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Classification of Wireless Sensor Networks Clustering Techniques

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Abstract

Wireless Sensor Network (WSN) is a distributed set of autonomous sensors which are used to monitor the physical environmental conditions like pressure, temperature, humidity etc. wireless sensor network (WSN) is built up of hundreds or even thousands of sensor nodes. Sensor node is a very small device which includes three basic components for sensing the physical environmental conditions: processing subsystem, sensing subsystem and wireless communication subsystem. Energy conservation is the main issue for designing the system, based on WSN. Wireless sensor network is a very interesting field for the researchers. In this transmission of packets exists between the sensor node and other nodes by using routing protocols. LEACH is one of the existing routing protocols. LEACH protocol based on clustering of nodes. LEACH protocol proposed two new schemes or two ways to select the cluster head. In LEACH protocol, clusters have more than two nodes and from them one node is working like a cluster head. Through the cluster head node, the non-cluster head node sends and receives data and cannot directly communicates with the other cluster nodes. LEACH protocol saves the energy, increases the network lifetime and balances the energy expense. In this paper, various techniques of clustering is discussed with advantages, disadvantages and comparison.

Keywords-WSN, leach protocol, clustering and lifetime

Introduction

Wireless sensor network (WSN) consists of sensors which deployed over geographical region for monitoring the environmental conditions like humidity,

temperature etc. The sensor networks are bi-directional. Each node connected to one or several nodes. Sensor nodes vary widely with single physical phenomena and complex devices combine with different sensing techniques. Sensor nodes can different from the communication capabilities e.g. ultrasound and infrared. It gives information only about the observed event.

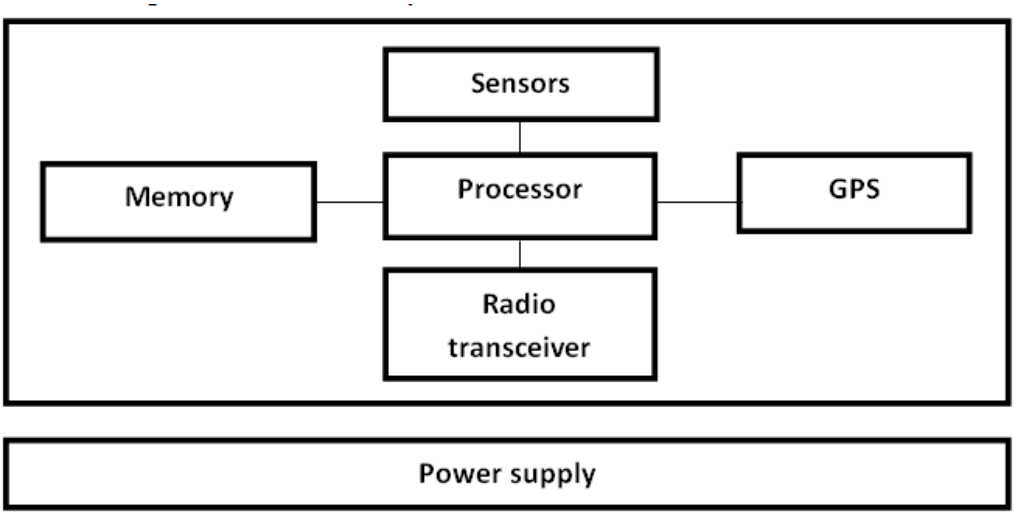

Fig. 1: Basic components for WSN

The basic components used in WSN are sensors, memory, GPS, processor and power supply.

Principle of clustering began from LEACH in year 2002. So this paper is emphasized on LEACH and then on its descendants.

LEACH

LEACH protocol stands for Low Energy Adaptive Clustering Hierarchy which is introduced by HEINZELMAN [1] and assumes that a dense homogeneous sensor network and energy constrained nodes report their data to the base station. MAC protocol based on TDMA is integrated in LEACH with clustering and a simple routing protocol. LEACH divides the sensor nodes into clusters and every cluster has a specific node i.e. cluster head. TDMA schedule is created by the cluster head and rest of the nodes of the cluster, is member nodes. To all the member nodes TDMA slots are assigned which is used to exchange the data between member nodes and cluster head. With the exception of their time slots member nodes spend their time in the sleep state. The cluster head spend significant amount of energy for their transmission if the sink node is away from the cluster head. The role of cluster head are energy consuming and is responsible for long transmission range and it is always switched on. Fixed node does not play this role because it burns out its energy immediately and the whole member nodes become headless. Each node decides

independently whether the other nodes become a cluster head or not. In LEACH protocol, nodes make a decision whether they become a cluster head or not at the same time. On the basis of received signal strength, cluster head is chosen. The portioning of network into clusters is time variable. Each cluster head node randomly picks a CDMA code for its cluster nodes. A critical parameter of network is determining the percentage for cluster head. If there is few number of cluster heads present then the distance b/w cluster head and member nodes wider. For the longer distance between the cluster head and the sink node cluster head will consume more energy for the transmissions of data.

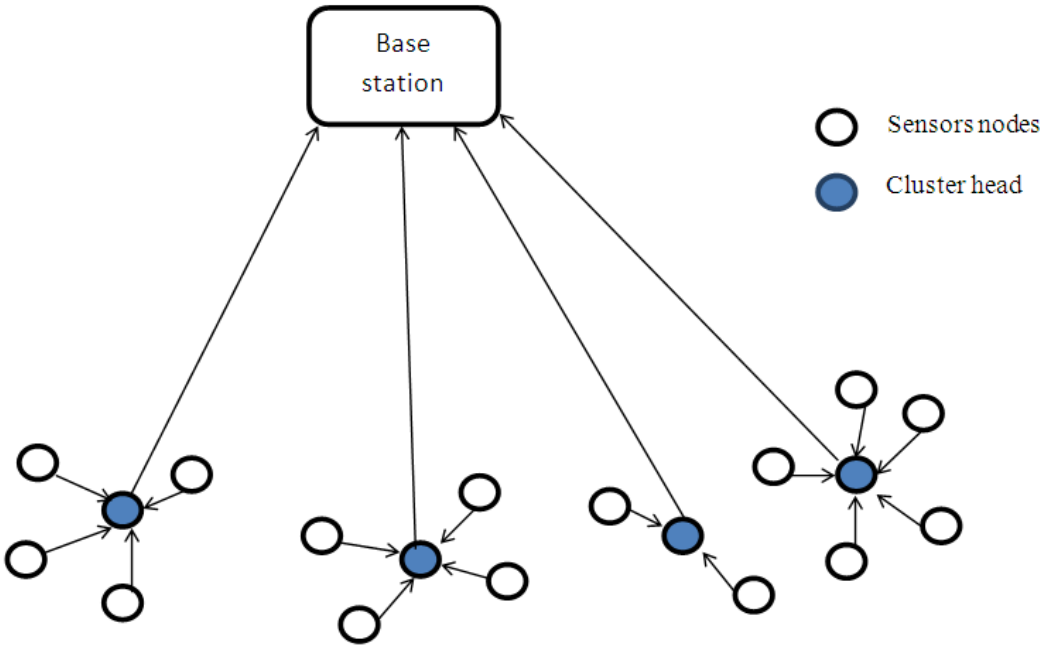

Fig. 2: Cluster formation

Set-Up phase

Set-up phase starts with the self-elected nodes. In set-up phase, cluster head node informs the neighborhood node with advertisement packet. Non-cluster head node picks the advertisement packet with the strong received signal. Using a CSMA protocol member nodes inform the cluster head nodes again. After the cluster set-up phase, the number of member nodes and identifiers are known by the cluster head.

$$T(n) = [p/\{1-p*(r \bmod 1/p)\}]: n \in G$$
$$T(n) = 0 : \text{otherwise}$$

Where p is the fraction of nodes and chooses themselves as a cluster head nodes and that can be done according to the threshold value T (n). T (n) value depends on the percentage of the cluster to become cluster head (p), r is the number of

rounds and the clusters that didn't become a cluster head in the last round (1/p) &is denoted by G.

Steady state phase

In this phase, the non-cluster head nodes start sense data and send it to the cluster head nodes according to the TDMA schedule. After collecting data from the member nodes the cluster head aggregates the data and send it to the sink node. The network goes into the set-up phase after certain time and chose the new cluster head. To reduce the interference from the nodes each cluster communicates which belongs to other clusters using different CDMA codes.

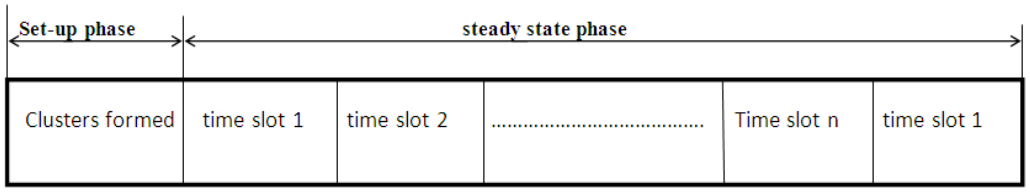

Fig. 3: Organization of LEACH rounds

LIMITATIONS IN LEACH PROTOCOL

When cluster head is randomly selected then the record for energy consumption is not there. A node with high energy and a node with low energy have same probability.

When low energy node is chosen as a cluster head then low energy node will die early and a wireless sensor network does not exist for a long time. Randomly chosen cluster head is a big problem in LEACH protocol.

LITERATURE REVIEW ON LEACH PROTOCOL DESCENDANTS

LEACH uses local control, randomization of adaptive cluster formation, self-configuring and application data processing techniques to achieve the desired goals. To reduce the collisions LEACH uses the TDMA and CDMA techniques. Formation of cluster is based on communication range, geographical region and types of sensors. The consumption of energy reduces by organized the sensor nodes into clusters. [2]

LEACH-C

LEACH-C stands for Centralized LEACH**.** Except cluster formation it is similar to LEACH. In centralized leach protocol, at the base station the cluster head selection is carried out. This algorithm has the disadvantages that it does not give the guaranteed information about the cluster head nodes. Clusters are adaptive in nature so, during the round poor clustering is set up and this affect the whole performance. To form clusters, central control algorithm is used and produces a good cluster by the distribution of cluster head throughout the network. [3]

LEACH-F

LEACH-F stands for fixed number of cluster-LEACH protocol. In this algorithm number of clusters is fixed throughout the network and cluster head rotated in the clusters. Leach protocol is identical to the steady phase of F-LEACH protocol. This protocol does not give the flexibility to sensor nodes or sensor node added or removed from the network. This protocol can or cannot provide the energy saving. [4]

LEACH-B

Researcher forms the algorithm for the formation of clusters. In this algorithm sensor node only know its own position and the final position of the receiver and does not know the all sensor nodes position in the network. LEACH-B protocol works under the following three phases: formation of cluster, selection of the clyster head algorithm and data transmission in multiple accesses. Energy dissipated is evaluated by calculating the distance between the final receiver and the cluster head. [5]

LEACH-ET

This algorithm choses the cluster head only when it satisfies the following conditions: (1) to reach energy threshold in one round and consumes energy by anyone cluster head nodes. (2) The energy threshold value should be known to each sensor node.If in the certain round, sensor node act like a cluster head then it calculates the energy dissipated value and compare that value with the value of threshold value. [6]

ENERGY LEACH

Thisprotocol improves the selection ofcluster head than of leach protocol. Residual energy of node is the main factor of this protocol that decides whether the sensor node turns into the cluster head in the next round or not. Energy leach improves the cluster head selection procedure. This protocol provides energy saving and longer network lifetime as compare to leach. [7]

TL-LEACH

Three layer leach works in the three types of phases: cluster set up, data transmission and cluster head casing. In this protocol the author improves the leach protocol which contains some of the cluster head and each cluster head is elected during the set-up phase and selected as a 2-level cluster heads and communicates with the base station. [8]

MH-LEACH

The communication mode is improved by this protocol from single to multi hop between the base station and cluster head. In leach protocol the distance between sink node and the cluster head node does not matter. In this protocol the cluster head communicates directly with the sink node. If distance between cluster head and base station is large then it will consume more power. In MH-LEACH protocol, multi-hop communication takes into consideration among the cluster head node and may adopt optimal path between the base station and the cluster head. [9]

Trust-Based LEACH
In this protocol security solution based on the methods of cryptography which does not incorporate with the new challenges. The author proposed a new protocol which is trust based leach for providing secure routing and decision making based on decision trust and for adaptively different decisions. [10]

TB LEACH
This protocol is based on time. The selection of cluster head is also based on time. The analysis between TB-LEACH and the leach protocol significantly shows the improvement which is done by formation of clusters. This protocol does not provide any global information about the construction of cluster and construct the cluster based on random timer algorithm. This protocol provides better efficiency and longer network lifetime. [11]

MS-LEACH
In this protocol the author analyzed the energy consumption problem for the multi-hop and single-hop transmission into the single cluster. This protocol based on the critical values. In this protocol the simulation results outperforms 200 percent in network lifetime. [12]

LEACH-TM
This protocol introduces the concept of trust, creates the multipath cluster head nodes which acts like a routers and designs a cluster head adjusting procedure. This protocol overcomes the deficiency of data transmission to make the data reliable and increase the network lifetime. [13]

LEACH-HPR
HPR uses prim algorithm in heterogeneous network to build the inter cluster routing and introduces the concept of selection of energy efficient cluster head node which makes the data more reliable and increases the network lifetime. This protocol is efficient to reduce the energy consumption. [14]

IEEEPB-LEACH
IEEPB stands for Improved Energy Efficiency PEGASIS based protocol. This protocol improves the energy efficient deficiencies and deficiencies of PEGASIS protocol. It uses different method to construct the chain that simplifies the problem of chain construction process and avoids long link formation. This protocol is divided into several phases and tries to find out distance between nodes and base station. [15]

ACT LEACH
ACT stands for arranging cluster size and transmission ranges. The main aim of this protocol is to reduce the size of cluster that lie close to the base station. The cluster head close to the base station relay more data. Every cluster consumes the same amount of energy. The cluster head near to base station do not exhaust their power

quickly. This protocol is used to calculate the radius of cluster to balance the energy dissipation. [16]

TLCH-LEACH

TLCH stands for Two Level Cluster Head LEACH protocol. In TLCH algorithm the clusters forming method and cluster head selection method are same as leach protocol. This paper states that distance between the base station and the cluster head is longer than the average energy or if the current cluster heads energy is not greater than average energy then the maximum energy node in the cluster selects as a secondary node. The secondary cluster head nodes are responsible for receiving data from the member nodes and send it to the cluster head. [17]

GA-LEACH

GA-LEACH means Genetic Algorithm low energy adaptive clustering hierarchy. Genetic algorithm performs only once before the first round of set up phase. The main function of genetic algorithm is that at the beginning of set up phase every node determines that it should be a candidate cluster head or not. [18]

Table 2: Time Line of clustering based on various parameters

S. NO.	Clustering based parameters	Abbreviation	Year	Brief Description
1	LEACH [2]	Low Energy Adaptive Clustering Hierarchy	2002	This protocol based on clustering. Every round starts with the set-up phase and follow the steady state phase when clusters are organized and transfer data to the base station and saves up to 15% of energy
2	LEACH-C [3]	Centralized leach	2002	Except cluster formation leach-c protocol is same as leach protocol. In leach-c protocol cluster head selection is carried out at base station.
3	LEACH-F [4]	Fixed number of clusters-LEACH	2002	In this algorithm fixed no. of clusters are used. A cluster numbers are calculated on the basis of validity tests and makes the optimal number of cluster nodes than leach algorithm and increase the network lifetime.
4	LEACH-B [5]	Balanced low energy adaptive clustering hierarchy	2003	Balanced leach uniformly distributes energy among all the nodes. For dead nodes or network information balanced leach performs better than other algorithms

5	LEACH-ET [6]	Energy threshold low energy adaptive clustering hierarchy	2006	In this, cluster will change only when anyone cluster head consume energy to reach energy threshold in one round and each sensor node know the threshold value.
6	LEACH-E [7]	Energy low energy adaptive clustering hierarchy	2007	This protocol improves the procedure of selection of cluster head and gives better energy efficiency and network lifetime.
7	TL-LEACH [8]	Three layer low energy adaptive clustering hierarchy	2007	This protocol works in three phases: data transmission, cluster set up and cluster ceasing.
8	Trust-Based LEACH [9]	Trust based low energy adaptive clustering hierarchy	2008	This protocol provides us the secure routing and decision making based on decision trust and for adaptively different decisions
9	TB-LEACH [10]	Time based-leach	2008	This protocol does not provide any global information about the construction of cluster and construct the cluster based on random timer algorithm. This protocol provides better efficiency and longer network lifetime.
10	MS-LEACH [11]	Combination of multi hop and single hop-leach	2009	This protocol depends on the critical values of cluster area. It increases the network lifetime by 200% than other algorithms (leach, c-leach, f-leach)
11	TM-LEACH [12]	Trust minimum-leach	2009	This protocol overcomes the deficiency of data transmission to make the data more reliable and increase the network lifetime.
12	HPR-LEACH [13]	Heterogeneous-leach	2010	HPR uses prim algorithm in heterogeneous network to build the inter cluster routing and introduces the concept of selection of energy efficient cluster head node which makes the data more reliable and increases the network lifetime. This protocol is efficient to reduce the energy consumption.
13	IEEPB-LEACH [14]	Improved energy efficient PEGASIS based protocol	2011	This protocol improves energy efficient PEGASIS based protocol. It uses different method to change the chain construction process to avoid the long link formation.
14	ACT-LEACH [15]	Arranging cluster sizes and transmission ranges	2012	This protocol increases the network lifetime by more than 15% to 20% than in comparison to leach and MR-leach

15	TLCH-LEACH [16]	Two level cluster head leach protocol	2013	This algorithm balances the energy consumption of nodes and increases the network lifetime. This algorithm is same as leach protocol.
16	GA-LEACH [17]	Genetic algorithm for leach	2014	This algorithm initially determines that each node be a candidate cluster head or not before the beginning of the set up phase.

Comparison between LEACH, LEACH-C, BALANCED-LEACH and R-LEACH algorithm

LEACH uses local control, randomization of adaptive cluster formation, self-configuring and application data processing techniques to achieve the desired goals. To reduce the collisions LEACH uses the TDMA and CDMA techniques. Formation of cluster is based on communication range, geographical region and types of sensors. The consumption of energy reduces by organized the sensor nodes into clusters.

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LEACH-Bstands for balanced leach. In this algorithm sensor node only know its own position and the final position of the receiver and does not know the all sensor nodes position in the network. LEACH-B protocol works under the following three phases: formation of cluster, selection of the clyster head algorithm and data transmission in multiple accesses. Energy dissipated is evaluated by calculating the distance between the final receiver and the cluster head.

LEACH-R protocol is the improved protocol as compare to leach protocol. This protocol improves the cluster head selection node. It reduces the efficiency of the nodes to choose as a cluster head which has low energy level it saves 20 percent of energy by selecting the node as a cluster head which has high energy level as compare to leach

Table 2: Comparison between LEACH, LEACH-C, BALANCED LEACH and R-LEACH algorithm

S. No.	Routing algorithm	Network lifetime in rounds	Rounds in which first node dead	50% node dead	No. of packets send (in total rounds)	Remaining energy (75% node dead)
1	LEACH	460	220	390	8710	1.30
2	LEACH-C	962	950	960	7634	1.19
3	BALANCED LEACH	1210	1190	1199	9550	1.19
4	R-LEACH	9999	996	1256	15765	0.50

CONCLUSIONS:

In this paper we study about the wireless sensor network (WSN) and different clustering techniques of leach protocol and its descendants. By studying different clustering technique we learn about the energy efficient algorithms and how these algorithms increase the network lifetime. Every effort is to provide the accurate and complete information about the energy efficiency clustering techniques or algorithms with leach protocol and its descendants.

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