SLGC: A NEW CLUSTER ROUTING ALGORITHM IN WIRELESS SENSOR NETWORK FOR DECREASE ENERGY CONSUMPTION

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ABSTRACT

Decrease energy consumption and maximizing network lifetime are important parameters in designing and protocols for wireless sensor network (WSN).Clustering is one of the efficient methods in energy consumption by Cluster-Head in WSN. Besides, CH can process and aggregate data sent by cluster members, thus reducing network traffic for sending data to sink. In this paper presents a new cluster routing algorithm by dividing network into grids. In each grid computes the center-gravity and threshold of energy for selecting the node that has the best condition base on these parameters in grid for selecting Cluster-Head in current round, also SLGC selecting Cluster-Heads for next rounds thereby this CHs reduce the volume of controlling messages for next rounds and inform nodes for sending data into CH of respective round. This algorithm prolong network lifetime and decrease energy consumption by selecting CH in grid and sending data of grid to sink by this CH. Result of simulation shows that SLGC algorithm in comparison with the previous clustering algorithm has maximizing network lifetime and decrease energy consumption in network.

KEYWORDS

Clustering, Grid, Threshold Energy, Distance, Center-gravity & Cluster-Head.

1. INTRODUCTION

Recent promotions in Electronic and wireless communications industries, has created the ability of designing low consumption, small size, low price and multi applications sensors. These small sensors have the ability of some acts such as receiving, process and sending the environmental data (based on the sensor type), and have created an idea for creation and development of networks that are named WSN [1]. The sensor networks architecture's performance is so that the sensors distribute randomly and uniformly in a region and detect control and process the events, and then they send the information to the Sink Station [2]. Whereas the sensors have high performance, they have some restrictions while developing in high scale. The sensors restrictions can be classified in some categories such as short radio broadcast, band width limitation, low energy power and no battery replacement conditions in most cases. When these restrictions should be managed in an environment including many nodes, so many challenges may be happened [3].Every sensor nodes usually is equipped by a wireless transceiver, a microcontroller

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and power supplier (a battery). Sensors are generally equipped with data processing and communication capabilities [15]. In wireless sensor networks (WSN), energy efficiency is an important issue [18, 19], and what to be done to this issue directly affects the network lifetime of WSN [20]. Hierarchical routing is an efficient way to lower energy consumption within a cluster. Due to the characteristics of wireless channels, multi-hop communications between a data source and a data sink are usually more energy efficient than direct transmission. However, because the cluster heads (CHs) closer to the data sink are burdened with heavy relay traffic, they drain much faster than other CHs. [21]

Some features of sensor network make it different from other wireless and traditional networks. These features are:

- Hardware bottleneck including size's restrictions, power supplier, process power and capacity
- Memory
- So many nodes
- High density of node's distributions in operation region
- Failure talent of the nodes
- Dynamic and periodic topological changes
- Using the broadcast communication instead of peer to peer method
- Data oriented network (The nodes don't have any identification code)

Protocols and sensor networks algorithm should have ability of self-organizing. Thus, routing protocols design should utilize maximum node's energy and increase network lifetime. Also, WSN routing networks should be simple and have few calculation's complexity, optimum energy consumption, few delay in data transferring from nodes to the Sink. In this regard, so many algorithms and protocols have been designed. One of these algorithms is hierarchical method. Aid of hierarchical methods is network clustering to several grids that each grid is managed by a Cluster-Head. By this method, many data aggregation methods could be done in each cluster. Clustering methods have some advantages. The first one is that they divide network to some different grids and each grid is managed by a Cluster-Head. The second one is to decreasing data redundancy because of data aggregation by the Cluster-Head. Sensor networks organization in clustered architecture lead to many clustering algorithm at recent years [4].In fact, Cluster-Heads can process, filter and aggregate data send by cluster members, then reducing network alleviating the bandwidth. Clustering saves energy power. [5, 6] The deployment of wireless sensor networks in many application areas requires self-organization of the network nodes into clusters. Clustering is a network management technique, since it creates a hierarchical structure over a flat network. [17]

In this paper we have presents a clustering algorithm that has clustering network into grids and sending data by the CH in each cluster thus increase network lifetime and decrease energy consumption. Also in SLGC the data of each cluster is send to BS via a single method. In section 3 we present Energy model of network, in section 4 describe SLGC algorithm and in section 5 show the results of simulation.

2. RELATED WORKS

Clustering Algorithm uses for gridding nodes and increasing of network lifetime. In each grid select one of the member nodes as a Cluster-Head and coordinator of actions in each cluster for example aggregation of data [7].

The clustering methods can be categorized into static and dynamic in sensor networks. The static methods aim at minimizing the total energy spent during the formation of the clusters for a set of given network parameters, such as the number of nodes in the network [8] The dynamic clustering methods deal with the same energy efficiency problem as the static ones but target for a set of changing network parameters, such as the number of active nodes or the available energy levels in a network [9]. One of the most famous clustering algorithms is LEACH [10]. LEACH is a distributed, proactive, dynamic algorithm that forms clusters of sensors based on the received signal strength and uses local CHs as routers to the sink [16].In LEACH (low-energy adaptive clustering hierarchy) the position of a CH was rotated among the nodes within a cluster depending on their remaining energy levels. It was assumed that the number of active nodes in the network and the optimal number of clusters to be formed were parameters that could be programmed into the nodes a priori. The LEACH algorithm is divided into rounds and each round separated into two phases, the set-up phase and the steady-state phase. Set-up phase including select the Cluster-Head for current round. Selecting Cluster-Head is based on the threshold T (n) given by:

$$T(n) = \begin{cases} \dfrac{p}{1 - p * (r \mod \frac{1}{p})} & if \quad n \in G, \\ 0 & otherwise \end{cases} \qquad (1)$$

Where p is the predetermined percentage of cluster heads (e.g., p = 0.05), r is the current round, and G is the set of nodes that have not been cluster heads in the last 1/p rounds. Cluster head broadcasts an advertisement message to the other nodes. Depending on the signal strength of the advertisement messages, each node selects the cluster head it will belong to. The cluster head creates a Time Division Multiple Access (TDMA) scheme and assigns each node a time slot. In the steady-state phase, the cluster heads collect data from sensor nodes, aggregate the data and send it to the base station. Since the decision to change the CH is probabilistic, there is a good chance that a node with much low energy gets selected as a CH. When this node dies, the whole cell becomes dysfunctional. Also, the CH is assumed to have a long communication range so that the data can reach the base-station from the CH directly. This is not always a realistic assumption since the CHs are regular sensors and the base-station is often not directly reachable to all nodes due to signal propagation problems. [11]

RCSDN is created based on rounds, in which each round contains two phases, setup and steady-state. In Steady–state Phase the nodes send the data they've received from the environment to the corresponding CH and after gathering data in the cluster head, data will be sent to the BS. The Set-up Phase in RCSDN starts by sending a start message via BS with a specified range to the environment. After a node receives the start message from the BS, it provides a relative estimate of its distance from the BS through the intensity of the received signal. Then it broadcasts a message for its neighboring nodes including ID, the distance to BS, and the level of remaining energy. Nodes bound in the radio range of this message, receive it and set this node as a neighbor node, and register its ID and energy level in their memory; again they proceed to estimate their distance with the neighboring node by calculating the intensity of the received signal and finally calculate their distance from the BS. This is the done by all nodes in the network and all nodes will acquire the ID, level of energy and distance of all neighboring nodes. In RCSDN we use a local threshold detector (Td) so that only nodes having selection conditions participate in competition for selecting CH. This threshold detector is locally calculated in each node to prevent the lack-of candidates' problem in some areas because of the central selection. [12]. In VIP [13] as sensor networks are deployed over various terrains, the complexity of their topology continues to grow. Voids in networks often cause existing geographic routing algorithms to fail. One algorithm for solving this problem is "virtual position", which is the first level of middle Position of all direct neighbors of a node. The middle position is:

$$(x'_A, y'_A) = \left(\frac{1}{n}\sum_{i=1}^{n} X_{A,i} , \frac{1}{n}\sum_{i=1}^{n} Y_{A,i} \right) \quad (2)$$

In this paper we produce the algorithm that use clustering and middle Position of nodes and threshold Energy for finding Cluster-Head (CH) in each grid.

3. NETWORK MODEL AND ENERGY MODEL

3.1. Network Model

The network model of this paper following this case:

- The BS and all nodes are stationary after deployment of Network.
- The initial energy of nodes is different and randomly.
- Nodes deployment in 2D space.
- Each node has information of coordinate and energy of itself and position of CH.

3.2. Energy Model

Sensors consume energy when they sense, receive and transmit data [14].Our energy model for the sensor network is based on the first order radio model assured [10]. In this model, the transmitter has power control abilities to dissipate minimal energy to send data to the receiver. In order to achieve an acceptable signal-to-noise ratio (SNR), the energy consumption of the transmitter is given by:

$$\begin{cases} E_{Tx}(n,d) = n(E_{elec} + \varepsilon_{fs} d^2) & d < d_0 \\ E_{Tx}(n,d) = n(E_{elec} + \varepsilon_{mp} d^4) & d \geq d_0 \end{cases} \quad (3)$$

Where, n is the number bit of the message and d is the distance. E_{elec} is the energy dissipated per bit to run the transmitter or the receiver circuit, and ε_{fs}, ε_{mp} is the energy dissipated per bit to run the transmit amplifier depending on the distance between the transmitter and receiver. If the distance is less than a threshold d0, the free space (FS) model is used; otherwise, the multi path (MP) model is used. The energy consumption of the receiver is given by:

$$E_{Rx}(n) = n(E_{elec}) \quad (4)$$

4. DESCRIPTION OF SLGC ALGORITHM

SLGC algorithm such as a RCSDN algorithm [12] is created based on rounds and divided into two phases, setup and steady-state. In the Set-up Phase, the CHs are determined and the cluster structures are formed. In Steady-state Phase the nodes send the data they've received from the neighbor nodes to the CH and after gathering data in the CH, data will be sent to the BS. In SLGC algorithm Energy and center-gravity are important parameters.

4.1. Setup Phase

In Setup Phase we specified several CHs for use to different rounds for increasing network lifetime. The Sink (BS) sent initial message for start network into all nodes and all nodes send the information that are useful for running network into Sink. The Sink (BS) after gathering initial data from nodes divides network into some grids based on network size and number of needed clusters. (Figure 1)

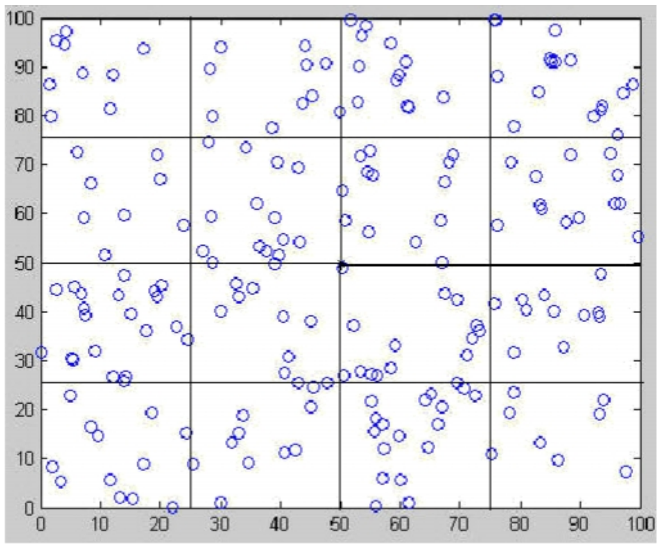

Figure1. Gridding network

The Cluster-Heads should be specified after formation of the clusters. For finding CHs, at first the threshold energy of nodes in each grid should be measured and all nodes that have less energy should be ignored from the candidates list. (α is a rate that will be specified by the simulator)threshold energy will be calculated by following equation:

$$E_\theta = \alpha * (\frac{1}{n} \sum_{i=1}^{n} E_i) \quad (5)$$

Following code should be performed for finding the initial candidate nodes set.

Pseudo code of selecting candidate node of energy

```
If Ei ≥ Eθ then
        Insert node i into T set    // T is a set of nodes that select for candidate nodes in cluster
        i(type)=candid
```

T is a set of nodes that their energy level is higher than the threshold and select for candidate nodes in grid. After adding node into T set the flag type of node change to a Candid type. Based on SLGC algorithm selecting CHs are based on energy and distance of the node to center-gravity of grid, therefore after filtering nodes base on energy in grid, should be measuring node's center-gravity that related to the node's location in each clusters for finding CHs for several rounds, based on the following equation:

$$(x'_A, y'_A) = \left(\frac{1}{n}\sum_{i=1}^{n} X_i,\ \frac{1}{n}\sum_{i=1}^{n} Y_i\right) \quad (6)$$

Next step is to specifying the CHs for different rounds in each cluster. At this step, sort T set ascending base on nodes that have the minimum distance to Gravity, and then nodes that have the less distance to center-gravity are selected as the CH for different rounds based on the specific rounds number from the sorted list. After find CHs for different rounds, save information to grid's table. Following code should be performed for finding the final CHs set for each grids:

Algorithm 1 Cluster formation and find CHs in one grid

1. If (mod(round_num, rmax)=0 //rmax: the number of rounds for selecting CHs for that
2. $E_\theta = \alpha * (\frac{1}{n}\sum_{i=1}^{n} E_i)$ //for all nodes in grid
3. $CG = (\frac{1}{n}\sum_{i=1}^{n} X_i,\ \frac{1}{n}\sum_{i=1}^{n} Y_i)$ //for all nodes in grid
4. For i=1 to n
5. If $E_i \geq E_\theta$ then
6. Insert node i into T set //T:set of nodes that select for candidate nodes in grid
7. i(type)=candide
8. Distance(i)=sqrt($(X_i-X_{CG})^2+(Y_i-Y_{CG})^2$)
9. End
10. Sort T set ascending base on minimum distance to gravity
11. CH= min(T) //select CH for current round
12. For next rounds base on rmax, select CHs base on minimum distance on sorted list

Follow chart shows the stages of selecting CHs for different rounds. (Figure 2)

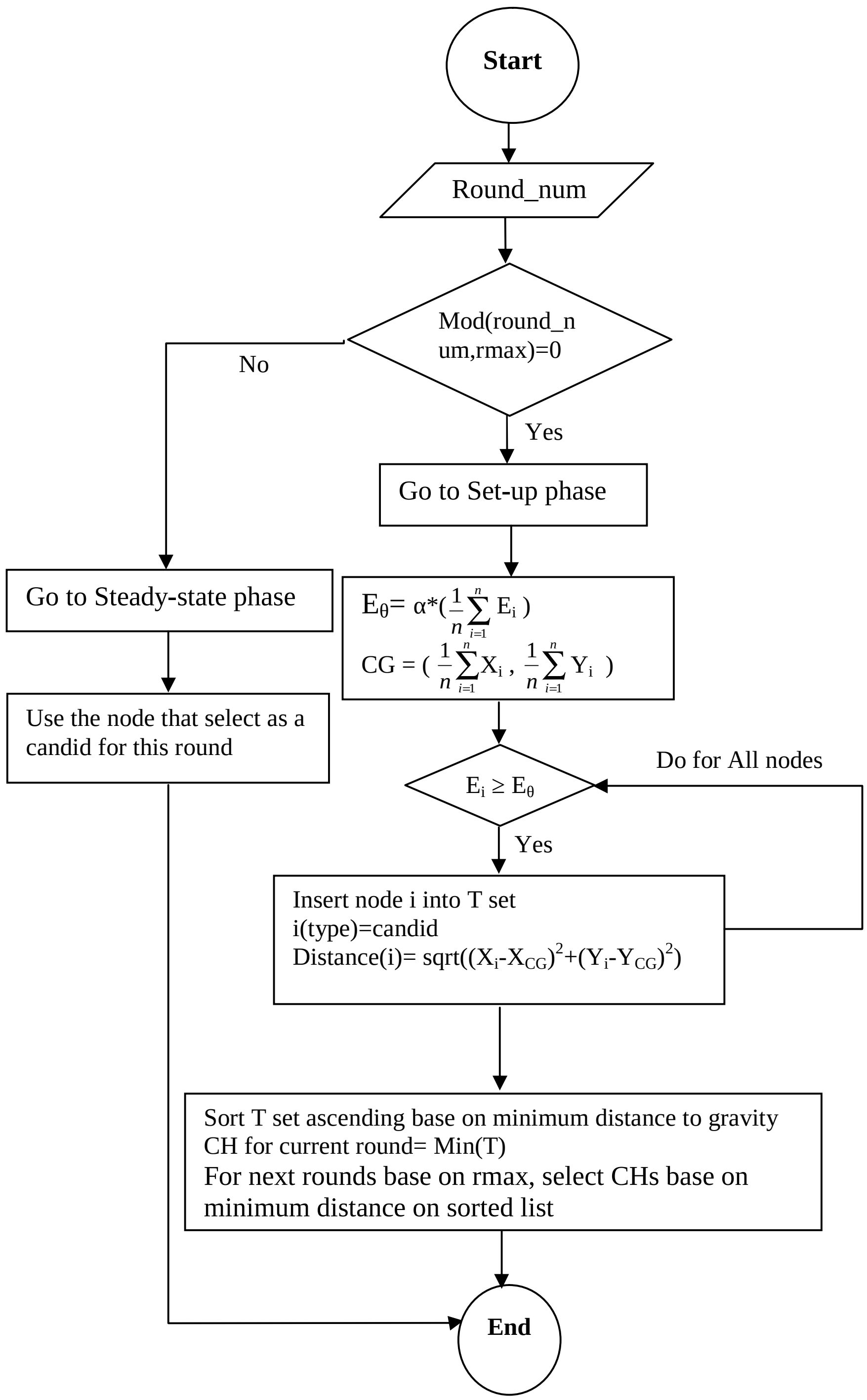

Figure 2. Chart of selecting CHs

4.2. Steady-state Phase

After sending and aggregating data in current round, the energy of CH and nodes are decreased, hence the threshold energy base on distance of nodes in grid into CH is decreased. Base on SLGC algorithm after execute of each round for selecting CH for next round after calculating new threshold energy if the energy of current round is higher than threshold, current CH remain CH for next round and all CH selected for next round shift one level down. This CH remain such as CH because has best situation among all candidate node in grid base on distance to gravity. This idea in SLGC algorithm reduces the volume of controlling messages for next rounds and increase network life time. Following code should be performed for set CH for next rounds:

Pseudo code of set CH for next rounds

//Calculate new threshold energy of grid

1. $E_{\theta(new)} = E_{\theta(old)} - (efs*(\text{sum of distance node to CH})^2)$ //efs: Transmit Amplifier types
2. If $E_{CH(\text{previous round})} \geq E_{\theta(new)}$
3. CH= CH(previous round)
4. Else
5. CH=CH(next CH from sorted T set)

All nodes should send their data to the Cluster-Head for aggregating and sending data to the BS, after specifying the candidate node.

5. SIMULATION

We simulated this algorithm; the parameters that use for simulation of this algorithm are as following table. The position of all nodes in coordinate is randomly.

Table 1. Simulation Parameters

Parameter	**Value**
Network size	100*100 m
Number of nodes	200
Base station location	50,50 m
Initial energy for node	rand [0.5,1] J
Eelec	50nJ/bit
ε_{fs}	10pj/bit/ m2
ε_{mp}	0.0013pj/bit/m4
Data aggregation energy	5nj/bit/signal
d_0	87m

SLGC algorithm have compare with the LEACH [10] method. We use the value of α=1.05 to compare our algorithm to LEACH.

5.1. The Effect of α Coefficient in Algorithm Efficiency

We have investigated the effect of α coefficient in algorithm efficiency, α is a coefficient for specified threshold energy for finding candidate node in grids. As figure 3 shows, increasing α don't have good efficiency for network lifetime. We can see that for α=1.05 an optimal value of network lifetime can be obtained.

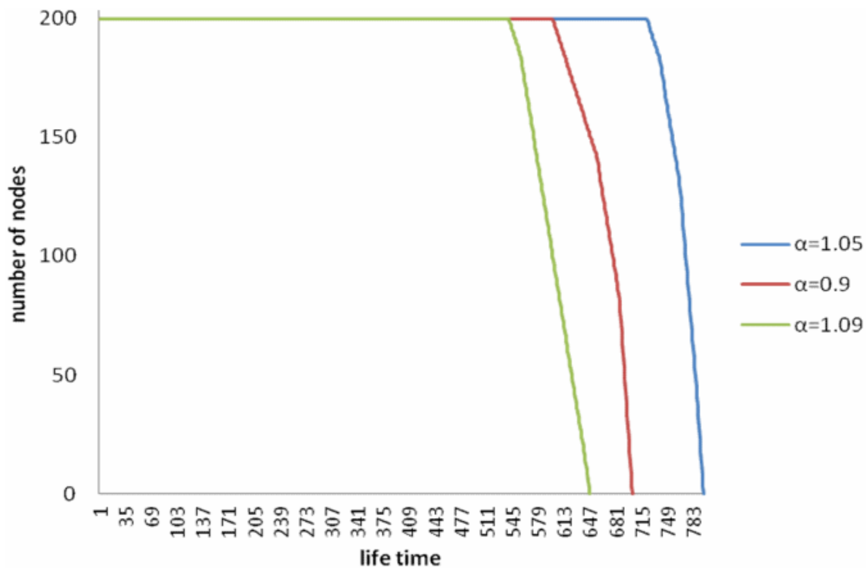

Figure 3. Effect of α coefficient

5.2. The Numbers of Create Grids

As show figure 4 and 5, finding CHs in LEACH and SLGC are different. In SLGC for reducing control messages we select CHs for some rounds base on best position in grid for decreasing energy consumption.

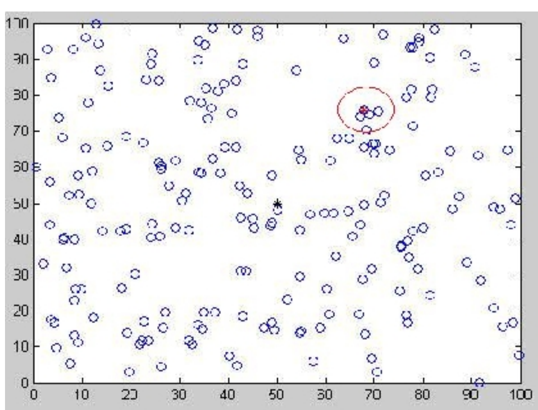

Figure 4. Gridding and find CH in LEACH

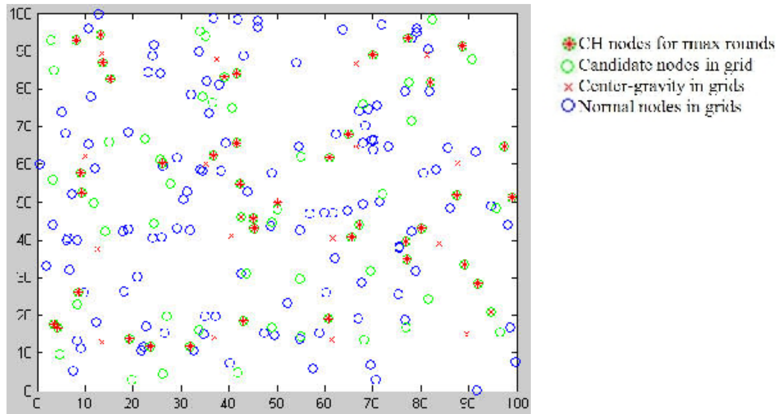

Figure 5. Gridding and find CHs in SLGC

5.3. The Number of Alive Nodes

Figure 6 shows the total number of alive nodes through simulation time. This figure shows that in SLGC the nodes have longer lifetime that in LEACH and SLGC decrease energy consumption in network. This result is as a selecting best CHs base on distance and thereshold of energy in grids for several rounds, then decrease energy consumption and volume of controlling message in network then increasing network lifetime.

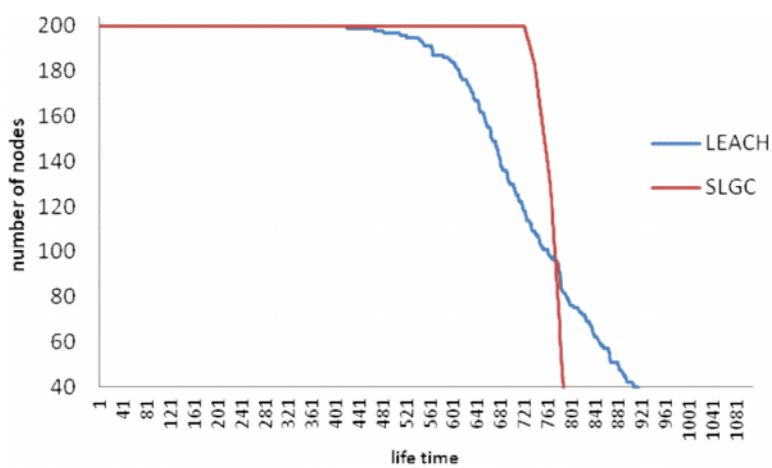

Figure 6. Total number of alive nodes in the SLGC and LEACH

5.4. Network Lifetime with Different Number of Nodes

We have compared SLGC in a network with a fixed size of (100×100) with a different number of nodes. In figure 7 shows the network lifetime until the first node dies and figure 8 shows lifetime until 30% nodes die. This result is as a selecting best CHs base on distance and thereshold of energy in grids. Selecting best CH cause that increase network lifetime and first node dead later than LEACH.

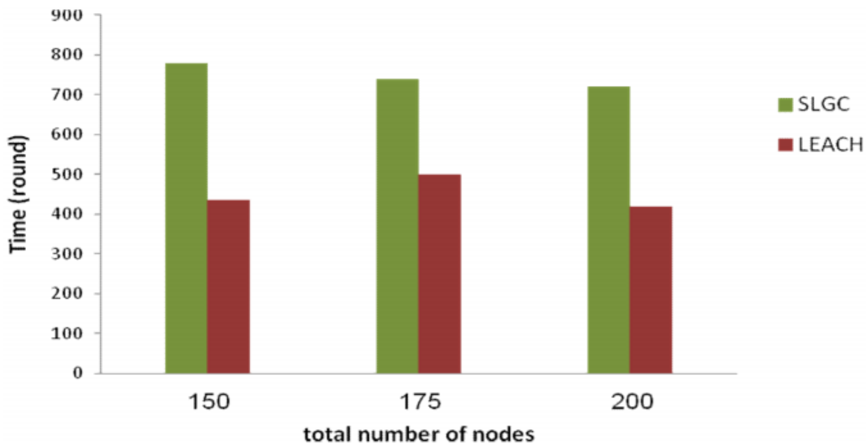

Figure 7. Network lifetime (first node die)

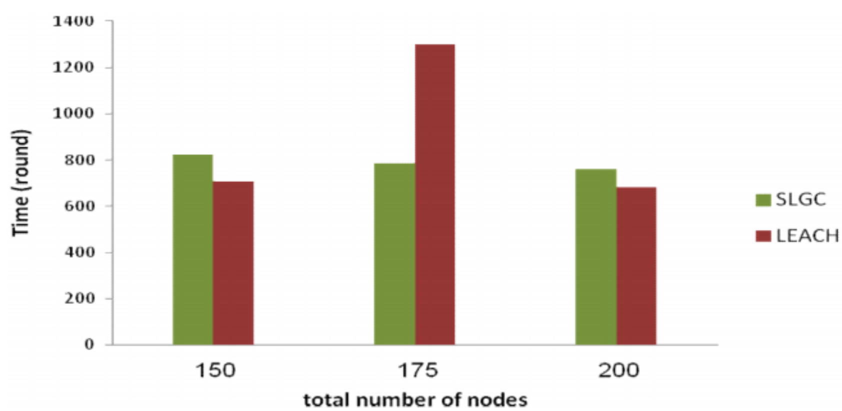

Figure 8. Network lifetime (30% nodes die)

6. Conclusions

In Wireless Sensor Networks (WSNs) there are a large number of sensors that requiring careful architecture and management of the network. Decrease energy consumption and maximize Network lifetime are important parameters in designing WSNs. Clustering is one of the efficient methods in energy consumption by Cluster-Head in WSN. In this paper we have presented a new cluster routing algorithm to gridding wireless sensor network. We have shown that it is possible to create an efficient method for creating clusters in sensor network by selecting best Cluster Heads in each grid, CHs select base on maximum energy in grid and distance of node to center gravity of each grid, CHs aggregate the information from nodes and sending this data to BS, hence increasing network lifetime and decreasing energy consumption. Also SLGC algorithm with selecting CHs for next rounds reduces the volume of controlling message in network. We have improved the presented algorithm in an efficient and compared it with the LEACH method in cluster formation. Results show a higher efficiency level of network lifetime and decrease of energy consumption.

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