HEGASIS: Hybrid, Energy Efficient Gathering in Sensor Information Systems

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ABSTRACT

Wireless Sensor Networks (WSNs) consist to group many sensor nodes with limited capacity of energy, communicating and computing. For this reason, conserving energy consumption is the most important design considerations in Wireless Sensor Networks The hierarchical clustering architecture is considered one of the best choices to satisfy this issue. To deal with this, many researchers proposed new hierarchical algorithms or improved some already existing ones. In this article, we propose a new clustering algorithm by combining two existing algorithms; HEED (Hybrid Energy-Efficient Distributed) using the clustering concept, and PEGASIS (Power-Efficient Gathering in Sensor Information Systems) using the chain concept organization.

In our proposal algorithm; the clusters are formed in the first iteration like the HEED concept. After this first step; the nodes belonging to the same cluster form a chain using the greedy algorithm. So that energy dissipation within clusters can be minimized and consequently, the lifetime of the network can be improved.

Keywords: Wireless sensor networks, Cluster Head, Routing protocols, Clustering, PEGASIS, HEED, Energy consumption, Network lifetime.

1. INTRODUCTION

New technologies are increasingly invading our lives, particularly those related to collect and report data in different domains (business, civil and military packages which includes surveillance, vehicle tracking, weather and habitat tracking intelligence, medical and acoustic statistics amassing; etc)[1] [26].They allow rapid and remote communication. Hence, the importance of the services offered by wireless network sensors.

A Wireless Sensor Network is a self-configuring of many sensor nodes to satisfy a defined objective, these sensors have limited capacities of processing, acquisition, transmission and battery power [26]. The main objective is to monitor and collect sensor data and then transmit the data to the BS [22]. The minimization of the energy consumption and the extension of the life time of the network are the biggest key challenges in this field [24].

The battery is considered to be the most important element to manage for a sensor .The nodes are powered by batteries with finite capacity and usually cannot be recharged [1] [2]

To minimize the energy consumption of the WSN, it is necessary to implement a strategy capable to reduce all aspects of WSN communication and networking the energy consumption of sensor nodes, by using a good routing architecture [24]. . For this way many protocols of self-organization have been proposed such as: LEACH (Low-Energy Adaptive Clustering Hierarchy), HEED, TEEN (Threshold-sensitive Energy Efficient sensor Network protocol), GRIDS (Geographically Repulsive Insomnious Distributed Sensors) .., using the clustering concept.

In this paper, we propose a new hierarchical clustering protocol capable of minimizing the network energy consumption .The main idea is to combine two existing protocols HEED and PEGASIS, for benefit their advantages and minimizing their disadvantages [3]-[4].We organize in a first phase the nodes of network in clusters following the same concept of HEED [5], to generate clusters with the same size and a consistent distribution of the clusters heads. After that, we move to organizing the nodes

of each cluster in chain, according the approach used in PEGASIS [6], in order to reduce the number of transmissions and receptions by using the data aggregation [7] [2].

The main objective of our protocol is to prolong network life time by reducing the energy consumption. It's realized by:

- Using the residual energy like the primary parameter in cluster organizing (the second parameter is the intra-cluster communication cost).To allow producing well-distributed cluster heads and compact clusters.
- Organizing the nodes belonging the same cluster in Chain, to minimize the chain size and eliminating the large delay generate in Pegasis, to reduce the energy consumption.

This paper is organized as follows. In the next section, we briefly describe the routing concept and its challenging   presented in the literature. In the third section, we describe the clustering and the popular Clustering protocols and its principles, advantages and limitations. In the last section, we describe our clustering algorithm HEGASIS, its principle and its properties.

2. RELATED WORK

2.1. Routing

The routing is the process to define the path between the source and the destination nodes for maintaining the routes in the network and reliable multi-hop communication [26].

The data sent by every node is transmitted directly or indirectly to the base station. In small networks when the base station and nodes so close, the single hope communication concept can be used. But generally, the wireless sensor network consists to regroup several nodes distributed in large area. The sink is a node that centralizes all the gathered data and works as an interface between the network and the application [23]. The sensor nodes are so far from the sink, they cannot communicate directly with the BS, and, therefore, intermediate nodes have to relay their messages with multi hop communication mechanism. An intermediate node has to decide to which neighbour an incoming message should be forwarded if the message is not destined to itself [8] and so of continuation until to reach the bases station.

The management of these routing tables s is a crucial task which is realized by the routing algorithm.

2.2. Routing challenging

Routing in WSNs is quite challenging, due to the several restrictions that distinguish them to the other networks, e.g., limited energy supply, limited computing power and limited bandwidth of the wireless links connecting sensor nodes [9]. Hence the necessity to offer data routing with minimum energy consumption, to prolong the lifetime of the network[23].

Several types of routing challenges affect this process in WSNs:

Node deployment: Node deployment in WSNs can be either deterministic or randomly performed. In the Deterministic approach, a predefined strategy is adapted for nodes positioning and data routing. However, in the randomly deployed nodes; each node chooses its location in the network randomly [8]. The network topology is generally variable further to the nodes mobility. This mobility affects the routing performance, for this reason, the routing protocol must provide topology information and routing decisions.

Energy consumption: The energy consumption is considered one of the important design considerations in Wireless Sensor Networks [8]. Therefore, the main issue of WSN is energy conservation [27]. Nodes exhaust generally their reserve of energy during the routing operations (performing computations, transmitting information. building their routing tables……), Furthermore, because of the limited energy resources of WSN nodes it's necessary to realize these operations with minimum energy consumption.

Scalability: A wireless sensor network is composed of several nodes deployed (hundreds, thousands or more).Several events can occur and change the initial topology of the network. Scalability remains one of the principal design specifications of WSNs [28]. So, the routing protocol shall allow the management for all nodes and to be scalable enough to respond to events in the environment [9].

Robustness: Wireless sensors network, is composed of numerous sensors deployed in large area. Generally, are deployed in difficult and crucial environments [10]. Thus, the role of the routing protocol is to be capable to offer data routing in different environments.

Delay: The delay of transmission is the major objective in some WSN applications (temperature sensor or alarm monitoring etc), routing data in minimum delay is important in this case.

2.3. Clustering

This technique consists to bring together geographically close nodes into groups called "clusters", by specifying on the one hand the strategy for the communication between the nodes inside cluster (intra-cluster) and between the different clusters (inter-cluster) [11].The clustering is the most way to reduce energy consumption in wireless sensor networks [25].; helped in reducing the redundancy of data transferred by aggregating the data of nodes within the cluster, at the cluster head [2]. It can stabilize the

network topology at the level of sensors and to offer best network scalability [11]. A clustering- based protocol balances the energy usage by giving equal chance to all nodes to become a cluster head[9].The clustering objective is to improve the network performance in terms of lifetime enhancement, overhead management, fault tolerance, and energy efficiency [12], by minimized the number of communication between nodes and reduce energy consumption [22] [26] .

2.4. Hierarchical protocols topology

In a hierarchical topology, nodes are organized into many clusters according to specific requirements and metrics. Each cluster is composed of many nodes, one of theme is a leader referred to as cluster head (CH) and it performs the special tasks (Collect, fusion and aggregation data) [11]. CHs collect data from member nodes, aggregate them, and finally forward it to either a neighbouring CH (multi-hop) or directly (single hop) to BS[25] .The hierarchical routing protocols are an efficient way to lower energy consumption within a cluster, performing data aggregation and fusion in order to decrease the number of transmitted messages to the BS [11] [23]. Hence, these protocols are designed to use minimum energy during sensing, processing and transmission. [27].

- Low Energy Adaptive Clustering Hierarchy (LEACH)

This is one of the first clustering algorithms for wireless sensor networks [11][28]. LEACH is a distributed algorithm proposed by W. R. Heinzelman, A. P. Chandrakasan and H. Balakrishnan[13]. The conceptpresented in LEACH has been a key inspiration for other hierarchical routing protocols like TEEN, PEGASIS [28]..Each node in LEACH makes autonomous decisions without any centralized control [11]. The main idea is to select the CHsrandomly and periodically. The probability of becoming a CH for each round is chosen to ensure that every node becomes a CH at least once within N/K rounds, where N is the number of nodes in the network and K is the desired number of clusters [14].

The main objectives are to extend the lifetime of the network, to offer equal distribution of the energy consumption between all nodes and to reduce the energy consumption in the nodes (through the data aggregation approach at the CH level).The algorithm is divided into two main phases:

Set-up phase

In the set-up phase, the main goal is to organize the clusters and select the cluster heads. To select CHs, each node determines a random number between 0 and 1, if this number is less than a threshold value T (i), the node i becomes CH, otherwise it becomes an ordinary node.

T(i) is defined as follows:

$$T(n) = \begin{cases} \frac{P}{1-P\times(r\times mod(\frac{1}{P}))} & \text{if } n \in G \\ 0 & \text{Else if} \end{cases} \qquad (1)$$

Where r is the number of the current period, P is the desired percentage of CHs, and G is the set of nodes that have not been selected as CH during the last 1/P periods.

-Each node decides or not to become the cluster head depending on the threshold value.

-After choosing the cluster head, the other nodes picks its own cluster head following the received signal amplitude, and joins the closest one. In case of equality, a random cluster head is chosen.

Transmission phase

Once the CHs are chosen and the clusters formed, each cluster head will create a TDMA schedule for its members. The CH receives all data of the nodes belonging to its cluster, merges collected data and sends an aggregated packet to the base station.
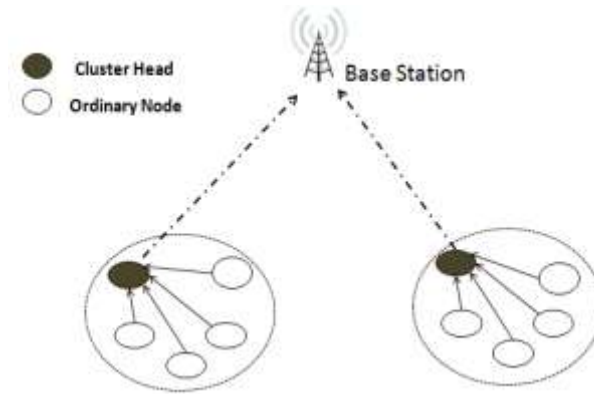
Figure 1: LEACH Network Topology

Table 1: LEACH Advantages / Disadvantages

Advantages	Disadvantages
-Reduce the control messages overhead - Low complexity algorithm	-The cluster heads are not uniformly distributed -Select the cluster head without considering the remaining energy -Send data in 1-Hop

- **Hybrid Energy-Efficient Distributed Clustering (HEED)**

HEED [5] is a distributed and hierarchical protocol introduced by Younis and Fahmy. It uses a one-hop communication model for intra-cluster communication and multi-hop communication model for inter-cluster communication. The main idea is to construct clusters by using two basic parameters: residual energy and intra-cluster communication cost. The first clustering parameter is to select (probabilistically) an initial set of cluster heads, and the second parameter is used to resolve conflicts when a node is in a situation to arbitrate between many CHs at the same time [5].

The initial parameters of this protocol have been defined as following [5]:

-The nodes are stationary;

-The links are symmetrical (the node v1 communicates with the node v2 with the same level of communication transmission between v2 and v1);

-The nodes are not equipped with GPS;

-All nodes have the same capabilities: processing and communication;

The protocol is divided into two main phases:
    Phase 1: Calculate the cost

At this stage each node calculates its CHprob probability to become a cluster head.

$$CHprob = Cprob \times Eresidual / Emax(2)$$

Where Eresidual is the estimated current residual energy in the node, and Emax is a reference maximum energy (corresponding to a fully charged battery).
    ✓ Phase 2: Affiliation

During this affiliation step, each node passes through a constant number of iterations until it finds a CH to communicate with the least possible power. This CH is selected among the nodes which have chosen to become CH with probability CHprob. These nodes constitute the set of the heads of the potential clusters SCH. SCH is defined for an iteration i, as following {CHs of step i-1 U CHs selected at the step i}. If a sensor doesn't find any CH in its vicinity, it doubles its probability and diffuses it back to its neighbors, then continues its search operation of the cluster head in its vicinity. The sensor stops its process either when its CHprob= 1 (in this case the sensor declares itself to be the cluster head), or when it finds a cluster head in its vicinity.
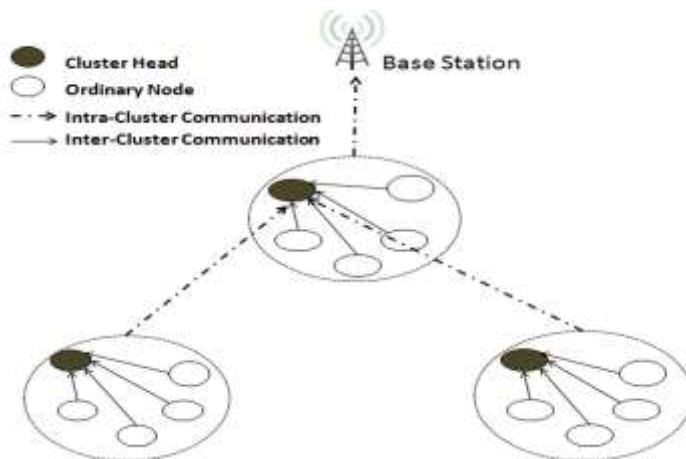
Figure 2: HEED Network Topology

Table 2 : HEED Advantages / Disadvantages

Advantages	Disadvantages
-Scalability for multi-hop communication -Uniform distribution of inter-cluster energy -Uniform distribution of CH -Generate Clusters with equilibrate Size -use of the two important parameters for CH election	-High overhead -The algorithm complexity

- Threshold-sensitive Energy Efficient sensor Network protocol (TEEN)

TEEN [16] is a hierarchical algorithm. It organizes the sensor nodes into multiple levels of hierarchy .The closer nodes form clusters. Where data's of all sensor nodes are aggregated and transmitted by the cluster heads until it reaches the base station. The clustering process use two thresholds named soft and hard threshold.

The Hard threshold represents the value of the attribute when the node must switch on its transmitter for send its data to the cluster head. The sensed value is stored in an internal variable in the node, called the sensed value (SV) .The nodes will next transmit data in the current cluster period, only when the current value of the sensed attribute is greater than the hard threshold, and differs from SV by an amount equal to or greater than the soft threshold.

In this Protocol, the nodes sense the medium continuously, but the data transmission is done less frequently.

Table 3: TEEN Advantages / Disadvantages

Advantages	Disadvantages
-Reducing the number of transmissions to the Base station -Data-centric nature of TEEN makes it suitable for time-concerned applications in which a quick response from the network is urgent for user	-Unsuitable for periodic report requiring applications -Difficulty to Define the exact value of the thresholds -if the thresholds are not received, the nodes will never communicate, and the user will not get any data from the network at all

- **ENERGY EFFICIENT HIERARCHICAL CLUSTERING (EEHC):**

EEHC [17] is a distributed randomly clustering algorithm, for heterogeneous wireless sensor environments. EEHC organizes the sensors in a network into clusters with a hierarchy of CHs. The CHs collect the information from each node within its cluster, and sends an aggregated report through the hierarchy of CHs to the BS.

The EEHC considers the residual energy of nodes; but it does not consider the initial energy of nodes. The nodes in the network are divided into three categories according to their initial energy: the normal nodes, the advanced nodes, and the super nodes. EEHC extends the network lifetime by introducing three degrees of heterogeneity: normal, advanced and super nodes.

The EEHC protocol consists of two phases: In the initial phase, a sensor node announces itself as a cluster head with probability P to its neighbouring nodes in communication range. This node called volunteer CHs. Nodes that are located within a k hops coverage of a CH receive this announcement message .Each node has received the message and are not a CH become members of the nearest cluster.

In the second phase, which is called multi-level clustering, hierarchy clustering levels are created. The initial clustering process is recursively repeated at the level of CHs to form h levels of cluster hierarchy. The objective is to assure the connectivity at h-hops between the CHs and the base station.

Table 4: EEHC Advantages / Disadvantages

Advantages	Disadvantages
-It extends the cluster architecture to multiple-hop architecture. -Consider residual energy of cluster head for selection -It is suitable for large networks.	-It has large time complexity

- **Low Energy Adaptive Clustering Hierarchy-Centralized (LEACH-C):**

LEACH-C [18] is an improved version based on LEACH. Proposed for solving same LEACH limitations such as: non-uniform distribution of cluster heads and choosing cluster-head randomly without considering the remaining energy of cluster head .In Leach-C, the CHs are randomly selected by the BS , whereas in LEACH cluster heads are randomly selected by the node itself .LEACH-C has two phase, set-up phase and steady state phase. In the set-up phase, the BS calculates the average energy value of all the nodes. Only the nodes with more energy than the average value have chance to be cluster heads.. After selecting the CH and associated nodes, the transmission phase takes place between nodes. Whereas the steady phase in LEACH-C is similar to LEACH protocol.

Table 5: EEHC Advantages / Disadvantages

Advantages	Disadvantages
-Optimal number of clusters -Uniform distribution of cluster heads -The residual energy is the parameter for the cluster head selection.	-Send data in 1-Hopoccurrences the overhead

- **Distributed Energy-Efficient Clustering** *(DEEC)*

DEEC [19] protocol is a cluster based method for multi-level and 2 level energy heterogeneous wireless sensor networks. When the cluster-heads are selected by a probability based on the ratio between residual energy of each node and the average energy of the network. If this probability is superior to threshold, the node can become a cluster-head. To calculate its probability, each node has to know its reserve of energy, its initial energy and the energy averages of the network. This last value is calculated in every round by the base station and diffused for all nodes .The nodes with high initial and residual energy will have more chances to be the cluster-heads than the low-energy nodes.
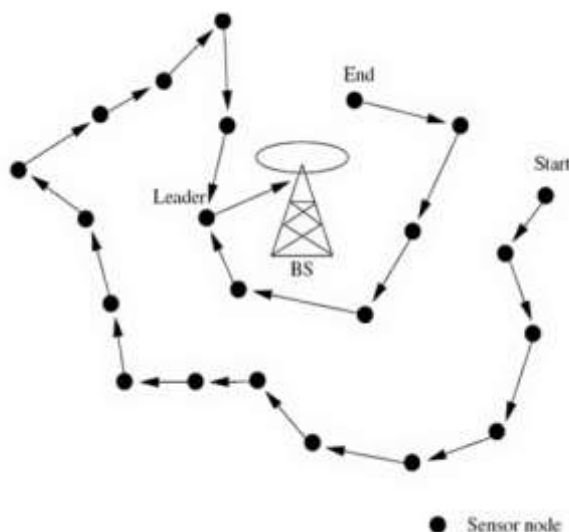
Table 6 : DEEC Advantages / Disadvantages

Advantages	Disadvantages
DEEC doesn't need any universal knowledge of energy at each election round	Advanced nodes are always punish in the DEEC, particularly when their residual energy reduced and when they come in the range of the normal nodes

2.5. PEGASIS (Power-Efficient Gathering in Sensor Information Systems)

PEGASIS [6] is a routing protocol which a chain based approach is followed .The main idea, each node communicates only with their closes neighbor and takes turns transmitting to the base station. In PEGASIS, all nodes have global knowledge of the network and the greedy algorithm is employed for chain construction.

The main objective is to increase the lifetime of each node by using collaboration techniques and to allow only local coordination between neighbor nodes, also to decrease the number of data transmission volume through the chain of data aggregation [15].

To form its chain, PEGASIS starts with the furthest node from the base station which represents the first node that will be attached to the chain, then the closest node to this node will be the next node to be added to the chain and so on. The algorithm begins with the furthest node to ensure that the furthest nodes from the base station have close neighbors [6]. For data gathering, each node receives the data from one neighbor, merges it with its own data and transmits it to the next node in the chain until one arrives at the head of the chain. It will be responsible for transmitting the information received from the different nodes to the base station.

Figure 3: PEGASIS Network Topology

Table 7: PEGASIS Advantages / Disadvantages

Advantages	Disadvantages
-Uniform distribution of energy conception -General expenses reduction by dynamic grouping. -Decrease in the number of transmissions and receptions by using data aggregation.	- Long delay in sending information -Requires a general knowledge of the network -Unsuitable for variable network topology

2.6. Comparison of LEACH, HEED and PEGASIS

Several researchers are proposed to compare these three algorithms (LEACH, HEED and PEGASIS) in terms of performance, energy consumption and maximizing the network lifetime. Below the results of the simulations carried out by their works[3]-[16].

In the case of LEACH protocol, the communication overhead (in terms of route energy in joules) increases with an increase in the number of nodes deployed in the network; on the other hand, the overhead are very small almost negligible, in the case of PEGASIS protocol and as a result it does not affect other network characteristics. Thus, PEGASIS outperforms the LEACH protocol in terms of communication overhead for dynamic cluster formation [20].

PEGASIS has almost constant consumption of the energy with time for a specific network size while for LEACH it decreases; when the number of nodes increases in the network the energy consumption increases [20].

PEGASIS makes it possible to extend the life of a network 2x compared to LEACH (2x the number of transmission rounds before the death of a defined percentage of network nodes)[20].

PEGASIS has the maximum capacity to route the packets in a defined time period than other two i.e. LEACH AND HEED.HEED is second best performer and LEACH is at number three[3].

In comparison concerning energy consumption, PEGASIS is better because it consumes approximately 33% less from LEACH and approx 19% from HEED [3]

3. PROPOSED ALGORITHM

Several articles are processing the two algorithms PEGASIS and HEED in order to present their advantages and disadvantages [3]-[4]-[15]. HEED allows a uniform nodes distribution, but its complexity generates a high overhead at each clustering round [15]. PEGASIS reduces the packet number of nodes communicating directly with the BS [3], and prolong the lifetime of the network, but generates a long delay in transmitting information [15].

Our proposed clustering protocol consists to combine the cluster formation approach used in HEED with the chain construction technique deployed in PEGASIS. In order to perform more energy efficiency, we present also a new methodology for re-clustering, to replace the one used by HEED which generates a significant increase in energy consumption due to the complexity of the algorithm to perform this task.

The protocol consists in three phases: Initialization, transmission and re-clustering. The first one is to organize the network in terms of clusters. The second step is for data transmission and the last step describes how the re-clustering is established.
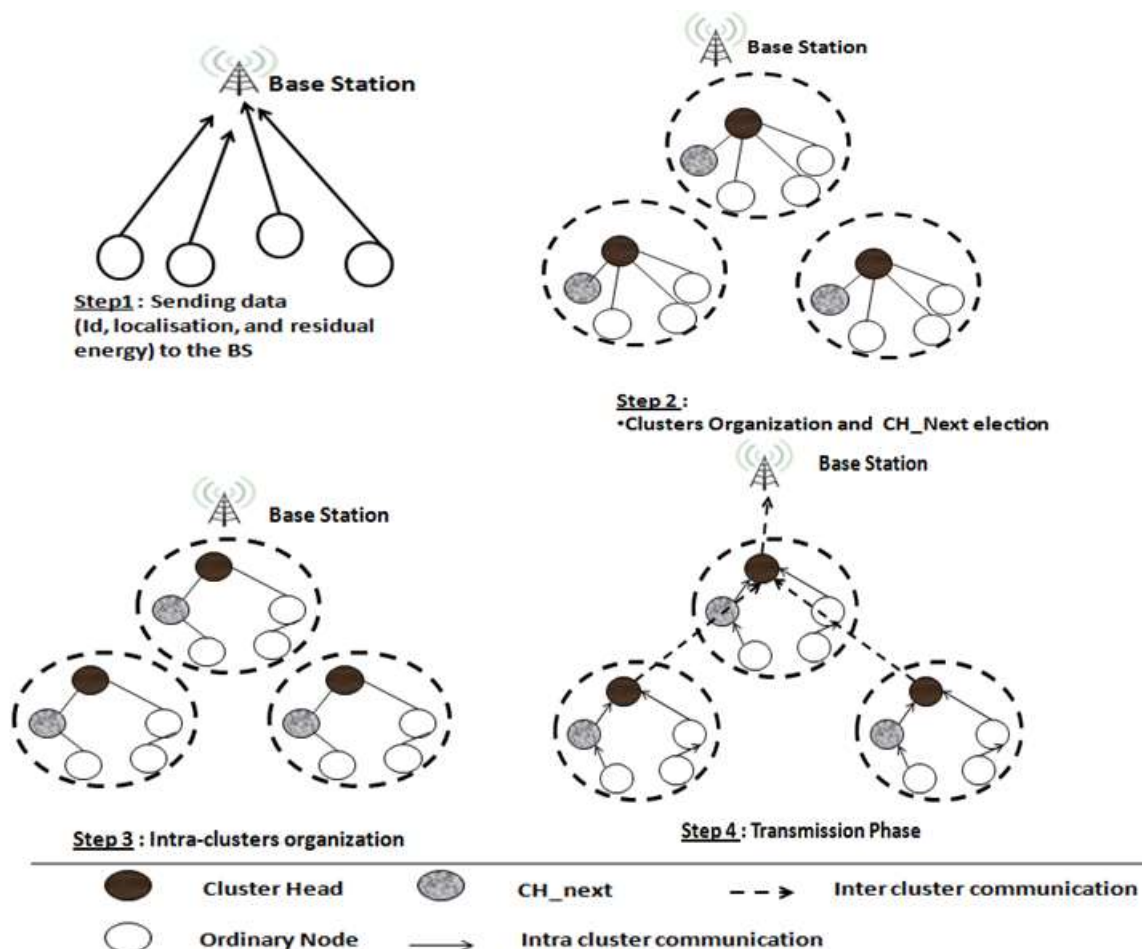

Figure 2: HEGASIS phases

3.1. Phase 1: Initialization Phase

Our protocol begins with initialization phase, initiated by the base station by diffusion an initialization message to the various sensors from the network. This first phase will be launched just once time at the beginning of our algorithm. This step is organized as follows:

Clusters Organization

This phase consists to organize the network in Clusters; using a similar method to clustering concept in HEED algorithm (based on the 2 parameters: Level energy and intra-cluster communication cost), and selects the first round to CHs election (similar to HEED).

This stage is divided in two phases.In the first stage; each node calculates its CHprob probability to become a cluster head.

$$CHprob = Cprob \times Eresidual / Emax \quad (3)$$

Where Eresidual is the estimated current residual energy in the node, and Emax is a reference maximum energy (corresponding to a fully charged battery).

After that, in the repetition phase, the sensor node finds the CH to which it can transmit data with minimum energy. The sensor node can send two types of status messages. One is tentative status,where the sensor node becomes tentative CH with CHprob less than 1. The sensor node has a final status i.e. it becomes a permanent CH when its CHprob has reached 1. If a sensor node has not received any message from CH, it elects itself as one of the CH. It sends a message to all its neighbors intimating its new status. In the finalization phase, the sensor node decides the CH to which it has to belong.

At the end of this stage, all nodes of the network are organized into clusters and each cluster joins its CH.

Once the cluster is formed and first round of CH selected, each CH designates its successor CH_Next which represents the new CH in the re-clustering phase (detailed in phase3).

- Intra-cluster organization

In this step, we organize the nodes of each cluster in chain. The chain will be formed inside each cluster by using the greedy algorithm, so that the nodes of the same cluster form a chain of close neighbours [21].

The greedy algorithm considers only the physical distance for selected next hop in every node and ignores the residual energy.

Chain creation is started at a node far from BS and the closest neighbor to this node will be the next node on the chain, Figure 2 shows node 0 connecting to node 3, node 3 connecting to node 1, and node 1 connecting to node 2 in that order.
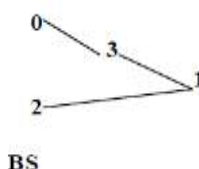

Figure 5: Chain construction using the greedy algorithm

3.2. Phase 2: Transmission Phase

After constructing the clusters, we proceed to gather data. This step is organized in two sections:

- Intra-cluster communication

In this operation, we use the same concept used in PEGASIS algorithm. Each node receives data from one neighbor, fuses it with its own data, and transmits the result data to the other neighbor on the chain until the CH. Each CH is responsible for coordination between the different members of the cluster, aggregates and sends the data collected to the base station.

- Inter-cluster communication

In inter-cluster communication, the multi-hop concept is used .Each CH uses the multi-hop to transmit the aggregated data to the others Cluster Heads until reach the Base Station. For minimizing the energy consumption, particularly in the large network with several nodes deployed.

3.3. Phase 3: Maintenance of clusters formed

The initial network structure will be changed, for this reason it´s important to implement a strategy to maintain and reconstruct an individual cluster or the entire network.

In HEGASIS, the main idea is to replace the CH by its CH_Next once he leaves the cluster, or its energy reaches the threshold T. With this method, the cluster set-up phase will just be implemented at the beginning of our protocol, to allow a considerable energy saving.

Each CH continues its data transmission iterations until its energy reaches an energy threshold S. This threshold represents the energy level where the CH must leave its role of CH and warns its CH_Next to take over to be the new CH.

$$S = C * CH\_Ener \quad (4)$$

Where C is a constant between 0 and 1 which is chosen experimentally, and CH_Ener is the residual energy of the CH.

If this CH_Next does not receive any package from his CH in an predefined interval time, it declares himself as new CH of cluster and it chooses its CH_Next.About the old CH,if it did not leave the cluster it becomes an ordinary node.

CH_Next represents the node with the highest energy level among the nodes of its cluster (if 2 nodes have the same energy level, choose the closest node). The new CH sends a message to all nodes of the cluster to inform them of this change. Each node of the cluster responds with a message specifying its residual energy, based on this information the new CH designates the CH_Next to complete the re-clustering step.

In HEED , the periodic cluster head rotation or election needs extra energy to rebuild clusters due the complexity to the HEED protocol .The main objective of our amelioration method , is to avoid the re-clustering phase in each round, and using a intra cluster concept for re-clustering organization .For prolonging the network life time and decrease the energy consumption.
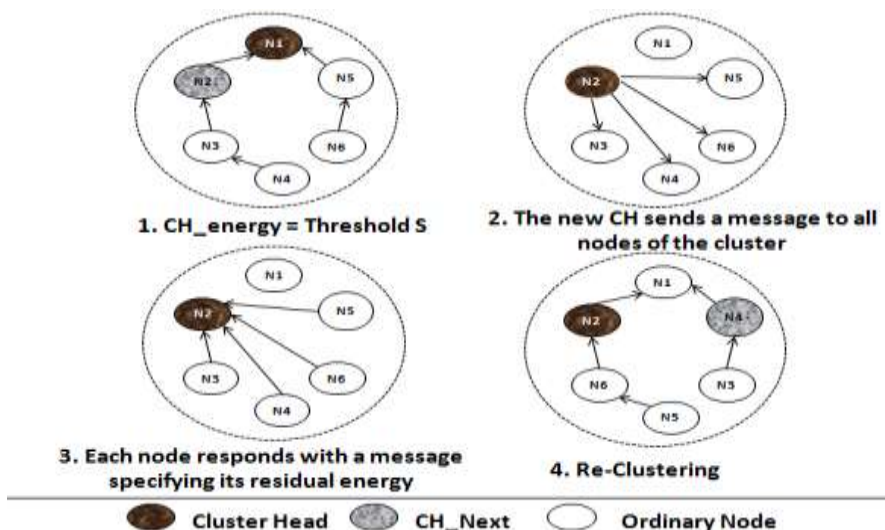

Figure 6: Maintenance of clusters

3.4. HEGASIS Objectives

HEGASIS consists to present a new clustering protocol based to 2 others existing protocols. This combination was realized later studying of the various protocols of clustering existing, to propose an algorithm which can minimize the limitations of these existing protocols and benefit from their key points, for it the main objectives of this algorithm are the following ones:

- To product a clusters with well-distributed cluster heads and uniform nodes distribution: prolonging network life-time by minimizing energy consumption;
- Increase the lifetime of each node by using collaborative techniques;
- To consume lesser communication bandwidth ;
- To adopt the chain concept in each cluster, for improving the excessive delay for the distant sensor node.
- Considering the node residual energy the main parameter for Cluster Head Election: To allow a good management of the Cluster Heads energy and to avoid the exhaustion of their energy.

4. CONCLUSION

In this article, we have proposed a new routing algorithm to enable management one of the biggest concerns in the wireless sensors network, to increase the sensors lifetime and reduce energy consumption. This was initiated by combining two existing protocols HEED and PEGASIS.

The algorithm is divided into 3 main phases: the first phase consists in structuring the sensors into clusters by electing the cluster heads. Then, we organize each cluster in chain; therefore, the nodes of the same cluster form a chain of close neighbors. The second phase describes the communications concepts used for transmitting data (intra-cluster, inter-cluster). In the last phase we explain how the re-clustering algorithm is established.

Nevertheless, this work represents a first iteration among others to come to obtain a better result,   for this it is necessary:

- To study the MAC layer of our algorithm by proposing a new approach enabling us to attain our initial objective which is to minimize the energy consumption of the nodes,
- To simulate our algorithm with NS2 stimulator, in order to evaluate its performance.

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