IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

ISO 3297:2007 Certified ⁜ Impact Factor 7.047 ⁜ Vol. 10, Issue 10, October 2022

DOI: 10.17148/IJIREEICE.2022.101002

A Review of Energy Optimization Techniques for Wireless Sensor Networks

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Abstract: Wireless Sensor Networks (WSNs) have come predominant in both artificial operations as well as particular use. With the arrival of Internet of Things (IoT) there has been emphasis on exploration, development and operation of WSNs. WSN nodes are characterized by low processing power, limited continuance, and immobility. Our major objective is to plan and develop a WSN irrespective of these constraints with high quality. In this paper we've presented an in-depth analysis of one of these constraints i.e., limited power availability in WSNs. We've presented a review of major ways to conserve power in WSNs. Especial focus is given on AI grounded power optimization ways including clustering, fuzzy logic, neural network- based ways etc.

I. INTRODUCTION

A WSN is a network of sensor nodes that communicate wirelessly and are posted over a large geographical area. Each node in WSN consists of at least 3 subcomponents - a sensor to sense the terrain in which it's posted, a processor for processing and storage - for storing data temporarily until it's transferred to a base station and a wireless transceiver for transmitting and entering data from other nodes or from base station. In order to power the discussed factors, WSN nodes generally also have an embedded battery inside them. The capacity of this battery is too limited and it's also inconvenient or occasionally indeed hard to constantly replace the battery because of the harsh terrain in which the WSNs are supposed to work. So, it's of consummate need to conserve as much energy as possible.

The general armature of WSN is shown in figure 1. The WSN consists of a sink node which is occasionally also appertained to as base station. WSNs also consists of a large number of sensors or sensors that are strategically placed above a large geographical area. The area over which the sensor nodes are spread is also called sensor field. The sensors as well as the sink can be stationary or moving. The sink is generally also connected with internet or some other form of WLAN. Users can operate and cover the entire WSN ever using the sink node.

All of the operations of WSN consume energy to work. Still the largest part of energy is consumed in transmitting messages from sensor node to sink node (long distance communication). Other operations like seeing of terrain or processing of data etc., typically consumes way too less energy than transmitting data. Energy conservation ways in WSNs generally follow two ways- either reduce the frequency of data communication from sensor node to sink node or reduce the frequency or quantum of data sensed by sensor nodes. This paper performs a check or further meetly a relative study of various WSN power optimization ways. Major emphasis is to reduce energy consumed during communication in WSN. Utmost of the ultramodern exploration and research apply artificial intelligence ways like clustering, neural networks, fuzzy logic, extreme literacy machines to achieve this thing. Therefore, these techniques take a centre stage in our study as well. We'll be exploring the major design principles, features and working of the current state of the art as well as under exploration energy conservation ways of WSNs.

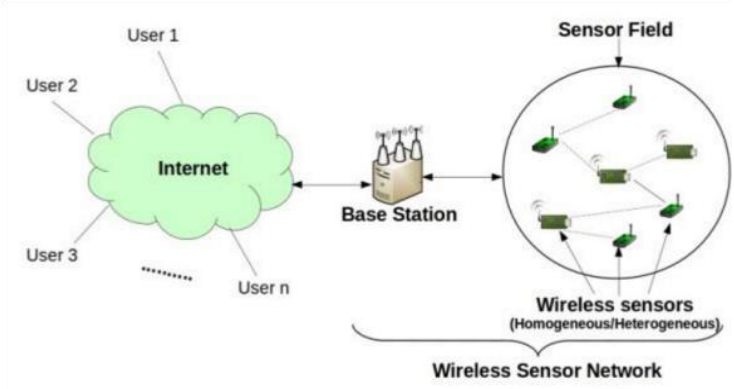

Fig 1 : The general architecture of WSN

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The rest of the paper is organized as follows- section two provides an overview of some affiliated work done in this field, section three discusses taxonomy of power optimization ways in WSNs. Section four compares these ways grounded on various parameters along with their advantages as well as failings. Section five concludes the paper and give further direction to our work.

II. RELATED WORK IN THIS FIELD

In (1), researches have handed us with a broad check of various energy conservation ways present in WSNs. They've given taxonomy of traditional energy effectiveness ways as well as the under- development energy effectiveness ways of WSNs. At the most abecedarian position, there are three energy conservation ways duty cycling, data driven approaches and mobility grounded approaches.

In duty cycling technique, a node goes into off- state or sleep state whenever a communication isn't needed. Since communication is needed veritably infrequently so putting a node in sleep state saves lot of energy. In data driven approaches, the major focus is how the data is sensed which also vastly effects the energy consumption of WSN. There are lots of samples sensed which aren't needed for calculations. Gratuitous calculation in the power constrained WSN node also impacts its battery longevity. Mobility grounded approaches focus on the mobility of WSN nodes. If a sensor node is mobile also it concentrates on how to collect its data. However, how it'll bear the communication, how it'll impact the overall network etc.

I.F. Akyildiz et al. in (2) provides a study on ultramodern day WSNs. They first bandy some introductory languages used in WSNs and also explore various sensing tasks. Next, they bandy various operations of WSNs. They also enumerate various factors that impact the overall design of a sensor node. They also bandy the communication armature of WSNs along with various algorithms and protocols that provide the working of WSNs. Eventually they discuss some exploration challenges in consummation of WSNs.

In (3) Ameer Ahmed Abbasi et al. gave a check of various clustering algorithms that are specifically designed for WSNs. They bandied about various confluence time algorithms where convergence time is the time needed ahead of all the routers or cluster heads reach an agreement about the topology of the WSN. They classified clustering algorithms in two orders-variable confluence time algorithms, constant confluence time algorithms. Variable confluence time algorithms are useful when number of nodes in WSN is low while constant confluence time algorithms are useful when number of nodes in WSNs is high.

A detailed performance evaluation of data aggregation in clustering grounded WSNs is handed by Adwitiya Sinha et al. in (4). They've collected sensor nodes grounded on their entropy. originally, sensors sensing analogous kind of data are placed in distinct clusters. In the worst case if no further cluster can be formed, also divergence of a node is calculated with respect to each cluster also nodes are placed in least divergent clusters. Incipiently they estimated performance of their scheme grounded on various parameters like confluence rates, average packet drop, transmission cost etc, using NS2 simulator. Their result demonstrate that their proposed scheme outperforms various current saving schemes of WSNs.

Dervis Karaboga et al. (5), proposed one further scheme for clustering in WSNs using bee colony algorithm. In bee colony algorithm, we try to pretend the behaviour of honey bee masses. The experimenters have proposed new algorithms called ICWAQ to produce cluster and elect cluster heads. Their proposed ICWAQ algorithm not only prolongs WSN continuance but also improves QoS of the WSN. Their experimental results show that ICWAQ works creditably with respect to other algorithms.

A fuzzy sense grounded clustering fashion is proposed by Jin- Shyan Lee et al. in (6). They've stoked fuzzy logic in LEACH algorithm for WSNs. In their fashion called LEACH- ERE, the cluster head is named using a fuzzy approach which focuses on anticipated residual energy which is the residual energy left in a sensor node if it'll be named as cluster head and complete its round. Therefore, the outflow of getting the cluster head is more effectively distributed among the various nodes in a cluster. Their simulation results show that the proposed scheme is more effective than utmost of other distributed algorithms for WSNs including LEACH and CHEF.

In (7), the experimenters have proposed yet another fuzzy grounded scheme for cluster head selection. Still, unlike other schemes, the selection of cluster heads will be carried out in the base station. The fuzzy inputs chosen by them are energy plane of sensor nodes and physical distance to base station. Their experimental result demonstrate that their proposed scheme is suitable to reduce energy consumption in First Node Diet (FND) round as well as it has also increased the outturn of the base station before FND.

III. CATEGORISATION OF POWER OPTIMIZATION TECHNIQUES

Power optimization ways can be mainly classified into five distinct orders as shown in figure2 - radio transmission optimization, reducing data inside WSN, power optimized routing modes, sensor nodes sleep / wake mechanisms and energy starvation modes etc.

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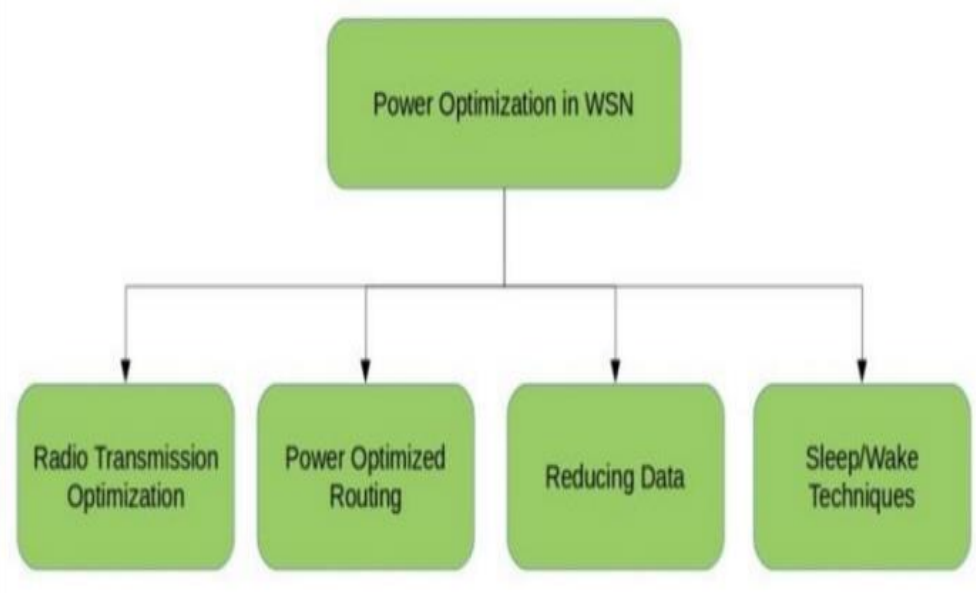

Fig 2: ways to achieve Power Optimization

Radio Transmission Optimization:

This is the first order of power optimization fashion which involves reducing the power consumed by radio element of a WSN. The radio sub element is responsible for transceiving (transmitting as well as receiving) the data to and from Sink node. Radio optimization can be farther be divided as perfecting modulation, cooperative communication, optimizing transmission power, designing intelligent radios that can elect the most applicable radio channel etc.

Power Optimized Routing technique:

Routing in WSN is needed in multihop WSN whilst the space among sensor node and sink is so big that records can't be transmitted at once among them. Routing additionally consumes a large amount of a assets of a useful resource confined sensor node. The nodes towards sink are regularly stressed with extra undertaking of routing records on behalf of the entire WSN to sink. This outcomes in rapid depletion of battery of nodes towards sink. Power optimized routing may be carried out via clustering, multipath routing, routing the usage of relay nodes or repeaters etc. In cluster primarily based totally routing the WSN is split into clusters or agencies and every cluster is controlled through a cluster head which is chosen from one of the nodes within the cluster. All the nodes belonging to a cluster first transmit their cluster head which in flip transmit it to sink node. Thus, power is conserved when you consider that majority of nodes best should transmit records over a completely brief range. In multipath routing techniques, there may be a couple of routes from sensor nodes to sink node on which records is transmitted. This now no longer best reduces community congestion however additionally distributes workload of routing. The drainage of battery at the paths from sensor node to sink is likewise decreased in comparison to unmarried route routing. In relay primarily based totally routing, more advantageous functionality nodes may be located in vital positions of WSN. They can assist in records transmission, evaluation and interpretation. Also, the sink node also can be made cell in order that maintains on transferring inside the WSN and collects records from diverse parts. Thus, no unique set of nodes could be overloaded with extra records transmission duties and could bring about longevity of the WSN.

Reducing data inside WSN:

Another popular fashion of power optimization is reducing the quantum of data generated, reused or transmitted in WSN. Data reduction inside WSN can be primarily achieved by two ways- reducing the frequency of sample collection and limiting gratuitous sample collection. Apart from this, other computer ways similar as data contraction and network coding can also be employed to dwindle the sensed data. Also, there are certain parameters that are largely identified and one can be inferred from the other. Therefore, this correlation can also be exploited to lessen the volume of data.

Sensor nodes sleep-wake mechanisms

A sensor node constantly eat power whether or not it`s operating or it is idle. A node in idle state may not do something but eat the analogous quantum of power as an operating node. Therefore, the pleasant end result to place the idle nodes in sleep mode and wake them up while there is a venture for them. The sleep wake mechanisms use a vital way referred to as responsibility cycling. Diverse nodes in a WSN are not stored unsleeping all of the time. Rather they are alternately

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positioned to sleep wake mode grounded on a few rested criteria. The nodes are probably sound asleep and may be wake up if a want arises or they are able to set their agenda comparable that they sleep for a while and additionally live unsleeping ultimately or they are able to sleep for arbitrary period of time earlier than waking up.

IV. COMPARISON OF SOME EXISTING POWER OPTIMIZATION TECHNIQUES IN WSN

Here we give a relative study of some of the best-known pathways and studies in WSN. The comparison is based on the following criteria - broadness, supporting generality, and elegance. The first criterion, i. H. In a broad domain, specific modes belong based on the previously mentioned classification (radio transmission optimization, power optimized routing, data reduction in WSN, sensor node sleep/wake mechanism, or other style) Define a domain. Alternative standards provide a foundation or key concept underlying a particular fashion. The final criterion is the benefits that certain fashions offer over others. There are many options in use or under development for energy optimization. We have shortlisted the measures that we consider to be important.

COMPARISON OF POWER OPTIMIZATION TECHNIQUES IN WSN

Technique	Broad Area	Underlying Concept	Merits
[8]	Routing	Clustering, Reactive Networks	Especially suited for time critical applications
[9]	Routing	Clustering randomized rotation of cluster heads	Achieves energy conservation of 8x than direct transmission
[10]	Reducing data	Context aware, rule-based framework	More energy reduction based on the context of sensor data
[11]	Others	Energy harvesting schemes	Sensor battery can be repleted in the field
[12]	Routing	Clustering, reducing energy consumption at hotspots	Useful when size of cluster cannot be determined in advance

Table 1: Comparision Table of Power Optimization Techniques in WSN

V. CONCLUSION

This paper provides an overview of various power saving schemes for WSN. We first compiled a taxonomy of power saving schemes, and many important ones were detailed, analysed and compared. One conclusion that can be drawn from this research is that most of the state-of-the-art research is focused on one specific method rather than combining two or more methods to save energy. We also have to consider the fact that with the advent of ubiquitous computing and the Internet of Things (IoT), there will soon be large, sophisticated and diverse sensor networks rather than simple standalone WSNs, so We need to analyse how it changes. This has implications for WSN's current power saving schemes, but this is left as unborn work for current research.

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