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WINGS TO YOUR THOUGHTS.....

REVISED DEEC PROTOCOL TO IMPROVE ENERGY EFFICIENY AND RELIABILITY IN WIRELESS SENSOR NETWORK

Divya[1], Tilak Raj[2]

Electronics and Communication
Somany Institute of technology and Managenent, Rewari
Maharishi Dayanand University, Rohtak
divya3arora@yahoo.com, uvtilak@gmail.com

Abstract: *Normally sensor nodes are spatially distributed throughout the region which has to be monitored; they self-organize in to a network through wireless communication, and collaborate with each other to accomplish the common task. Basic features of sensor networks are self-organizing capabilities, dynamic network topology, limited power, node failures and mobility of nodes, short-range broadcast communication and multi-hop routing, and large scale of deployment. The key challenge in sensor networks is to maximize the lifetime of sensor nodes due to the fact that it is not feasible to replace the batteries of thousands of sensor nodes. Therefore, computational operations of nodes and communication protocols must be made as energy efficient as possible. In this work, a routing protocol is proposed which is energy efficient and the results will be compared with other routing protocols of same category like DEEC(Distributed Energy Efficient Clustering).*

1. Introduction

Unlike other networks, WSNs are resource limited, they are deployed densely, they are prone to failures, the number of nodes in WSNs is several orders higher than that of ad hoc networks, WSN network topology is constantly changing, WSNs use broadcast communication mediums and finally sensor nodes don't have a global identification tags [1]. The major components of a typical sensor network are figure 1:

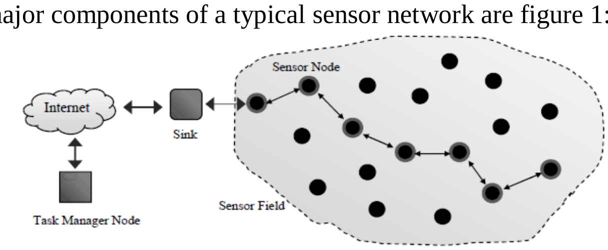

Figure 1: Components of Wireless Sensor Networks

- *Sensor Field*:

A sensor field can be considered as the area in which the nodes are placed.

- *Sensor Nodes*

Sensors nodes are the heart of the network. They are in charge of collecting data and routing this information back to a sink.

- *Sink*

A sink is a sensor node with the specific task of receiving, processing and storing data from the other sensor nodes. They serve to reduce the total number of messages that need to be sent, hence reducing the overall energy requirements of the network. The network usually assigns such points dynamically [1]. Regular nodes can also be considered as sinks if they delay outgoing messages until they have aggregated enough sensed information. Sinks are also known as data aggregation points.

- *Task Manager*

The task manager also known as base station is a centralized point of control within the network, which extracts information from the network and disseminates control information back into the netw.3ork. It also serves as a gateway to other networks, a powerful data processing and storage centre and an access point for a human interface. The base station is either a laptop or a workstation. Data is streamed to these workstations either via the internet, wireless channels, satellite etc. [1]. Hundreds to several thousand nodes are deployed throughout a sensor field to create a wireless multi hop network. Nodes can use wireless communication media such as infrared, radio, optical media or Bluetooth for their communications. The transmission range of the nodes varies according to the communication protocol is use.

2. Sensor Network Challenges

Wireless sensor network uses a wide variety of application and to impact these applications in real world environments, we need more efficient protocols and algorithms. Designing a new protocol or algorithm address some challenges which are need to be clearly understood [2]. These challenges are summarized below:

2.1 Physical Resource Constraints The most important constraint imposed on sensor network is the limited battery power of sensor nodes. The effective lifetime of a sensor node is directly determined by its power supply. Hence lifetime of a sensor network is also determined by the power supply. Hence the energy consumption is main design issue of a protocol. Limited computational power and memory size is another constraint that affects the amount of data that can be stored in individual sensor nodes. So the protocol should be simple and light-weighted. Communication delay in sensor network can be high due to limited communication channel shared by all nodes within each other's transmission range [3].

2.2 Ad-hoc Deployment: Many applications are requires the ad-hoc deployment of sensor nodes in the specific area. Sensor nodes are randomly deployed over the region without any infrastructure and prior knowledge of topology [4]. In such a situation, it is up to the nodes to identify its connectivity and distribution between the nodes. As an example, for event detection in a battlefield the nodes typically would be dropped in to the enemy area from a plane.

2.3 Fault-Tolerance: In a hostile environment, a sensor node may fail due to physical damage or lack of energy (power). If some nodes fail, the protocols that are working upon must accommodate these changes in the network. As an example, for routing or aggregation protocol, they must find suitable paths or aggregation point in case of these kinds of failures [5].

2.4. Scalability: Most of the applications are needed; the number of sensor nodes deployed must be in order of hundreds, thousands or more [6, 7]. The protocols must be scalable enough to respond and operate with such large number of sensor nodes.

2.5. Quality of Service: Some real time sensor application are very time critical which means the data should be delivered within a certain period of time from the moment it is sensed, otherwise the data will be unusable .So this must be a QoS parameter for some applications.

2.6Unattended operation**:** In many application sensor networks is deployed once, and after deployment have no human intervention. Hence the nodes themselves are responsible for reconciliation in case of any changes [8].

2.7. Untethered: The sensor nodes are not connected to any energy source. They have only a finite source of energy, which must be optimally used for processing and communication. To make optimal use of energy, communication should be minimized as much as possible.

2.8. Security: Security is very critical parameter in sensor networks, given some of the proposed applications. An effective compromise must be obtained, between the low bandwidth requirements of sensor network applications and security demands for secure data communication in the sensor networks (which traditionally place considerable strain on resources).Thus, unlike traditional networks, where the focus is on maximizing channel throughput with secure transmission [9].

3. Applications of Wireless Sensor Network

3.1 Military Applications

The concept of wireless sensor network is very closely related to the military applications. Regarding military applications the area of interest extents from information collection to enemy tracking, battle field surveillance or target tracking. Classification algorithms use, for instance, input data that come from seismic and acoustic signal sensing [10]. For example, in near future mines can be replaced by sensor nodes which will detect the intrusion of hostile units. In spite of being used in war times wireless sensor nodes can also be used in peace times such as homeland security, property protection and etc.

3.2 Environment Monitoring

These applications are related to animal tracking, behavior monitoring wildlife protection, weather conditions and environmental disasters monitoring. Sensor nodes are deployed indoor to monitor light and temperature. The capability of sensor nodes to detect light, air pollution, frame status (windows and doors), air streams can be utilized for optimal control of indoor environment

3.3 Agricultural Applications

Sensor nodes are deployed in the agricultural fields with the firm motive of enhancing the efficiency and growth of cultivation describes the case of deploying sensor nodes in a vine yard, and how the sensor networks turned out to be useful for the farmers from the time of growing grapes to wine production and marketing [11].

3.4 Support for logistics

Wireless sensor networks are used in case of fleet management, which tracing of loading trucks and tracking of parameters regarding carried goods.

3.5 Human Centric Applications

Human Science and health care systems can also benefit from the use of wireless sensor networks [12]. For patients monitoring inside hospitals and at home, tracking the patients vitals or other information of interest and making it available to doctors for further medication at anytime from anywhere securely through the Internet. Cognitive disorders, which perhaps lead to Alzheimer’s, can be monitored and controlled at their early stages, using wireless sensors.

3.6 Public Safety

In applications where chemical, biological or other environmental threats are monitored, it is vital that the availability of the network is never threatened. Attacks causing false alarms may lead to panic responses or even worse total disregard for the signals.

3.7Industrial Applications

The monitoring of material fatigue was made by experts introducing the observed situation inside devices to be collected on a central site for processing. Further sensing techniques were developed on the form of wired sensors; nevertheless its implementation was slow and expensive due the necessary wiring. WSNs bring the best of both methods by sensing the events without the need of expert personnel and the cost of wiring [12].

4. Energy Consumption Model

Energy efficiency is one of the most important design constraints in wireless sensor network architectures [2]. The lifetime of each sensor nodes depends on its energy dissipation. In applications where the sensor nodes are totally dependent on no rechargeable batteries, sensor nodes with exhausted batteries will cease operation. A typical sensor node consists mainly of a sensing circuit for signal conditioning and conversion, a digital signal processor, and radio links [3,4]. Hence, during the life cycle of the sensor node, each event or query will be followed by a sensing operation, performing necessary calculations to derive a data packet and send this packet to its destination. Thus, we divide the energy consumption model into the following sub models; the communication energy consumption model, followed by the computation energy consumption model and finally the sensing energy consumption model (As shown in Figure 2).

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Although energy is dissipated in all of the models of a sensor node, we mainly consider the energy dissipations associated with the communication energy consumption since the core objective of algorithm is to develop an energy-efficient network layer routing protocol to improve network lifetime. The transmission and receive energy costs for the transfer of a k-bit data message between two nodes separated by a distance of d meters is given by Eqs. 1 and 2, respectively.

$$E_T(k,d) = E_{TX}k + E_{amp}(d)k \quad \text{..................(1)}$$

$$E_R(k) = E_{Rx}k \quad \text{..................................(2)}$$

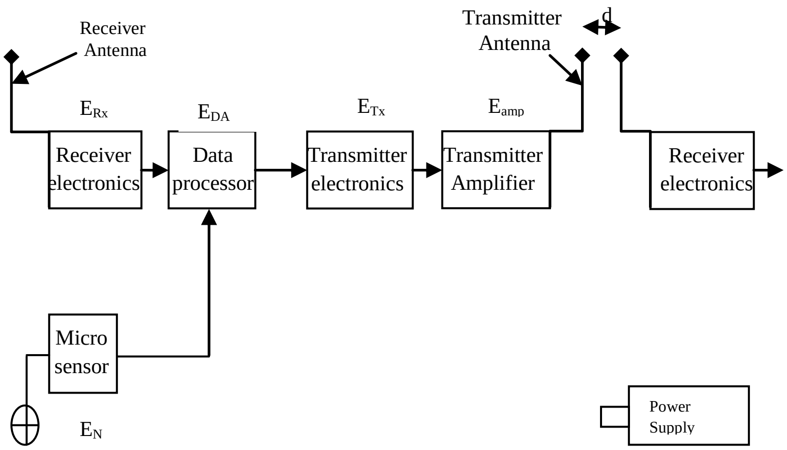

Figure 2: Energy Consumption Model

Where ET (k,d) in Eq. 1 denotes the total energy dissipated in the transmitter of the source node, and ER(k) in Eq. 2 represents the energy cost incurred in the receiver of the destination node. The parameters ETx and ERx in Eqs. 1 and 2 are the per bit energy dissipations for transmission and reception, respectively. Eamp(d) is the energy required by the transmit amplifier to maintain an acceptable signal-to-noise ratio in order to transfer data messages reliably. As is the case in [30], we use both the free-space propagation model and the two ray ground propagation model to approximate the path loss sustained due to wireless channel transmission. Given a threshold transmission distance of d0, the free-space model is employed when d≤d0, and the two-ray model is applied for cases where d<d0. Using these two models, the energy required by the transmit amplifier Eamp(d) is given by Eq. 3.

$$E_{amp}(d) = \begin{cases} \varepsilon_{FS} d^2 & , d \le d_0 \\ \varepsilon_{TR} d^4 & , d > d_0 \end{cases} \quad \text{...........(3)}$$

where E and amp denote transmit amplifier parameters corresponding to the free-space and the two-ray models, respectively, and d0 is the threshold distance given by Eq. 4.

$$d_0 = \sqrt{\varepsilon_{FS} / \varepsilon_{TR}} \quad \text{............................(4)}$$

5. Proposed Algorithm

The foundation of proposed protocol lies in the realization that the base station is a high-energy node with a large amount of energy supply. Thus, proposed protocol utilizes the base station to control the coordinated sensing task performed by the sensor nodes. In proposed protocol, the following assumption is to be considered.

- A fixed base station is located in the middle of the region.
- The nodes are equipped with power control capabilities to vary their transmitted power.
- Each node senses the environment at a fixed rate and always has data to send to the base station.
- All sensor nodes are immobile.

- ***Revised DEEC Protocol***

The radio channel is supposed to be symmetrical. Thus, the energy required to transmit a message from a source node to a destination node is the same as the energy required to transmit the same message from the destination node back to the source node for a given SNR (Signal to Noise Ratio). Moreover, it is assumed that the communication environment is contention and error free. Hence, there is no need for retransmission.

There is a modified version of DEEC, follows the view of DEEC and adds another type of node called super nodes to increase the heterogeneity, which is known as Revised DEEC. Revised DEEC is a three level heterogeneous network. The three types of nodes in Revised DEEC protocol are normal, advance and super nodes. Each node will became a cluster head using a threshold, within 1/p rounds. The selection of cluster head is based on remaining energy of the node and average energy of the network. According to node's initial and residual energy the epochs of being cluster-heads is different. A node whose residual and initial energy is high have more chances to become a cluster head [11]. As this is a three level heterogeneous networks, nodes will have different reference value of probabilities which are given by:

$$p_i = \begin{cases} \dfrac{P_{opt} E_i(r)}{(1 + m.(a + m_o.b))\bar{E}(r)} \text{.........} if \;\; s_i \text{ is the normal node} \\[2ex] \dfrac{P_{opt}(1+a) E_i(r)}{(1 + m.(a + m_o.b))\bar{E}(r)} \text{.........} if \;\; s_i \text{ is the advanced node} \\[2ex] \dfrac{P_{opt}(1+b) E_i(r)}{(1 + m.(a + m_o.b))\bar{E}(r)} \text{.........} if \;\; s_i \text{ is the super node} \end{cases}$$

...............(5)

where, m= percentage of advanced nodes
P_{opt} = desired probability of cluster heads
m_o= percentage of super nodes
a= fraction of energy enhancement of advance nodes
b= fraction of energy enhancement of super nodes
Ē(r) = average energy of the network

$$T(s_i) = \begin{cases} \dfrac{p_i}{1 - p_i.\left(r \bmod \dfrac{1}{p_i} \right)} \text{.............} if \;\; p_i \varepsilon\, G' \\[2ex] \dfrac{p_i}{1 - p_i.\left(r \bmod \dfrac{1}{p_i} \right)} \text{.............} if \;\; p_i \varepsilon\, G'' \\[2ex] \dfrac{p_i}{1 - p_i.\left(r \bmod \dfrac{1}{p_i} \right)} \text{.............} if \;\; p_i \varepsilon\, G''' \end{cases}$$

............(6)

Threshold for cluster head selection $T(s_i)$ is calculated for normal, advanced, super nodes by putting values given below: where G'= group of normal nodes that have not become cluster heads within the last $1/p_i$ rounds where s_i is normal node,G" = group of advanced nodes that have not become cluster heads within the last $1/p_i$ rounds where s_i is advanced node,G'''= group of super nodes that have not become cluster heads within the last $1/p_i$ rounds where s_i is super node [11].
The probabilities calculated depend on the average energy of the network at round r; hence we have to calculate it. The average energy of the network is anticipated as:

$$\overline{E}(r) = \frac{1}{N} E_{total}\left(1-\frac{r}{R}\right) \quad \text{............(7)}$$

where, R denotes the total rounds of the network lifetime. R can be calculated as

$$R = \frac{E_{total}}{E_{round}} \quad \text{...(8)}$$

Total energy of the network E_{total} is calculated by

$$E_{total} = N.(1-m).E_o + N.m.(1-m_o).(1+a).E_o + N.m.m_o.E_o.(1+b)$$
$$= N.E_o.\ (1+m.(a+m_o.b)) \quad \text{..............................(9)}$$

where, N= total number of nodes
E_o = initial energy for normal node
The energy dissipated in a round E_{round} is given by

$$E_{round} = L(2NE_{elec} + NE_{DA} + kE_{amp}d^4_{toBS} + NE_{fs}d^2_{toCH}) \quad \text{................................(10)}$$

where, k = number of clusters
$d_{to\ BS}$ = the average distance between cluster head and the base station and
$d_{to\ CH}$ = the average distance between the cluster members and the cluster head.
E_{elec} = electronic energy
E_{fs} = energy for free space loss
E_{amp} = energy for multipath loss

As mentioned earlier that heterogeneous network is more performance efficient and scalable than homogenous network.
Based on above equations and conditions, nodes sends the data to their respective cluster heads and energy consumption will be calculated. Cluster Head will aggregate the data and send it to the base station and energy consumption will be calculated for each node and cluster heads. In round 2, the nodes will become cluster heads according to probability condition i.e. according to minimum distance from base station and threshold energy. After selection of cluster heads, Nodes sends the data to their respective cluster heads, that will be selected according to the minimum distance of a particular node from cluster heads and energy consumption will be calculated. Cluster Head will aggregate the data and send it to the base station and energy consumption will be calculated. This process will be repeated until the whole network gets down or number of rounds finished. Performance will be evaluated according to parameters like network lifetime, energy dissipation, data packets sent etc.

6. Implementation & Results

6.1 Parameter Value

Table 5.1 Network Parameters

Network field:100x100m	
N (Number of nodes):	100
Initial energy:	0.5 Joule
Eelec (E.Dissipation for ETx&ERx):	50 nJ/bit
ε fs (free space):	10 pJ/bit/m^2
εmp (Multipath fading):	0.0013 pJ/bit/m^4
EDA (Energy Aggregation Data):	5 nJ/bit/signal
Data packet size:	4000 bits
Tool used for implementation : R2016a	MATLAB

Figure 3 shows the comparison of routing protocol DEEC and Revised DEEC in terms of Number of nodes alive. As we can see in figure, when number of rounds increases; the numbers of nodes alive are comparatively less in DEEC as compared to proposed protocol. Figure 4 depicts the number of nodes dead with respect to number of rounds. As we can see in figure, when number of rounds increases; the numbers of nodes dead are comparatively less in proposed protocol as compared to DEEC. Here, we can observe that proposed routing technique performs better as compared to DEEC. Figure 5 shows how much data will be sent from nodes to SINK. From figure 5, we can observed that, in DEEC protocol data sent to base station is relatively less as compared to revised DEE protocol. Figure 6 shows number of cluster head formed per round.

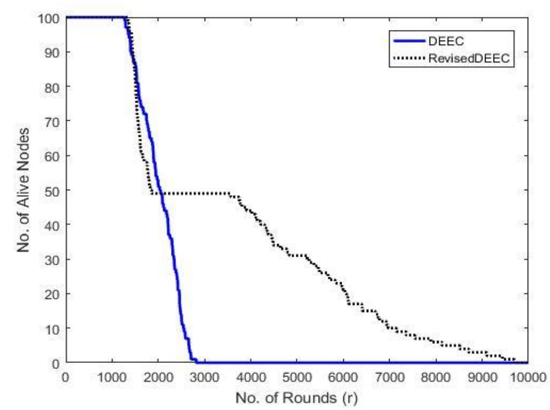

Figure 3: Number of Rounds vs Number of Nodes Alive

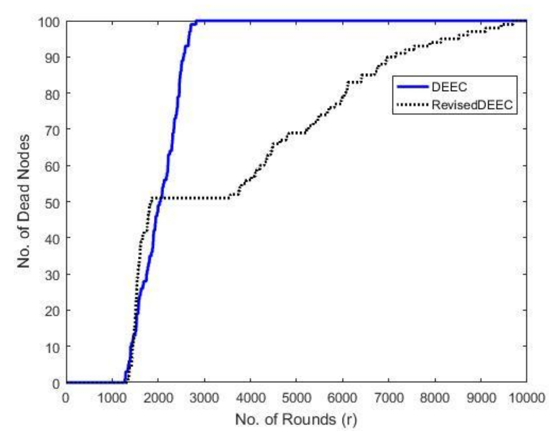

Figure 4: Number of Rounds vs Number of Nodes Dead

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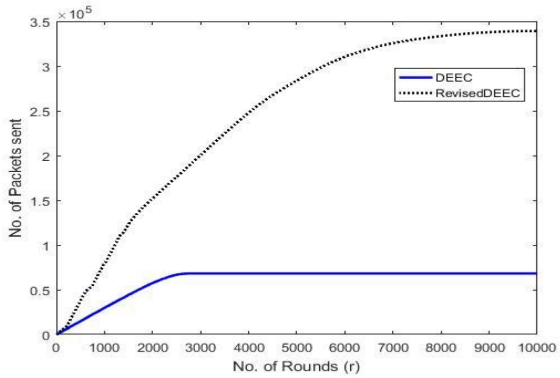

Figure 5: Number of Rounds vs Data Packets sent to base station (SINK)

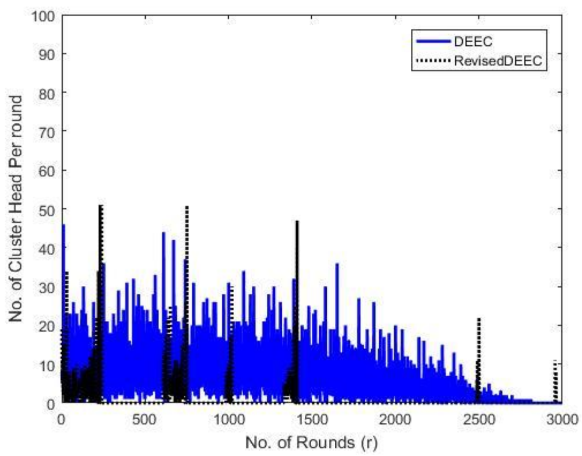

Figure 6: Number of Rounds vs Number of Cluster Head per Round

7. Conclusion and Future Work

The proposed routing protocol which is hierarchical routing based with the whole control to the base station or we can say that base assisted. Proposed routing technique is compared with already developed routing protocol DEEC by the help of MATLAB. A comparison between two is done on the basis of data packet sent and the system lifetime of network. System lifetime is basically for how long the system works. Here, we can observe that proposed routing technique performs better as compared to DEEC. But there is no security and authentication while communicating. So this can be another research area where this can be considered. So in future, security can be applied to proposed routing technique.

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