

A Loose Virtual Clustering algorithm for efficient routing of MANETs

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ABSTRACT: Mobile ad hoc networks (MANETs) exhibit heterogeneity in the power levels. MANETs can improve network scalability, connectivity using high power nodes but, the throughput of power heterogeneous MANET is affected by these nodes. To overcome this problem, a loose-virtual-clustering-based (LVC) routing protocol for power heterogeneous (LRPH) MANETs is proposed. The algorithm aims at creating bi-directional links by exploiting the advantages of high-power nodes. In order to decrease the interference raised by high-power nodes, routing algorithms are developed to avoid packet forwarding via high-power nodes. We demonstrate the system implementation and experimental results through simulations.

KEYWORDS: Mobile ad hoc networks (MANETs), power varied nodes, virtual clustering, routing.

I. INTRODUCTION

Mobile ad hoc network (MANET) is a self-configuring, infrastructureless network of mobile devices connected by wireless and can change locations as shown in fig 1.1. Nodes in MANET can communicate with each other and can move anywhere without restriction. Mobility is not restricted and characteristics of MANETs are easily deployable, so they are very popular and suitable for emergencies, natural disaster and military operations. Movable network consists of devices with different characteristics in terms of transmission power, means it's an ability of lower power nodes to receive transmissions from higher power nodes but reverse is not true. A cross layer framework offers a simple and effective approach for media access control and supports routing in power varied ad hoc networks. By this the overall throughput of the power varied network is improved by 25 % over traditional layered approaches [1].

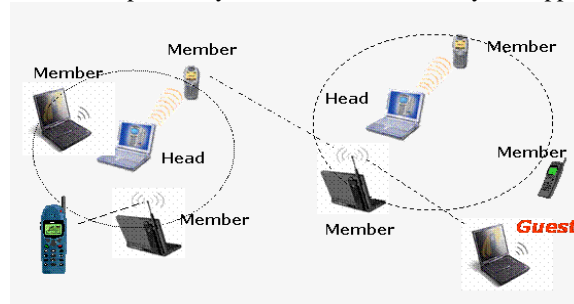


Fig. 1.1 MANET Architecture

The benefits of high-power nodes are the expansion of network coverage and also have advantages in power and data transmission rate. So, researchers have made efforts to examine these advantages, like backbone construction i.e., virtual backbone is constructed in a distributed and localized fashion while considering many incompatible objectives like fast convergence, and low computation cost [2]. Topology control helps in conserving the energy by either reducing transmission power per node or preserving energy-efficient routes for the entire network [3]. But, the large transmission range of high power nodes leads to large interference, which reduces the spatial utilization of network channel resources. Because of different transmission power, unidirectional links will occur in MANETs. Hence our aim is to replace unidirectional links with bidirectional links.



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Vol. 2, Issue 4, April 2014

Many routing protocols in power varied MANETs are designed only to find the unidirectional links and to avoid the transmissions based on these links without making use of the benefits of high-power nodes. The routing performance of power heterogeneous MANETs should be improved by considering the advantages and neglecting the disadvantages of high-power nodes. Hence, in this paper we proposed a loose-clustering-based (LVC) routing protocol for power varied MANETs, i.e., LRP which achieves better throughput. We build LVC to detect unidirectional links by making use of the benefits of high-power nodes. Clustering is a scheme to improve the performance of the network. In order to achieve optimized clustering, a hierarchical cooperation scheme is used. The number of hierarchical stages and the related cluster sizes which maximize the total throughput is chosen. This scheme is applied for random networks by developing clustering algorithm in which the entire network is divided into quadrilateral clusters, each with equal number of nodes [7]. In the existing clustering schemes, each node in the network plays a certain role as cluster head, member, or gateway. Due to cluster formation, a hierarchical routing is done in which routes are recorded between clusters instead of between nodes. So, there is an increase in route lifetime, thus decreasing the amount of routing control overhead [8]. In our clustering scheme, a loose coupling relationship is established between nodes because the cost of cluster construction and maintenance decreases. High-power nodes are used for cluster formation but they are avoided for packet forwarding to reduce interference.

II. RELATED WORK

In [9] author used the comprehensive summary of the routing protocols for MANETs in which the nodes are mobile, the network topology changes rapidly, affecting the availability of routing paths. So, important challenge in the design of algorithms for a mobile ad hoc network is that its topology is dynamic. Comparison of the performance of the following routing protocols AODV, CBRP, DSR, and DSDV are studied and compared based on mobility, load and size of the ad hoc network and the results shows that, CBRP has a higher overhead than DSR because of its periodic hello messages while AODV's end-to-end packet delay is the shortest when compared to DSR and CBRP [10]. Examples of routing protocols for heterogeneous MANETs are MC (Multiclass) which is a position aided routing protocol for power varied MANETs. MC routing utilizes the more powerful nodes as backbone nodes. The routing area is divided into many small, equal-sized cells and a B-node is maintained in each cell. Most of the routing activities (packet forwarding) are among B-nodes so, there is reduction in routing hop count and makes the routing more efficient and reliable, since B-nodes have large transmission range, and are more reliable. Then, a new MAC protocol, i.e. hybrid MAC (HMAC), is designed to cooperate with the routing layer. Based on the cell structure and HMAC, MC achieves better performance [4]. Hierarchical optimized link state routing (HOLSR) is a routing protocol for large-scale heterogeneous networks and is defined as a network of movable nodes that are characterized by different communication capabilities like multiple radio interfaces. It is proposed to improve the scalability of OLSR and helps in reduction of routing control overhead in large heterogeneous ad hoc networks [5]. In [6] author used Device-Energy-Load Aware Relaying framework (DELAR) that focuses on energy conservation in heterogeneous MANETs consisting of powerful nodes and normal nodes. It achieves energy conservation from power-aware routing, transmission scheduling and power control. Our approach makes use of loose coupling relationship between nodes in cluster which is better than previous existing approaches.

III. PROPOSED ALGORITHM

We consider two types of nodes in the networks: B-nodes with high power nodes and a large transmission range. G-nodes - low power with small transmission range. The number of B-nodes (Backbone nodes) and G-nodes (General nodes) are denoted as N_B and N_G , respectively and their transmission ranges as R_B and R_G , respectively. The state of G-nodes in the network is defined as $G_{isolated}$ - G-node that is not covered by any B-node. G_{member} - G-node whose bidirectional neighbours (BNs) are covered by its cluster head. $G_{gateway}$ - G-node whose BNs are not covered by its cluster head.

Abbreviation:

- LVC: Loose Virtual Clustering
- LRP: Loose-virtual-clustering-based Routing protocol for Power Heterogeneous
- BND: Bidirectional Neighbor Discovery
- AN: Aware Neighbor
- LAT: Local Aware Topology
- GLI: G-node LVC Initialization

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(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 4, April 2014

- BLI: B-node LVC Initialization
- TTL: Time to Live
- CMR: Cluster Member Register
- CHD: Cluster Head Declare
- LR and GR: Local Routing and Global Routing
- RREQ: Route Request
- RREP: Route Request Replay
- RERR: Route Error
- DSR: Dynamic Source Routing
- MC: Multiclass

A. LVC Algorithm

1) *BND*: Unidirectional links are eliminated by discovering bidirectional links as shown in fig 3.a.1. *BND* packet consists of its own information ex: ID, type, state and the information on its discovered neighbors.

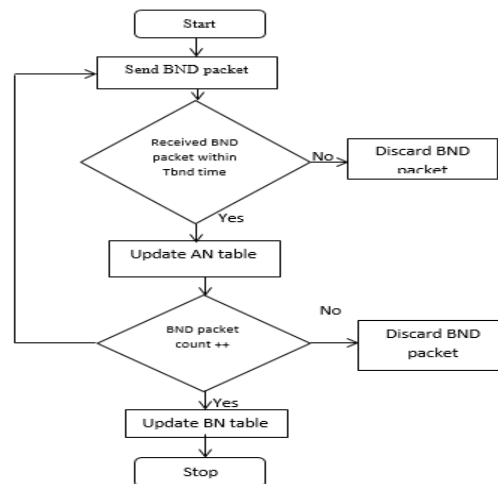


Fig 3.a.1. Flowchart for Bidirectional neighbour discovery

2) *LVC*:

To derive benefits of B-node, LVC algorithm is designed. B-node is chosen as a cluster head to establish a loose coupling relationship with G-nodes. G-nodes (Gmember or Ggateway) which are covered by B-nodes will participate in cluster formation. LVC has two features: i) avoidance of overhead which is caused by reconstruction and maintenance of the cluster when the B-node count is small. ii) Even though all G-nodes are in the Gisolated state, LRPH protocol is adaptive to the high number of B-nodes. By exchanging control packets, all nodes build a local aware topology (LAT) table which stores a local topology information based on discovered bidirectional links. Construction of LVC is as shown in fig 3.a.2

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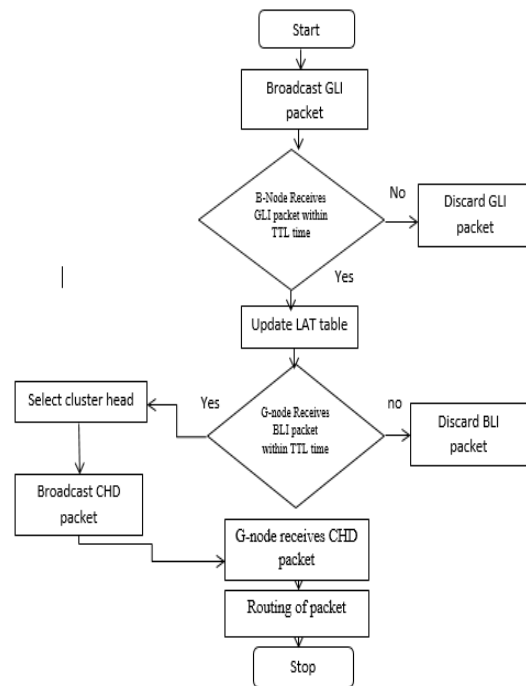


Fig 3.a.2 . Flowchart for building up of LVC

Received CMR packets and CHD packets are used to build LAT by all B-node, and all G-nodes respily.

3) LVC Maintenance:

It is activated when the links between nodes fail, particularly when node n_i detects any of the following conditions based on the periodical BND packets.

- If node n_i does not receive the BND packet from node n_j in the AN table within a specified time, n_j should be out of its coverage range.
- If node n_i receives the BND packet from node n_j and node n_j is not in the AN table, a new link between n_i and n_j should be added.

LVC maintain by G-nodes:

Step1: G-node n_i updates its node state, AN and BN tables.

Step 2: • If n_j is the cluster head of n_i , a new cluster head is acquired. Initially, n_i calculates the path to the old cluster head conforming with LAT and then updates the topology information related to n_j in LAT. Then, new cluster head is selected by n_i . At last, n_i multicasts CMR packets to both the new and old cluster heads n_j . Now node n_i registers to the new cluster head and notifies the old cluster that n_i is out of the transmission range of n_j .

- If n_j is a B-node but not the cluster head of n_i , n_i leaves the coverage range of B-node n_j , and n_i updates the topology information on n_j in LAT.

- If n_j is G-node and in the BN table, the bidirectional link fails. G-member or G-gateway nodes send the BN update (BNU) packet to the cluster head for updating the BNs.

Step 3: After receiving CMR packets, B-node broadcasts CHD packets. If the cluster head receives BNU packets, it broadcasts BNU packets again in one hop. The G-node updates the cluster and LAT information in conformance with received packets.

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 4, April 2014

LVC maintain by B-nodes:

Step 1: B-node n_i updates LAT, AN and BN tables.

Step 2: If n_j is in the BN table of n_i , n_i broadcasts BNU packets in one hop to update the LAT tables of all nodes within its coverage range.

4) Cluster Head Selection:

The number of B-nodes in the AN table maintained at any G-node g_i is denoted by N . The cluster head of g_i is found as shown in fig 3.a.4

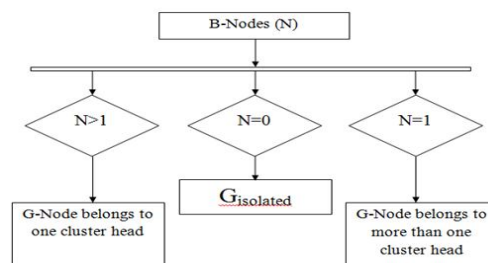


Fig 3.a.4. Cluster head selection

B. Routing Components in LRP: It includes route discovery and route maintenance.

1) Route Discovery Procedure: If a source node S needs to send a data packet to destination node D , S first searches the path to D in its route memory, if S directly sends the data packet else it activates the route discovery procedure to discover a route to D as shown in fig 3.b.1. This procedure consists of the local routing (LR) and global routing (GR) components.

LR: The route to D will be directly obtained, if D is in the LAT table.

GR: If D is not in the LAT table, S broadcasts a route request (RREQ) packet to discover the source route to D , after receiving the complete route to D , it replies with a route reply (RREP) packet to S . When S receives the RREP packet, it inserts the new route into its route cache and sends data packets.

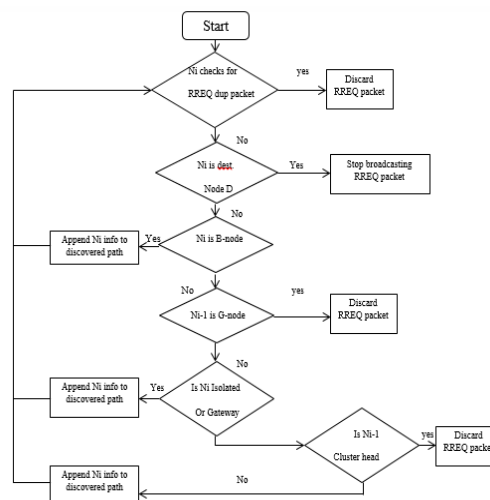


Fig 3.b.1 Flowchart for forwarding of RREQ packet



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Vol. 2, Issue 4, April 2014

Now a node obtains a complete source route to D , it replies with a RREP packet to S directly. Because the RREP packet is delivered using unicast, the bidirectional links will be used. If packets are forwarded through B-nodes, throughput of a network will be decreased, so we exclude B-nodes in the path by replacing B-nodes with multihop G-nodes. But this scheme increases route hops and finally network throughput can be improved. A timer is set and if expires, drop the packet. If the route discovery fails for many times, data transmission will be cancelled.

2) *Route Maintenance Procedure*: Whenever a link failure occurs and is detected by middle node through the BN table, the route maintenance is activated. A route error (RERR) packet is created and sent to the source node along the reverse route. When any middle node (including the source node) along the route receives the RERR packet, the route with the broken link will be removed from the routing memory. When the source node receives the RERR packet, a next round of route discovery procedure is activated. Expected results include three parameters - packet throughput, less packet delay and more packet delivery ratio and can be evaluated as shown in table 2.1, 2.2, 2.3.

Table 2.1 Comparison of LRPH throughput

Throughput increases	When Rb of B-nodes increases		
	LRPH-B	MC	DSR
LRPH	25%	10%	55%

Table 2.2 Comparison of LRPH delay

Delay decreases	When Rb of B-nodes is 1000m		
	LRPH-B	MC	DSR
LRPH	35%	30%	65%

Table 2.3 Comparison of LRPH Packet delivery ratio

PDR increases by	When Rb of B-nodes is 1000m		
	LRPH-B	MC	DSR
LRPH	25%	20%	45%

IV. CONCLUSION

Development of LVC-based routing protocol named LRPH for power heterogeneous MANETs, improves the network throughput largely. We designed an LVC algorithm to eliminate unidirectional links and to benefit from high-power nodes in transmission range and reliability. We developed routing schemes to optimize packet forwarding by avoiding data packet forwarding through high-power nodes.

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BIOGRAPHY



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