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A Discussion of WSN Energy Optimization Methods

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Abstract: *Over the course of many decades and the use of a wide range of technological approaches, the issue of optimizing energy consumption in wireless sensor networks (WSNs) has been resolved. These technologies may be categorized as those that entail making physical modifications to the network nodes or sensors, as well as those that involve making changes to the routing protocol, dealing with different optimizations on the network parameters, and so on. There were a few different protocols that were proposed as ways to increase the lifetime of the sensor node. As a consequence of these protocols, wireless energy transfer (WET) has been viewed as a potentially useful strategy for prolonging the lifetime of WSN. However, it is also feasible to save energy on the network by compressing the data flow inside the network, reducing the amount of overhead involved in transmission, and increasing the amount of energy that can be sent wirelessly.*

Keywords: Wireless Sensor Networks, Energy-Efficient Techniques

I. INTRODUCTION

A wireless sensor network is often characterized as a collection of cooperative sensors that are positioned to perceive different environmental factors like temperature, humidity, pressure, and so on. These sensors understand the information that their neighbors provide and use that interpretation to guide their placement. The sensing element, processing element, and power supply make up the crucial parts of the WSN, which are the sensors. Due to their simplicity and need for operation, the sensors' memory and power supply are always causes for worry. For the sensor networks to be accurate, they must thus be kept. When comparing memory and power sources, we must give the latter greater weight since they are the most important and fundamental components of the network. Energy conservation in sensor networks is the subject of a vast amount of study, which may be generally categorized into:

1. Developing a protocol to optimize energy. LEACH, PEGASIS, Low energy adhoc sensors. Delay aware routing protocol, TDMA protocols
2. Devising a hardware solution to optimize energy.
3. Dedicated sensors to optimize task on each sensor. (Load balancing)
4. Clustering approach to resolve energy consumption inthe network.
5. Introducing cloud to optimize the operation andstorage in sensors.
6. Optimization achieved through altering the datapacket parameter
7. Optimization achievedthrough varying sensorparameters.
8. Energy optimization using nature inspired algorithms.
9. Hybrid algorithms.
10. Energy reduction using miscellaneous methods.
11. Wireless Energy Transfer
12. Genetic algorithms

The rest of the paper is organized to cover the following 11 point in the literature survey and methodology consequently. Finallya conclusion based on the following work will be given at the conclusion section.

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II. LITERATURE SURVEY

Developing a protocol to optimize energy

This method has been identified to build a routingprotocol that ensures energy efficiency through optimization some of the case studies are made on the following protocols and the discussions are discussed as follows:

- TDMA
- LEACH
- PEGASIS
- DARA

TDMA: Time division multiple access protocol

Energy Aware Routing for Low Energy Ad Hoc Sensor Networks [1] is the first study that has been taken into consideration. In this work, optimum pathways are constructed to minimize processing and connection overheads throughout every network transmission. Additionally, a simulated study that was conducted demonstrates the improvement in network throughput when this technique was used. The implementation of Time Division Multiple Access (TDMA) protocols is the next strategy that is taken into consideration in order to save energy. In order to minimize communication overheads in the network, the paper "Energy-Efficient TDMA MAC Protocol for Wireless Sensor Networks Applications [2]" offers an efficient TDAM, MAC solution for railroad applications. In this study, the clustering heads are installed in railway carriages and the MAC layer has been rebuilt to accommodate the TDMA protocol that has been implemented on the network. A comparison is also made between this work and the Bit-Map aided Protocol (BMA).

LEACH: Low energy adaptive clustering hierarchy

The alternative strategy for energy conservation using routing protocol represents a significant scientific advance and was thought to be the best option. Low Energy Adaptive Clustering Hierarchy (LEACH) is the name of this technique [3]. In order to lessen the burden on a single sensor, LEACH suggests the following technique: randomized modulation of the high-energy cluster-head location via exchanges between the sensors. As a result, the network's burden is divided equally, and a cluster head is chosen to make sure the following procedures are followed across the board. The LEACH protocol views its iterations as rounds, with clusters forming during the set up phase, which initiates the transfer, and the stable phase, which transmits. Once this framework is completed, BS will get the data directly from the source.

PEGASIS: Power-efficient gathering in sensorinformation systems

PEGASIS, a chain-based protocol that gathers power efficiently in sensor information systems [4], joins nodes in the vicinity to send data to a sink. The initiative to send the data comes from the node that is closest to the base station. When a data transmission is required, a chain is established based on the random placement of nodes assigned weights.

DARA

Coordinated multi-input multi-output (MIMO) communications to increase WSN lifespan. Virtual antenna arrays, or virtual MIMO (VMIMO) nodes, are created by grouping together single-antenna sensor nodes. In this case, the author has created a distributed cooperative cluster protocol (CCP) to choose cluster nodes in order to balance the load and maximize energy and communication overhead. These chosen nodes will be referred to as cooperating nodes (CN), and an algorithm has been developed to identify the best CN.

Dedicated sensors to optimize task on each sensor

The available method is “Load balancing Based Approach to Improve Lifetime of Wireless Sensor Network [8]”, provides dedicated sensors to optimize task on each sensor. This approach accepts heterogeneous network which is formed by the sensor nodes with different energy levels and processing power. Cluster are made such that at least one high computing node is deployed nearby each other node. Initially the nodes with high energy level and processing power are nominated. Consequently a cluster head (CH) is elected and designated a communication range. The nodes with minimum energy are asked to sleep and the information of those nodes will be maintained with the CH. This

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repeats until the CH nodes energy reaches a threshold value, post which the CH activates sleeping nodes. Thus the energy isoptimized through load balancing

DARA

Proactive routing algorithms are the next strategy for energy conservation after DARA [5]. The packets' end-to-end latency is reflected in DARA. As a result, the router and the gateway route the packets. According to the protocol, every user should be connected to a router at the footprint, and there should always be a specified path from the router's incoming node to the gateway. The user may now choose the closest router and its footprint, however in order to prevent confusion, the user must select only one router.

Devising a hardware solution to optimize energy

In this approach the problem of energyconservation has two approaches: they are:

- Design level optimization
- New hardware development

Design level optimization [6]

It is also a proven method to reduce the energy consumed by sensors during the transmission. The details of this can be understood as follows:

Devising a new hardware

The research article "A Cooperative MIMO Framework for Wireless Sensor Networks [7]" offers an innovative method for communication optimization-based energy optimization. The author has suggested using clustering to address the network's energy usage. Two approaches that use a clustering strategy to tackle the energy optimization issue are presented and are as follows:

- EECS
- HEED

EECS: An energy efficient clustering scheme inwireless sensor networks [9]

It is a research article with an emphasis on pure clustering-based energy optimization. The LEACH protocol and the EECS protocol function similarly. In this case, the network is split up into groups, with a CH in each group. Communication between the CH and BS occurs in a single hop. The nodes send a first message to the group to verify the power level in order to start the data transmission. After the data is received, the nodes are allocated workloads and create clusters within the network.

HEED: Hybrid energy efficient distributed [10]

It is a clustering protocol, this one. It uses the elements of the network architecture that are regarded as secondary and the residual energy as the primary parameter. The main assumption is that each node starts off with the same quantity of energy, or homogeneity.

The impact of heterogeneity on node energy is examined in this research. In other words, certain sensors will be somewhat more energetic than the other nodes, forming the heterogeneity. We must add additional nodes to the sensor network in order to reenergize it since the existing nodes' lifespan is insufficient.

Introducing cloud to optimize the operation andstorage in sensors

Connecting sensor networks to the cloud is another approach that may be used for energy optimization [11]. The following concept is discussed in Design and Optimization of Traffic Balance Broker for Cloud-Based Tele health Platform. The memory allocation and server requests are handled by the cloud broker in this design.

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Optimization achieved through altering the datapacket parameter

The study "Energy Efficiency based Packet Size Optimization in Wireless Sensor Networks [12]" provides a clear explanation of packet size optimization, which is optimization accomplished by changing the data packet parameter. Noticing events, analyzing sensed data, and interacting with neighboring nodes are crucial WSN tasks. Due to the energy restriction, QoS parameters have been taken into account to enhance the aforementioned functions. This article proposes consumption characteristics and channelization as an alternative to the conventional Forward Error Correction technique for handling the parameters.

Optimization achieved through varying sensorparameters

The study "Energy -Efficient Target Coverage in Wireless Sensor Networks [13]" discusses target coverage mechanism as another energy optimization technique. In this mechanism, the sensor nodes are separated into many sets, each of which covers all the targets, in order to extend the network lifespan. Only one of these sensor sets is operational at a time due to their sequential triggering. Depending on the need, the sensors from the active set are either in the deep state or the active state. The network will last longer when it switches from active to sleep mode.

Energy optimization using nature inspired algorithms

An innovative method of optimizing energy utilizing Modified Particle Swarm Optimization and Ant Colony Optimization algorithms is presented in Optimization of Energy Consumption in Wireless Sensor Networks based on Nature-Inspired Algorithms [14]. These are the nature-inspired algorithms, such as Particle Swarm Optimization, Bee Colony Optimization, and Ant Colony Optimization, that alter the conventional algorithms' construction methods. To improve efficiency, a more sophisticated algorithm has been suggested here in place of the current ones.

Hybrid algorithms

In order to minimize energy consumption, mobile base stations, data mules, and mobile relays are taken into consideration in the paper Minimizing the Energy Consumption in Wireless Sensor Networks [15]. In this case, the data is collected by the mobile base station, and multiple hop transmission is needed to stabilize the transmission load. The base station rapidly runs out of battery power as it computes the data from the visiting nodes.

Energy reduction using miscellaneous methods

The term "Data Mules" refers to the makeshift version of mobile stations that gather data from sensor nodes and transmit it to the base station. They function similarly to the polling officials who regularly visit the station to see whether any data is available. They now additionally create a route that is able to detect data mobility and optimize accordingly. On mobile stations, data relays are also a type of replacement.

Wireless energy transfer

Wireless Energy Transfer is a potential method of energy optimization that is presented in the article "Throughput Optimization for Massive MIMO Systems Powered by Wireless Energy Transfer." In wireless networks, far-field wireless energy transfer benefits devices with low power [1]. The term "WET" describes the process of moving energy from a power transmitter to a power receiver using radiative electromagnetic waves. Since the electromagnetic frequency (EM) is decreasing quickly across space, in order to comprehend WET in practice, the EM energy must be concentrated into a tiny ray in order to provide an effective power broadcast—a process known as energy beam formation.

Genetic algorithms

Energy optimization in wireless sensor networks has also been achieved via the use of evolutionary algorithms. GAEEP is one such energy optimization approach that is inspired by genetic algorithms [16]. The purpose of this article is to accomplish network scalability and lifespan exploitation by clustering sensor nodes. The following is a tabulation of metrics used to support the clustering strategy, based on the work previously discussed:

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Derivational model on pure clustering and comparisonstudy

Clustering is a widely utilized technique for determining the energy optimization solution in the WSN. When designing a routing protocol, the clustering strategy is a tried-and-true way to solve the node lifespan issue. As a result, a vital routing protocol with a suitable algorithm to fulfill the objective is created. Hierarchical routing is one option that may be selected in this regard [18]. Clustering taxonomy [20] is the word that will be used throughout the remainder of the text.

Node

- **Ordinary node:** It is node that does not participate in the clustering activities and it would just sniff around the network to analyses the incoming and outgoing packets.
- **Gateway:** This node is responsible from transmission of packets from source to destination.
- **Cluster Head:** The node that will be elected in the cluster to be a head to initiate the process of communication and monitor the cluster.
- **Clustering attributes of clusters**
- **Cluster count:** It is the number of clusters that are present in the network and based on the cluster count we can categories the clustering schemes as :
- **Fixed cluster:** The scheme is called to be fixed if the number of clusters are fixed and predetermined by the CH.
- **Variable cluster:** The scheme is called to be variable ifthe number of clusters is not predetermined and the CH forms a cluster randomly.
- **Cluster size:** It refers to the number of nodes in the cluster. There is classification of the network based onthis as:
- **Uniform Clusters:** The networks are formed by clusters which have equal number of nodes in all the clusters.
- **Non-Uniform Clusters:** The networks are formed by clusters which have unequal number of nodes in all the clusters.
- **Intra cluster schemes:** It speaks about the data dissemination from source to destination in WSN that incorporated clustering. There are 2 schemes in this, namely:
- **Single hop intra cluster routing:** Here the data is transmitted from source to CH directly.
- **Multi hop intra cluster routing:** Here the data is transmitted to CH through multiple hops.
- **Inter cluster communication:** Here the communicationis between the CH and BS directly which is single hop communication.

Capabilities of CH

- Agility: It refers to the movement of clusters and here the classification is made as:
- Mobile clustering: Here the CH moves around thecluster and hence the cluster structure has to be preserved.
- Stationery clustering: Here the CH is fixed and movesonly in the limited area.
- Functionality: It describes about the functions that are performed on a cluster and they are:
- Management of data by the CH
- Maintaining structure of data by the CH
- Consistency in energy: It is about the energy distribution in the cluster. There are 2 classification which are:
- Homogenous energy cluster where the energy distribution is equal in the cluster and election of CH is random.
- Heterogeneous energy cluster where the energy distribution is unequal in the cluster and hence CH election is predetermined.

Clustering activities that are scheduled from initial tofinal phase of the network are

Construction cluster: This is about how the clusters are formed in the network and there are also schemes related to this. They are:

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- Distributed Cluster formation: A cluster is formed in the network which is a result of all the nodes and their equal participation.
- Centralized Cluster formation: Here the clusters are formed by the CH alone.
- Hybrid Cluster formation: It is a combination of the above said methods.
- Cluster head selection: The selection of the cluster head can be done is these two possible ways:
- Prior assigned: CH is elected out of various parameters of cluster
- Random: CH election is done in random.

Clustering algorithm characteristics

- Convergence Rate: Here the algorithms are classified based on the convergence time i.e., more the number of nodes converge to the time at the same time more constant is the rate and for variable it is contradictory to the above statement.
- Distribution estimation: Here the classification is made on the coverage of nodes in the cluster, based on which it is either termed as probabilistic od iterative.

Classification of clustering

We cluster using a number of different approaches. Generally speaking, depending on where the cluster configuration is situated, it may be divided into two categories: intra- and inter-cluster routing. Since we are primarily concerned with energy optimization inside the cluster, intra-clustering is the routing approach that has been selected. Non-intensity based and intensity based regions make up the areas in the intra-cluster routing. The network is shown to consume more energy in the intensity zone due to the high data rate and volume of transactions. This is the actual section where the energy optimization has to be applied. Here, multi-hop routing is employed, which consumes less energy by sending the necessary data to the nearest node and then routing it to the intended receiver rather than sending it directly to the destination. Intensity-based zones use the TDMA approach, while non-intensity sectors utilize the CSMA/CA method. These days, choosing a cluster head is a problem, and LEACH and LEACH-C are the techniques for doing this. The network sink in LEACH-C schedules and synchronizes data based on information received from the cluster head and cluster. The cluster head selection process starts as soon as the node has sufficient energy remaining to complete the cycle.

Characterizing the hierarchical clustering on the WSN, four categories are used:

- Chain based routing
- Tree based routing
- Grid based routing
- Area based routing
- Chain based hierarchical routing:
- The algorithms that are identified are:

III. CONCLUSION

After comparing all of the previously mentioned works, it can be concluded that a novel routing protocol that aids in WSN energy optimization has been developed via extensive study. By inserting the many parameters that have been mentioned, every category that has been covered so far culminates in the production of an algorithm. Therefore, utilizing a clustering technique, it is suggested to build a new routing protocol that suffices the current situation.

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