ISSN: 2277-3754
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 1, Issue 4, April 2012

A Power Efficient Cluster-based Data Aggregation Protocol for WSN (MHML)

Hiren Thakkar, Sushruta Mishra, Alok Chakrabarty

Abstract*— Wireless Sensor Networks (WSNs) is a network of an inexpensive low coverage, sensing, and computation nodes. The difference between the wireless networks and WSN is that sensors are sensitive to energy consumption. In design of routing protocols for WSN the energy saving is the crucial issue. Till today many protocols have been proposed for energy efficiency in continuous driven clustered sensor network. In this paper, we propose a modification in Low Energy Adaptive Clustering Hierarchy (LEACH) protocol. Our modified protocol is considering residual energy as a criterion for a node to be a cluster head during Cluster head selection and Clusters setup phase. We also proposed multi level data aggregation among Cluster heads to reduce the packet size which in turn reduces the transmission and receiving energy for a node. We also proposed multi-hop transmission of aggregated data. The data aggregated by Cluster heads will not be transmitted to base station directly but through multi-hop transmission by Cluster heads which are nearer to base station, which in turn reduces the transmission distance and so as energy consumption of nodes. Our main focus to achieve energy efficiency is by reducing packet size by multi level data-aggregation among Cluster heads and by proper selection of nodes as Cluster heads by considering maximum residual energy of a node as a constraint.

Index Terms—**Cluster Head, Energy Efficiency, Multihop Communication, Multi Level Data Aggregation.**

I. INTRODUCTION

Wireless Ad hoc Sensor Network (WASN) has recently attracted a considerable amount of attention due to its application potentials. Despite similarity to research issues in ad hoc networking and distributed systems, there are several requirements that are fairly unique to WASN leading to many recent innovations to the different layers of the traditional protocol stack. Recent advances in technology have made low-cost, low-power wireless sensors a reality. Sensor networks formed from such sensors can be deployed in an ad hoc fashion and cooperate to sense and process a physical phenomenon. As each sensor has a finite battery source, an important feature of sensor network is energy efficiency to extend the network's lifetime. Each node in a sensor network is typically equipped with one or more sensors, a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, since in most Wireless sensor network applications the energy source is a battery, energy plays an important role in wireless sensor network, and preserving the consumed energy of each node is an important goal that must be considered when developing a routing protocol for wireless sensor networks.

In this paper, we introduce an MHML (**M**ulti**H**op Communication **M**ulti**L**evel Data Aggregation) Routing protocol which is a modified version of the well known LEACH protocol. In this paper we have proposed three contributions in existing LEACH protocol to enhance the lifetime of the network.

1. We are considering residual energy of nodes as parameter who intends to become the cluster heads instead of randomized Cluster head selection.
2. Multi level data aggregation among cluster heads to reduced the packet size.
3. Multi hop communication from Cluster Head (CH) to base station to reduce transmission distance.

The Key features of our MHML protocol are:

1. Localized coordination and control for cluster set-up and operation.
2. Rotation of the duty of Cluster heads and the corresponding clusters based on residual energy of a node.
3. Local as well as global data aggregation to reduce the overall communications cost.

The advantage of cluster based approach for transmitting data to the base station leverages the advantages of small transmit distances for most nodes, and few nodes need to transmit far distances to the base station. But our MHML protocol tries to reduces those few nodes, which has long transmit distance by introducing multi hop data transmission to base station.

A.RADIO ENERGY DISSIPATION MODEL [1]

We assumed a simple model for the radio hardware energy dissipation where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics as shown in the fig.1. Using this radio model, to transmit k-bit of message at distance'd' the radio expends:

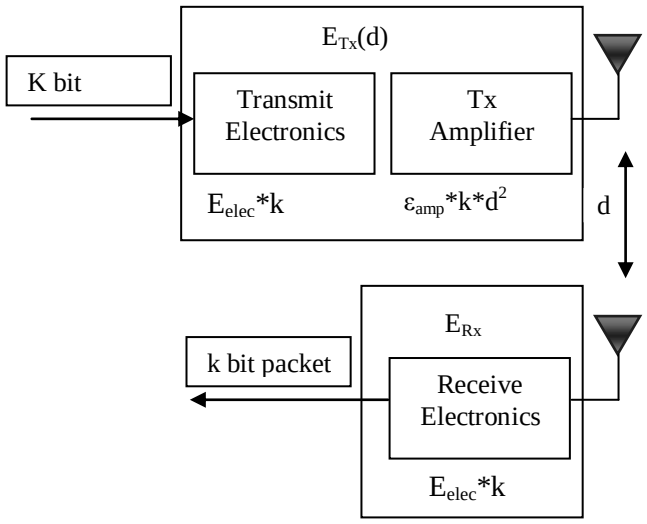


Fig.1: Radio energy dissipation model [1]

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d) \quad (1)$$

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

ISSN: 2277-3754
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 1, Issue 4, April 2012

and to receive this message, the radio expends:

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

II. REVIEW OF LEACH PROTOCOL

Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol for sensor networks is proposed by W. R. Heinzelman et.al [1] which minimizes energy dissipation in sensor networks. It is very famous hierarchical routing algorithms for sensor networks which make clusters of the sensor nodes based on the received signal strength shown in fig.2. The 5% of the total number of nodes becomes the cluster head which act as router to the sink [7]. Energy consumption is less as transmission will only be done by cluster head. Data fusion and aggregation are local to the cluster. Cluster heads change randomly over time to balance the energy dissipation of nodes. The node chooses a random number between 0 and 1. The node becomes a cluster head for the current round if the number is less than the following threshold:

$$T(n) = \begin{cases} \dfrac{p}{1 - p * \left(r \bmod \dfrac{1}{p} \right)} & if n \in G \\ 0 & otherwise \end{cases} \quad (3)$$

Where p is the desired percentage of Cluster heads (e.g. 0.05), r = the current round, and G is the set of nodes that have not been Cluster heads in the last 1/p rounds [1]. The time of first state for saving the protocol payload. Fig.3 shows the process and it is shown in Appendix.

III. SYSTEM MODEL

Assumptions:

This paper considers a WSN deployed for real life applications. The following assumptions are made about the sensor nodes and the network model:

1. The base station (i.e. sink node) is located inside the sensing field.
2. Nodes are location-aware, i.e. equipped with GPS capable antennae.
3. The communication channel is symmetric.
4. Data gathered can be aggregated into single packet by cluster heads.
5. Nodes are left unattended after deployment. Therefore, battery re-charge is not possible.

The working flow chart of LEACH is shown in fig.4, The Cluster head selection and Cluster formation is shown in fig.5 with TDMA schedule creation and actual data transfer in steady state phase.

IV. DESCRIPTION OF LEACH PROTOCOL

LEACH protocol provides a conception of round. LEACH protocol runs with many rounds. Each round contains two states: Cluster setup state and Steady state. In cluster setup state, it forms cluster in self-adaptive mode; in steady state, it transfers data. The time of second state is usually longer than

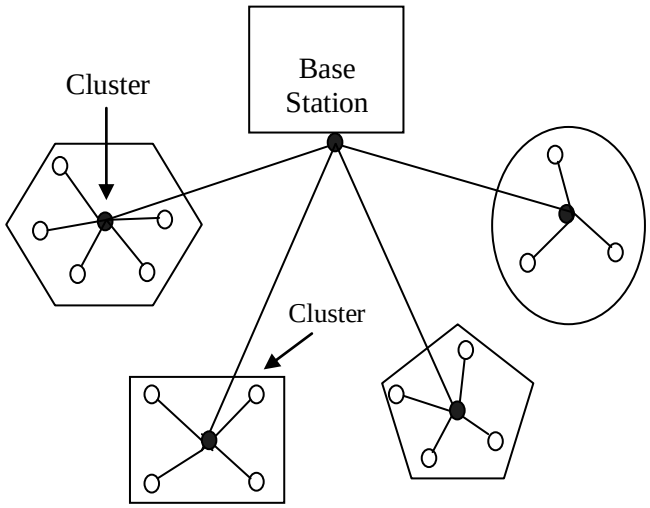


Fig.2: Cluster-based mechanism of LEACH in WSN

V. MHML PROTOCOL

MHML protocol has two improvements over existing LEACH protocol. Details of improvements will be presented in the following two sub-sections.

1. The criterion for selecting Cluster heads. LEACH protocol randomly selects Cluster head at each round. Therefore, energy of some nodes may exhaust too quickly due to being selected as Cluster head many times. In this paper, our modified protocol chooses the node as a Cluster head which has maximum residual energy, and this will prevent the whole network to die too early.
2. In LEACH after Data aggregation Cluster head sends their data directly to base station, which may be at far- distance and consumes more energy possibly. In our protocol we suggested a modification. With Multi-hop data transmission and Multi-level data aggregation, we reduce the transmission distance and packet size which in turn reduces the energy consumption.

Our MHML- protocol improves the Cluster head selection procedure. It makes residual energy of node as the main matrix which decides whether these nodes turn into Cluster head or not in the next round. In first round of communication, every node has the same probability to turn into Cluster head. We selects 'n' (n=p * N, where N= total no. of nodes present, p= probable no. of nodes to become Cluster heads), nodes randomly as Cluster heads, the residual energy of each node is different after one round of communication. So after one round of communication, we select 'n' nodes with more residual energy as Cluster heads, and so on until all nodes are dead. Our MHML protocol divides into many rounds, and each round contains *Cluster formation phase* and *Steady state phase.*

In cluster formation phase:

1. Base station decides whether a node will turn into cluster head or not by comparing residual energy.
2. Some nodes with more residual energy turn into Cluster heads and send cluster head information to inform other nodes. The other nodes with less residual energy turn into common nodes, and send cluster joining information to cluster head.

ISSN: 2277-3754
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 1, Issue 4, April 2012

In steady state phase:

1. Nodes in a cluster, sends their data according to TDMA table, and cluster head receives, and aggregates the data.
2. The Cluster head will not sends the data directly to the base station; instead the aggregated data is sends to the base station via Multi-hop transmission with Multi-level aggregation of aggregated data by Cluster heads.

The flow chart of LEACH protocol is shown in fig.4

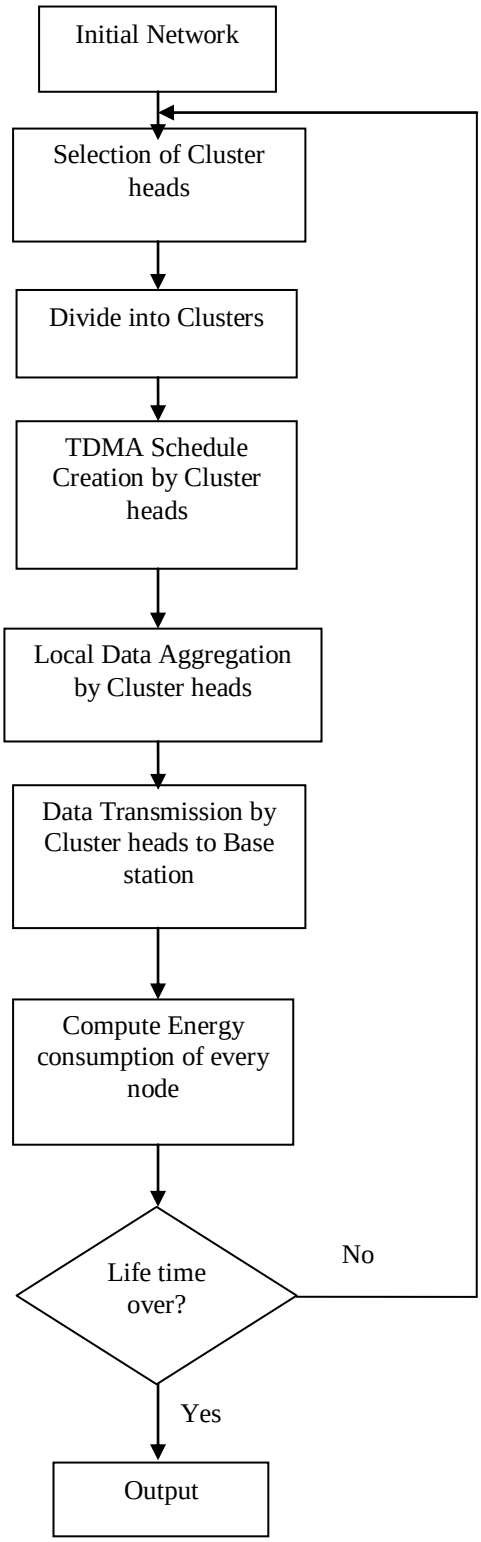


Fig.4: Flow chart of LEACH protocol

Figure 5 is shown in Appendix.

VI. ALGORITHM

We have suggested two separate algorithms for both Cluster head selection in Setup phase and for data transmission in Steady state phase.

***Algorithm 1: Cluster head Selection Algorithm*:**

Input: No of Sensor nodes, Initial node energy, probability (p), No of rounds.

Output: Cluster heads, Clusters.

Start:

1. Base station broadcasts Beacon packets.
2. All Sensor node replies with residual energy and location.
3. If network life time is not over then,
   i. For first round, Cluster heads are randomly selected.
   ii. For rest of the rounds, Base station chooses p% of the nodes as Cluster heads having more residual energy.
4. If a node is Cluster head then,
   i. It broadcasts its Cluster head advertisement packet.
   ii. All non-Cluster head nodes, sends joining request packet to those cluster head, who's received signal strength is more.
5. Cluster head accepts the joining request and forms respective clusters.

End.

The Cluster head selection is the crucial decision. In our proposed algorithm, first base station broadcasts beacon packets. As soon as sensor nodes receives beacon packet, They send their residual energy and location as a reply to base station. For the first round of communication we used randomized approach in selection of Cluster head, as in the first round the entire sensor nodes are assumed to have equal energy level and have same probability to become the Cluster head. In successive rounds base station chooses the Cluster head based on the residual energy of a node. Once the Cluster-heads are selected, they start forming clusters. Cluster heads broadcast advertisement packets to announce themselves as a Cluster heads. Sensor nodes replies to respective Cluster heads their cluster joining request packet based on received signal strength of Cluster heads advertisement packets. Now Cluster heads grant the joining request packets arrived from non-Cluster head nodes and form the clusters .After Cluster head selection and cluster formation, Steady state phase starts. In Steady state phase actual data transmission occurs. Steady state phase lasts longer then Setup phase.

***Algorithm 2*: *Data Transmission Algorithm*:**

Input: Cluster heads, Clusters.

Output: Actual data transmission, Residual energy of network, No of dead nodes.

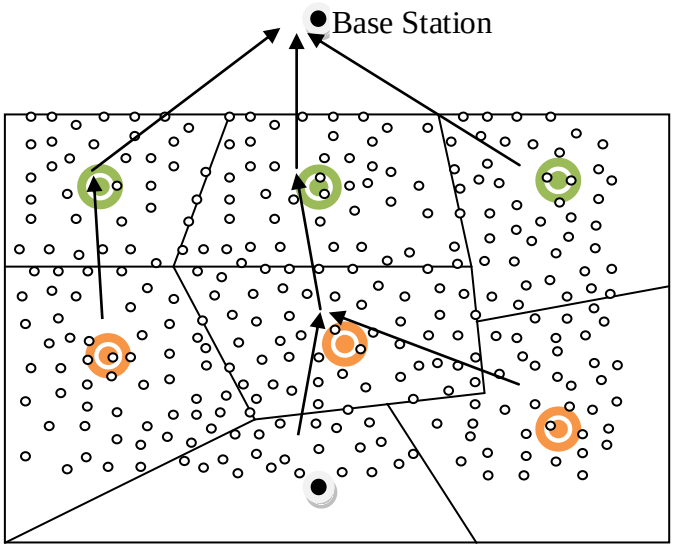
Start:

1. Cluster head creates TDMA schedule for all sensor nodes in their cluster.
2. All Cluster heads chooses different CDMA codes to avoid radio interference among inter-cluster communication.
3. All non-cluster head nodes send their sensed data to Cluster head as per the assigned TDMA schedule.
4. All Cluster heads aggregate their cluster's data.
5. Cluster heads send their data to other Cluster heads which lies in between base station and itself, which in turn

ISSN: 2277-3754
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 1, Issue 4, April 2012

aggregates data with their own data to reduce packet size and send it to base station.

End:



Once the clusters are formed, our protocol now enters into steady state phase in which actual data transmission occurs. Cluster head creates TDMA schedule as per the no. of nodes present in their cluster. Sensor nodes are assumed to have sensed data all the time ready to transmit, so as soon as sensor nodes turn come, it starts sending their data to Cluster head. After one cycle of data transmission, Cluster head aggregates the data. Now aggregated data is sends to base station in Multi-hop transmission Multi-level data aggregation way. Fig.6 explains the concept of MultiHop transmission with MultiLevel aggregation of aggregated data. Here in data transmission phase, first Cluster heads aggregate their data locally and send it to those Cluster heads which lies in between base station and itself. This also recursively aggregate and send data to those Cluster heads which again lies in between base station and itself, this process continues until there are no Cluster heads left in-between. This way we have reduced the transmission distance between Cluster heads and base station with reduction in packet size by suggesting multi level data aggregation. Both the factors have significant impact on energy saving. As the communication distance is reduced due to MultiHop communication, we gain the energy efficiency and as the packet size is reduced due to Multi Level data aggregation, we gain energy is efficiency.

VII. CONCLUSION

In this paper we considered a well known protocol for wireless sensor networks called LEACH protocol which is the first and the most important protocol in the wireless sensor network which uses cluster based broadcasting technique. Followed by an overview of LEACH protocol implementation. We proposed a MHML protocol which tries to reduce the energy consumption by proper selection of cluster head in setup phase and by reducing the transmission distance and packet size in steady state phase.

REFERENCES

[1]. W.B.Heinzelman et al., "Energy Efficient Communication Protocol for Wireless Micro sensor Networks", Proceedings of the 33rd Hawaii International Conference on System Science-2000.

[2]. M.Bani Yassein, A.Alzou'bi, Y.Khamayseh, W.Mardini "Improvement on LEACH protocol of Wireless Sensor Network(VLEACH)",International Journal of Digital Content Technology and its Applications, Volume 3, Number 2,June 2009.

[3]. Wei Bo Hu Han-ying Fu Wen "An Improved LEACH Protocol for Data Gathering and Aggregation in Wireless Sensor Networks", International Conference on Computer and Electrical Engineering, 2008.

[4]. Fan Xiangning, Song Yulin "Improvement on LEACH Protocol of Wireless Sensor Network", International Conferences on Sensor Technologies and Applications, 2007.

[5]. K.Padmanabhan, Dr.P.Kamalakkannan "Energy Efficient Adaptive Protocol for Clustered Wireless Sensor Networks", IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 5, No 1, September 2011.

[6]. Vivek Katiyar, narottam Chand, Gopal Chand Gautam, Anil Kumar "Improvement in LEACH Protocol for Large-scale Wireless Sensor Networks", Proceedings of ICETECT 2011.

[7]. Rajesh Patel, Sunil Pariyani, Vijay Ukani "Energy and Throughput Analysis of Hierarchical Routing Protocol (LEACH) for Wireless Sensor Network" International Journal of Computer Applications, Volume 20-No.4.April 20.

AUTHOR BIOGRAPHY

Hiren Thakkar received his B.E degree (Computer Engineering) in 2009 from Sardar Patel University, New V V nagar, Gujarat, India. Currently he is pursuing his M.Tech degree from Department of CSE, IIIT Bhubaneswar, Odisha, India. His area of research is Wireless Sensor Networks.
E-mail: hiren.iiit@iiit-bh.ac.in

Sushruta Mishra received his B.Tech degree in 2009 from BPUT, Rourkela, Orissa, India. Currently he is pursuing his M.Tech degree from Department of CSE, IIIT Bhubaneswar, Odisha, India. His area of research is Wireless Sensor Networks.
E-mail: mishra.sushruta@iiit-bh.ac.in

Alok Chakrabarty received his Ph.D. degree in 2011 from Assam University, Silchar, Assam, India. Currently he is working as an Assistant Professor in the Department of CSE, IIIT Bhubaneswar, Odisha, India. His areas of research are Pattern Recognition, Wireless Sensor Networks and Natural Language Processing.
E-mail: mcscalok@gmail.com

ISSN: 2277-3754
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 1, Issue 4, April 2012

APPENDIX

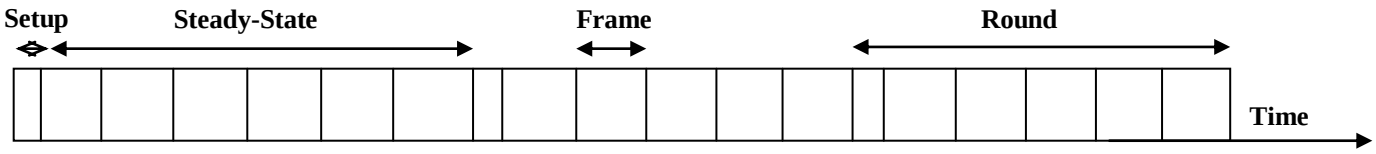
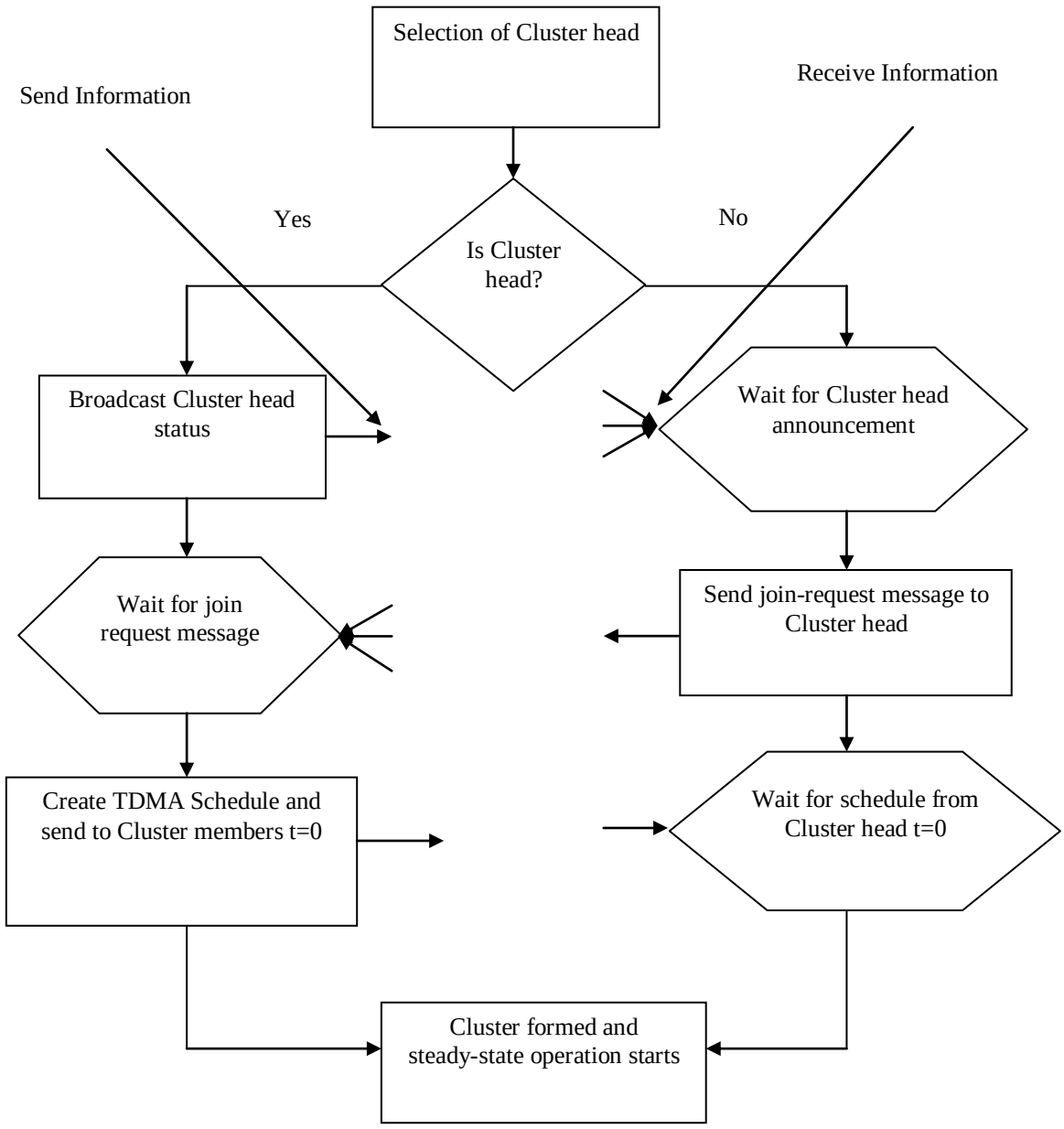


Fig.3 Operation time of LEACH [4].

Fig.5: Cluster selection of LEACH protocol [7].



ISSN: 2277-3754
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 1, Issue 4, April 2012