Throughput Enhancement using Cluster Based Approach in Wireless Ad-Hoc Networks

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Abstract

The multi-hop packet radio networks also named mobile ad-hoc networks(MANETs) have a dynamic topology due to the mobility of their nodes. A notable amount of energy is utilized every time a signal is sent and received by a mobile node. Many such signals and power are wasted to update the positional information of the nodes in the scenario. We propose a clustering technique for managing power in ad-hoc network. Cluster formation involves election of a mobile node as cluster head and it controls the other nodes in the newly formed cluster. This power management approach within cluster would help in reducing the system power consumption, improves Packet Delivery Ratio(PDR) and hence end-to-end network throughput can be enhanced. Simulation studies are carried out in order to achieve a better throughput performance and lower transmit power than a network without such a scheme.

Keywords- MANET ,clustering, cluster-head.

1. Introduction

Ad-hoc networks[7] are networks in which the member nodes are near to each other, but don't necessarily hold permanent connections with each other. The nodes functions both as router and host. Due to the limited transmission range, multiple hops may be needed for one node to exchange data with another across the network. A wireless ad-hoc network[8] is a decentralized wireless network, and is ad-hoc because each node is willing to forward data for other nodes, and so the determination of which nodes forward data is made dynamically based on the network connectivity. Mobile Ad-hoc Networks(MANETS)[9] 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[8] environments. 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 .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. Clustering has evolved as an important research topic in MANETS as it improves the system performance by reducing battery power(expenditure of energy). As power based concept is introduced in this paper it attempts to improve the end-to-end network throughput and the average power consumption..Higher powers cause a higher interference level, more collisions occur, and hence there will be more transmission attempts. By reducing the transmission power levels at each node such that the node can directly connect to only a small subset of nodes in the network, the interference zones are considerably reduced. However, under this proposition a packet has to be relayed by many intermediate nodes in order to reach the destination since there is a large number of transmissions, throughput may again degrade due to the increase in interference. Our cluster based approach attempts to dynamically reach a near optimal power level such that the network throughput is brought close to the maximum achievable throughput. The main advantage of our approach is less energy utilization and will also lead to improve end-to-end network throughput.

Various routing algorithms have been proposed for wireless ad-hoc network in the literature. Those algorithms are mainly focused on establishing routes, and maintaining those routes under frequent and unpredictable connectivity changes[2][3]. In earlier work[1]-[6], cluster concept is not used. If the nodes are highly mobile, the power management algorithm might fail to cope with the fast and sudden changes due to fading and interference conditions.

The rest of the paper is organizd as: Section 2 deals with literature survey, 3 with proposed scheme,4 with simulation results and section 5 concludes.

2.Literature Survey

We present below a survey of different power control protocols for throughput enhancement.

2.1. **A power Controlled Dual Channel (PCDC) MAC protocol.**

To produce power-efficient routes, PCDC[1] allows the MAC layer to indirectly influence the routing decision at the network layer by controlling the power level of the broadcasted RREQ packets. PCDC uses the signal strength of the overhead control request-to-send/clear-to-send(RTS/CTS) signal to build a power-efficient network topology. Simulation results showed that PCDC can improve the end-to-end throughput by over 45%..

2.2. **POWMAC**:

A Single-Channel Power control Protocol for Throughput Enhancement in Wireless Ad-Hoc Networks POWMAC[2] is based on a single transceiver circuitry, and it operates over a single channel for data and control packets. POWMAC adjusts the transmission powers of data packets to allow for some interference margin at the receiver. POWMAC uses an access window(AW) to allow for a series of (RTS/CTS) exchanges to take place before several concurrent data packet transmissions can commence. This protocol utilizes Transmission Power Control(TPC) to increase network throughput while preserving the collision avoidance property of the 802.11 scheme.

2.3. **Performance Analysis of Power Management Policies in Wireless Networks**

[3] Presents analytical model to characterize the energy performance trade-off of various power management policies in wireless networks. The main findings are, i)the “best” time-out driven power management policy exhibits a threshold structure depending on the traffic loads, and ii)the IEEE 802.11 PSM like polling-based power management policies are oblivious of the traffic characteristics and thus are not energy-efficient under light traffic load and suffer from significant performance degradation at higher traffic load(with both delay and energy consumption).

2.4 **An MAODV Based Energy Saving Multicast Routing Algorithm**

Most of the nodes in MANET use battery as its energy, it is necessary to improve on energy-saving method. Based on the MAODV[4] protocol, a new method called PPEF is introduced that uses both hops and energy consumption level of each node together for multicast routing. It brings the energy forecasting into the establishment of multicast tree and combines energy consumption and hops for path selection. The results shows that 10% less dead nodes in PPEF than MAODV. The lifetime and delivery rate in PPEF alo have good effect.

2.5 **Power-Aware Multiple Path Multicast AdHoc on Demand Distance Vector Routing Protocol**

Energy conservation is extremely challenging in multi-hop environments, where the mobile nodes should also consume energy to route packets for other nodes and to guarantee the connectivity of the network, a Power-Aware Multiple Path Multicast AdHoc on Demand Distance Vector Routing Protocol (PAMPMAODV)[5] is introduced. In order to utilize the battery effectively a different strategy has been proposed for route selection. The route selection has been designed to select multiple routes based on hop count, end-to-end delay and residual battery capacity.

2.6. **Power Control in Wireless Ad-hoc Networks for Energy Efficient Routing with Capacity Maximization**.

In wireless ad-hoc networks, constrained operation is very important due to the limited battery capacity[6]. One of the reasons for excessive energy expenditure in this network is irregularly distributed node patterns which impose large interference range on a certain area. In this protocol a simple and energy efficient on demand routing scheme by using discrete level of power control and priority based packet scheduling is

presented. This protocol can alleviate cumulative interference problem in dense area by reducing transmission power range and provides better way to deliver data than other routing protocols which use fixed transmission power.

We have reviewed several power management protocols which helps to know the main characteristics in wireless ad-hoc networks. With this survey we see that a notable amount of energy is utilized every time a signal is sent and received by a mobile node. Many such signals and power are wasted to update the positional information of the nodes in a wireless scenario. To minimize this utilization, clustering algorithm is proposed.

3. Proposed Clustering Scheme

In a cluster[4], objects are mutually closer to each other than to objects in other clusters. The cluster structure need to be maintained as the new mobile nodes may enter the network and the existing nodes may move out or lose their battery power[5].It occurs in the case of both cluster-heads and member nodes. The Highest-Degree Algorithm, also known as connectivity-based algorithm[6][7] is used. The algorithm is based on the degree of nodes assumed to be the number of s of a given node. Whenever the election procedure is needed nodes broadcast their identifier(ID) which is assumed to be unique in the same network. According to the number of received IDs every node computes its degree and the one having the maximum degree becomes cluster-head(CH).

3.1. Cluster formation

Initially, each node broadcasts beacon message to notify its presence to the s. A beacon message contains the state of the node. Each node builds its list based on the beacon messages received. The cluster-head election is based on the degree and energy of the nodes. The degree of a node is computed based on its distance from others. Each node broadcasts its id to the nodes that are within its transmission range. The node with maximum number of s (i.e., maximum degree) is chosen as a cluster head. The s of a cluster head become members of that cluster and can no longer participate in the election process. Since no cluster heads are directly linked, only one cluster head is allowed per cluster. Any two nodes in a cluster are at most two hops away since the cluster-head is directly linked to each of its s in the cluster. Basically, each node either becomes a cluster-head or remains an ordinary node.

Clustering Algorithm For A Particular Node Named 'V'

ACTION 1:

Broadcast a beacon signal to all its neighbour nodes in the transmission range;

Process the beacon signals received from the neighbour nodes in the network and form the connection matrix, A

ACTION 2:

Calculate degree of node V

ACTION 3:

Broadcast node degree(dv) to all its neighbour nodes;

Process the signals received from the neighbour nodes in the network

ACTION 4:

Find the node with highest degree in the neighbourhood;
If (dv is the highest degree)
Declare itself as the Cluster-head;
Else
Send request to join the Cluster
formed by the neighbour with highest degree

Fig3.1 depicts the formation of a cluster based on the connectivity-based clustering algorithm where node which is darkened is elected as the cluster- head.

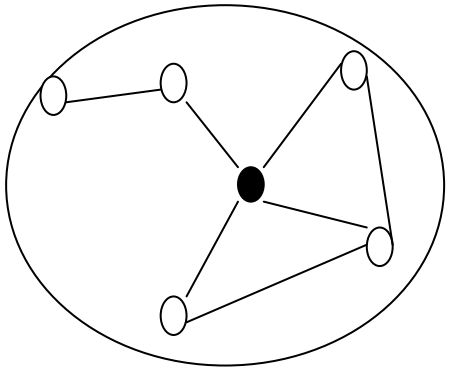

Figure3.1: Cluster Formation

3.2. Cluster maintenance

There are defined two distinct types of operations for cluster maintenance: the battery power [6] threshold property and the node movement to the outside of its cluster boundary.

3.2.1. Node Movements

The node movements can be in the form of node joining or node leaving a cluster. These operations will have only local effects on the clustered topology if the moving node is a CM node. If the leaving node is CH node, the cluster reorganization has to be performed for the nodes in the cluster by evoking the clustering algorithm. The power management based routing is recommended for networks characterized by low mobility patterns, namely pedestrians. The position of each node is updated periodically, every certain number of seconds.The new position is determined using the current position coordinates, the speed of the mobile node, and the direction of motion.

3.2.2. Battery Power Threshold

The battery power of the nodes participating in the Clustering changes continuously. The Cluster-Heads Power [6] decreases more rapidly when compared to the Cluster members. When the Cluster-Heads Battery Power falls below a threshold then the node is no longer able to perform its activates and a New Head from the members available need to be chosen.

Cluster-Head

ACTION:
Verify the threshold on the Cluster -Head's Battery power;
If (Battery power < Threshold)
Cluster-Head sends a
LIFE_DOWN message to all its Neighbours;
All the Member nodes participate
in the Re-Election Procedure
using
Clustering Algorithm and the
Node with highest degree is
selected as the New Cluster-Head;
Else
Re-election is not needed;

End-to-End Network Throughput :Percentage of packets that reach their destinations successfully and is given by

Throughput=11200000*pdr

Packet Delivery Ratio(pdr)=No.of packets delivered /No.of packets sent.

Control Overhead= No.of packets delivered /No.of control packets sent.

Delay= Time between data packets received by the routing level at destination.

4. Results and Analysis

The basis of our algorithm is connectivity-based algorithm as it maintains stable clustering structure and maximizes lifetime of mobile nodes in the system,and achieves good end-to-end throughput. We have simulated a system of N nodes using OMNeT++ simulator. To measure the performance of our algorithm, we identify the following metrics:(i)the no. 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 no. of nodes in each cluster head.

Fig4.1 shows the results of end-to-end throughput with respect to the no. of nodes in the ad-hoc networks.Power management without cluster concept gave lower throughput as that of power management with cluster concept.

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

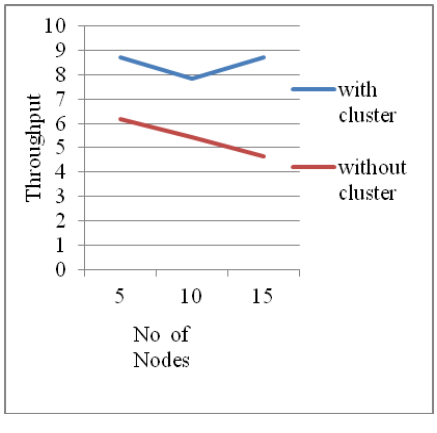

Fig 4.1: End-to-End Network Throughput

Fig 4.2 shows that Packet Delivery Ratio(pdr) increases as no. of nodes increases pdr is greater in system with the cluster as compared to system without cluster.

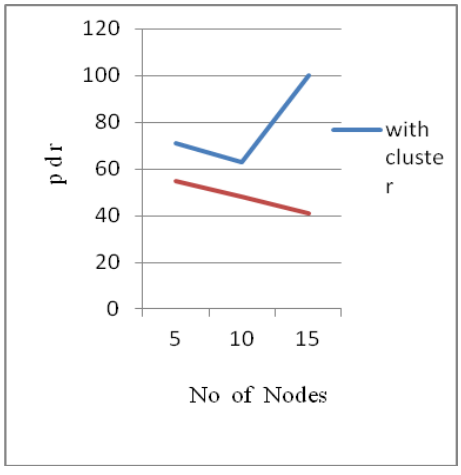

Fig 4.2: Packet Delivery Ratio

Fig 4.3 shows that latency decreases as no. of nodes increases latency is low in system with the cluster as compared to system without cluster

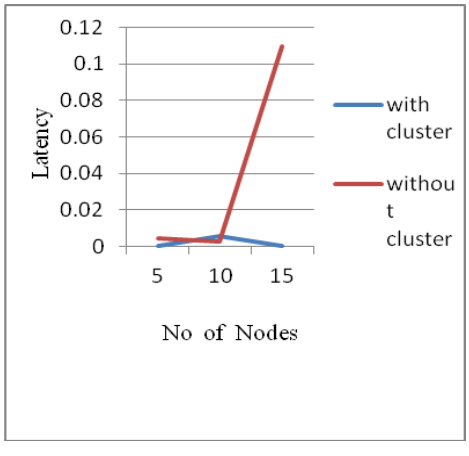

Fig 4.3: Latency Measured

5. CONCLUSION

In this paper a cluster based concept is introduced in wireless ad-hoc network, and compared its performance with the system without cluster formation. Within its cluster the power might wish to adapt to communicate with different nodes. The former scheme performs better in terms of achieving higher end-to-end network throughput. Simulations further show a network with a power management with cluster implemented will have better performance than a network without such a scheme.

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