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Efficient Adaptive Loose Virtual Clustering Based Routing For Power Heterogeneous MANETs Using Local Geographical Topology

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Abstract* – Power heterogeneity is common in mobile ad hoc networks. There are increasing interests and use of mobile ad hoc networks with the fast progress of computing techniques and wireless networking techniques. Mobile network consists of devices with heterogeneous characteristics in terms of transmission power, energy, capacity, radio, etc. In such a heterogeneous network, different devices are likely to have different capacities and are thus likely to transmit data with different power levels. However, the throughput of power heterogeneous MANETs can be severely impacted by high power nodes. To address this issue, a loose virtual clustering based (LVC) routing protocol for power heterogeneous (LRPH) MANETs is defined. To explore the advantages of high power nodes, we develop an LVC algorithm to construct a hierarchical network and to eliminate unidirectional links. However the node loose clustering just on the categories of the node will not be sufficient. The current approach just assumes the quality based on the power aspect, which cannot be taken as a standalone parameter. To overcome this problem, geographical information of the node (GPS) is used which increases the ability of network in terms clustering. Each node periodically broadcasts a beacon containing its position to another node. A Well known position based Greedy Perimeter Stateless Routing (GPSR) is used which reduces delay in terms of clustering

***Index Terms*- MANET, GPS, GPSR, LPRH, OSLR, Routing, Clustering, Greedy Routing**

I. Introduction

In recent years, there has been growing research interest in heterogeneous mobile ad hoc networks (MANETs). Such mobile network consists of devices with heterogeneous characteristics in terms of transmission power [1], [2], energy [3], capacity, radio [4], etc.

A typical example of power heterogeneous MANETs is the vehicular ad hoc networks (VANETs), which are composed of heterogeneous wireless equipment carried by human and vehicles. In such a heterogeneous network, different devices are likely to have different capacities and are thus likely to transmit data with different power levels.

IEEE 802.11 is the most popular and practical technology deployed by a communication device in a vehicular network. Therefore, in the vehicular communication environment, wireless networks based on ad hoc technology can provide a more convenient communication solution for passengers, drivers, or vehicles on the road. For example, a passenger could establish a connection with other nearby passengers to share or to search information, or a driver could query the real time traffic information and share the traffic information with other drivers. The most attractive application based on VANET is to design the intelligence transport system to improve driving safety.

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. High power nodes also generally have advantages in power, storage, computation capability, and data transmission rate. As a result, research efforts have been carried out to explore these advantages, such as backbone construction and topology control. On the other hand, the large transmission range of high power nodes leads to large interference, which further reduces the spatial utilization of network channel resources [5], [6].

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Because of different transmission power and other factors (e.g., interference, barrier, and noise), asymmetric or unidirectional links will exist in MANETs.

The existing system explores the advantages of high power nodes by LVC algorithm and eliminates unidirectional links. There is a problem because of mobility, each node changes its position and nodes cannot found which is nearest cluster to join. In this paper, the position based routing protocol GPRS is designed to choose the intermediate forwarding nodes that lie on the shortest path or close to the shortest path from the source to the destination based on GPS. Greedy Perimeter Stateless Routing (GPSR) is a well known and most commonly used position based routing protocol for MANETs.

II. Related Work

Numerous routing protocols have been developed in the wireless networking community to target various scenarios, and much research effort has been paid to study the taxonomy of ad hoc routing protocols and to survey the representative protocols in different categories [7]–[8]. For example, Boukerche *et al.* [9] provided the comprehensive summary of the routing protocols for MANETs. Unfortunately, most of the existing protocols are limited to homogenous networks and perform ineffectively in power heterogeneous networks.

Multiclass is a position aided routing protocol for power heterogeneous MANETs. The idea of MC is to divide the entire routing area into cells and to select high power node in each cell as the backbone node (B-node). Then, a new medium access control (MAC) protocol called hybrid MAC (HMAC) is designed to cooperate with the routing layer. Based on the cell structure and HMAC, MC achieves better performance. However, a fixed cell makes MC to work well only in a network with high density of high power nodes. The Geographic and Energy Aware Routing (GEAR) algorithm proposed in [9] for wireless sensor networks works as follows: The entire ad hoc network is divided into grids.

If an intermediate node lies within the same grid as that of the destination node, the packet is flooded to the entire grid; otherwise, the packet is forwarded to the best next hop node with the largest weighted cost of the distance to the destination and the energy available.

Hierarchical optimized link state routing (HOLSR) is a routing protocol proposed to improve the scalability of OLSR for large-scale heterogeneous networks. In HOLSR, mobile nodes are organized into clusters according to the capacity of a node. However, if the node is at higher hierarchy, then it needs to maintain more information. In [3], a cross-layer-designed device–energy–load aware relaying (DELAR) framework that achieves energy conservation from multiple facets, including power-aware routing, transmission scheduling, and power control, is proposed. DELAR mainly focuses on addressing the issue of energy conservation in heterogeneous MANETs. In [1], a cross layer approach to address several challenging problems raised by link asymmetry in power heterogeneous MANETs is developed. In particular, an algorithm at the network layer was proposed to establish reverse paths for unidirectional links and to share the topological information with the MAC layer. In the link layer, a new MAC protocol was presented based on IEEE 802.11 to address the heterogeneous hidden/exposed terminal problems in power heterogeneous MANETs.

LRPH takes the double edged nature of high power nodes into account. To exploit the benefit of high-power nodes, a novel hierarchical structure is maintained in LVC, where the unidirectional links are effectively detected. A loose coupling relationship is established between nodes.

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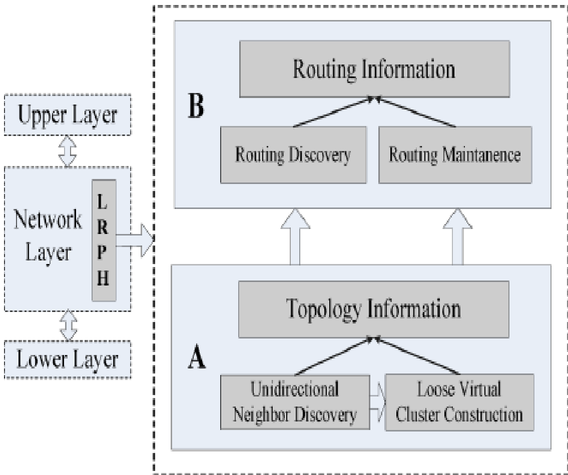

Figure1: Overview of LPRH.

LRPH [10] consists of two core components. The first component (Component A) is the LVC algorithm that is used to tackle the unidirectional link and to construct the hierarchical structure. The second component (Component B) is the routing, including the route discovery and route maintenance. In LVC, unidirectional links in the network can be discovered using a BN discovery scheme. To exploit the benefits of high power nodes, LVC establishes a hierarchical structure for the network. Based on the LVC, LRPH is adaptive to the density of high power nodes.

III. Proposed System

Different from the existing routing on power heterogeneous MANETs, our proposed approach rely on geographic information of the node using GPS and GPSR. Our proposal considers both the advantages and disadvantages of high power nodes. In addition, some In addition, some realistic factors have been taken into consideration, including unidirectional links and the loose coupling relationship between nodes in cluster.

A) Network Model

There are two types of nodes in the networks: B-nodes and general nodes (G-nodes). B-nodes refer to the nodes with high power and a large transmission B- 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 *NB* and *NG*, respectively. Because of the complexity and high-cost of nodes, we assume that *NB* << *NG*.

B) GPSR

Greedy Perimeter Stateless Routing (GPSR) [11] is a well known and most commonly used position-based routing protocol for MANETs. GPSR works as follows: The source periodically uses a location service scheme to learn about the latest location information of the destination and includes it in the header of every data packet. If the destination is not directly reachable, the source node forwards the data packet to the neighbour node that lies closest to the destination. Such a greedy procedure of forwarding the data packets is also repeated at the intermediate nodes. In case, a forwarding node could not find a neighbour that lies closer to the destination than itself, the node switches to perimeter forwarding.

With perimeter forwarding, the data packet is forwarded to the first neighbour node that is come across, when the line connecting the forwarding node and the destination of the data packet is rotated in the anti-clockwise direction. The location of the forwarding node in which greedy forwarding failed (and perimeter forwarding began to be used) is recorded in the data packet. We switch back to greedy forwarding when the data packet reaches a forwarding node which can find a neighbour node that is away from the destination node by a distance smaller than the distance between the destination node and the node at which perimeter forwarding began.

During both greedy forwarding and perimeter forwarding, the energy available at the chosen neighbour node to forward the data packet is not considered. This motivated us to optimize the greedy forwarding phase of GPSR by considering the energy available at the neighbour nodes of a forwarding node before deciding the next hop node for transmitting the data packet.

C) Greedy Forwarding Algorithm Used In GPSR

Let (*XD*, *YD*) and (*XF*, *YF*) respectively denote the locations of the destination node *D* and the forwarding node *F* that has the data packet addressed to the destination node *D*.

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Figure 2, illustrates the pseudo code for the greedy algorithm used at a forwarding node in the traditional GPSR. The forwarding node *F* computes the distance between itself and the destination node *D* as well as the distance between each of its neighbour nodes and *D*. If a neighbouring node *I* of the forwarding node *F* is relatively closer to *D*, then the progress (i.e. fraction of the distance covered) with the potential selection of *I* as the next hop node would be the difference in the distance between *F* and *D* and the distance between *I* and *D* divided by the distance between *F* and *D*. Among such neighbour nodes, the neighbour node that has the maximum value for the progress is the node that lies closest to the destination and is chosen by *F* as the next hop to forward the data packet. If the forwarding node *F* could not find a neighbour node that lies closer to the destination than itself, then the node switches to perimeter forwarding.

Position-based routing protocols do not conduct on demand route discovery to learn and maintain routes. Instead, forwarding decisions are taken independently for each data packet at every forwarding node (including the source) depending on the position of the forwarding node, the intermediate nodes and the destination. Normally, the source includes its estimated location information of the destination in every data packet. The position based routing protocols are mostly designed to choose the intermediate forwarding nodes that lie on the shortest path or close to the shortest path from the source to the destination. This motivated us to optimize the greedy forwarding phase of GPSR by considering the energy available at the neighbour nodes of a forwarding node before deciding the next hop node for transmitting the data packet.

Input: Forwarding Node *F*, Destination *D*, *Neighbor-List* (*F*)
Auxiliary Variables: *Progress* (*F*, *I*) where $I \in$ *Neighbor-List* (*F*)
Maximum-Progress
Output: *Next-Hop-Node* // if Greedy forwarding is successful
NULL // if Greedy forwarding is not successful and perimeter forwarding is needed
Initialization: *Next-Hop-Node* = NULL
Maximum-Progress ← 0.0

Begin *GPSR Greedy Forwarding Algorithm*

$Distance_{F\text{-}D} = \sqrt{(X_F - X_D)^2 + (Y_F - Y_D)^2}$

for every neighbor node $I \in$ *Neighbor-List* (*F*) **do**

$Distance_{I\text{-}D} = \sqrt{(X_I - X_D)^2 + (Y_I - Y_D)^2}$

if ($Distance_{I\text{-}D} < Distance_{F\text{-}D}$) **then**

$Progress(F, I) = \frac{Distance_{F-D} - Distance_{I-D}}{Distance_{F-D}}$

if (*Maximum-Progress* < *Progress* (*F*, *I*)) **then**
Maximum-Progress = *Progress* (*F*, *I*)
Next-Hop-Node ← *I*
end if
end if
end for

if (*Maximum-Progress* > 0.0) **then**
return *Next-Hop-Node* // Greedy forwarding is successful
else
return NULL // Greedy forwarding is not successful and
// perimeter forwarding is needed
end if

End *GPSR Greedy Forwarding Algorithm*

Figure 2 : GPSR Greedy forwarding algorithm

IV. CONCLUSION

Power heterogeneity is a double edged sword in power heterogeneous MANETs because mobile nodes have different transmission power. The throughput of power heterogeneous MANETs can be severely impacted by high power nodes. The proposed system using GPRS improves the routing of power heterogeneous MANETs by efficiently exploiting the advantages and avoiding the disadvantages of high power nodes based on GPS which reduces delay in forming a cluster. Hence, the channel space utilization and network throughput can be largely improved by GPRS.

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