Base Station Location for Energy Efficient in Wireless Sensor Network

Aziz Hanifi[1], Jafar Amiri[2], Tofig Kazimov[3]
[1-3]Institute of Information Technology of ANAS, Baku, Azerbaijan
[2]Dept. of Computer and IT Engineering Tabriz Technical College, Iran
[1]*hanifi_aziz@yahoo.com*, [2]*jafar_amiri85@yahoo.com*

Abstract— **Energy constraints of wireless sensor networks are an important challenge. Data Transmission requires energy. Distance between origin and destination has an important role in energy consumption. In addition, the location of base station has a large impact on energy consumption and a specific method not proposed for it. In addition, a obtain model for location of base station proposed. Also a model for distributed clustering is presented by cluster heads. Eventually, a combination of discussed ideas is proposed to improve the energy consumption. The proposed ideas have been implemented over the LEACH-C protocol. Evaluation results show that the proposed methods have a better performance in energy consumption and lifetime of the network in comparison with similar methods.**

Keywords— clustering; sensor network; data correlation; time series; energy prediction

I. INTRODUCTION

Efficient design and implementation of wireless sensor networks has become a hot area of research in recent years, due to the vast potential of sensor networks to enable applications that connect the physical world to the virtual world. By networking large numbers of tiny sensor nodes, it is possible to obtain data about physical phenomena that was difficult or impossible to obtain in more conventional ways. Each sensor node has limited energy and in most applications, replacing energy sources are not possible. So lifetime of sensor nodes is highly dependent on energy stored in their battery. Clustering is a designing method that used for management of wireless sensor networks. Therefore, clustering in sensor networks has advantages such as data aggregation support [1], data gathering facilitation [2], organizing a suitable structure for scalable routing [3], and efficient propagation of data in the network [4]. On the other hands, Distance between nodes and base station has a direct impact on energy nodes. So the placement location of the base station plays an important role in energy nodes.

Data gathering in wireless sensor networks is an important operation in these networks and for this purpose many methods have been proposed. The LEACH1 [5] protocol has been considered as a hierarchical basic method. This method is suitable for monitoring applications. Each node periodically senses the information and sends them. Many improvements in LEACH protocol have been presented. LEACH-C2 method [6] is an example of these improvements. In LEACH-C, the forming of clusters is done using a centralized algorithm by the base station in the starting of each period. Another improvement to this algorithm is the use of estimation. One of these algorithms is LEACH-CE3 [7]. In the proposed technique energy level collected from all nodes in two primary periods but not collected in the other periods. Instead, the average energy of initial periods is used. There is some proposed clustering methods that ABCP [8] and ABEE [9] and HMM [10] are samples of them.

Each sensor node is observer of a physical phenomenon. Also physical phenomenon such as temperature and ... continuously change in time. So the information provided by sensor nodes is dependent on each other. To precise estimation of node energy, it is essential for the cluster head to aware of data time correlation, So with existence of data time correlation and using energy estimation of nodes, a method is proposed such that the cluster head can specify nodes energy precisely to determine a future cluster head in a distributed way.

The exact location of the base station placement is another challenge that can affect in life network. Since any solution to this challenge is provided. So the idea is presented, where is the density of nodes to the base station detects the location, and put him in a place where most of their distance from the base station nodes is less. And ultimately prevent the waste of energy in the network. These methods avoid the overhead excess and increase the network lifetime.

The remaining of this article is organized as follows: In section 2 related works are reviewed. In section 3, we introduce algorithms for correlated data, the ideas of distributed clustering technique, locating the base station and a hybrid of the proposed ideas. Analysis of experiments with existing nodes offered in Section 4, and we finally in section 5 summarize and discuss the scheme.

[1] Low-energy Adaptive Clustering Hierarchy

[2] LEACH-Centralized

[3] LEACH-C-Estimate

II. Related Work

A. LEACH

LEACH [11] is the first and most popular energy-efficient hierarchical clustering algorithm for WSNs that was proposed for reducing power consumption. In LEACH, the clustering task is rotated among the nodes, based on duration. Direct communication is used by each cluster head (CH) to forward the data to the base station (BS). It uses clusters to prolong the life of the wireless sensor network. LEACH is based on an aggregation (or fusion) technique that combines or aggregates the original data into a smaller size of data that carry only meaningful information to all individual sensors. LEACH divides the a network into several cluster of sensors, which are constructed by using localized coordination and control not only to reduce the amount of data that are transmitted to the sink, but also to make routing and data dissemination more scalable and robust. LEACH uses a randomize rotation of high-energy CH position rather than selecting in static manner, to give a chance to all sensors to act as CHs and avoid the battery depletion of an individual sensor and dying quickly.

The operation of LEACH is divided into rounds having two phases each namely (i) a setup phase to organize the network into clusters, CH advertisement, and transmission schedule creation and (ii) a steady-state phase for data aggregation, compression, and transmission to the sink.

B. LEACH-C

LEACH offers no guarantee about the placement and/or number of cluster heads. In [12], an enhancement over the LEACH protocol was proposed. The protocol, called LEACH-C, uses a centralized clustering algorithm and the same steady-state phase as LEACH. LEACH-C protocol can produce better performance by dispersing the cluster heads throughout the network. During the set-up phase of LEACH-C, each node sends information about its current location (possibly determined using GPS) and residual energy level to the sink. In addition to determining good clusters, the sink needs to ensure that the energy load is evenly distributed among all the nodes. To do this, sink computes the average node energy, and determines which nodes have energy below this average.

Once the cluster heads and associated clusters are found, the sink broadcasts a message that obtains the cluster head ID for each node. If a cluster head ID matches its own ID, the node is a cluster head; otherwise the node determines its TDMA slot for data transmission and goes sleep until it's time to transmit data. The steady-state phase of LEACH-C is identical to that of the LEACH protocol.

C. LEACH-CE

In the LEACH-CE method [7], the energy level of all nodes collected only in two primary periods and not be collected in other periods. Instead because of knowing information about energy level of nodes, we can calculate energy consumption average for each node by using information of two primary periods. This means that reducing calculated energy level from the energy level of node, causes predicting current energy level of node. The problem of this algorithm is that firstly energy estimation is not done precisely and secondly if nodes have correlated data, while not sending correlated data means that previous data is valid, so this plan of clustering is not suitable and efficient.

III. The Proposed Method

Presentation of methods three ideas are proposed here: 1. the data time correlation, 2. the distributed clustering model, 3. the exact location of the base station and the hybrid method from them.

In the data time correlation algorithm, Time Series Forecasting method (TSF[4]) used to decide sending or not sending of data. Then in time t in the beginning of each period, base station send percentage of error e(t) to all nodes. First data sensed by node and sent. Second and third and fourth data sent based on the improved TINA algorithm. Then the node runs time series function to determine the value of prediction of trend line model, to create trend model. In the next times the sensed data compared with predicted value of trend model, if the difference between these two values exceeds a threshold value, data sent to the given node and the node recalculate prediction function of trend model to update the trend line. Otherwise, the sensor node does not send the sensed data with this insurance that sensed data placed in accuracy range of data. So only some data have to be sent that are very different from the trend line model. This help to prevent energy loss.

For doing the best clustering that is necessary to know the energy of nodes. For this, let us divide Leach-c protocol to three phases: set up-state, steady-state, setup-distributed. In the first phase, the nodes send their positions and energy to the base station. In a centralized way, the base station does the first period of clustering. In the steady-state phase, data nodes are sent to the cluster heads and in the end of period, the remaining energy of every node is sent to its corresponding cluster head. In the third phase, clustering is done by head clusters, in this phase, for each node, the data time correlated algorithm is applied as the following. We call the proposed model of energy consumption nodes EDC[5] and explain as follow.

The location of base station is important in a network in which the density of nodes in a region is more than the others, so it is desired that the base station is located in a region with more density of nodes. We call this method, dynamic base station. In this method, the base station has no information about the position of networks. Thus, according to the method which is presented, we try to locate the base station in a region with more density of nodes.

We call the proposed model of energy consumption nodes DBS[6] and explain as follow.

BS node should be informed of data time correlation in nodes to estimate precisely energy of them. Therefore cluster head create a table that containing list of all members of the cluster. Cluster head registers every node in to the table that have correlated data and do not sent in certain times. In the end of each period, cluster head sends this table with collected data

[4] Time Series Forecasting
[5] energy efficient distributed clustering
[6] Dynamic base station

to the base station. This table contains nodes ID and number of times that these nodes not sent data. Base station uses this information for clustering decisions in centralized methods. Ultimately that cause to energy estimation in centralized methods is more carefully while the best clustering is created and the network lifetime increases. So in total lifetime of the network, first phase has done once but setup and steady-state phases done as in leach-c.

A distributed algorithm to determine cluster heads

As previously mentioned, in energy estimation by LEACH-EDC, LEACH-C protocol divided to three phases: setup-state, steady-state, setup-distributed and this algorithm is proposed as following.

a) *Setup-state phase*

1) Start of network
2) Base station receives position and energy of all nodes.
3) Base station does the clustering.
4) Base station runs the DBS algorithm.

b) Setup-state phase

5) if clustering has changed

4.1) if the node is cluster head, and then it must wait to receive data.

4.2) Otherwise, the node is normal and sends its data.

4.3. If the period is ended, the next phase starts, otherwise, the steady-state phase continues.

4.4. At the end of each period, the nodes send their own remaining energy and positions to the corresponding cluster head.

c) Steady-state phase(Hybrid method)

Set up- distributed phase:

5. Cluster head determines a future cluster head by selection algorithm.

6. The future head cluster declares to neighboring nodes that it is now cluster head.

IV. Simulation and Evaluation of Methods

A. Simulation environment

The simulation has been done on the Linux operating system Redhat9.0 and using network simulator instrument NS2. LEACH and LEACH-C protocols implemented on the uAMP project at MIT University over NS2.
The defined scenario for the simulation environment is specified as below:

- Sensor network topology with 100 nodes
- Network size 100m * 100m
- Total cluster of 5
- Data transfer rate equal to 1Mbps
- Base station location (50, 100)
- Duration of each period 20 seconds
- Radio propagation speed 3 * 10^8 m/s
- Primary energy of each node 2 Jules

Receivers and transmitters following of model [3] that their parameters are:

$$E_{elec} = 5.0\times10^{-8}\,J/bit, E_{tx} = E_{rx} = 5.0\times10^{-8}\,J/bit$$

$$\varepsilon_{free\text{-}space\text{-}amp} = 1.0\times10^{-11} J/bit/m^2, \varepsilon_{two\text{-}ray\text{-}amp} = 1.3\times10^{-15} J/bit/m^4$$

E_{tx}, E_{rx} are needed energy to send and receive for each bit.

Test is done by LEACH, LEAC-C, LEACH-C-EDC and LEACH-C-DBS protocols.

B. The result of simulation

Fig.1 shows the amount of energy consumption in each period. In fig.8, we compared LEACH, LEACH-C, and the proposed algorithm LEACH-C-EDC and DBS and then we have considered the value of correlated data in discussed algorithms. And the DBS algorithm only has been incorporated in the LEACH-C-EDC. We can see the EDC method has better performance than all of mentioned methods. It is clear the DBS have a great impact on energy consumption.

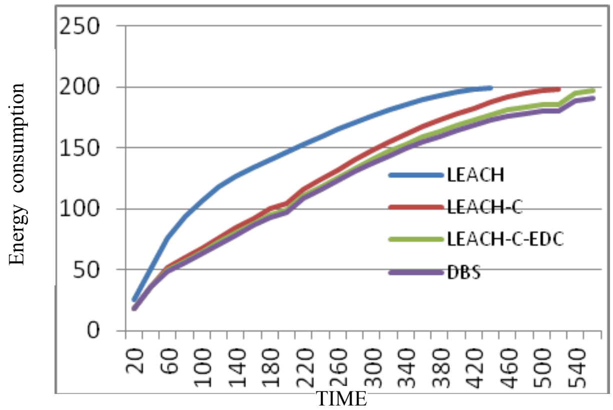

Figure 1. Total energy consumption in the network topology

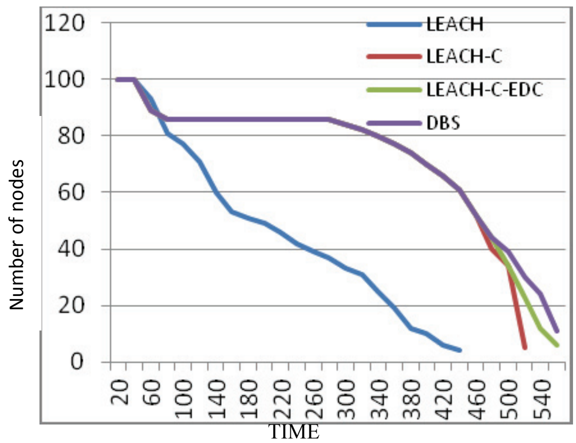

Figure 2. Number of alive nodes in each period

Fig.2 shows the number of alive nodes at different times. In this Fig.2, 4 methods that mentioned above are assessed by the number of alive nodes in each period. As in Fig.2, in the

LEACH-C-EDC and DBS methods the number of alive nodes is more than all other methods. In Fig.2, in the centralized protocols nodes death time has been started from 300, but in the distributed protocols death of nodes has started from 100.

V. Conclusion

In the present paper, we have determined the optimal location of base station for improving the energy consumption. Moreover this article solves the problem of correlated data in all of discussed protocols in this paper. So the nodes that have time correlated data and sending this data wastes their energy and thus network lifetime will decrease. By using the algorithm of data time correlation, the problem will be raised. Also we have eliminated periodic sending of nodes data in leach-c protocol.

By using collected data of the nodes, cluster head appoints future cluster head. That is no need for nodes to send all their data to the base station. Cluster head appoints future cluster head by calculating network topology.

Totally we improved the lifetime of network by using simulation in LEACH, LEACH-C, LEACH-C-EDC and proposed DBS algorithms. Also we improved energy consumption by using estimation methods. In the future works we will try to use classification of nodes distances scheme to estimate energy of nodes more precisely.

References

[1] Jafar amiri and masoud sabaei , "A new energy efficient data gathering approach in Wireless Sensor Networks",(730) Wireless Communications - 2011.

[2] Eui-Hyun JUNG, Member, Sung-Ho LEE, Jae-Won CHOI. "A Cluster Head Selection Algorithm Adopting Sensing-Awareness and Sensor Density forWireless Sensor Networks". IEICE TRANS. COMMUN., VOL.E90–B, NO.9 SEPTEMBER 2007

[3] Mahmood Ali and Sai Kumar Ravula. "REAL-TIME SUPPORT AND ENERGY EFFICIENCY IN WIRELESS SENSOR NETWORKS". School of Information Science, Computer and Electrical Engineering Halmstad University Box 823, S-301 18 Halmstad, Sweden January 2008

[4] Ameer Ahmed Abbasi a,*, Mohamed Younis. "A survey on clustering algorithms for wireless sensor networks", 0140-3664/$ - see front matter _ 2007 Published by Elsevier B.V.

[5] M. J. Handy, M. Haase, D. Timrnermann, "Low Energy Adaptive Clustering Hierarchy with Deterministic Cluster-Head Selection" IEEE, 2002.

[6] Wendi B. Heinzelman, Anantha P. Chandrakasan, Hari Balakrishnan, " An Application-Specific Protocol Architecture for Wireless Microsensor Networks" ,2002 IEEE.

[7] Siva D. Muruganathan, Daniel C. F. Ma. "A Centralized Energy-Efficient Routing Protocol for Wireless Sensor Networks". 0163-6804/05/$20.00 © 2005 IEEE.

[8] M. Demirbas and H.Ferhatosmanoglu, "Peer-to-Peer Spatial Queries in Sensor Networks", Proceeding of 3rd IEEE International Conference on Peer-to-Peer Computing (P2P '03), pp.32-39, 2003.

[9] S. Banerjee and S. Khuller, "A Clustering Scheme for Hierarchical Control in Multi-hop Wireless Networks", Proceedings of IEEE INFOCOM, 2001

[10] G.H. Riahy, M. Abedi. "Short term wind speed forecasting for wind turbine applications using linear prediction method", 0960-1481/$ - see front matter r 2007 Elsevier Ltd.

[11] Shio Kumar Singh 1, M P Singh 2, and D K Singh, "Routing Protocols in Wireless Sensor Networks -A Survey", International Journal of Computer Science & Engineering Survey (IJCSES) Vol.1, No.2, November 2010.

[12] W. B. Heinzelman et al., "An Application-Specific Protocol Architecture for Wireless Microsensor Networks,"