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A TRANSMISSION RANGE BASED CLUSTERING ALGORITHMFOR TOPOLOGY CONTROL MANET

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ABSTRACT

This paper presents a novel algorithm for clustering of nodes by transmission range based clustering (TRBC).This algorithm does topology management by the usage of coverage area of each node and power management based on mean transmission power within the context of wireless ad-hoc networks. By reducing the transmission range of the nodes, energy consumed by each node is decreased and topology is formed. A new algorithm is formulated that helps in reducing the system power consumption and prolonging the battery life of mobile nodes. Formation of cluster and selection of optimal cluster head and thus forming the optimal cluster taking weighted metrics like battery life, distance, position and mobility is done based on the factors such as node density, coverage area, contention index, required and current node degree of the nodes in the clusters.

KEYWORDS

transmission range, power optimization, Topology formation, adhoc networks

I. INTRODUCTION

Mobile ad hoc networks (MANETs) represent complex distributed systems that comprise wireless mobile nodes that can freely and dynamically self-organize into arbitrary and temporary, "ad-hoc" network topologies. This helps people and devices to seamlessly internetwork in areas with no pre-existing communication infrastructure, e.g., disaster recovery environments. Clustering has evolved as an important research topic in MANETs as it improves the system performance by reducing the battery power (expenditure of energy), by decreasing the cluster size increasing the link stability of large MANETs [S. Tang, et al,2006]. As MANETs have a limitation of battery power, cluster formation [S. Tang, et al,2006] is expensive in terms of power depletion of nodes. This is due to the large number of messages passed during the process of cluster formation. In this paper, we use the self-organizing principles for binding a node to a cluster [Agarwal,Motwani,2009]. The main motivation of this work is to reduce the ower based on predicted distance of one-hop nenergy consumption. First, HELLO packets are transmitted with maximum transmission power, P_{max}, at some time t_0. It contains the information about the node's current position, speed and deviation. As HELLO packet is received, each node computes

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the position and the distance of its neighbors for the future time instant $t_0 + \theta$. A node then selects an appropriate transmission power level through optimal power assignment algorithm.

After computing transmission power for its one-hop neighbors, it is embedded on the HELLO packet and transmitted. Through received one-hop neighbor information in the HELLO packet[Pandey ,Shukla,2009; Hu Xi,Wang Han-xing,Zhao Fei,2006] and its own list of computed power levels, a node can eventually decide the optimal power to get connected with all of its neighbors. If the neighbor's neighbor is also within its range and if the power required to reach the one is greater than from the existing neighbor, a transmission power [Gajurel, Malakooti, 2007] is further reduced for the nearest neighbor. In this way, optimal power is calculated for every time interval for the snapshot of the predicted topology.

II.RELATED WORK

This section reviews prior work on topology control using transmission power adjustment, beginning with centralized algorithms and then considering distributed approaches.

Centralized Algorithms: There are two centralized algorithms where the induced topology is 1-connected or 2 –connected that are connected either to only one node or both the nodes, and where the optimization criterion is MINMAX (i.e. minimize the maximum power utilized by any node) This work is generalized in to show that if the desired topology property is *monotone,* the optimization goal is MINMAX, the power assignments can be computed in polynomial time. A monotone property holds even when a node increases its transmission power and hence at any transmission power usage a node gets connected in a cluster.

Distributed Algorithms: In large and dynamic networks, centralized algorithms are not suitable due to the lack of responsiveness. The excessive amounts of information that need to be collected by a central node makes it les suitable. *Distributed* algorithms, *Local Information No Topology* (LINT) and *Local Information Link- State Topology* (LILT)[kashtani,Mouftaf,2005] rely on partial topology information collected by a routing protocol and adjust transmission powers to maintain the desired number of neighbors of each node. In particular, LINT relies on the neighborhood information that is obtainedbyprotocols[M.Nagaratna,Prasad,Raghavendra 2009], while LILT exploits some amount of global topology information collected when the network is operated with a link-state routing protocol. Although both protocols guarantee that the resulting network is k-connected, neither is able to guarantee strong connectivity [Mehmet Ali, Khabazian, 2006].

To select the optimum power level, the algorithm considers the smallest power level. One of the main interests to perform topology control is to guarantee the connectivity of the network graph. In order to guarantee network connectivity, topology management can be frequent. This is inherently related with the physical scenario and, more specifically, with the network dynamics. In the particular case of wireless sensor networks, nodes are often static [S. Tang, et al, 2006]. The expected connectivity can then be assured by adapting the nodes' transmitting ranges once at the beginning of the network operational time. Nevertheless, if nodes are mobile, the relative distances between nodes are likely to change over time, which requires continuous adaptation in order to avoid discontinuities. An inherent characteristic of wireless networks relies on the directionality of the associated graph [Hu Xi, Wang Han-xing, Zhao Fei, 2006]. Two mobile hosts or nodes in such a MANET can communicate directly with each other through a single-hop route in the shared wireless media if their positions are close enough.

The research in MANETs has attracted a lot of attention recently since MANETs play a critical role in situations where a wired infrastructure is neither available nor easy to install [S. Tang, et al, 2006] .Since host mobility causes frequent unpredictable topological changes, efforts have been devoted in particular to the design of clustering strategies to organize all the hosts in a MANET into a clustering architecture. This way, the transmission overheads for the update of routing tables after topological changes can be reduced [Agarwal, Motwani, 2009; Guo-Xing Jiang, Zhi-Ya Yang, 2008]. In fact, research has demonstrated that routing on top of clustering architectures is much more scalable than flat routing [Rajan, Chandra,Reddy,Hiremath,2008]. In addition, a clustering architecture can facilitate spatial reuse of resources to increase network capacity [Hu Xi, Wang Han-Xing, Zhao Fei,2006]. For example, under a non overlapping clustering architecture, two clusters may use the same frequency or code set if they are not adjacent. Furthermore, in a clustering architecture, when a mobile host changes its position, it is sufficient only for the hosts within its cluster to update their topology information, but not for all the hosts in this network.

III.CLUSTERHEAD ELECTION PROCEDURE

In this paper, we describe the cluster head election procedure by means of the weighted clustering algorithm [Tolba, Magoni, 2007; Yu-Xuan Wang, Forrest Sheng Bao, 2007] and the steps are as follows:

(i): Find the neighbors of each node v (i.e., nodes within its transmission range). This gives the *degree* dv of the node.

(ii): Compute the running average of the speed for every node. This gives a measure of mobility and is denoted by Mv.

(iii): For every node, compute the *sum of the distances* Pv = $\sum \sqrt{\left((x_2 - x_1)^2 + (y_2 - y_1)^2 \right)}$ with all its neighbors.

(iv): Compute the *degree-difference Dv*
for every node v, where d_v is the node degree of each node and M_v is mobility with which node moves randomly.

$$D_v = d_v - M_v \quad (1)$$

(v): Compute the time, Tv, of a node v during which it acts as a cluster head. Tv indicates how much battery power has been consumed since we assumed that consumption of battery power is more for a cluster head than for an ordinary node and it is generated randomly.

(vi): Calculate a combined weight

$$I_v = C_1 D_v + C_2 P_v + C_3 M_v + C_4 T_v \quad (2)$$

for each node v. The coefficients C_1,C_2,C_3,C_4 are the weighing factors for the corresponding system parameters.

(vii): Choose the node with a minimum Iv to be the cluster head. All the neighbors of the chosen cluster head can no longer participate in the election algorithm.

(viii): Repeat Steps 2 to 7 for the remaining nodes in a cluster.
Figure 1 depicts the formation of a cluster based on the weighted clustering algorithm where node 6 is elected as the cluster head.

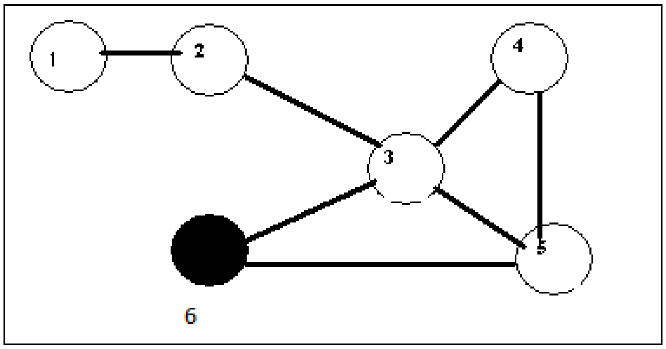

Figure1.ClusterFormation

IV.PROPOSED ALGORITHM

(TRBC-TRANSMISSION RANGE BASED CLUSTERING)

We propose our framework that is based on the two phases as given below.

A.PHASE I: IDENTIFYING THE TRANSMISSION RANGE

(i): By using weighted clustering algorithm (WCA) the election of cluster head is done among the incoming nodes.

(ii): Distances are calculated for the nodes that enter into the cluster.

(iii): The maximum distance of the nodes generated is taken as the radius for coverage area in the transmission range.

(iv): The distance(r) between each node with Cluster head are calculated.

(v): The desired transmission range is calculated based on the desired node degree and the current node degree where the nd_d equals contention index incremented by one.

$$nd_d = C.I + 1 \ , C.I = nodedensity * r$$

(vi): The transmission range is thus calculated by using the formula

$$Tr = \sqrt{((nd_d / nd_c) / \operatorname{cov} eragearea)}$$

Where nd_d is the desired node degree and nd_c is the current node degree, the coverage area equals the area covered by the cluster.

(vii): The distance of the nodes generated are compared with the average transmission range.If found, the transmission range of any node is not within the average transmission range, then the nodes are considered as out of range of the cluster and they are eliminated to get joined to any other cluster.

B.PHASE II: LINK STABILITY

(i): The stable paths are to be found based on selection of stable forwarding nodes that have high stability of link connectivity.

(ii): The link stability is computed by using the parameters such as received power, distance between neighboring nodes.

(iii): The proposed scheme is simulated over a large number of MANET nodes with wide range of mobility and the performance is evaluated.

(iv): The link stability is thus calculated by using the formula

$$L_s = R / D$$

Where R is the transmission range and D is the distance between the neighboring nodes

(v): Thus the link stability is found and based on which the height of connectivity can be a calculated among the clusters. Figure 2 and Figure 3 depict the formation of cluster head and cluster formation before and after the identification of the transmission range and link stability. Before the identification of transmission range the number of clusters formed is more when compared to number of clusters after the identification of transmission range. The reduction in the number of clusters leads to greater stability and battery power consumption is decreased. Thus the longevity of the cluster is increased. And the cluster head also selected optimally.

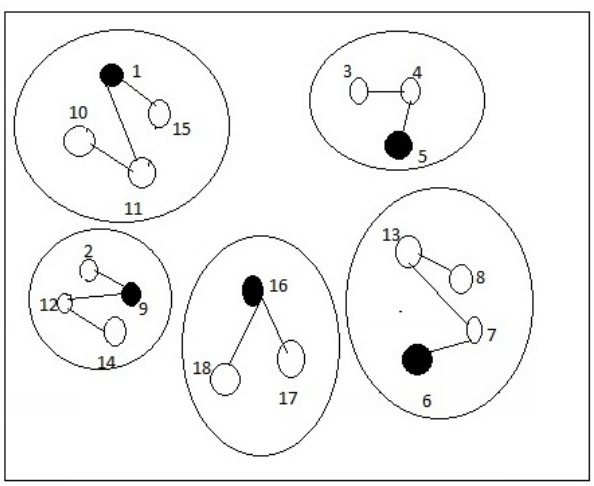

Figure 2: cluster formation before the identification of transmission range

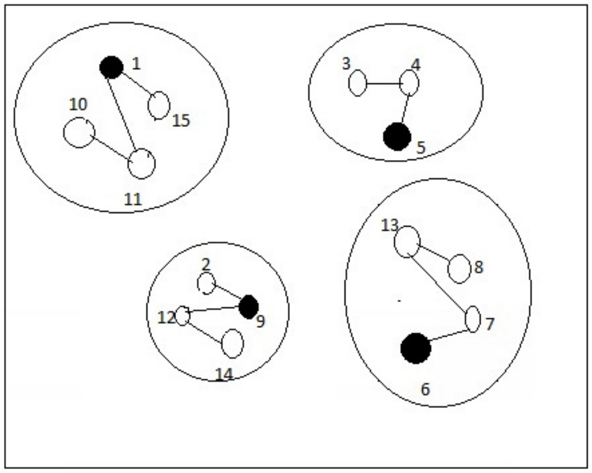

Figure 3: cluster formation after identification of transmission range

V.RESULTS AND ANALYSIS

The basis of our algorithm is weighted clustering algorithm as it maintains stable clustering structure, minimizes the overhead for the clustering set up and maintenance maximizes lifespan of mobile nodes in the system, and achieves good end-to-end performance. We have simulated a system of *N* nodes using MATLAB and NS2 simulator [Kurkowski, et al,2005] where nodes are taken as multiples of 10 as 10, 20,30…during the runtime. The nodes could move in all possible directions with displacement varying uniformly between 0 to a maximum value. To measure the performance of our algorithm TRBC, we identify two metrics: (i) the number of cluster heads, (ii) node degree and (iii) the transmission range of nodes. Every time a cluster head is identified, its transmission range gives the number of nodes in each cluster head. We also study how the transmission range factor changes as the system evolves and how well connected the nodes are in a cluster. Due to the importance of keeping the node degree as close to the ideal as possible, the weight $w1$ associated with mv was chosen high. The next higher weight $w2$ was given to Dv, which is the sum of distances. Mobility and battery power were given low weights.

The values used for simulation were$w1 = 0.7$, $w2 = 0.2$, $w3 = 0.05$ and $w4 = 0.05$. Note that these values are arbitrary at this time and should be adjusted according to the system requirements.
Figure4 depicts the average number of clusters formed with respect to the transmission range in the Ad-hoc networks. If the node density increased, TRBC produced clusters with high mobility in comparison with WCA regardless of node speed. As a result, our algorithm gave better performance in terms of the number of clusters when the node density and node mobility in the network is high.

Figure5 shows the results of end-to-end throughput of the average number of nodes formed with respect to the transmission range in the Ad-hoc networks. WCA gave lower throughput as the node density and mobility increased. Regardless of the number of nodes and the node speed, TRBC gives consistently better end-to-end throughput in comparison with WCA .

Figure6 shows the result of graph in NS2 simulator generated for 3 scenarios with number of nodes as 25,60,100 and for sending 300 packets,500 packets, 800 packets taking the throughput in the Y-axis and no. of packets sent in the X-axis. It can be seen that the throughput increases constantly with the no. of packets being sent. No. of packets are taken to be 10000,20000,30000,etc.and the corresponding throughput has also been recorded in terms of 10000,20000 etc. Results illustrated in Figure.5 and Fig 6 prove the results of distributed and dynamic clustering approach used in TRBC.

Results obtained from simulations proved that the proposed algorithm achieves the goals.

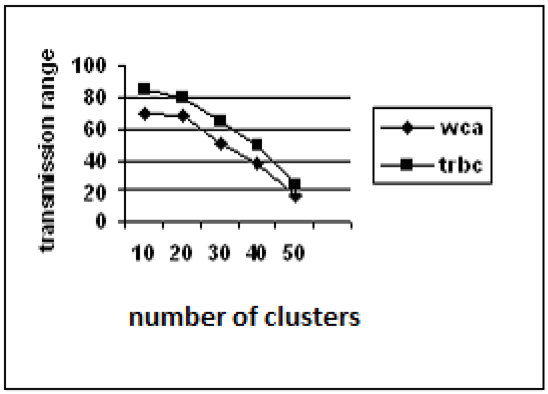

Figure 4: comparison of no. of clusters Vs transmission range

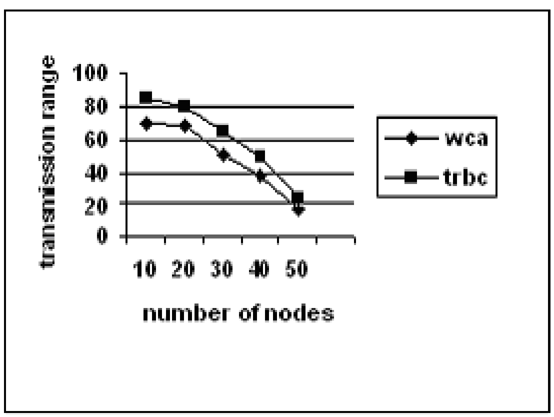

Figure 5: comparison of no .of nodes Vs transmission range
WCA (weighted clustering algorithm)
TRBC(TransmissionRangebasedClustering)

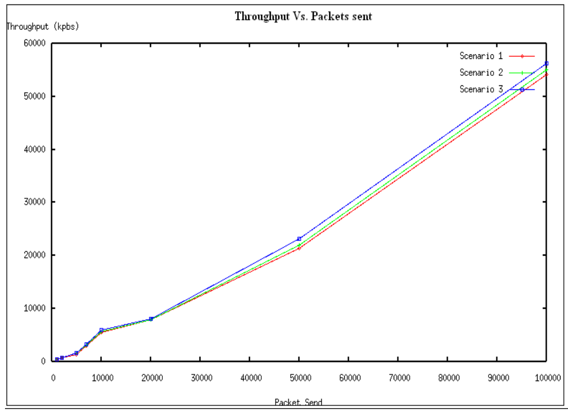

Figure 6:comparison of throughput Vs no. of packets sent

VI.CONCLUSION

Our algorithm TRBC reduces the number of clusters when compared with WCA.Hereby the load balancing factor gets optimized. And also the link stability gets increased. .It is evident from this that topology control in adhoc networks can conserve power usage by exploiting the spatial orientation of network nodes. However its crucial to address issues such as topology control, overheads when designing the algorithms.. In order for ad hoc networks to achieve widespread use, the adhoc networking community has been working on improving its scalability. By building and maintaining hierarchies among network devices, large-scale networks can scale up.

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