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Enhancement of lifetime using different Protocols in wireless sensor network

Amandeep Kaur[1], Jatinder Singh[2]

[1] Department of Computer Science and engineering
BBBEC Fatehgarh Sahib,+91-9717074561
Neetu_4232@yahoo.co.in

[2] Department of Computer Science and engineering
BBBEC ,Fatehgarh Sahib,+91-9814830404
jatinder.saini@bbsbec.ac.in

ABSTRACT

Increasing lifetime in wireless sensor networks is a major challenge because the nodes are equipped with low power battery. For increasing the lifetime of the sensor nodes energy efficient routing is one solution which minimizes maintenance cost and maximizes the overall performance of the nodes LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering-based protocol that utilizes randomized rotation of local cluster base stations (cluster-heads) to evenly distribute the energy load among the sensors in the network. Incorporates data fusion into the routing protocol to reduce the amount of information that must be transmitted to the base station. In addition, LEACH is able to distribute energy dissipation evenly throughout the sensors, doubling the useful system lifetime for the networks we simulated. Also we call the proposed protocol as RESIDUAL ENERGY EFFICIENT PROTOCOL as modification in the basic LEACH protocol in terms of residual energy (ratio of energy in current round to total energy of the network) of nodes. Since LEACH has many drawbacks, many researchers have tried to make this protocol performs better by improving cluster head selection algorithm by several parameters. LEACH stochastic cluster head selection algorithm is extended by adjusting the threshold T (n). Considering these parameters, simulation results shows that the proposed protocol REAP 1 and REAP 2 could better reduce energy consumption and prolong lifetime of the wireless sensor network with respect to the parameters FND (First Node Dies), HND (Half Node Dies) and LND (Last Node Dies) comparative to LEACH , NEAP-1 and NEAP -2.

Keywords: LEACH, MTE, DTE, NEAP, REEP, LND, FND, HND

I. INTRODUCTION

In this Paper, the modifications and enhancements to the LEACH protocol are discussed which are ultimately incorporated into the design of the target protocol.

In LEACH [1] [2], probability of becoming a cluster-head is based on the assumption that all nodes start with an equal amount of energy, and that all nodes have data to send during each frame. If nodes begin with different amounts of energy, the nodes with more energy should be cluster-heads more often than the nodes with less energy, in order to ensure that all nodes die at approximately the same time. This can be achieved by setting the probability of becoming a cluster-head as a function of a node's energy level relative to the aggregate energy of the cluster in the network [6], rather than purely as a function of the number of times the node has been cluster-head:

Probability of becoming cluster-head = Energy of the node/Energy of the cluster

We call the proposed protocol as RESIDUAL ENERGY EFFICIENT PROTOCOL as modification in the basic LEACH protocol in terms of residual energy (ratio of energy in current round to total energy of the network) of nodes. So, this residual energy concept will increase the overall energy of the network, and hence lifetime of the network will increase.

1.2. Residual energy efficient algorithm detail

Protocol rounds are repeated periodically, with each round consisting of the following phases.

1.2.1. Advertisement phase: The first round (i.e. round number zero) is started by each node calculating Threshold value (or probability to become cluster-head) using same method as used in LEACH protocol and comparing the threshold value with random no (0 to 1) selected by the node. If the threshold value is greater than the random number chosen then the node becomes the cluster-head for this round.

Drawbacks of LEACH

The randomization of electing cluster-head nodes can distribute the load among the network; it suffers from the following drawbacks-

- It assumes that the energy of all the nodes is same and remains so with time.
- The election of cluster-head nodes ignores the residual energy information about the nodes and this will easily result in the cluster head nodes disable.
- It ignores the distance factor between the nodes and the base station

Since LEACH has many drawbacks, many researchers have tried to make this protocol performs better by improving cluster head selection algorithm by several parameters.

LEACH's stochastic cluster head selection algorithm is extended by adjusting the threshold T(n), Residual LEACH Protocol, as follows:

$$T(n) = \frac{p}{1 - p(r \bmod \frac{1}{p})} \frac{E_{current}}{E_{\max}}$$

Where $E_{current}$ is the remaining energy of the sensor nodes and E_{max} is the initial energy of the node before transmission.

As an improvement in LEACH's algorithm and Residual LEACH algorithm, the threshold value of the node can be extended by adjusting the threshold T(n) by considering residual energy of the nodes, distance between the nodes and the base station and the number of consecutive rounds in which a node has not been a cluster head as parameters as follows:

$$T(n)_{new} = \frac{p}{1 - p(r \bmod \frac{1}{p})} \frac{E_{current}}{E_{\max}} \frac{D_{avg}}{D_{\text{sink}}}$$

Where D_{avg} is the average distance of the farthest node from all other nodes, and D_{sink} is the distance from node i to Base station.

After a significant amount of time of operation, the residual energies of the sensors would become very low and then this threshold value will be very low. This can result in a situation where all the live sensors are one member cluster head. In this case the energy consumption rate will be very high. To break this stuck condition another modified equation of the threshold value is given by:

$$T(n)_{new} = \frac{p}{1 - p(r \bmod \frac{1}{p})} \frac{D_{avg}}{D_{\text{sink}}} \left[\frac{E_{current}}{E_{\max}} + (r_s div \frac{1}{p}) \left(1 - \frac{E_{current}}{E_{\max}} \right) \right]$$

Since the goal is to maximize the lifetime of the network or to minimize the energy consumption, according to the new proposed formula the lifetime of the network will be greater than the above mentioned formulae.

Where p = the desired percentage of cluster heads, r = the current round, and G is the set of nodes that have not been cluster-heads in the last 1/p rounds, r_s = number of consecutive rounds in which a node has not been cluster head.

1.2.2. Cluster Set-up Phase

After each node has decided to which cluster it belongs, it must inform the cluster-head node that it will be a member of the cluster. Each node transmits this information back to the cluster-head again using a CSMA MAC protocol through a message we call the selection message. The contents of the selection message are:

- The selection message flag CLUSTER_SELECT_MESSAGE
- Cluster-head identity
- Self node id

1.2.3. Schedule Creation Phase

The cluster-head node receives all the messages for nodes that would like to be included in the cluster. Based on the number of nodes in the cluster, the cluster-head node creates a TDMA schedule telling each node when it can transmit. This schedule is broadcast back to the nodes in the cluster along with the CDMA spreading code to be used for data transmissions within the cluster. The schedule creation broadcast message consists of the following fields:

- The schedule message flag SCHED_MESSAGE
- The CDMA spreading code to be used for communications within the cluster
- The TDMA schedule consisting of N number of {node-identity(node_id) – TDMA time-slot} pairs

1.2.4. Data Transmission Phase or Steady-state Phase

Once the clusters are created and the TDMA schedule is fixed, data transmission can begin. If the nodes have data to send, they send it during their allocated transmission time to the cluster head. A data message which is sent to cluster-head consists of the following fields: The Data message flag DATA_MESSAGE

- Identity of the source node *n*
- Cluster-head id
- Residual energy left in node n
- The actual data if any

When all the data has been received, the cluster head node performs signal processing functions to compress the data into a single signal. Then cluster-head checks if its energy is greater then what is required to send the aggregated data to base station plus sending cluster-head status to all its members. If the energy is greater, then it just sends the aggregated data to base station. Otherwise (if energy is less or equal to the amount needed to send the aggregated data to base station plus sending cluster-head status to all its members) cluster-head will send the CLUSTER_HEAD_DOWN status to all its members.

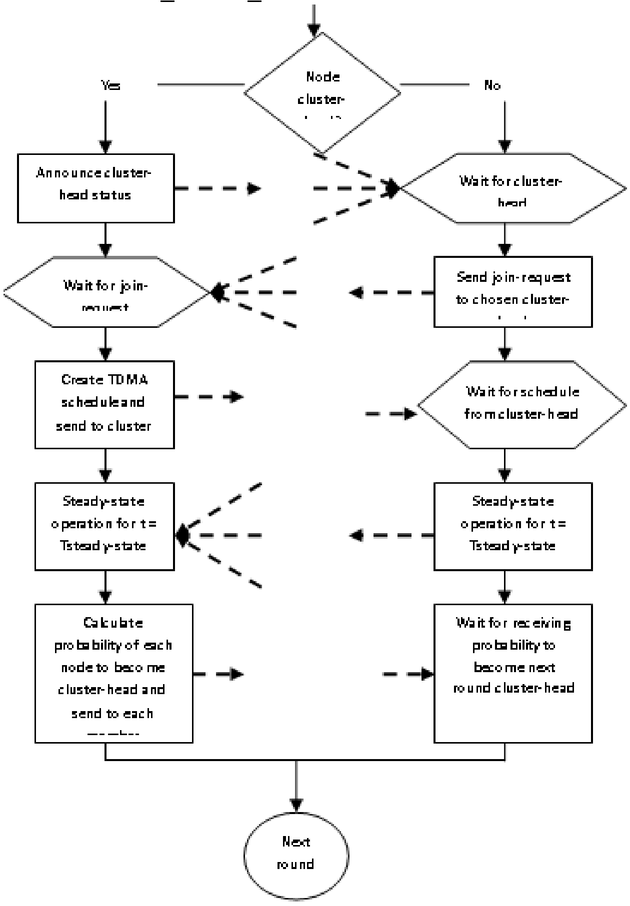

Figure1.2: Flow-graph of the distributed cluster formation algorithm.

The cluster-head status message contain following field:

- The message flag CLUSTER_HEAD_DOWN
- The cluster-head id
- The probability of becoming cluster-head for each node.
  Where T(n) = Energy of the node/total energy of the cluster. On receiving this message all member of the cluster will stop transmitting the data until next round begins.

• All nodes are able to reach BS.
• All nodes always have data to send.
• Symmetric propagation channel.
• Cluster-heads perform data compression.
• When node energy value less than 0, we say node is dead; when surviving nodes with in network are less than 5, we consider network is out of work.

Advantages

- Optimises the distance between head nodes and other nodes reducing energy consumption and chances of loss of signal strength.
- Optimises the distance between the inter cluster head nodes, thus optimising the communication between head nodes and central server.
- The new approach selects the optimized node as head node which has the minimal cost in terms of energy while communicating with other nodes, thus increasing the lifetime of the network

2.2 Radio Parameters

Wireless micro sensor network simulations using MATLAB are performed to determine the network lifetime in terms of number of nodes alive in the network, of the different protocol architectures discussed in this thesis. For these experiments, the random 100-node network is used. The base station was placed 75 meters from the closest node, at location (x=50, y=175). The radio electronics energy is set to 50nJ/bit and the radio transmitter energy is set to 10 pJ/bit/m^2 for distances less than d_0 = 87m and 0.0013 pJ/bit/m^4 for distances greater than d_0 = 87m.The energy for performing beam forming computations to aggregate data was set to 5nJ/bit/signal. These parameters are summarized in Tables 1.1 and 1.2.

Table1.1: Radio parameters values

Description	**Parameter**	**Value**
Radio electronics energy	E_{elec}	50 nJ/bit
Energy for beam forming	E_{BF}	5 nJ/bit
Cross-over distance for Friss and two-ray ground attenuation models	d_o	87 m
Radio amplifier energy	ε_{friss_amp} $\varepsilon_{two\_ray\_amp}$	10 pJ/bit/m^2 0.0013 pJ/bit/m^4

Table 1.2: Characteristics of the wireless sensor network

Nodes	100
Network size	100m * 100m
Base station location	(50,175)
Radio propagation speed	3*10^8 m/s
Data size	500 bytes

2.3 Simulation Results

To evaluate the performance of various protocols, the simulations are performed on MATLAB using random 100-node network with one base station. Figure 2.1 shows a random 100-node network.

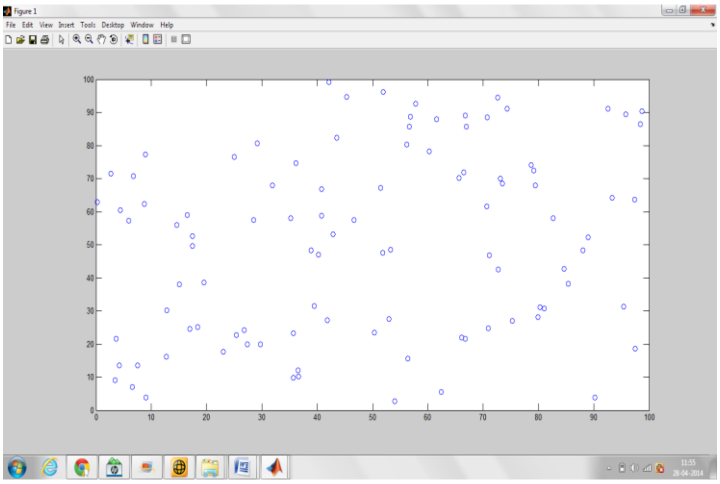

Figure 2.1: A 100 node random network.

A set of nodes elects themselves cluster-head depending upon the energy left, the clusters within the specified sensing field are shown in figure 2.2. Therefore, (for P= 0.05 and the threshold given) at time t, the random test network and its cluster formation is shown in figure 2.2.
A set of nodes elects themselves cluster-head depending upon the energy left, the clusters within the specified sensing field.the average energy dissipation is least for putting the value for number of clusters =5. Therefore, (for P= 0.05) at time t, the random test network and its cluster formation is shown in figure 2.2.

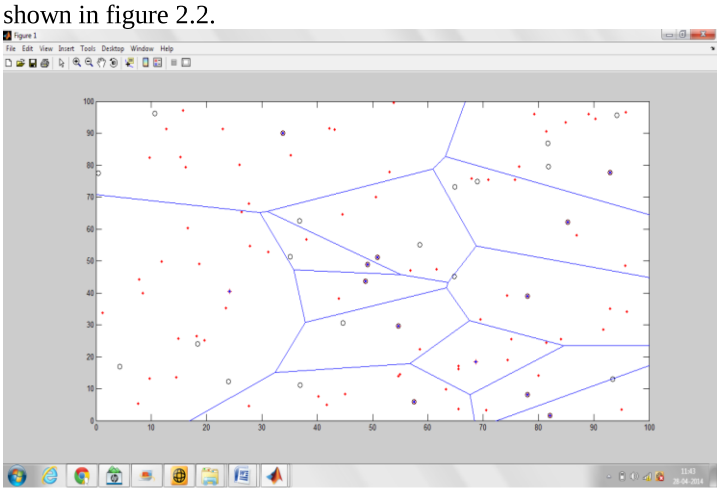

Figure 2.2: Cluster head nodes and cluster formation at time t.

2.3.1Energy Dissipation Comparison of residual-LEACH and LEACH Protocols

In wireless sensor networks, the energy consumption and the network lifetime are important issues for the research of the routing protocol. This thesis introduces a residual LEACH protocol with hierarchical clustering for wireless sensor networks that distributes loads among more powerful nodes. Compared to the existing clustering protocols, residual protocol has better performance in CH election and forms adaptive power efficient and adaptive clustering hierarchy. The simulation results presented that it significantly improves the lifespan and the energy consumption of the wireless sensor networks compared with LEACH protocol.

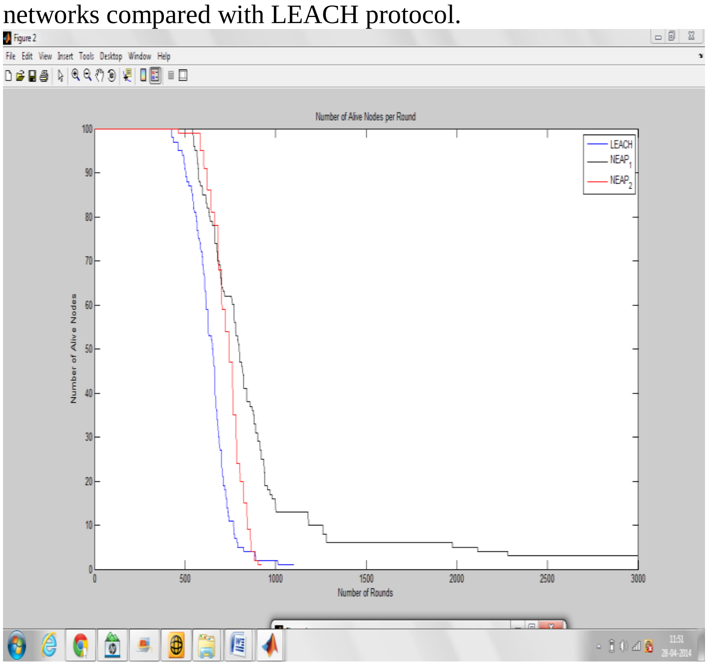

Figure 2.3: Lifetime Comparison of protocols without Distance Factor with Energy =0.5J **(LEACH, NEAP 1, NEAP 2)**

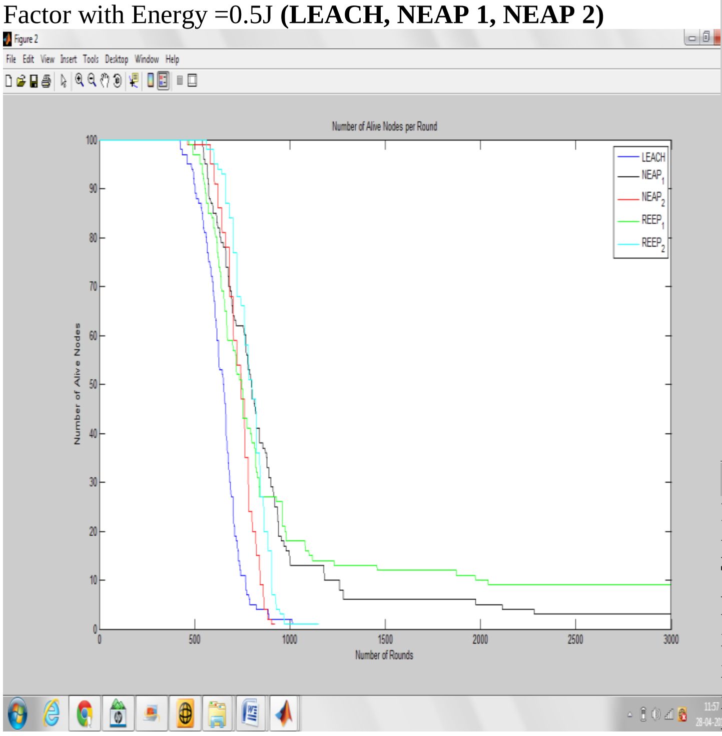

Figure 2.4: Lifetime Comparison of various protocols by adding Distance Factor (LEACH, NEAP 1, NEAP 2, REEP 1, and REEP 2).

2.3.2Lifetime Comparison of Various Routing Protocols

To evaluate the performance of various protocols, the simulations are performed on MATLAB using random 100-node network with one base station. The simulations are performed in order to determine network life time. The network life time is defined as the number of nodes alive for number of time rounds.

Regarding the network life time, there are following regulations are considered. When a node's energy is less than 0, we say that node is dead. When surviving nodes with in network are less than 5, i.e. 95 nodes are dead; we consider that network is out of work. In this thesis matrix approach is used to define the network life time. FND- first node dies, this matrix define the time during which first node of the network is dead. HNA- half nodes alive, this matrix define the time during which half of the nodes of network alive and half are dead. LND- last node dies, this matrix defines the time during which last node of the network is dead.

These three matrices define the uses of wireless sensor networks for different applications. In some applications it is desired that all nodes remains alive for example surveillance applications, so FND must have high value. In some applications it is desired that at least some nodes alive so that data can be gathered from surrounding nodes.

In this thesis basic LEACH protocol is simulated and the results are compared with Residual-LEACH in terms of network life time. The figure 2.5 shows the graph between number of nodes die versus time in number of rounds for LEACH and NEAP1, NEAP2, REEP1, REEP2.

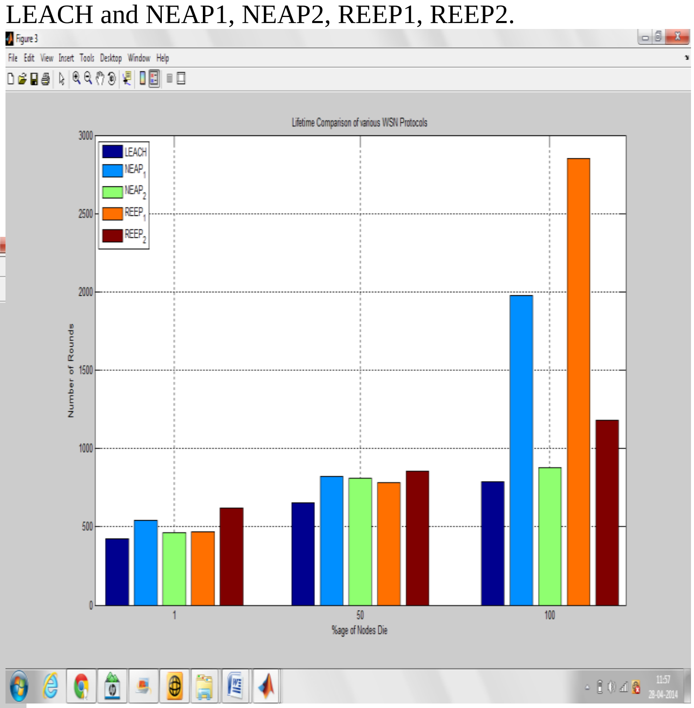

Figure 2.5: Lifetime comparison of different communication protocols for WSN.

The simulation shows that for REEP 1 life time of network is higher than that for other protocols life time so there is improvement in network life time by Approx 20%. This increase in life time is because of residual energy which increases total energy of the network and hence increases in life time of network than leach protocol.

Conclusion

The LEACH routing protocol was designed to increase network lifetime. Since nodes are active until energy becomes finished in nodes battery. LEACH protocol takes in concern only the current energy level and calculates how much possibility a node has, to be selected as clusterhead.The Enhanced cluster head selection algorithm using LEACH not only concerns about the current energy level but also takes into account the position or location of that node to be selected as cluster head. If the node, to be selected as CH is near rest nodes within or outside (neighbor clusters) a cluster, then it will consume less energy for communication. So the new proposed scheme calculates the distance of the node from other nodes within the cluster as well as the distance of the node from the neighbor cluster heads and the distance from the centre position of the cluster to the neighbor clusterheads.These factors are there in the new proposed scheme. Hence the proposed one is improved compared to the previous LEACH algorithm in terms of energy conservation.

If we analyse the new mathematical formula for increasing network lifetime, we will find enhanced results with the new. The new proposed scheme obviously has future scope for betterment of increasing network lifetime. There will be more advancement in placing CH over the cluster to minimize energy conservation. The two new factors need further studies and practical implementation to understand their exact importance and efficiency. After further study and research they can be raised to the power n and m respectively where n and m can be any rational number.

In this work, we evaluate a novel energy adaptive protocol (NEAP) with hierarchical clustering for heterogeneous wireless sensor networks. In considered wireless sensor network, nodes send sensing information to a cluster-head and then the CH transmit data to base station. The certain clustering algorithms with special method periodically electing cluster-heads then cluster-heads aggregate the data of their cluster nodes and send it to the base station. We assume that all the nodes of the network are spread heterogeneous, at first all nodes battery power is equal, all sensor nodes have limited energy and the base station is fixed and not located between sensor nodes and most of them are static and only a few are mobile. Residual leach named as NEAP 1 and residual leach 2 named as NEAP 2.REEP 1 and REEP 2 include the concept of distance BS to all other nodes for residual leach and residual leach 2 respectively.

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BIOGRAPHIES

Amandeep Kaur received her B.Tech degree in Computer Science and engineering from Indo Global College of Engineering in 2008 and pursuing M.tech in Computer Science and engineering From BBSBEC, Fatehgarh Sahib, Punjab.

Er.Jatinder Singh saini working as Assistant Professor in Computer Science and engineering at BBSBEC, Fatehgarh Sahib, and Punajb.He has Teaching Experience of more than 6 year and research experience is 3 years. His specialization is wired and wireless network.