An Self Regulating Clustering in Wireless Sensor Network using Particle Swarm Optimization

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Abstract— In a wide variety of application areas including geophysical monitoring, precision agriculture, habitat monitoring, transportation, military systems and business processes, Wireless Sensor networks (WSNs) are envisioned to fulfill complex monitoring tasks. WSN properties and requirements are both unique in the networks world and extremely diversified between themselves. Most of these applications demands efficient organization of network topology for data collection, data aggregation and load balancing to increase the network lifetime and Scalability of the network. The network must be autonomous and self organizing. WSN constraints demand an efficient and optimal clustering protocol for its operations. In order to facilitate low power consumption, fault tolerance, scalability, WSNs should be clustered hierarchically and aggregated data should to be routed energy efficiently with minimum latency. In this paper, we introduce a new approach for clustering wireless sensor networks based on Particle Swarm Optimization (PSO). Using the optimal fitness function, which aims to extend network lifetime. The parameters used in these Techniques are the distance from the base station, intra-cluster distance from the cluser head and inter cluster distance.

Key words: Wireless Sensor Networks, Clustering, Particles Swarm Optimization, Fitness Function

I. INTRODUCTION

Present technological advances in wireless communication have made it possible for low cost, low complexity miniature sensor devices to capture environmental and tactical data and transmit them to a base station. Each sensor device is equipped with a wireless communication transceiver and a reasonably powerful processor which is capable of signal processing and complex computation. With these sensors, it is possible to conceive applications where very large number of these inexpensive sensor nodes could be deployed and form a self-organizing wireless sensor network. The design and development of networks connecting numerous sensor nodes pose several significant challenges. These low- cost and low-power devices are characterized by limited computation, communication range, memory storage and battery power capabilities (Karaki J. N. A. et al., 2004). Some of the key challenges in realizing such networks deal with scaling network protocols to large number of nodes, designing simple and efficient protocols for different network operations, and designing power-conserving protocols. Limited battery powers of sensor nodes demand routing protocol for sensor network which consume minimum possible amount of energy and hence give longer life to the system. In a sensor network, sensor nodes are the potential source of information and they need to send their sensed/collected information to a remote base station (BS)/Sink.

Generally, it needs a fixed amount of energy to receive one bit of information and an additional amount of energy to transmit the same. This additional amount depends on the transmission range. So, if all nodes transmit directly to the sink, then they will quickly deplete their energy. Therefore, a multi-hop transmission is needed to give longer life of the network. Clustering sensor networks, is an effective technique to increase the scalability and survivability Of nodes, the main goal of clustering is to divide network to a set of individual and limited nodes that can be easy controlled. by apply clustering can routing table size, repeats end messages reiteration and energy consumption is reduced and enhance the network lifetime, until the nodes their data transfer to the shortest distance of associated cluster heads In this Research paper an Self Regulating approach of clustering is proposed using Particle Swarm Optimization.

II. RELATED WORKS

Sensor network have been actively considered in recent research in national as well as in international level. Much research on the design of large-scale wireless sensor networks is in process. The main objective is to increase the lifetime and scalability of wireless sensor network (WSN.).

Hu and Hing (2007) proposed a Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol. LEACH is representative of cluster-based routing protocols. It is also the first proposal in wireless sensor network and can reduce power consumption on avoiding the communication directly between sink and sensor nodes. In a sensor field, sensor node senses data and sends data to the sink called round. The working procedure for LEACH is finished in a round. Before gathering the sensed data at each round, the huge numbers of sensor nodes divide into several clusters and choose a cluster head randomly by self-organization. Each cluster head is in charge of the sensed data from the sensor nodes in the cluster. The cluster head aggregates the received data, and then send to the sink directly. Nazir and Hasbullah (2010) proposed Energy Balanced Clustering (EBC) in WSN. In this Algorithms for energy balanced cluster formation, cluster head selection, intra cluster and inter cluster communication in WSN are proposed. Old Cluster head is used for selection of new cluster head. TDMA slots are used for intra cluster communication. To send the data to the sink, a cluster head sends data to other cluster head that is nearer to the base station. Latiff and Ahmad (2011) proposed an energy-efficient protocol for the movement of mobile base station using Particle Swarm Optimization (PSO) method in WSN. Since the base station in sensor networks is usually a node with high processing power, high storage capacity and the battery used can be rechargeable, the base station can be utilized to collect data from each sensor node in the sensing area by moving closer to the transmitting node. Simulation results demonstrate that the proposed protocol can improve the network lifetime, data delivery and energy consumption compared to existing energy efficient protocols developed for this network.

R. Alageswaran et al. (2012) proposed an efficient method for finding optimized position of sink node using PSO. The initial constraints in finding optimal Base-Station (BS) locations in two-tiered wireless sensor networks using PSO are relaxed by placing Application Nodes (AN) dynamically based on Euclidean distance and probability of selection. This system is tested by establishing communication between the nodes and sink through the application nodes using query-driven model of WSN.

III. Tools Used

Network Simulator 2 (NS2) is used to simulate the proposed approach. Network Simulator 2 is a discrete event network simulator implemented in Linux-based platform. Where the timing of events is maintained by a scheduler and it is able to simulate various types of network such as Wireless Ad hoc Network, Wireless Sensor Network etc. Besides that it also implements variety of applications, protocols such as TCP and UDP, network elements such as signal strength, traffic models such as FTP and CBR, router queue management mechanisms such as Drop Tail and many more. OTCL script in NS2 makes network models with their own specific topology, protocols and all requirements need. Some more tools are required for generating different types, size and speed of data, for providing mobilization to sensor nodes and for generating graph etc.

IV. Network Model

For each node a unique identity is assigned

- The nodes are aware of self-position. (via GPS)
- The nodes are homogeneous network, it means that have identical processing potency.
- The nodes have limited energy and after disperse there is no battery charging capabilities.
- Each node has an initial value which is **Emax** and BS has no restrictions on energy, memory and communication.
- Links are symmetric that is two nodes v1 and v2 can use the same transmission power to connect.

V. Proposed Approach

Particle swarm optimization (PSO) is one of the latest population based evolutionary optimization techniques which is based on the behaviors of bird flocking and fish schooling.

PSO is based on this scenario: there is a group of birds (fish) who search for food without knowledge about the exact place of it but, they know how far it is. Each bird (particle) can be informed about its best previous position and the best previous position of all other birds and how to follow these two positions. In PSO, each solution (particle) behaves like a bird in the search space. Each particle has a velocity too, which shows the direction of its flying and also has a fitness that shows how good this particle is. This fitness is calculated by a function. In this research work Our proposed Algorithium is composed of two phase:

- Clustering phases
- Data transmission phases

A. Clustering Phase

In clustering phase, the particles are generated randomly. Then the best points are selected as the cluster heads and other nodes which are located near each cluster head becomes the member of the cluster and then fitness function is calculated for every cluster heads. If the fitness function is better than global best it is substituted. This process is donefor1000generation.Theneach node prepares a control message that contains identity and value of its residual energy and sends it directly to the base station .The base station which receives the information performs clustering operation.

In this proposed algorithm to estimate the optimal number of clusters. The first Select the number of clusters. Also to measure rate of clusters separation the different distance between cluster than total center of data set for the number of clusters considered, and then calculated the ratio between two, since the clustering is more desirable .The clusters are more compact and farther apart So, for the number of clusters where the index is maximum the clustering is more desirable and the optimal number of clusters is achieved. Validation index is composed of two parts, F1and F2:

$$\text{Validity} = \max(F1+F2) \qquad \ldots(1)$$

Whatever the amount of the above criterion is greater clustering is better. eq.(2) denotes the F1 index and figure (a) illustrates the cluster dispersion and density of nodes in each cluster here inter-cluster distance(Inter)for which farther is better. intra-cluster distance(Intra) for which closer is better.

$$F1 = \left(\frac{\text{inter}*2}{\sqrt{\text{intra}*2}}\right) \qquad (2)$$

$$\text{Intra (c)} = \sum_{i=1}^{c}\sum_{j=1}^{N}(X_J - X_I) \qquad (3)$$

c is the number of clusters, N is the number of nodes, Xj is the cluster head and Xi denotes the distance of the nodes from its relative cluster head. The intra cluster separation is shown in the above eq (3).

$$\text{Inter (c)} = \sum_{j=1}^{c}(Xj - Xi) \qquad (4)$$

To calculate the inter clusters separation ,the distance between the centers of the clusters and the center of total data set is calculated.

$$F2 = \frac{cluster\ heads\ degree + (residual\ energy*2)}{centrality + distance\ to\ base\ station} \qquad (5)$$

Residual energy: because of the rest energy effect in being cluster heads is more effective we considered double its coefficients.

Cluster scale: the number of inter-cluster nodes divided by the total number of network nodes. Moreover in the above relationship (centrality)is obtained as follows:

$$\text{Centrality} = \frac{\sqrt{\sum\frac{dis^2}{n}}}{100} \qquad (6)$$

In which $\sum dis^2$ is the sum of squared distances of nodes to cluster heads. It is assumed that each node is aware of its position, and can calculate its distance from the base station.

When the number of clusters change from 2 to16 the slope of our validity index change dramatically. Now with local search around the intervals, the exact number of clusters can be achieved.

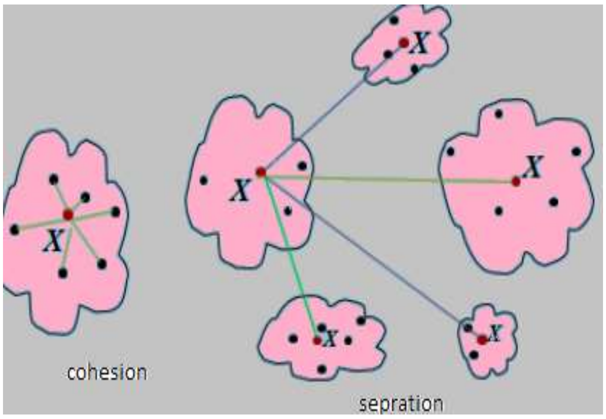

Fig. 1: Performance of proposed index

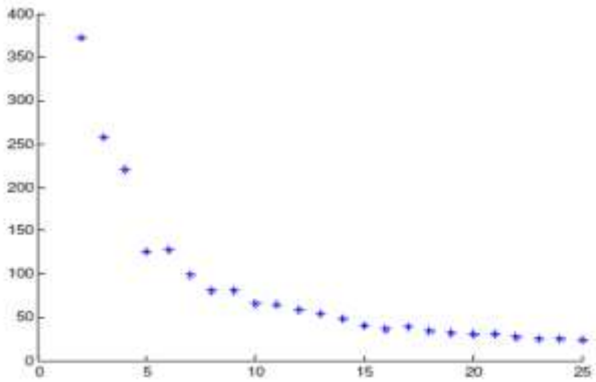

Fig. 2: The proposed validity index when of the number of clusters change

B. *Data Transmission Phases*

After cluster formation and cluster heads election of each cluster; data can be transmitted by the normal nodes to corresponding cluster heads. In this phase, each normal node is connected to the nearest cluster head. Cluster heads are assigned with the implementation of a TDMA schedule to each cluster member. Each node in the allocated interval sends its data to cluster head in the form of data message. The cluster heads aggregate and transmit data towards base station after receiving all messages from cluster member nodes.

VI. CONCLUSIONS

In this paper, we introduce a new approach for sensor network clustering using Particle Swarm Optimization (PSO) algorithm. The parameters which are used in the algorithm are distance from the base station, intra-cluster distance and cluster heads distance from each other and inter cluster distance. Our goal was to propose a new cost function to select the best cluster heads that combine the various criteria affecting the energy efficiency of cluster heads and cluster heads rotation among the nodes. Also, using the proposed algorithm the network coverage is evaluated and compared with some previous methods which have proved better performance. Delay and Throughput is also improved but Network Life Time is not improved as desirable.

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