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Energy Efficient Data Collection in Wireless Sensor Network

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Abstract: The use of wireless devices is expanding day by day and is affecting all the aspects of human life throughout the world. Most of these wireless devices are based on very small sensors that translate parameters or events in the physical world into signals that can be measured and analyzed. These tiny sensors thus form a wireless sensor network when employed in a particular area or region. The constraint most often associated with sensor network is that sensor nodes operate with limited energy budgets. As a consequence, the first and foremost important challenge for wireless sensor network is energy efficiency. This paper proposes the various data collection schemes considering energy efficiency as one of the most investigated themes in wireless sensor network based on underlying topology.

Keywords: Wireless sensor network, energy efficiency, data collection, network lifetime.

I. INTRODUCTION

Wireless sensor network comprises of spatially distributed autonomous devices that use sensors for observing and recording the physical conditions of the ambience, collecting the data and then transmitting it at a central location. Because of the above specific features they have a wide range of application and some of them are military, environmental, health, home and other commercial areas [1].

As the sensor nodes are small and battery operated, they have confined energy which should be used in an absolute manner. Thus the limited sensor resources (specifically, the battery power) are easily consumed. So the main issue in sensor network is to conserve the sensor energy thus enhancing the network lifetime. In order to achieve energy efficient wireless sensor network there are two aspects that can be considered- (1) reducing or minimizing the energy consumption of individual nodes which can be performed mainly in two ways: by reducing the communication time (i.e. Turning off the sensor node to sleep state whenever it does not need to transmit or receive any data), reducing the traffic or by reducing the transmitted power of the sending node (using multi-hop communication). (2) Enhancing the life cycle which can be done by implementing a good network topology, choosing an appropriate routing protocol etc. [2].

Imparting or exchanging the information between nodes in the deployment area is a must to send data from all sensors to the base station and then to the end user. Sensor nodes suffer from restricted power-sources and hence it is ineffectual to transmit their data to sink node directly [3]. Alternatively, an appropriate data gathering algorithm is required to collect the information from these nodes in an energy efficient manner while improving the network lifetime. So in this paper energy efficient data collection schemes have been widely discussed and compared using factors like energy consumption, scalability, robustness, coverage, connectivity etc.

The rest of the paper is organized as follows: section 2 describes the importance of energy efficiency in wsn. Section 3 includes techniques used in data collection. Section 4 consist of underlying topologies. Section 5 gives an overview of comparison of energy efficient protocols and in section 6 we conclude the paper.

II. ENERGY EFFICIENCY IN WSN

In a restrained resource environment, the utilization of every limited resource must be esteemed. However, network lifetime occupies the remarkable position as a measure for energy consumption [4]. Network lifetime can be described as the time period from the first transmission in WSNs to the instant when the number of nodes falls below a threshold still consisting of their remaining energy depending upon the type of application [5].

In wireless sensor network, sensor nodes perform useful operation like the sensor nodes with event information perform communication functionalities in order to transmit their packets to the sink. They also take part in forwarding the packets received from other nodes to the sink [6].

On the other hand these nodes perform unwanted operations like overhearing, retransmission, listening to media when idle. One of the examples of the above undesirable operations is when node A is transmitting a packet to node B, the nodes C, D and E can hear A’s transmission and will defer their transmission if they have a packet to send. However at the end of A’s transmission, all the three nodes will sense the channel as idle and will try to send their packets at the same time. This will result

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in collision at any node that is receiving packets from the other nodes. The energy efficiency can thus be improved by avoiding the above mentioned undesirable operations of a node.

III. ENERGY SAVING TECHNIQUES USED IN DATA COLLECTION

A. Data Aggregation

Since sensor nodes might produce redundant data; similar packets form different nodes can be aggregated to reduce number of transmissions. In data aggregation technique, information or messages gathered from different sources is combined with the help of the functions such as suppressing (in which duplicate copies of the same message is eliminated) minimum, maximum and average [7]. Data aggregation technique mainly reduces the number of transmissions and thus saves the energy of the sensor network.

As shown in Fig 1, the data received from two sources is aggregated at node Y and then the integrated data (labeled 'a+b') is sent from Y to the sink node. The outcome of this is that fewer transmissions are required to transmit the information from both the sources to the sink which leads to the conservation of energy [8].

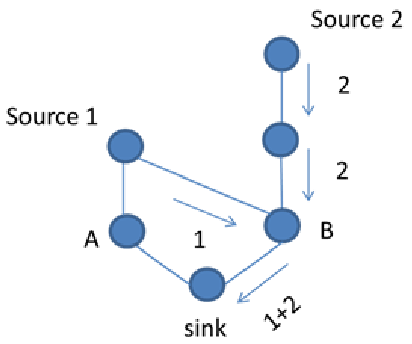

Fig 1. Data aggregation

There is another approach in data aggregation in which data gathered from different sources is fused and this fused data is directly send to the sink node in reduced size. But this approach lacks in terms of accuracy and precision of data that is why not widely used.

B. Mobile sink

The accumulated data from all the sensor nodes is forwarded to the sink. It can be a base station or any access point. The sink may communicate with the task manager/end user via the internet/satellite or any type of wireless network (like Wi-Fi, Wi-max, mesh network).
According to the multi-hop transmission, data packets through different sensors are sent to the sink node and sensors nearer to the sink node need to receive and transmit data from other sensors that are located far away from the sink. The closer to the sink a sensor is, the more data it needs to forward. This results in lots of computation and communication resources are required to process the data relaying work for the sensors that are closer to the sink compared to those that are only one hop away from the sink, means that they can directly transmit the data packets to the sink node. This creates a situation where the sensors nearer to the sink consume more energy and drain their energy at a much faster than the others. These sensors has a negative impact on the network lifetime, because a large portion of sensors nearer to the sink when die, huge amount of data cannot reach the sink and degrade the performance of the network. This problem is addressed as 'hotspot' problem and is illustrated in Fig 2.

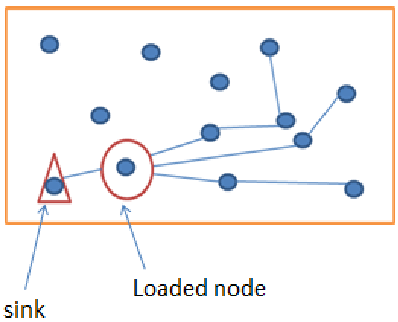

Fig 2. Sink mobility technique

In the above Fig 2, sensor node which is encircled is heavily loaded node. The data transmissions paths are denoted by the lines in the figure. The encircled sensor is responsible for forwarding the data from other sensors and therefore energy dissipation is focused on that particular node [9, 10, 11].

Recent approaches focus on switching the burden from the sensors to the sink node for minimizing energy consumption. This is achieved by allowing the sink node to be mobile and travel in the network area, inspect for the sensors which are sending the data and move closer to them. The basic idea behind the sink mobility approach is to transfer the load of data processing and energy consumption from sensors to the sink in order to maximize network lifetime. Also movements of sink nodes result in reduced transmission distance and lesser intermediate nodes for data relaying [12, 13, 14].

C. Scheduling

An enormous class of sensing-actuation and critical monitoring systems are deployed to (i) observe or detect events that require immediate notification (ii) transmit delay sensitive instruction to a particular node or set of nodes.

Such systems require bi-directional delay guarantee. On the other hand, energy constrained nodes in sensor network are dominated by longevity concerns. Therefore, in such systems the design consideration must not only aim to decrease the power consumption but also guarantee proper packet delivery over multi-hop transmissions [15,16]. Scheduling can be implemented in many ways-

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i. Sleep scheduling: sleep scheduling is apparently the most proficient mechanism to increase the lifespan of sensor networks with energy constraint. Sleep scheduling can be categorized into two types- synchronized sleep wake scheduling protocol and asynchronous sleep wake scheduling protocol. In the prior one, each and every node has knowledge when adjoining nodes will wake up. Then each node interchange synchronization message with other nodes. It causes the communication overhead while in the latter, each sensor nodes wake-up independently. When the neighbor nodes will wake-up then only each node can evaluate the value. Asynchronous mechanisms are not as efficient as synchronous and also offer large delay. The advantage of using asynchronous method is that they are easier to implement [17, 18, 19].

ii. Wake-up scheduling: Researchers in ad-hoc and sensor networks have proposed new ways to save energy without enduring the latency issues related with the wake up process. This scheduling can be categorized into-

- Wake-up on demand- whenever an event occurs, nodes can be signaled and awakened at that point of time. So in this case the node moves from passive mode to active mode at the time of need. This results in lesser amount of energy to be consumed.
- Scheduled wakeups- A node cannot be in any mode for infinite amount of time. They follow random wake- up patterns and it is assumed that nodes in the network are time synchronized. There exists another class which does not require synchronization among the nodes are termed as asynchronous wake-up mechanisms.

IV. WIDELY USED TOPLOGIES FOR DATA COLLECTION

A.Tree-Based Topology-

In this topology, a logical tree is constructed by the sensors deployed in the environment. Data is passed from the leaf node to its parent nodes. The receiver node after aggregating the received data with its own data sends this data to receiver parent's node. The concept behind constructing the logical tree is that it avoids flooding. Another reason is that data can be sent using unicast instead of broadcast. In this way the topology saves energy.

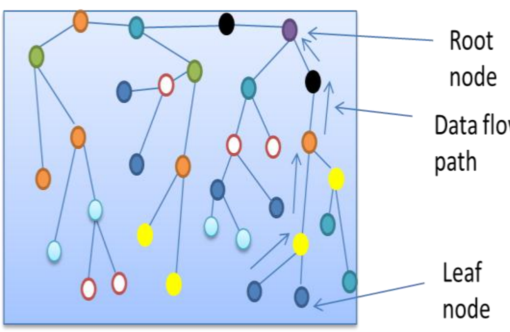

Fig 3. Tree topology

B.Cluster Based Topology-

Many routing protocols use clustering to create a hierarchal structure and to minimize the path cost. There are mainly three elements while describing clustering based topology: sensor nodes (SN's), base station (BS), cluster head (CH). The main task of the SN is to collect the data and transmit it to the sink node. The BS is concerned with the data processing, where the data is accessed by the end user. The CH is the gateway between the BS and SN.

In cluster based approach, whole network is divided among clusters. Each cluster has a cluster head (CH) that performs the role of the aggregator i.e. it aggregates data received from cluster members and then transmits the information to base station [20].

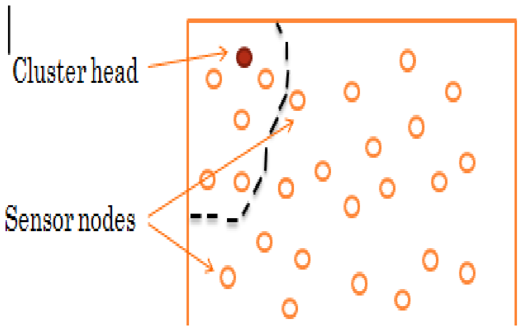

Fig 4. Clustering technique

The selection of cluster head is dependent upon the lifetime. A node elects itself as the cluster head if it perceives the longest lifetime among all its neighboring nodes. After this election, the node broadcasts this information with its lifetime to all its neighbor nodes. Some implementation of cluster based protocols is low energy adaptive clustering hierarchy (LEACH), hybrid energy efficient distributed clustering approach (HEED), clustered aggregation technique (CAG) etc.

C.Flat Topology-

In flat networks, all the sensor nodes plays the same role and cooperates to perform the sensing task. In this network, data aggregation is achieved by data-centric routing, in which the base station sends queries to sensor nodes via flooding. In response, the sensor nodes send messages back to base station.

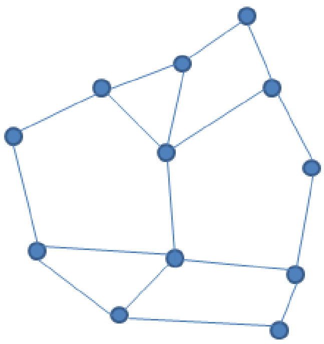

Fig 5. Flat topology

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Some examples of routing protocol based on flat topology are sensors protocols for information via negotiation (SPIN), directed diffusion (DD), rumor routing (RR), gradient based routing (GBR) etc. [19,20].

D.CDS-
To address some issues such as communication overhead, bandwidth efficiency, overall energy consumption, backbone can be utilized. This removes unnecessary transmissions links by shutting down redundant nodes.
The nodes in wireless sensor network forward the data to the sink via other nodes. Because of limited number of resources, minimum energy needs to be spent in the above energy consuming task. This facilitates the need of virtual backbone that reduces the number of hops required to reach the sink with the assumption that all nodes have equal transmission range. In connected dominating set all elements are connected i.e. it generates a connected graph. Some nodes in the CDS are chosen as dominators and other are referred as dominates. The minimum CDS is chosen as the backbone to minimize the number of hops. Every node is adjacent to this virtual backbone. The data received by the dominator is relayed through MCDS towards the sink for minimum hop communication [21].

V. SOME ENERGY EFFICIENT PROTOCOLS

Protocol	Merits	Limitations
LEACH	Each protocol has equal chance to become cluster head. Uses TDMA so it keeps cluster heads away from unnecessary operations.	Uses single hop communication so cannot be used in large scale networks.
Directed diffusion	It is data-centric; all communication is neighbor to neighbor with no need for node addressing mechanism. Energy efficient since it is on demand.	Cannot be applied to all sensor network applications since it is based on query based data delivery.
SPIN	Topological changes are localized since each node needs to know only its single-hop neighbors.	Cannot guarantee data delivery. Not good for application such as intrusion detection
SMAC	Overhearing avoidance	latency
TRAMA	No central entity required	Delay for end to end communication

VI. CONCLUSION

In this paper, we have described energy efficient data collection techniques. These techniques have been classified based on the topology such as tree, cluster, CDS etc. Based on these topologies and techniques different protocols have been surveyed that contribute to save energy and maximize network lifetime.

REFERENCES

[1] I. F. Akylidiz, W. Su, Y. Sankarasubramaniam and E. cayirci " A survey on sensor networks" IEEE communication magazine, vol. 40, august 2002.
[2] F. Chen, L. Guo, C. Chen "A survey on energy management in wireless sensor networks" IERI Procedia 3(2012) 60-66.
[3] A. I. Alhasnat, A. A. Alhasnat, K. M. Alatoun, A. AlQaisi "Data gathering in wireless sensor network using intermediate node", IJCNC, vol. 7, No. 1, Jan 2015.
[4] I. Dictrich and F. Dressler " On the lifetime of wireless sensor network", ACM transactions on sensor network, Jan 2009.
[5] M. Abozahhad, M. Farrag and A. Ali " A comparative study of energy consumption for wireless sensor networks" IJGDC, 2015.
[6] W. Ye, J. Heidemann, D. Estrin, "An energy efficient MAC protocol for wireless sensor network".
[7] M. Dagar and S. Mahajan, "Data aggregation in wireless sensor network: a survey", international journal of information and computation technology", ISSN 0974-2239, volume 3, number 3(2013), pp 167-174.
[8] K. Maraiya, K. kant, N. Gupta, " WSN: a review on data aggregation" international journal of scientific and engineering research, volume 2, issue 4, april 2011, ISSN 2229-5518.
[9] S. R. Wankhade and N. A. Chavhan, " A review on data collection method with sink node in wireless sensor network", international journal of distributed and parallel systems, vol. 4, No. 1, Jan 2013.
[10] Y. Chen, Z. Whang, T. Ren, Y. Liu and H. Lu " Maximizing lifetime of wireless sensor network with mobile sink nodes", Hindawi publishing corporation, volume 2014(2014).
[11] M. I. Khan, W. N. Gansterer and G. haring, " Static vs mobile sink: the influence of basic parameters on energy efficiency in wireless sensor network", elsevier, may 2013, vol. 36, pages 965-978.
[12] S. Jain, R. C. Shah, W. Brunette, G. Borriello, S. Roy, "Exploiting mobility for energy efficient data collection in wireless sensor network", volume 11 Issue 3, June 2006, journal mobile networks and applications.
[13] J. Guo, "Sink mobility schemes in wireless sensor network for network lifetime extension", electronic thesis and dissertations, 2012.
[14] J. Luo, J. Panchard, M. Piorkowski, M. Grossglauser, J. P. Hubaux, IEEE/ACM.
[15] A. Keshavarzian, H. Lee, L. Venkatraman, " Wake up scheduling in wireless sensor network", 2006 ACM 1-59593-368-9/06/0005.
[16] B. Baby, J. M. Jacob, "A survey on sleep schedule in wireless sensor network", IJERT, ISSN:2278-0181, vol. 2, March-2013.
[17] J. Ma, W. Lou, Y. Wu, X. Y. Li, G. Chen, " energy efficient TDMA sleep scheduling in wireless sensor network", IEEE 2009.
[18] S. L. Yedage, Prof. D. C. Mehtre, "Wake up scheduling for energy consumption in wireless sensor network with increase throughput", IJISET, vol. 1 issue 5, July 2014.
[19] R. Sarad, K. Bhame, V. Wabale, A. Katake, "A survey on lifetime maximization of wireless sensor network using load balancing" IJIRCC, vol. 3, Issue 11, Nov. 2015.
[20] Q. Mamun, "A qualitative analysis of different logical topologies for wireless sensor network", Sensors 2012, 12, 14887-14913; doi:10.3390/s121114887.
[21] S. Vijayasharmila, Dr. P. Ganesh Kumar, S. Kamlesh, 'A Survey on Connected Dominating Sets (CDS) Both in the Wireless Sensor Networks and Wireless Ad Hoc Networks', IJERT, vol. 4, Issue 02, Feb 2015.

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