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Particle Swarm Algorithm based Optimized Clustering Method for WSN Lifetime Enhancement

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Abstract: This work mainly focus on the network based algorithm development that can support for enhancing the entire network lifetime. The work truly follows the objective that can balance the energy consumption among all sensor nodes to enhance the lifetime of the network so that there would be no overflow sensor nodes used to run out of energy before the others. Generally, the energy consumption by a sensor node integrated sensing, communication and data processing. Among the three operations, a sensor node expends the maximum energy in the data communication. A major concern is the design and development of energy management algorithm that wishes to recover energy in order to extended network lifetime.

Keywords: Clustering algorithms, Multidimensional systems, Optimization methods, Wireless sensor network.

1. Introduction:

Wireless sensor networks (WSNs) are special ad hoc networks that provide the monitoring of physical word through numerous tiny, cheap and smart sensor nodes dispersed in desired area of interest1. These sensor nodes are autonomously accommodated to sense, process and wirelessly convey environment conditions to a base station2. WSN has been widely used in different applications such as habitat and industry monitoring, medical diagnosis, environment monitoring and agriculture3-5. Wireless sensor nodes are commonly powered by restricted capacity batteries which replacement is delicate in hostile environment where hundreds of nodes are randomly deployed. Therefore, nodes must be able to operate in low power modes to increase the longevity of their power supplies. Hence, energy optimization and efficiency are extremely important factors to be considered in WSN6. Among energy consumption sources in a sensor node, energy used in wireless data communication has the most critical impact. Routing is one of the crucial energy efficient techniques employed in WSN that aims to lower the communication energy burden7, 8. Cluster-based routing architectures are widely used in wireless sensor network due to their energy efficiency and load balancing in the network9-11. Sensor nodes in cluster architecture are grouped into clusters in which a cluster head (CH) is elected and group of source nodes are directly attached to the cluster head. Generally, a cluster network employs single hop routing in each cluster12. The one-hop clustering can reduce the energy consumption of communication by forwarding source nodes data to the cluster head via one hop. However, when communication distance increases, single hop communication consumes more energy and becomes less energy efficient method. For a large network, where inter-node distance is important, multi-hop communication is energy efficient approach13,14. For this reason, we proposed to employ a multi-hop communication in clustered routing architecture to mainly prolong the network lifetime by saving transmission energy.

2. Related Work:

In this work, **Jason Tillett, (2002) [1]** advise a brand new application of the optimization approach referred to as Particle Swarm Optimization (PSG) to the problem of clustering nodes. The PSG technique is an evolutionary programming method wherein a 'swarm' of take a look at solutions, analogous to a herbal swarm of bees, ants or termites, is authorized to interact and cooperate to discover the satisfactory approach to the given problem. In a typical optimization, a few feature or fitness is used as a criterion for the optimization. Here we use application specific criteria, where we're equalizing the range of nodes, and candidate cluster-heads in every cluster, with the objective of minimizing the energy expended through the nodes at the same time as maximizing the full records collected. The objective criteria fit with the implementation of a wireless, ad hoc, sensor community with cluster-head routing and records aggregation. The PSO optimization technique was used efficiently to cluster a node set of N nodes into M clusters wherein there exist A nodes which can be available to take at the role of cluster-head. The set of rules converges in only more than one optimization steps, for each vicinity division, for a big range of node populations, available cluster-head populations and desired clusters.

Wireless sensor networks (WSNs) are mainly characterised by their restrained and non-replenishable electricity supply. Hence, the need for electricity green infrastructure is becoming more and more important since it affects upon the community operational lifetime. Sensor node clustering is one of the techniques that may enlarge the lifespan of the complete network through statistics aggregation at the cluster head. In this work, **N. M. Abdul Latiff, (2007) [2]** gift an electricity-aware clustering for wireless sensor networks the usage of Particle Swarm Optimization (PSO) algorithm which is applied at the base station. We outline a brand new cost feature, with the goal of simultaneously minimizing the intra-cluster distance and optimizing the strength intake of the network. The performance of our protocol is in comparison with the widely known cluster-based totally protocol evolved for WSNs, LEACH (Low- Energy Adaptive Clustering Hierarchy) and LEACH-C, the later being an advanced version of LEACH. Simulation effects display that our proposed protocol can acquire better network lifetime and facts shipping at the base station over its comparatives. In this work we've offered an energy-aware clusterbased protocol for wireless sensor networks the usage of particle swarm optimization (PSO) algorithm.

The elegance of complicated structures occasionally referred to as swarm systems is a rich source of novel computational methods which can solve tough troubles efficiently and reliably. When swarms clear up issues in nature, their competencies are typically attributed to swarm intelligence; perhaps the fine-recognised examples are colonies of social bugs consisting of termites, bees, and ants. In latest years, it has proved viable to discover, summary, and exploit the computational ideas underlying some sorts of swarmintelligence, and to installation them for medical and industrial functions. One of the fine-evolved strategies of this type is particle swarm optimisation (PSO) [1]. In PSOs, which can be stimulated by means of flocks of birds and shoals of fish, a number of easy entities, the debris, are located inside the parameter area of a few hassle or function, and every evaluates the fitness at its contemporary place. Each particle then determines its motion thru the parameter area by means of combining some issue of the records of its personal fitness values with those of one ormoremembers of the swarm, and then moving through the parameter space with a pace decided via the places and processed fitness values of these different contributors, along with some random perturbations. The participants of the swarm that a particle can interact with are known as its social neighbourhood. Together the social neighbourhoods of all debris form a PSOs social community. **Riccardo Poli,(2008) [3**] offered a hen's eye view of PSO programs. This has been acquired by means of figuring out and analysing around 700 PSO software works stored in IEEE Xplore database at the time of writing.

In wireless sensor networks, the use of energy efficient infrastructure inclusive of clustering can be used to prolong the community lifetime and save you community connectivity degradation. In such systems, the overall performance of the clustering scheme is typically prompted by means of the cluster head selection technique and the wide variety of clusters. **N. M. Abdul Latiff, (2008) [4]** presented a dynamic clustering method with multi-objectives that mechanically determines the most advantageous number of clusters inside the community. The set of rules, which is based totally on binary Particle Swarm Optimization (PSO), removes the need to set the number of clusters a priori. In addition, a multi-goal method is utilized inside the cluster head choice set of rules to be able to choose the first-rate set of cluster heads. Simulation outcomes exhibit that the proposed protocol can achieve an foremost quantity of clusters, in addition to lengthen the community lifetime and boom the information shipping at the bottom station when as compared to other well known clustering algorithms. In this paintings, we have proposed a dynamic clustering algorithm for WSNs the use of a binary multi-goal PSO algorithm.

Energy efficient communique is a plenary issue in Wireless Sensor Networks (WSNs). Contemporary power efficient optimization schemes are centered on decreasing electricity consumption in diverse aspects of hardware design, data processing, community protocols and operating machine. In **Manian Dhivya, (2011) [5]** work, optimization of community is formulated through Cuckoo Based Particle Approach (CBPA). Nodes are deployed randomly and prepared as static clusters by way of Cuckoo Search (CS). After the cluster heads are decided on, the statistics is gathered, aggregated and forwarded to the bottom station the usage of generalized particle approach algorithm. The Generalized Particle Model Algorithm (GPMA) transforms the community strength intake problem into dynamics and kinematics of numerous debris in a pressure-discipline. The proposed technique can substantially lengthen the community lifetime whilst as compared to standard methods. The cuckoo Based Particle Approach is advanced to reap energy green Wireless Sensor Network and multimodal goal features.

3. Methodology:

Our proposed algorithm is composed of two clustering and data transmission phases

3.1. 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.

3.2. Proposed Validation index As previously mentioned, the clustering is more desirable in which intra-cluster density is higher and in another word, the clusters are more cohesive and inter-cluster density is lower. Based on this principle, in the proposed method 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 composedoftwoparts,F1andF2:

$$validity = \max(F1 + F2) \quad (7)$$

Whatever the amount of the above criterion is greater clustering is better. eq.(8) denotes the F1 index and Figure 3 illustrates the cluster dispersion and density of nodes in each cluster:

$$F1 = \left(\frac{inter \times 2}{\sqrt{intra \times Z}}\right) \quad (8)$$

Inter: inter-cluster distance for which farther is better.
Intra: intra-cluster distance for which closer is better.

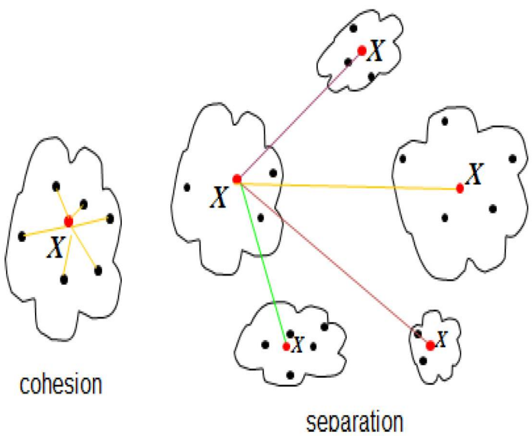

Fig 1. Performance of the proposed index

Eq. (9),(10) denotes the intra and inter cluster separation:

$$i_{ntra(c)} = \sum_{i=1}^{c} d\,\Sigma_{j=1(X_J - X_l)}^{N} \quad (9)$$

In Eq. (9) the total distance between nodes in each cluster and its cluster head ia calculated in which **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 following equation:

$$\text{Inter(c)} = \sum_{j}^{c} = 1(Xj - X) \quad (10)$$

To calculate the inter clusters separation ,the distance between the centers of the clusters and the center of total data set is calculated. For cluster range specified the amount of this index calculate and show in chart. In the conditions in which the slope of the curve is sharper the estimate of the number of clusters is more accurate. Then with local search around the slope the optimal number of clusters can be reached. Eq. (11) Explains how to calculate F2. F2= cluster heads degree+(residual energy62) / centrality + distance to base station (11) 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:

$$\text{centerality} = \frac{\sqrt{\frac{\Sigma dis^2}{100n}}}{100} \quad (12)$$

In which, $\sum d\,is^2$ 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. F2 associated per experimental cluster heads to obtain and then its totalfor12experimental cluster heads is summed. Using 2 coefficient for energy is due to that in discussion of election the rest energy of cluster heads than other parameters have more important and is more effective and for a reason we are considered double its coefficient. In F1 formula without use of value coefficient, F1 than F2 was too small and invalidity could not significant effect so, we used -morecoefficientsthatcouldbalancebetweenF1 andF2effect is created. .As can be seen in this experiment, 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.

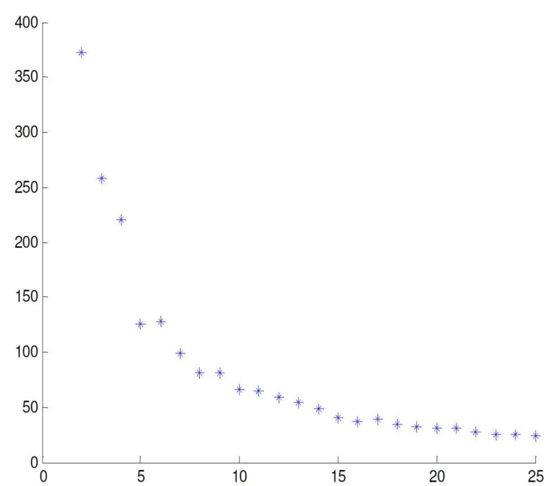

Fig 2: The proposed validity index when of the number of clusters change

3.3 Data transmission phase

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. Then the energy consumption of all nodes is computed.

4. Result and Discussion:

To evaluate the proposed approach and analyze its impact on the energy of the entire network, we have performed in MATLAB tool multiple simulations with various random node placements. Table 1 shows simulation parameters used in this work. A packet size of L = 2000 bits is used, 50 sensor nodes are randomly deployed in a network dimensions of 100m x 100m as shown in Fig. 3. The base station is placed at (x=50 m, y=-100 m) and 0.05 is the probability of a node to be a cluster head in the proposed approach. All nodes begin with a starting energy level of 0.5 J. This value is commonly used in the literature since it provides small enough energy to quickly see the effect of the suggested algorithm.

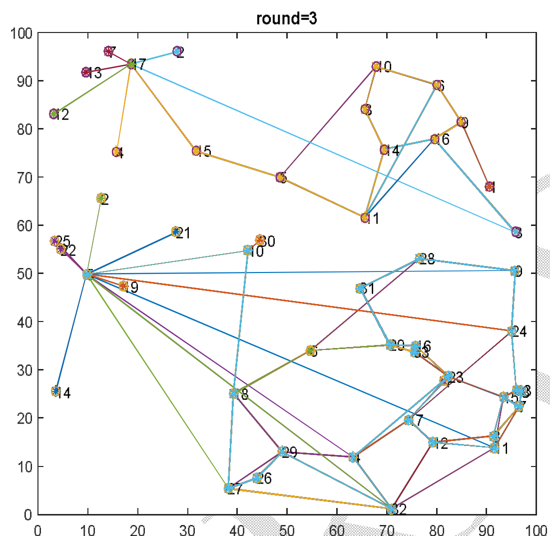

Fig. 3. Node distribution and routing in WSN

Table 1.Simultation parameters

Parameters	**Values**
Transmission and receiving energy	50nJ/bit
Energy amplification for free space	10pJ/bit/m^2
Energy amplification for multi path	0.0013pJ/bit/m^2
Nodes initial energy	0.5J
Data aggregate energy	5nJ/bit/message
Packet size	2000 bits
Percentage of CH	5%
Number of nodes	50
Network size	100m x 100m
Base station position	50mx -100m

The comparison we carried-out in this work between the proposed approach and MTE protocols is based on some key performance metrics such as: First Node Dies (FND), Half of Nodes Alive (HNA) and Last Node Dies (LND) and Energy Depletion Rate (EDR). Table II summarizes the results of these metrics (FND, HND and LND) for LEACH, MTE and our proposed approach.

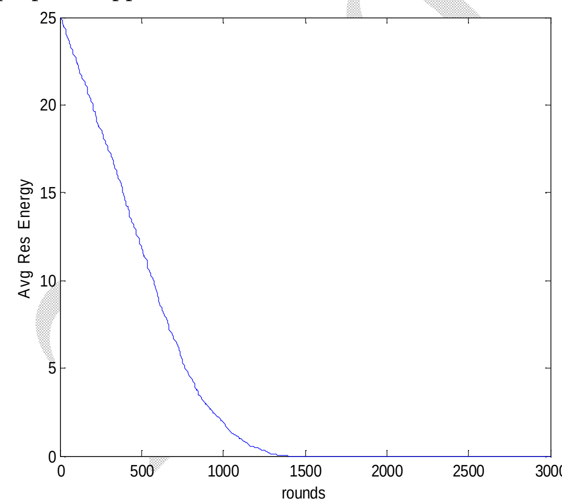

Fig. 4. Average Residual energy and Number of rounds.

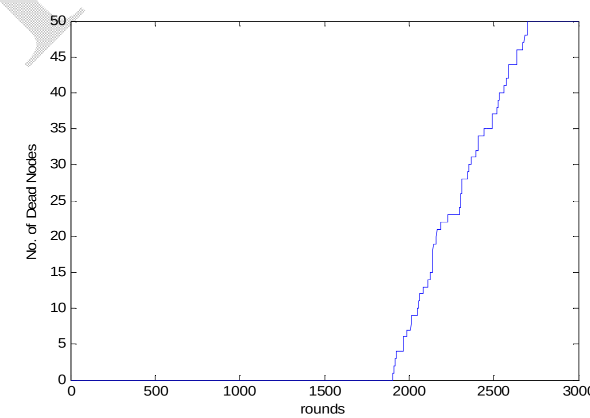

Fig. 5. Number of dead node and Number of rounds.

5. Conclusion:

In this work, we introduce a new approach for sensor network clustering using Particle Swarm Optimization (PSO) algorithm. The parameters which are used in the algorithm are residual energy, density, distance from the base station, intra-cluster distance and cluster heads distance from each other. 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 and improved network lifetime and energy consumption.

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