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A Survey on Energy Efficiency Problem in Wireless Sensor Networks

Rajdeep Kaur
Computer Science and Engg. SGGSWU, Fatehgarh Sahib, India

Ravneet Kaur
Assistant Professor. Computer Science and Engg, SGGSWU, Fatehgarh Sahib, India

Gursharan Kaur
Computer Science and Engg. SGGSWU, Fatehgarh Sahib, India

Abstract--- Energy Efficiency plays a vital role in wireless sensor network. As wireless sensor nodes are operated by using small batteries, which do not have much energy. Thus energy conservation is a critical issue to be considered. To save energy in WSN, number of techniques and protocols has been investigated. This paper presents a comprehensive survey on energy efficient approaches in WSNs.

Keywords: energy conservation, wireless sensor network, clustering, lifetime, data aggregation.

I. INTRODUCTION

Wireless sensor network (WSN) have gained much more attention from researchers, because the applications of WSN have significantly increasing over vast and varied areas such as biomedical and healthcare Applications, pollution monitoring, habitat monitoring and many others [1].WSN allow real time data processing at minimal cost. Wireless sensor network built of few or thousands of spatially distributed autonomous sensor nodes which are capable of sensing, data processing, and communication with each other via radio transceivers. They coordinate with each other to forming a network to remotely interact with the physical world in order to collect information from an area of interest in robust and autonomous manner. One of the most active research field in WSN is of energy conservation. The main focus of this problem is on how we can prolong the lifetime of wireless sensor network and also how to improve reliability of the link. The lifetime of a sensor network can be extended by jointly applying different approaches [2].

Since, there are three main tasks of sensor node. Based on these tasks, power consumption can be categorized into three parts:

• ***Sensing***- Sensing power depends upon the nature of application. More power is required for continuously monitoring applications than the time to time monitoring applications.

• ***Communication***- Sensor node utilizes maximum power in the data communication. The components of receiver and transmitter consume the valuable power.

• ***Data processing***- In data processing, Energy expenditure is less than communication, but still it is considered [3].

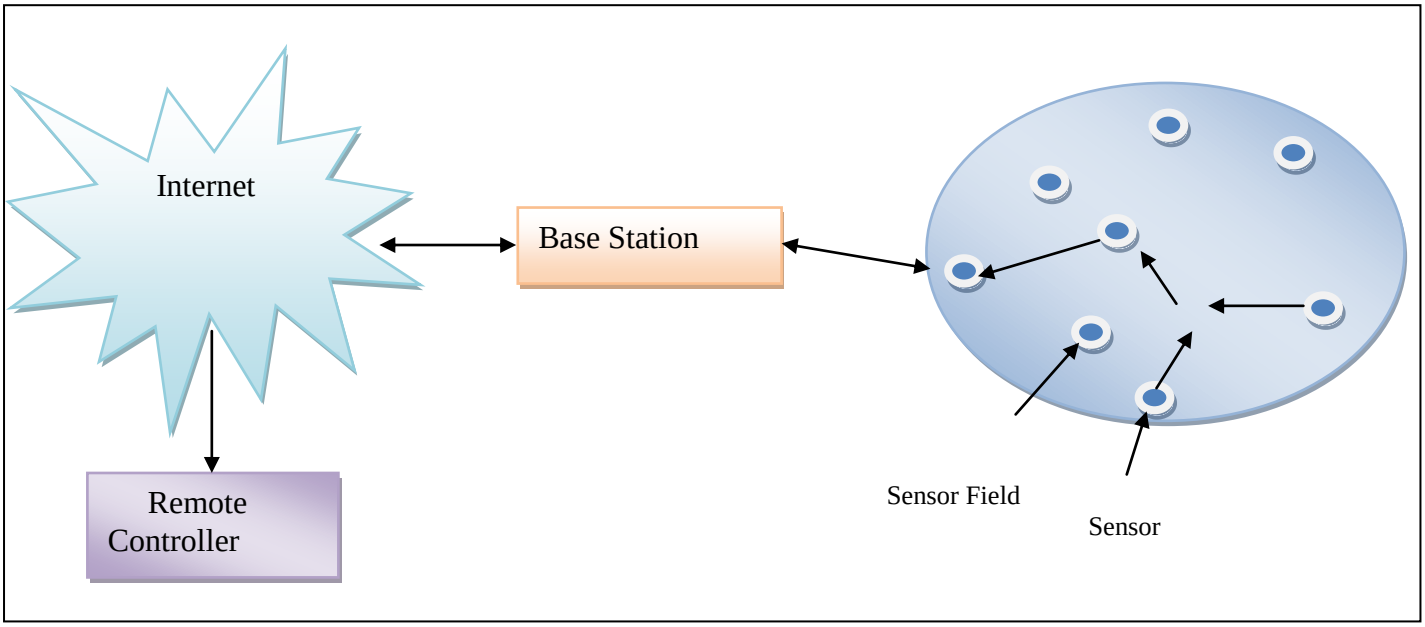

Figure1 Wireless Sensor Network

To overcome the limitation of energy, solutions can be of either hardware level or software level:

- **At *hardware level,*** it is possible to add solar cell or scavenge energy from motion of winds. Batteries and Microcontrollers are used to improve energy efficiency. Most hardware level provides the multiple power saving states- ON, OFF, IDLE for each component of the device so that they remain active for specified time, only when required.
- **At *software level*** , solutions are targeted as
  i) *Minimizing Communication:* Minimizing number of messages is a good solution to minimize energy consumption. With good MAC protocol, routing algorithm, number of messages to be transmitted gets reduced and thus the power consumption.
  ii) *Creating sleep/wake up schedules for nodes:* Solutions to schedule sleep/wake-up patterns vary considerably. Many solutions attempt to keep active the minimum number of nodes, called sentries, while put all remaining nodes to sleep mode. In order to balance energy consumption a rotation is performed periodically where new sentries are selected for the next period of time.[1][2]

So whatever implementation is done in wireless sensor network, power management is of the prime focus. For this, hardware and software solutions must be provided. This paper is organized as follows: we discuss various approaches to energy conservation. In the second section various approaches of energy efficiency are summarized and finally, we conclude the paper.

II. Literature Survey

Sorooshyaristract Siamak et al. in 2008 [4] studied Autonomous Dynamic Power Control for Wireless Networks User-Centric and Network-Centric Consideration. Author presented an estimator based algorithm for distribute power control. The given algorithm is a optimal for power efficiency. The algorithm is predictive, with a user performing autonomous interference estimation and prediction prior to adapting transmitting power. A multiple access wireless network frequently modeled as a collection of radio links separating transmitters and receivers consider the random probability nature of the link gains. Sorooshyaristract Siamak conjectures that depending on a user's application and the network dynamics, a power control policy follows one of two strategies: Greedy approach, Energy efficient approach. A critical feature of this algorithm is the capability of a user to allocate power so as to address various user-centric and network-centric objectives by being either greedy or energy efficient. Simulation results demonstrate superb performance with respect to robustness to stochastic detriments caused by a time varying channel and noisy measurement.

Gao Qiang et.al. in 2010 [5] proposed Improving Energy Efficiency in a Wireless Sensor Network by Combining Cooperative MIMO with Data Aggregation. This paper described that wireless sensor nodes in wireless sensor network gain energy from small batteries .So it is a critical issue to be consider to improve lifetime of sensor nodes by minimizing the energy consumption. Gao Qiang combined the cooperative MIMO and Data Aggregation techniques to significantly reduce the energy used by sensor nodes. Here a new energy model is derived that considers the relationship between data generated by nodes and the distance between the for a cluster based sensor network by employing the combined techniques. Using this model, the effect of cluster size on average energy consumption by each node can be analyzed. Compare with traditional Single-Input-Single-Output systems and MIMO systems without data aggregation, the proposed strategy has simulated its performance and results shows that this strategy is a superior in terms of energy efficiency for different cluster sizes. Thus result of this scheme save bulk of energy, if cluster is of optimal size i.e. neither too long nor too small and sensor nodes are efficiently distributed in cluster.

Nguyen Diep N et al. in 2011[6] projected a Cooperative Clustering Protocol For Energy Constraint Networks. **I**n wireless sensor network, a wireless sensor node has a single antenna. Nodes can be grouped into virtual antenna arrays that act as virtual MIMO nodes .To minimize the imbalance in the residual energy at nodes , Nguyen Diep N divide the whole problem into two parts : determine the optimal number of cluster nodes in each cluster and cluster node selection problem. Nguyen Diep N proposed a multi-hop energy-balanced routing mechanism for clustered WSNs with a novel cost metric. Cooperative and Clustering Protocol consist of three phases: clustering/re-clustering, cooperation, and transmission. The first two phases were executed less frequently than the last phase: Phase 1: Clustering Phase 2: Cooperation, Phase 3: Transmission phase. This protocol takes into account the concept of VMIMO. The simulation result shows that CPP prolongs wireless sensor network lifetime about three times that of existing cooperative protocols.

Sarangi .S et al. in 2011 [7] has presented Genetic Algorithm based on mobility Aware Clustering for Energy Efficient Routing in Wireless Sensor Network. Author described that Wireless sensor nodes is very sensitive to energy. Thus the lifetime of Wireless sensor network totally depend upon sensor nodes. According to Sarangi .S, the lifetime of WSN can considerably improve by using clustering mechanism that distributes the overall load, data aggregation and efficient cluster head selection. This issue has being more critical with increase in mobile nodes due to faster change in some parameters such as distance to gateway and speed. Sarangi .S proposed a GROUTE algorithm based on well known Genetic algorithm. The proposed algorithm consider the mobility of nodes and create optimal cluster in more efficient way in order to have energy efficient transmission of data across wireless sensor network. GROUTE uses neighborhood information from all nodes in order to choose cluster heads and their cluster members. If any node determines that it move away from its cluster head, then that node behaves like an isolated cluster head and perform transmission directly to gateway until gateway performs re-clustering. The result show that mobility awareness of sensor nodes results in saving of large extent of energy.

Karmimi mohammad et al. in 2012 [8] stated that the lifetime of a network depends upon the energy of sensor node which is limited by battery lifetime. Clustering mechanism consider a powerful technique of energy management in wireless sensor network. Here Karmimi mohammad uses two approaches. First one is Genetic Algorithm and second one is Harmony Search Algorithm and combination of them. In this paper optimal cluster head selection has performed according to residual energy and node's position. This scheme first partition the whole network into optimal number of clusters and instead of choosing the node with remainder power, select the node using genetic algorithm ,considering the distance and remaining energy that significantly reduces the energy consumption in each iteration. The Karmimi mohammad stated that the large number of cluster head need to transmit more data to base station that leads to higher energy consumption. Thus in this work, the constant number of cluster heads has taken, which in turn balance the energy consumption.

Wzng Sheng-Shin et al. in 2012 [9] introduced a clustering technique to provide energy and reliable routing in wireless sensor network. This technique considered status of node, link condition and uses a clustering metric, called Predicted Transmission Count (PTX) and gateway. The main motive of this technique is to establish persistent routing path by detecting the number of cluster head and gateways. This technique also considered undirected graph. As ELECT prefer cluster head candidate associate with stable link to become a cluster head. This study has also considered a well known metric, called Expected Transmission Count (ETX). The simulation results of this technique show that ELECT consumes significantly less energy than other techniques.

Sourabh Jain et al. in 2012 [10] proposed an energy efficient maximum lifetime routing algorithm for wireless sensor networks. In order to maximizing the lifetime of these nodes, most of the routing algorithm in wireless sensor networks uses the energy efficient path. These routing algorithms select a best path for data transmission and this consume less energy. But a single efficient path puts extra load to a specific node causing minimization of lifetime. This paper proposed an energy efficient maximum lifetime routing algorithm. It is based on a greedy heuristic technique to maximize lifetime of the system. For maximizing the system lifetime proposed algorithm has used the energy as the cost of links for constructing energy efficient path.

Mathapati Basavaraj S. et al. in 2012 [11] studied that the sensor nodes are operate by batteries. Thus energy conservation is a critical issue. To tackle this problem **Mathapati Basavaraj S** proposed a Energy Efficient Cluster based Mobility Prediction Routing protocol (EECMPR). Kalman filter has used in this proposal. In this Mechanism the cluster head selection is based upon the weight i.e. the node with high weight is selected as a cluster head based upon residual energy and transmission range parameters. The position of each mobile node is carry at the respective nodes using kalman filter which gives information about status update that consists of acceleration and position. This information send to the cluster head which processes this information and further send it to base station. The base station then predicts using this information of status update and compares all the received information taken from cluster head. At last base station send data packets to sensor nodes after Predicting optimal node's position. The simulation results show that this technique minimizes the overall overhead of wireless sensor network.

Zahmatkes.A et al. in 2012[12] proposed a Genetic Algorithm-Based Approach for Energy-Efficient Clustering of Wireless Sensor Networks. Zahmatkes.A used a multi-purpose algorithm named as Genetic algorithm to optimize the number of sensor nodes within a cluster and ultimately reduced transmission cost. The total transmission cost entirely concerned with the total number of cluster head taken and their location in the network. Thus the main objective is to generate a optimal clustering technique to optimize energy consumption. The performance of GA is greatly affected by a number of factors, such as the population size, the probability of mutation and crossover.

Kannadhasan.S et al. in 2013 [13] studied that energy efficiency and data aggregation are key issues in wireless sensor network. Wireless sensor network consists of a large number of autonomous sensor nodes. The group of sensor nodes forms a cluster. Each cluster controlled by cluster head. The data aggregated by cluster head from all ordinary nodes within the cluster transmit data to base station. In this paper, Graph theory is used to detect the shortest path. Kannadhasan.S divided proposed work in four phases as 1.Distance calculation, 2.Energy calculation, 3.Shortest path detection 4.Acknowledgement. The network nodes are represented by vertices and also direct connection between the nodes by edges. Finding shortest path to send data from cluster head to base station is based upon the distance calculation and energy calculation. The results were simulated by NS2 simulator. The results show that the sensor nodes utilize less power and have long life.

Tuah Norah et al. in 2013 [14] studied that wireless sensor network with very limited power source due to hardware constraint. The sensor nodes operated by using tinny batteries and these batteries hold a very limited amount of energy. To tackle this problem, clustering technique is used. Tuah Norah stated that in heterogeneous wireless sensor network, some percentage of sensor nodes is equipped with more energy than all remaining nodes in wireless sensor network. Thus sensor nodes can be classified as sensor nodes and super sensor nodes. The super sensor nodes have more energy capabilities. The cluster head are selected among super sensor nodes. Cluster head aggregate the data from all sensor nodes and further send that data to base station or user. This process continues until the entire energy drains out. In this paper energy consumption analysis is divided into two phases i.e. Energy Consumption Model analyzes the energy

consumed by cluster head node, while data aggregation from other nodes and energy required for data transmission to base station. The author describes three level heterogeneous energy protocols. According to this, whole work of iteration is divided into three parts: Cluster head selection, cluster formation, and Data communication. The eligibility of the proposed work demonstrated by the results from the simulation which results in a significant increase in network lifetime.

Elbhiristate Brahim et al. in 2013 [15] studied saving energy and increasing the lifetime of wireless sensor network are challenging tasks. Using various spectral clustering techniques, Elbhiristate Brahim et al proposed a algorithm, called Spectral Classification for Robust clustering in wireless sensor networks (SCRC-WSN). Here in this spectral partitioning method, graph theory is used for partition the fixed network into network into clusters. All the nodes that form a cluster send data to cluster head which is elected by them and cluster head further send this data to base station. This proposed technique considers the node's residual energy to elect cluster head. The three main steps of the proposed SCRC-WSN protocol 1.Preprocessing, 2.clustering, 3.Cluster head election, 4.steady state phase. SCRC-WSN algorithm determines the clusters before specifying the cluster heads. SCRC-WSN used the concept which offers a better use and optimization of dissipated energy in the network. In this situation, the network base station (BS) computes the adjacency and the laplacian matrices of the network graph in order to run the SCRC-WSN protocol. The strategies introduced into the SCRC-WSN protocol allow it to out-perform its performances by saving more energy and enlarging more effectively network lifetime.

III. CONCLUSION

This paper performs a review on wireless sensor networks. In this survey paper, an overview of some of the recent work on energy conservation in wireless sensor networks is provided. Then look at some of the important works on design related to energy conservation problems in sensor networks. The main focus of our attention is on clustered sensor networks. We noted that several optimization tools and techniques were useful in designing and dimensioning of wireless sensor networks. In the future, this wide range of application areas will make sensor networks an integral part of our lives. The sink node and sensor node were mostly stationary thus research can be done by assuming sink and source node as mobile.

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