# Energy-Efficient Hierarchical Routing Protocol for Homogeneous Wireless Sensor Network

**Muhammad Sajjad Hussain[1] and Dr. Md. Abdul Mottalib[2]**

[1]Assistant Professor, Department of CSE Manarat International UniversityDhaka, Bangladesh
[2]Professor and Head, Department of CIT Islamic University of Technology,
Organization of Islamic Conference Gazipur, Bangladesh

**Abstract**
Wireless Sensor Networks (WSNs) have paved the way for a new horizon of monitoring and gathering information. One of the most decisive criteria for smooth operation of WSNs is the limited energy supply of the sensor nodes. Numerous elegant energy-efficient routing protocols have been proposed in the literature for solving this problem, e.g. LEACH [1], PEGASIS [2], Hierarchical PEGASIS [3], LEFC [4]. But these protocols seem to suffer from transmission overhead. In this paper we propose Co-Axial Fixed Cluster (CFC), a new energy-efficient hierarchical routing protocol, for homogeneous wireless sensor network. Mathematical analysis reveals that Co-Axial Fixed Cluster (CFC) outperforms LEACH [1] by 683% longer lifetime for the period when WSN remains fully functionally operational. CFC uses fixed cluster and multiple designated cluster-head (CH) nodes at the center of each cluster. Only the designated CHs transmit data to the base station or to another designated CH node. Among the designated cluster-head nodes at the center of each cluster, only one node remains in active state and performs the duty of the CH of the respective cluster. Rest of the designated cluster-head nodes of each cluster remain in sleep state and just prior to the death of current CH node of a cluster, another one from among the designated cluster-head nodes take over the responsibility of the CH. Furthermore, not every active designated CH node of each cluster transmits data to the base station in each round. Rather one of the active designated CH node also acts as second level CH node and receives data from other active designated CH nodes and transmits it to the base station after data fusion. This scheme reduces transmission overhead and increases the lifetime of the WSN significantly.

***Keywords***
*Wireless Sensor Network; Hierarchical Routing of Wireless Sensor Network; Homogeneous Wireless Sensor Network Routing Protocol.*

## 1. Introduction

A Wireless Sensor Network (WSN) usually comprises of hundreds or thousands of replenishable sensor nodes spreading like a web in the field. These sensor nodes have embedded sensors in them for sensing various forms of energy e.g. sound, light, heat. These sensor nodes are capable of transmitting and receiving data to each other or directly to a base-station (BS), usually located outside the WSN area. BSs are assumed to have comparatively stable power supply. WSNs generally suffer from several drawbacks e.g. limited computing power, limited energy supply and limited bandwidth for data transmission. Energy efficiency of the sensor networks is an important research topic and the lifetime of WSNs could be considered as the most significant performance in the WSN [6]. Since wireless communications consume significant amounts of battery power, sensor nodes should spend as little energy as possible receiving and transmitting data [2].

A typical application in a sensor web is gathering of sensed data at a distant base station (BS) [2]. Like LEACH [1] and PEGASIS [2] our model sensor network has the following properties:

- The BS is fixed at a far distance from the sensor nodes.
- The sensor nodes are homogeneous and energy constrained with uniform energy.
- The energy cost for transmitting a packet depends on the distance of transmission.
- Each sensor node has power control and the ability to transmit data to any other sensor node or directly to the BS.

In each round of this data-gathering application, all data from all nodes need to be collected and transmitted to the BS, where the end user can access the data [2]. The LEACH [1] protocol furnished a prodigious solution to this problem. Approximately 5% nodes declare themselves as CHs in each round. Clusters are formed dynamically in each round. CHs receive and fuse data in each round and transmit it to the base-station (BS). LEACH uses a TDMA/CDMA MAC to reduce inter-cluster and intra-cluster collisions [5]. The PEGASIS [2] protocol presented a marvelous solution to the same problem. Instead of forming clusters, PEGASIS forms a chain among the sensor nodes and ensures that each sensor node transmits and receives only one message in each round. This reception and transmission occurs only with a close neighbor. In each round only a single node transmits data to the BS. Obviously different nodes perform this responsibility of transmitting to the BS in different rounds. PEGASIS performs better than LEACH

Manuscript received November 5, 2011
Manuscript revised November 20, 2011

by about 100% when 1% of nodes die [2]. Hierarchical PEGASIS [3] is an extension to PEGASIS, which aims at decreasing the delay incurred for packets during transmission to the base station and proposes a solution to the data gathering problem by considering energy x delay metric [7]. In order to reduce the delay in PEGASIS, simultaneous transmissions of data messages are pursued here. Hierarchical PEGASIS has been shown to perform better than the regular PEGASIS scheme by 60% [3]. PEGASIS/ HIERARCHICAL PEGASIS assumes that all nodes maintain a complete database about the location of all other nodes in the network. But the method through which the node locations are obtained is not outlined [5]. In addition, the single leader can become a bottleneck [5]. LEFC [4] presented another magnificent solution to this data-gathering problem. LEFC combines LEACH and FCA [6] to propose low-energy fixed clustering scheme to improve energy efficiency. In order to reduce the energy dissipation, LEFC uniformly divides the sensing area into fixed clusters where the cluster –head is deployed at the center of the cluster area [4]. Moreover, to improve the energy efficiency in the cluster based on the fixed clustering, the cluster head is elected by the LEACH scheme [4]. LEFC outperforms LEACH with more 60% network lifetime. LEFC is a GPS based solution but GPS free solution is always preferred [5]. In this paper we attempt to present a new energy-efficient hierarchical routing protocol, Co-Axial Fixed Cluster (CFC), for homogeneous WSN. CFC uses fixed cluster and multiple designated cluster-head nodes at the center of each cluster. Our scheme eliminates the overhead of dynamic cluster formation or chain formation. CFC combines LEACH [1] and FCA [6] to some extent for developing this new protocol.

## 2. Radio Model for CFC

In our scheme we use the same first order radio model which has been used in LEACH [1] and PEGASIS [2]. Radio dissipates Eelec= 50 nJ/bit to run the transmitter or receiver circuitry and ∈amp= 100pJ/bit/m2 for the transmit amplifier to achieve an acceptable signal to noise ratio. The radios have power control and can expend the minimum required energy to reach the intended recipients. We assume that transmitter electronics (ETx-elec ) and receiver electronics (ERx-elec ) are equal. We assume, ETx-elec =ERx-elec = Eelec = 50 nJ/bit. Transmit Amplifier, ∈amp = 100 pJ/bit/m2.We also assume an energy loss of r2 due to channel transmission. Thus to transmit a k-bit message a distance d using our radio model, the radio expends:

ETx (k,d) = Eelec * k + ∈amp * k * d2 and to receive this message, the radio expends:

ERx (k) = Eelec * k

In our analysis, we used a packet length k of 2000 bits. There is also a cost of 5 nJ/bit/message to fuse messages.

Like LEACH [1], we also assume that all sensors are sensing the environment at a fixed rate and thus always have data to send to the end-user. We assume initial battery energy to be 0.25 Joule/node.

## 3. Detailed Procedure of CFC

Our routing scheme at first divides the entire WSN area into number of small squares or grids. In our scheme, the size of the WSN area is 50m X 50m as shown in figure 1. Base station (BS) is located at (25, 150), which is at least 100m from the nearest node. Each square represents a cluster and each square is of the same size. The number of clusters should be as close to as possible equal to the optimal percentage of cluster heads. In our scheme, the whole WSN area has been divided into four clusters and A, B, C, D are the centers of the squares. But according to LEACH [1] the optimal number of CHs for a 50m x 50m WSN area containing 100 sensor nodes is 5%. So the number of clusters in our scheme is very close to the optimal percentage. On average there will be 25 active nodes per cluster in our scheme i.e. 100 active nodes in the entire WSN area.

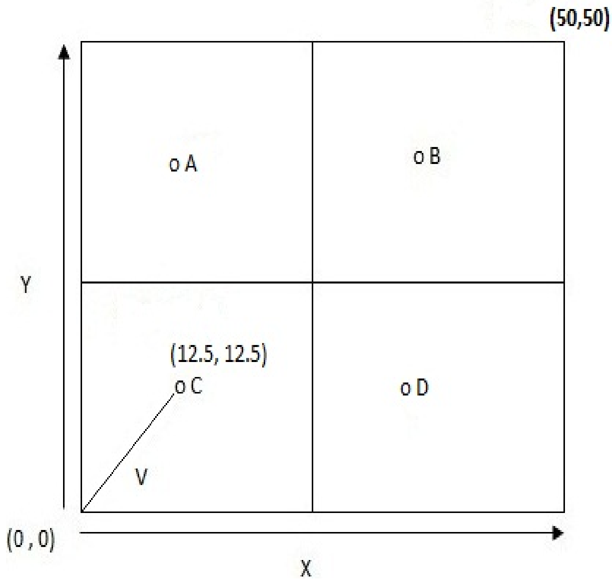


Figure 1 Four cluster areas of CFC protocol

In our scheme, we use dedicated sensor nodes to operate as cluster heads (CHs). There are two types of nodes in our scheme: one type of nodes will only work as non CH nodes and the other type of nodes will only work as CH nodes. Since, there are total 4 clusters, as such 4 nodes will work as CH nodes and rest 96 nodes will work as non CH nodes. In our scheme, at first only 96 non CH nodes will be randomly placed in the WSN area. Since the non CH nodes will only transmit data to the respective CH nodes and the CH nodes will transmit data to the base station or to other CH nodes, which is a high energy transmission, as such the life time of CH nodes will be much shorter than those of non CH nodes. To ensure the longest lifetime of the network and to ensure that the non CH nodes and the last CH nodes of each cluster die almost at the same time, our scheme uses multiple prospective CHs at the center of each square or cluster. Among these multiple prospective CH nodes only one node will act as CH and rest of the prospective CH nodes will remain in sleep state. So that when one cluster head node dies, only then another node from among the prospective CH nodes can take over the responsibility of the CH and declare itself as new CH. As such, at any moment of time only 100 sensor nodes will actively participate in sensing and transmitting data i.e. at any moment of time only 100 sensor nodes will form the integral part of the WSN. How many prospective CH nodes we need to place at the center of each square that we can determine a priori through calculation, which has been furnished below in the mathematical analysis section of this paper. Our scheme ensures that the last cluster head node of each cluster dies almost at the same time when the non CH head nodes die.

At first, the 96 non CH sensor nodes are randomly placed over the entire WSN area. Subsequently, prospective CHs are placed in a deterministic fashion at the centers of the 4 squares at location A, B, C and D within a circle of diameter 0.5m (50 centimeter). These prospective CHs know from their MAC layer that they are dedicated CHs. Other nodes, which are not at the center of the square, never become CH and these nodes also know from their MAC layer that they are non CH nodes. Our calculation shows that we need to use 22 prospective CHs at each A and B locations. We also need to use 24 prospective CHs at each C and D locations. So in total we need to use 92 prospective CHs. The total number of nodes we need to use in our scheme is (96+92) = 188.

At the setup stage of the network, four fixed clusters will be formed keeping the prospective CHs at the center of each cluster. Only one node will function as CH for a cluster from among the prospective CHs of that cluster. Other prospective CHs will remain in sleep mode and will only become active at a predefined time as scheduled by the current CH. The current cluster head node will assign this predefined time to other prospective CH nodes based on the distance between the CH and the base station i.e. it can assign this time based on the energy usage of first round. Once the energy level of this current CH node goes below a threshold limit or that predefined time reaches, only then the current CH node assigns another node from among the prospective CHs as the new CH for that cluster. Then this new CH remains in active state and the rest of the prospective CHs go to the sleep state.

In each round, non CH nodes transmit data to the respective CH nodes and then the CH nodes fuse the data and transmit it either to the base station (BS) or to a second level CH. In our case, one of the active CHs of four squares will also perform the duty of the second level CH. That means other active CHs will transmit data to this second level

CH and this second level CH transmits this data to the BS. In each round this second level cluster headship changes. That means within four consecutive rounds an active CH transmits data to the BS once and transmits data to the second level CHs thrice.

At the very first round, the elected CH of each cluster will broadcast a message by declaring itself as CH and each non cluster head node will decide to which cluster-head it wants to belong and ultimately clusters will be formed. Each cluster-head broadcasts the message with the same energy. Throughout the lifetime of the network, each node will remain a member of the same cluster. As a result the size and shape of the clusters remain same and the node membership of a cluster remains static. Our scheme uses a TDMA/CDMA MAC to reduce intra-cluster and inter-cluster collisions as is done in LEACH [1].

## 4. Parameters of Calculation for CFC

Based on our WSN area: approximate distance between A to BS is 113 m. Distance between B to BS is 113 m. Distance between C to BS is 138 m. Distance between D to BS is 138 m. Maximum distance between the CH and a non-CH node, v = 17.68 m. Because, v2= (12.5)2 + (12.5)2. But the diameter of the circle is 0.5m or radius 0.25m. As such v has been taken as 18m, because (17.68 +0.25)m is approximately 18m.

## 5. Lifetime Calculation for Non-CH Nodes of CFC

From Figure 1, Maximum distance between the CH and a non CH node = v = 18m . Therefore, d=v=18m. Each node sends a single message to the CH in each round.

Cost for transmission of one message to the CH by a node (d=18m)

= $E_{elec} * k + \in_{amp} * k * d^2$ = 0.0001 Joule + 0.0000648 Joule = 0.0001648 Joule.

Considering initial battery energy to be 0.25 Joule/node, 0.25/0.0001648= 1516.99 rounds.

As such, a non cluster-head node is supposed to die approximately after 1516 rounds.

A non cluster-head node will also receive five messages at the setup phase of the network. Among these five messages, four messages are cluster-head declaration messages and one message for receiving the TDMA schedule. Cost for receiving one message by a node

= $E_{elec} * k$ = 0.0001 Joule. Therefore, Cost for receiving five messages by a node

= 0.0005 Joule, which is equivalent to energy cost of transmission of three messages.

As such a non-CH node is supposed to die after 1516-3 = 1513 rounds in CFC.

## 6. Lifetime Calculation for CH Nodes of CFC

**(a) Calculation for d=138m:**

Cost for transmission of one message to the BS by the CH (d=138m)
= $E_{elec}$ * k + $\in_{amp}$ * k * $d^2$ = 0.0001 Joule + 0.0038088 Joule = 0.0039088 Joule.

Within every 4 rounds, a CH transmits data to the base station once (d=138m) and transmits data to the other CHs rest three times (d= 36m maximum).

One-Fourth of the cost of transmission of one message to the BS by the CH (d=138m)
= 0.0009772 Joule ……………………………….(i)

Cost of transmission of one message to the other CHs (d= 36m maximum)= 0.0003592 Joule.

Cost of transmission of three messages to the other CHs (d= 36m maximum)
= 0.0010776 Joule ………………….……...(ii)

One-Fourth of the cost of (ii)
= 0.0002694 Joule ………………..…….…(iii)

Average cost of transmission in one round for a CH
= (i) + (iii) =0.0012466 Joule .………………….(iv)

In our scheme, a cluster has approximately 25 nodes. So, each of the CH will receive 24 messages in each round. Cost for receiving 24 messages by a CH
= 24 * $E_{elec}$ * k = 0.0024 Joule ….……………..(v)

There is also a cost of 5 nJ/bit/message for data fusion. Total 24 messages will be received by the CH. Size of each message is 2000 bits. Energy cost for data fusion by the CH
= 5* 2000*24 nJ =0.00024 Joule ……..……….(vi)

Total energy cost of a CH per round
= (iv) + (v) + (vi) =0.0038866 Joule…..……….(vii)

Considering initial battery energy to be 0.25 Joule/node,
0.25 / 0.0038866 = 64.32 rounds……..……...(viii)

That means a CH node remains alive for 64.32 rounds.

But the very first CH node will spend a little more energy than (vii). The reason behind is that it will have to transmit one CH declaration message and one TDMA schedule message at a distance of 54m. The distance between (12,12) and (50,50) is 54m., this is the maximum distance possible between a node and a CH. Further more, each CH node spends a little more energy, than (vii). The reason behind is that when the energy level of the current CH node goes below the threshold limit, at that moment the current CH needs to transmit one message at a distance d=0.5m for the other prospective CHs. So, that a node from among the other prospective CHs takes over as the new CH. Again, for receiving this message other prospective CHs waste energy. Although the energy wastage for the above-mentioned reasons is negligible, yet we take the lower bound (floor value) of (viii) and that becomes 64 rounds for compensating these extra energy costs. As such a CH node is supposed to die after 64 rounds. Now, the lifetime of a non CH node is 1513 rounds. But the lifetime of a CH node is 64 rounds. We need to have CHs for the entire lifetime of the WSN.

Hence, we need 1513/64= 23.64 CH nodes…………..(ix)

Taking the upper bound (ceiling value) of (ix), we find 24 CH nodes.

As such we need to place 24 prospective CHs at each C and D.

**(b) Calculation for d= 113m:**

Similarly we can show that we need to place 22 prospective CHs at each A and B locations.

## 7. Parameters of Calculation for LEACH

From LEACH [3], it is evident that for a 100 node random topology of WSN within a 50m X 50m area, the optimal number of cluster-heads to have in the system is 5%. Therefore, desired percentage of cluster-heads, P = 0.05 and 1/P = 20. Using the threshold T(n) of LEACH [3], each node becomes a cluster-head at some point within 1/P =20 rounds and once a node becomes CH, it cannot become CH for the next 1/p=20 rounds. That means for every 20 rounds, a node in LEACH, operates as CH once and operates as non-CH for 19 times. Minimum distance between the BS and a node is 100m [3]. We assume, that the maximum distance between the CH and a non-CH node v = 18 m. Although in some cases it is supposed to be more or less than 18m. But v =18m has been taken for convenience of calculation. Because in case of CFC the maximum distance between the CH and a non-CH node v = 18 m. We consider initial battery energy to be 0.25 Joule/node, Message size K= 2000 bits, $E_{elec}$= 50 nJ/bit, $\in_{amp}$= 100 pJ/bit/$m^2$.

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

$E_{Rx}$ (k) = $E_{elec}$ * k

## 8. Energy Cost Calculation for a non-CH node of LEACH in 19 Rounds

In LEACH, there are total five CHs in each round. Therefore, each of the 95 non-CH nodes receives 5 messages from the CHs, through which the non-CH nodes come to know which are the CHs. Each non-CH node sends a message to its respective CH, informing that it wants to be a member of that cluster. Each non-CH node receives a TDMA schedule from its respective CH. Each non-CH node sends its collected data to the CH.

Therefore, in each round a non-CH node transmits total (1+1) = 2 messages and

in each round a non CH node receives total (5+1) = 6 messages.

For simplicity we have assumed, that the distance between the CH and a non-CH node is 18 m. Therefore, d = 18m. However, in practical situation it may be more or less than 18m. But in case of our simulation the actual distance between the CH and a non-CH node has been calculated and used in the simulation.

Cost for transmission of one message to the CH by a node (d=18m) = $E_{elec} * k + \in_{amp} * k * d^2$
= 0.0001 Joule + 0.0000648 Joule = 0.0001648 Joule
Cost for transmission of two messages to the CH by a node (d=18m)
= 0.0003296 Joule……………………………….(x)
Cost for receiving one message by a node = $E_{elec} * k$ = 0.0001 Joule.
Cost for receiving six messages by a node
= 0.0006 Joule ……………………………….…(xi)
Total energy cost for each round for a non-CH node
= (x) + (xi) =0.0009296 Joule
Total energy cost for 19 rounds as non-CH
= 0.0176624 Joule………………………...……(xii)

## 9. Energy Cost Calculation for a CH node of LEACH in One Round

Each CH node broadcasts an advertisement message to the rest of the nodes declaring itself as a CH. In each cluster there are total 20 nodes. Among these 20 nodes 19 are non-CH nodes and 1 is CH node. Therefore, each CH receives 19 messages from the non-CH nodes. Through these messages non-CH nodes inform their respective CHs that they want to belong to that cluster. Each CH broadcasts a TDMA schedule for its respective non-CH nodes. Each CH receives approximately 19 messages from the non-CH nodes through which it receives the data of the non-CH nodes. Each CH transmits a message to the BS for sending data.
As a result, in each round a CH transmits total (1+1+1)= 3 messages.
In each round a CH receives total (19+19) = 38 messages.
Minimum distance between the BS and a node is 100m.
Cost of transmission of one message at a distance of 100m
= $E_{elec} * k + \in_{amp} * k * d^2$ =0.0001 Joule + 0.002 Joule
=0.0021 Joule …………………………………(xiii)

The size of the WSN area is 50m x 50m. The CH declaration message and the TDMA schedule message of any CH should reach all the nodes. Therefore, the value of d is equal to the length of the diagonal of the field, i.e. d=70.71m.
Cost of transmission of two messages at a distance of 70.71m
= 2 * ($E_{elec} * k + \in_{amp} * k * d^2$)
= 2*0.00109998 = 0.00219996 Joule...……….(xiv)
Cost for receiving 38 messages
= 38* ($E_{elec} * k$ ) =(38* 0.0001) Joule = 0.0038 Joule ………..(xv)
Total cost for transmission of 3 messages and reception of 38 messages
=(xiii) + (xiv) + (xv) = 0.00809996 Joule………………………(xvi)

There is also a cost of 5 nJ/bit/message for data fusion. Total approximately 19 messages will be received as data by the CH. Size of each message is 2000 bits.
Energy cost for data fusion of 19 messages by the CH
= 5* 2000*19 nJ = 0.00019 Joule …..……….(xvii)
Total cost for transmission of 3 messages, reception of 38 messages
and data fusion = (xvi) + (xvii) = 0.00809996 Joule + 0.00019 Joule
= 0.00828996 Joule……………………..……(xviii)

This cost (xviii) is incurred by each node only for one round when it acts as a CH.

## 10. Average Energy Cost of One Round in LEACH for a Node

Energy cost for total 20 rounds in LEACH
= (xii) + (xviii) = 0.02595236 Joule………….(xix)
Average energy cost for one round in LEACH
= 0.02595236/20 Joule = 0.001297618 Joule

## 11. Lifetime Calculation of a Node in LEACH

Considering initial battery energy to be 0.25 Joule/node,
0.25/ 0.001297618 = 192.66 rounds …….……(xx)
Taking the upper bound (Ceiling value) of (xx) it becomes 193 rounds.
That means in LEACH, nodes are supposed to die just after 193 rounds, even earlier for the nodes which are further away from the BS. Since, the non CH nodes of CFC remain alive for 1513 rounds and the nodes of LEACH remain alive for 193 rounds, therefore CFC increases the lifetime of a WSN 683% than that of LEACH [1].

## 12. Simulation Results

We performed our simulation using Turbo C. Our simulation results very well support our mathematical analysis results. Our simulation results show that the first node of LEACH dies at round number 180 and last CH node of cluster A of CFC dies at round number 1431. It may be mentioned here that our simulation results also show that at round number 1431, one CH node of cluster B, 3 CH nodes of cluster C and 3 CH nodes of cluster D were alive in CFC but not a single non CH node died till that round. In our simulation cluster A contained 26 non CH nodes, cluster B contained 25 non CH nodes, cluster C contained 22 non CH nodes and cluster D contained 23 non CH nodes. That means our simulation shows that till round number 1430 the entire WSN of CFC was fully operationally functional.

It shows CFC, our scheme, increases the lifetime of the WSN 7.98 times longer than that of LEACH. That means our scheme outperforms LEACH by 698% longer lifetime. Total energy involved in LEACH is 0.25 x 100= 25 Joule and total energy involved in CFC is 0.25 x 188 = 47 Joule.

Table 1 Simulation Results

| | *LEACH* | *CFC* |
|---|---|---|
| WSN remains fully operationally functional (Round) | 179 | 1430 |

| | *LEACH* | *CFC* |
|---|---|---|
| Total Energy Involved (Joule) | 25 | 47 |

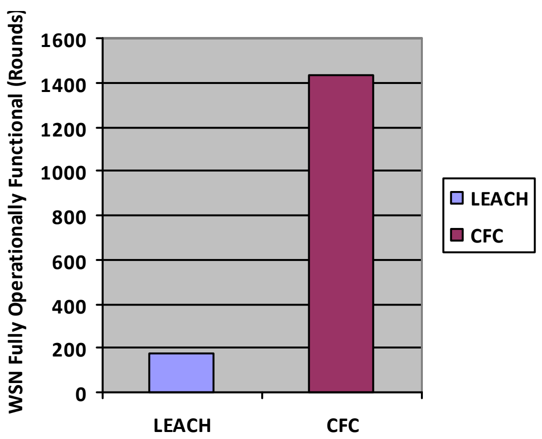


Figure 2 (a) Comparison of simulation results of LEACH and CFC

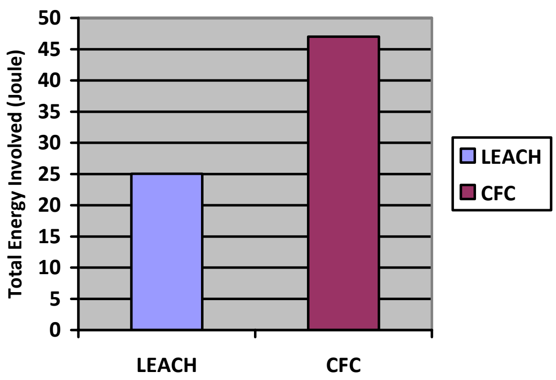


Figure 2 (b) Comparison of simulation results of LEACH and CFC

## 13. Conclusion

In this paper CFC, a new energy-efficient hierarchical routing protocol for homogeneous Wireless Sensor Network (WSN) is proposed to prolong the lifetime of cluster-based WSN. The proposed protocol, CFC, uses fixed clusters and multiple designated cluster-head nodes at the center of each cluster. Our scheme eliminates the overhead of dynamic cluster formation or chain formation. Although in CFC we need to use 88 additional nodes i,e. instead of total 100 nodes in LEACH we need to use total 188 nodes in CFC but that increases the lifetime of a WSN 683% longer than that of LEACH [1]. This is a significant improvement in respect to energy-efficiency.

## References

[1] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, Energy-Efficient Communication Protocol for Wireless Microsensor Networks, Proceedings of the 33rd Hawaii International Conference on System Sciences (HICSS '00), ISBN: 0-7695-0493-0, p.3005-3014, (January 2000).

[2] S. Lindsey, C. Raghavendra, PEGASIS: Power-Efficient Gathering in Sensor Information Systems, IEEE Aerospace Conference Proceedings, (2002), Vol. 3, 9-16 ISSN:1790-5117,pp. 1125-1130.

[3] S. Lindsey, C. S. Raghavendra, and K. Sivalingam, Data Gathering in Sensor Networks using the Energy*Delay Metric, Proceedings of the IPDPS Workshop on Issues in Wireless Networks and Mobile Computing, San Francisco, CA, ISBN:0-7695-0990-8, (April 2001).

[4] Y.F. Huang, N.C. Wang, and M.C. Chen, Performance of a Hierarchical Cluster-Based Wireless Sensor Network , IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing, (2008), ISBN 978-0-7695-3158-8.

[5] J. N. Al-Karaki, A.E. Kamal, Routing Techniques in Wireless Sensor Networks: A Survey, IEEE Wireless Communications, Volume 11, Issue 6, ISSN:1750-5117, p.26-28, (Dec 2004).

[6] Y.F. Huang, W.H. Luo, J. Sum, L.H. Chang, C.W. Chang, and R.C. Chen, Lifetime Performance of an energy efficient clustering algorithm for cluster-based wireless sensor networks, LNCS 4743, Springer-Verlag Berlin Heidelberg, ISBN 978-90-365-2745-3 , pp. 455---464, (Aug. 2007).

[7] K. Akkaya, M. Younis, A Survey on Routing Protocols for Wireless Sensor Networks, Elsevier Ad Hoc Network Journal, Vol 3/3, ISBN:0-470-86736-1, p.325-349, (2005).

**Muhammad Sajjad Hussain,** obtained his M. Sc. in Computer Science and Information Technology from Islamic University of Technology (IUT), Organization of Islamic Conference(OIC), Bangladesh in 2009. He obtained his B.S. in Computer Science from the College of West Virginia, USA in 2000. He is an Assistant Professor of the Department of Computer Science and Engineering, Manarat International University, Dhaka, Bangladesh. His research interests include MAC and Routing protocols of Wireless Sensor Network.

**Abdul Mottalib** received his PhD in Computer Science and Engineering from Indian Institute of Technology (IIT), Kharagpur, India in 1993 and MS in Computer from AIT, Thailand in 1984. He obtained his MSc and BSc (Hons) in Applied Physics & Electronics from Dhaka University in 1977 and 1976 respectively. He is a Professor and Head of the Department of Computer Science and Information Technology, Islamic University of Technology (IUT), Board Bazar, Gazipur, Bangladesh since September 1998 and former Professor and Chairman of the Department of Computer Science in the Dhaka University.

His current research interest is Computer Networking, Bioinformatics and Bangla Processing. Dr. Mottalib published more than 100 research papers in various international & national journals and conference proceedings and visited more than 30 countries to attend conference, seminar, workshop and training program. He supervised more than 60 thesis works. He developed the first Bangla word processing software “Bangla”. Dr. Mottalib received Gold Medal as the best paper award for his research paper on "Computer Based Bengali Voice Synthesis" presented in the International Conference on Computer and Information Technology in January 2001.

He also worked as organizing chair, session chair, keynote speaker, paper reviewer, etc in various national & international seminar, workshop, conference, etc. He is an author of the books on HSC Computer Studies Paper I & II and B.Sc. Level Data Structures Fundamentals. He is a member of IEEE. He has been working as an expert member in many National & International Committees such as academic council, syndicate, syllabus committee, selection committee, exam committee including PhD & MS, etc.