International Journal of Electronics Engineering (ISSN: 0973-7383)
Volume 11 • Issue 1 pp. 659-663 Jan 2019-June 2019 www.csjournals.com

Advanced Energy Optimization Technique using Cooperative MIMO in WSN

[1]Rashmi Pratap, [2]Pushpendra Kumar
[1]Computer Science and Engineering Department, MNNIT Allahabad, Allahabad, India
[2]Central Research Laboratory, BELGhaziabad, Ghaziabad, India

Abstract: The Advanced energy optimizing algorithm provides a technique to minimize the problem of energy constraint in wireless sensor environment. It proposes a method of applying of Cooperative MIMO with selective multi-casting technique in the sensor network to minimize the individual energy consumption of nodes. In the proposed work, the overall residual energy of the nodes is maintained in a way that the life of cluster is increased. At the time of installation, these nodes are embedded with internal batteries. The energy of these batteries is limited and tends to reduce over time. The residual energy is the remaining energy of a node at a point of time. The cluster life is maximized using the concept of residual energy. The nodes are compared on the basis of their residual energy and then selected for the transmission. This protocol of energy optimization is for the fields where number of nodes is high.
Keywords: Cooperative MIMO; Residual Energy.

I. Introduction

In wireless sensor networks (WSNs) sensor nodes are typically powered by batteries with a limited lifetime and, in most cases, the batteries cannot be recharged. The energy problem in wireless sensor networks remains one of the major barriers preventing the complete exploitation of this technology. To save energy in WSNs, many techniques and protocols have been investigated under different approaches, such as through reducing transmit power or condensing data for transmission or the combination of the two. By creating diversity using the cooperative multi-input-multi-output (MIMO) technique that exploits distributed single antennas on a group of neighboring nodes, less transmit power is required than that in a single-input-single-output (SISO) system under the same bit-error-rate and throughput performance requirements. The superiority of cooperative MIMO over SISO in energy efficiency can also be achieved even when taking into account the effect of extra training overhead required in MIMO systems and different channel propagation conditions [1].Here in this paper an engaging approach is proposed by taking the help of residual energy concept to figure out the best nodes for the communication process.

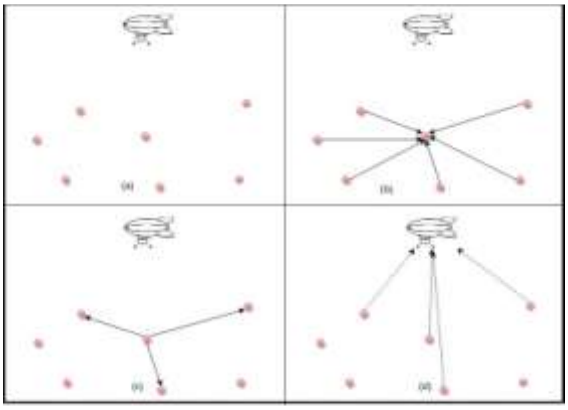

Fig. 5.(a)Overview of proposed system (b)gathering phase (c)selective multicasting phase (d)long haul communication

The overall life time of the cluster is increased marginally by raising the individual life span of the nodes.

Sensor networks are basically comprised of sensor nodes which may be small or large in number depending upon the nature of its application. These sensor nodes run with the help of batteries installed inside them which are generally non- rechargeable. This scenario requires increasing the battery life of these sensors. To save battery life we must optimize the energy dissipation in various functionalities of a sensor. A sensor node has to perform 3 basic tasks- sensing, computation, and transmitting. Sensing and processing of data consumes many times lesser power as compared to the transmission of data. Therefore the need is to lessen the amount of data for transmission. One of the best ways to achieve this is by using the Data Aggregation scheme. Our proposal is based on the applications where the number of nodes is large and the precision of data at the receiving end is not the key requirement. The model involves two paramount technologies that are MIMO technology and Data Aggregation. MIMO, or multiple input multiple output, is a technique where multiple antennas are used at both the transmitter and the receiver to increase the link reliability, the spectral efficiency, or both.

In a network of sensor nodes where the sink or the access point is located at some distant point, the above technologies are used to transmit data to the sink. The sensor nodes are uniformly distributed in the region with nodal density and subjected to strict energy constraints. They are self-organized into clusters and cooperate on signal transmission to the access point (AP). We assume that each cluster consists of n sensor nodes (i.e. the cluster size is n), and that the amount of data sensed by each node is L bits within a defined period of time. Since the nodes in the same cluster are closely spaced, the data sensed by them are correlated. Through the aggregation process data are compressed using their correlation properties and consequently much less data needs to be transmitted from the cluster to the remote AP. We assume that nodes in the wireless sensor network are equipped with a single antenna due to the limited physical size. The individual nodes with a single antenna in the same cluster transmit information cooperatively to the AP. At the receiver side, we assume that the sink is equipped with a single antenna for simplicity.

II. ENERGY MODEL

Referring to Fig. 1, the sensor nodes are uniformly distributed in the region with nodal density ρ and subjected to
strict energy constraints. They are self-organized into clusters
and cooperate on signal transmission to the access point (AP). We assume that each cluster consists of n sensor nodes (i.e.
the cluster size is n), and that the amount of data sensed by each node is L bits within a defined period of time. Since the nodes in the same cluster are closely spaced, the data sensed by them are correlated. Through the aggregation process data are compressed using their correlation properties and consequently much less data needs to be transmitted from the cluster to the remote AP. We assume that nodes in the wireless sensor network are equipped with a single antenna due to the limited physical size. The individual nodes with a single antenna in the same cluster transmit information cooperatively to the AP. For simplicity, we assume that the AP is also equipped with a single antenna, which leads to a cooperative multi-input-single-output (MISO) system. As MISO is a variation of the MIMO, we choose to use the term MIMO thereafter in the paper to describe this scenario and this does not affect the conclusion we draw with regards to the performance comparison with the SISO system.

The total energy consumption for transmitting L bits each from n nodes in a cluster to the AP, Etot, can be divided into two components- the energy consumption of local communication for data exchange and compression, Eintra, and the energy consumption of long-haul communication for nodes to transmit the compressed data to the AP cooperatively, Elh, which is given by

$$E_{tot} = E_{intra} + E_{lh} \qquad (1)$$

Each sensor node in a cluster senses information from its surrounding and then passes that information to the corresponding cluster head. During this local communication, as the data can be highly correlated, the cluster head aggregates different copies of data received from different nodes to remove the redundant part. Now one compressed copy is prepared which contains data of all the nodes. This data is sent back to few nodes having residual energy more than the threshold energy.

A. Energy Consumption of Local Communication Eintra

In describing the details of energy consumption made by data exchange and data compression during local communication, we propose a centralized data aggregation scheme, in which a central node of a cluster collects data sensed by all the nodes in the cluster, integrates and compresses the data, and then distributes the compressed data back to the nodes. The centralized data aggregation scheme works in three phases as follows:

Gathering phase: each member node in a cluster uses different time slot to transmit their raw sensor data to a central node with data rate R_{intra} for compression. The central node can be any member node in the cluster but normally the node located at the center of the cluster is chosen.

Compressing phase: As the data sensed by sensor nodes in a cluster is correlated, the data gathered at the central node is compressed in this phase. The extent of correlation in the data from different sources can be a function of the distance between them, thus the size of cluster used will impact on the compression efficiency of clusters.

Selective Multicasting phase: The central node broadcasts the compressed data to the selected nodes within the same cluster. The same transmission data rate is used as in the gathering phase. These nodes of the cluster decode the received data simultaneously.

Each sensor node in a cluster senses information from its surrounding and then passes that information to the corresponding cluster head. During this local communication, as the data can be highly correlated, the cluster head aggregates different copies of data received from different nodes to remove the redundant part. Now one compressed copy is prepared which contains data of all the nodes. This data is sent back to few nodes having residual energy more than the threshold energy.

The energy consumption for nodes to exchange and compress their data with the CAS in a cluster is the sum of energy consumption in three phases, which is given by

$$E_{intra} = E_{ga-CAS} + E_{comp-CAS} + E_{smCAS}, \quad (2)$$

where E_{ga-CAS}, $E_{comp-CAS}$ and $E_{bro-CAS}$ are the energy consumption of gathering phase, compressing phase and broadcasting phase in the CAS respectively.

According to [3], the energy dissipated in gathering phase can be divided into two main components: the energy consumption of the power amplifier and the energy consumption of all other circuit blocks.

The energy dissipated in gathering phase is

- $$E_{ga-CAS} = (n-1)P_{PA\text{-}intra}\frac{L}{Rintra} + (n-1)(P_T + P_R)\frac{L}{Rintra}$$

; (3)

Where $P_{PA\text{-}intra}$ denotes the local power consumption of power amplifier on the transmission side, P_T and P_R are the power consumption of circuit blocks at transmitter and receiver side respectively. The transmission data rate is given by R_{intra} = b:B with b the constellation size (bits per symbol) and B the modulation bandwidth.

$$P_{PA-intra} = (1+\alpha)E_{intra}\, R_{intra} \times \frac{(4\pi d)^2}{(G_t G_r \lambda^2)} \times M_l N_f (4)$$

where α= (ξ/η)-1 with ξ the peak to average ratio (PAR) andη the drain efficiency of the RF power amplifier. E_{bintra} is the energy per bit required for a given BER requirement.

The energy dissipated in compressing phase is given by

$$E_{compCAS} = nLE_{comp} \ (5)$$

where Ecomp denotes the energy cost per bit for data compression.

The energy dissipated in selective multicasting phase is

$$E_{disCAS} = P_{PAintra}\frac{In}{Rintra} + (q(m)P_T + (m)P_R)\ \frac{In}{Rintra}) \quad (6)$$

where m is the number of nodes with residual energy greater than threshold energy. We assume that the threshold energy is 10% of the energy that is possessed by the node at the time of its installation.

Residual energy= Total energy- Energy Dissipated

B. Energy consumption of long-haul communication Elh

The cluster head is also selected on the basis of residual energy. The node with highest residual energy is selected as the head for the cluster. During the long-haul communication, the sensor nodes in a cluster encode the compressed data In according to orthogonal STBC scheme and transmit it to the AP cooperatively. The energy consumption during the long-haul communication E_{lh} is given by

$$E_{lh} = P_{PA\text{-}lh}\frac{In}{Rlh} + (mP_T + P_R)\frac{In}{Rlh} \quad (7)$$

where $P_{PA\text{-}lh}$ is the power consumption of the power amplifiers at the transmitting side and R_{lh} denotes the transmission bit rate defined as $R_{lh} = R_S.b.B$, R_S is the spatial rate of encoding scheme. Here we use a rate 1/2 orthogonal STBC, thus $R_S = 1/2$.

When the channel only experiences a square-law path loss the power consumption of the power amplifiers at the transmitting side P_{PAlh} is given by according to [2], [3]

$$P_{PA-lh} = (1 + \alpha)E_{bih}R_{lh} \times \frac{(4\pi d_{lh})^2}{(G_tG_r\lambda^2)} \times M_lN_f \quad (8)$$

where E_{blh} is the average energy per bit required for a given BER requirement.

We assume that the distance of access point from each node is same because access point and cluster are much farther than the maximum separation of cluster.

For the centralized data aggregation scheme, node can be worked out by combining (1), (2), (3), (5), (6) and (7) as

$$E = \frac{1}{nR_{intra}}\{[(n-1)L + I_n]P_{PAintra} + [(n-1)Lq(n)I_n]P_T + [(n-1)(L+I_n)]P_R\} + LE_{comp} + \frac{I_n}{mR_{lh}}[P_{PAlh} + (mP_T + P_R)] \quad (9)$$

Where m $<= n$

The energy consumption in the proposed model is much lesser than the existing model.

III. EVALUATION AND OPTIMIZATION OF ENERGY-EFFICIENT ADVANCED SYSTEMS

The simulation is done in MATLAB tool for programming and also for plotting the required graph. While evaluating the energy model of the model, we assume the following system parameters

TABLE I

PT = 150mW	λ= 0:12M
PR = 100MW	ECOMP= 5NJ/BIT/SIGNAL
η= 0.35	EB-INTRA = EB-LH = 104
B = 10KHZ	L = 1000BITS
GTGR = 5DBI	DLH = 5000M
ML = 40DB	B = 2
NODES= 50	EO = 1000J

System Parameters

First we evaluate the energy efficiency of cooperative MIMO systems with data aggregation based on the energy model built. We compare the proposed systems to existing cooperative MIMO systems with data aggregation (CMIMO) in terms of energy efficiency.

The energy consumed per node of the existing model is given as

$$E_{CMIMO-A} = \frac{1}{nR_{intra}}\{[(n-1)L + I_n]P_{PAintra} + [(n-1)Lq(n)I_n]P_T + [(n-1)(L+I_n)]P_R\} + LE_{comp} + \frac{I_n}{nR_{lh}}[P_{PAlh} + (nP_T + P_R)]$$

Firstly, assuming the nodes to be constant in number, that is 50, the graph is plotted for theresidual energy of the nodes. A visible difference is seen in the energies of two models. Theproposed model saves energy and the cluster lasts longer than the existing model.

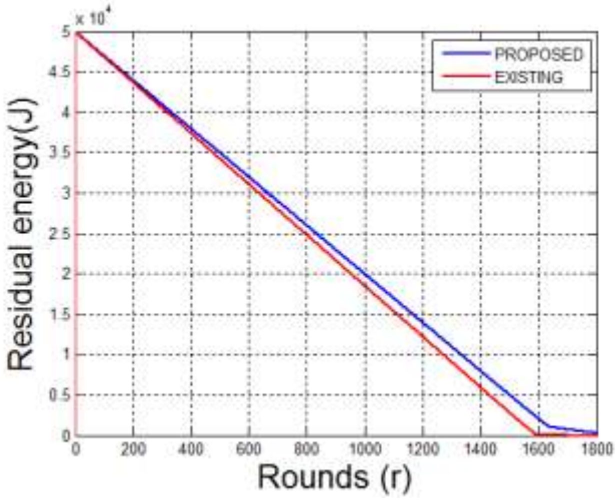

Fig. 2.Residual energy of nodes over number of rounds for Advanced energy model and Existing model

International Journal of Electronics Engineering (ISSN: 0973-7383)
Volume 11 • Issue 1 pp. 659-663 Jan 2019-June 2019 www.csjournals.com

Residual energy of each node decreases with increasing number of rounds in both the cases. The graph clearly shows that the proposed model saves energy more than the existing one.

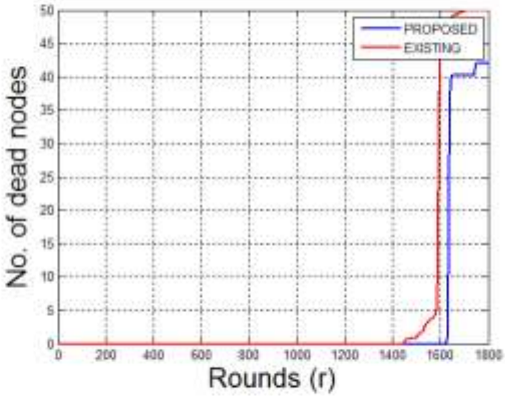

Fig. 3.Number of dead nodes nodes over number of rounds for Advanced energy model and existing model

When the residual energy of nodes is reduced to zero, the node is said be dead. In our case the nodes tend to live longer than the existing algorithm.

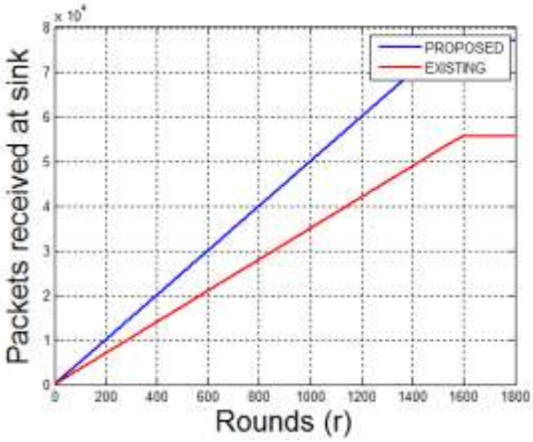

Fig. 4.Packets received at the sink over number of rounds

Each node while alive can participate in the communication with with the sink. The packets received at the sink are shown in the figure 4.

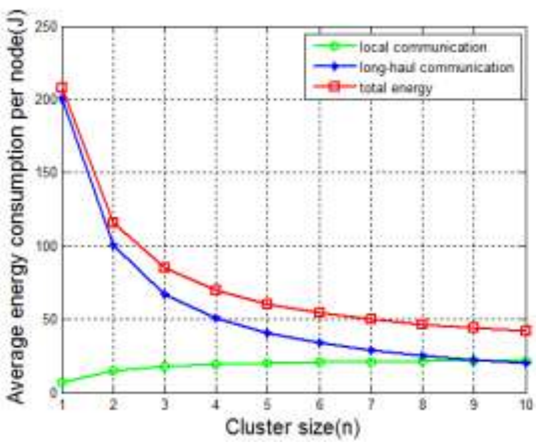

Fig. 5.The energy consumption per node over cluster size and its components

Figure 5 shows the individual energy dissipation in both kind of communication and also the total energy consumption. It shows that long haul communication overhead makes a reasonable and dominating effect on the total energy.

IV. CONCLUSIONS

The proposed advanced energy optimizing algorithm provides a technique to minimize the problem of energy constraint in wireless sensor environment using the method of selective multi-casting in the wireless sensor network. The protocol succeeds in minimizing the individual energy consumption of nodes and therefore the total energy consumption. In a cooperative MIMO the energy consumed by the local communication and long haul communication is due to all the nodes of a cluster. In this proposed work, the energy consumption is reduced by selecting few nodes on the basis of their residual energy which perform the communication process with the sink.

We have seen in the experimental results section that there is a major increment in the residual energy of the nodes as compared to the previous works. The number of packets received at the sink is also increased drastically.

First of all, the results obtained from the above work are satisfactory. Yet still, as far as protocol is concerned, there is much scope to improve the protocol and design new models.Secondly, since this protocol deals with the static network, it can be enhanced by changing the nodes to be mobile and can be simulated to find out variation from the static one. Further work can be done on the basis of the application of the network.

ACKNOWLEDGMENT

I would like to express my deep and sincere gratitude to my thesis supervisor 'R.S. Yadav', professor and Head of Computer Science and Engineering Department, for giving me the opportunity to do thesis and providing invaluable guidance throughout this thesis. I am extremely grateful to Suresh Kumar (research scholar, Computer Science and Engineering Department) for their support, caring and motivating for paper publication.

REFERENCES

[1] Zuo, Yi, Qiang Gao, and Li Fei. "Energy optimization of wireless sensor networks through cooperative MIMO with data aggregation." 21st Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications. IEEE, 2010.

[2] Abhilash, L. N., Devaansh Goenka, and Chetan Kumar. "Dynamic data aggregation for energy optimization in multi-hop Wireless Sensor Networks." Advance Computing Conference (IACC), 2014 IEEE International. IEEE, 2014.

[3] Nadeem, Q., et al. "Simple: Stable increased-throughput multi-hop protocol for link efficiency in wireless body area networks." Broadband and Wireless Computing, Communication and Applications (BWCCA), 2013 Eighth International Conference on. IEEE, 2013.

[4] Xiangning, Fan, and Song Yulin. "Improvement on LEACH protocol of wireless sensor network." Sensor Technologies and Applications, 2007. SensorComm 2007. International Conference on. IEEE, 2007.

[5] Nadeem, Q., et al. "M-GEAR: gateway-based energy-aware multi-hop routing protocol for WSNs." Broadband and Wireless Computing, Communication and Applications (BWCCA), 2013 Eighth International Conference on. IEEE, 2013.

[6] S. K. Jayaweera, "Virtual MIMO-based cooperative communication for energy-constrained wireless sensor networks,"

IEEE Trans. Wireless Commun., vol. 5, no. 5, pp. 984-989, May 2006.

[7] J. G. Proakis, Digital Communications, 4th ed. New York: McGraw-Hill,2000.

[8] S. Cui, A. J. Goldsmith, and A. Bahai, "Modulation optimization under energy constraints," in Proc. IEEE International Conference on Communications, AK, pp. 2805-2811, May 2003.