Latest Algorithms in Wireless Sensor Networks for Energy Conservation: A Survey

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***Abstract* —Wireless sensor networks have wide range of advantages which made it to use in various range of applications. The major constraint in such application lies in the limitation of energy resource. The sensors are often equipped with tiny and irreplaceable batteries. Due to the battery resource constraint, it is important to operate nodes in an efficient way. It arise the need of energy efficient routing algorithms to prolong the network lifetime. This paper reviews the various energy efficient techniques for Wireless Sensor Networks.**

***Keywords: Wireless Sensor Networks, energy consumption, battery resource*.**

I.INTRODUCTION

The wireless sensor networks are the type of heterogeneous networks. These networks composed of more number of small and low cost devices, these devices are called as nodes. These nodes are referred information to base station. A sensor network is a deployment of massive numbers of small, inexpensive, self powered devices that can sense, compute and communicate with other devices for the purpose of gathering local information to make global decisions about a physical environment. A collection of sensor nodes work collaboratively to perform a common application. In many WSN applications, the sensor nodes are battery driven and often very difficult to recharge or change the batteries. Thus, a good WSN design needs to be energy efficient. A WSN contains four units as:

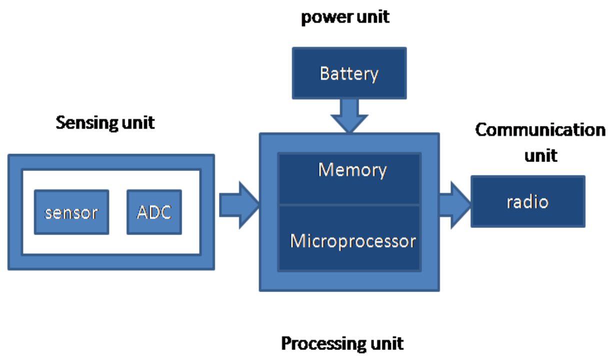

Figure 1: Units of WSN.

Microprocessor:
It is suited for sensor nodes due to their flexibility to connect other devices. It can also perform tasks after it process information and then controls the functionality of other components.

Transceivers:
The transceiver provides the functionality of both transmitter and the receiver. Radio frequency communication is best suited for sensor networks. Sensor networks use the frequency between the range of 433Mega hertz and 2.4 gigahertz.

External memory:
Two kinds of memory are used on the basis of the type of storage: user memory for storing applications or personal data and programming memory for program the device.

Power Source:
Batteries are the main source for sensor networks. Sensors can sense, store and collects information. For all this functions they consume power.

Sensors:
Sensors are the small tiny particles which sense, store and then collect information's. Sensor node consists of three types of components: sensing, processing and communicating. Sensor is a device that responds to the change in its surroundings in a measurable manner. There are two types of sensors such as active and passive. Active sensors gather data by probing into the environment, while passive sensors gather data without actually troubling the environment.

ADC:
ADC is an analog to digital convertor that allows exploiting the information-theoretic redundancy of the input signals for increasing the efficiency of operation and reducing the power consumption of the converter.
A sensor node generally consists of components such as memory, a processor, sensors, actuators and they have communication ability. Through in a wireless medium, the sensor nodes are allowed to communicate with each others. The wireless mediums have no wired connection. E.g.: radio or infrared network.

These nodes are deployed in a randomly to make an ad hoc network communicate among themselves. In WSN, nodes can be easily add and removed if required. Sensor nodes have the ability to sense surrounding environment. WSN network is used in many applications such as military areas, precision agriculture, home automation, healthcare, building and habitat monitoring, disaster management and observation of earthquake, but WSN has some restrictions, it provide limited energy supply and limited computations. The main problem in wireless sensor network is battery life limited.

A WSN is different from other popular wireless networks like cellular networks, wireless local area networks (WLAN) and Bluetooth in many ways. Compared to other wireless networks, a WSN has much more nodes in the network, the distance between neighboring nodes is much shorter and application data rate is also much low. Due to these characteristics, energy consumption in a sensor network should be minimized. The WSN has several advantages such as ease of deployment, extended range of sensing, improved lifetime, fault tolerance and improved accuracy. The various techniques that are used for energy conservation are:

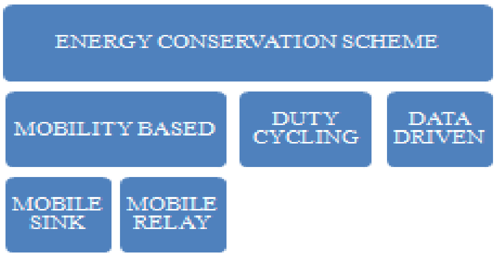

Figure 2: Energy conservation schemes in WSN.

II. TECHNUQUES USED FOR ENERGY CONSERVATION:

Multiple sink:

If the sensor nodes are uniformly deployed in regular geometric region, such as a circular region or in a rectangular region, the sink node will be placed at the center of the region. Most researches and simulations were carried out based on this placement strategy. Efrat et al. [1] and Jun and Hubaux [2] applied the P-Median Problem (PMP) model to determine the sink node placement, which was proved to be non-deterministic polynomial-time hard (NP-hard). It has been proved in [3] that the center of the circle is optimal position for a base station in WSNs, but the conclusion is only suitable for the uniform deployment of nodes. In [4], the sink node position was chosen to maximize the combined weight of data flows so that the energy consumption could be reduced. If multi sources want to send data to single sink then traffic occurs which leads to collisions of data. So providing multiple sink is the best solution for data collection process. When implementing multi sink the more number of data can send within shorter duration therefore due to less time consuming of data transmission automatically the energy for transmission also reduced. Deployment of multiple sink leads to load balancing in sensor networks.

Cluster Formation:

Cluster formation is achieved after the deployment of sensor nodes. Cluster is nothing, just grouping some amount of nodes together. The use of beacon packet creates clusters for data collection. Cluster heads transmits data packets to multiple nodes with two timers namely retransmit timer and connection lost timer. Cluster architecture is especially useful for sensor networks because it's inherent suitability for data fusion. The data collected from all members of the cluster can be fused at the cluster-head, and only the resulting information needs to be communicated to base station. Reduced delay in data gathering process results in control of buffer overflow in this sensor network.

Mobility:

Mobility is the one of the factor that reduces the energy consumption. Normally, the sensor node that is nearer to base station losses energy soon than the sensor nodes farther too from base station. For energy balancing the sensor node which near to base station is move to farther and the sensor nodes that farther from base station move towards to base station. Due to this load balancing, the overall average energy consumption is minimized. It avoids the failing of sensor nodes that near to base station. It also reduces delay in data delivery due to base station mobility and evenly distributed load among sensor nodes. The speed of mobile nodes should be carefully planned to avoid data loss. It has two cases: Mobility is applied for only sensor nodes, only for sink.

Sleep scheduling:

The basic mechanism for sleep scheduling is to select a subset of nodes that to be awake in a given epoch time while the remaining nodes are in the sleep state that minimizes energy consumption, by this method the overall energy consumption could be reduced. In WSNs mainly focus on two targets: point coverage and node coverage. For point coverage (also known as spatial coverage), the awaken nodes in each epoch are chosen to cover every point of the deployed field. Existing point coverage oriented algorithms differ in their sleep scheduling goals by minimizing energy consumption [5], or minimizing average event detection latency [6]. For node coverage (which is also called as network coverage), awake nodes are selected to construct a globally connected network and that each asleep node is an immediate neighbor of least one awake node [7], [8].

III. LATEST ALGORITHMS IN THESE TECHNIQUES:

EA-FSR:

Mobility techniques algorithm: Energy Aware Fisheye State Routing (EA-FSR) is the expansion work of FSR (Fisheye State Routing). It comes below table driven implicit hierarchical routing protocol. It uses ‘‘fisheye’’ technique [9], i.e. eye of fish captures more details of pixels near the focal point. Number of data is inversely proportional to the distance from the focal point. In routing, these approaches corresponds to maintaining accurate distance and path quality information about the immediate neighbors of a sensor node, with progressively less detail as the distance increases. This protocol is similar to link-state based routing protocol it maintains topology information at every node. In link state routing, the link state messages are generated and distributed into the network whenever node senses a topology change. But in FSR technique, link state messages are not flooded. Each node maintains a link state table based on up-to-date information received from neighbors only. The neighbor does not perform flooding of messages. Through in this exchange processes, the entries in the topology table with small sequence numbers are replaced by the ones with larger sequence numbers. This allows nodes to have the most recent information's at every point of time. Then the dijkstra's shortest path algorithm is applied on the topology table to select a node from the set of neighbor nodes to forward the data packets [10]. This mechanism ensures the shortest path length between a source node and sink node but this may lead to the selection of same neighbor node every time a source node transmits data. This leads to the increased energy consumption of selected node while decreasing the energy consumption of the other neighboring nodes. It causes energy imbalances in the network and also forms energy holes.

//Energy aware path selection algorithm:

//N is the set of all nodes in the network
// 's' denotes node that transmits data towards sink at any instant of time
// 'v' is any neighbor node of 's' and D(v) is the energy of the node 'v' at a particular instant
// 'w' is neighbor of node 's' that is selected for further transmission of the information

1. Initialization
   N = { s }
2. For all neighbors 'v' of 's'
   If 'v' is one hop neighbor
   Then
   D(v) = energy(v)
3. Loop
4. Find 'w' not in 'N' such that D(w) is maximum
   Add 'w' to 'N'
5. Repeat 2-4 for each 'w' until sink node in 'N'

To avoid the problem of energy imbalance and formation of energy holes, a new mechanism for shortest path selection is suggested. It uses the energy as the basis for selecting a neighbor node rather than the shortest path length. The energy of all the neighboring nodes is compared to find the node having maximum residual energy. Then this node is selected to forward the data packets. This process is performed for every node which has some packets to transmit. This mechanism ensures the energy balancing in the sensor network as only one node is not constrained with the job of forwarding the data packets. Also, this ensures uniform energy consumption of all nodes in the network that decreases the energy-hole formation. The energy consumption of EA-FSR is 3.13 J (mA h).

It is found that the energy consumption of the EA-FSR is lower than FSR. The percentage decrease is around 11.8% after implementing energy aware routing algorithm.

SMCA:

Combination of Multi-sink, cluster and mobility technique algorithm: Static and Multiple mobile-sink Clustering Algorithm (SMCA). In Hierarchical routing phase: For node *Si* in one cluster, the energy consumption cost to send data to its cluster head *(CH) Si*. In the mean time, *Si* tries to find another *Sj* to relay the data which may consume less energy than directly communication with *CH* to *Si* [11] . Since the direction of data transmission can be randomly chosen, various nodes can be chosen, which also turn out to cause various energy consumption. Suppose *Si* chooses *Sj* as its pass on node and let *Sj* have direct communication with the *CH* to *Si* . To deliver *l* –length packet to the CH, the energy consumed by *Si* and *Sj*. Each *Si* chooses *Sj* with smallest E2 (*Si, Sj, CH Si*) as the relay node if necessary:
E2 (*Si* , *CH Si*) = Min(E2 (*Si* , Sj, *CH Si*)) By comparing the smaller one is chosen:
E (*Si* , *CH Si*) = Min(E1 (*Si* , *CH Si*), E2 (*Si* ,*CH Si*)). Here it is necessary to compare E (*Si* ,*CH Si*) and *E*(*Si* , *BS*) and decide the final route. Thus SMCA was introduced to defeat this extra work.

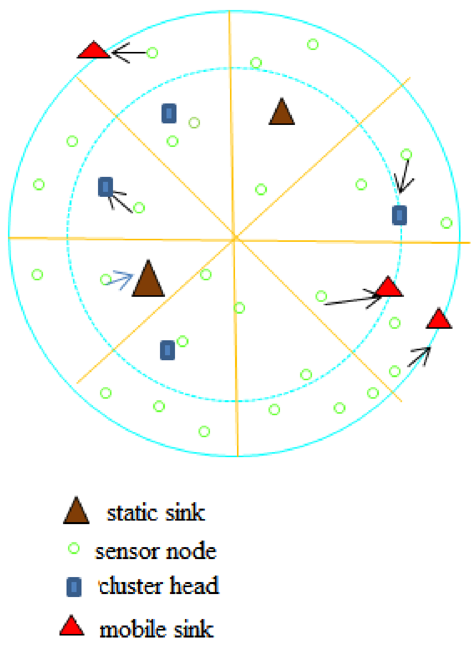

Figure 4: SMCA algorithm architecture

Here both multiple and mobile sink with static sink nodes are deployed. Suppose whenever sink node appears near to it then cluster head can directly forward packet to sink node. In this case sink node is both static and mobile [12]. Thus, energy is saved. Sensor nodes will calculate least distance that required to forward data packets. A sensor node calculates the minimum energy required with the help of the formula: *Min* (*E* (*Si, CH), E* (*Si, BS*)). The energy consumption results of SMCA is 50nJ/bit.

GCKN:

Sleep scheduling and mobility technique algorithm: The sleep scheduling problem in duty cycled WSNs with mobile nodes (referred to as mobile WSNs in the following) employing geographic routing. The two geographic distance based connected-*k* neighborhood (GCKN) sleep scheduling algorithms. The first one is geographic-*distance-based connected-k neighborhood for first path*1 (GCKNF) sleep scheduling algorithm, aiming at geographic routing utilizing only first transmission path in duty-cycled mobile WSNs. The second one is *geographic-distance-based connected-neighborhood for all paths*2 (GCKNA) sleep scheduling algorithm, for geographic routing concerning all paths explored in duty-cycled mobile WSNs. The main contributions of GCKN algorithm are summarized as follows.

1) This algorithm is a new work proposing and analyzing sleep scheduling algorithms for geographic routing in duty-cycled mobile sensor networks, which takes full advantages of both duty cycling and sensor mobility.

2) Specifically, these two GCKN algorithms effectively extend existing geographic routing algorithms designed for static WSNs into duty-cycled mobile WSNs by applying sleep scheduling. The GCKNF sleep scheduling algorithm is designed for shortest first transmission paths for geographic routing in duty cycled mobile WSNs. The GCKNA sleep scheduling algorithm aims at shortening all routing paths for multipath transmissions in duty-cycled mobile WSNs. These GCKN algorithms integrate the connected-*k* neighborhood requirement and geographic routing requirement to change the asleep or awake state of the sensor nodes.

//Pseudo code of GCKN algorithm

Run the following at each node *u*

1. Get the geographic distance between itself and the mobile sink *granku.*
2. Broadcast *granku* and receive the geographic distance ranks of it currently awaken neighbors *Nu*. Let *Ru* be the set of these ranks.
3. Broadcast *Ru* and receive *Rv* from each v ϵ Nu.
4. If |*Nu*| < k or |*Nv*| < k for any v ϵ *Nu*, remain awake.
5. Compute *Cu* = { *v* | *v* ϵ *Nu* and *grankv* < *granku* }.
6. Go to sleep if both the following conditions hold. Remain awake otherwise.
   - Any two nodes in Cu are connected either directly themselves or indirectly through nodes within *u*'s 2-hop neighborhood that have *grank* less than *granku*.
   - Any node in *Nu* has at least *k* neighbors from *Cu*.
6. Return.

The proposed two geographic-distance based connected-*k* neighborhood (GCKN) sleep scheduling algorithms for geographic routing schemes to be applied into duty-cycled mobile WSNs [13]. This can include the advantage of sleep scheduling and mobility.

IV. CONCLUSION:

Energy is the most critical resource in wireless sensor networks that must be used carefully. For energy conservation, various techniques such as sleep scheduling, multi-sink, mobility and clustering is discussed. The recent algorithms in these techniques were also studied. On analysis, SMCA algorithm is found to be best among these algorithms.

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