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A Study and Analysis of Enhancing Energy Techniques in WSN

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Abstract— Wireless Sensor Network is broadly used in many areas including security surveillance. As sensor nodes use energy from batteries for sensing the data and transmitting data, it consumes the energy for these operations. Optimizing energy consumption in sensor nodes is an emerging research area in today's era and also a challenging task, Energy consumption of nodes is a great challenge in order to maximize network lifetime. Unlike other networks, it can be hazardous, very expensive or even impossible to charge or replace exhausted batteries due to the hostile and inaccessible nature of environment.

Researchers are invited to design energy efficient protocols while achieving the desired network operations. In this paper, main concentration is on different techniques to reduce the consumption of the limited energy budget of sensor nodes. After having identified the reasons of energy waste in WSNs, energy efficient techniques are classified into five classes, namely data reduction, control reduction, energy efficient routing, duty cycling and topology control. Each of them is then detailed by presenting subdivisions and giving many examples.

1. INTRODUCTION

A wireless sensor network consists of sensor nodes deployed over a geographical area for monitoring physical phenomena like temperature, humidity, vibrations, seismic events, and so on [1]. Wireless sensor networks (WSNs) consist of a possibly large amount of wireless networked sensors required to operate in a possibly hostile environment for a maximum duration without human intervention. Typically, a sensor node is a miniature device that includes four main components: a sensing unit for data acquisition, a microcontroller for local data processing and some memory operations, a communication unit to allow the transmission/reception of data to/from other connected devices and finally a power source which is usually a small battery. WSNs support a wide range of applications such as target tracking, environmental monitoring, system control, health monitoring or exploration in hostile environment. For data gathering applications, which represent the main use of WSN applications, the goal is to detect any event occurring in the area of interest and to report it to the sink. [2] are the earliest papers proving that if the communication range is at least twice the sensing range, a full coverage implies connectivity among active nodes inside the area of interest. Application scenarios for WSNs often involve battery- powered nodes being active for a long period, without external human control after initial deployment. In the absence of energy efficient techniques, a node would drain its battery within a couple of days. This need has led researchers to design protocols able to minimize energy consumption. In [3], authors present taxonomy of energy conservation schemes. Their very interesting classification, however, does not include energy efficient routing protocol, overhead reduction, data aggregation and cross-layering mechanisms. In this survey, with this lack is addressed by providing a new classification integrating more techniques.

2. NETWORK LIFETIME DEFINITION

The most challenging concern in WSN design is how to save node energy while maintaining the desirable network behavior. WSN is designed in such a way that energy efficient technique is used to maximize network lifetime. The latter depends drastically on the lifetime of any single node. However, in the literature, there is no consensus for the definition of network lifetime. The majority of authors use a definition suitable for the context of their work. . Here is an overview of the most common definitions. It is the amount

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of time that a wireless Sensor Network would be fully operative. One of the most used definitions of network lifetime is the time at which the first network node runs out of energy to send a packet, because to lose a node could mean that the network could lose some functionalities. Network life time is based on connectivity. In [4] authors define the lifetime as the minimum time when either the percentage of alive nodes or the size of the largest connected component of the network drops below a specific threshold. Some authors consider that network is alive as long as application functionalities are ensured. Kumar et al. [5] state "we define the lifetime of a WSN to be the time period during which the network continually satisfies the application requirements". As a conclusion, network lifetime must take into account connectivity and coverage if needed by the application supported by WSN.

3. CLASSIFICATION OF EFFICIENT TECHNIQUES

In WSNs, sensors dissipate energy while sensing, processing, transmitting or receiving data to fulfill the mission required by the application. It is obvious that minimizing data extracted from transducer will save energy of very constrained sensors. Experimental results confirm that communication subsystem is a greedy source of energy dissipation.

There is also a great amount of energy wasted regarding communication in states that are useless from the application point of view, such as [5]:

- Collision: when a node receives more than one packet at the same time, these packets collide. All packets that cause the collision have to be discarded and the retransmission of these packets is required.
- Overhearing: when a sender transmits a packet, all nodes in its transmission range receive this packet even if they are not the intended destination. Thus, energy is wasted when a node receives packets that are destined for other nodes.
- Control packet overhead: a minimal number of control packets should be used to enable data transmissions.
- Idle listening: is one of the major sources of energy dissipation. It happens when a node is listening to an idle channel in order to receive possible traffic.
- Interference: each node located between transmission range and interference range receives a packet but cannot decode it.

As network lifetime has become the key characteristic for evaluating WSN, for improving network lifetime, these techniques are analyzed here. Some main classes of energy efficient techniques are analyzed, namely, data reduction, protocol overhead reduction, energy efficient routing, duty cycling and topology control.

Data reduction focuses on reducing the amount of data produced, processed and transmitted. For instance, data compression and data aggregation are examples of such techniques.

In Protocol overhead reduction, the aim of this technique is to increase protocol efficiency by reducing the overhead. periods of messages are adapted depending on the stability of the network, or on the distance to the source of the transmitted information. In energy efficient routing protocols should be designed with the target of maximizing network lifetime by minimizing the energy consumed by the end-to-end transmission and avoiding nodes with low residual energy.

The duty cycling means the fraction of time nodes are active during their lifetime. Nodes sleep/active schedules should be coordinated and accommodated to specific applications requirements.

Topology control it focuses on reducing energy consumption by adjusting transmission power while maintaining network connectivity. A new reduced topology is created based on local information.

Reasons of Energy WASTE → ↓ Techniques	Sensing Processing	Communication	Collision	Overhearing	ControlPackets	Interference
Protocol overhead reduction	–	M	S	S	M	S

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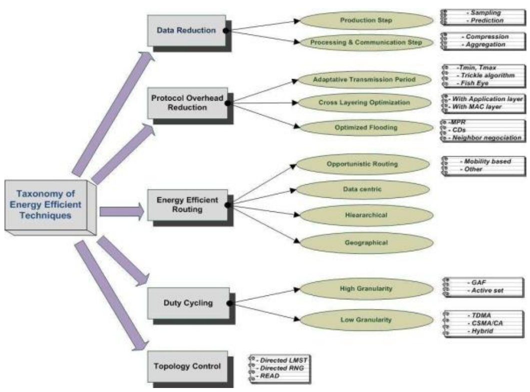
Energy efficient routing	–	M	S	M	S	M
Duty cycling	M	M	M	M	S	M
Topology control	–	M	M	M	–	M

Table I shows how each energy efficient technique class tackles sources of energy waste. The 'M' symbol means a main impact, whereas a 'S' symbol means a secondary impact. Now, these different classes are detailed.



4. RECENT TECHNIQUES TO IMPROVE THE ENERGY EFFICIENCY

4.1. Novel Fuzzy Logic

Novel based algorithms are good in determining the load balance in WSNs. This technique is used in [6]. The techniques works well in physical layer and data link layer**.** It focuses on reducing the whole power consumption while maintaining good performance in terms of the ratio of throughput to workload. This method is used for environment monitoring. Energy consumption is evaluated based on three components i) sensing, ii) processing, iii) transmission. Centralized mechanism is proposed in order to regulate the sleeping time of the field. Activities of microcontroller and of a connected sensor have a low impact on the battery consumption. This approach dynamically changes the sleeping time in order to increase the battery duration of sensor devices. It is not possible to determine the behavior of the nodes since they are often used to monitor sporadic events.

Evaluation of performance in novel fuzzy logic

In both topologies, the best result is obtained by the proposed approach using Gaussian membership functions. In fact, the battery is fully discharged after 169, 950s, i.e. after 47 hours and 21 minutes in the star topology and after is fully discharged after 174, 945s, i.e. after 47 hours and 53 minutes in the cluster topology.
Using the fuzzy-based approach the Th (throughput) / Wl (wavelength) fluctuates between 70% to 30% with Gaussian membership functions in the star topology and between 80% to 45% in the clustered topology.
Qualities
This improves the lifetime of the devices in WSN and the approach dynamically works on changing sleeping time in order to increase the battery life.

4.2. Delay Aware Routing Protocol

In [7] author developed the method based on Packet forwarding scheme. The method is used in homogeneous nature. In this method, sink is GPS enabled. Main activities performed are neighborhood management, deadline estimation, data forwarding. Sensor node senses the occurrence of an event or a data packet arrives to it. It is focused on performance comparison between **g**rid and random deployment of sensor nodes. The performance of the protocol can be compared to some of its related protocol.

There is a need to do simulation to make it suitable also in context characterized by real time constraints

4.3. Fixed Competition Based Clustering Approach (FCBA)

In [8], author proposed a technique based on clustering and CH (cluster Head) formation, this algorithm includes as follows. It is cluster based. Novel clustering approach used. This protocol is for fixed WSNs. The results are compared with popular

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approach LEACH which is good in homogeneous distributed clustering. The main issue in any proposed architecture is to maximize the life time of the nodes in WSNs. Selection of the CH is the key issue in clustering algorithm

4.4. Position Responsive Routing Protocol (PRRP)

In [9], author used the Cross layer design methodology. In comparing LEACH and CELRP, CHs are selected in novel way. Nodes are distributed in grid, which is used or relevant for forest fire surveillance systems and disaster managements system. Surroundings are tier based cluster location and sink is in middle. Energy consumption is directly proportional to distance. Tree routing mechanism applied (each node transmits the data to its closest node) transmission distance is shortest. A node can only be allowed to join a tree if its energy is sufficient to survive for complete round. Leaf nodes will be “ON” only for one slot just to transfer the data to its parent. Non – leaf will remain “ON” for more slots. This protocol is good for more round of data transmission. Average energy consumed at the initial round is that the three initial phases are for setup and no data transmission takes place during this. This energy is defined as overhead energy. In improving the network lifetime, impressive performance are suggested by author. Nodes are distributed randomly. Each node in this protocol transmits its data to the closest neighbor. Each round of processing time consists of four phases i) gateway selection (GS), ii) Tree building (TB), iii) Schedule building (SB), iv) Transmission of the data.

PRRP is similar to LEACH protocol in which any node can communicate with the sink and the data collection or transmission mechanism is the time based schedule. Collectively for all rounds together including 1, 5, and 10 rounds altogether. Simulation results illustrate that with PRRP nodes can stay longer and utilize their maximum possible energy for longer time period. For example, after a 10-round test run, the figure shows that the last node of the LEACH protocol dies after 275 seconds while PRRP nodes start dying after 350 seconds.

4.5. Energy Aware Routing protocol (PDORP)

In [10], energy optimization is carried out by using hybrid algorithms. Optimization of communication layers, the actual node optimization, cross layer optimization. It is a power efficient gathering sensor information system. DSR (Dynamic Source Routing) protocol is used and this is more suitable in terms of small energy density. Main aim is to choose and identify dead nodes and then choose another suitable path for the transmission so that the transmission becomes smoother and less energy gets consumed. There are two routings protocols used i) Proactive (PEGASIS protocol) and ii) Reactive (DSR protocol) for routing methodology in order to obtain fast and non-damaged path along lower transmission delay. Trust checking is carried out for every round of transmission. Hybridization of GA and BFO optimization is applied to identify the energy efficient paths. The key issues are high in bit error rate; network suffers from the packet overhead.

4.6. Energy Efficient Credit-Based (EECB)

In [11] author explores Energy Efficient Credit Based protocol which selects the most optimal cluster heads based on priority of relay nodes. This protocol has slightly higher packet loss and lower data delivery rate. Such protocol uses candidate nodes for transmission between clusters and uses Directed-Diffusion (DD) for flat routing into hierarchical. Directed-Diffusion (DD) ignores the nodes which are not in the path of sink nodes so, the energy wastage slashed down in this way. Sensors with maximum energy reminders will be selected as Cluster. If the sink node is in the sending limitation of cluster head radius or there is not any relay node, data will be sent to the sink node directly. Otherwise, the cluster head selects the node with the highest amount of route choice as the next hop.

The method improved the network lifetime and energy consumption, at the expense of packet loss and data delivery. When the network started, this method achieves a higher data-delivery than LEACH algorithm but after the 100th time slice, LEACH performed better in terms of data delivery and packet loss.

5. NEW TECHNIQUES FOR

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ENERGY SAVING

Sensor nodes are tiny and typically powered by small batteries for which replacement even if possible is highly expensive and intricate [12]. Every technique proposed includes the common factors like end-to-end delay or end-to-end reliability, cluster head formation for larger transmission regions, multipath and single path transmissions, environment based changes, application based protocols.

Equation used in [13] for optimal broadcast bit error probability and hence the optimal long dual distance that maximizes the energy efficient is derived. It is suitable for real time applications, but energy consumption remains constant for traditional fixed distance. This method works on node density factors and it is good for lower node density system. [14]

In [15], authors explained list of protocols and categorized then into three parts – i) data centric, ii) Hierarchical, iii) location based. Network flow and QoS also the common factors which are discussed more in every proposed system.

Flooding – without the need of any algorithms and topology sensor nodes broadcast the data.

Gossiping – A nodes sends the packet to a randomly selected neighbor.

LEACH (Low Energy Adaptive Clustering Hierarchy)

A very popular technique to solve the energy consumption issues and the protocol is referred multiple times by various authors. Number of clusters is 5% of total nodes. It works only on single hop routing and not suitable for large regions.

PEGASIS (Power Efficient Gathering in Sensor Information Systems)

This protocol outperforms LEACH by 100-300%. Hierarchical PEGASIS is better than PEGASIS and improves delayed transmission.

MECN (Minimum Energy Consumption Network)

Main aim is to find sub network which will have less number of nodes and will require less power for transmission between any two particular nodes.

Rendezvous Algorithm

This algorithm proposed subset of nodes which server as rendezvous point and aggregates the data from source and transfer to the base station when arrives. This algorithm combines the approach of controlled mobility and data caching in network. In mobility enabled WSN is the increased latency in data collection, there it is giving bottleneck performance.

SPIN (Sensor Protocol for Information Negotiation)

A node advertises for metadata to the destination node. Then the nodes which get the advertisement send the requests back for the data. After that the actual data is transferred to the required node. [16]

TEEN

If the threshold is not reached then the data is not communicated to the base station there were no messages to inform the base station that whether the node has gone dead or the data is not crucial enough to be repeated. APTEEN overcomes this drawback. [17]

6. CONCLUSION

How to maximize network lifetime despite a very limited energy budget? In this paper, different techniques are summarized that tackle the energy efficiency challenge in WSNs and classified in some main classes. For each class of techniques, source of energy waste is explored for control.

This paper also includes the new techniques and recent studies improvised for saving the energy and thrashing the bottleneck of energy consumption in WSNs. Different techniques used in different scenarios based on placing of sensor nodes in WSNs and also based on conditions, application, different environments in every area the respective techniques

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works well with manageable throughput.

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