# ANALYSIS OF LOOSE VIRTUAL CLUSTERING BASED ROUTING ALGORITHM FOR POWER HETEROGENEOUS MANETS

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**Abstract**
**A mobile ad hoc network (MANET) is a multi-hop wireless network formed by a group of mobile nodes that have wireless capabilities and are in proximity of each other. As nodes are mobile in a MANET, links are created and destroyed in an unpredictable way, which makes quite challenging the determination of routes between a pair of nodes that want to communicate with each other. Power heterogeneity is common in mobile ad hoc networks (MANETs). With high-power nodes, MANETs can improve network scalability, connectivity and broadcasting robustness. However, the throughput of power heterogeneous MANETs could be severely impacted by high-power nodes. MANETs are a kind of wireless ad hoc networks that usually has a routable networking environment on top of a link layer Ad hoc network. To address this issue, we present LRPH, a loose virtual clustering based routing protocol for Power Heterogeneous MANETs. In particular, to explore the advantages of high-power nodes, we develop a loose virtual clustering algorithm to construct a hierarchical network and eliminate unidirectional links. To reduce the interference raised by high-power nodes, we develop routing algorithms to avoid packet forwarding via high-power nodes. Via the combination of analytical modelling, simulations, and real-world experiments, we demonstrate the effectiveness of LRPH on improving the performance of power heterogeneous MANETs.**

**Index Terms: Clustering, Routing Algorithm, Power Heterogeneous, MANETs.**

## I. INTRODUCTION

Mobile Ad hoc Network (MANET) is a collection of mobile nodes equipped with both a wireless transmitter and a receiver that communicate with each other via bidirectional wireless links either directly or indirectly. Industrial remote access and control via wireless networks are becoming more and more popular these days [3]. One of the major advantages of wireless networks is its ability to allow data communication between different parties and still maintain their mobility. However, this communication is limited to the range of transmitters. This means that two nodes cannot communicate with each other when the distance between the two nodes is beyond the communication range of their own. MANET solves this problem by allowing intermediate par-ties to relay data transmissions. This is achieved by dividing MANET into two types of networks, namely, single-hop and multihop. In a single-hop network, all nodes within the same radio range communicate directly with each other. On the other hand, in a multihop network, nodes rely on other intermediate nodes to transmit if the destination node is out of their radio range. In contrary to the traditional wireless network, MANET has a decentralized network infrastructure. MANET does not require a fixed infrastructure; thus, all nodes are free to move randomly MANET is capable of creating self-configuring and self-maintaining network without the help of a centralized infrastructure, which is often infeasible in critical mission

applications like military conflict or emergency recovery.
Minimal configuration and quick deployment make MANET ready to be used in emergency circumstances where an infrastructure is unavailable or unfeasible to install in scenarios like natural or human-induced disasters, military conflicts, and medical emergency situations Owing to these unique characteristics, MANET is becoming more and more widely implemented in the industry However, considering the fact that MANET is popular among critical mission applications, network security is of vital importance. Unfortunately, the open medium and remote distribution of MANET make it vulnerable to various types of attacks. For example, due to the nodes' lack of physical protection, malicious attackers can easily capture and compromise nodes to achieve attacks. In particular, considering the fact that most routing protocols in MANETs assume that every node in the network behaves cooperatively with other nodes and presumably not malicious, attackers can easily compromise MANETs by inserting malicious or non-cooperative nodes into the network. Furthermore, because of MANET's distributed architecture and changing topology, a traditional centralized monitoring technique is no longer feasible in MANETs. In such case, it is crucial to develop an intrusion-detection system (IDS). In present days, mobile communication has increased in usage and popularity. Tasks earlier handled by wired communication can now be performed using wireless devices offering different styles of technologies (such as IEEE 802.11, IEEE 802.16, Bluetooth and so on) that also provide for the user the advantage of the mobility. For some tasks, such as the ones involved during emergency network scenarios, the use of wireless devices is mandatory. Some relevant scenarios include coalition military operation, disaster relief efforts, and on-the-fly team formation for a common mission, such as search and rescue. The problem is how to improve the routing performance of a power heterogeneous MANET by efficiently exploiting the advantages and avoiding the disadvantages of high-power nodes, which is the focus of our paper. In this paper, we develop a Loose Virtual Clustering (LVC) based routing protocol for power heterogeneous MANETs, named LRPH (*L*VC-based *R*outing for *P*ower *H*eterogeneous). Our protocol is compatible with the IEEE 802.11 DCF protocol. It does not rely on geographic information [8], or multi-radios multi-channel [9], and can be deployed on general mobile devices, including laptop, PDAs, and others. 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 detected effectively. Clustering is a known scheme to improve the performance of the networks [2]. However, in the existing clustering schemes, each node in the network should play a certain role (e.g., cluster head, member, or gateway). We define this as a strong-coupling cluster. In a strong-coupling cluster, the cost of constructing and maintaining a cluster may increase significantly and affect the network performance. In our clustering, a loose coupling relationship is established between nodes. Based on the LVC,

## II. RELATED WORK

Numerous routing protocols have been developed in the wireless networking community to target various scenarios, and many research efforts have been paid to study the taxonomy of the ad hoc routing protocols, and conducted the survey of the representative protocols in different categories [5]–[7]. For example, Boukerche *et al.* [6] 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. There are some routing protocols for heterogeneous MANETs. For example, MC (Multiclass) [9] is a position aided routing protocol for power heterogeneous MANETs. The idea of MC is to divide the entire routing area into cells, and select a high-power node in each cell as the backbone node. Then, a new MAC protocol, denoted as hybrid MAC (HMAC), is designed to cooperate with the routing layer. Based on the cell structure and HMAC, MC achieves better performance. However, the fixed cell makes MC work well only in a network with high density of high-power nodes. Work in presented a cross-layer approach, which extends the MAC and network layers to minimize the problems caused by the link asymmetry and exploits the advantages of heterogeneous MANETs simultaneously. Work in [2] proposed a cross-layer designed Device-Energy-Load Aware Relaying framework, denoted as DELAR, to achieve energy conservation from multiple facets, including power-aware routing, transmission scheduling, and power control. DELAR mainly focuses on addressing the issue of energy conservation in heterogeneous MANETs. Work in developed a cross-layer approach to address several challenging problems raised by link asymmetry in power heterogeneous MANETs. In particular, an algorithm at the network layer was proposed to establish reverse paths for unidirectional links and share the topological information with the MAC layer. In the link layer, a new MAC protocol was presented based on the IEEE 802.11 to address the heterogeneous hidden exposed terminal problems in power heterogeneous MANETs. Different from the existing routing on power heterogeneous MANETs, our proposed approach does not rely on the geographic information or multi-radio multi-channel, and can be deployed on general 802.11 based mobile devices.

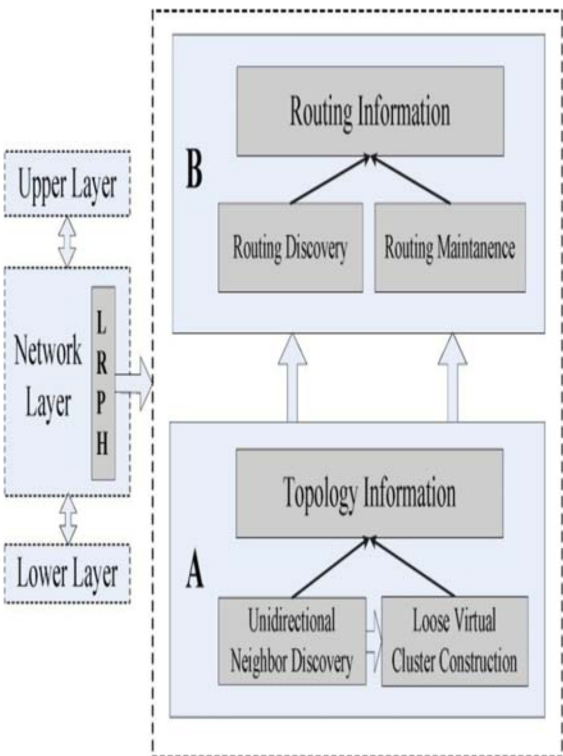
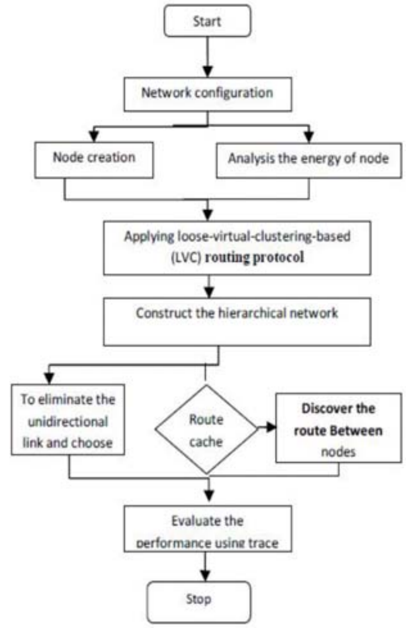



Figure.1 Overview of the LRPH

Our proposal considers both the advantage and disadvantage of high-power nodes. In addition, some realistic factors have been taken into consideration, including the unidirectional links and loose-coupling relationship between nodes in cluster. In the near future, computing environment can be expected based on the recent progresses and advances in the computing and communication technologies. Next generation of mobile communications will include both prestigious infrastructure wireless networks and novel infrastructure less mobile ad hoc networks (MANETs). Power heterogeneity is common in mobile ad hoc networks (MANETs). With high power nodes, MANETs can improve network scalability, connectivity and broadcasting robustness. However, the throughput of power heterogeneous MANETs could be severely impacted by high-power nodes. 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. The proposed system considers the power aware routing protocol for a MANET formed of heterogeneous nodes. The proposed approach takes into consideration the battery status of nodes when building the routing table. The developed routing scheme is to optimize packet forwarding by avoiding data packet forwarding through high-power nodes. Due to high mobility of nodes in mobile ad hoc networks (MANETs), there exist frequent link breakages which lead to frequent path failures and route discoveries. A neighbour coverage-based probabilistic rebroadcast protocol is used for reducing routing overhead in MANETs. This approach combines the advantages of the neighbour coverage knowledge and the probabilistic mechanism, which can significantly decrease the number of retransmissions so as to reduce the routing overhead, and can also improve the routing performance. The ability of lower power nodes to receive transmissions from higher power nodes but not vice versa. This not only poses challenges at the routing layer, but also results in an increased number of collisions at the MAC layer due to high nodes initiating transmissions while low power communications are in progress. Previously proposed routing protocols for handling unidirectional links largely ignore MAC layer dependencies [3]. The capacity scaling laws of mobile ad-hoc networks comprising heterogeneous nodes and spatial in homogeneities [4]. Most of previous work relies on the assumption that nodes are identical and uniformly visit the entire network space. Moreover even the channels may not all be identical; they may possibly have different propagation characteristics, and may support different sets of transmission rates. Much prior research on multi-channel networks has assumed identical channels and radio capabilities [5]. Flooding in mobile ad hoc networks has poor scalability as it leads to serious redundancy, contention and collision. It can also enhance the reliability of broadcasting. It can also used in mobile and static wireless networks to implement scalable broadcast and multicast communications. Broadcasting is a fundamental and effective data dissemination mechanism for route discovery, address resolution and many other network services in ad hoc networks. While data broadcasting has many advantages, it also causes some problems such as the broadcast storm problem, which is characterized by redundant retransmission, collision, and contention. In a MANET, one challenging issue is to construct a virtual backbone [8] in a distributed and localized way while balancing several conflicting objectives: small approximation ratio, fast convergence, and low computation cost. Many existing distributed and localized algorithms select a virtual backbone without resorting to global or geographical information. However, these algorithms incur a high computation cost in a dense network. The simulation results showed that the proposed algorithm performs better with the end to end delay metric, throughput metric and packet delivery ratio metric. The proposed algorithm reduces the routing overhead and improves the performance of entire network. As the performance of the proposed algorithm is analyzed between two metrics in future with some modifications in design considerations the performance of the proposed algorithm can be compared with other routing protocol. We have used very small network of 50 nodes, as number of nodes increases the complexity will increase.




### III. B. LVC Algorithm

One drawback of heterogeneity of MANETs is that unidirectional links may exist between two neighbouring nodes (B-node or G-node). In LVC, unidirectional links in the network can be discovered using a BN discovery scheme. (1) Discovery of Bidirectional Links Bidirectional links are discovered by sending a neighbour discovery packet (BND) by a node to all its neighbours. This packet is used by nodes to create a bidirectional neighbour table BN.

**Steps to discover Bidirectional links**

**Step 1**: Each node sends BND packet to all its neighbouring nodes in a single hop.

**Step 2:** Wait for time TBND and collect all BND packets from neighbour nodes. Use these packets to create an aware node (AN) table AN = N**B**RB(gi) ∩ NGRG(gi).

**Step 3:** Next, again send the BND table to all neighbouring nodes, now with node's AN table as well.

**Step 4:** The nodes check whether its own information is present in the BND packet from neighbour node. If yes the node is added to the BN table. (2) LVC To exploit the benefits of B-nodes, we design a novel LVC algorithm. In LVC, a B-node is chosen as the cluster head and establishes a loose coupling relationship with G-nodes. 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

Gisolated state. All nodes build a local aware topology (LAT) table by exchanging control packets during building LVC. The basic step is building a local aware topology table (LAT).

**Step 1:** G-nodes send G-node initialization packets (GI) to all B-nodes in its AN table. The packet will have the information on its Bidirectional links.

**Step 2:** Each B-node once receiving the GI packets will add the BN to LAT. The B-node then sends B-node initialization (BI) packets to all G-nodes in its coverage area.

**Step 3:** Once G-node receives the BI packet, it updates the LAT table.

**Step 4:** A G-node declares it as a member to cluster head by sending cluster member, register (CMR) packet to cluster head.

**Step 5:** Cluster head replies with a cluster head declare (CHD) packet and updates it LAT. Cluster head maintains the LAT for each member G-node. 3) Cluster Head selection Each G-node, Gi selects the B-node which has the shortest distance (by any shortest path algorithms) to node Gi Using LAT table G-nodes can easily find out the B-node nearest to it.

## IV. SIMULATION RESULTS

The proposed algorithm implemented with Network Simulator 2. Simulation parameters are as follows: The Distributed Coordination Function (DCF) of the IEEE 802.11 protocol is used as the MAC layer protocol. The radio channel model follows a Lucent's Wave LAN with a bit rate of 2 Mbps, and the transmission range is 250 meters. We consider constant bit rate (CBR) data traffic and randomly choose different source-destination connections. Every source sends four CBR packets whose size is 512 bytes per second. The mobility model is based on the random waypoint model in a field of 1;000 m _ 1;000 m. In this mobility model, each node moves to a random selected destination with a random speed from a uniform distribution [1, max-speed]. After the node reaches its destination, it stops for a pause time interval and chooses a new destination and speed. In order to reflect the network mobility, we set the max-speed to 5 m/s and set the pause time to 0. The Max Delay used to determine the rebroadcast delay is set to 0.01 s, which is equal to the upper limit of the random jitter time of sending broadcast packets in the default implementation of AODV in NS.

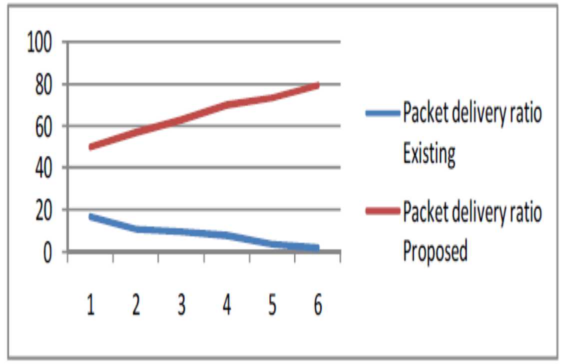



Figure.3 Performance Evaluation for Simulation time vs PDR

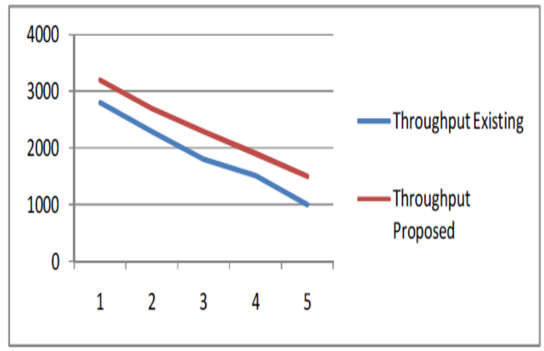



Figure.4 Performance Evaluation for Packet size vs Throughput

## V. CONCLUSION AND FUTURE WORK

In this paper, we developed a loose virtual clustering based routing protocol named LRPH for power heterogeneous MANETs. We designed a loose virtual clustering algorithm to eliminate unidirectional links and to benefit from high-power nodes in transmission range, processing capability, reliability, and bandwidth, such that to change homogeneous network into effective heterogeneous network protocol. We focused on the IEEE 802.11-based power heterogeneous MANETs in this project. In 802.11-based power heterogeneous MANETs, mobile nodes have different transmission power, and power heterogeneity becomes a double-edged sword. To address this issue, we presented a loose-virtual-clustering-based routing protocol for power heterogeneous MANETs with Geo-routing. To reduce the interference raised by high-power nodes, we develop routing algorithms to avoid packet forwarding via high-power nodes, if not needed. And we have proposed Geo-routing technique to improve the Heterogeneous communication with low overhead. The future work in the development of the proposed algorithm includes improvements to both the query localization and the load checking algorithm. Currently the location information used for the query localization is disseminated in an on-demand manner. Further techniques, which could possibly make the dissemination process faster and more efficient, have to be investigated.

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