Energy Saving Strategy based on Adaptive Transmission Power Scheme and Adaptive Network Configuration for WSN

Sneha S .Chavan[1], Prof. Sujata Agrawal[2]

[1, 2]Electronics & Telecommunication Department, SKN College of Engineering, Vadgaon Bk., Pune, India

Abstract: ***For full deployment and exploitation of Wireless Sensor Network energy consumption remains as a major obstacle nowadays. Energy awareness and energy efficiency are two desirable characteristics of Wireless Sensor Network. To minimize the energy consumption from both the sensor node level and network level an energy efficient strategy is proposed. By using localization algorithm the physical location of the sensors after they have been deployed is determined. After that the distance between transmitter and receiver is estimated before available transmission to minimize the communication energy consumption. Then the lowest power needed to transmit the measurement data is determined and calculated.***

Keywords: Wireless Sensor Network, Localization, Received Signal Strength Indication (RSSI), Energy Efficiency, Adaptive Transmission Power Scheme, Adaptive Network.

1. Introduction

Wireless Sensor Network (WSN) consists of autonomous sensor nodes. These nodes can be deployed in the field for monitoring unattainable area. The areas like forest fires, glaciers, deserts, deep oceans can be monitored by using sensor nodes [2]. A wireless sensor node consists of sensing, communication, computing, actuation and power components. These components are integrated. Sensor node consists of radio-trans-receiver, a microcontroller, a memory unit and set of transducers. By using these components, sensor node acquires and process data from deployed regions. Sensor nodes resources are limited in terms of processing capability, wireless bandwidth, battery power and storage space. In most of the application each sensor node is usually powered by a battery and it has to work for several months to one year without recharging. Thus energy consumption problem is major obstacle for full deployment and exploitation of WSN technology.

This paper is organized as follow. Section II gives literature survey on various methods for reducing energy consumption; section III describes about localization, Section IV describes briefly the algorithm of localization. Adaptive transmission power setting schemes for node level energy savings and adaptive network configuration for network level energy saving are given in section V. Results and discussions for the localization algorithm are presented in section VI followed by Conclusion in section VII.

2. Literature Survey

Various different approaches have been used for reducing energy consumption. Few of these approaches are as follows.

2.1 Duty Cycling Approach

By using sleep/wake up protocols and media access control protocol duty cycling can be achieved. To improve the network life time sparse topology and energy management approach have been proposed. In this approach redundant notes are set to sleep mode [3]. To reduce the energy consumption, traffic adaptive medium access protocol has been designed. In this protocol, the sensor nodes are allowed to assume a low-power ideal state when they are not working [4]. Duty cycling is a distributed algorithm in which sensor nodes decide when to transition from active to sleep and back. At the same time it allows neighboring nodes to be active. Due to which packet exchange become feasible even when nodes operate with low duty cycle.. These schemes are not suitable to data those are samples by sensor nodes. Hence to improve the energy efficiency even more data driven approaches can be used [5].

2.2 Data Driven Approach

Data compression and energy efficient data acquisition are two main parts of data driven approach. To reduce the amount of information sent by source nodes data compression can be applied. Many different methods can be used to compress data. As an e.g. the data can be compressed by using variable data length coding which uses Walsh function. This method has proved to be very energy efficient in signal transmission [6]. Secondly energy efficient data acquisition schemes are used to reduce the energy spent by sensing sub system. They can also reduce the energy spent for communication as well. By dividing sensor network into several sub systems and communicating only high level inferences between sub systems more energy can be saved. By using this method the energy consumption decreases as the data to be transmitted decreases [7]. Adaptive sampling algorithm can be used for energy efficient data acquisition to reduce the energy consumption in sensor network [8].

Another schemes like i) Modulation scaling scheme ii) Multihop routing scheme [9] iii) Network sectioning [10] and low power hardware [11] can be used for energy aware transmission. In this paper we proposed an energy saving strategy for node level using adaptive radio frequency power setting and network level energy saving through adaptive network configuration. In this paper we have also proposed localization algorithm to geographical location of sensor nodes.

3. Location of Sensor Nodes

The main problem in WSN is to locate the geographical locations of sensor nodes. Determining the geographical location of a node is called as localization. To detect and record events location information is used. If the accurate location information is not obtained by user then related application cannot be accomplished. For a large scale networks or in networks where sensors move manual configuration of locations is not feasible. Providing each sensor with GPS (General Positioning System) is very expensive in terms of energy consumption and cost. So one solution to this problem is to use nodes called beacon nodes who have their location information at all times. By using these beacon nodes the location of other nodes can be determined. The beacon assists the unknown nodes in localizing themselves. Localization algorithm can be divided in two types;

i) Range Free
ii) Range Base

Range base algorithm measures the distance between unknown nodes and beacon. Then the co-ordinates of unknown nodes are calculated by using measured distance. In Range free algorithm the distances between unknown nodes and beacon is indirectly obtained by the connectivity information. Then the co-ordinates of unknown nodes are determined by using indirectly obtained distances.

4. Localization Algorithm

In this paper we have proposed ALwadha algorithm for localization. ALwadha algorithm uses a method that selects almost the minimum possible number of references to achieve and accurate position estimation. This selection method is based on the low error approach. ALwadha algorithm uses three types of filters. By using these filters, we can achieve design objectives such as energy efficiency, accuracy, robustness and security.

4.1 Filter One

A known node uses this filter which has received a location request packet to decide if it will act as a reference node and send a location request packet. A know node should satisfy two conditions in order to act as a reference node. Firstly, it's probability of accuracy should be more than a specific value (Pres). Secondly, it's probably of accuracy should be more than the required accuracy level sent by the requesting node (Lacc). This filter works on the available information instead of taking information from neighboring knowns. The requesting node will receive 'Location Responses' packets only from R set of references.

4.2 Filter Two

The node applies this filter to select a subset of references S, based on the references location error. The probability of accuracy of the sub set S should be greater than certain value (Pmin). The node applies this filter twice firstly to select subset $S_\circ$ to estimate an initial position ($\hat{z}$) and secondly to select a subset S.

4.3 Filter Three

The node uses the initial position ($\hat{z}_\circ$) to eliminate those references with high distance measurement error. The result of this filter is R. This filter is only applied if at least one of the references in the subset $S_\circ$ has an estimated distance error greater than a certain value.

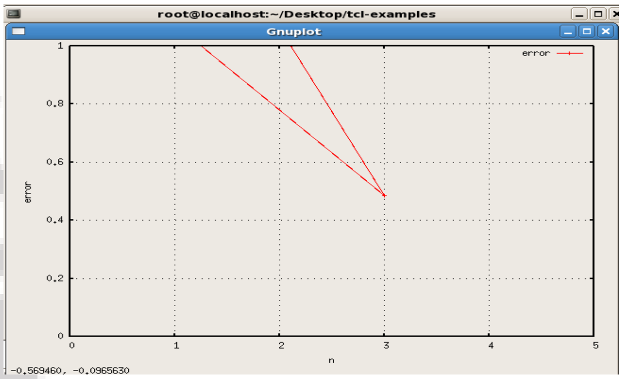

Figure 1: .Gnuplot for localization error

Figure 1 shows localization error by using a ALwadha algorithm. It can be seen that ALwadha algorithm not only uses low numbers of references, but requires low number of iterations to get an accurate position which also reduces the computation cost. Thus ALwadha algorithm achieves the better level of accuracy.

5. Node Level and Network Level Energy Saving Relation

Once the sensor nodes have been localized, we proposed methods for node level energy saving and network level energy saving. Adaptive transmission power scheme and periodic sleep wake up is used for node level energy saving. An adaptive network configuration scheme is used for network level energy saving.

6. Results and Discussions

For the experimental tests two sensing schemes were used. Figure 2 shows the sensing scheme1 and Figure 3 shows sensing scheme 2.

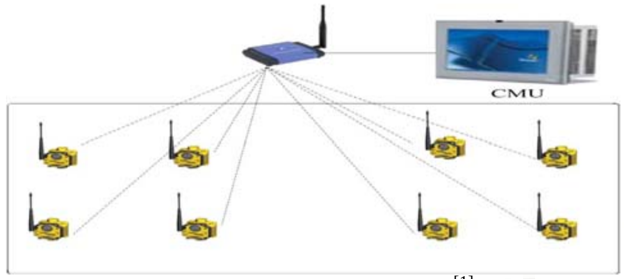

Figure 2: Sensing scheme 1[1]

In scheme1 each sensor node transmits data to CMU. In scheme2 the sensors are grouped into different clusters. The data from sensors is transmitted to cluster head. Then the cluster head transmits them to CMU.

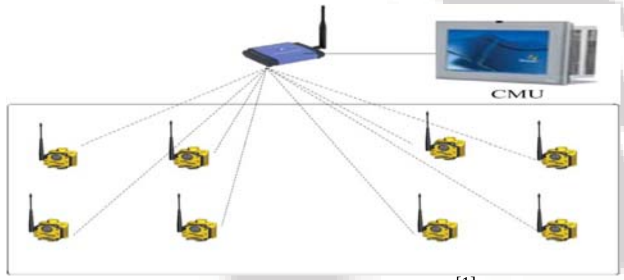

Figure 3: Sensing Scheme 2[1]

For sensing scheme 1 the comparison between the fixed transmission power setting (traditional scheme) and adaptive transmission power setting was done. Figure 4 shows communication energy consumption of one sensor node.

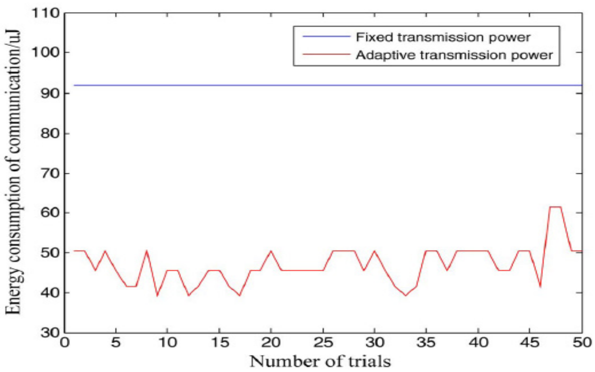

Figure 4: Communication energy consumption under different transmission power settings [1]

As shown in figure 4 the blue curve shows the energy consumption for fixed transmission power setting and red curve shows the energy consumption of adaptive transmission power setting. It can be seen from graph that when adaptive transmission power setting is applied the energy saving achieve up to 50%. As the number of sensor nodes increases node-level energy saving scheme will be more effective. Thus node-level energy saving scheme is more efficient than fixed transmission power setting scheme.

For network level energy savings, the results were obtained by using scheme 1 and scheme 2. The sensor nodes are deployed as shown in figure 5. Then the sensing scheme 1 and 2 are applied on that. The results that we get can be seen in figure 6. Blue curve shows the energy consumption when scheme 1 is applied and Red curve shows the energy consumption when scheme 2 is applied.

Figure 5: Network structure [1]

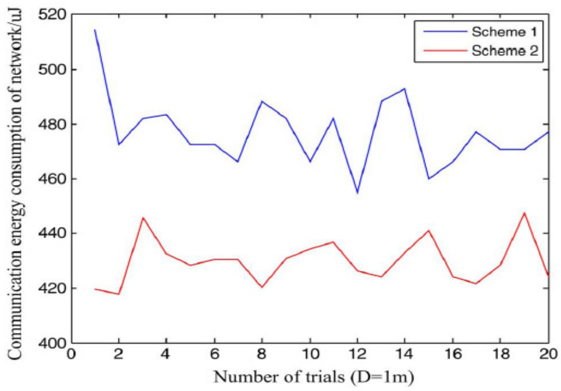

Figure 6: Communication energy consumption of scheme 1 and scheme 2 for D=1m[1]

From Figure 6 it can be concluded that scheme 2 is more efficient than scheme 1 as it saves more energy. Communication energy consumption was estimated with different distances from figure 7 and figure 8 it can be shown that as the distance between CMU and cluster head increases adaptive network configuration scheme achieves more and more energy savings.

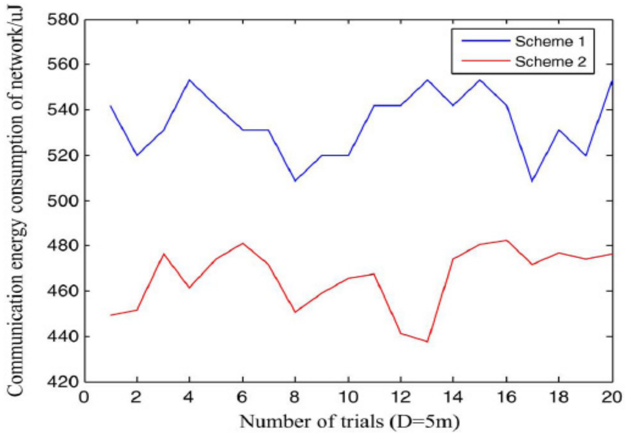

Figure 7: Communication energy consumption of scheme 1 and scheme 2 for D=5m [1]

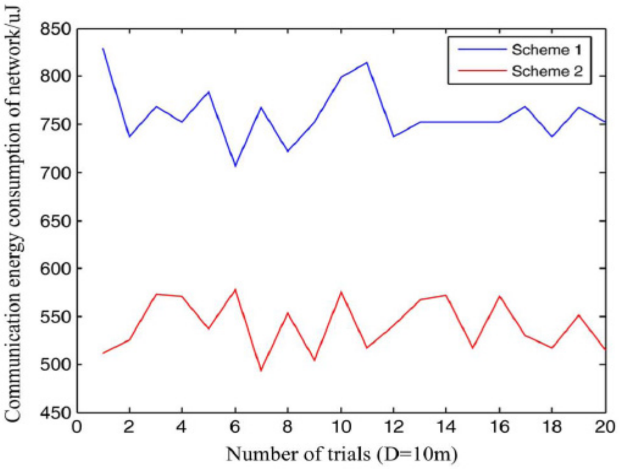

Figure 8: Communication energy consumption of scheme 1 and scheme 2 for D=10m [1]

7. Conclusions

In this paper we have presented the node level energy saving and network level energy saving which can help in constructing an energy efficient Wireless Sensor Network. By using adaptive transmission power setting and periodic sleep/wake up scheme we have achieved node level energy saving. Network level energy saving is achieved by using adaptive network configuration. The results have proved that these schemes are more effective for energy saving in Wireless Sensors Network. In future more modifications can be done in proposed methodology to achieve more energy efficient WSN.

Acknowledgment

It is my pleasure to get this opportunity to thank my beloved and respected Guide Prof. Sujata Agrawal who imparted valuable basic knowledge of Electronics specifically related wireless communication. We are grateful to department of Elect. and Tele. Comm., Smt. Kashibai Navale College of Engineering, Pune for providing us infrastructure facilities and moral support.

References

[1] Ruquiang Yan, Hanghang Sun, and Yuning QianY. “Energy Aware Sensor Node Design With Its Application in Wireless Sensor Networks.” in Proc.IEEE vol. 62, no.5, pp. 1183–1191, May 2013.
[2] C.Chong and S.P Kumar. “Sensor Networks:Evolution, Oppurtunities, Challenges.” in Proc.IEEE vol. 91,no.8 pp. 1247–1256 August 2003.
[3] C. Shurgers, V.Raghunathan, and M.Srivastava . “Power Management for Energy Aware Communication Systems.” ACM Trans. vol. 2, no.3, pp. 431–447, August 2003.
[4] V.Rajendra,K.Obraczka, and J.J Garcia-Luna-Aceves, "Energy- Efficient, collision-free medium access control for Wireless Sensor Network,"vol.12,no.1,pp.63-78, Feb.2006 .
[5] A. Giuseppe, C.Marco, and D. F. Mario, “Energy conservation in wireless sensor networks: A survey,” Ad Hoc Netw. vol. 7, no 3, pp.537–568, May2009.
[6] A. Kadrolkar, R. Gao, and R. Yan, “Energy efficient data transmission for manufacturing system health monitoring,” in Proc. 9th Int. Conf. FrontiersDes. Manuf., Changsha, China pp. 65–70,Jul 2010.
[7] R. Yan, D. Ball, A. Deshmukh, and R. Gao, “A Bayesian Network approach to Energy-Aware distributed sensing,” in Proc. IEEE Sens. Conf.,Vienna, Austria, , pp. 44–47. Oct. 2004.
[8] C. Alippi, G. Anastasi, M. D. Francesco, and M. Roveri, “An Adaptive Sampling algorithm for effective Energy management in Wireless Sensor Networks with energy-hungry sensors,” IEEE Trans. Instrum. Meas.vol. 59, no. 2, pp. 335–344, Feb. 2010.
[9] E. Biyikoglu, B. Prabhakar, and A. Gamal, “Energy efficient packet transmission over a wireless link,” IEEE/ACM Trans. Netw., vol. 10, no. 4,pp. 487–499, Aug. 2002.
[10] R. Gao, A. Deshmukh, R. Yan, and Z. Fan, “Energy efficient wireless sensor network for dynamic system monitoring,” in Proc. SPIE vol. 5999, no. 4, pp. 1–10 ,2005.
[11] A. Wang, W. Heinzelman, A. Sinha, and A. Chandrakasan, “Energy scalable protocols for battery-operated micro sensor networks,” J. VLSI Signal Process. Syst. Signal Image Video Technol., vol. 29, no. 3, pp. 223–237, Nov. 2001.

Author Profile

Sneha Chavan received the B.E. degree in Electronics and Tele-communication Engineering from KIT’s K.I.T. College of engineering, Kolhapur, Maharashtra, India. Now, she is pursuing M.E. degree in Signal Processing from Smt. Kashibai Navale College of Engg., Pune, Maharashtra, India.