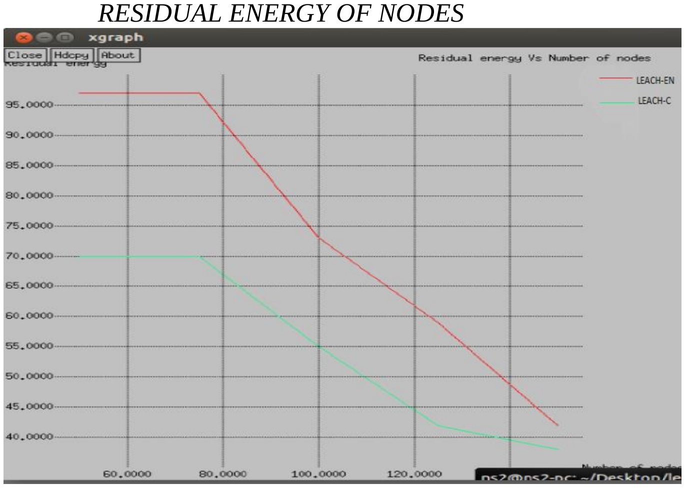


Figure 16 Comparison between residual energy of nodes

Figure 16 shows the comparison between residual energy of nodes in the network. Residual energy is nothing but the remaining energy at all nodes. The proposed protocol LEACH-EN show that when the number of nodes increases the energy among the nodes is balanced and residual energy using the LEACH-EN tend to be higher than the LEACH-C protocol. The number of nodes is taken along the x-axis and the energy in joules/bit is taken along the y-axis.

VII. CONCLUSION

The energy efficient hierarchical cluster based routing protocol seems to provide efficient routing based on two features. Firstly, the movement of nodes among the clusters will thus improvise the energy, as a node move closer to a base station hence distance is reduced for transmission. After consideration of this scenario the energy level is measured using LEACH-C based approach. Secondly, compressing data at the sending end and decompressing it with LEACH-C based approach for the energy level monitoring can prove to be energy efficient.

Thus an energy efficient hierarchical routing protocol LEACH-EN is compared with the original LEACH-C under the above considerations and LEACH-EN seems to perform well to a certain extent when compared with that of the original LEACH-C protocol.

REFERENCES

[1] Y. Yu, V.K. Prasanna, and B. Krishnamachari, Information Processing and Routing in Wireless Sensor Networks, chapter 1, World Scientific Pub Co Inc, 2006.

[2] A.M. Zungeru, L. Ang, and K.P. Seng, "Classical and swarm intelligence based routing protocols for wireless sensor networks: A survey and comparison," Journal of Network and Computer Applications, vol. 35, no. 5, pp.1508–1536, September 2012.

[3] M.C. Arboleda and N. Nasser, "Comparison of clustering algorithms and protocols for wireless sensor networks," in Canadian Conference on Electrical and Computer Engineering, CCECE '06'.

[4] W.R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient communication protocol for wireless microsensor networks," in Proceedings of the 33rd Annual Hawaii International Conference on System Sciences.

[5] O. Younis and S. Fahmy, "Heed: a hybrid, energy efficient, distributed clustering approach for ad hoc sensor networks," IEEE Transactions on Mobile Computing, 2004.

[6] M. Chatterjee, S.K. Das, and D. Turgut, "WCA: A Weighted Clustering Algorithm for M obile Ad Hoc Networks," ClusterComputing, pp. 193-204, 2002.

[7] M . J. Handy, M . Haase, D. Timmermann, Low energy adaptive clustering hierarchy with deterministic cluster-head selection [C], Proceedings of IEEE International Workshop on Mobile and Wireless, Communications Networks, 2002, 368-372

[8] Jian Xu, Dandan Qin "A new LEACH-Based Routing Clustering Protocol in WSN", Journal of information & computational Science (2013), 6005-6011, http://www.joics.com.

AUTHORS

First Author – R. Swathi, Department of ECE, Bannari Amman Institute of Technology
Second Author – S. Kirubakaran, Department of ECE, Bannari Amman Institute of Technology

Third Author – C. Kamalanathan, Department of ECE, Bannari Amman Institute of Technology