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# Routing Protocols and Algorithms for Wireless Sensor Networks


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**ABSTRACT**

Wireless Sensor Networks (WSNs) are attracted more attention than ever before due to the recent technology development. Wireless sensor networks depend on small battery powered devices with limited energy resources. Anonymous nodes change dynamically Network topology of WSNs. New applications and require non-conventional paradigms are enabled for designing algorithms by using WSNs. As the use of WSNs is increasing day by day, the main target is to design an effective and energy aware protocol in order to increase the network lifetime for specific application environment. Owing to the requirement for low device complexity together with low energy consumption (i.e., long network lifetime). In this research the proposed work using LEACH, ST for TEEN and M-GEAR protocols is applied. Our goal is to design a gateway based energy aware multi-hop routing protocol using MATLAB and compare the performance for M_GEAR with LEACH and TEEN protocols. Here our work describe an energy-efficient multi-hop routing protocol using gateway node to maximization the life time wireless sensor network and for the minimize energy consumption of sensor network. The network is divided into logical regions. Each region uses a various communication hierarchy. Two regions of the network use direct communication topology .the other two regions are further sub-divided into clusters and use multi-hop communication hierarchy. Because of the heavy energy burden, the cluster head dies and life time of network minimizes. As the distances between base station and the nodes are far, our work put gateways as intermediate between the cluster head and base station to reduce the distance. Every node elects itself as a CH independent of other region. This technique encourages better distribution of CHs in the network Cluster head is chosen randomly in M-GEAR protocol due to the low of current energy of some cluster heads of cluster.



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## 1. Introduction

A wireless sensor network consists of a large number of small compact devices organized into a collaborative network called sensor nodes. The surrounding conditions in the environment ambient the sensors are measured and then these data are converted into electric signals that can be processed to reveal some of the characteristics about phenomena situated in the zone around these sensors. In this way, we can get the information about the zone which is far away [1].

Habitat sensing, biomedical applications, weapon sensors for ships, Radiation and nuclear-threat detection systems, and seismic monitoring all of these and more use sensor networks. Interest has focusing on networked biological and chemical sensors for national security applications; on the other hand, evolving interest extends to direct consumer applications. Existing and potential applications of sensor networks contain, among others, military sensing and physical security. There are many applications of sensor network such as: traffic surveillance, process control, video surveillance, air traffic control, inventory management, building and structures monitoring, national border monitoring, distributed robotics, environment monitoring, military sensing and physical security, weather sensing, etc. [2],[3].

## 2. Energy Consumption Model

As wireless sensor Networks have very limited battery power, the residual energy on the nodes are curtail for the lifetime. Accordingly, the energy-efficient communication technology is essential to wireless sensor networks. Transmitting or receiving data, processing data, and idle listening generate the consumption of energy. One of the most popular energy dissipation model for WSN is proposed by Heinzelman called the First Order Radio Model which we use it in our simulation as shown in Fig 1.[4], [9].

As it is shown in table 1, we assume a simple model where the radio dissipates Eelec= 50nJ/bit to run the transmitter or receiver circuitry and $E_{amp}$ = 100pJ/bit/$m^2$ for the transmit amplifier.

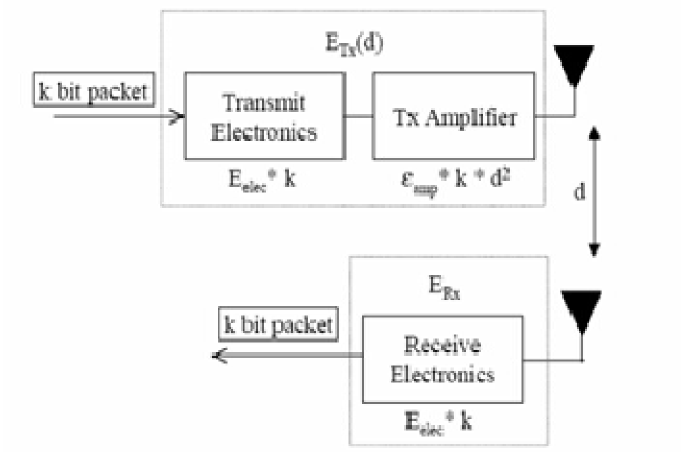


Fig.1: First order model

Table 1.

| *Operatio* | *Energy Dissipated* |
|---|---|
| Transmitter Electronics $E_{tx-elec}$ | 50nJ/bit |
| Receiver Electronics $E_{rx-elec}$ | 50nJ/bit |
| Transmit Amplifier $E_{Tx-amp}$ | 100pJ/bit/$m^2$ |

We know that the energy required to transmit a signal is proportional to the square of the distance. Then, we get the total energy dissipation for transmitting k bits of data to be:
circuitry energy dissipation + transmission energy dissipation =

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

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

the energy used to receive a k-bit signal is:

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

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

the First Order Radio model is Based on many routing protocol which are examined to optimize the energy efficiently routing in wireless networks.

## 3. Routing Protocols And Algorithms

For designing the routing protocols in wireless sensor networks we must remember energy efficiency, scalability, latency, fault-tolerance, accuracy and QoS. Most routing protocols are classified as data-centric, hierarchical and location based protocols. They are classified depending on the network structure and applications.

Overview details of routing protocols are discussed but in this paper we are interested in hierarchical and location based protocols as shown in [5],[6].

In a hierarchical or cluster based methods architecture, using higher energy nodes to process and send the data and information more than low energy nodes. In the network, nodes do different parts. That means the creation of clusters and assigning special tasks can greatly share to overall system lifetime, efficiency, scalability and energy to cluster heads [7]. In location-based protocols, sensor nodes are addressed by means of their locations. We need to know the location information for sensor nodes of sensor networks in order to calculate the distance between two particular nodes so that we can estimate energy consumption [8].

### *3.1. Low Energy Adaptive Clustering Hierarchy Algorithm (LEACH)*

LEACH is a clustering routing protocol in which the data is collected from sensor nodes to a cluster head belonging to the cluster. After data aggregation process, the data is sent to the sink node [9]. The cluster head is changed randomly by this algorithm, which successively consumes more energy than any other node belonging to the cluster every time period in order that making all sensor nodes in this network use their node energy equally and extend the life time of the network. Data aggregation is performed by the cluster head and the data is sent to the sink node. So that all over communication costs is minimized. This following function explains how the cluster head is determined.

$$T(n) = \begin{cases} P/(1-P(r \bmod 1/P) & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

Where P is the cluster heads’ percentage which is required, G is the set of nodes that have not been cluster-heads in the last 1/P rounds and r is the current round number. A two phases is contained in each round: a set-up phase and a steady state phase. The former is a stage for configuration of a cluster head and a cluster, and the latter is a stage for data transfer by the TDMA schedule. A random number is generated in the range of 0 and 1by every sensor node when a new round starts. By using Equation (1), each sensor node calculates a threshold value and matches the two numbers. The node is accepted as a plain node if the generated number is greater than the threshold value, otherwise; the node is presented as a cluster-head. An advertisement messages are broadcasted over neighbour nodes by the nominated cluster-head. The advertisement messages which are received form the neighbour node spread all over the network. The neighbour node selects one of the broadcasting nodes that transmit the strongest broadcasting signal as its head cluster node. Each node forwards a “Join-REQUEST” message to the cluster head. Then the node is registered onto the cluster-head’s own member node table.

A TDMA schedule is made for data transfer by the cluster head within the cluster network and broadcasts the schedule to its member nodes. Every node in a cluster network forwards data to its cluster head by the TDMA schedule in the next steady state phase. The aggregated data is sent by the cluster head to the sink node. Once a cluster head has been selected many rounds of data frame transfer are performed followed by a repeat of the cluster reconfiguration procedure to reduce the overhead of the cluster head selection [15].

### *3.2. Threshold Sensitive Energy Efficient Sensor Network Algorithm (TEEN)*

TEEN [10], [11] is a cluster set up hierarchical routing protocol based on LEACH. This protocol is utilized for time-critical applications. It has two propositions [12]:

- The BS and the sensor nodes have the same initial energy.
- The BS can transmit information to all nodes in the network specifically

Nodes sense the medium continuously in this protocol however the data transmission is done less frequently. The network includes simple nodes, first-level cluster heads and second-level cluster heads. TEEN uses LEACH's methodology to construct cluster. First level CHs are constructed away from the BS and second level cluster heads are constructed near to the BS.

A CH transmits two types of information to its neighbours—one is the hard threshold (HT) and other is soft threshold (ST). In the hard threshold, if the detected characteristic is in the range of interest then it reduces the number of transmissions, the nodes send data. On the other hand, in soft threshold mode, any little change in the rate of the sensed attribute is sent. The environment of nodes is sensed continuously and the nodes store the sensed value for transmission. Then the node sends the sensed value if one of the following conditions are convinced:

- Sensed value > hard threshold (HT).
- Sensed value ~ hard threshold >= soft threshold (ST).

In this paper we are interested in ST for TEEN algorithm.

### 3.3. *Geographic and Energy-Aware Routing Algorithm (M-GEAR)*

To improve network lifetime and energy consumption, we use a gateway node at the centre of the network field. The mission of gateway node is to gather data from CHs and from nodes near gateway, aggregation and sending to BS. Adding rechargeable gateway node is better than adding sensor nodes because of the recharging of gateway node is much cheaper than the price of sensor node [13].

- Initial Phase:
  - Sink broadcasts a HELLO packet.
  - Sensor nodes transmit acknowledge packet.
  - Sink stores all information of nodes in Node Data Table.
  - Node Data Table contains Residual Energy, node ID and distance of node from Sink and Gateway node.
- Setup Phase*:*

Sink portions the nodes into four logical areas:

  - Direct communication is used for two areas.
  - Clustering technique is used for two areas.
- CH Selection:

CHs are elected in each separated area. Let ri represent the number of rounds to be a CH for the node S i. Every node elect itself as a CH once each r i = 1/p rounds. At the start of first round, all nodes in both areas have have similar energy level and have similar chance to be CH. CH is elected on the basis of the remaining energy of sensor node and with a probability p. In each round before it is required to have n x p CHs.

A node can be CH only once in an epoch and the nodes not elected as CH in the current round feels right to the set C. The probability of a node to (belong to set C) elect as CH increases in each round. It is required to uphold balanced number of CHs. A node Si belongs to set C autonomously selects a random number between 0 to 1 at the start of each round.

The node becomes CH If the generated random number for node Si is less than a predefined threshold T(s) value in the current round. The value of threshold can be found as:

$$T(S) = \begin{cases} (p1-p\times(r \bmod (1/p)) & \text{if } s \in C \\ 0 & \text{otherwise} \end{cases} \quad (4)$$

Where P = the desired percentage of CHs, r = the current round and C = set of nodes not elected as CH in current round. After selecting CHs in each region, CHs inform their role to neighbor nodes. CHs transmit a control packet using a CSMA. Each node transmits acknowledge packet after receiving control packet from CH. When node finds the nearest CH, it becomes member of that CH.

- Scheduling*:*

Each CH creates TDMA based time slots for its member nodes. CH aggregates sensed data from all the associated nodes in its own scheduled time slot. Otherwise nodes switch to idle mode. Nodes turn on their transmitters at time of transmission. Hence, energy dissipation of individual sensor node decreases.

- Steady-State Phase*:*

The sensed data from all sensor nodes are transmitted to CH. Gateway node receives data from CHs and forwards to BS.

## 4. Performance Evolution

### *4.1. Simulation Setting:*

To evaluate the performance of LEACH, TEEN and M-GEAR algorithms, we have implemented them using MATLAB. We have performed the simulation on a network of 100 nodes and a fixed BS (1.5*xm, 0.5*ym). In the network, the nodes are placed randomly. All the nodes start with an initial energy of 0.5J. The sensor network nodes distributed randomly in a bounding area of 100x100 units. All parameters are shown at the table 2.

Table 2

| Parameter | Value |
|---|---|
| $E_0$ | 0.5J |
| $E_{elec}$ | 50nJ/bit |
| $E_{fs}$ | 10pJ/bit / $m^2$ |
| Eamp | 0.0013pJ/bit/$m^4$ |
| $E_{da}$ | 5pJ/bit |

### *4.2. Results:*

- *Average energy dissipated:*

The average dissipation of energy for nodes is shown over time in the network as in Fig. 2, Fig. 3 and Fig. 4.They perform various functions such as transmitting, receiving, sensing, aggregation of data etc.

- *Total number of nodes DEAD:*
-

The overall lifetime of the network is indicated. More importantly, it gives an idea of the area coverage of the network over time as shown in Fig. 5, Fig. 6 and Fig. 7.

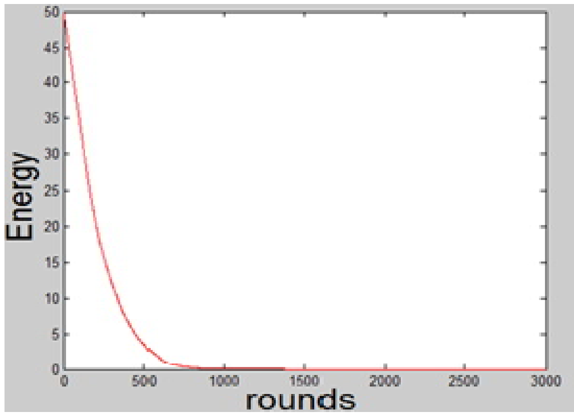


Fig. 2: Energy consumption for LEACH

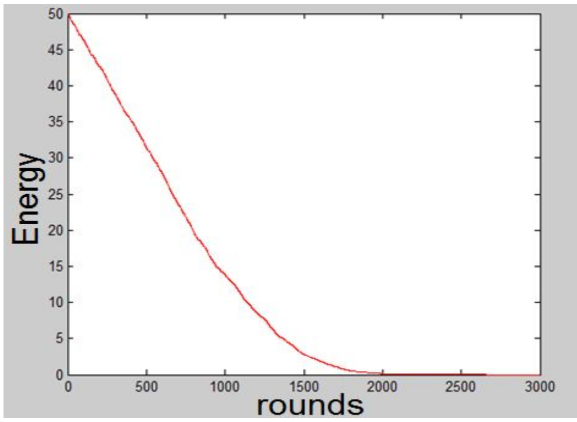


Fig. 3: Energy consumption for TEEN (ST)

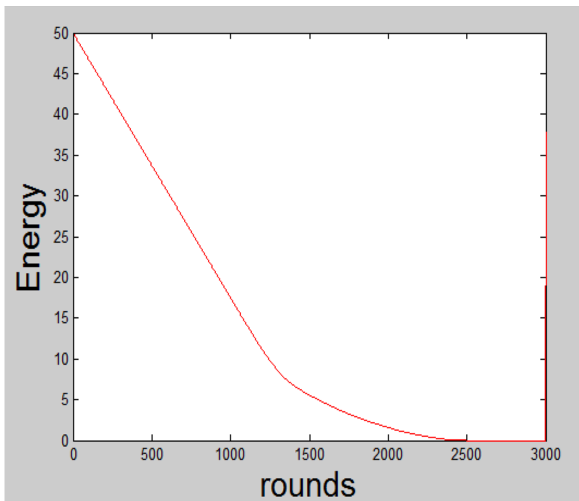


Fig. 4: Energy consumption for M-GEAR

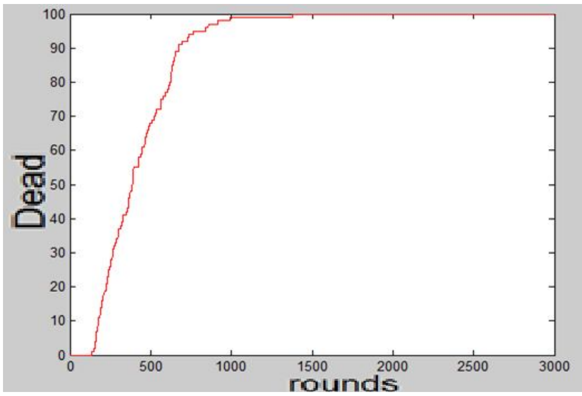


Fig. 5: Number of dead nodes by using LEACH

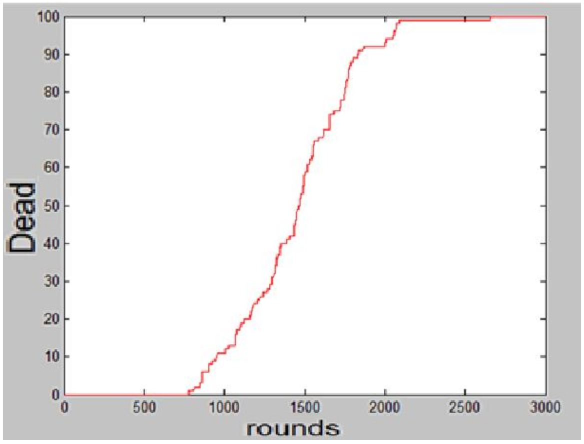


Fig. 6: Number of dead nodes by using TEEN (ST)

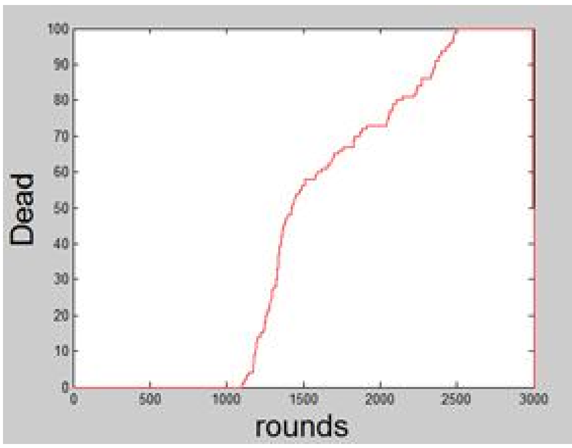


Fig. 7: Number of dead nodes by using M-GEAR

## 5. Conclusion And Future Work

The algorithm used in this paper is a little bit complicated and formal we aim in succeeding work to develop a more simplify a systematic algorithm use intelligent technique like round roben algorithm in balance loading for energy dissipation ,time saving and job request assignment**.**

## References

[1] A.Gupta, “Clustering Approach for Enhancing Network Energy using LEACH Protocol in WSN,” International Journal of Wired and Wireless Communications Vol.2, Issue 1, October, 2012, ISSN: 2319-9520.

[2] K.Sohraby, D. Minoli,and T.Znti, “Wireless Sensor Networks Technology, Protocols, and Applications,” book 2007 ISBN-13: 978-0471743002.

[3] Li, Yingshu, Thai, My , “Wireless Sensor Networks and Applications;” book 2008 ISBN 978-0-387-49592-7.

[4] S.Cho,B.Shrestha,K.La,B. Hong, J.Lee “An Energy-Efficient Cluster-Based Routing in Wireless Sensor Networks;” book 2011 ISBN 978-3-642-27201-1.

[5] N.Rathi, J.Saraswat, and P. Bhattacharya, “A Review On Routing Protocols For Application In Wireless Sensor Networks;” International Journal of Distributed and Parallel Systems (IJDPS) Vol.3, No.5, September 2012R.

[6] W.Seah, and Y. Tan,"Sustainable Wireless Sensor Networks;" book 2010 ISBN 978-953-307-297-5.

[7] P. Garg and R Rani, “A Survey on Wireless Sensor Networks Routing Algorithms;” IJITKMSpecial Issue (ICFTEM-2014) May 2014.

[8] S.Singh, M. Singh, and D. Singh, “ Routing Protocols in Wireless Sensor Networks-A Survey,” International Journal of Computer Science & Engineering Vol.1, No.2, November 2010.

[9] W. Heinzelman, A. Chandrakasan and , H. Balakrishnan, “Energy-efficient routing protocols for wireless microsensor networks,” in Proc.33rd Hawaii Int. Conf. System Sciences (HICSS), Maui, HI, Jan. 2000.

[10] A. Manjeshwar, and D. Agrawal, " TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks;” *IEEE* 2001.

[11] D. Ram, and D. Shah, “Analysis Of Different Hierarchical Routing Protocols Of Wireless Sensor Network;” IJRET: International Journal of Research in Engineering and Technology ISSN: 2321-7308 ,2014.

[12] H. Kim, H. Seo and C. Kim, “Modeling of Energy-efficient Applicable Routing Algorithm in WSN;” International Journal of Digital Content Technology and its Applications Volume 4, Number 5, August, 2010 .

[13] Q. Nadeem, M. Rasheed, N. Javaid, Z. Khan, Y. Maqsood and A. Din, “ M-GE GEAR: Gateway-Based Energy-Aware Multi-Hop Routing Protocol for WSNS,” IEEE 8th International Conference on Broadband and Wireless Computing, Communication and Applications (BWCCA’13), Compiegne, France July 2013.

[14] S. Parvin and M. Rahim, “Performance Evaluation of LEACH and PEGASIS: Two Prominent Routing Protocols for Wireless Sensor Networks;” www.researchgate .com Feb-2015.