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Research Article

Energy Efficient Hierarchical Clustering Heuristic for Wireless ad hoc Network

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Abstract

The field of ad hoc networks has pulled significant interest in the research community in recent years. The capability of setting up an on demand self-organizing wireless network is attractive in many application scenarios such as disaster relief, temporary events, and battle-field situations. The objective of cluster analysis is the classification of objects according to resemblances among them, and organizing of data into groups. This paper discuss ideas and steps that are going to be applied to achieve energy efficiency in wireless ad hoc network cluster. Mobility is one of the key characteristics of mobile ad hoc networks. Maintaining connectivity and maximizing the network lifetime are the two issues and the areas of most importance. With the implementaton of clustering algorithm, routing and clustering overheads cost becomes very less. Our demonstation to energy conservation for adhoc routing is being done.

Keywords: *Keywords: Cluster, ClusterHead (CH), Hierarchical Cluster, Energy efficient clustering heuristic and wireless adhoc network*

Introduction

Cluster analysis techniques are concerned exploring data sets to access whether or not they can be summarized meaningfully in terms of objects which resemble each other and which are different in some respects from individuals in other clusters(Fig 1). Cluster heuristics are suitable for networks where nodes have different capabilites with respect to power, data rates, computing resources, or have different roles in an application scenario. Link expiration and frequent re-affilation are the most important parameters for a stable clustering heuristics. Ad hoc network can be categorized in to two types depending on the features of wireless devices: homogenous and hetrogenous. Without using any existing infrastructure or centralized administration a Wireless Ad-hoc Network consists of wireless mobile nodes that dynamically form a temporary communication network resulting in a rapidly changing network topology subject to swift changes to which it must react in order to continue effectively. This dynamic topology, varied/limited mobile node capability and limitations of link bandwidth for wireless adhoc network pose scalability problems that are not just a challenge but a threat to the success of widespread use of Wireless Ad-hoc Networks. A node consumes significantly less energy for information processing than for communication. This characteristic of a sensor node makes it important to concentrate more on reducing transmission of redundant data during the transfers of sensed information from each node to the sink. Power control is an practical method for energy efficiency among the existing approaches. In ad hoc networks because there is no infrastructure acting as co-ordination and connection may exist between any two different nodes in the network.

Hierarchical technique offers a better approach to energy minimization and scalability features as compared to other routing techniques. Clustering is mostly applicable for hetrogenous network as the nodes are of different radio capacity, battery energy and transmission rate. Clustering algorithms can be classified in to two categories: cluster head based and non cluster head based(Cai et al 2003). In (Hou & Tsai 2001) clusterhead based scheme outperforms the non clusterhead scheme in term of reducing traffic overhead for large scale adhoc network. In direct communication the Mobile Adhoc nodes directly transmit their sensing data to the destination without any coordination between the two. However, in Cluster- based WSNs, the network is divided into clusters. Each sensor node exchanges its information only with its cluster head (CH), which transmits the aggregated information to the BS. Aggregation and fusion of sensor node data at the CHs cause a significant reduction in the amount of data sent to the destination and so results in saving both energy and bandwidth resources. On the other hand, clustering is particularly crucial for scaling the network to hundreds or thousands of nodes .In many applications, cluster organization is a natural way to group

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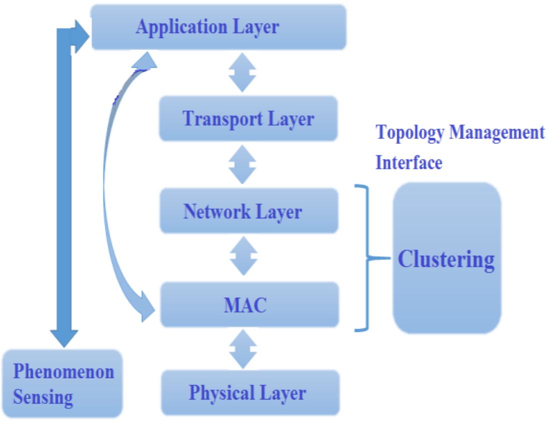
spatially close sensor nodes in order to exploit the correlation and eliminate the redundancy that often shows up in the sensor readings.



Cross Layer Design Approach for unified Clustering and Communication Protocol

In this paper, an attempt has been made to develop deterministic energy-efficient clustering protocol for various coverage area, packet length and nodes to analyse the performance of the network. The performance parameters such as number of rounds and energy dissipation are analysed. The deterministic energy-efficient clustering heuristic for wireless adhoc networks is discussed and their characteristics are also explained.

The purpose of forming cluster are to stablize the end to end comunication path and to improve the network stability. Cluster stability is defined to be the lifetime of the clusterheads and the membership time of cluster members. Due to mobility of nodes, cluster reformation frequently occours and affects both inter-cluster and intra-cluster route changes and reclustering overhead offset the benefit gained from the cluster by cluster path discovery.

There are researches related to clustering algorithm of non uniformly distibuted ad hoc networks (kawadia and Kumar 2003). General clustering discussions can be found in (Ramathandran, kapoor, sarkar & Agarwal 2002) and (chen , Liestman & liu 2004). Research shows that when the network scale becomes large , these protocols generate significant routing overhead and finally make the network performance unacceptable(Cano & Manzoni 2000, das , perkins & Royer 2000, Perkins & royer 1999). A simple and fast techniqe that uses the node unique identifier to determine which nodes to become clusterheads and other nodes become cluster members is LID.

Reclustering occours when either cluster member or clusterhead changes its location. A similar technique to LID where each node is asssigned a weight, highest weight node becomes the cluster is WCA. Reclustering occours when heavier weighted node enters in to the field of current cluster head. Weighted Clustering Algorithm (WCA) combines the node degree, transmission power, mobility, battery power and uses the weighted sum of these node status metrics to determine the cluster heads. The (α, t)–Cluster algorithm evaluates the intra- cluster reachability of the mobile nodes. Clusters are dynamically constructed to ensure path availability in each cluster. Other clustering algorithms consider communication cost and energy consumption use node contention to select cluster heads and bound cluster sizes. The cluster stability is not the design objective of these algorithms. Stable clusters will have the benefits of providing stable end-to-end communication paths and enabling good network scalability.

Theoretical Consideration

Cluster Definition

An ad hoc network is described by a node set $V = \{n_1, n_2, n_3, \ldots, n_N\}$ and a node connectivity set $E = \{e_{ij}\}$. The node set V gives all the nodes in the network and the connectivity set E denotes all the 1- hop links among the nodes in V. Clustering Partition $C = \{C_1, C_2 \ldots, C_K\}$ of the N nodes into K disjoint clusters, the connectivity is defined as

$$Conn(\mathfrak{C}) = \sum_{i=1}^{N}\sum_{j=1}^{L} x_{i,nn_{i(j)}}$$

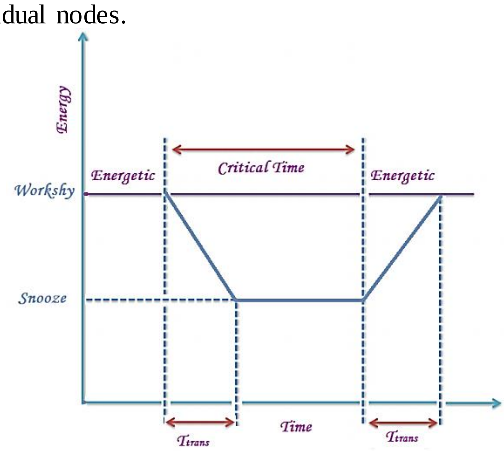
where L is a parameter giving the number of nearest neighbors to use. The connectivity has a value between zero and 1 and should be minimized.

We define a cluster to be a subset of $\Pi = \{\pi_1, \pi_2, \ldots, \pi_M\}$ be a set of M base clustering results, which is referred to as a cluster ensemble.

Proposed Work

Our algorithm takes the node mobility and energy into account, but differs from the generic weight-based schemes in that we have designed the specific indicator metric to quantitatively measure each node's suitability to become a cluster head rather than using the general concept to of weight.

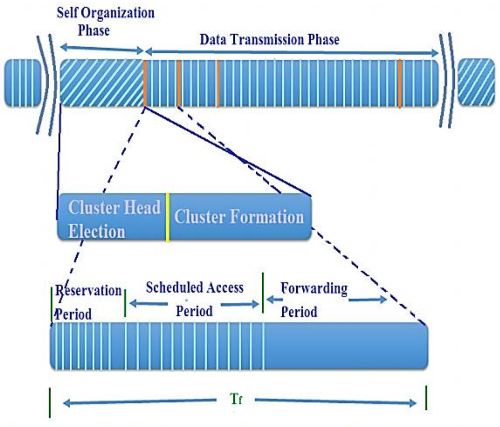
Energy consumption can be reduced by employing multi-hop communication for a specific cluster in Hierarchical mannner and thus performing aggregation of data and fusion in a way that decreases the number of data carried across the network. Reduction in energy consumption in data transmission is achieved since the ClusterHead is involved in transmission to the destination rather than individual nodes.



State Transition Diagram from WorkShy to Snooze Mode

In multi-hop broadcasting there is a limit for transmission because the highest amount of energy that can be wasted is the minimum transmission energy of neighbouring nodes. In multi-hop broadcasting, the data are required to be processed by each node along the multi-hop path, which creates delay in the formation of cluster. As mobility is the major cause for the network topology changes, the node mobility status takes the priority in our indicator metric and the node energy status plays the subsidiary role, which is different from the WCA where all the factors are mixed through using pre-assigned factor weights.

Cluster heads are saddled with the responsibility for data aggregation and performing routing for its cluster member's information to the base station. Also, the clusters that consist of many nodes have a higher burden than clusters with fewer nodes as the CHs for those large-sized clusters have to receive, aggregate and transmit more data. A CH can be elected randomly or pre-assigned by the designer of the network. A CH can also be elected by taking into consideration the residual energy of nodes in the cluster.



Organization of Unified Clustering and Communication Protocol

The CHs are known to have higher burdens than member nodes; therefore, the role of CH is rotated to share the burden and thus improving the useful lifetime of those clusters. The formation of a cluster is driven by cluster members, who search for available cluster heads and request membership in a cluster. Cluster members operate independently of other cluster members when searching for a ClusterHead.

Assumptions:

- All nodes are Homogenous in nature.
- All nodes start with same initial energy
- Each link is symmetric.
- Normal nodes transmit directly to there respective Cluster Heads within a partcular cluster
- ClusterHead use multi-hop routing to relay data to destination
- Every node has an ID or node address that identifies the node uniquely.
- Every node is able to estimate its energy lasting time based on its energy usage.
- Every node reports its status accurately when the nodes exchange information.

The initial energy $E_{ini}(n)$ of node is observed.

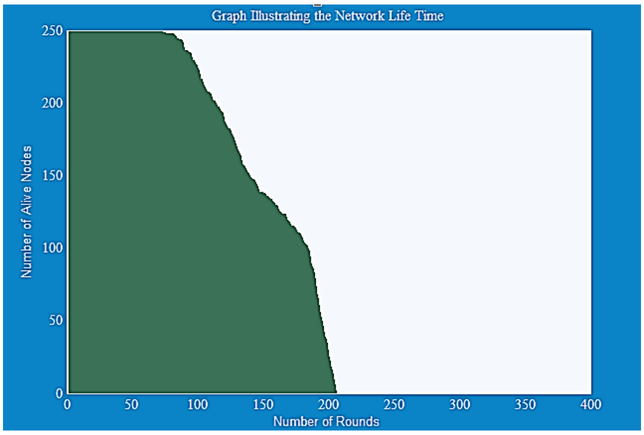
Distance d(n) from each node to the destination or to the corresponding higher level ClusterHead is measured.

Estimation of the energy required by each node for transmission within the cluster not to destination or to higher level ClusterHead for two and three cluster formation within a cluster is carried out using the formula: $(E_{amp}*k*d^2)$.

The maximum energy after the subsequent transmission round for each node is estimated and selection of ClusterHead is done using the formula: max $(E_{in}(n)-E_{amp}*k*d^2)$, then after the ClusterHead selection is carried out, the next cluster head selection will take place after the current round is completed.

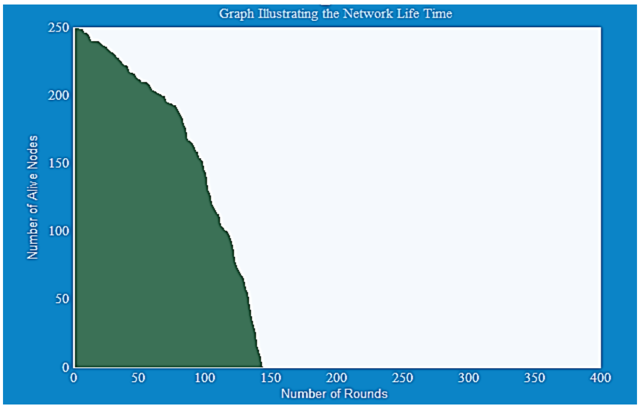
Experimental Consideration

Based on the prediction of transmission energy via shortest route to the destination, ClusterHeads are selected. the clusters are formed geographically into different sizes to see how it could effect the network lifetime as showen in fig.

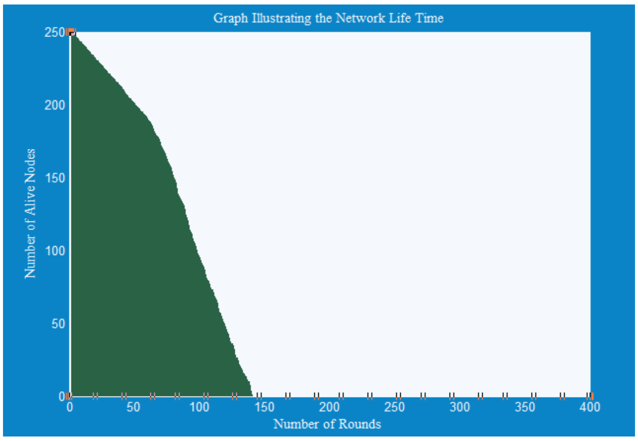


2-level-Hierarichal Cluster

In every round of simulation through prediction of transmission energy ClusterHead selection and optimization is performed. Role rotation of ClusterHeads and geographical formation of sensor nodes into cluster is also carried out.

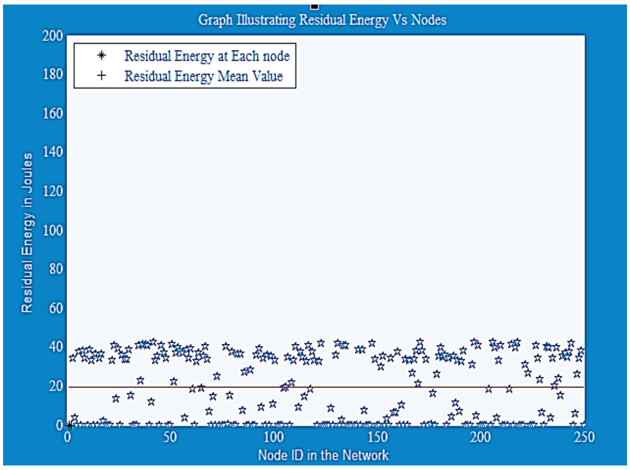


1-level-Hierarichal Cluster

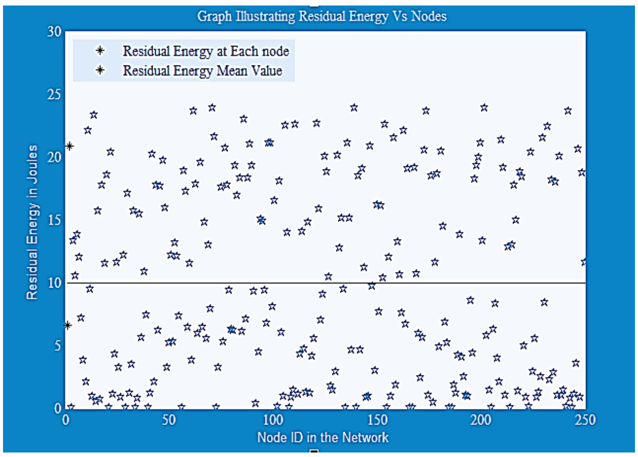


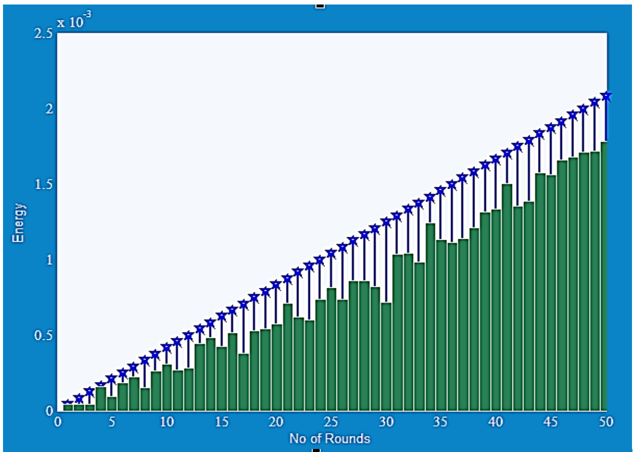
Non-Hierarichal Cluster

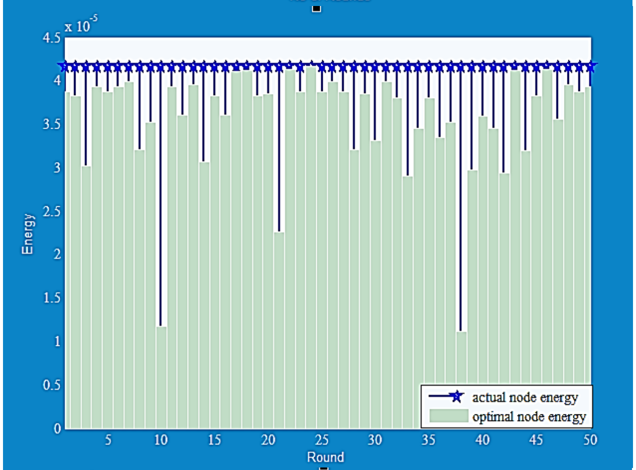
Data aggregation to the destination is done once this process is completed. Hierarichal technique, uses the predict of smallest transmission energy via the shortest route possible to send data to destination can increase the network lifetime. The emphasis of this technique transmitting data to destination that is carried out formally through salient important features like ClusterHead rotation, ClusterHead election and Cluster optimization.

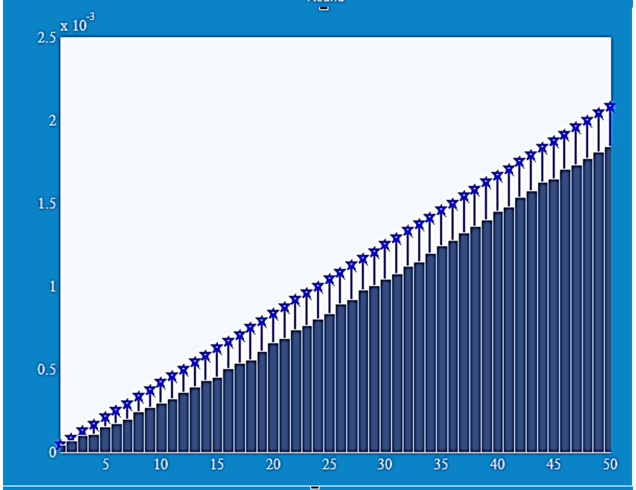


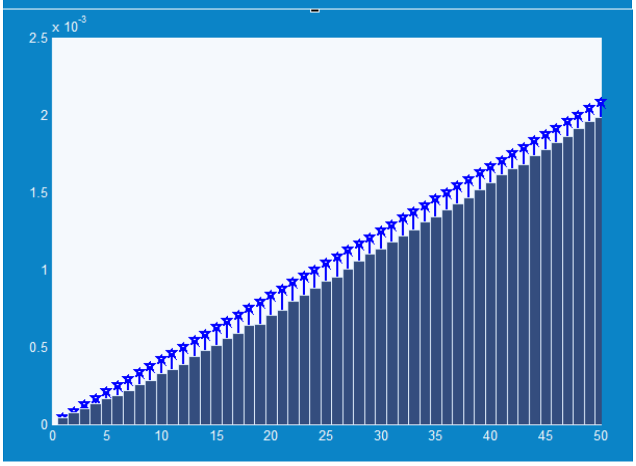
Energy efficiency of network can be further improved by using Hierarichal routing techniques.











Conclustion

First node dies faster in non-Hierarichal formation since all nodes tend to send captured data via one randomly selected ClusterHead per round. Results show that no of live nodes are more in Hierarichal structure compared non-Hierarichal structure. Mean residual energy ans variance of residual energy of the nodes increases as the level of Hierarichy increases upto an optimal level. This means that the nodes will remain active for a longer duration of in Hierarichal structure. The cluster will be more stable and lifetime of the network will be increase.

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