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An Effective Cluster-Based Routing With Link Quality For Power Varied Manets

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ABSTRACT: The fast paced progress in the Mobile Ad Hoc Networks (MANETs) has enabled the use of a number of wireless applications on the move. These MANETs exhibit heterogeneity in the power levels. In such a heterogeneous network, different devices are likely to have different capacities and are thus likely to transmit data with different power levels. With high-power nodes, MANETs can improve network scalability, connectivity, and broadcasting robustness. However, the throughput of power heterogeneous MANETs can be severely impacted by high-power nodes. In this paper, we develop a loose-virtual-clustering-based (LVC) routing protocol for power heterogeneous MANETs, i.e., LRPH. To explore the advantages of high-power nodes, we develop an LVC algorithm to construct a hierarchical network and to eliminate unidirectional links. To reduce the interference raised by high-power nodes, we develop routing algorithms to avoid packet forwarding via high-power nodes. We demonstrate the system implementation and experimental results through simulations in Network Simulator [ns2].

KEYWORDS: Clustering, mobile ad hoc networks (MANETs), power heterogeneous, routing.

I. INTRODUCTION

Mobile ad hoc networks (MANETs) are collection of mobile nodes that intercommunicate on shared wireless channels. The topology of the network changes with time due to mobility of nodes. Nodes may also enter or leave the network. These nodes have routing capabilities which allow them to create multi hop paths connecting nodes which are not within radio range. The routing protocols can be roughly divided into three categories: proactive (table driven routing protocols), reactive (on-demand routing protocols), and hybrid. The primary goal of such an ad hoc network routing protocol is to provide correct and efficient route establishment between pair of nodes so that messages may be delivered in time.

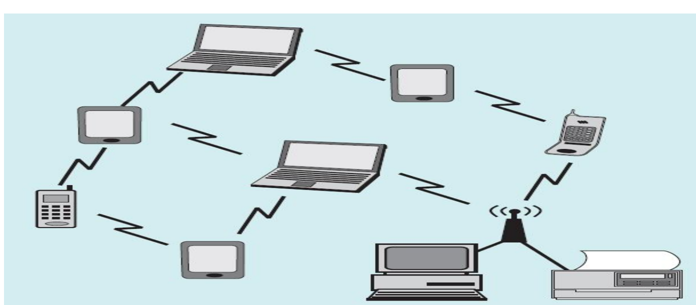

Fig. 1 a MANET example

In 802.11-based power heterogeneous MANETs, mobile nodes have different transmission power, and power heterogeneity becomes a double-edged sword. On one hand, the benefits of high-power nodes are the expansion of network coverage area and the reduction in the transmission delay. However, the existing routing protocols in power heterogeneous MANETs are

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only designed to detect the unidirectional links and to avoid the transmissions based on asymmetric links without considering the benefits from high-power nodes. Hence, the problem is how to improve the routing performance of power heterogeneous MANETs by efficiently exploiting the advantages and avoiding the disadvantages of high-power nodes, which is the focus of this paper.

However, in the existing clustering schemes, each node in the network should play a certain role (e.g., cluster head, member, or gateway) [20]. We define this as a strong coupling cluster. In a strong coupling cluster, the cost of constructing and maintaining a cluster may significantly increase and affect the network performance. In our clustering, a loose coupling relationship is established between nodes. Based on the LVC, LRPH is adaptive to the density of high-power nodes. Recall that high-power nodes with a larger transmission range will create large interference areas and low channel spatial utilization. In such case, we developed routing algorithms to avoid packet forwarding via high-power nodes.

II. RELATED WORK

Existing routing protocols in power heterogeneous MANETs are only designed to detect the unidirectional links and to avoid the transmissions based on asymmetric links without considering the benefits from high-power nodes. Our evaluations are based on three transmit power assignment models that reflect some realistic network scenarios with unidirectional links. Our results indicate that the marginal benefit of using a high-overhead routing protocol to utilize unidirectional links is questionable. We study the performance of three techniques for AODV for efficient operation in presence of unidirectional links, viz., Black Listing, Hello, and Reverse Path Search. While Black Listing and Hello techniques explicitly eliminate unidirectional links, the Reverse Path Search technique exploits the greater network connectivity offered by the existence of multiple paths between nodes.

The large transmission range of high power nodes leads to large interference, which further reduces the spatial utilization of network channel resources. Because of different transmission power and other factors (e.g., interference, barrier, and noise), asymmetric or unidirectional links will exist in MANETs. Existing research results show that routing protocols over unidirectional links perform poorly in multihop wireless networks. However, the existing routing protocols in power heterogeneous MANETs are only designed to detect the unidirectional links and to avoid the transmissions based on asymmetric links without considering the benefits from high-power nodes.

III. SYSTEM MODEL

A. Network Model

There are two types of nodes B nodes and general nodes (G-nodes). B-nodes refer to the nodes with high power and a large transmission range. G-nodes refer to the nodes with low power and a small transmission range. The numbers of B-nodes and G-nodes are denoted as N B and N G , respectively. Because of the complexity and high-cost of B-nodes, we assume that N(B)>> N(G).

We assume that each node is equipped with one IEEE802.11b radio using a single channel. The theoretical trans-mission ranges of B-nodes and G-nodes are R(B) and R(G), respectively. To reflect the dynamic nature of MANETs in practice, we assume that transmission ranges may be 10%deviated from theoretical values. Hence, unidirectional links may exist not only in the link between B-nodes and G-nodes but in the link between two homogeneous nodes as well.

Definition 1–G isolated: G isolated is defined as a G-node that is not covered by any B-node.

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Definition2–G member: G member is defined as a G-node whose bidirectional neighbors (BNs) are covered by its cluster head.

Definition 3–G gateway: G gateway is defined as a G-node whose BNs are not covered by its cluster head.

whereas those nodes uncovered by the B-nodes (e.g., G isolated) will not be involved in the clustering. Two features appear in LVC.

First, the loose clustering avoids heavy overhead caused by reconstructing and maintaining the cluster when the density of B-nodes is small. Second, LRPH protocol can be adaptive to the density of B-nodes, even when all G-nodes are in the G isolated state. All nodes build a local aware topology (LAT) table by exchanging control packets during building LVC. Notice that the LAT table stores a local topology information based on discovered bidirectional links. The detailed procedures for constructing LVC are presented in the following.

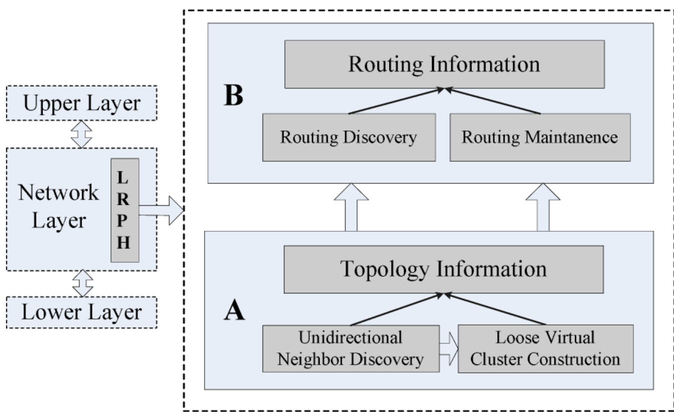

Fig 2: Overview of ERLP

Procedures for Building LVC:

Step 1: Each G-node broadcasts G-node LVC initialization(GLI) packets to all B-nodes in the AN table. The BN information in the BN is added to GLI. Notice that GLI will only be delivered within the limited area controlled by time-to-live (TTL). Because TTL is very small, broadcasting GLIpackets will not incur much overhead to the network.

Step 2: Each B-node waits for T LVC to collect GLI and build the LAT table for the local topology information local_topo_info based on the BN information in GLI. Then, the B-nodes broadcast B-node LVC initialization (BLI) packets within one hop and notifies local_topo_info to all the G-nodes within its covered range.

Step 3: After sending GLI packets in Step 1, the G-nodes wait T LVC for receiving BLI packets from the

B-nodes. Then, the G-nodes build LAT based on the local_topo_info received in BLI packets.

Step 4: Each G-node determines its own state based on the definitions about G-nodes and selects the cluster head using the scheme proposed in Section III-B4. Then, each node takes the following operation according to its state.

• If a G-node is in either the G member or G gateway state, it multicasts cluster member register (CMR) packets to both the new and old cluster heads. Notice that CMR packets will only be sent to the new cluster during the initialization .Similar to the GLI packet, the information in CMR contains the BNs. The routes to the new and old cluster heads can be obtained based on the topology in LAT table.

• If a G-node is in the G isolated state, it cannot receive any BLI packets and does not have a cluster head. Hence, the G-node will do nothing.

Step 5: Each cluster head waits for T LVC to collect CMR packets from its cluster members and rebuild the LAT for its cluster members. The topology information on cluster members will be managed by the cluster head. Then, the cluster head broadcasts cluster head declare (CHD) packets to the G-nodes covered by the cluster head in one hop.

Step 6: When a G-node receives CHD packets, it knows the topology information and updates the information into LAT. However, the B-node does not process received CHD packets. After the given six steps of initialization, a hierarchical structure is established. In particular, all B-nodes build the LAT based on the received CMR packets, and all G-nodes build LAT based on the received CHD packets.

A. Routing with Link Quality

Route Discovery Procedure: When source node S wants to send a data packet to destination node D, S first searches whether the route to D exists in its route cache. If the route exists, S directly sends the data packet. Otherwise, S activates the route discovery procedure to find a route to D. The route discovery process consists of the local routing (LR) and global routing (GR) components described in the following.

LR: If D is in the LAT table, the route to D will be directly obtained. To reduce the interference from data transmission from a B-node, the route calculation intends to avoid B-nodes in the path.

GR: If D is not in the LAT table, S broadcasts a route request (RREQ) packet to discover the source route to D. When a node receives the complete route to D, it replies with a route reply (RREP) packet to S. After S receives the RREP packet, it inserts the new route into its route cache and sends data packets. The forwarding procedure for RREQ and RREP packets will be described in the following.

RREQ/RREP Forwarding Procedures: For node n(i) , we assume that the node sequence associated with the discovered path in the received RREQ packet is $n_1 \rightarrow n_2 \rightarrow \cdots \rightarrow n_{i-1}$; then, the RREQ packet will be processed as follows.

Step 1: n(i) determines whether the RREQ packet is a duplicate packet. If so, the RREQ packet will be discarded. Otherwise, go to Step 2.

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Step 2: If n i is destination node D, or n i could obtain the route to D from the route cache or the LAT table ,the broadcast of RREQ packets will be stopped, and a complete path from S to D will be discovered. Otherwise, go to Step 3.

Step 3: If n i is a B-node, it will be appended to the node sequence of the discovered path in the RREQ packet. Then, the RREQ packet will be broadcasted continually. If n(i) is a G-node, go to Step 4.

Step 4: If n i−1 is a G-node and is not in the BN table (unidirectional links), the RREQ packet will be discarded. When n(i) is a BN of n i−1 , the action will

be taken based on the node's state. Particularly, if S(n(i)) = G gateway or S(n(i))=G isolated, go to Step 5; otherwise, go to Step 6.

Step 5: When a G-node in the G gateway or G isolated state receives RREQ packets, it will append n(i) to the node sequence of the discovered path in the RREQ packet and continually broadcast the RREQ packets.

Step 6: When a G-node in the G member state receives RREQ packets, it will check the type of node n i−1 . If n i−1 is the cluster head of n i , RREQ will be discarded. Otherwise, n(i) will be appended to the node sequence of the discovered path in the RREQ packets, and the RREQ packets will be broadcast continually.

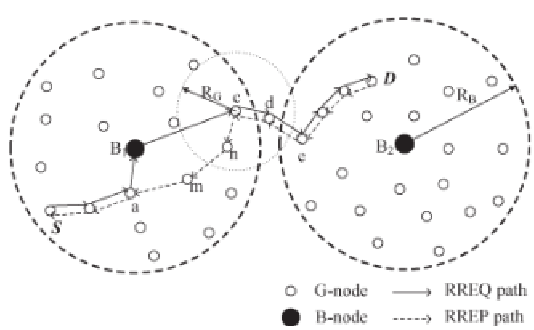

Fig 3. Processing RREP Packet

When a node obtains a complete source route to D, it replies with a RREP packet to S directly and notifies S about the discovered route. Because the RREP packet is delivered using unicast, the bidirectional links will be used. Although this scheme may increase route hops and delay, network throughput can be ultimately improved.

RREP packet. Assume that the route to destination is S →··· → a → B 1 → c → d··· → D, where B 1 → c is a unidirectional link. Therefore, when c receives the RREP packet, it replaces the route a → B 1 → c in the

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IV. PERFORMANCE EVALUATION

During simulation time the events are traced by using the trace files. The performance of the network is evaluated by executing the trace files. The events are recorded into trace files while executing record procedure. In this procedure, we trace the events like packet received, Packets lost, Last packet received time etc. These trace values are write into the trace files. This procedure is recursively called for every 0.05 ms. so, trace values recorded for every 0.05 ms.

The NS2 after running a successful simulation traces Packet received, Packet loss ratio and residual energy are traced. These parameters are traced against AODV protocol and the enhancement is shown. The performance shows that the proposed protocol has clear advantage over the AODV protocol in the above parameters.

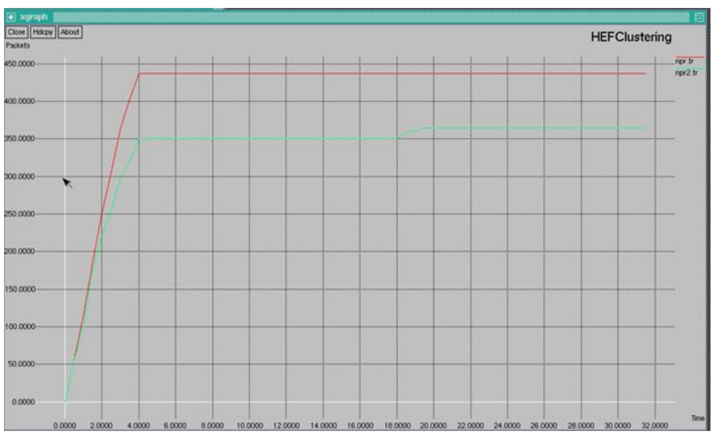

Fig 4. Packet loss ratio vs AODV

The packet loss ratio has been greatly reduced by using ERLP protocol by optimizing the chance of loss. The performance can also be evaluated with respect to residual energy and throughput. The use of link quality can reduce the setup time for new paths. Also utilizing the high power nodes can improve the performance of the overall problem.

V. CONCLUSION AND FUTURE ENHANCEMENT

They have developed an MEC based routing protocol named LRPH for power heterogeneous MANETs. LRPH is considered to be a double-edged sword because of its high-power nodes. We designed an MEC algorithm to eliminate unidirectional links and to benefit from high-power nodes in transmission range, processing capability, reliability, and bandwidth.

We developed routing schemes to optimize packet forwarding by avoiding data packet forwarding through high-power nodes. Hence, the channel space utilization and network throughput can be largely improved. Through a combination of analytical modeling and an extensive set of simulations, we demonstrated the effectiveness of LRPH over power heterogeneous MANETs. A proof-of concept system on Microsoft WinCE has been also implemented, and real-world experiments have been conducted and validated our theoretical and simulation findings well.

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