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Power Efficient Gathering in Sensor Information Systems Protocol Using K-means Clustering Algorithm

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Abstract **—Power-Efficient Gathering in Sensor Information Systems (PEGASIS) protocol is energy efficient protocols designed to prolong the lifetime of the network by reduction of energy consumption. In this paper a modification is proposed to the PEGASIS algorithm where sensor nodes are clustered in groups, clustering is done by k-means algorithm, and each group is treated as PEGASIS. In addition the proposed algorithm used rechargeable sensor nodes. Two parameters are searched to select chain leader: Euclidean distance of sensor node to the base station and residual energy of sensor node. Each cluster head data is transmitted directly to the base station. Simulation results showed the proposed algorithms improved in comparison with original PEGASIS.**

Keywords **—K-means, PEGASIS, Wireless Sensor Networks (WSNs) , Cluster Head (CH).**

I. INTRODUCTION

WSNs contain hundreds or thousands of sensor nodes where sensor nodes distributed over wide geographical area and they work with each other to output high quality information from ambient environment. Each sensor node takes its decisions on its operation, the information it presently has, and its familiarity of its computing, communication, and energy resources. Every one of these distributed sensor nodes able to gather and direct data to other sensor nodes or to the base station(s). The base station may be mobile or stationary capable of delivering data reports to the user through the communication infrastructure or the Internet as shown in figure 1, [1].

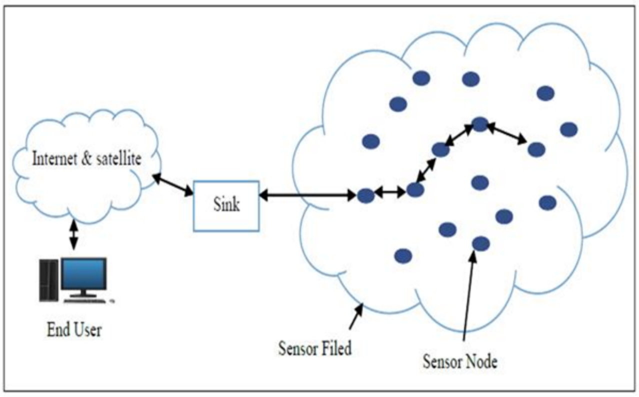

Fig. 1 Wireless sensor network [1]

PEGASIS was proposed by Stephanie Lindsey et al [2]. It is a basic chain -based routing protocol in which, sensor nodes only connect and communicate with nearest neighbor into a chain. To transmit the aggregated data to the base station, PEGASIS chooses a node to become CH in each round, which has randomly location in the chain. PEGASIS is near optimal solution on energy-efficient but it is still some limi-tations in this protocol. Firstly, the CH is selected at random location in chain, (no considering about the energy residual and location of the base station). Secondly, some "long link" inevitability still exists between neighboring nodes in PEGASIS, which is cause of unevenness of energy con-sumption distribution among nodes. Moreover, the trans-mission phase of PEGASIS may become high delay and a bottleneck at the CH node since the CH is a single in "long chain" [3].

II. RELATED WORK

In reference [3] Concentric Clustering enhancement to PEGASIS scheme by dividing the sensor network into concentric clusters in order to consider the location of base station. In each concentric level, chain constructed between sensor nodes by using Greedy algorithm and one node selected as cluster-head. Multiple-hops between cluster-heads from the highest (farthest) cluster level to the lowest level near to the base station. Each sensor node is assigned to level according to signal strength to base station. Number of levels depends on number sensor nodes and base station position. The protocol that proposed gave better results than PEGASIS protocol and reduces redundant data transmission. Simulation results showed that enhanced PEGASIS protocol is better than the PEGASIS and reduces redundant data transmission. Mobile sink improved energy-efficient PEGASIS-based routing protocol (MIEEPB) [4] proposed which based on base station motion. The sensing area divided into four zones and nodes in each zone ordered into chain by Greedy algorithm. In order to elect the chain head need to find weight of each sensor node which is equal the residual energy for the node divided by its distance to the base station. It is supposed that the base station has ineffective energy and it's able to move at fixed route from one zone to another, stop in each zone for specific time and collect data from sensors in their sites. PEGASIS with mobile sensor nodes (M-PEGASIS) [5] where nodes change their position according to random waypoint mobility model, after moving, if a node doesn't find a close neighbor in its transmission range, it goes into sleep mode for a random period of time and then wakes up, this method is repeated until it discovers one in its transmission range. Gathered data is done by transfer information from sensor to another. Leader selection is based on residual energy and distance with base station for each sensor. Sleep scheduled and tree-based clustering approach routing algorithm (SSTBC) [6] in order to use the energy of sensor nodes efficiently to prolong the network lifetime. SSTBC pre-serves energy by turning off the radio (entering sleep mode) of unnecessary nodes, which detect almost the same information, based on their location information to eliminate redundant data. To reduce energy depletion SSTBC build minimum spanning tree with the root as the cluster head from active nodes in a cluster to forward data packets to base station.

Our proposed protocol adds feature to PEGASIS to support rechargeable sensors. In addition modified the topology PEGASIS by using k-means clustering algorithm.

III. Proposed Work

The proposed approach based on clustering k-means clustering algorithm used for grouping N nodes into k groups. The algorithm used to solve the clustering problem to find optimal value of the objective function which is Euclidean distance between the node and the center of the cluster. The smaller value of the objective function, means better clustering results. The formula of objective function expressed as follows:

$$\arg\min\left(\sum_{j=1}^{k}\sum_{x_i \in S_j} d_{ij}^{2}\right) \qquad (1)$$

Where S_j is the cluster j and is d_{ij} Euclidean distance between coordinate of sensor node x_i and coordinate of centroid C of cluster S_j.

$$d_{ij} = \left\| x_i - C_j \right\| = \sqrt{(x_i - C_j)^2} \qquad (2)$$

The basic steps of the algorithm are:

Initialize: Make selection of number of clusters k, total nodes inside sensor network N.

Step (1): initial centers is selected randomly.

Step (2): The Euclidean distance from each node to all centroids is calculated by following equation:

$$\sum_{j=1}^{k}\sum_{i=1}^{N} d_{ij} = \left\| x_i - C_j \right\| \qquad (3)$$

Step (3): The sensor nodes are divided into the cluster according to the minimum distance. If the x_i is the closest to the C_i in the iteration, then x_i will join the cluster S_i, where each sensor node joins only to one cluster.

Step (4): When the clustering is done, the new cluster centroids positions are calculated by the following:

$$C_j^{t+1} = \frac{\sum_{i=1}^{n} x_i}{n}, \quad 1 \le j \le k \qquad (4)$$

n indicate the total sensor nodes into cluster S_j ([7]-[9]):

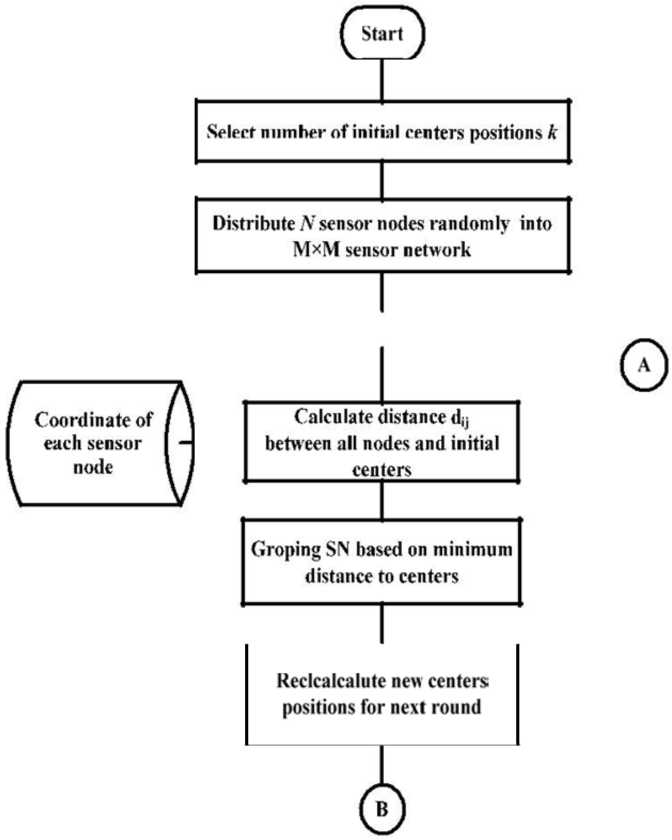

Fig. 2 Flow chart of k-means clustering algorithm part 1

Step (5): Chain Leader Selection

After performing clustering the CH selection step is take place. Select k cluster head from N node, these CHs become the leaders in their clusters to control the transmission of data to base station. The proposed method for CH selection is based on weight W allocated to each sensor node. Each node calculates its distance from the base station use Euclidean distance $diBS$:

$$diBS = \sqrt{(xi - xBS)^2 + (yi - yBS)^2} \qquad (5)$$

Where x_i, y_i, x_{BS} and y_{BS} is the x and y coordinate of SNs and BS respectively.The weights are calculated by dividing the nodes residual energy on its distance from BS as follow-ing equation:

$$w_i \;\; E_i \, / \, d_{iBS} \tag{6}$$

Where E_i the remaining energy of sensor node i and calculated as following:

$$E_i \;\; E_0 \;\; E_t \tag{7}$$

Where E_0 initial energy of each sensor nodes, E_t is sum of energy that sensor node deplete in transmission, reception and aggregation of data. For each cluster, the chain leader is selected by comparing the weights of all the sensor nodes. The node with the maximum weight is chosen as a chain leader.

Step (6): Chain Building

In this step the multiple chains building in direction of base station each chain consist one leader, which is last and nearest sensor node to base station. The single chain building is same as PEGASIS. The proposal is base station transmits hello packet to all nodes in a sensor network collect information about the position, nodes ID and distance. In each cluster, base station finds the farthest sensor node from the chain leader node. The farthest node is called as the start sensor node. Start node finds its nearest node, each node finds the distance from nearest not connected node. Each node i in chain act as a parent to node (i-1), and receives data from it. If one of the nodes in the chains deplete its energy the nodes is bypassed in next rounds and constricting new chain.

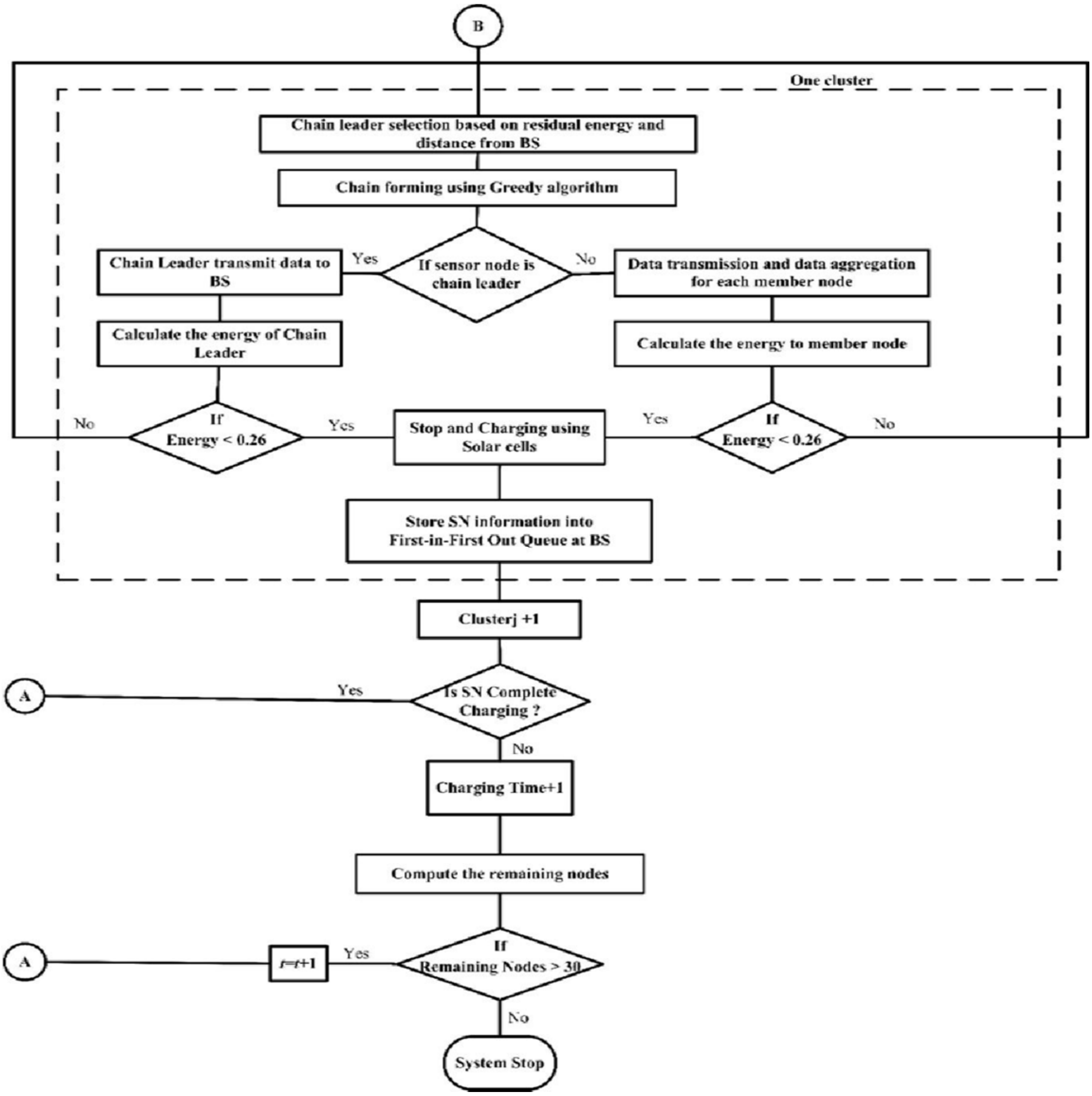

Fig. 3 Flow chart of k-means clustering algorithm part 2

IV. Results And Discussion

In order to study the proposed approach, by using MATLAB to simulate different scenarios of 100 sensor nodes deployed uniformly inside a layout of 100x100 square meters. 5 % of the sensor nodes are selected to be chain leaders. The initial energy for each sensor node was set to be 0.5 joule. It is worth to note that the initial energy for the rechargeable batteries scenario was used to recharge sensors to this value. Table 1 summarized the simulation parameters.

Table (1) simulation parameters used

Parameter	Value
Simulation area	$100\times100m^2$
Number of clusters (k)	5
Sensors number	100
Base station location	(50,150)
Initial energy of Nodes (E_0)	0.5J
Data packet size	2000 bits/Packet
E_{elec}	50nJ/bit
ϵ_{fs} ϵ_{mp}	$10pJ/bit/m^2$ $0.0013pJ/bit/m^4$
Charge threshold	0.26 J
Recharge time	2 days(48 hours)
Threshold node die	3 times
Rounds number	5000

In order to perform the simulations for proposed algorithms. The following assumptions are made:

All the sensor nodes in the network are homogeneous and energy constrained, the sensor nodes are stationary.
The base station is immobile and has no energy constrained.
Sensor node can measure distances roughly based on the received signal strength.
All packets that are transmitted at the same size.
Nodes always have data to send.
All sensor nodes are sensing the surroundings at a same rate.
The radio channel is symmetric such that energy necessary for transmitting a packet from a sensor node (A) to another sensor node (B) is the similar to the energy required for transmitting a packet from the sensor ode (B) to the sensor node (A).
The effect caused by signal collision and interference in the wireless channel is ignored.
All sensor nodes can be recharged using solar cell.

The performance of the proposed modifications can be evaluated by the following metrics are calculated [10]:

1. Network lifespan: interval from the beginning of WSN work till the expiry of last alive sensor node or system stop.
2. The Total Residual Energy: It represents the total residual energy of all sensor nodes in the network per round its calculated by the following equation :

$$E_{total} = \sum_{i=1}^{N} E_C \qquad (8)$$

Where Ec current energy level of a sensor node and N number of sensor nodes in the simulation.

In fig. 4 shows the intial centers chosen at random locations and base station at coordinate (50,150) and in fig.5 shows the chains formed by k-means PEGASIS.

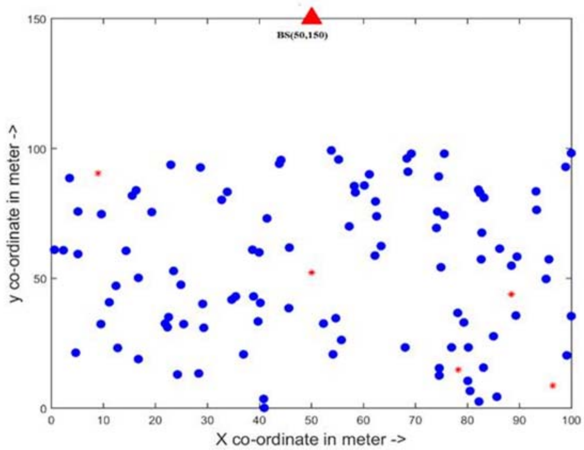

Fig. 4 initial centroids locations

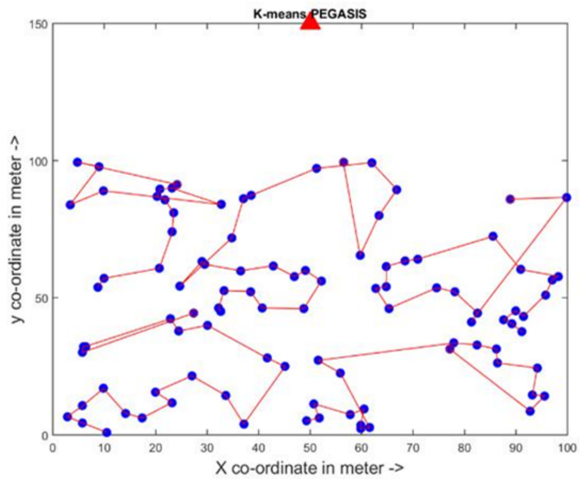

Fig. 5 Chains formation in k-means PEGASIS

Now, we compare network lifetime of k-means PEGASIS with original PEGASIS in homogeneous network. We carry out simulations for 5000 rounds. Fig 6 describe the number of alive sensor nodes during the network duration.

Comparison shows that network lifetime for k-means PEGASIS is better than original PEGASIS which are approximately 4593 rounds and 2481 rounds respectively. In k-means PEGASIS the percentage improvement in network lifetime is 85% in comparison with original PEGASIS.

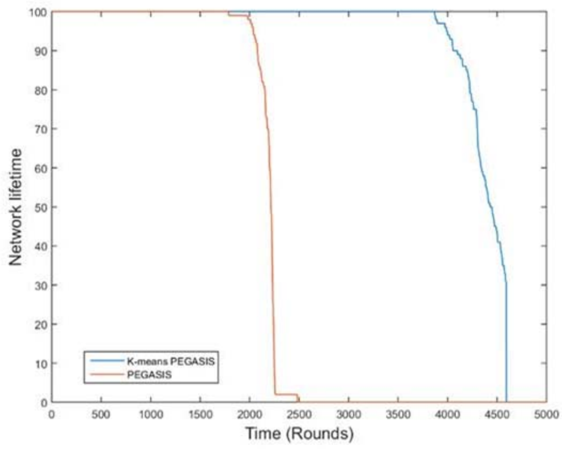

Fig. 6 Comparison network lifetimes

Fig. 7 shows the residual energy for the proposed algorithm in comparison with original PEGASIS.

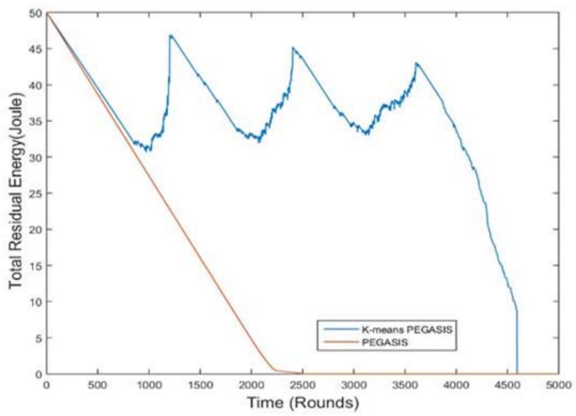

Fig. 7 Total residual energy

CONCLUSION AND FUTURE WORK

In this paper, multi-chain of k-means PEGASIS along with induction of rechargeable sensor nodes .k-means PEGASIS can prolong the network lifetime. . Our considerations are supportive in diminishing the delay in data delivery and distances between the connected sensors through smaller chains. As for future directions, we are striving to evaluate the proposed algorithms by using NS2 program to make better understanding to result analysis.

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