Cluster Head Selection Techniques for energy efficient Wireless Sensor Network: A Survey

Santokh Singh[1] Gagandeep Singh[2]
[1,2]Department of Computer Science Engineering
[1,2]Chandigarh Engineering Colleges, Landran, India

Abstract— Wireless sensor networks are widely considered as one of the most important technologies. The Wireless Sensor Network (WSN) is a wireless network consisting of ten to thousand small nodes with sensing, computing and wireless communication capabilities. They have been applied to numerous fields such as healthcare, monitoring system, military, and so forth. Recent advances in wireless sensor networks have led to many new protocols specifically designed for sensor networks where energy awareness is an essential consideration. Energy efficiency is thus a primary issue in maintaining the network. Innovative techniques that improve energy efficiency to prolong the network lifetime are highly required. Clustering is an effective topology control approach in wireless sensor networks. This paper elaborates several techniques like LEACH, HEED, LEACH-B, PEACH, EEUC of cluster head selection for energy efficient in wireless sensor networks.

Key words: Wireless sensor networks, Cluster head

I. INTRODUCTION

Recent advances in micro-electro-mechanical systems (MEMS) technology, wireless communications, and digital electronics have enabled the development of low-cost, low-power, multifunctional sensor nodes that are small in size and communicate untethered in short distances. These tiny sensor nodes, which consist of sensing, data processing, and communicating components, leverage the idea of sensor networks based on collaborative effort of a large number of nodes [1]. Such sensors are generally equipped with data processing and communication capabilities. The sensing circuitry measures ambient conditions related to the environment surrounding the sensor and transform them into an electric signal. Processing such a signal reveals some properties about objects located and/or events happening in the vicinity of the sensor. The sensor sends such collected data, usually via radio transmitter, to a command center (sink) either directly or through a data concentration center (a gateway) [3].

WSN is a network of tiny battery powered sensor nodes of limited on-board processing, storage and radio capability. Sensor nodes are usually deployed in a random fashion, and collect the context information and perform the given mission through the cooperation with other nodes. Each sensor node transmits the sensed data to other sensor nodes or Base Station (BS). Here direct communication to the BS is impractical if the number of sensor nodes is large as a few hundreds or thousands [2]. In order to achieve high energy efficiency and increase the network scalability, sensor nodes can be organized into clusters. The high density of the network may lead to multiple adjacent sensors generating redundant sensed data, thus data aggregation can be used to eliminate the data redundancy and reduce the communication load. In periodical data gathering applications, both methods promise to efficiently organize the network since data collection and processing can be done "in place" [4].

There are three methods that can be considered as possible networking protocols: direct communication, multi-hop routing, and clustering. As direct communication between the base and a large number of sensors is extremely energy consuming, and the multi-hop routine is considered as globally inefficient, clustering seems to be the appropriate method to use, In order to send information from very high number of sensor nodes to the base station, It is necessary and economical to group sensors into clusters. Each cluster will contain a cluster head. Each cluster head gathers and sends data, from its group of sensors, to the base station. Parameters for variation of energy consumption in the nodes, there are three main problems: How many sensors should be connected to each cluster head, how many clusters is needed, and where should each cluster head be positioned. The clusters of sensors must be nonoverlapping [5]. Hierarchical clustering mechanisms are especially effective in increasing network scalability and reducing data latency, and have been extensively exploited. [7]

I. LITERATURE SURVEY

Geon Yong Park (et al) 2013 proposes an efficient cluster head selection method using K-means algorithm to maximize the energy efficiency of wireless sensor network. Wireless sensor network consists of hundreds to thousands of sensor nodes gathering various data including temperature, sound, location, etc. It is usually difficult to recharge or replace the sensor nodes which have limited battery capacity. In this paper idea of discovering the cluster head minimizing the sum of Euclidean distances between the head and member nodes. Experimental results shows better performance compared to classical algorithms like LEACH and HEED and planned to minimize the clustering time [2].

Kemal Akkaya (et al) 2003 shows recent routing protocols for sensor networks and presents a classification for the various approaches pursued The three main categories discussed are: data-centric, hierarchical and location-based [3].

Seema Bandyopadhyay (et al) 2003 propose a distributed, randomized clustering algorithm to organize the sensors in a wireless sensor network into clusters also integrate the algorithm to generate a hierarchy of cluster heads and examine that the energy savings increase with the number of levels in the hierarchy. By using wireless sensor network the communication or message passing process must be designed to conserve the limited energy resources of the sensors. Clustering sensors into groups, so that sensors communicate information only to cluster heads and then the cluster heads communicate the aggregated information to the processing center, may save energy. And planned to consider an underlying medium access protocol

and investigate how that would affect the optimal probabilities of becoming a clusterhead and the run-time of the algorithm [6].

Wendi Rabiner Heinzelman (et al) 2000 proposes LEACH Low-Energy Adaptive Clustering Hierarchy a clustering-based protocol that utilizes randomized rotation of local cluster base stations cluster-heads to evenly distribute the energy load among the sensors in the network. Wireless distributed microsensor systems will enable the reliable monitoring of a variety of environments for both civil and military applications. LEACH uses localized coordination to enable scalability and robustness for dynamic networks, and incorporates data fusion into the routing protocol to reduce the amount of information that must be transmitted to the base station. Simulations show that: LEACH reduces communication energy by as much as 8x compared with direct transmission and minimum transmission- energy routing. [8]

Ossama Younis (et al) 2004 proposes a novel distributed clustering approach for long-lived ad-hoc sensor networks HEED (Hybrid Energy-Efficient Distributed clustering), that periodically selects cluster heads according to a hybrid of the node residual energy and a secondary parameter , such as node proximity to its neighbors or node degree. HEED terminates in O(1) iterations, incurs low message overhead, and achieves fairly uniform cluster head distribution across the network. Simulation results demonstrate that HEED prolongs network lifetime, and the clusters it produces exhibit several appealing characteristics. [9]

Andrea Depedri (et al) introduced some innovations in the algorithm giving origin to LEACH-B. Networking together hundreds or thousands of cheap microsensor nodes allows users to accurately monitor a remote environment by intelligently combining the data from the individual nodes. Proposed algorithm is based on classical LEACH.LEACH-B presents a new strategy of cluster heads election and cluster formation. Simulations results shows that LEACH-B outperform LEACH-A in a large class of situations and applications and in particular when: The final receiver is closer to the sensors and The deterministic attenuation due to the path-loss has a value of α larger than 2.5. [10]

SangHak Lee (et al) proposes a new distributed clustering and data aggregation algorithm, CODA (Cluster-based self-Organizing Data Aggregation), based on the distance from the sink in ad-hoc wireless sensor networks. Sensor Networks have recently emerged as an important computing platform. However, the energy constrained and limited computing resources of the sensor nodes present major challenges in gathering data. Simulation results show that the proposed algorithm balances the energy dissipation over the whole network thus prolongs the network lifetime. [11]

Kyung Tae Kim (et al) 2005 propose a new approach called energy-driven adaptive clustering hierarchy (EDACH), which evenly distributes the energy dissipation among the sensor nodes to maximize the network lifetime. Wireless sensor network consists of small battery powered sensors. Therefore, energy consumption is an important issue and several schemes have been proposed to improve the lifetime of the network. This is done by using proxy node replacing the cluster-head of low battery power and forming more clusters in the region relatively far from the base station. The proposed approach will be more important when the wireless sensor network is deployed in large area and the base station is far from the network. Simulation results show that while comparing with existing schemes such as LEACH (Low-Energy Adaptive Clustering Hierarchy) and PEACH (Proxy- Enabled Adaptive Clustering Hierarchy) reveals that the proposed EDACH approach significantly improves the network lifetime. And planned to comparison of the EDACH approach with other approaches such as simulated annealing and taboos search. [12].

Bhaskar Krishnamachari (et al) 2002 forms a data-centric routing and compare its performance with traditional end-to-end routing schemes. Sensor networks are distributed event-based systems that differ from traditional communication networks in several ways: sensor networks have severe energy constraints, redundant low-rate data, and many-to-one flows. Data-centric technologies are needed that perform in-network aggregation of data to yield energy-efficient dissemination. They investigated some of the factors affecting performance, such as the number of placement of sources, and the communication network topology. The formation of an optimal data aggregation tree is generally NP-hard. They examine the impact of source-destination placement and communication network density on the energy costs and delay associated with data aggregation. Also examine the complexity of optimal data aggregation. [13]

I.F. Akyilidiz (et al) 2002 illustrates the concept of sensor networks which has been made viable by the convergence of microelectro-mechanical systems technology, wireless communications and digital electronics. The sensing responsibilities and the potential sensor networks applications are explored, and a review of factors influencing the design of sensor networks is provided. Then, the communication architecture for sensor networks is outlined, and the algorithms and protocols developed for each layer in the literature are explored. And conclude that flexibility, fault tolerance, high sensing fidelity, low-cost and rapid deployment could be considered as future effort. [1]

Chengfa Li (et al) 2005 proposes an Energy-Efficient Unequal Clustering (EEUC) mechanism for periodical data gathering in wireless sensor networks. Clustering provides an effective way for prolonging the lifetime of a wireless sensor network. When cluster heads cooperate with each other to forward their data to the base station, the cluster heads closer to the base station are burdened with heavy relay traffic and tend to die early, leaving areas of the network uncovered and causing network partition. Proposed method partitioned the nodes into clusters of unequal size, and clusters closer to the base station have smaller sizes than those farther away from the base station. Thus cluster heads closer to the base station can preserve some energy for the inter-cluster data forwarding. And also propose an energy-aware multihop routing protocol for the inter-cluster communication. Simulation results show that our unequal clustering mechanism balances the energy consumption and sensor nodes and

achieves an obvious improvement on the network lifetime. [4]

Malka N. Halgamuge (et al) 2003 proposed an energy optimized cluster formation for a set of randomly scattered wireless sensors. Sensors within the same cluster could communicate with each other with the help of cluster head only. Cluster head maintain the link between sensors and base station. And conclude the main three categories used in sensor cluster formation: 1) Clustering algorithms known in data mining (e.g. SOM, K-mean, Fuzzy C-mean, Subtractive) 2) Use of optimisation algorithms such as Genetic Algorithms for cluster formation 3) Clustering algorithms known in networking research. [5]

Mao YE (et al) propose a novel energy efficient clustering scheme (EECS) for single-hop wireless sensor networks, which better suits the periodical data gathering applications. Proposed method elects cluster heads with more residual energy in an autonomous manner through local radio communication with no iteration while achieving good cluster head distribution. Data gathering is a regular but key operation in many applications of wireless sensor networks. Innovative techniques that improve energy efficiency to prolong the network lifetime are highly required. In proposed method they remove the assumption of single-hop and design an energy efficient protocol for both intra-cluster and inter-cluster data transmission in EEUC. Simulation results show that EECS prolongs the network lifetime significantly against the other clustering protocols such as LEACH and HEED. [7]

R.Devika (et al) 2013 shows different routing protocol with advantages and limitations. The Wireless Sensor Network is a wireless network consisting of ten to thousand small nodes with sensing, computing and wireless communication capabilities. WSN are generally used to monitor activities and report events, such as fire, overheating etc. in a specific area or environment. It routs data back to the Base Station (BS). And conclude that major issue in wireless sensor networks is energy efficiency due to limited energy resources of sensors that could be resolve out with routing protocols to prolong the life time of individual sensors [15].

Sangho Yi (et al) 2007 we propose PEACH power-efficient and adaptive clustering hierarchy protocol for wireless sensor networks. It helps in clustering protocols to minimize the energy consumption of each node, and maximize the network lifetime of wireless sensor networks. PEACH forms clusters without additional overhead and supports adaptive multi-level clustering. PEACH can be used for both location-unaware and location-aware wireless sensor networks. Simulation results demonstrate that PEACH significantly minimizes energy consumption of each node and extends the network lifetime, compared with existing clustering protocols and concludes that performance of PEACH is less affected by the distribution of sensor nodes than other clustering protocols. [14].

II. CONCLUSION

WSN is most emerging ubiquitous computing technology which can be employed in wide spectrum of application. One of the major issues in the design of routing protocol for WSN is energy efficiency due to limited energy resources of sensors. In this present paper, we surveyed several techniques like LEACH, HEED, LEACH-B, PEACH, EEUC of cluster head selection for energy efficient in wireless sensor networks. By using these routing protocols cluster head selection in wireless sensor networks for energy efficient could be increased. These protocols are dynamic in nature.

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