INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 4, Issue 4)
Available online at: www.ijariit.com

A survey on various energy-efficient routing protocols in WSN

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ABSTRACT

The applications and the role of Wireless Sensor Networks (WSNs) in real-world encourage researchers to elaborate and explore more information about it. As we know a WSN consist of thousands of sensor nodes (static or mobile) which gather information from a specific region and then transmit its base station (static or mobile) with some mechanism. There are various protocols that are proposed to govern this communication in an effective way. But the challenges such as energy consumption, mobile sink scheduling, and data aggregation still need to improve. So that the lifetime of WSN can be extended. This paper cover and present a survey on some protocols and related research works for WSN challenges that improve the performance of the network.

Keywords— *WSN, Routing Protocols, Energy Consumption*

1. INTRODUCTION

Wireless Sensor Networks (WSNs) is the most important technology in this century. When many sensors cooperatively monitor large physical environments, they form a WSN. A sensor node is responsible for data collection from a particular region. It also analysis, correlate and aggregate its own sensor data and data from other sensor nodes. These nodes communicate with each other and also send collected data to a base station (BS) using their wireless connectivity. This wireless transmission capability allowing them to disseminate their sensor data to remote processing, analysis, visualization, and storage systems. The capabilities of nodes in any network depends upon the complexity of the WSN. A group of simple sensor nodes can easily handle and monitor a single physical structure. But for more complex structures, a combination of many different sensing techniques is required. A simple sensor mainly collect and communicate data about the observed environment, whereas advance sensor nodes perform extensive processing and aggregation functions. Such advance nodes (devices) have the capability to access additional supporting technologies, for example, Global Positioning System (GPS) receivers, which allow nodes to accurately determine their positions. However, such systems usually consume too much energy to be feasible for low-cost and low-power sensor nodes.

1.1. WSN Architecture

Figure 1 shows two sensor fields monitoring two different geographic regions and connecting to the Internet using their base stations. Sensor nodes are distributed inside the field sense and transmit data to their respective base station. A base station process, analyze and extract meaningful information from the collected data. In a wireless network, these base station turned to sink nodes. From these base stations, the user can access the data through the internet.

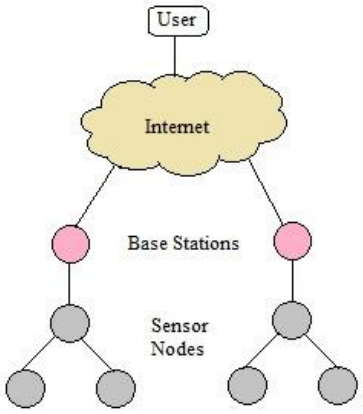

Fig. 1: Basic WSN

1.2. WSN Challenges

While the sensor network is better than other distributed systems in many areas, but still they face many unique challenges. These challenges impact on network designing and its performance.

(a) **Energy Efficiency:** The first and often most important design challenge for a WSN is energy efficiency. Less energy consumption enhances the network lifetime. In order to minimize energy, several energy-, efficient protocols and algorithms for wireless sensor networks have been proposed by researchers. The sensor nodes must operate with limited energy budgets. The sensor nodes are powered through batteries, which must be either replaced or recharged when depleted.

(b) **Security:** Many wireless sensor networks collect sensitive information. The wireless connectivity for remote operation of sensor nodes increases their vulnerability to malicious attacks. Wireless sensor networks need new and more secure solutions for connection establishment and key distribution, node authentication, and privacy.

(c) **Data Aggregation:** When data transmission from all sensors to the sink is not required, but an average value or the minimum and maximum value are required. This process is

aggregation and it gave a summary instead of whole information which consumes less energy. Data aggregation helps in reducing the redundant data collected from member nodes. Mainly cluster head performs data aggregation in order to reduce the number of data packets and save energy.

1.3. Energy Consumption

Reducing power consumption is the most important objective in the design of a sensor network. It is difficult to change or recharge batteries in sensors. Energy consumption is can be defined as the transmitting and receive energy the network consumes. An efficient routing protocol is required for sending and receiving data packets to reduce energy consumption. So all systems and their processes with its communication protocols for sensors and sensor networks must reduce energy consumption. Energy Consumption is a very challenging problem in sensor network because the batteries of wireless sensor nodes have very limited capacities. Due to this problem, every solution elaborated for these networks should be aimed at minimizing the energy consumption.

1.4. Scheduling Mobile Sink

Scheduling of mobile sink is an important topic in a wireless sensor network. Mobile sink mitigate the network performance issue, which static WSNs can't solve properly. But mobile sink consumes energy with its movement in network and data gathering from nodes. The energy consumption in data gathering is proportional to the total number of static sensors in WSN. To consume less energy mobile sink should travel the shortest distance as much as possible. This could be achieved only with efficient scheduling of mobile sink. Sink scheduling an NP-hard problem should be tackled with heuristic approaches.

1.5. Clustering

Clustering can be defined as the division of the nodes in the groups on the basis of some mechanism. Clustering is done to achieve the energy efficiency and the scalability of the network. Clustering can be extremely effective in one-to-many or many-to-one for communication in the win. For WSN simplicity, the number of clusters is set to the same number as that of mobile sinks. In these clusters, all nodes sense information from network region and then give a report to another node called cluster head. Each cluster in the network has a cluster head which is elected with some mechanism. Cluster head aggregate and transmit data to the sink. The clustering approach has proved to be one of the most effective mechanisms to improve energy efficiency in WSNs. Clustering is mainly useful for those applications that require scalability to hundreds or thousands of nodes.

2. LITERATURE SURVEY

LEACH (Low Energy Adaptive Clustering Hierarchy) is an effective communication protocol for the wireless sensor network. The nodes (sensors) are distributed in a network region and energy dissipation is evenly distributed throughout all nodes. The network region is divided into clusters as in conventional clustering. In each cluster, a cluster head is selected which is only responsible for transmitting data packets from that cluster to the base station. All nodes in the cluster transmit their data to cluster head where data is aggregated and compressed. To avoid dying of cluster head as in conventional protocols, LEACH randomly rotates the cluster head position which is based on high energy. The sensor which has high energy is chosen as a new cluster head. Thus LEACH is helped to enhance the lifetime of the network [1].

TEEN (Threshold sensitive Energy Efficient sensor Network protocol) is used as a hierarchical clustering scheme. All nodes in the network are homogeneous and begin with the same initial energy. In this hierarchical clustering scheme, each cluster has a cluster head which collects data from its cluster members, aggregates it and sends it to the base station or an upper-level cluster head. TEEN classifies sensor networks into proactive and reactive networks. Proactive network periodically provides information at regular intervals. Whereas, reactive network instantly give information which nodes sensed. TEEN is good for time-critical applications where it provides data efficiently [2].

HEED (Hybrid Energy Efficient Distribution) is a clustering approach for the ad hoc wireless network. In HEED, the cluster heads are periodically and probabilistically selected on basis of their residual energy value. It can be used for designing energy-efficient hierarchies for routing protocols, in which higher tier sensor nodes should have more residual energy. HEED use primary clustering parameter to probabilistically select an initial set of cluster heads and intra-clustering to consider as a secondary parameter to increase energy efficiency and further prolong network lifetime. This approach can be effective for some sensor applications that require efficient data aggregation to prolonged network lifetime, such as environmental information gathering applications [3].

TTDD (Two-Tier Data Dissemination) provides scalable and data delivery in an effective manner to multiple mobile sinks for the larger scale wireless sensor network. It uses a grid structure in which only that nodes can propagate queries for data dissemination who are located on grid points. Location-aware sensors allow data source to periodically construct a grid structure throughout the network field and then forward data at the sensors closest to grid points. Here each query travels two tiers to reach a source. The first tier (lower) is within the local grid square of sink's current location and the second (higher) is made of dissemination nodes on the grid. With this grid structure for each data source, queries from multiple mobile sinks are restricted within their local cells only. This helps to avoid excessive energy consumption and network overload from flooding by multiple sinks [4].

GROUP (Grid-clustering Routing Protocol) is a cluster based effective and energy-efficient routing protocol for large-scale wireless sensor networks. All sensor nodes dynamically divided into grid-clusters where one node is selected as a cluster head in each cluster. Sinks transmit queries to each node through cluster heads. And data queries are transmitted back via cluster heads to sink. For cluster gird formation, all sinks chose primary sink on the basis of its distance to the center of the network. This primary sink start cluster grid construction. GROUP distribute the energy load among the nodes and provide in-network processing to reduce the amount of information that must be transmitted to the sink [5].

EEABR (Energy-Efficient Ant-Based Routing) protocol is based on Ant Colony Optimization (ACO) metaheuristic. This protocol builds a colony of artificial ants that travel through the network, search for paths between win nodes and sink nodes. These paths are energy-efficient and short in distance. Each and every ant select next sensor node to go, this selection is based on the probability that is a function of energy. And the amount of pheromone trail present on that path. When traveling backward from destination node on the constructed path, ant update pheromone trail amount on the basis of energy quality and the number of nodes of the path. These artificial ants consume less energy because the communication load is low. This helps to maximize energy savings, contributing to prolonging the lifetime of the wireless sensor network [6].

Y.-C. Wang et. al (2010) proposed two heuristic based methods for dispatching problem of mobile sensors to the event locations. These heuristics schedule traveling paths for mobile sensors. A centralized heuristic tries to minimize the energy of sensors mobility in the network while balancing energy. Whereas, a distributed heuristic utilizes a grid-based structure for event locations to bids for mobile sensors. This dispatch algorithm can extend the system lifetime of WSN by reducing and balancing the energy consumption of mobile sensors [7].

Y.-S. Yun et. al (2010) proposed a framework for delay tolerate applications to maximize the network lifetime with a mobile sink. Instead of data transmission immediately, a node temporarily store data and deliver it to mobile sink when it is at the most favorable location. This paper utilizes the advantage of sink mobility plus prove why it is better than stationary sink mobile and conventional mobile sink techniques [8].

T.-L. Chin et. al (2012) proposed a data collection method with mobile sensors in WSN. The method work in two parts. First, it senses and detects the critical location, and then it collects data from this location along the shortest routes. An approach called Balanced Route Planning (BRP) is developed which used to find shortest patrolling paths for mobile sensors. And, evaluation proves that BRP is fairly effective scheme [9].

J. Zhong et. al (2012) explore the optimal sink mobility in order to maximize the network lifetime. An Ant Colony Optimization algorithm for mobile sink scheduling (ACO-MSS) is developed. The proposed ACO-MSS makes use of ACO global search ability and newly designed heuristic to search nearly optimal solutions. Final, results demonstrate that the proposed ACO-MSS give a very promising performance in solving the MSS problem [10].

Y. Gu et. al (2013) proposed an efficient mobile sink scheduling technique with delay constraint. A single mobile sink which is assumed to have limitless energy travel over sink sites to gather information with delay constraints. A unified framework is proposed to analyze the sink and its mobility. Sub-problems are induced and generalize them with optimal algorithms. This paper shows why mobile sink is beneficial in WSN [11].

Y.-P. Chi et. al (2013) proposed an Energy-Aware Grid-Based Routing Scheme (EAGER) to disseminate data between the target and multiple mobile sinks. Network region is divided into equal size grid cells and a unique number called Grid Identification is assigned to all cells. EAGER uses the concept of rerouting that reconstructs new data dissemination paths between multiple mobile sinks and sources. It also provides a time scheduling mechanism in which idle grid head allowed to sleep for a set of the period. EAGER conserve more energy effectively [12].

P. Singh et. al (2014) present an Energy-Efficient Grid-Based Data Dissemination (EEGRDD) routing mechanism. EEGBDD is proposed for data dissemination from multiple sources to multiple mobile sinks. The alternate dissemination nodes are select in advance during grid formation. And, when the current dissemination node reaches to low threshold value it is replaced by an alternative. Also, a diagonal forwarding algorithm is proposed which allow only a single dissemination node to forward data and query. In the end, EEGBDD performs better than existing data dissemination techniques [13].

H. Salarian et. al (2014) proposed a heuristic method called Weighted Rendezvous Planning (WRP). It finds a near-optimal traveling tour for a mobile sink that minimizes the energy consumption of nodes. WRP selects a set of Rendezvous points which prevent energy holes formation. WRP enables a mobile sink to extract all data from nodes within a given deadline while conserving the energy usages. This energy-efficient and path selection strategy for WSN to reduce energy consumption and maximize lifetime [14].

N. Ismat et. al (2014) proposed a Virtual Grid Distribute Clustering (VGDC) for efficient clustering in mobile WSN. The entire network field is divided into equal size grids to perform distributed clustering. Each grid contains only one cluster head, whereas all cluster heads are linked together. It provides complete coverage that more nodes are connected to cluster heads. VGDC improve the reliability at cluster heads and minimize direct transmission between sink and nodes [15].

Z. Zhou et. al (2016) proposed a three-phase heuristic method for efficiently scheduling mobile sink in hybrid WSN. The network is divided into grid cells and these grids are grouped into clusters. These clusters arranging themselves by allocating or deallocating gird cells in order to balance the energy consumption in them. This technique generates optimal grid cell division for the network which prolongs the network lifetime [16].

M. Thakur et. al (2016) proposed an inter-cluster based on ACO algorithm for routing of data packets in WSN. This paper induces NLEACH when inter-cluster ACO aggregate data. This method reduces energy consumption in transferring unnecessary data sent by sensors. The implementation of ACO in mobile sink based NLEACHthe protocol gives the effective result as compared to other technique discussed in this paper [17].

S. Sharma et. al (2017) proposed a Mode Switched Grid-based Routing (MSGR) protocol which uses the benefits of grid-based protocols. It allows sensors to disseminate data in an effective way toward a mobile sink. The grid heads of each grid switched between active and sleep modes. The head nodes which are not taking part in the routing put on sleep mode. In this way, the energy is saved and network lifetime is improved. MSGR avoid rerouting as compared to EAGER [18].

Table 1: Comparison of various routing protocols

Protocols	Year	Description	Outcomes
LEACH [1]	2000	It is a cluster based technique that randomly rotates cluster heads to distribute energy among all the sensor nodes in the network. In each round new cluster, heads collect and send data to the base station.	The randomized rotation (of cluster heads) and energy distribution (among nodes) schemes of LEACH protocol reduce more energy dissipation and enhance the lifetime of the network.
TEEN [2]	2001	This protocol is based on hierarchical clustering. Here the data from the cluster head can be sent directly to the base station or its aggregate and transmit via another cluster head called upper-level cluster head.	TEEN is very efficient in energy consumption and response time. So, it is well suited for time critical applications in WSN.

HEED [3]	2004	It is used for Ad-hoc wireless network. The cluster heads are probabilistically assigned which are based on the residual energy of nodes. HEED introduce a two-level hierarchical protocol to increase efficiency.	The probabilistic selection of cluster heads results in a uniform distribution across the network. HEED protocol is effective in prolonging the network lifetime and supporting scalable data aggregation.
TTDD [4]	2005	It is based on a grid structure where multiple mobile sinks are periodically enabled to receive data. Mobile sink floods its data queries to show its interest, however, this flooding is limited within a single cell of the grid structure only.	TTDD efficiently deliver data from multiple sources to multiple mobile sinks as compared to stationary sinks in large-scale WSN.
GROUP [5]	2006	It is a grid-based protocol where the only a small number of nodes participating in cluster head selection. Here the sensor nodes are dynamically organized into grid cluster and the energy load is evenly distributed among nodes.	GROUP is a multi-hop clustering protocol with lower delay. It is scalable and energy-efficient routing protocol for large-scale wireless sensor networks.
EEABR [6]	2006	It is based on ant colony optimization metaheuristic routing protocol. In this protocol with the help of special ants, the distance between nodes and base stations are optimized.	EEABR minimize communication workloads and save energy. It also contributes to increasing the lifetime of the wireless network.

3. CONCLUSION

This paper review some WSN protocols which improves network efficiency. Static WSNs are limited to achieve a better result. Mobile sink improves the capability of WSNs. But mobile sink scheduling is still a challenge. Sink traveling distance should be minimal as possible for energy consumption. Designing such energy efficient protocols is very important too. Grid-based structure perform better than conventional clustering approaches, which makes simple routing paths. It is capable of improving the network lifetime. ACO based routing is also considered in seek of optimal solutions. In future, we would like to work on a mobile sink scheduling strategy using ACO to find out optimal paths.

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