Power Optimization in Wireless Sensor Network – Review

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Abstract: **Wireless Sensor networks (WSN), energy conservation is an important aspect to extend the network life time. In such networks, there exists one more issue i.e limited power for each node. As the node is in continuous communication mode, it will drain up quickly. Hence, there is a necessity of energy conservation in wireless Sensor networks. In earlier, a vast research is carried out on this objective. In this paper, a brief review is carried out on the earlier energy conserving approaches, proposed by various authors. The energy conservation can be carried out by scheduling the nodes, communication scenario, MAC etc. According to the scheduling proposed for energy conservation, the entire approaches are categorized into three categories, such as cluster based scheduling, communication based scheduling and MAC based scheduling. All the scheduling approaches outlined here have their own advantages and disadvantages based on various conditions and applications.**

Keywords: Energy conversation, Scheduling, cluster, communication scenario, MAC

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I. INTRODUCTION

In recent years, wireless technology has gained great interest in industrial applications. With harsh industrial control environment, however, wireless networks are required to comply with several requirements pertaining to reliable communication. Sensor networks are an upcoming technology in the area of wireless mode communication. Sensor networks comprise of special subset of wireless networks since they don't require the existence of centralized message passing units. Simple wireless networks require existence of static base stations (BS), which are responsible for routing messages to and from mobile nodes (MNs) with in the specified transmission area. Sensor networks, on the other hand, don't require the existence of any device other than two or more Mobile Nodes (MNs) willing to cooperatively form a network. Instead of relying on a wired BS, to coordinate the flow of messages to each MN, the individual MNs form their own network and the forward packets to and from each other. This adaptive behavior, allows network to be quickly formed even under the most adverse conditions. An important issue in the design of wireless networks is the energy efficiency provision to increase the life time of network.As Sensor network are dynamic network, nodes are dynamic in nature. Due to the dynamicity, in such network, the resources are constraint. Each node shows a limited resource of offered bandwidth and power level. Due to such dynamicity the nodes offer high interferences under high traffic density and intern drain power at a faster rate. The offered inference directly effects the node lifetime and intern overall network performance. It is hence required to conserve power in Sensor network. For the energy conservation various approaches were proposed in past.

This paper gives a brief review about various approaches proposed earlier for energy conservation based on scheduling in wireless Sensor networks. The entire scheduling approaches were categorized into three categories such as cluster based scheduling, communication based scheduling and MAC based scheduling.

Rest of the paper is organized as follows: section II illustrates the complete details about the earlier approaches proposed for energy conservation in Sensor networks based on scheduling. Section III concludes the paper.

II. LITERATURE REVIEW

Basically, there are three classes of energy efficient sensor and sensor network routing protocols employing a sleepmode in the literature, cluster-based scheduling, communication scheduling based and MAC scheduling based. The main objective of all of them is to achieve energy efficiency by employing different topology management techniques. This section presents a brief review of these three classes of routing to provide abetter understanding of the current research issues in this area.

A. Cluster based Scheduling

In cluster-based routing protocols, all nodes are organized into clusters with one node selected to be cluster-head for each cluster. This cluster-head receives data packets from its members, aggregates them and transmits to a data sink. In some cluster-based routing protocols, the cluster-head assigns TDMA slots to its members to schedule the communication and the sleep mode. Low-Energy Adaptive Clustering Hierarchy (LEACH) [1] is designed for proactive sensor networks, in which the nodes periodically switch on their sensors and transmitters, sense the environment and transmit the data. Nodes communicate with their cluster-heads directly and the randomized rotation of the cluster-heads is used to evenly distribute the energy load among the sensors. Threshold sensitive Energy Efficient sensor Network protocol (TEEN) [2, 3] is designed for reactive networks, where the nodes react immediately to sudden changes in the environment. Nodes sense the environment continuously, but send the data to cluster heads only when some predefined thresholds are reached. Adaptive Periodic Threshold sensitive Energy Efficient sensor Network protocol (APTEEN) protocol [4] combines the features of the above two protocols by modifying TEEN to make it send periodic data. The cluster-based routing protocols can arrange the sleep mode of each node to conserve energy. However, the high complexity and overhead are incurred. In [5], [6] the cluster based scheme is developed to realign the network distribution for power saving. The clustering approach rearranges the node distribution, to achieve the power conservation.

B. Communication Scheduling

In [7] the node operation are scheduled with their operating cycles to achieve power saving. The nodes are scheduled for different operating phases such as sleep, wake, transmit and ideal to conserve the nodes power. In the conservation of energy resource in Sensor network various energy conservation approaches [8-10] were proposed in past. Among these all approaches a communication scheduling approach is observed optimal, as the controlling is operational controlled, hence giving lower demand for device changing. In the area of scheduling based communication, controlling of device switching, enabling, buffering [11-13] or routing [10] based controlling were proposed. However the scheduling based coding primarily demands for data precision, as in most scenarios it is observed that while scheduling of energy resources data are transferred via different nodes and the probability of data lost, or data fragmentation increases [14]. Hou and Tipper have proposed flat structure based protocol called Gossip-based Sleep Protocol (GSP) [15] that employs probabilistic based sleep modes. At the beginning of a gossip period, each node chooses either to sleep with probability p or to stay awake with probability 1 - p for the period, so that all the sleep nodes will not be able to transmit or receive any packet during the period. When an active node receives any packet, it must retransmit the same. All sleeping nodes wake up at the end of each period. All the nodes repeat the above process for every period. In [16], the author proposed a centralized scheme for extending the lifetime of densely deployed wireless sensor networks by keeping only a necessary set of sensor nodes active. It presents an algorithm for finding out which nodes should be put into sleep mode depending upon their location in sensing area. After deciding which nodes should be in sleep mode, and which nodes should be in active mode, the sink node generates a tree structure for routing purpose by using a breadth-first search (BFS) over the connective graph of active nodes. The whole process runs periodically. In this case, if the period is large and any node goes down in the middle of this period, then the whole routing structure can be disturbed. However, if we reduce the period, the operation performed at the beginning of each period is more, and hence, the energy consumption over whole network is also increased. From the above, it is clear that the equal consumption of energy and sharing of load by all nodes is an important requirement to prolong the network lifetime. However, if the nodes for sleeping are chosen randomly as in [15], a path from source to sink may not always be present, and sufficient numbers of nodes have to remain awake to ensure the existence of such a path. Alternatively, data can be stored at a node till a neighboring node towards the sink is found, but this approach would delay the delivery of the message to the sink considerably.Alternatively, a fixed path may be chosen from a node to the sink as in [16]. The problem with the approach in [16] is that the whole process is centralized, and the decisions of the sink node need to be conveyed to all the nodes. However, in this approach, delay to transmit data from source to sink will be less as such a path will always exist.

C. MAC Scheduling

While many MAC protocols have been designed for wireless Sensor networks, they are not optimized for the energy characteristics of network, where nodes cannot control their wakeup schedules as the energy charging times are dependent on environmental conditions. Wireless MAC protocols can be classified into two categories centralized MAC with a coordinator and distributed MAC. Centralized MAC protocols, like polling [17, 18], require a centralized coordinator to determine the order of transmissions. Distributed MAC protocols like CSMA require nodes to coordinate the transmissions among themselves. In [19], sleep and wakeup schedules are proposed to reduce energy usage and prolong network lifetime at the expense of longer delays. Since these schemes assume the use of batteries in their scenarios, energy conservation therefore is a key consideration. Sleep and wakeup algorithms have also been designed for sensor networks with energy harvesters. The performance of different sleep and wakeup strategies based on factors such as channel state, battery state and environmental factors are analyzed in [20] and game theory is used to find the optimal parameters for a sleep and wakeup strategy to tradeoff between packet blocking and dropping probabilities [21]. However, they assume the use of a TDMA-based wireless access system and the impact of different MAC protocols on network performance is not analyzed. Sift [22] is another protocol designed for event-driven sensor networks to minimize collisions in a slotted CSMA system. Another class of MAC protocols which use code assignments is used in DS-UWB wireless networks [23]. However, code assignment as well as the complexity of encoding and decoding is open problems in sensor networks with limited processing resources. An optimal transmission policy [24] can be used to achieve better performance when the data generated is of different priorities. As the power are heavily drained under high traffic condition, to control the power conservation under high interference MAC protocol is defined in [25], [26]. The approach, of energy preservation using energy harvesting [29] approach is proposed. Energy harvesting is an upcoming approach in wireless sensor networks. Energy harvesting is a process of energy generation by the utilization of node interface. In the process of energy harvesting an on demand medium access protocol is proposed in [27], [28]. This approach develops a scheduling approach of node operation to conserve energy and harvest energy based on movement from ideal listening time of receiver to transmitter unit. To conserve energy based on harvesting RF-MAC protocol was recently proposed in [30]. The approach proposed an energy transmission via RF media to recharge the distributed nodes over wide distributed nodes. However this method, doesnot concentrate on nodes interference and distribution simultaneously. There are other researchers that their methods worked based on coarse-grained schedules; whereas each node communicates according to their fixed interval schedule, which there are an active window and a sleep window [31, 32]. However, these scheduling methods are not considering the characteristics of the workload. The S-MAC [33] presents nodes periodic synchronize duty cycle as a mechanism to reduce idle listening. In SMAC, every node follows a periodic active/sleep schedule. In the active period, nodes turn on to transmit/receive data. Due to the low duty cycle operation, the network is energy efficient, but the drawback is the SMAC increases the packet delivery latency. Furthermore, in the source node, sampling need to be read when it is in sleep mode, and it must wait in the queue until the active mode period. Therefore, other nodes wait until the receiver gets active before it forward a packet from the previous hop. This major deficiency is known as sleep latency, and if all nodes have same schedule synchronization, then it has long schedule length that contains active period time plus the sleep period time. In another research [36], to reduce sleep latency as well as energy efficient, they used adaptive listening. In the path of transmission, one or more nodes ahead can retain awake for additional time. This method is used in extension of the S-MAC, and T-MAC protocols [34, 37]. The result of this method is a reduction of sleep latency, but it increases slightly energy consumption, and it is not recommended for the long path communications. The Power Save Mechanism (PSM) [38] topology, process the packet routing, which packets for the short time buffered by transmitter station (STA) and packets be delivered to destination later. The transmission occurs at the some agreed intervals. When the transmitter STA queue becomes empty, it turns to the sleep modes. To maintain the QoS besides energy conservation, an extension of PSM protocol introduced [39], which works for some WSN applications. This method used traffic indication map and organized data frame scheduling in the queue. The other topology introduced for multi-hop wireless network is SPAN [40]. The SPAN is a distributed and randomized algorithm, and the sleep schedule decision is locally. That means nodes make local decisions on whether going to sleep mode or transmit backbone as a coordinator. The nodes' decision is based on benefit estimation of the node’s neighbors and energy availability, which how many of their neighbors will receive the benefit from that node to be awake Geographic adaptive fidelity [41] is a routing protocol that attempts to decrease energy consumption by turning off the power of unnecessary nodes. The GAFBone is an extension of GAF protocol with additional backbone in data communication [42]. Other approaches implemented, and used for power management protocols to provide communication backbone. The connected backbone is responsible, when other nodes sleep for routing the packets [35, 43]. The performance of backbone method is sufficient for real-time communication routing. However, it cannot conserve any energy and while there is no need for any communication, backbone is still awake. In some applications of wireless sensor network when the workload is light, the backbone activity is completely unnecessary and not accepted. Furthermore, the backbone method cannot shape the traffic communication or characterize the workload.

III. CONCLUSION

A brief review is carried out in this paper on the routing protocols for energy conservation based on scheduling. The entire approaches are classified into three classes based on the scheduling mechanism. The energy conservation can be obtained in Sensor networks by scheduling the nodes, the communication of nodes, and the protocol based on which they are communicating etc. according to this, the total approaches are categorized into three classes and explained briefly. The clustering approach rearranges the node distribution, to achieve the power conservation. In communication based scheduling, delay to transmit data from source to sink will be less as such a path will always exist. In WSN we need a MAC scheduling protocol to consider energy efficiency, reliability, low access delay and high throughput as major priorities to accommodate with sensor’s limited resources and to avoid redundant power consumption.

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