Energy Efficient Clustering Algorithms in Wireless Sensor Networks: A Survey

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Abstract

To maximize network lifetime in Wireless Sensor Networks (WSNs) the paths for data transfer are selected in such a way that the total energy consumed along the path is minimized. To support high scalability and better data aggregation, sensor nodes are often grouped into disjoint, non overlapping subsets called clusters. Clusters create hierarchical WSNs which incorporate efficient utilization of limited resources of sensor nodes and thus extends network lifetime. The objective of this paper is to present a state of the art survey on clustering algorithms reported in the literature of WSNs. Our paper presents a taxonomy of energy efficient clustering algorithms in WSNs. And also present timeline and description of LEACH and Its descendant in WSNs.

Keywords: *wireless sensor networks, clustering, energy efficient clustering, LEACH, network lifetime, energy efficient algorithms, energy efficient routing.*

1. Introduction

Energy usage is an important issue in the design of WSNs which typically depends on portable energy sources like batteries for power .WSNs is large scale networks of small embedded devices, each with sensing, computation and communication capabilities. They have been widely discussed in recent years [1-3]. Micro-Electro-Mechanical System (MEMS) sensor technology has facilitated the development of smart sensors, these smart sensors nodes are small devices with limited power, processing and computation resources. Smart sensors are power constrained devices that have one or more sensors, memory unit, processor, power supply and actuator [4]. In WSNs, sensor nodes have constrained in term of processing power, communication bandwidth, and storage space which required very efficient resource utilization. In WSNs the sensor nodes are often grouped into individual disjoint sets called a cluster, clustering is used in WSNs, as it provides network scalability, resource sharing and efficient use of constrained resources that gives network topology stability and energy saving attributes. Clustering schemes offer reduced communication overheads, and efficient resource allocations thus decreasing the overall energy consumption and reducing the interferences among sensor nodes. A large number of clusters will congest the area with small size clusters and a very small number of clusters will exhaust the cluster head with large amount of messages transmitted from cluster members. LEACH protocol is hierarchical routing based on clustering and find the optimal number of clusters in WSNs in order to save energy and enhance network lifetime. In this work, we have surveyed the state-of-art of clustering algorithms in WSNs. We have discussed the advantages and disadvantages of clustering along with a survey of LEACH and its descendant.

Given the importance of clustering for WSNs, rest of the paper is organized in following structure; Section II presents the Challenges and limitations of wireless sensor networks. Section III presents an overview of hierarchical routing in WSNs. Section IV presents a survey on state-of-art of clustering algorithms reported in the literature and section V presents the conclusion of the paper.

2. Challenges and limitation of wireless sensor networks

In WSN sensor nodes have limited processing power, communication bandwidth, and storage space. This gives rise to new and unique challenges in data management and information processing. In-network data processing techniques, such as data aggregation, multicast and broadcast need to be developed. Network lifetime is the key characteristics used for evaluating the performance of any sensor network [6]. A lifetime of the network is determined by residual energy of the system, hence main and most important challenge in WSN is the efficient use of energy resources. Literature shows the energy efficiency is introduced in WSNs using any of the following mechanisms: Energy conservation mechanism, Power conservation mechanism, Energy harvesting mechanism and Energy efficient routing.

2.1 Energy aware routing

The aim of routing in WSNs is to find out and maintain routes in WSNs. Routing challenges with reference to WSNs [19] are Energy consumption without losing accuracy , Node deployment, Link heterogeneity, Data reporting model , Scalability, Network dynamic transmission media, Connectivity, Coverage, Data aggregation, Quality of services.

3. Hierarchical Routing in WSNs

The main target of hierarchical routing or cluster based routing is to efficiently maintain the energy usage of sensor nodes by involving them in multi-hop communication within a particular cluster. Cluster formation is generally based on the energy reserve of sensors and sensors proximity to the Cluster Head (CHs). Clustering plays an important role for energy saving in WSNs. With clustering in WSNs, energy consumption, lifetime of the network and scalability can be improved. Because only cluster head node per cluster is required to perform routing task and the other sensor nodes just forward their data to cluster head. Clustering has important applications in high-density sensor networks, because it is much easier to manage a set of cluster representatives (cluster head) from each cluster than to manage whole sensor nodes. In WSNs the sensor nodes are resource constrained which means they have limited energy, transmit power, memory, and computational capabilities. Energy consumed by the sensor nodes for communicating data from sensor nodes to the base station is the crucial cause of energy depletion in sensor nodes.

3.1 Pros and Cons of clustering in WSNs

The pros of Clustering are that it enables bandwidth reuse thus can improve the system capacity [7]. Due to the fact that within a cluster, all the normal nodes send their data to the CHs so energy saving is achieved by absence of flooding, multiple routes, or routing loops. Due to the fact that clustering enables efficient resource allocation and thus help in better designing of power control and other advantage is due to the fact that any changes of nodes behavior within a cluster affect only that cluster but not the entire network, which will therefore be robust to these changes. There are also several cons of existing clustering schemes in WSNs like in the selection of the cluster heads, some algorithm selects cluster heads only according to the ID number or residual energy of the sensor nodes. Science all the data in sensor network are sent to the base station, the traffic near the base station is higher. The sensor nodes in these areas will therefore run out energy earlier. The base station will then be isolated and as a result, the residual energy stored in the other sensor nodes will be wasted. Another disadvantage is the energy is wasted by flooding in route discovery and duplicated transmission of data by multiple routes from the source to the destination [7].

4. Clustering Algorithms in WSNs

Fig.1 shows the taxonomy of clustering algorithms in WSNs

4.1 CACC: Clustering Algorithm based on Cell Combination [8]

In this paper author proposed a clustering algorithm which based on cell combination for the networks. Sensor nodes are distributed densely and the energy of sensor nodes is always limited. In this clustering algorithm, the monitoring region is divided into hexagonal cells by considering the geographic location information of nodes. Each cluster consists of at least seven hexagon cells. Nodes with the same cluster identity form a cluster and the cluster head in each cluster is elected from the central cell of each cluster. The shape of the cells consider nearly circular in order to improve channel reuse and energy efficiency.

4.2 VAP-E: Energy-Efficient Clustering -Virtual Area Partition [9]

In this authors proposed an energy efficient clustering algorithm which based on virtual area partition in heterogeneous networks environment where the maximal transmission power of each node may be different. Authors found that VAP-E can balance the load between clusters, enhance the energy efficiency of sensor nodes, prolong the lifetime of networks, and improve the efficiency of communications. Authors also compare this algorithm with respect to LEACH and LEACH-E and found that VAP-E can enhance the stability period and network life time with the same simulation condition.

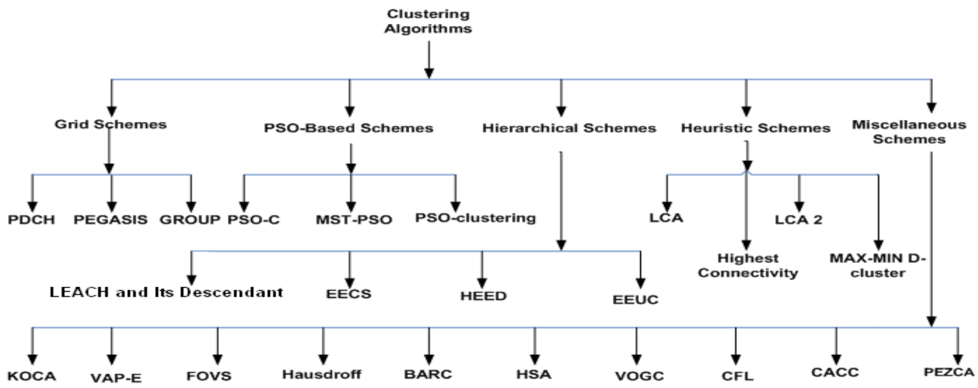

Fig.1: Taxonomy of clustering algorithms in WSNs

4.3 CFL: Clustering for Localization [10]

Authors proposed a clustering algorithm which uses a combined weight function and tries to divide the sensor nodes so that a minimum number of clusters with maximum number of sensor nodes in each cluster could be achieved. The weight functions at each sensor node, which is a combination of different parameters including: residual energy, number of neighbors and transmission power. Basically CFL clustering algorithm is designed for localization in WSNs. It is unable to work when the distribution of sensor nodes are not good.

4.4 FoVs: Overlapped Field of View [11]

Authors proposed a clustering algorithm for wireless multimedia sensor networks based on overlapped Field of View (FoV) areas. The main contribution of this algorithm is finding the intersection polygon and computing the overlapped areas to establish clusters and determine cluster membership. For dense networks, overlapping FoVs causes wasting power of the system because of redundant sensing of the area. The aim of the clustering method is prolonging network lifetime and energy conservation.

4.5 KOCA: K-Hop Overlapping Clustering Algorithm [12]

Authors proposed a clustering algorithm based on K-hop overlapping which is used to overcome the problem of overlapping multi-hop clustering for WSNs. Goal of KOCA algorithm is generating connected overlapping clusters that cover the entire sensor network with a specific average overlapping degree. Authors also found that KOCA produces approximately equal-sized clusters, which allow equally distributing the load evenly over different clusters. In KOCA, clustering formation terminates in a constant time regardless of the network size. Under contention and severe errors, up to 10 percent, KOCA communication overhead is reduced due to the dropped packets. Author's simulation results show that clusters are approximately equal in size. This is requiring achieving load balancing between different clusters.

4.6 PEZCA: Power-Efficient Zoning Clustering Algorithm [13]

Authors proposed a Power-Efficient Zoning Clustering Algorithm (PEZCA) which uses two algorithms: classical LEACH (Low-Energy Adaptive Clustering Hierarchy) and PEGASIS (Power-Efficient Gathering in Sensor Information Systems). In this algorithm, base station consider at a center of the scenario and the scenario area is divided into multiple fan shaped regions and the clusters closer to the base station have smaller sizes than those farther away from the base station. Thus CHs (cluster heads) nearest to the BS (base station) can preserve more energy for inter-cluster data transmission. PEZCA provide more balance in energy consumption and life time of network comparisons to LEACH.

4.7 VoGC: Voting-on-Grid clustering [14]

In this author combined voting method and clustering algorithm, and developed new clustering schemes for secure localization of sensor networks. Authors also found that the newly proposed approaches have very good performances on localization accuracy and the detection rate of malicious beacon signals. In this scheme, malicious beacon signals are filtered out according to the clustering result of intersections of location reference circles. Authors used a voting-on-grid (VOGC) method instead of traditional clustering algorithms to reduce the computational cost and found that the scheme can provide good localization accuracy and identify a high degree of malicious beacon signals.

4.8 BARC: Battery Aware Reliable Clustering [15]

In this clustering algorithm authors used mathematical battery model for implementation in WSNs. With this battery model authors proposed a new Battery Aware

Reliable Clustering (BARC) algorithm for WSNs. It improves the performance over other clustering algorithms by using Z-MAC and it rotates the cluster heads according to battery recovery schemes. A BARC algorithm consists of two stages per round for selection of cluster heads: initialization or setup and steady state. In this formation of cluster, take place by electing a set of CHs. BARC enhances the network lifetime greatly compare to other clustering algorithms.

4.9 Hausdroff Clustering [16]

Authors considered that, once cluster formations take place it's remaining same throughout the network lifetime. This algorithm maximizes the lifetime of each cluster in order to increase the life time of the system. Cluster life time can be enhanced by rotating the role of cluster heads (CHs) among the nodes in the cluster. Cluster heads selection basically based on the residual energy of the sensor nodes and it also used the proximity of neighbors as a secondary criterion for enhancing energy efficiency and further prolong the network lifetime. The Hausdroff clustering algorithm is equally applicable for both uniform and nonuniform sensor node initial energy distribution.

4.10 HSA: Harmony Search Algorithms [17]

This is music based metaherustic optimization algorithm which is analogous with a music improvisation process where musician continue to polish the pitches in order to obtain better harmony. By which it optimizing the energy consumption and minimizing intra-cluster distance of the network. In this the base station computes and allocates nodes into clusters according to the information of their residual energy and location. The operation has two phases: clustering setup and data transmission. This algorithm provides improvement in term of power consumption and network life time over LEACH protocol. With a small network diameter, energy consumption of the network is almost same when using different clustering protocols.

4.11 PEGASIS: Power-Efficient Gathering in Sensor Information System [18]

By this author proposed algorithm PEGASIS that is a chain based protocol provide improvement over LEACH algorithms. In PEGASIS, each node communicates only with a close neighbor and takes turns transmitting to the base station, thus reducing the amount of energy spent per round. Using greedy algorithm, the nodes will be organized to form a chain, after that BS can compute this chain and broadcast it to all the sensor nodes. Energy saving in PEGASIS over LEACH takes place by many stages: First, in the local data gathering, the distances that most of the sensor nodes transmit are much less compared to transmitting to a cluster-head in LEACH. Second, only one node transmits to the BS in each round of communication. PEGASIS outperforms LEACH by limiting the number of transmissions, eliminating the overhead of dynamic.

4.12 Max-Min D-Cluster Algorithm [19]

Authors proposed a clustering algorithm in which no nodes are more than d-hops away from the cluster head. The cluster head selection strategy developed, by having each sensor node initiate a 2d round of flooding, from which results are considered. In order to select the cluster head nodes, follow a set of rule in which 1^{st} d round called flummox, used to propagate largest node IDs and after completion of this round 2^{nd} d round start which is called flagmen. This algorithm is applicable only when two assumptions are made: all nodes that survive the flood max elect themselves cluster heads. During flooding, no node ID will propagate further than d-hops from originating node. This algorithm provides load balancing among the cluster heads.

4.13 PDCH: Pegasis Algorithm Improving Based on Double Cluster Head [20]

Authors proposed an algorithm based on hierarchical chain topology and this algorithm using bottom level cluster head and super level cluster head to improve the load balance. In the hierarchical structure, base station (BS) is the center of a circle. The BS will predefine the number of levels and every node's distance to BS decided the level which it belongs to. Every node receives the signal from the BS, then according to the signal strength to detect the distance to BS. PDCH outperform to PEGASIS algorithm and it is also useful for large networks.

4.14 GROUP [21]

GROUP clustering algorithms based on clustering algorithm that provides scalable and efficient packet routing for large-scale WSNs. Only some parts of total number of sensor nodes participate in formation of cluster heads (CHs). In this, cluster heads are arranged in a grid manner and primary sink (One of the sink), dynamically and randomly builds the cluster grid. Greed Seed (GS) is a node within a given radius from the primary sink. Any queries from sink to nodes are propagated from greed seed to its cluster heads and so on.

4.15 EECS: Energy Efficient Clustering Schemes [22]

Authors proposed an algorithm in which cluster formation is different from LEACH protocol. In LEACH protocol cluster formation takes place on the basis of a minimum distance of nodes to their corresponding cluster head. In

EECS, dynamic sizing of clusters takes place which is based on cluster distance from the base station. The results are an algorithm that addresses the problem that clusters at a greater distance from the sink requires more energy for transmission than those that are closer. Ultimately it provides equal distribution of energy in the networks, resulting in network lifetime. Thus main advantage of this algorithm is the full connectivity can be achieved for a longer duration. So we can say it provides reliable sensing capabilities at a larger range of networks for a longer period of time. It provides a 35 percent improvement in network life time over LEACH algorithm.

4.16 EEUC: Energy Efficient Unequal Clustering [23]

This scheme is distance based scheme similar to EECS and it also required that every node has global identification such as its locations and distances to the base station. Hotspot is the main problem in WSNs because of multi hopping that occurs when CHs closer to the sink tend to die faster compare to another node in the WSNS, because they relay much more traffic than remote nodes. This algorithms partition the all nodes into clusters of unequal size, and clusters closer to the sink have smaller sizes than those farther away from the sink. Thus cluster heads (CHs) closer to the sink can conserved some energy for the inter-cluster data forwarding. Energy consumed by cluster heads per round in EEUC much lower than that of LEACH standard but similar to HEED protocol.

4.17 LCA: Linked Cluster Algorithms and LCA2 [24]

A link cluster algorithm which was one of the oldest clustering algorithms developed for wired sensor networks, but later developed also for wireless sensor networks. In LCA each node has a unique ID number and selection of cluster heads in this algorithm depends upon two factors: Node has the highest ID number in the cluster. If none of its neighbors' are cluster heads. Since LCA used TDMA frame for communication between the nodes, where each frame has slots for each network in the network to communicate. This means that LCA is only applicable for small networks and for larger network LCA impose greater communication delay. Authors proposed LCA2 algorithm, in order to eliminate the election of an unnecessary number of cluster heads, as in LCA.

4.18 Highest-connectivity cluster algorithm [25]

Authors, propose a highest-connectivity cluster algorithm which is similar to LCA. In this algorithm instead of using the ID number for selection of cluster heads authors used connectivity by node. In this the node which is connected more number of nodes is elected as a cluster head. Highest-connectivity cluster algorithm suffers from additional overhead associated with more frequent topology changes. Highest-connectivity cluster algorithm has a slightly larger cluster size than d-hop Max-Min clustering algorithms.

4.19 PSO-Clustering [26]

Authors proposed PSO-clustering which have four variants of PSO: PSO-TVIW (PSO with time varying inertia weight), PSO-TVAC (PSO with time varying acceleration constants), HPSO-TVAC (hierarchical PSO-TVAC) and PSO-SSM (PSO with supervisor student mode) for energy aware clustering in WSNs. This algorithm is applicable only when each node has fixed Omni-directional transmission range, the sensor field should be mapped into a 2-Dimensional space and nodes are randomly distributed. After deployment of the nodes, the nodes are static and the positions of the nodes are known to the base station. The base station runs the clustering algorithm and updates nodes about their cluster-head and all nodes should have same transmission ranges and hardware configurations.

4.20 PSO-C: Centralized-PSO [27]

Authors proposed centralized-PSO algorithms, in which the nodes which have energy above average energy resource are elected as the cluster heads. In this authors also compare this algorithm with LEACH protocol and with LEACH-C. Simulation results show that PSO outperform to LEACH and LEACH-C in term of network life time and throughput etc. It also outperforms GA and K-means based clustering algorithms.

4.21 MST-PSO: Minimum Spanning Tree-PSO [28]

Authors proposed a minimum spanning tree-PSO based clustering algorithm of the weighted graph of the WSNs. The optimized route between the nodes and its cluster heads is searched from the entire optimal tree on the basis of energy consumption. Election of cluster head is based on the energy available to nodes and Euclidean distance to its neighbor node in the optimal tree. Others have concluded that network life time does not depend on the base station location or residual energy of the node. Once the topology decided to then network life time becomes almost settled. Author's shows two techniques for improving network life time: reduce the startup energy consumption of the transmitter and receiver, and optimized the network topology.

4.22 LEACH and Its Descendant

Low Energy Adaptive Clustering Hierarchical Protocol (LEACH) uses the following techniques to achieve the design goals: randomized, self-configuring and adaptive cluster formation, Local control for data transfers and low-energy media access control and application specific data processing. LEACH protocol has many rounds and each round has two phases, a setup phase and steady state phase, in set up phase it provides cluster formation in adaptive manner and in the steady state phase transfer of data takes place. LEACH uses a TDMA or a CDMA MAC to reduce inter-cluster and intra cluster collisions. Cluster formation based on many properties such as the number and type of sensors, communication range and geographical location. The energy consumption of the information gathered by the sensors node to reach the sink will depend on the number of cluster heads and radio range of different algorithms, because the energy consumption can be reduced by organizing the sensor nodes in the clusters [38].

LEACH-F: In this author proposed an algorithm in which the number of clusters will be fixed throughout the network lifetime and the cluster heads rotated within its clusters. Steady state phase of LEACH-F is identical to that of LEACH. LEACH-F may or may not be provided energy saving and this protocol does not provide the flexibility to sensor nodes mobility or sensor nodes being removed or added from the sensor networks.

LEACH-C: LEACH cluster formation algorithm has the disadvantages of guarantee about the number of cluster head nodes and its placement. Since the clusters are adaptive, so there is poor clustering set-up during a round will affect overall performance. However, using a central control algorithm to form the clusters may produce better clusters by distributing the cluster head nodes throughout the network.

LEACH-B : Authors proposed decentralized algorithms of cluster formation in which sensor node only knows about own position and position of final receiver and not the position of all sensor nodes. LEACH-B operates in following phases: Cluster head selection algorithm, Cluster formation and data transmission with multiple accesses. Each sensor node chooses its cluster head by evaluating the energy dissipated in the path between final receiver and itself. It provides better energy efficiency than LEACH.

LEACH-ET: In this cluster will change only when one of the following conditions is satisfied: first, Energy consumed by anyone of the cluster head nodes (CHs) reach energy threshold (ET) in one round. Second, every sensor node should know the energy threshold (ET) value. If in initial phase, anyone of the cluster head nodes dies. If any sensor node acts as a cluster head node (CHs) in a certain round, it should have the energy dissipated value and compares the dissipated value with the energy threshold (ET) value.

Energy–LEACH: it provide improvement in selection of cluster heads of LEACH protocol It makes residual energy of the node as the main factor which decides whether these sensor nodes turn into the cluster head or not in the next round. E- LEACH improves the cluster head election procedure that is chosen in LEACH protocol node cannot be chosen to be a cluster head node. This protocol provides longer network life time and energy saving compared to LEACH protocol

TL-LEACH: its works in three phases, cluster-head casing, Cluster setup and data transmission. In this protocol the author improve the LEACH in which some of the cluster heads elected during setup phase in LEACH were chosen again as the level-2 cluster heads (CHs), which have the communication with the base station

MH-LEACH: In this author proposed a protocol which improves communication mode from a single hop to multi hop between cluster head and base station. In LEACH protocol each cluster head directly communicates with sink and the distance between the sink and cluster head does not matter, if the distance is large it will consume more power. So modified form like MH LEACH protocol which adopt an optimal path between the base station and cluster head and multi hop communication takes place among cluster heads.

ACHTH –LEACH: The author has induced ACHTH - LEACH to improve LEACH and rectify its defects. The clusters are set up based on the Greedy k-means algorithm. The cluster heads are elected by considering the residual energy of sensor nodes. And the cluster heads may adopt two-top transmission to reduce the energy spent on sending data to the BS. The simulation results show that ACHTH-LEACH effectively prolong the lifespan of the network by the balanced clustering approach and the two-hop communication to the BS. The performance of ACHTH-LEACH can be further improved if some parameters and threshold values are optimized in and the percent of nodes alive is less than threshold values are optimized.

MELEACH-L: In this paper the authors enumerated energy-efficient multi-channel routing protocol for wireless sensor networks. With the aid of controlling the size of each cluster and separating CHs from backbone nodes, MELEACH-L manages the channel assignment among neighbor clusters and the cooperation among CHs during the data collection. Analysis and simulations clearly show the validity of the two criteria for large-scale WSNs and the energy-efficiency of MELEACH-L.

Table1: Time line of LEACH and Its Descendant

S.N.	LEACH and Its Descendant	Abbreviation	Year of Publication
1	LEACH [49]	Low energy adaptive clustering hierarchy	2002
2	LEACH-C [49]	Centralized - Low energy adaptive clustering hierarchy	2002
3	LEACH-F [50]	Fixed no. Of Cluster- Low energy adaptive clustering hierarchy	2002
4	LEACH-B [51]	Balanced- Low energy adaptive clustering hierarchy	2003
5	LEACH-ET [52]	Energy threshold- Low energy adaptive clustering hierarchy	2006
6	LEACH-E [53]	Energy- Low energy adaptive clustering hierarchy	2007
7	TL-LEACH [54]	Three Layer- Low energy adaptive clustering hierarchy	2007
8	A -s LEACH [31]	Advanced-solar aware- Low energy adaptive clustering hierarchy	2007
9	S- LEACH [55]	Secure- Low energy adaptive clustering hierarchy	2008
10	Trust Based –LEACH [36]	Trust Based- Low energy adaptive clustering hierarchy	2008
11	LEACH-DCHS-CM [37]	Cluster maintenance - Low energy adaptive clustering hierarchy-DCHS	2008
12	TB- LEACH [38]	Time based- Low energy adaptive clustering hierarchy	2008
13	MAT- LEACH [40]	Mobile agent based- Low energy adaptive clustering hierarchy	2008
14	Armor- LEACH [42]	Advance LEACH routing protocol for micro-sensor networks	2008
15	LEACH-Mobile [45]	Low energy adaptive clustering hierarchy-Mobile	2008
16	A-LEACH [41]	Advanced- Low energy adaptive clustering hierarchy	2008
17	ME- LEACH-L [34]	More energy efficient - Low energy adaptive clustering hierarchy-L	2009
18	Re-cluster- LEACH [46]	Re-cluster- LEACH- Low energy adaptive clustering hierarchy	2009
19	LEACH-H [44]	Low energy adaptive clustering hierarchy-H	2009
20	O- LEACH [43]	Optical- Low energy adaptive clustering hierarchy	2009
21	LEACH-TM [39]	Low energy adaptive clustering hierarchy-trust-minimum transmission	2009
22	MS- LEACH [35]	Combination of **multi-hop** and **single hop**- Low energy adaptive clustering hierarchy	2009
23	Hybrid-LEACH [32]	Hybrid- Low energy adaptive clustering hierarchy	2009
24	LEACH-D [29]	Low energy adaptive clustering hierarchy-D	2010
25	P-LEACH [30]	Low energy adaptive clustering hierarchy-partition	2010
26	ACHTH- LEACH [33]	Adaptive cluster head election and two hop transmission- Low energy adaptive clustering hierarchy	2010
27	MR- LEACH [47]	Multi-hop hop routing- Low energy adaptive clustering hierarchy	2010
28	HPR- LEACH [48]	Heterogeneous- Low energy adaptive clustering hierarchy	2010

MS-LEACH: In this paper the authors have analyzed the problem of energy consumption of the single-hop and multi-hop transmissions in a single cluster. Finally a critical value of the cluster area size is determined. MS-Leach is based on the critical value. Simulation results clearly show that MS-Leach outperforms at most by 200% in term of network lifetime. It is proposed as future work its relationship between multi-hop and single-hop transmissions will be analyzed in-depth in various protocols and new mechanisms of routing will be developed.

Trust-Based LEACH: Since the commonly security solution based on cryptography and other traditional methods which cannot incorporate new challenges from internal attackers, and trust is recognized as a novel approach to defend against such attacks. In this paper the authors have proposed a trust-based LEACH protocol to provide secure routing, while keeping the necessary functionalities of the original protocol. The decision-making is based on the decision trust, evaluated independently and adaptively for different decisions by basic situational trust.

LEACH-DCHS-CM: The authors have presented a LEACH-DCHS-CM algorithm against the characteristic of the frequent formation of the clusters in LEACH-DCHS algorithm. Highlighted the option of using energy balance clustering algorithm when the number of failed nodes up to a certain extent. As a future wok main concentration on the "certain value" settings of nodes also deserve further research.

TB-LEACH: A new protocol of Cluster-Head Selection Algorithm for LEACH based on time (TB-LEACH). Principle of TB-LEACH is stated and the main flowchart and pseudo codes realizing TB-LEACH. Analysis between new protocol and LEACH protocol is done which significantly shows that there is an improvement which is done by formation of a constant number of clusters; TB-LEACH constructs the cluster by using an algorithm based random-timer, which doesn't require any global information. Also the simulation results confirm the TB-LEACH provides the best energy efficiency and the longer network lifetime in comparison to LEACH.

LEACH-TM: In this paper as compared to LEACH which have certain drawbacks a new improved LEACH-TM introduces the concept of Trust, designs the cluster-head adjusting procedure and establishes a multi - path with cluster-heads acting as routers. The simulation confirms that LEACH-TM over comes the deficiency makes in the reliability of data transmission, the distribution of cluster heads and the lifetime of networks.

A-LEACH: LEACH protocol suffers with the problem that Head node spends the more energy in comparison to others. In this paper it is proposed how effectively to process data using a mobile agent technique based LEACH. So that the task of energy saving and reliable data is fulfilled. In this paper, the authors have elaborated how to select the cluster heads in every round which depends both on current state probability and general probability.

Armor-LEACH: This protocol as compared to LEACH, Sec-LEACH the Armor-LEACH provides large sensor networks with high energy saving, and high level of performance, three times better. Simultaneously it produces a higher level of security than it produced by LEACH and TCCA. Final results produced provide a very efficient solution for sensor networks communications.

A-LEACH: In this paper Author has elaborated energy-efficient communication protocol, called optical LEACH (a-LEACH), for hybrid sensor networks that incorporate distributed optical fiber sensor links located at the center and two isolated wireless sensor networks (WSNs) with randomly scattered nodes. Simulation results indicate performance in terms of lifetime is simulated with -30% improvements over LEACH protocol.

LEACH-H: In order to enhance life span of WSN a new protocol LEACH-H is developed which includes pros and cons of both LEACH and LEACH-C. Analysis of LEACH and LEACH-C is working out by authors which are classic WSN cluster routing protocols. It is suitable for applications in the large-scale WSN.

LEACH-Mobile: Protocols such as LEACH suitable for clusters are best suited for routing in wireless sensor networks. LEACH-M which is developed and best suited for mobility centric environments with some modification was suggested in the basic scheme. LEACH-Mobile is one such protocol. The proposed LEACH-M protocol improves in the mobile scenario by ensuring whether a sensor node is able to communicate with its cluster head

Re-Cluster-LEACH: This paper puts forward a new routing protocol on the basis of LEACH protocol: A Re-cluster-LEACH routing protocol based on node density. This protocol improves the cluster head selection algorithm in LEACH, increase cluster-based data fusion and brings forward the algorithm of the second selection of a cluster head. The paper also makes improvements on the most important flaw in LEACH single hop transmission

MR-LEACH: In this paper, it has proposed a multi-hop routing protocol with low energy dynamic cluster hierarchy to minimize the energy consumption of sensor nodes. The performance evaluation section has shown that MR-LEACH performs well compared to similar approaches given that network is divided into an optimal number of layers.

LEACH-HPR: In this paper, LEACH-HPR introduced an energy efficient cluster head election method and using the improved Prim algorithm to construct an inter-cluster routing in the heterogeneous WSN. Simulation results show LEACH-HPR is more efficient to reduce and balance energy consumption and hence enhance the lifetime of WSN

5. Results

We have surveyed the state-of-art of different clustering algorithms in wireless sensor networks along with LEACH and descendant reported in the literature of WSNs till today and presented the comparison of different LEACH descendant. We have found that the some energy efficient algorithms increases the network lifetime Although every effort has been made to provide complete and accurate state of the art survey on energy efficient clustering algorithms along with LEACH and its descendant as applicable to WSNs.

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