Energy Efficient Protocols in Wireless Sensor Networks: A Survey

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Abstract

Wireless Sensor Networks (WSNs) consists of huge number of Sensor Nodes (SNs) with sensing, communication and processing capabilities. SNs have limited energy supply, storage and computational capacity. In recent years energy efficient computation is a major concern in WSN. The critical aspects include reduction in the energy consumption of SNs so that the network lifetime can be extended to reasonable times. For this purpose many novel innovative techniques based on energy efficient computation have been proposed. In this paper, we present a brief analysis on energy efficient computation protocols. We have also presented a comparison of these protocols.

Keywords: *WSN, Energy Efficiency, Aggregation.*

1. Introduction

WSNs have gained worldwide attention in recent years; particularly with the proliferation in technology which has facilitated the development of smart SNs. WSN consist of small SNs with sensing, computation, and wireless communications capabilities. These SNs measure ambient conditions in the environment surrounding them and then transform these measurements into signals that can be processed to reveal some characteristics about phenomena located in the area around these SNs. WSN contain hundreds or thousands of these SNs, and these SNs have the ability to communicate either among each other or directly to an external Base Station (BS). Basically, each SN comprises sensing, processing, transmission, mobilizer, position finding system, and power units [1]. The use of pervasive networking technology gives WSN a new kind of scope that can be applied to a wide range of uses. These can be roughly differentiated into monitoring space, monitoring things, and monitoring the interactions of things with each other and the encompassing space. The first category includes environmental and habitat monitoring, precision agriculture, indoor climate control, surveillance, and intelligent alarms. The second includes structural monitoring, condition-based equipment maintenance, medical diagnostics, and urban terrain mapping. The most dramatic applications involve monitoring complex interactions, including wildlife habitats, disaster management, emergency response, ubiquitous computing environments, asset tracking, healthcare, and manufacturing process flow [2]. Energy efficient computing is necessary for at least two reasons as shown in Fig 1. First, sending all the raw data to a BS for centralized processing is very costly in terms of energy consumption. Second, merely communicating user's requirement need to be compromise lot of QoS Parameters in light of energy constraints.

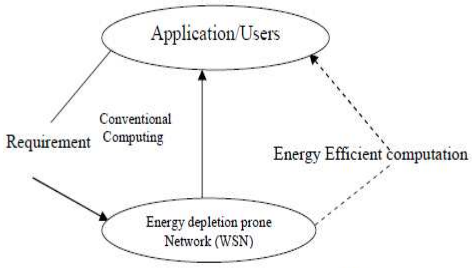

Figure 1: Computing in WSN

2. Energy Efficient Computing in WSN: Challenges

WSN offer a powerful combination of distributed sensing, computing and communication. The emerging WSN technology promises to fundamentally change the way humans observe and interact with the physical world. To realize such a vision, efficient computing is necessary for following reasons.

Resource constraints: The resources constraints in WSN involve energy, memory, bandwidth, processing capability, buffer size, and limited transmission power. Among them, energy is a primary issue since energy is severely constrained in SN and it is not feasible to replace or recharge the battery for SNs that are often expected to work in a remote or unattended environment. Computation intensive algorithms, expensive signaling protocols, or overwhelming network states maintained at SNs are not feasible.

Data redundancy: WSNs are characterized by high redundancy in the sensor data. However, the redundancy in the data helps loosen the robustness/reliability requirement of data delivery, but it unnecessarily spends more precious energy. Data fusion or data aggregation is a solution to reduce redundancy in the data.

Network dynamics: Network dynamics causes are SN failures, wireless adaptive link failures, SN mobility, and SN state transitions. Such a highly dynamic network greatly increases the need of distributed computation.

Load balance: In order to prolong network lifetime, energy load must be evenly distributed among all SNs so that the energy at a single SN or a set of SNs is not be drained out.

Scalability: The number of SN deployed in a region may be in the order of hundreds or thousands. Based on the application, the number may reach value of millions. WSN must be scalable enough to operate over long period of time.

Coverage: In WSNs, each SN obtains a certain view of the environment. A given SNs view of the environment is limited both in range and in accuracy; it can only cover a limited physical area of the environment. Hence, area coverage is also an important design parameter in WSN.

3. Infrastructure Support for Computing in WSN

In order for WSN to effectively perform computation, some necessary infrastructure needs to be established. This includes neighbor discovery and management, synchronization, localization, clustering and grouping, and data collection infrastructure.

Neighbor discovery and management refers to the process in which SNs discover their neighbors, learn their properties, and control which neighbors to communicate with expensive signaling protocols, or overwhelming network states maintained at SNs are not feasible.

Synchronization refers to the process in which SNs synchronize their clocks. It is necessary because sensory data is often not useful in absence of proper temporal reference frame.

Localization refers to the process in which SNs obtain their position or coordinate information. Similar to synchronization, localization is necessary because sensory data needs to be put in a spatial reference frame.

Clustering and grouping refers to the process in which SNs organize themselves into clusters or groups for some specific function.

Data collecting infrastructure ensures that sensory data is transported correctly and efficiently to one or a few collection points, sometimes called data sinks. Data aggregation deals with this distributed computing of data within network. These techniques are tightly coupled with gathering of data at the SNs as well as how packets are routed, and have a significant impact on energy consumption.

4. Energy Efficient Techniques in WSN

Based on the above issue, several techniques have to be exploited, even simultaneously, to reduce the energy consumption in WSN. At a very general level, we identify some enabling approaches as explained below:

Distance-Energy Cluster Structure Algorithm (DECSA) [3] is a distributed competitive unequal clustering algorithm based on clustering routing algorithm LEACH. The algorithm continues in round and each round consists of initialization and stable working stages. In initialization phase Cluster Head (CH) and base station CH is elected based on distance and residual energy and TDMA time slots are assigned to member nodes by the appropriate CH. In working stage after receiving message from Base Station (BS), according to different values of TBCH, BCH select maximum TBCH CH as a next hop and rest hop can be selected in same manner to form complete communication path.

Energy Balancing Cluster Routing Protocol Based on Mobile Agent (EBMA) [4] is energy balanced protocol based on mobile agent. In EBMA, the complete network is divided into clusters and each cluster consists of many hexagon cells and obtains cellular topology. The ordinary nodes connect to the closest mobile agent which acts as CH and is responsible for managing all SNs in that cluster and needs to be active, while the ordinary SNs can go to a sleep state when they have no tasks to perform. The number of mobile agents should be limited to reduce the cost but must ensure efficient gathering.

Energy Efficient and Balanced Cluster-Based Data Aggregation Algorithm (EEBCDA) [5] is unequal cluster based algorithm. The operation of EEBCDA is also divided into rounds and every round consists of a set-up phase and a steady-state phase, especially, there is a network-division phase before the first round. The network is divided into rectangular regions called swim lanes, then, each swim lane is further partitioned into smaller rectangular regions, called grids. The node with maximal residual energy of each grid is selected as CH. The grids away from BS are bigger and have more nodes to participate in CHs rotation to balance energy consumption. Then, each ordinary node chooses the closest CH to join a cluster. And TDMA time slots are assigned to member nodes by the appropriate CH. In steady state phase every member sends data to CH during its allocated transmission slot according to the TDMA schedule. Afterward, every CH aggregates the collected data and sends the fused data to BS. For the sake of CHs selection in next round, each member transmits its residual energy along with its data to CH at the last time of data gathering in every round.

dYnamic and scalable tree Aware of Spatial correlaTion (YEAST)[6] is a spatial correlation aware algorithm to perform efficient data collection in WSN. Based on the correlated region, which is the region SNs collect similar readings, the algorithm maximizes data aggregation along the communication route, and decreases the costs in the route discovery. A hybrid routing approach composed of proactive part is responsible for discovering the positions of both the neighbors and the sink used later to construct the routing infrastructure and the routing itself and reactive part is responsible for clustering nodes aware of spatial correlation and constructing data aggregation aware routes to transmit the collected data. Finally, the YEAST algorithm uses dynamic routes to ensure load balancing in the delivery of data. The YEAST algorithm is performed in four phases. In phase 1, SNs store the sink's and neighbor's position. In phase 2, consists of cluster formation, the election of a coordinator among the nodes that detected the occurrence of a new event, and the division of the event area into cells. In Phase 3, when an event happened, the coordinator sends a packet to the sink node informing its position. The sink node sends notifications to all other coordinators about the new coordinator Position and to the new coordinator the positions of coordinators that already exist. Finally, Phase 4 is responsible for creating the routing tree connecting all coordinators to the sink node and sending the collected data to the sink node. Each variation defines a new approach for a coordinator node to create its straight lines. In YEAST-CF (Closest First) the closest coordinators to the sink node are the first to create their straight line segments to the sink. YEAST-FF (Farthest First) the farthest coordinators from the sink are the first to create their straight line segments to the sink. YEAST-BC (Best Combination) this variation of the YEAST algorithm checks all possible combinations of straight lines and chooses the combination that provides the shortest Euclidean distance to create the routing tree. This approach is optimal, since it finds the routing tree of lowest cost.

In Energy conserving routing algorithm [7] for WSN consists of two phases routing setup and data transmission phase. In routing setup phase we divide the SNs into several scheduling sets and they work alternatively. So the sensors do not have to be active all the time thereby energy. In data transmission phase when choosing the next sensor to forward the data the distance from the BS to the sensor and its current energy level is taken into consideration to distribute the network power consumption among the sensors. When in network no more sensors have sufficient energy to run, it generates new scheduling sets automatically. Data collection contains the routing setup phase and the data transmission phase. During this phase, the scheduling sets check the energy levels of their member nodes when they finish working for a period. If there is any node whose next hop nodes are all with energy levels below a threshold value, the corresponding scheduling set is eliminated from the list. Periodically, the network constructs new scheduling sets with all the available nodes unless it cannot make even one scheduling set with all the available nodes.

Energy Efficient Load Balancing Clustering Algorithm (EELBC) [8] is minimum heap based clustering algorithm. In this algorithm restricted nodes (node able to communicate with only one gateway) is assigned to their corresponding gateway. Then the min heap is build based on the no. of SNs in the gateway. The gateway having min nodes is the root of min heap. Now the nearest node is assigned to gateway and heap is rearranging again .Then the nodes from open nodes (able to communicate with more than one gateway) is assigned to gateway and within its communication range. The procedure is repeated until all the SNs are allotted to their correct gateway. This algorithm satisfy load balancing property by assigning SN to that CH having minimum no. of SN and conserve energy by assigning node to nearest CH.

5. Conclusion

WSNs are used in lots of applications in which sensed information must be gathered from remote location. In this paper we have discussed some of the challenges, energy efficient computation protocols and have given the comparison of these protocols as shown in Table 1. As the requirement of energy efficiency for each WSN differ based on application, it is infeasible to design a protocol which satisfies the requirements in all scenarios of WSN. Although these energy conserving techniques look promising, there are still many challenges that need to be solved in WSN. Therefore, further research is necessary for handling these kinds of situations

Table 1: Energy Efficient Techniques in WSN: Analysis

Protocol	***Category***	***Features***	***Advantages***	***Limitation***
DECSA[3]	Clustering Aggregation	Multihop communication	Avoid direct communication . Good for unbalanced Energy consumption	Extra overhead
EBMA[4]	Clustering Duty cycling Aggregation	Multihop communication	No overhead for CH selection Time slots reduce probability of collisions. Balance energy consumption.	Limited mobile agents
EEBCDA[5]	Clustering Aggregation	Unequal cluster size	Balance energy dissipation based on CH rotation.	Extra overhead
Energy Conserving Routing Algorithm for WSN[6]	Routing Duty cycling	Multiple sink reduces transmission latency	Distribute power consumption by constructing scheduling sets. While selecting next node energy as well as distance from BS also taken into consideration	Nodes closer to sink carry more traffic
YEAST[7]	Clustering Aggregation	Hybrid approach	Adaptive Reduces redundancy by exploiting spatial correlation Adjust size of correlated region according to application requirements	Requires position information
EELBC[8]	Clustering	Less complexity	Load balancing	Extra overhead in rearranging heap

References

[1] Jamal N. Al-Karaki, Ahmed E. Kamal, “Routing Techniques in Wireless Sensor Networks: A Survey”, in proceeding of IEEE Wireless Communications, 2004 Vol.11, pp.26-28.

[2] David Culler, Deborah Estrin and Mani Srivastava ,” Overview of Sensor Networks”, in proceedings of IEEE Vol. 37, No. 8, 2004, pp. 41-49.

[3] Zhu Yong, Qing Pei,” A Energy-Efficient Clustering Routing Algorithm Based on Distance and Residual Energy for Wireless Sensor Networks”, in proceedings of International workshop on information and electronics engineering ,Vol. 29, 2012, pp. 1882-1888.

[4] Kai Lin, Min Chen, Sherali Zeadally, Joel J.P.C. Rodrigues,” Balancing energy consumption with mobile agents in wireless sensor networks”,in proceedings of Future Generation Computer Systems, 2012, pp. 446-456.

[5] Jun Yuea, Weiming Zhang, Weidong Xiao, Daquan Tang, Jiuyang Tang,” Energy Efficient and Balanced Cluster-Based Data Aggregation Algorithm for Wireless Sensor Networks”, in proceedings of International Workshop on Information and Electronics Engineering,Vol.11,2012,pp.2009-2015.

[6] Leandro A. Villas, Azzedine Boukerche, Horacio A.B.F. de Oliveira, Regina B. de Araujo, Antonio A.F. Loureiro,” A spatial correlation aware algorithm to perform efficient data collection in wireless sensor networks”,in proceedings of Elsevier, 2012.

[7] Yuping Dong, Hwa Chang, Zhongjian Zou and Sai Tang ,” An Energy conserving Routing Algorithm for Wireless Sensor Networks”, in proceedings of International Journal of Future Generation Communication and Networking,Vol.4, No. 1,2011,pp.39-54.

[8] Pratyay Kuila, Prasanta K. Jana,” Energy Efficient Load-Balanced Clustering Algorithm for Wireless Sensor Networks”, in proceedings of 2nd International Conference on Communication, Computing & Security,Vol.6, No. 1,2012,pp.771-777.

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