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A Review of Energy Efficient Clustering in Wireless Sensor Networks

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***Abstract*— Wireless Sensor Networks (WSN) have become very popular in recent years because they provide low cost solutions to real- world applications. The sensor nodes in WSN have limited computational capability, energy and bandwidth. These constraints tend to limit the network lifetime. The goal of my paper is to present the compressive review of the recent literature work on various aspects of the wsn on reduction of energy consumption.**

Index Terms— **WSN, Sensor node, network lifetime, energy efficiency.**

I. INTRODUCTION

Wireless Sensor Network(WSN) is a type of network in which multiple sensor nodes are installed to monitor the conditions of any area (i.e. temperature, vibrations, pressure, humidity, sound etc) on a large scale and these nodes collectively pass their data throughout the network to a main location i.e. sink[1][2][3]. WSN may consist of few to several thousands of nodes. Each sensor node is comprised of the following parts: a microcontroller, memory, sensors and actuators, communication device and a power source. Each device has sensing as well as communication capability. The topology of network varies from star network to a multi-hop mesh network.

Small size, low computational power, low cost and easy communication within short ranges are the most popular and best features of wireless sensor nodes. In hostile environments, the energy source of the sensor nodes is difficult to recharge or replace. However, different researches, techniques and protocols are employed for energy efficiency management and hence prolonged network lifetime. Greater network lifetime, reliable data transfer to base station, energy conservation, and scalability are the main issues to be addressed in the area of wireless sensor networks.

There are several applications of WSNs such as in area monitoring for forest-fire detection, industrial monitoring for waste water monitoring, agriculture as well as in military applications for intrusion detection etc[4][5].

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II. ARCHITECTURE OF WSN

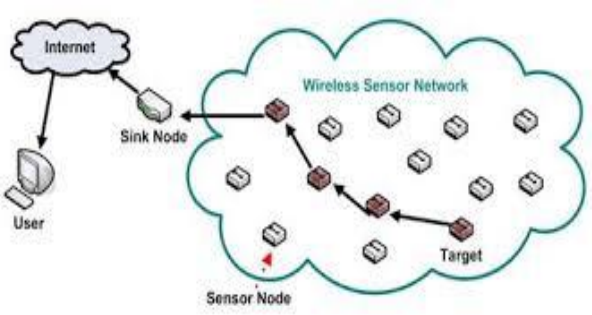

Figure 1 Architecture of WSN

The architecture of WSN is shown in Figure 1. It consists of multiple wireless sensor nodes which are organized and installed on the basis of the required applications and a sink or base station that is situated near or within the radio range. The base station broadcasts the information packets to the neighboring sensor nodes which performs the sensing task accordingly and returns the data to the base station .

Major challenges in WSN are:

(i) limited energy resource
(ii) impossible IP addressing scheme
(iii) limited bandwidth
(iv) lesser memory capacity[6]

Energy supply for a node is of prime importance because the batteries have a small capacity and recharging is a complicated and volatile process. Therefore, the energy dissipation of nodes must be tightly controlled. The major consumers of energy are the radio front ends, microcontroller, memory and depending on the type, sensors. The energy consumed differs according to the distance between sender and receiver nodes [7]. However, this can be reduced by grouping the nodes into clusters.

III. DESIGN ASPECTS OF WIRELESS SENSOR NETWORKS

The following aspects must be taken into account while designing wireless sensor networks-

Energy Conservation- As compared to the wired networks, the sensor networks are limited in energy supplies. Therefore, these networks must be designed to use the limited energy efficiently. As it is almost impossible to replace the batteries of sensor nodes, energy efficiency management can considerably increase the network lifetime.

Limited Bandwidth- Wireless sensor networks are

characterized by limited bandwidth. Theoretically, the bandwidth can be as high as 54Mbps but practically, this is not the case because of the interference caused by other communications.

Low Quality Communications- Wireless channel communications is generally less reliable than wired channel communications and the quality of communication is greatly influenced by environmental conditions. As WSN is deployed in remote areas, low quality communication is expected.

Unstructured and time-varying network topology- Network topology may vary with time due to node failure. As a result, calculating the values of network parameters is a complicated thing [8].

IV. CLUSTERING

Clustering divides the network into groups of sensors nodes which are close to each other geographically.

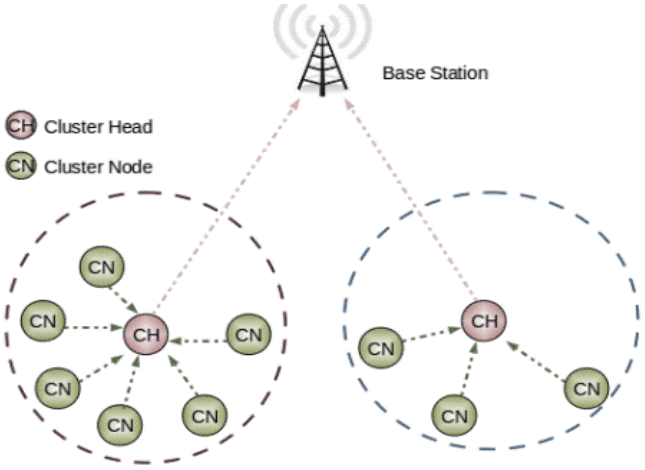

Figure 2 Clustering in WSN

As shown in figure, a cluster head is associated with each cluster which is responsible for controlling all of its activities like transmission, dissemination, management and maintaining topology. By clustering approach in WSNs, energy consumption, scalability and lifetime of a network can be improved[9]. Cluster head nodes either send the data directly to the base station i.e. single-tier network, or data is routed through the intermediate cluster head nodes to the base station i.e. two-tier network. In other works, cluster head acts as a sink for sensor nodes and base station acts as a sink for cluster head nodes.

There are various clustering approaches developed till date. These are probabilistic clustering protocols like LEACH[9], HEED[10] and non- probabilistic clustering approaches like graph-based protocols, weight-based protocols and biologically inspired clustering protocols like particle-swarm optimization(PSO)[11].

V. LITERATURE SURVEY

W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient communication protocol for wireless microsensor networks," Here, a clustering based protocol known as LEACH is proposed which minimizes the energy consumption by rotating the cluster heads randomly inside the network. It reduces the energy consumption by eight times as compared to direct transmission and minimum transmission energy routing[9].

O. Younis and S. Fahmy, "HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks," Here, to increase the energy efficiency, the authors considered various clustering parameters, first is to select an initial set of cluster heads and second parameter is an intra-cluster "communication cost" which is a function of cluster properties like cluster-size and power-levels[10].

R. V. Kulkarni and G. K. Venayagamoorthy, "Particle swarm optimization in wireless-sensor networks: a brief survey," Paper proposed a summary of PSO optimization in different areas of WSN such as increasing lifetime, localization, cluster head selection etc[11].

J. Wang, X. Yang, T. Ma, M. Wu, and J.-U. Kim, "An energy-efficient competitive clustering algorithm for wireless sensor networks using mobile sink," In this paper, a controlled mobile sink node is considered and to improve the network performance, sink mobility is ombined with the clustering algorithm[12].

T. Kang, J. Yun, and K. Han, "A clustering method for energy efficient routing in wireless sensor networks," This paper proposed a distributive algorithm for the cluster head selection and avoids redundancy. The results prove that this scheme performs better than the LEACH algorithm in terms of enhancing network lifetime[13]

N. A. B. A. Aziz, A. W. Mohemmed, and B. S. Daya Sagar, "Particle swarm optimization and Voronoi diagram for wireless sensor networks coverage optimization," Here, the author used graph theory to find the fitness function and PSO to find the optimal solution for sensor position which provides finest solution i.e PSO is utilized to place the sensors in region of interest whereas the coverage of present position of sensor is calculated by voronoi diagram. Sampling method i.e. grid is used where predetermined no. of points are used to calculate coverage. [14].

Roslin S.E., "Genetic algorithm based cluster head optimization using topology control for hazardous environment using WSN," A hierarchical network is developed using genetic algorithm. This hierarchical network controls the network topology without disturbing the network properties. The analysis has been performed on N- tier architecture for various node densities and it has been found out that two- tier architecture performs better in terms of energy consumption. Although genetic algorithm gives an optimized list of cluster heads, there are possibilities of local minima which could be further improvised by simulated annealing which results in global minima[6].

A.S. Uma maheswari, Mrs. S. Pushpalatha," Cluster Head Selection Based On Genetic Algorithm Using AHYMN Approaches in WSN", In this paper a new method which is based on AHYMN approach and genetic algorithm is implemented to choose a cluster head in WSNs dynamically. It is quicker and also more accurate to detect the node with higher energy and to select the cluster head by this proposed method. In addition, nodes with heterogeneous characteristics has been used in this network. Some of the advantages of heterogeneous nodes are: the longer lifetime of networks, decrease in data transference delay and increase in network's reliability[15].

Kiranpreet Kaur1, Harjit Singh, "Cluster Head Selection using Honey Bee Optimization in Wireless Sensor Network" This paper proposes Honey Bee Optimization with some parameters over energy distributed clustering(EDC) algorithm for efficient cluster head selection. Here, leader is set as the intermediate node between cluster head and base station [16].

Yang E, Erdogan AT, Arslan T, Barton N, "An improved particle swarm optimization algorithm for power-efficient wireless sensor networks" In this paper, the author employed Metropolis algorithm along with the standard PSO algorithm to increase the exploration ability of PSO. The algorithm is used in the base station[17].

E. Rashedi, H. Nezamabadi-pour, and S. Saryazdi, "GSA: A Gravitational Search Algorithm," " GSA is another latest optimization algorithm which is based on Newton's laws of gravity and mass interactions. The position of the mass corresponds to the solution of the problem [18].

Marjan Kuchaki Rafsanjani, and Mohammad Bagher Dowlatshahi, "Using Gravitational Search Algorithm for finding near-optimal base station location in two-tiered WSNs. Here, authors employed GSA to find the best solution for the base station location in two-tier WSN and the performance of proposed GSA is compared with PSO[19].

Paolo santt, "Topology Control in Wireless Ad Hoc and Sensor Networks" Here, the author described different types of topology control protocols both for stationary networks as well as mobile networks. Topology control protocol is mainly classified as homogeneous and non-homogeneous which is further classified into location based, neighbor-based and direction-based protocols [8].

VI. CONCLUSION

We have studied many papers related to power-efficient cluster head selection in wireless sensor networks. After studying 19 papers for insight view of what till now has been done for energy consumption reduction in wireless communication, it has been noticed that nearly every author has used optimization schemes for optimal cluster head selection. Most of the algorithms are based on PSO optimization or its variant but due to drawback falling in local optima, we have found gravitational search algorithm more efficient than PSO or GA as it is a global search optimization technique.

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