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Enhancement in BEENISH Protocol to increase Lifetime of the Network

Naveen, Dr. Mritunjay Kumar Rai
Lovely Professional University, Phagwara
{naveensharma44@gmail.com, raimritunjay@gmail.com}

Abstract- Wireless Sensor network has no central controller. Energy consumption is the major issue of wireless sensor network. In this paper, we have discussed routing protocol which utilized more energy. The energy must be quantized for computational purposes. Giving greater probability to nodes with higher energy, to be selected as CH, helps in better distribution of energy and more reliable message transmission. So, during different simulation time, each CH has responsibility of gathering data from nodes in its cluster, local compression and transmitting it to the base station; forcing it to dissipate larger portions of its energy. Further, EBEENISH is dynamic in nature. This means that there is no prior allocation of the different levels of energy in the sensor nodes. Also this is a scalable protocol i.e. knowledge of precise location of each node in the field is not a mandatory criteria. Hence, distributing the energy consumption on round bases to all the nodes reduces global energy dissipation and achieves longer network lifetime and stability.

Keywords- BEENISH, EBEENISH, WSN, ALIVE NODES, DATA GATHERING

1. Introduction

Wireless sensor networks comprises of many individual nodes which interconnect to form a system that operates as one. These sensor nodes play the main task of sensing the environmental conditions and maybe control them too. We need a collaboration of large number of such sensor nodes as it is not possible for a single node to cover large geographical areas. Sensor networks perform two main operations; they are data dissemination or spread of queries throughout the network and second is the data collection or gathering from individual sensor nodes and pass it on to sink [9]. The nodes use wireless communication, mostly wireless radio, to connect with each other and also with base station. The data collected is rarely processed by the nodes due to memory and battery limitations; hence it is passed on to remote device where it is analysed, processed upon or stored. The sensor nodes may differ in their physical size but the cost of these depends upon the complexity of each node.

1.1 Challenges for WSN: There are many issues of WSN. These are as follow:

1. Type of service: The service type as perceived by a conventional communication network mainly involves moving bits from one place to another. For a WSN moving of bits is not the actual purpose but just a means to an end. What is expected out of WSN is to provide meaningful information and/or actions about a given task [5].

2. Quality of Service (QoS): QoS generally refers to the quality as perceived by the user/application while in the networking community. In other words QoS is accepted as a measure of the service quality that the network offers to the applications/users. QoS is characterized as a set of service requirements to be met when transporting a packet stream from the source to its destination. In this scenario, QoS refers to an assurance by the Internet to provide a set of measurable service attributes to the end-to-end users/applications in terms of delay, jitter, available bandwidth, and packet loss.

3. Fault tolerance: Due to any factor, which may be physical damage to the node or dead battery, a node may run out of service. This leads to a broken link. Overall functioning of the network should not be affected by this. One way to overcome such a glitch is by deploying redundant nodes [7].

4. Scalability: Number of nodes in action is mostly application dependent. Since such number varies from hundreds and thousands of nodes per WSN, the employed architectures and protocols must be able scale to these numbers [8].

5. Wide range of Densities: Number of nodes per unit area aka node density is a variable quantity per WSN or within a network. Application requirements set the node density. Even for a given application, node density can vary as the nodes may fail or move from their position. Also node density is not homogeneous through put the network, density can vary over time and space. Network should be flexible enough to adapt to these variations [10].

1.2 Routing Protocols: There are vast numbers of routing protocols available for WSNs [11]. Routing is the process of finding best path through which data can be sent from source to destination which is mainly base station [9]. When individual networks are connected together to create an Internetwork or large network, connecting devices routes the packets to final destinations and these connecting devices are known as routers or gateways. Various routing protocols can be broadly classified into three categories:

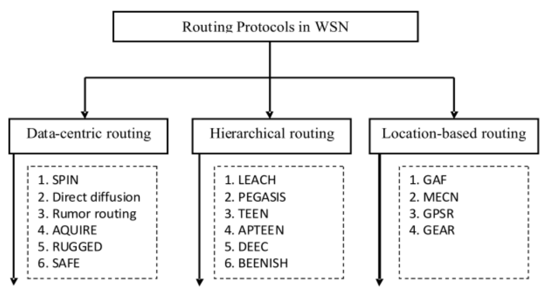

Fig.1 Routing protocols

2. Review of Literature

Shah *et al.,* (2012) [1] introduced this routing protocol for homogeneous networks while keeping the merits of distributed clustering as well. Two nodes belonging to same application and nearest to each other are grouped into a pair. There is deployment of GPS (Global Positioning System) to collect location of all nodes. The paired nodes switch between "Awake" and "Sleep" mode in turns. Cluster heads are selected by distributed algorithm. In this way EESAA minimizes energy consumption while optimizing stability of network much more than LEACH, SEP and DEEC.

Latif *et al.,* (2012) [2] is a consolidated paper regarding joint performance analysis of four cluster based hierarchical routing protocols; LEACH, TEEN, SEP and DEEC. Comparison is done by simulating these in MATLAB. Performance matrices taken are number of alive nodes, number of dead nodes and packets sent to BS. Sensor nodes can sustain their energy only for certain number of rounds. Making nodes to last for more number of rounds, increases network lifetime. Clustering process is explained in form of three states: Advertisement state, Setup state and Steady state. Finally after careful examination of the results obtained, author has concluded that DEEC outperforms among other protocols by providing feasible optimum solutions against constraints of modelled frame work.

Aslam *et al.,* (2012) [3] designed Centralized Energy-Efficient Clustering (CEEC) routing protocol. This protocol has been implemented for three levels of heterogeneity. It tries to address the drawbacks of SEP, E-SEP and DEEC. In these protocols there is no provision for uniform geographical dissemination of high-energy nodes which are most likely to assume the role of Cluster-Heads. Also the distributed clustering algorithm introduces the additional computational overhead. In CEEC, base station is fixed with additional responsibility of selecting optimum number of cluster heads. The network topology is segmented into three local regions for three types of nodes present with base station on top. Normal nodes are present nearest to BS while super nodes are placed at the far end. Guaranteed number of CHs increases the throughput of CEEC.

Boulfekhar *et al.,* (2013) [4] suggests another way for energy efficiency through multipath routing scheme. Instead of routing all the data through a single low cost routing path, EERP (Energy-Efficient data Routing Protocol) distributes the traffic across various good paths selected on the bases of cost function and node energy. All nodes maintain Neighbors Information Table to look up for neighbor with minimum cost. Hence distribution of Network Load delays some particular nodes to run out of energy and produce partition in the network. This enhances network stability and lifetime.

Rupali *et al.,* (2013) [5] proposed an energy efficient dynamic power management technique. Network as a whole expends energy in communication. Another way for power consumption is at each node level itself. Author we can reduce power consumed by each sensor node by shutting down some components of sensors according to our algorithm which enhances network life time and saves other resources. Energy consumption in wireless sensor networks is influenced by many factors.

3. Balanced energy efficient network integrated super heterogeneous protocol for wireless sensor networks (beenish)

It is a clustering based routing protocol that achieves energy efficiency by carefully assigning the role of cluster head to higher-energy node on probability bases in heterogeneous environment [14]. So, during different simulation time, each node has responsibility of gathering data from nodes in its cluster, local compression and transmitting it to the base station; forcing it to dissipate larger portion of its energy. Hence, distributing the energy consumption on round bases to all the nodes reduces global energy dissipation and achieves longer network lifetime and stability. BEENISH has nodes classified into four types: Normal, Advanced, Super and Ultra-Super nodes. It lets each node deplete energy evenly by revolving the cluster-head task among all nodes [8].

Any node s_i (i=1,2,...N) becomes CH after n_i rounds, where n_i is rotating epoch. Node that assumes the role of CH has more energy expenditure. We need to maintain p_{opt} N CHs in each round. LEACH achieves this by making each node as CH after every $n_i = 1/p_{opt}$ rounds as all nodes are assumed to be possessing equal quantity of energy. In the case of Heterogeneous networks, we cannot keep equal epoch for all nodes. If done so, the nodes with low energy will die out soon. E-BEENISH applies the approach to calculate epoch for each node based on its residual energy, $E_i(r)$. Sensor nodes with elevated energy are more probable to be selected as CHs. So in our protocol, BEENISH, extreme nodes get to be CH more often than others. This ensures equal distribution of energy amongst all the nodes.

In conclusion wireless sensor networks have emerged out to be the most applicable field in modern world. With such a vast application area like military applications, medical & healthcare, security & surveillance, agriculture underwater monitoring and lot more [4]. As these sensor nodes are self organising and have limited battery resources and highly scalable networks will pose some challenges in its design, deployment and communication. Most wireless sensor networks are developed according to the application requirements and have different specifications. Therefore it is actually impractical and not required to implement all the design objectives in a single network. If we take the scenario of efficient routing in wireless sensor networks, we may consider only important performance metrics in order to design energy-efficient routing protocol. Topology control – namely, power control, backbones, and clustering – is a powerful means to change the appearance and properties of a network for other protocol layers: MAC layer looks over resource management, routing protocols deal with laying out a roadmap for communication. By-and-by we can say that topology control significantly improves operational aspects of a network, such as lifetime, stability and throughput. However, designing an optimal topology is a rather expensive process and suitable assumptions and heuristics have to be used instead.

4. Proposed Methodology

The researchers have proposed different classification of routing protocols like, flat routing hierarchical routing and location based routing etc. Hierarchical (clustering) routing protocols are the mostly energy efficient routing techniques in WSNs. We have reviewed various clustering protocols which have shown good performance in enhancing the network lifetime of the whole wireless sensor network. LEACH and its descendents, which no doubt increase the efficiency in terms of energy consumption but there is always scope of improvement. In this work we are considering presently the most energy efficient protocol which is actually based on dynamic clustering as one of the hierarchical routing technique. It lets each node expend energy evenly by rotating the cluster-head role among all nodes. Most of the battery power in wireless sensor networks is consumed in determining the optimal path between the event-driven sensor node and the base station.

Heterogeneity plays vital role in enhancing further the network life time of the existing homogeneous WSNs. In this chapter we are considering the most energy efficient existing routing protocol with some modifications like availability of some fraction of nodes with more energy level than other normal nodes and location of BS within the deployed area of the sensor nodes.

In nutshell sensor nodes have to perform *sensing*, *data processing* and *communication* in an isolate physical area. The battery cannot be replaced. Thus there must be best energy efficient routing algorithm to be implemented in every sensor network such that the network lifetime is increased many folds.

4.1 EBEENISH- Enhanced balanced energy-efficient network integrated super heterogeneous routing protocol

Enhanced Balanced Energy-Efficient Network Integrated Super Heterogeneous protocol works on the guidelines of BEENISH i.e. CH are dynamically selected based on residual energy of individual node and overall average energy of the network. The difference lies in quantization of energy levels. BEENISH had nodes classified into four types: Normal, Advanced, Super and Ultra-Super nodes. Here we introduce one more type of node, Extreme node, along with exciting four types. It lets each node expend energy evenly by rotating the cluster-head role among all nodes.

Any node s_i (i=1,2,...N) becomes CH after n_i rounds, where n_i is rotating epoch. Node that assumes the role of CH has more energy expenditure. We need to maintain p_{opt} N CHs in each round . LEACH achieves this by making each node as CH after every $n_i = 1/p_{opt}$ rounds as all nodes are assumed to be possessing equal amount of energy.

We also need to calculate average energy of network for r^{th} round. This is done using the following formula

$$\bar{E}(r) = \frac{1}{N} E_{total}\left(1 - \frac{r}{R}\right)$$

where, R is the number of rounds till all nodes die. The calculation for R is done as same in DEEC.

$$R = \frac{E_{total}}{E_{round}}$$

where, E_{round} is energy dissipated per round.

We need optimal number of CHs to cover the whole WSN area. So at the commencement of each round, each s_i node computes probability threshold. Based on the value obtained, the node makes a decision whether to be a CH or not.

$$T(s_i) = \begin{cases} \frac{p_i}{1 - p_i\left(r mod \frac{1}{p_i}\right)}, if\ s_i \in G \\ 0, otherwise \end{cases}$$

where, r is the current round and

G denotes set of nodes eligible to become CH.

The node should not have been a CH in recent epoch n_i. All nodes in set G select a number between 0 and 1 randomly. For node s_i to be CH in current round, the number should be less than $T(s_i)$.

In the case of Heterogeneous networks, we cannot keep equal epoch for all nodes. If done so, the nodes with low energy will die out soon. E-BEENISH applies the approach to calculate epoch for each node based on its residual energy, $E_i(r)$. Sensor nodes with higher energy are more likely to be selected as CHs. So in our protocol, E-BEENISH, extreme nodes get to be CH more often than others. This ensures equal distribution of energy among all the nodes.

4.2 Algorithm

/*Setup Phase */

1. START

/* In **Setup Phase** the tasks are performed and initiated by Sink */

2. INITIALIZATION

k is desired number of clusters set by $p_{opt}N$, where N is the number of sensor nodes deployed from these we take fraction of nodes m, m_0, m_1 and m_2 to have a, b, u and mm times more energy than normal nodes respectively.

input:→ number of nodes, number of rounds

output: → packets transmitted to Base Station

/* creating heterogeneity in node energies*/

3. for I ← 1 to rounds

4. for j ←1 to N

/* compute probability of distribution of normal nodes from all nodes*/

5. J ←1 to N

/* compute probability of distribution of advance nodes from normal nodes*/

6. J(A) ← 1 to J

/* compute probability of distribution of super nodes from advanced nodes*/

7. J(S) ← 1 to J(A)

/* compute probability of distribution of super-ultra nodes from super nodes*/

8. J(US) ← 1 to J(S)

/* compute probability of distribution of extreme nodes from super-ultra nodes*/

9. J(E) ← 1 to J(US)

10. End for loop

/* Select Cluster Heads $\mathbf{CH_i}$ from N nodes based on $\mathbf{p_i}$ i.e. average probability of a node to be Cluster Head*/

11. T(N) → p_i /*Probability Threshold*/

12. End for loop

13. Create TDMA Schedule for all Nodes of $\mathbf{Cluster_i}$

/* End of Setup Phase */

14. for v←1 to round

/* round →Total number of rounds */
/* Responsible Node Selection Phase */
15. for i←1 to k
16. for Alive_node←1 to s_i
/* Alive_node →Nodes whose residual energy is greater than or equal to threshold energy **(E_{trsh})**
17. Send ($E_{avg}{}^{j}{}_{i}$, $E_{residual}{}^{j}{}_{i}$) information to CH_i
18. End For
/* CH_i performs following tasks */
19. Call Responsible_Node_Selection ( )
/* Select CHi for the current round and TCHi for next round */
20. End For loop
/* Steady State Phase */
21. For i←1 to k
22. For Alive_node←1 to s_i
23. Send data to **CH_i**
/* Data transmission by Alive_nodes */
24. End For loop
25. Send aggregated data to Sink/Base station
/* Data transmission by CH_i */
26. End For loop
27. End For loop
28. END
/* End of the Algorithm*/

5. Experimental Results

The whole scenario of performance of the energy efficient heterogeneous routing protocols in wireless sensor networks has been shown in MATLAB. Efficiency of routing algorithms in WSNs are measured through various performance metrics like Network Lifetime, throughput and the number of dead nodes found during whole network operation. These performance metrics can be evaluated in MATLAB with higher accuracy. Hence MATLAB is widely used tool for executing the programming code. Results can be obtained in graphical forms and also in form of numerical values.

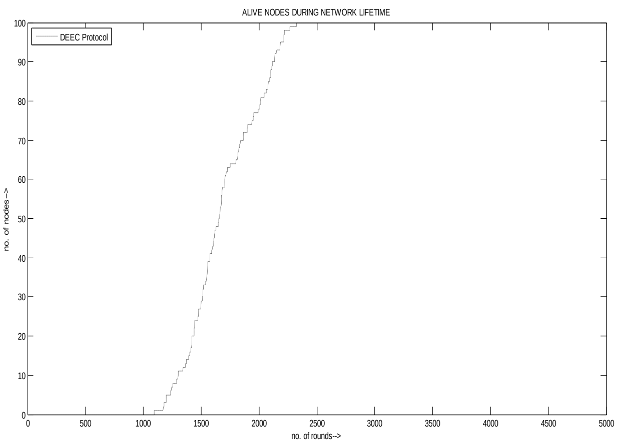

Fig.5.1 Alive nodes during Network Lifetime for DEEC

Alive nodes: Stability period for the network is till the time first node dies. From Fig.4.1, we examine that first node dies at 1094 for DEEC. The time between first node die and when all nodes run out of energy is the instability period. Last node dies at 2323th round for DEEC. This also determines the Network Lifetime.

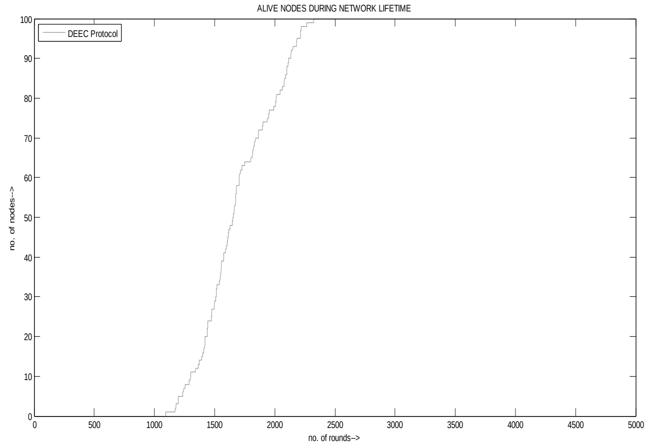

Fig.5.2 Alive nodes during Network Lifetime for BEENISH

Alive nodes: Stable period for BEENISH is till round 1222 and network lifetime lasts for 2899 rounds. There is concentration of more number of alive nodes in this proposed protocol than existing protocols.

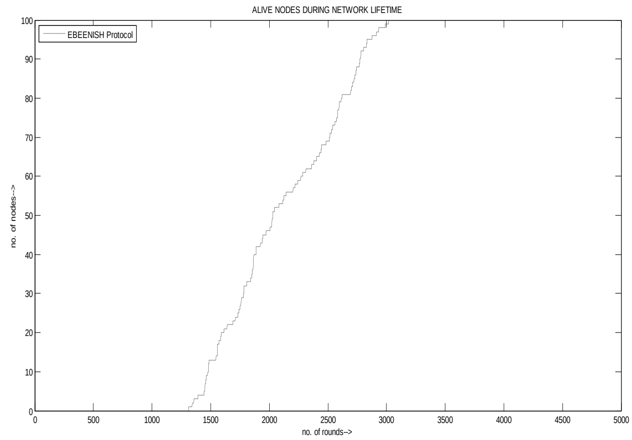

Fig.5.3: Alive nodes during Network Lifetime for EBEENISH

Alive Nodes: BS is located within the deployed area of WSN, which results in less number of dead nodes in the clusters which are far away from the BS. First node dies at 1313th round. Thus more number of nodes is alive in our protocol which will helps in preserving the energy of sensor nodes to maximum extent. The network lifetime of the whole WSN has shown significant improvement our existing protocol with nodes lasting up to 3018 rounds.

5.1 Comparative Results: The simulating environment comprises of 100 sensor nodes deployed in 100m x 100m field. All nodes are assumed to be either stationary of micro-mobile. The radio parameters taken in this simulation are given in Table 1. To show the improvement achieved, results of EBEENISH are compared with that of BEENISH and DEEC. As seen from Fig.3, first node die for DEEC, BEENISH and EBEENISH is at 1094, 1222 and 1313 rounds respectively. Also all nodes die at 2323, 2899 and 3018 rounds, respectively. Fig.4 supports our claim that more data is being sent to BS in EBEENISH over BEENISH and DEEC. Following the similar trend there is steady increase in throughput values with DEEC producing throughput of 0.198, BEENISH following with increased value of 0.495 and finally EBEENISH with highest value of 0.802. EBEENISH is more competent as compared to all protocols in terms of stability period, network life time, throughput and packets sent to the BS, hence achieves our motive of energy efficiency.

Table.1 Results obtained after simulation

Protocol	Round First Node Dies	Round Last Node Dies	Packets sent to BS	Throughput
DEEC	1094	2323	$2.76*10^4$	0.198
BEENISH	1222	2899	$6.55*10^4$	0.495
EBEENISH	1313	3018	$9.43*10^4$	0.802

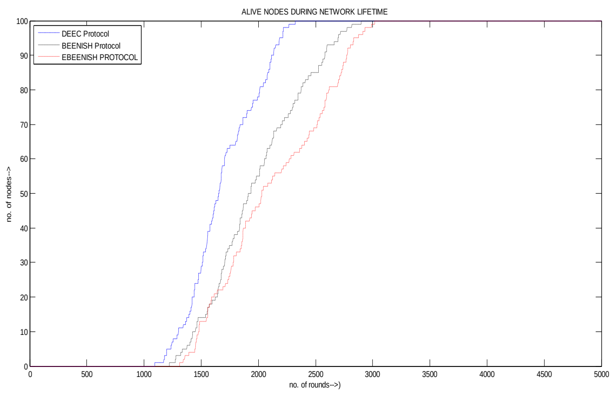

Fig.5.4: Comparison of Alive nodes

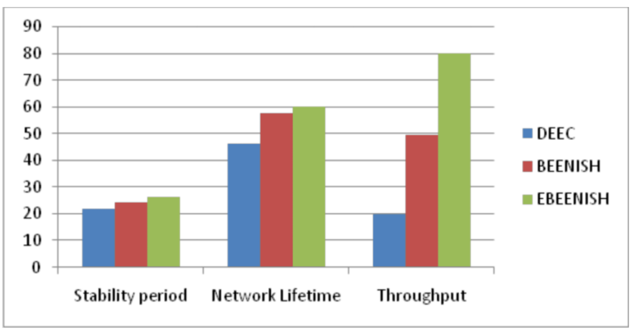

Fig.5.5 Percentage wise representation of performance metrics

Processing the data obtained for further interpretation we find that DEEC has stability period for 21.88% of rounds and all nodes die after 46.46% rounds. BEENISH shows first node die after 24.44% rounds and extends lifetime to 57.98% of the rounds. EBEENISH maintains its stability period for 26.27% of rounds while network lifetime is enhanced upto 60.36% rounds.

6. Conclusion

In this paper we proposed an energy efficient routing protocol for wireless sensor networks in which the battery power of the sensor nodes is of limited capacity and cannot be replaced. Sensor need to deal with more recurrent topological changes (not just because of mobility, but also because of failing nodes, sleep scheduling, loss of service by environment intrusion, etc) and have as principal goal to extend network lifetime by power conservation. In our proposed algorithm we modified the existing protocol by taking heterogeneous network. Hence, EBEENISH is a clustering based routing protocol that achieves energy efficiency by carefully assigning the role of cluster head to higher-energy node on probability bases. EBEENISH outperforms base protocol BEENISH by 1.83% in network stability, 30.7% increase in throughput and enhanced life period by 2.98%.

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