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A Survey of Energy Optimization Techniques In Wireless Sensor Networks

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Abstract: Wireless Sensor Network (Wans) have become predominant in both industrial applications as well as personal use. With the advent of Internet of Things (IoT) there has been a re-emphasis on research, development and application of WSNs. WSN nodes are characterized by low processing power, limited lifetime, and lack of mobility. So the major challenge is to design a high quality WSN irrespective of these constraints. In this paper we have presented an in depth analysis of one of these constraints i.e., limited power availability in WSNs. We have presented a review of major techniques to conserve power in WSNs. Especial focus is given on AI based power optimization techniques including clustering, fuzzy logic, nueral network based techniques etc.

Keywords: WSN, sensors, wireless sensor networks, energy efficiency, power optimization.

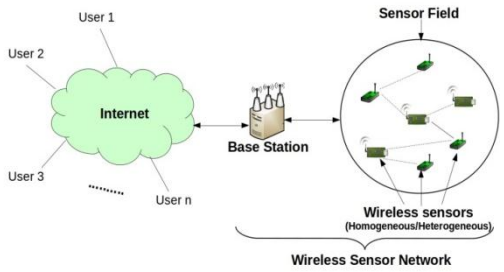
I. INTRODUCTION

A WSN is a network consisting of sensor nodes that communicate wirelessly and are deployed over a large geographical area. Each node in WSN consists of at least 3 subcomponents- a sensor to sense the environment in which it is deployed, a processor for processing and/or analyzing sensed data, storage- for storing data temporarily until it is sent to a base station and a wireless transceiver for transmitting and receiving data from peer nodes or from base station. In order to power the above mentioned components WSN nodes usually also have an embedded battery inside them. The capacity of this battery is very limited and it is also very inconvenient or sometimes even impossible to frequently replace the battery because of the harsh environment in which the WSNs are usually deployed. So it is of paramount importance to conserve as much energy as possible.

The general architecture of WSN is shown in figure 1. The WSN consists of a sink node which is sometimes also referred to as base station. WSNs also consists of a large number of sensors that are distributed above a large geographical area. The are 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 usually also connected with internet or some other form of WAN. Users operate and monitor the entire WSN remotely using the sink node.

All the operations of WSN consume energy. However the highest percentage of energy is consumed in transmitting messages from sensor node to sink node (long distance communication). Other operations like sensing of environment or processing of data etc. normally consumes way too less energy than transmitting of data. Energy conservation techniques in WSNs usually follow two techniques- either reduce the frequency of data communication from sensor nodes to sink nodes or reduce the frequency or amount of data sensed by sensor nodes.

This paper performs a survey or more appropriately a comparative study of various WSN power optimization techniques. Major emphasis is to reduce energy consumed during communication in WSN. Most of the modern research apply artificial intelligence techniques like clustering, neural networks, fuzzy logic, extreme learning machines to achieve this goal. Thus these technique takes a center stage in our study as well. We will be exploring the major design principles, features and working of the current state of the art as well as under research energy conservation techniques of WSNs.



Architecture of Wireless Sensor Network

The rest of the paper is organized as follows- section two provides an overview of some related work done in this field, section three discusses taxanomy of power optimization techniques in WSNs. Section four compares these techniques based on various parameters along with their applicability as well as shortcomings. Section five concludes the paper and give future direction to our work.

II. RELATED WORK

In [1], researches have provided us with a broad survey of various energy conservation techniques present in WSNs. They have given taxonomy of traditional energy efficiency techniques as well as the under-development energy efficiency techniques of WSNs. At the most fundamental level, there are three energy conservation techniques- duty cycling, data driven approaches and mobility based

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approaches. In duty cycling technique, a node goes into off-state or sleep state whenever a communication is not required. Since communication is required very rarely so putting a node in sleep state saves lots of energy. In data driven approaches, the major focus is how the data is sensed which also considerably impacts the energy consumption of WSN. There are lots of samples sensed which are not at all required. Also unnecessary computation in the power constrained WSN node also impacts its battery life. Mobility based approaches focus on the mobility of WSN nodes. If a sensor node is mobile then it focus on how to collect its data, how it will relay the message, how it will impact the overall network etc.

I.F. Akyildiz et al. in [2] provides a study on modern day WSNs. They first discuss some basic terminologies used in WSNs and then explore various sensing tasks. Next they discuss various applications of WSNs. They also enumerate various factors that impact the overall design of a sensor node. They also discuss the communication architecture of WSNs along with various alogorithms and protocols that facilitate te working of WSNs. Finally they discuss come research challenges in realization of WSNs.

In [3] Ameer Ahmed Abbasi et al. gave a survey of various clustering algorithms that are specifically designed for WSNs. They discussed about various convergence time algorithms where convergence time is the time required before all the routers/cluster heads reach an agreement about the topology of the WSN. They classified clustering algorithms in two categories- variable convergence time algorithms, constant convergence time algorithms. Variable convergence time algorithms are useful when number of nodes in WSN is low while constant convergence time algorithms are useful when number of nodes in WSNs is high.

A detailed performance evaluation of data aggregation in clustering based WSNs is provided by Adwitiya Sinha et al. in [4]. They have clustered sensor nodes based on their entropy. Firstly, nodes sensing similar kind of data are placed in distinct clusters. In the worst case if no more cluster can be formed, then divergence of a node is calculated with respect to each cluster then nodes are placed in least divergent clusters. Lastly they evaluated performance of their scheme based on various parameters like convergence rates, average packet drop, transmission cost etc. using NS2 simulator. Their result demonstrate that their proposed scheme outperform various current energy conservation schemes of WSNs.

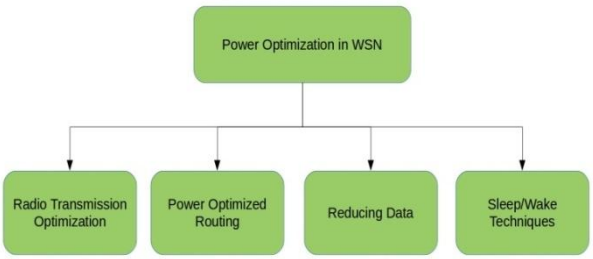
Dervis Karaboga et al. [5], proposed one more scheme for clustering in WSNs using bee colony algorithm. In bee colony algorithm, we try to simulate the behavior of honey bee swarms. The researchers have proposed new algorithms called ICWAQ to create cluster and select cluster heads. Their proposed ICWAQ algorithm not only prolongs WSN lifetime but also improves QoS of the WSN. Their experimental results show that ICWAQ works respectably with respect to other algorithms.

A fuuzy logic based clustering technique is proposed by Jin-Shyan Lee et al. in [6]. They have augmented fuzzy logic in LEACH algorithm for WSNs. In their technique called LEACH-ERE, the cluster head is selected using a fuzzy approach which focuses on expected residual energy which is the residual energy left in a sensor node if it will be selected as cluster head and complete its round. Thus the overhead of becoming the cluster head is more appropriately distributed among the various nodes in a cluster. Their simulation results show that the proposed scheme is more efficient than most of other distributed algorithms for WSNs including LEACH and CHEF.

In [7], the researchers have proposed yet another fuzzy based scheme for cluster head selection. However, unlike other schemes, the selection of cluster heads will be carried out in the base station. The fuzzy inputs chosen by them are energy level of sensor nodes and physical distance to base station. Their experimental result prove that their proposed scheme is able to reduce energy consumption in First Node Dies (FND) round as well as it has also increased the throughput of the base station before FND.

III. TAXONOMY OF POWER OPTIMIZATION TECHNIQUES IN WSNS

Power optimization techniques can be broadly classified into five distinct categories as shown in figure 2- radio transmission optimization, reducing data inside WSN, power optimized routing techniques, sensor nodes sleep/wake mechanisms and energy repletion techniques etc.



Architecture of Wireless Sensor Network

Radio Transmission Optimization:
This is the first category of power optimization technique which involves reducing the power consumed by radio component of a WSN. The radio sub component is responsible for transcieving (transmitting as well as receiving) the data to and from sink node. Radio optimization can be further sub categorized as : improving modulation, collaborative communication, optimizing transmission power, designing intelligent radios that can select the most appropriate radio channel etc.

Power Optimized Routing Technique
Routing in WSN is required in multihop WSN when the distance between sensor node and sink is so large that data can not be transmitted directly between them. Routing also consumes a considerable amount of a resources of a resource constrained sensor node. The nodes closer to sink are often burdened with additional task of routing data on

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behalf of the whole WSN to sink. This results in fast depletion of battery of nodes closer to sink. Power optmized routing can be achieved through clustering, multipath routing, routing using relay nodes or repeaters etc. In cluster based routing the WSN is divided into clusters or groups and each cluster is managed by a cluster head which is selected from one of the nodes inside the cluster. All the nodes belonging to a cluster first transmit their cluster head which in turn transmit it to sink node. Thus energy is conserved since majority of nodes only have to transmit data over a very short range. In multipath routing techniques, there is more than one path from sensor nodes to sink node on which data is transmitted. This not only reduces network congestion but also distributes workload of routing. The drainage of battery on the paths from sensor node to sink is also reduced as compared to single path routing. In relay based routing, enhanced capability nodes can be placed in crucial positions of WSN. They can help in data transmission, analysis and interpretation. Also the sink node can also be made mobile so that keeps on moving within the WSN and collects data from various parts. Thus no particular set of nodes will be overloaded with additional data transmission tasks and will result in longetivity of the WSN.

Reducing data inside WSN

Another popular technique of power optimization is reducing the amount of data generated, processed or transmitted in WSN. Data reduction inside WSN can be primarily achieved by two techniques- reducing the frequency of sample collection and limiting unnecessary sample collection. Apart from this, other computer techniques such as data compression and network coding can also be utilized to diminish the sensed data. Also there certain parameters that are highly correlated and one can be implied from the other. Thus, this correlation can also be exploited to lessen the quantity of data.

Sensor nodes sleep wake mechanisms

A sensor node always consume energy whether it is working or it is idle. A node in idle state will not do anything yet consume the similar amount of energy as a working node. Thus the best solution to put the idle nodes in sleep mode and wake them up when there is a task for them. The sleep wake mechanisms utilize an important technique known as duty cycling. Various nodes in a WSN are not kept awake all the time. Rather they are alternatively put to sleep wake mode based on some predicated criteria. The nodes might be sleeping and can be awaken if the need arises or they can set their schedule such that they sleep for some time and then stay awake for sometime or a they can sleep for random duration of time before waking up.

IV. COMPARISON OF SOME EXISTING POWER OPTIMIZATION TECHNIQUES IN WSN

Now we provide a comparative study of some of the popular techniques and researches in WSNs. The comparison is done based on the following criteria- broad area, underlying concepts and merits. The first criteria i.e., broad area defines in which area a particular technique belongs based on the aforementioned taxonomy (radio transmission optimizatiom, power optimized routing, reducing data inside WSN, sensor node sleep wake mechanisms, or other methods). The second criteria provides the underlying or main concept which acts as a cornerstone of a given technique. The last criteria is merit that given technique provides over others. There numerous power optimization techniques that are either in use or under development. We have shortlisted those techniques which we think are of significant importance.

V. COMPARISON OF POWER OPTIMIZATION TECHNIQUES IN WSN

Technique	Broad Area	Underlying Concept	Merits
[8]	Routing	Clustering, Reactive Networks	Specially 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 can not be determined in advance
[13]	Sleep/Wake	Coverage-guarantee, clustering	The entire network is guaranteed to be covered, energy balance

CONCLUSION

This paper gives an overview of the various power conservation schemes in WSNs. We first discussed the taxonomy of power conservation schemes and then discussed, analyzed and compared few important ones in detail. One conclusion that we can draw from this study is that most of the modern day researches focus on only one specific technique rather than focusing on a a combination of two or more techniques to conserve power. Also with the advent of ubiquitous computing and Internet of Things(IoT), we also have to consider the fact that soon there won't be simple standalone WSNs rather there will be large convoluted heterogeneous sensor networks so we will have to re-analyze how they will impact the current

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power conservation schemes for WSNs which is left as a future work to our current study.

REFERENCES

[1]. Anastasi, G., Conti, M., Di Francesco, M., & Passarella, A. (2009). Energy conservation in wireless sensor networks: A survey. Ad hoc networks, 7(3), 537-568. Akyildiz, Ian F., et al. "Wireless sensor networks: a survey." Computer networks 38.4 (2002): 393-422.
[2]. Abbasi, Ameer Ahmed, and Mohamed Younis. "A survey on clustering algorithms for wireless sensor networks." Computer communications 30.14 (2007): 2826-2841.
[3]. Sinha, Adwitiya, and Daya Krishan Lobiyal. "Performance evaluation of data aggregation for cluster-based wireless sensor network." Human-Centric Computing and Information Sciences 3.1 (2013): 1-17.
[4]. Karaboga, Dervis, Selcuk Okdem, and Celal Ozturk. "Cluster based wireless sensor network routing using artificial bee colony algorithm." Wireless Networks 18.7 (2012): 847-860.
[5]. Lee, Jin-Shyan, and Wei-Liang Cheng. "Fuzzy-logic-based clustering approach for wireless sensor networks using energy predication." Sensors Journal, IEEE 12.9 (2012): 2891-2897.
[6]. Siew, Zhan Wei, et al. "Fuzzy logic based energy efficient protocol in wireless sensor networks." ICTACT J. Commun. Technol.(IJCT) 3.4 (2012): 639-645.
[7]. Younis, Ossama, Marwan Krunz, and Srinivasan Ramasubramanian. "Node clustering in wireless sensor networks: recent developments and deployment challenges." Network, IEEE 20.3 (2006): 20-25.
[8]. Manjeshwar, Arati, and Dharma P. Agrawal. "TEEN: a routing protocol for enhanced efficiency in wireless sensor networks." Parallel and Distributed Processing Symposium, International. Vol. 3. IEEE Computer Society, 2001.
[9]. Heinzelman, Wendi Rabiner, Anantha Chandrakasan, and Hari Balakrishnan. "Energy-efficient communication protocol for wireless microsensor networks." System sciences, 2000. Proceedings of the 33rd annual Hawaii international conference on. IEEE, 2000.
[10]. Chong, Suan Khai, et al. "Energy conservation in wireless sensor networks: a rule-based approach." Knowledge and information systems 28.3 (2011): 579-614.
[11]. Tuna, Gurkan, Vehbi Cagri Gungor, and Kayhan Gulez. "Energy harvesting techniques for industrial wireless sensor networks." inIndustrial Wireless Sensor Networks: Applications, Protocols, Standards, and Products, GP Hancke and VC Gungor, Eds (2013): 119-136.
[12]. Wei, Dali, et al. "An energy-efficient clustering solution for wireless sensor networks." Wireless Communications, IEEE Transactions on 10.11 (2011): 3973-3983.
[13]. Nan, Guofang, et al. "CDSWS: coverage-guaranteed distributed sleep/wake scheduling for wireless sensor networks." EURASIP Journal on Wireless Communications and Networking 2012.1 (2012): 1-14.