Journal of Engineering Sciences

Vol 11, Issue 7,July/2020

ISSN NO:0377-9254

A SURVEY ON ENERGY EFFICIENCY AND ROUTING CHALLENGES IN WIRELESS SENSOR NETWORK

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***Abstract*— Wireless sensor networks (WSNs) form an essential part of industrial application. There has been rising interest in the possible use of WSNs in applications such as environment monitoring, disaster management, health care monitoring, intelligence surveillance and defense reconnaissance. The energy-balanced routing protocols prolong the network lifetime by uniformly balancing the energy consumption among the nodes in the network. In this paper, we present a clear image of both the energy-efficient and energy-balanced routing protocols for WSNs. This paper gives a summary of different routing strategy used in wireless sensor networks and gives a brief working model of energy efficient routing protocols in WSN. We have also compared these different routing protocols based on metrics such as energy consumption, throughput, network lifetime, delay, packet delivery ratio. The study concludes with the recommendation to the future trend in the energy efficiency model for the sensor networks.**

***Keywords*— Wireless Sensor Networks Challenges, Routing in WSNs, Energy consumption, Network Lifetime, Energy Efficiency**

1. INTRODUCTION

Wireless sensor networks (WSNs) shows potential technology for monitoring large regions at high spatial and temporal resolution. [1] A wireless sensor network (WSN) consists of spatially extend self-directed sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to considerately pass their data through the network to a main location. Sensor nodes organize among themselves to produce high-quality information about the physical environment. [2] The upgrading of wireless sensor networks was forced by military applications such as battlefield surveillance; traffic avoidance, enforcement and control systems, industrial process control, environment monitoring, and so on. In [3-4] most of the applications sensor nodes are equipped with small, irreplaceable batteries with limited power capacity. [5]In contrast to other networks, this fact can be exploited at the network layer to improve energy efficiency and bandwidth requirements. [6]An energy-efficient hierarchical topology categorize method is familiar in WSN using time slots, in which a cluster-head selecting approach decreases the difference in the cluster size of LEACH and the task mechanism for the active node makes the energy consumption uniform in the cluster. The paper [7] has proposed several different approaches. In this paper, mobile nodes are used as the mobile sink which moves crossways the sensing field to collect data. On the other hand, the mobile sink reduces the communication overhead for sensor nodes close to the base station or the sink, which leads to the uniform energy consumption. In literature [8], when routing algorithms choose a path, the data packet is composed through the network, and the source node sends it to the nearest nodes in the network, randomly. The general diagram of WSN is shown in fig. 1[9].

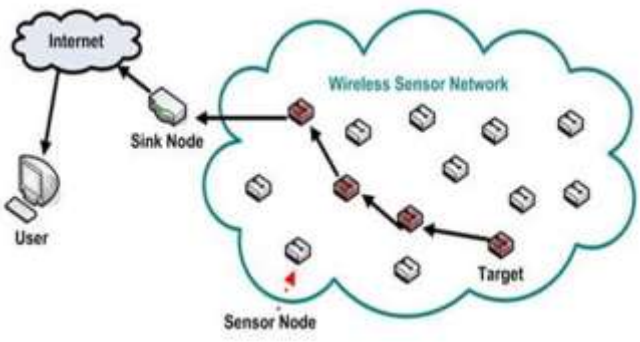

Figure 1 an Example of a WSN

2. RELATED WORK

The importance of developing energy-efficient and energy-balanced routing protocols for WSNs cannot be over emphasized. There are frequent ongoing works on the design of energy-efficient and energy-balanced routing protocols for WSNs. In this section we confer some previous work done in this field by some researchers as follows.

In this paper [10], they proposed a novel next-hop selection method; moreover, the routing loop and redundant hops detection and elimination mechanism have been built up. To expand the network lifetime, the energy-balanced routing algorithm builds its routes based on a weighted sum of node's depth, residual energy and energy density.

In this paper [11], an energy balanced routing protocol (EBRP) for wireless sensor networks is proposed and we divide the network into more than a few clusters by using K-means++ algorithm and select the cluster head by using the fuzzy logical system (FLS). This paper proposes a genetic algorithm (GA) to obtain the fuzzy rules.

In this paper [12], they propose energy efficient and reliable routing algorithm based on DS evidence theory (DS-EERA), the DS evidence theory is applied to WSN routing decision-making. For each sensor node, the factors such as residual energy, the shortest path to the sink node, node traffic, energy density of neighboring nodes and the forward space are taken into account when selecting the next hop. Thus, the above factors are abstracted into three indexes: "transmission energy efficiency ratio", "idleness degree" and "energy density factor", which can be observe as three evidences.

In this paper [13], Low Energy Adaptive Clustering Hierarchy (LEACH) is presented with the addition of Cuckoo Search (CS) and Support Vector Machine (SVM) concept. On the basis of healthy function, the nodes property such as energy consumed by each node is categorized. Those nodes that have higher energy compared to the defined function are put in one category and remaining in another category. These two categories of nodes are provided as an input to SVM and train the system.

In this paper [14], they proposed the use of LEACH (Low Energy Adaptive Clustering Hierarchy) algorithm to which ensures a balance among energy consumption and postponement to resolve energy problem in WSNs. In WSN, the major problem encounter is energy whole problem which results from energy depletion in the nodes near the BS. The CH collects the sense and processed information from the sensors and transmits them to the base station for the analysis.

The Following table shows the summary of related works.

Table I. Summary of related works

REFERENCES	PROPOSED WORK	TECHNIQUE USED	PERFORMANCE METRICS
Lin Li and Donghui Li (2018)	In this paper, we divide the network into several clusters by using *K*-means++ algorithm using the fuzzy logical system (FLS)	Proposed energy-balanced routing protocol (EBRP) genetic algorithm (GA)	EBRP prolongs the network lifetime by 57%, 63%, and 63%, respectively comparing with protocols such as LEACH, LEACH-C, and Stable Election Protocol (SEP)
Waleed KH.Alzubaidi (2019)	In this paper Network size have been increased, so it increased the rate of energy consumption.	Efficient cluster head selection algorithm and Authentication based secure routing clustering(ASRC)	ASRC prolongs network lifetime and improves energy efficiency based on packet delivery ratio by 0.9.
Sadeer Rasheed Ahmed, Mohammed Aboud Kadhim (2019)	This work proposed the use of LEACH (Low Energy Adaptive Clustering Hierarchy) algorithm to which ensures a balance between energy consumption and delay to resolve energy problem in WSNs	LEACH (Low Energy Adaptive Clustering Hierarchy) algorithm	Improvement of the network lifetime by 20%-25%
Navjot Kaur, Manish Mahajan, Rajeev Sharma (2019)	The problem of LEACH protocol like which node is considered as Cluster Head (CH) is overcome by CS (Cuckoo Search)	Low Energy Adaptive Clustering Hierarchy (LEACH) with Cuckoo Search (CS) and Support Vector Machine (SVM)	Increase Throughput value by 27.11% Reduction of energy consumption by 21.86 %
Haibo Liang, Shuo Yang, Li Li and Jianchong Gao (2019)	The paper proposes a method that uses improved LEACH protocol and the Voronoi diagram principle to cluster	Improved LEACH protocol	Network lifetime is increased by 127% Data packets received increased by 71.4%

C. Sivakumar, P. Latha Parthiban (2019)	Proposed system involves the design of LP search algorithm, which segregates the nodes into three groups with different energy level	a novel LP algorithm	Increased throughput by 23% Improved network lifetime by 10% Reduced energy consumption by 78%
Stephanie Mwika Mbiya, Gerhard P. Hancke, Bruno Silva (2020)	In this paper, a routing algorithm that uses centrality measures to select the shortest path (a low-energy path between the source and destination node) is implemented	An Efficient Routing Algorithm for Wireless Sensor Networks based on Centrality Measures	Proposed algorithm better than Dijkstra's algorithm based on execution time Proposed Algorithm : 1.6 Dijkstra's algorithm : 2.3
Liangrui Tang, Zhilin Lu and Bing Fan (2020)	In this paper, the DS evidence theory is applied to WSN routing decision-making	Energy Efficient and reliable routing algorithm based on DS evidence theory (DS-EERA)	DS-EERA algorithm is less than 25% with high energy efficiency The network lifetime of the DS-EERA is 170% and 310% longer than the MCRP and FLEOR respectively

3. WSN ROUTING TECHNIQUES

In this section, we explain the terms commonly used in the development of a WSN. Most significantly, some of these terms are used to organize the survey energy-efficient and energy-balanced routing protocols in consequent sections.

3.1. DATA-CENTRIC PROTOCOLS

In data-centric routing, the sink sends queries to definite regions and waits for data from the sensors located in the preferred regions. Since data is being requested through queries, attribute based naming is essential to specify the properties of data. SPIN is the first data-centric protocol, which considers data compromise between nodes in order to eliminate unnecessary data and save energy [15].

3.2 HOMOGENEOUS AND HETEROGENEOUS WSNS

WSNs can be categorized based on their infrastructure as homogeneous WSNs or heterogeneous WSNs. In homogeneous WSNs, all the SNs have comparable hardware components such as the sensing subsystems, processing subsystem, radio subsystem, and power supply unit. A major reason for propose heterogeneous WSNs is to equip some SNs with bigger sensing range and more battery power to attain longer transmission. Although deploying homogeneous WSNs can be quite easy in similarity to heterogeneous WSNs, heterogeneous WSNs are more useful in factual deployments because they are close to practical scenarios. Different energy-efficient and energy-balanced routing protocols have been proposed over the years assuming homogeneous or heterogeneous WSN structures.

4. ROUTING CHALLENGES AND DESIGN ISSUES IN WSN

The design of routing protocols in WSNs is induce by many challenging factors. These factors must be overcome before efficient communication can be achieved in WSNs.The Classification of Routing Protocols of WSN is shown in figure 2 [16].

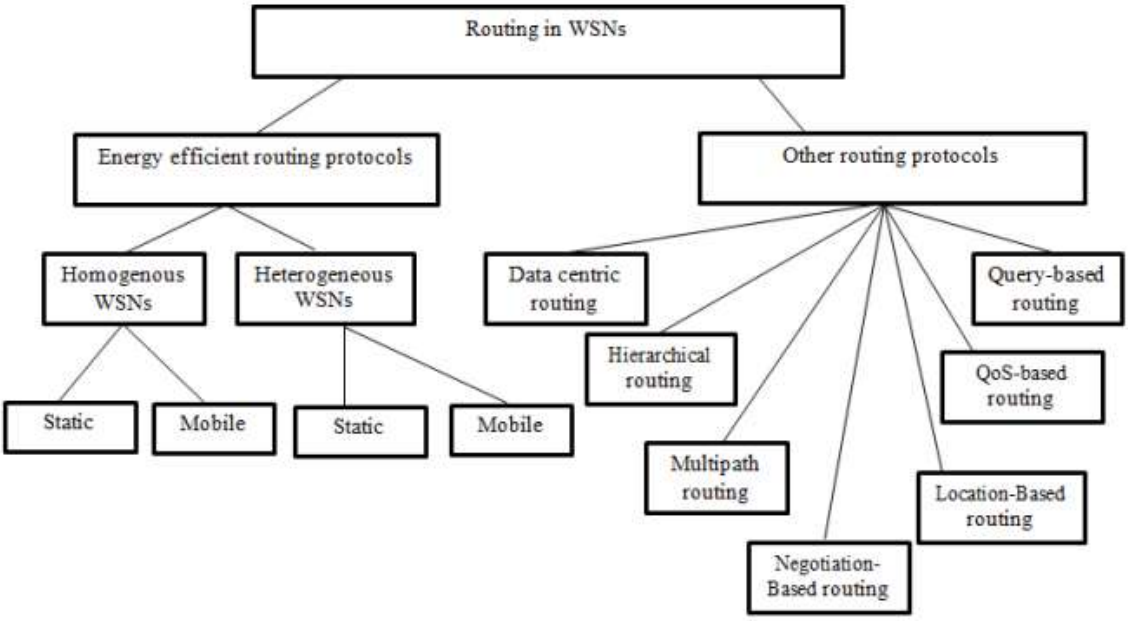

Figure 2 Routing Protocols

4.1 ENERGY CONSUMPTION WITHOUT LOSING ACCURACY

Sensor nodes can make use of their inadequate accept of energy performing computations and transmitting information in a wireless environment. As such, energy- control forms of interaction and computation are essential. In a multi hop WSN, each node plays a vital role as data sender and data router.

4.2 NODE/LINKHETEROGENEITY

In many studies, all sensor nodes were supposed to be homogeneous, i.e., having equal measurements in terms of computation, communication, and power. In whatever way, depending on the application a Sensor node can have different role or capability. The actuality of heterogeneous set of sensors elevated many technical issues related to data routing. Hence, the burden of transmission to the BS is operated by the set of cluster-heads

.4.3 FAULT TOLERANCE

Some sensor nodes may fail or be stopped due to lack of power, physical damage, or environmental intercession. The failure of sensor nodes should not affect the overall work of the sensor network. This may required hard adapt transmit powers and directing rates on the existing links to reduce energy consumption, or rerouting packets through regions of the network where more energy is accessible. Therefore, multiple levels of repetition may be needed in a fault-tolerant sensor network.

4.4 SCALABILITY

The number of sensor nodes position in the sensing area may be in the order of hundreds or thousands, or more. Any routing strategy must be able to work with this huge number of sensor nodes. In addition, sensor network routing protocols should be expansible enough to respond to events in the environment. Until an event occurs, most of the sensors can remain in the sleep state, with data from the few last sensors providing a coarse quality.

4.5 CONNECTIVITY

High node density in sensor networks prevents them from being completely separated from each other. Therefore, sensor nodes are supposed to be

highly connected. This, however, may not stop the network topology from being variable and the network size from being concentrated due to sensor node failures. In addition, connectivity depends on the, possibly random, dispersion of nodes.

4.6 QUALITY OF SERVICE

In some applications, data should be delivered within a short period of time from the moment it is sensed; or else the data will be useless. Therefore surrounded latency for data delivery is another situation for time-constrained applications.

5. CONCLUSION

Energy consumption is a major optimization problem relating to WSN applications in general. Concentrating on the energy consumed during data transmission, this survey paper reviewed different energy-efficient and energy-balanced routing protocols that attempt to extend the network lifetime and functionality by minimizing the energy consumption in the network. Comparison of these protocols is with the help of various performance metrics like throughput, network lifetime, Energy consumption, packet delivery ratio and Route discovery delay and energy efficient. This paper started with an introduction to Wireless Sensor network and different related work is reviewed followed by techniques used in WSN. Routing Challenges and design issues faced in WSNs are discussed next. Energy efficient routing which is the strong topic of research in WSNs section is discussed.

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