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A SURVEY ON ENERGY BALANCE IN WIRELESS SENSOR NETWORK

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Abstract-In Wireless Sensor Networks the sensorsare distributed autonomous to monitor Environmental Surveillance and Health Care, Commission Power, Computation Capacity and Data Storage and Habitat Monitoring. So energy saving should be done to prolong network lifetime. Energy saving hasadvantage in designing routing protocol, clustering algorithms and duty cycle.
The goal of our survey is to present a comprehensive review of the recent literatures since the publications first C. Efthymiou, S. E. Nikoletseas, and J. D. P. Rolim, "Energy balanced data propagation in wireless sensor networks," *Wireless Networks*, 2006 [1], second H. Zhang and H. Shen, "Balancing energy consumption to maximize network lifetime in data-gathering sensor networks," *Parallel and Distributed Systems,IEEE Transactions*, 2009 [2] and third Tong Liu, Tao Gu, Ning Jin, and YanminZhu,"A Mixed Transmission Strategy to Achieve Energy Balancing in Wireless Sensor Networks," Wireless Network, *IEEE Transactions,* 2016 [3]

Keywords-Wireless networks, Energy Balancing, Hop-by-hop, Corona, Slice Based, Network Prolong

I. Introduction

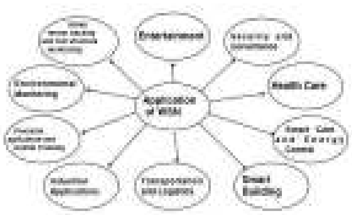

Fig. 1.Application of Wireless Sensor Networks

A Wireless Sensor Network (WSN) is constituted of sensing devices called sensors, which communicate wirelessly (see [4] for excellent surveys). These sensors are small with inadequate processing and computing resources and they are inexpensive compared to traditional sensors. A sensor node can sense, measure, and gather information from the environment based on some local decision process. Later, it transmits the sensed data to the user. Fig .1 shows different applications of wireless sensor network. In the initial stages, the research in WSN was taken forward by the surveillance applications in military and on the battlefield. Later on, WSNs were found to have use in interesting applications like moisture control in agriculture area, forest fire detection, building automation and security applications. For thispurpose it is to required to save energy and prolong the network approaches including hop-by-hop transmission technique, clustering technique and slice based model for altering power saving mode. In this technique energy aware data gathering has also been introduced. Sensors near the sink die out early compared to the other sensors. The reason is due to overuse. The energy balance problem in wireless sensor networks was first introduced in [5]. Inspired by this work, several works extend to study the energy balance problem in data propagation.

In this paper, we opt to categorize energy balancing algorithms proposed in the literature for WSNs. We report on the state of the research and summarize a collection of published schemes stating their features and shortcomings. We also compare the different approaches and analyze their applicability. The rest of the paper is organized as follows: Section II presents the various system models for WSN. In Section III, we discuss different energy balancing techniques. Section IV deals with the discussion and present classification of the various approaches pursued. Finally, Section V concludes the paper.

II. System Model

The arrangement of sensor nodes is placed in a medium such that they can interact with each other and also share their sensed information [4]. These sensor nodes usually follow the broadcast type of communication. These sensor nodes are characterized by restricted energy, low computational capabilities and limited amount of memory. The micro-sensors are deployed in an area of interest, in order to monitor crucial events and propagate the collected results to a base station or SINK.The sensor is made up of microelectromechanical system (MEMS) which are already small sized, low power and inexpensive.

III. Energy Balancing Goal For Wireless Sensor

A. Hop-by-Hop

Efthymiou, Nikoletseas, and J. D. P. Rolim (see[1]) proposed hop-by-hop algorithm. Decision taken by algorithm in each step will decide to propagate data from sensor to sensor. Algorithm helps to decide to choose

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between one-hop (indirectly) or to send data directly to the sink. One-hop is cheap compared to direct transmission. Direct transmissions are expensive but bypass the sensor present near the sink. Direct transmissions are used in rare cases. This isbecause the sensors which are present near the sink tend to die early due to overuse. This algorithm achieved energy balancing following the process by detail analyzing the probabilityof each propagation.

Hop-by-hop algorithm contributes in analyzing energy efficient and energy balance among sensors for data propagation. Probabilities are based on network size and distancefrom the sink at time.This Algorithm is energy efficient along with energy balancing. The model of the sensor network is random along with uniform events 'N' considered as total number in a certain period.'S'. The location of sink is fixed and it is powerful control center. Wireless sensor can be adjusted by broadcasting message from the sink. Transmission range are of two types here R (for network operator) and i.R (I = d/R d=distance between sensor and sink). This model overcomes energy balance problem in former algorithm

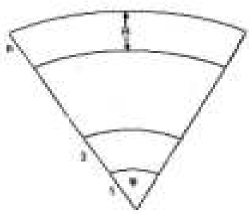

Fig 2 Sensor Network with n ring sectors, angle φ and ring "width" R

As you can see in the fig. 2 Virtual area is considered with an angle φ and the rings are divided into 'n' sectors or slices. The radius of first slice is 'R' and radius of the slice i is defined two waysi.e, i.R and (i-1)R. The energy spent on transmitting is directly proportional to the transmission distance. Based on the above details, network model is setup. Next is distributed data prorogation. Here it considers only one sensor for sensing the event in the presence of other sensor. A number of events occur in each ring and later the message is delivered to the sink. The sensors are placed uniformly and randomization should be done to achieve load balancing by evenly spreading the load.

Events are propagated from ring sector Ti (Pi probability) to Ti-1 (Next sector) and then directly to sink S. If Pi is increased then data is passed directly to sink. If Pi is decreased due to energy consumption then data is bypass through nearby sensor and it will reach sink. So therefore calculation of Pi is done in each Ti. This will be helpful for energy balancing. Data message is fixed throughout data propagation. So in finding Pi, i is distance between sensor and sink which can be found at the time of setup phase. After obtaining recurrency, energy balancing is achieved. Later calculation of P_i is quite straightforward.

The energy balancing property is achieved if any ring sector propagates each message which it handles with probability Pi to the next sector and later directly to the sink. Here P is not dependent on N events. The energy is average and similar in all network sensors, where each message will finally get to the sink. If Pi is small, then data transmission will be direct transmission and if Pi is large, then data transmission it will be hop-transmission. This theory is energy efficient and energy balanced. As the value of Pi decreases due to energy consumption they should spend more energy in sending message i.e., transmit directly to the sink (if it is close to the sink). Whereas for large network direct transmission to the sink occur after some hops which leads to energy balance. But if the fading factor increases then direct transmission to the sink are even less potential. So, this is why Pi increases when fading factor increases. Later recovering from fading the probabilities Pi is done. So with this theory energy balance and energy efficiency is achieved.

B. Corona

Haibo and Hong [2] proposed Energy Balanced data gathering (EBDG) protocol for energy balancing and data gathering in the sensor, later extended EBDG is introduced. It implies that sensors to sink direct transmission are not energy efficient. To overcome drawback multi-hop is preferred than direct to sink for long transmissions, but multi-hop tends to use close by sink sensors which will die at early stage and energy holes is created. This leads to unbalance energy across the nodes. In this network, Mixed routing scheme alternates between hop-by-hop and direct transmissions. In long distance transmissions hop-by-hop is used and for short distance direct transmission is used. Now energy balancing can be easily obtain. It shows that mixed routing scheme beats other routing strategies in term of Network Lifetime Minimization (NLM).

Energy balance and maximization network lifetime problems are investigated. Sensors are deployed in random uniform around the area. Here the probability is same in the entire corona. The sensor network is divided into corona. And the same probability is used by direct and hop-by-hop transmission.

The energy consumption problem is further divided into two sub-problems

a. Intra-corona energy consumption balancing (Intra CECB)

b. Inter-corona energy consumption balancing (inter CECB)

Intra CECB solves the problem by dividing the corona based on data received. Inter CECB solves the problem by allocating the received data between direct and hop-by-hop transmissions. NLM problem can be solved by calculating the number of coronas divided in the network. So to balance energy among one corona and different corona, EBDG is designed.

Network model is same as the *Efthymiou, Nikoletseas, and J. D. P. Rolim* protocol. Sensors distributed in circular Area A, radius R and node distribution densityρ. Sink located at center and maximum transmission range Rmax . Here Rmax$\geq$ R which means each node can communicate directly with the sink. Data gathering operation is divided into rounds and later data is propagated towards sink. If the operation is taking place between the adjacent rounds then rest of nodes will be turn off, as this will save energy. Here the data generated by each round is 'l'.

Data Aggregation model proposed is

$\varphi(x) = mx+c$ Where φ = data output, m& c values are dependent

m = 0	c > 0	Data aggregation
0 < m < 1	c = 0	Data aggregation
m = 1	c = 1	NoData aggregation

TABLE I.Data Aggregation values

Here we consider energy on the transmitting side and circle Area A is divided in concentric coronas C1 ,C2…..Cn with same radius r=R/n. Data is forwarded to neighbor round i.e., C to Ci-1. T be the number of round, F(u) amounts of data forward in hop-by-hop, D(u) amounts of data transmitted in Direct transmission.

It is assumed that same data distribution among nodes in same corona. For direct transmission radius is r and for hop-by -hop transmission radius is r′. (r'>r to balance energy among nodes in the same corona)

Problem	Solution
Intra corona	Balance energy between nodes in corona
Inter corona	Optimal data distribution
NLM	Divide optimal number of coronas.

TABLE II.Slice model

Inter-corona Energy consumption solves the problem if the amount of data is balanced in the corona. Then only energy will be balanced in the corona. To observe that, a localized based on routing scheme is designed to balance energy consumption among nodes in each corona.

The sufficient and necessary condition for Intra CECB

$E(u) = F(u).\varepsilon_t(r') + D(u).\ \varepsilon_t(i.r) + S(u).\varepsilon_r$

E(u)= Total amount of energy

S(u) = Total amount if data received

$F(u).\varepsilon_t(r')$ = energy spent through hop-by-hop transmission

$D(u).\ \varepsilon_t(i.r)$ = energy spent through direct transmission

$S(u).\varepsilon_r$ = energy consumption for receiving data

By calculating data distribution ratio allocation of the data distribution problem will be solved by Inter CECB. The network lifetime Maximization can be achieved by balancing energy consumption among all the nodes in the network. As the energy consumption gets balanced, all nodes have the same energy in the network. Data Distribution Ratio Computation (DDRC) algorithm is used to compute n coronas, Pi and di. As we know that r' should be longer than r for hop-by-hop. r' depends on the number of sub coronas i.e r'> $\left(1+\frac{1}{w}\right)r$

If w is small, then r' is large. If w is too long, then the width of sub corona will be small.Then each zone will become thin and large result is larger r. In hop-by-hop transmission energy sufficient is better compared to single hop. Later network is divided into few coronas, further divided into sub corona. Additional energy is spent in hop-by-hop transmission for recurring data is compare to Direct Transmission. The object of NLM problem is solved by calculating optimal number of coronas in terms of maximizing the network lifetime. While calculating NLM, it is reported as nonlinear integer programming problem. By using heuristic algorithm it can be solved.

The EBDG protocol is divided into two phases:

Network set-up phase and data gathering by using the message broadcast message signal from the sink to the portion of coronas, sub-corona parameter is placed. Data Gathering stage is based on EBDG, which are in two States i.e active and sleep. In active stage data is transmitted, received and data aggression, whereas in sleep state nodes turn off its radio to save energy.

Scheduling is done in all nodes in a network to finish repeating of data to the sink in an order from the outermost sub corona to the innermost sub corona. This scheduling scheme provides the opportunity to data aggregation to each node. This will help to reduce data collision. In EDBG, each node alternates between direct transmission and hop-by-hop transmission to balance energy consumption.

At any time slot, there are only two sub-corona whose nodes are in active state. The nodes in corona only transmit the data, and the node in another corona receives the data. This is done so as to avoid data collision. Extension to large-scale data gathering sensor network is done by employing the advantages of clustering techniques. Because clustering techniques will divide the larger portion into cluster and each small node will contact the cluster head through single or multi hop routing.Here author have shown the solution to maximize network lifetime through balancing energy consumption from uniform deployed data gathering sensor network.

C. Slice Based

Liu, Gu, Jin and Zhu [3] proposed that energy balanced data is done then potentially can save the energy consumption and prolong network lifetime. Traditional hop-by-hop transmission propagates the data but result in poor energy balance. This problem can be addressed by applying slice–based model, further divided into inter-slice and intra–slice energy balancing. Probability based strategy is proposed for this problem named inter-slice Mixed Transmission protocol and intra -slice forwarding technique. By combining these two techniques Energy-balance Transmission protocol is proposed to achieve total energy balancing. This technique can overcome the drawbacks of hop-by-hop transmission and cluster based routing protocol.

Energy balancing problem is that nodes lying near the sink will die early compare to other nodes and in other case if node sends data directly to the sink than it will consume energy. So there will be energy imbalance in the network. To overcome this problem slice based network model is proposed. The area of the network is partitioned into slice with same width R and sensors are divided uniformly. The transmission range is R. To balance energy across is called inter slice and to balance energy. Energy across nodes in the slice is called Intra-slice energy balancing.

Inter-slice Mixed Transmission (IMT) [3] strategy is proposed to achieve Inter-slice energy balancing which will allow each sensor node to make opportunistic choice off its transmission range for sending packet. Linear programming is done for optional transmission probabilities. By using this, sensors near the sink use low power energy and sensors away from the sink use high power to send data to the sink. Hence energy balancing consumption is achieved between the slices.

When compared to traditional hop-by-hop data collection MT has two main advantages

a. Longer distance transmission with less delay.

b. Nodes have choice to select transmission power.

Intra-slice forwarding technique helps to Inter-slice energy balancing by allowing nodes with lower energy to forward their packets to the nodes with higher energy in the same slice and then the data can be propagated to the next slice through inter-slice transmission.

ETP is design by combining Inter slice mixed transmission strategy and the intra-slice forwarding technique to achieve total energy balancing during data collection and hence prolong network lifetime. This proposed protocol performs better than hop-by-hop and clustering based routing. Sensors are placed randomly uniform within the range of the network events occur periodically and probability space distribution in space is uniform. Data aggregation problem is not considered here. The energy spent on delivering which is believed the most important factor affecting network lifespan. Energy consumed by receiving side is also taken into consideration, unlike some existing work; typically ignore receiving side energy consumption denoted by Cr.

All the batteries of the sensor will drain out at the same time. So relay nodes should be chose wisely to make network to make network lifetime as long as possible. Here events are denoted by Z and lifetime is denoted by T. Events are proportional to T. The more number of events get supports, the longer the network survives. The area is divided into n sector or slices. The slice area can corner area network by taking a proper large angle. The slice is shaped by two successive disk sector with Radius equal to iR and (i-l) R respectively the difference between two sectors is R which is the radius of the slice. By using slice model, the maximum transmission ‘m’ distance of a sensor into the multiple of slice Radius R. When m is greater than n then packets send directly to the sink node, when m =1 the process will be hop-by-hop transmission.

Inter-slice energy balancing problem, nodes in the slice consider as a whole. All slice drain energy at the same rate. The energy consumed by slice Si in the lifetime is decided by data sent to upper slice and data received from lower slices. Fi, j denoted as the total number of data events transmitted from Si to Sj in the lifetime T. With the help of flow count energy can be calculated.

The above equation is the energy balance equation, to ensure that the network will finally achieve inter-slice energy balancing. It will eliminate unnecessary transmission overhead in the network. Intra-slice Mixed Transmission (IMT) will decide based on probability distribution. The transmission probability between two slices will be decided.

Based on this probability, end node in the network determines its next slice to propagate its data towards the sink. It will consider only the next slice, but not the next node in the slice. There is no difference in choosing in next nodes as we consider the energy received by the slice. To choose battery larger than Cr with maximum remaining battery in the relay, maximum life of a node is difficult to obtain in real life due to some of the reasons like energy in the slice drain out at same time, no data packet is dropped and part of energy consumed by Intra-slice transmission. A feedback mechanism is used so as to know about the next node relay energy so that no unbalanced energy left in the network. The results are same as hop-by-hop transmission. The problem in Intra-slice energy balancing is as one node dies the other node die more quickly in the same slice, it should make all the nodes die at the same rate. To overcome this problem Intra-slice forwarding algorithm is designed. It will decide which node should be selected as relay and when Intra-slice transmission is needed. The main idea of this protocol is the node with less energy receives the data it should transfer the data to the other node in the same slice with maximum energy.

Two main factors affecting the design of Intra–slice forwarding algorithm, first sending node should select intra-slice transmission than inter-slice transmission and the second factor is if two much Intra-slice transmission takes place in the slice than there will be energy imbalance in the Intra-slice and reduce network lifetime. A node in a slice will receive a packet and it will decide to send it to adjacent slice. It will compare the node energy with the adjacent slice energy (using threshold Energy). By using Inter- slice mixed Transmission approach the node will deliver the packet.

IV. Discussion

Drawback of a hop-by-hop transmission model [1] is it hardly achieves energy balancing since the sensors nodes lying closer to the sink are always transmit more packets than those lying farther away from the sink. In Slice model[3], the result will be the same as the hop-by-hop model when the maximum transmission range m is restricted by one hop. Thus, there exists a relation between transmission range m and network size n. This relation assists for practical implications for network development and management. In reality it's difficult to achieve energy balancing through Inter-Slice. Reasons for not achieving maximum lifetime, it cannot be ensured that the energy in each slice drain out at the same time, it is difficult to guarantee that no packet is dropped and all packets are delivered to the sink exactly when the lifespan ends, such that equality constraint [4] fails and part of energy in b_i will be consumed by intra-slice transmission. Some slice will exhaust first, which becomes the bottleneck of prolonging network lifetime. A second chance is given to select next hop without considering enough energy to send and receive. To maintain the information of a slice a feedback is mechanism is set up.

V. Conclusion

Thus, we have presented here the survey of different energy balancing based routing algorithms for hop-by-hop transmission, Corona based and Slice based algorithm to identify energy unbalancing or reducing energy data redundancy and cluster based fault detection techniques to identify faulty nodes in time and eliminate it from the network. We have also presented the analysis of surveyed algorithms based on parameters like energy consumption, network lifetime, detection and recovery time etc. Using this analysis, our future work is the simulation of an algorithm that can be used to prolong network lifetime with less energy consumption.

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