# Presenting a New Routing Protocol for increasing Lifetime of Sensor Network

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**Abstract**

Sensor Networks are systems with restrict resources that are scattered on a large scale with numerous deployment density and are used in aggregating data in a intelligent style. In this paper the concept of "efficient energy consumption" in routing protocol of sensor network, which causes to increase the lifetime of sensor network, has been studied and a taxonomy of various techniques for efficient energy consumption is presented. Also a new routing protocol is presented in a way that proposal protocol uses some special techniques to consume energy efficiently. After that we have simulated proposal routing protocol and compared its function with recent protocols and we have observed that proposal routing protocol increase the lifetime of sensor networks.

***Keywords:*** *Sensor Network, Routing Protocol, Efficient Energy Consumption, Lifetime of Sensor Network.*

## 1. Introduction

Sensor networks are used as a new tool in applications like military, hospital control, domestic, etc. A sensor network consists of a lot of sensor nodes that they spread in an expected area and the purpose of this architecture is to aggregate desired information from environment and send them to the base station by the use of intelligent styles. In these styles it is tried to consume the energy of sensor nodes efficiently in order to increase the lifetime of sensor network.

Routing protocols in sensor networks from network structure point of view can be divided into two main categories: flat and hierarchical. In flat routing protocols the concept of leader node dose not exists and all nodes are same. SPIN [1] and GBR [2] are some examples of this category. In hierarchical routing protocols the act of clustering and classification of nodes are done and some nodes are considered as leaders. From this group of protocols we can name LEACH [3], TEEN [4], GAF [5] and max-min length energy constrained [6].

Indeed there are other categories of protocols like data centric, location based, energy aware. In a way that each routing protocol can belong to one or several of mentioned groups.

In data centric protocols, interesting issues are scattered in order to sensual tasks assign to nodes. There are two ways to scatter interesting issues:

- Sinks scatter their favorite topics to nodes.
- Nodes send a notice to sinks for their available data and wait for a request from the sink which is interested to that data.

Data centric routing protocols need an attribute-base addressing mechanism in a way that in this routing user can query the characteristics of a phenomenon instead of query a node. For example the query that "which areas temperature is more than 70 F?" can be used instead of "what is the temperature of a specific node?" Some examples of this category are SPIN [1], GBR [2] and TEEN [4].

In location based routing protocols, location information are used for sending data to desired areas instead of sending them to whole network. GAF [5] is an example of this category.

In energy aware routing protocols, the main focus is on efficient consumption of sensor nodes' energy to increase the lifetime of network. An example of this category is max-min length energy constrained [6].

The structure of this paper is that in second section some introductions about efficient consumption of energy and its effect on increasing the lifetime of network are presented. In third section by using some techniques for efficient energy consumption, a new routing protocol is developed and is simulated along with max-min length energy constrained routing protocol [6] and the results of

the simulation is presented. And in the last section a summery of this paper and conclusion is presented.

## 2. Efficient Energy Consumption in Routing Protocols

The main topic that is discussed in this paper is limitation in energy that has effect on the lifetime of sensor network. The lifetime of sensor network is the time takes until a node or some nodes discharge their energy.
So considering special characteristics of sensor networks such as limitation in nodes' energy and etc, we should use special routing protocols to increase the lifetime of sensor networks in a way that they differ from other routing protocols such as ad-hoc network routing protocols. In technical term these routing protocols that consider the limitation of sensor nodes' energy are called energy aware routing protocols.
Energy aware routing protocols may use different techniques for efficient energy consumption in a way that efficient energy consumption causes to increase the lifetime of sensor network. As it is displayed in Fig. 1 these techniques are clustered in two groups: reduction of total energy consumption and fair energy consumption.

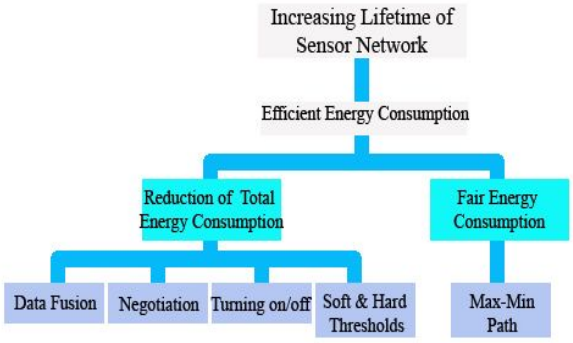


Fig. 1 Taxonomy of efficient energy consumption

### 2.1 Reduction of total energy consumption

For this purpose we should decrease the number of transmitted data packets efficiently without loosing information. In other words, we prevent from transferring repeated and useless data packets.
To do this, it is possible to use four techniques: 1) Data fusion 2) Negotiation 3) Turning on/off 4) Soft and Hard thresholds.
In "data fusion" technique, which is usually perform by some special nodes like cluster head, received data packets which are overlapped with other data packets and represented a similar sensed phenomenon fused together so the number of transmission data packets decrease effectively and therefore the total energy consumption will be reduced. This technique in protocols like LEACH [3] is used. Increasing the delay is the defect of this design because cluster heads have to buffer received data packets for a while in order to fusion them.
In "negotiation" technique before sending actual data packets to a node first that node will be queried, with the use of Meta data, to understand whether it is interested in receiving that data or not. In case that node had not received that data packet before and has the conditions of receiving that data, it will announce, with the use of Meta data, that it is interested in receiving that data. Then the actual data packet will be sent to that node. So transferring redundant data packets has been avoided effectively and it causes to reduce the total energy consumption. This technique has been used in some protocols like SPIN [1].
In the technique of "Turning on/off", it is tried to turn off the transmitter radio circuits of some sensor nodes when there is no need to their cooperation. As it is displayed in Fig. 2 the major part of sensor nodes energy consumes in the phase of radio communication [7], so this technique causes to reduce the total energy consumption. This technique has been used in some protocols like GAF [5].

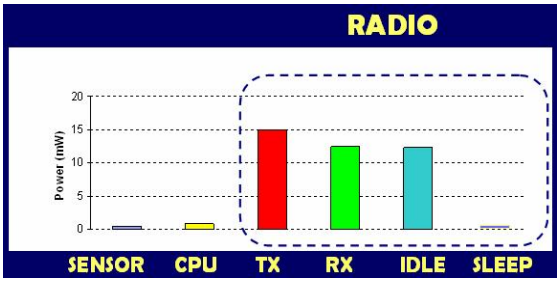


Fig. 2 The amount of energy consumption in different functions of nodes [7]

In "Soft and Hard thresholds" technique by spreading both soft and hard thresholds, it is tried to avoid transmitting data packets that are not in expected range or indicate similar data. These thresholds are related to attributes of sensed data. The hard threshold allows the sensor nodes to transmit data only when their sensed attribute be in an expected range. Consequently the number of transmission decrease sufficiently. Once a node senses a new data, which is valid considering hard thresholds, it transmits that data only when it's attribute in comparison with pervious data changes by an equal amount or greater than the soft threshold. Subsequently soft threshold decreases the number of transmission if there would be a few or no changes in the attributes of data that is sensed. So this technique causes to reduce the number of transmitting data packets, consequently total energy consumption is also

reduced. This technique has been used in some protocols like TEEN [4].

### 2.2 Fair energy consumption

For this purpose the energy of sensor nodes should be consumed fairly. In other words in routing, sensor nodes should be cooperated in a way that the energy of some nodes does not finish earlier than other nodes. To do this, the "max-min path" technique can be used. It should be taken into consideration that consuming the energy of sensor nodes unfairly, causes that some nodes loose their energy earlier than others consequently it causes to reduce the lifetime of sensor network. Fig. 3 displays a diagram of node's energy consumption at a moment for an instance of this kind of network. While Fig. 4 displays a diagram of fair energy consumption of sensor nodes [2]. As you see total energy consumption in both diagrams are the same but in figure 4 sensor nodes have consumed energy more fairly so the energy of some nodes do not finish fast consequently the life time of sensor network increases.
In "max-min path" technique when there is a data packet for sending, that data packet would be sent from a path which the minimum energy of that path's nodes is more than the minimum energy of other candidate path's nodes. So this technique causes that nodes which have lower energy do not take part in routing consequently their energy will not finish soon. This technique has been used in some protocols like max-min length energy constrained [6].

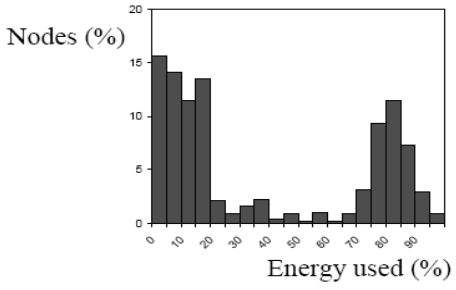


Fig. 3 Nodes' energy while inefficient energy consumption [2]

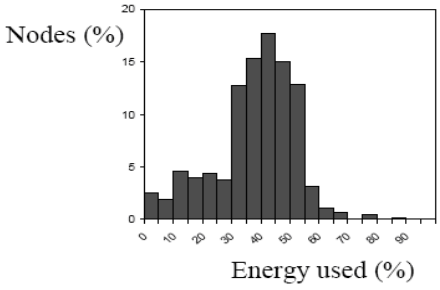


Fig. 4 Nodes' energy while efficient energy consumption [2]

## 3. Presenting a new routing protocol

In this section we have applied the "Soft and Hard Thresholds" and the "Turning on/off" techniques, which are presented in section 2, on max-min length energy constrained protocol [6] and we have developed a new routing protocol and simulated it. Indeed you should take it into consideration that max-min length energy constrained protocol [6] is equipped with technique of "max-min path" in advance.
In our proposal protocol first, in order to apply the "Soft and Hard Thresholds" technique sink sends two parameters ($T_s$ for soft threshold and $T_h$ for hard threshold) to sensor nodes. After receiving these parameters, sensor nodes only transmit the data packets which satisfy these thresholds. Second, in order to apply the Turning on/off" technique clustering is done. Clustering in our proposal protocol is done in this way that if we consider the radio transmission domain of nodes as *L* meter, we can create the clusters as a square with sides of *L/2.82* which starts from the sink. It guarantees that a cluster head in a cluster is able to communicate with other cluster heads in neighbor clusters. Indeed a technique without any need to GPS is also presented in [8] for creating clusters with constant, equal and symmetrical shapes without overlapping. We used this technique too.
After clustering, in each cluster the node which contains the maximum energy is chosen as the cluster head. After that each cluster head order its members to turn off and only itself remain on the cluster to cooperate in routing jobs. After a while that routing of data packets have been done, each cluster head order its members to turn on so that all nodes participate at the phase of choosing the new cluster heads. Considering that the majority of energy will be consumed in communication phase and since the majority of nodes will be turned off, consequently the total energy consumption will be reduced.
Indeed a lot of turned off nodes May causes an interruption in sensing jobs. So regarding spreading density of nodes we can consider an *R* parameter in a way that each cluster head while ordering "turn off", choose *R* nodes to have chance remains "turn on".
For simulation we have used Glomosim [9] simulator. For this purpose we have considered a network which includes 500 nodes that are spread in a 400*400 *m2* area randomly and the domain of radio transmission of nodes is 40 *m*. Each sensor node has a randomly initial energy between 1000 *mj* to 10000 *mj*. In this simulation the nodes use the 802.11 protocol in MAC layer. The size of packets is considered 64 byte and we produce 800 data packet randomly in nodes so that the packets contain random temperatures between 1 and 100. Indeed for simulation it is supposed that sensor network monitor temperature

changes, $T_h$ (hard threshold) is between 20 and 80, and $T_s$ (soft threshold) is 10.

Eq. (1) and (2) show the amount of consumed energy while sending and receiving *k* bit data in *d* meter distance. Indeed *E_elec* is the necessary energy for executing circuits/orbits and switching action among bites that usually is 50 *nj/bit* and *E_amp* is the necessary energy for amplifies radio for radio transmitting, that usually is 100 *pj/bit/m2*.

$$E\_Tx(k,d) = E\_elec * k + E\_amp * k * d^2 \quad (1)$$

$$E\_Rx(k,d) = E\_elec * k \quad (2)$$

Next parts are presented for investigation of "the fairness factor", "the number of received packets by sink" and "the average of remaining energy" about our proposal protocol and max-min length energy constrained protocol [6].

## 3.1 Fairness factor

In simulation we have used *f* for fairness factor which is calculated through Eq. (3) and it is the agent of fair energy consumption among nodes and its domain is between 0 and 1. Its optimal value is 1 and as it gets closer to 1, the energy consumption would be fairer among nodes. *n* is the number of nodes that in our simulation we have considered it 500.

$$f = \left(\sum_{i=1}^{n} (E_i)\right)^2 \div \left(n \times \sum_{i=1}^{n} (E_i)^2\right) \quad (3)$$

In this part of simulation we have compared our proposal protocol with max-min length energy constrained protocol [6] from *f* factor point and we have shown the results in Fig. 5.

As shown in Fig. 5 at the beginning of simulating, because the energy distribution is not the same among nodes, *f* factor is low in both of them. But in course of time with performing both protocols, *f* factor has increased. Also our proposal protocol performs a little bit better and the reason is that max-min length energy constrained protocol [6] only uses "max-min path" technique. And this technique by itself causes the increase of *f* factor. But our proposal protocol not only uses "max-min path" technique but also uses "Turning on/off" technique that in the latter after clustering the state of nodes which contain less energy changes to turn off mode. So their energy consumption is prevented. And it causes the increase of *f* factor. Indeed the more *R* parameter increases, *f* factor decreases slightly. And it inclines to max-min length energy constrained protocol [6].

## 3.2 The number of received packets by sink

In this part of simulation we have compared our proposal protocol with max-min length energy constrained protocol [6] from the point of the number of received packets by sink. Simulating result is demonstrated in Fig. 6.

Indeed it should be considered that naturally in our proposal protocol the number of sensed data packets is more than received data packets by sink, since some of the sensed data packets are assigned to nodes which are turned off and no routing operation is done on them. Indeed as shown in Fig. 6 by increasing the *R* parameter, the rate of sensing tasks increases and vice-versa. Also some data packets are omitted by applying "Soft and Hard thresholds" technique, that this omission is effective because omitted data packets are related to unacceptable and repeated information.

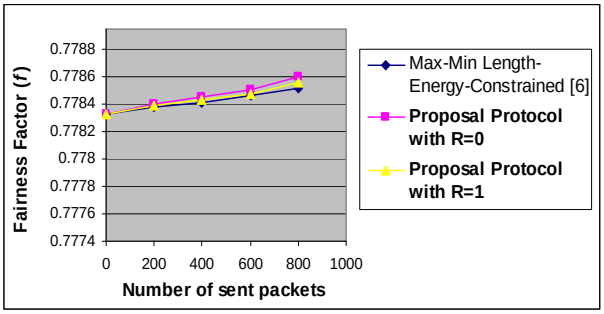


Fig. 5 The fairness factor

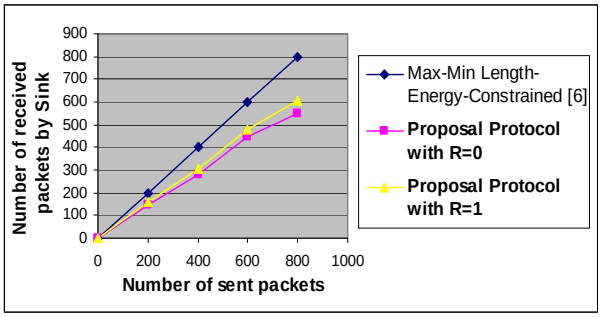


Fig. 6 The number of received packets by Sink

## 3.3 The average of remaining energy

In this part of simulation we have compared our proposal protocol with max-min length-energy-constraint routing protocol [6] from average of remaining energy point and the results are shown in Fig. 7.

As it can be seen in Fig. 7 the amount of total energy consumption in our proposal protocol has decreased drastically. One of the major reasons of this event is omitting unacceptable or repeated data packets. Another major reason is the state of turned off unnecessary nodes and preventing from consuming their energy.

 

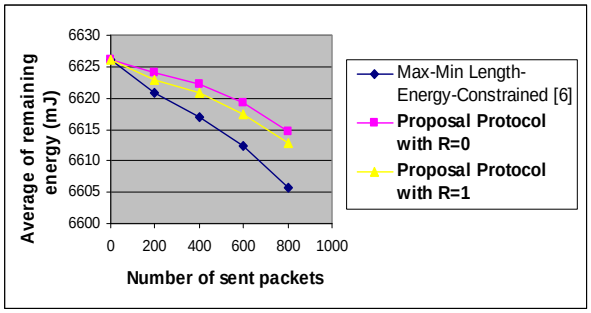


Fig. 7 The average of remaining energy of nodes

## 4. Conclusions

In this paper, first we discussed energy limitation in sensor networks and it relation with lifetime of sensor network. Then presented two ways for increasing the lifetime of sensor network: 1) reduction of total energy consumption 2) fair energy consumption. Then we discussed different techniques of each mentioned ways. We also stated that a suitable routing protocol should use techniques of both ways at the same time.

Also, by using some techniques, we expand max-min length-energy-constraint routing protocol [6] and we presented a new routing protocol that increased the lifetime of sensor network through reduction of total energy consumption and fair energy consumption.

At the results of simulation demonstrated, this new routing protocol helped to efficient energy consumption in a way that efficient energy consumption causes to increase the lifetime of sensor network.

Indeed it should be considered that proposal protocol have close relationship with application. For example the proposal protocol is good for applications such as monitoring temperature changes that have suddenly changes and cannot be used in application that require periodic information reports.

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