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Optimization Routing and Employment for Wireless Sensor Network

M.Samyuktha*, B.Muneeswari, K.Aruna Devi,

Department of Electronics and Communication Engineering, SACS MAVMM Engineering College, Madurai, Tamil Nadu, India-625 301

Abstract : The applications of Wireless Sensor Networks (WSNs) have grown enormously. In this paper, the proposed mechanism used to enlarge the lifespan of network and provide more efficient functioning procedures that is clustering. Clustering is a process to subdivide the sensing field of sensor network into number of clusters. Each cluster selects a leader called cluster head. A cluster head may be elected by either the sensor node pre-assigned by the network designer, or forming cluster based on the priority of the data to the transmitted to the sink node. The throughput, Packet delivery ratio, interference, energy and time are the considered factors in finding efficient path of data communication among the sensor nodes within the cluster. Through simulations the proposed routing protocol shows energy efficiency and improved packet delivery ratio better connectivity rate. Through the presentedapproach is shown to reduce end-to-end delay up to 15 times forWireless networks while improving Packet Delivery Ratio (PDR) and Energy Consumption in comparison with hierarchical protocol.

Keywords : Routing, Networks, MANET

I. Introduction

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 can be severely impacted by high-power nodes. To address this issue, we present a loose-virtual-clustering-based (LVC) routing protocol for power heterogeneous (LRPH) MANETs. 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. Via the combination of analytical modeling, simulations, and real-world experiments, we demonstrate the effectiveness of LRPH on improving the performance of power heterogeneous MANETs.

A WSN consists of small-sized sensor devices, which are equipped with limited battery power and are capable of wireless communications. When a WSN is deployed in a sensing field, these sensor nodes will be

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responsible for sensing abnormal events (e.g., a fire in a forest) or for collecting the sensed data (temperature or humidity) of the environment. In the case of a sensor node detecting an abnormal event or being set to periodically report the sensed data, it will send the message hop-by-hop to a special node, called a sink node. The sink node will then inform the supervisor through the Internet.

In general, due to the sensory environments being harsh in most cases, the sensors in a WSN are not able to be recharged or replaced when their batteries drain out of power. The battery drained out nodes may cause several problems such as, incurring coverage hole and communication hole problems. Thus, several WSN studies have engaged in designing efficient methods to conserve the battery power of sensor nodes, for example, designing duty cycle scheduling for sensor nodes to let some of them periodically enter the sleep state to conserve energy power the WSN designing energy-efficient routing algorithms to balance the consumption of the battery energy of each sensor node or using some data aggregation methods to aggregate similar sensory data into a single datum to reduce the number of transmitted messages to extend the network lifetime of the WSN . he relocation of sensor nodes will also expand their battery energy. A compromise approach is to use a mobile sink to relocate its position instead of relocating the sensor nodes. the sensor node a near the sink will quickly drain out its battery power after relaying several rounds of sensed data with reported tasks being performed by other sensor nodes, and consequently the WSN will die. We call node a hot-spot. In the case of the sink being capable of moving, before the hot spot node a drains out all of its battery energy, the sink can move to another position to relieve the situation of heavy energy consumption of node a. In this paper, the proposed scheme relates a sink relocating to guide the sink when and where to move to. Some mathematical performance analyses are given to demonstrate that the proposed sink relocating scheme can prolong the network lifetime of a WSN. We have also conducted simulations to investigate the performance of the EASR method against some traditional methods by numerical simulation. The organization of this paper is as follows. In the next section we will briefly describe some background related to the considered problem, which includes the energy model of a WSN, the energy- efficient routing scheme that will be incorporated into the EASR scheme, and the related works of sink relocation.

II. Manet

In 802.11-based power heterogeneous MANETs, mobile nodes have different transmission power, and power heterogeneity becomes a double-edged sword. On one hand, thebenefits of high-power nodes are the expansion of networkcoverage area and the reduction in the transmission delay. Highpowernodes 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 [7] and topology control[8]. On the other hand, the large transmission range of high power rnode leads to large interference, which further reducesthe spatial utilization of network channel resources [9], [10].Because of different transmission power and other factors (e.g.,interference, barrier, and noise), asymmetric or unidirectionallinks will exist in MANETs. Exfisting research results show that routing protocols over unidirectional links perform poorlyin multihop wireless networks [11]. However, the existingrouting protocols in power heterogeneous MANETs are onlydesigned to detect the unidirectional links and to avoid thetransmissions based on asymmetric links without consideringthe benefits from high-power nodes. Hence, the problem is howto improve the routing performance of power heterogeneousMANETs by efficiently exploiting the advantages and avoidingthe disadvantages of high-power nodes, which is the focus ofthis paper.

In this paper, we develop a loose-virtual-clustering-based (LVC) routing protocol for power heterogeneous MANETs,i.e., LRPH. Our protocol is compatible with the IEEE 802.11distributed coordination function (DCF) protocol. It does notrely on geographic information [12], [13] or multi radio multi channels[13], [14], and can be deployed on general mobiledevices, including laptops, personal digital assistants, etc.LRPH takes the double-edged nature of high-power nodes intoaccount. To exploit the benefit of high-power nodes, a novelhierarchical structure is maintained in LVC, where the unidirectionallinks are effectively detected. Clustering is a knownscheme to improve the performance of the networks [15]–[19]. However, in the existing clustering schemes, each nodein the network should play a certain role (e.g., cluster head,member, or gateway) [20]. We define this as a strong couplingcluster. In a strong coupling cluster, the cost of constructingand maintaining a cluster may significantly increase and affect the network performance. In our clustering, a loose couplingrelationship is established between nodes. Based on the LVC, LRPH is adaptive to the density of high-power nodes. Recallthat high-power nodes with a larger transmission range will createlarge interference areas and low channel spatial utilization.In such case, we developed routing algorithms to avoid packetforwarding via high-power nodes. We conducted extensiveanalysis, simulations, and real-world experiments to validatethe effectiveness of LRPH. Simulation results show that LRPHachieves much better performance than other existing protocols.We have implemented LRPH in NS2 environmentand conducted real-world experiments. Our data matches thetheoretical and simulation findings well.

III. Related Work

Numerous routing protocols have been developed in thewireless networking community to target various scenarios, andmuch research effort has been paid to study the taxonomy of adhoc routing protocols and to survey the representative protocolsin different categories [21]–[24]. For example, Boukerche *et al.*[21], [23] provided the comprehensive summary of the routingprotocols for MANETs. Unfortunately, most of the existingprotocols are limited to homogenous networks and performineffectively in power heterogeneous networks.There are some routing protocols for heterogeneousMANETs. Multiclass (MC) [12] is a position-aided routingprotocol for power heterogeneous MANETs. The idea of MC isto divide the entire routing area into cells and to select a high power node in each cell as the backbone node (B-node). Then,a new medium access control (MAC) protocol called hybridMAC (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 wellonly in a network with high density of high-power nodes. In[13], a cross-layer approach is presented that simultaneouslyextends the MAC and network layers to minimize the problemscaused by link asymmetry and exploits the advantagesof heterogeneous MANETs. Hierarchical optimized link staterouting (HOLSR) [14] is a routing protocol proposed to improvethe scalability of OLSR for large-scale heterogeneousnetworks. In HOLSR, mobile nodes are organized into clustersaccording to the capacity of a node. However, if the node is athigher 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 frommultiple facets, including power-aware routing, transmissionscheduling, and power control, is proposed. In [1], a cross-layer approach to address several challenging problems raised by link asymmetryin power heterogeneous MANETs is developed.

In particular, an algorithm at the network layer was proposed to establishreverse paths for unidirectional links and to share the topologicalinformation with the MAC layer. In the link layer, a newMAC protocol was presented based on IEEE 802.11 to addressthe heterogeneous hidden/exposed terminal problems in powerheterogeneous MANETs.Different from the existing routing on power heterogeneousMANETs, our proposed approach does not rely on geographic information or multi radio multichannel and can be deployed ongeneral 802.11-based mobile devices. Our proposal considersboth the advantages and disadvantages of high-power nodes.In addition, some realistic factors have been taken into consideration,including unidirectional links and the loose couplingrelationship between nodes in cluster.

IV. Proposed System

To improve the network performance and to address theissues of high-power nodes, we propose an LRPH MANETs.LRPH consists of two core components.The first component (Component A) is the LVC algorithm thatis used to tackle the unidirectional link and to construct thehierarchical structure. The second component (Component B)is the routing, including the route discovery and route maintenance.In the following, we first list the network model anddefinitions. We then present the two components in detail.

A. Network Model

There are two types of nodes in the networks: B-nodes andgeneral nodes (G-nodes). B-nodes refer to the nodes with highpower and a large transmission range. G-nodes refer to thenodes with low power and a small transmission range. Thenumbers of B-nodes and G-nodes are denoted as *NB* and*NG*, respectively. Because of the complexity and high-cost ofB-nodes, we assume that *NB* _ *NG*.We assume that each node is equipped with one IEEE802.11b radio using a single channel. The theoretical transmissionranges of B-nodes and G-nodes are *RB* and *RG*,respectively. To reflect the dynamic nature of MANETs inpractice, we assume that transmission ranges may be 10%deviated from theoretical values. Hence, unidirectional linksmay exist not only in the link between B-nodes and G-nodesbut in the link between two homogeneous nodes as well.

B. LVC Algorithm

Here, we introduce the LVC algorithm. In LVC, unidirectionallinks in the network can be discovered using a BNdiscovery scheme. To exploit the benefits of high-power nodes,LVC establishes a hierarchical structure for the network.

1) BND: To eliminate unidirectional links, we present aneffective scheme to discover bidirectional links. In particular,each node periodically sends a bidirectional neighbor discovery(BND) packet, containing its own information (e.g., ID, type,state, etc.) and the information on its discovered neighbors. Thediscovered neighbors refer to the nodes learned by the receivedBND packet. All nodes build aware neighbor (AN) and BNtables based on the received BND packets. Using the BN table,the BNs can be identified.*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.

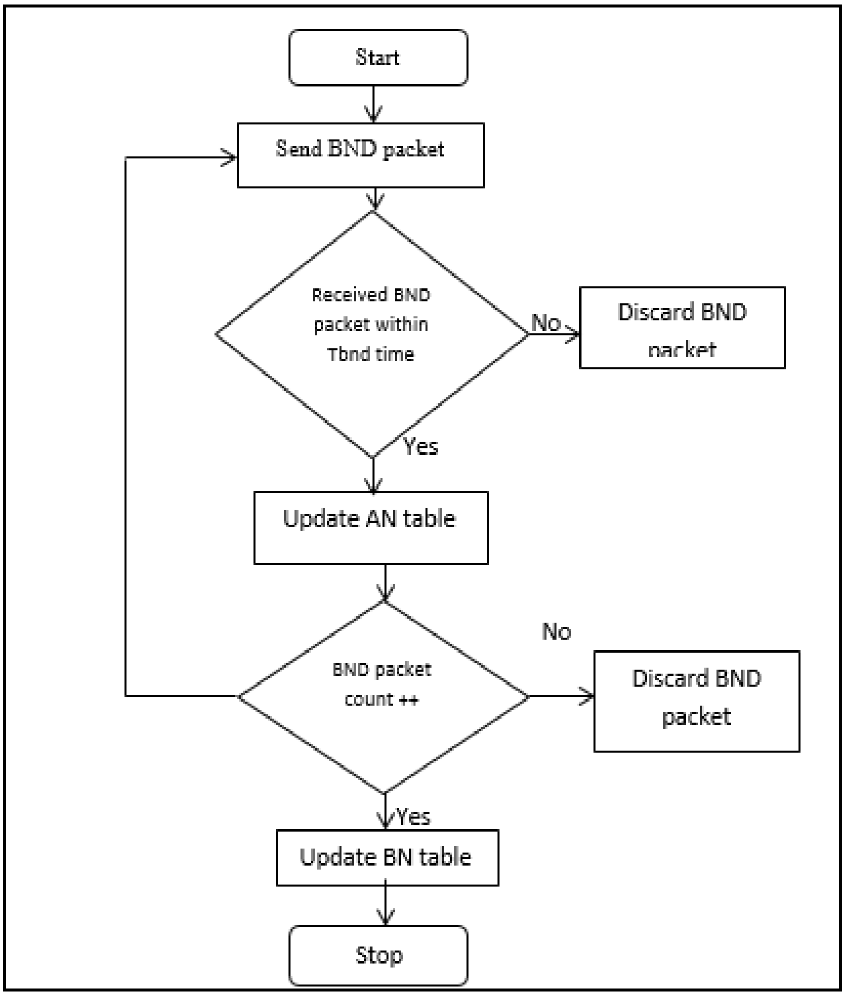

Fig 1: Flowchart for Bidirectional neighbor discovery

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 (*G* member or *G* gateway) 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 *G* isolated 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. Received CMR packets and CHD packets are used to build LAT by all B-node, and all G-nodes reply.

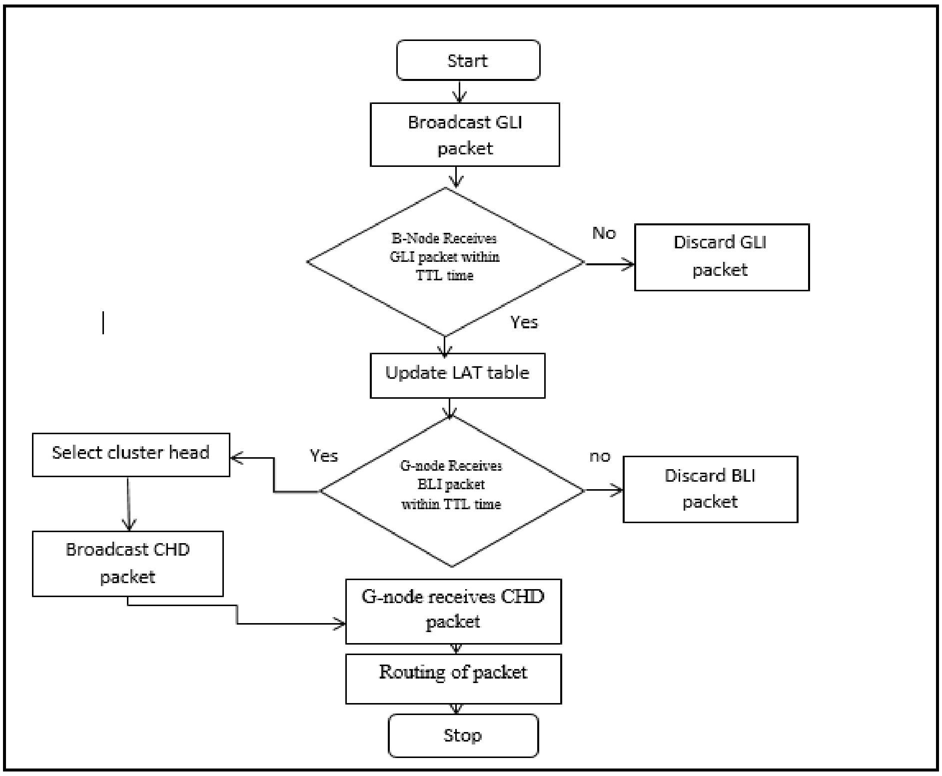

Fig 2: loose-virtual-clustering

C. LVC Maintenance

When the links between nodes fail, particularly when node ni detects any of the following conditions based on the periodical BND packets. If node n_i does not receive the BND packet from node nj 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 *nj*and node *nj*is not in the AN table, a new link between $n_i$and *nj*should be added.

D. LVC maintain by G-nodes

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

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

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

• If *nj*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 recieving CMR packets, B-node broadcast 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.

E. LVC maintain by B-nodes:

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

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

F. Cluster Head Selection:

The number of B-nodes in the AN table maintained at any G-node *gi*is denoted by N . The cluster head of *gi*is found as shown in fig3.a.4

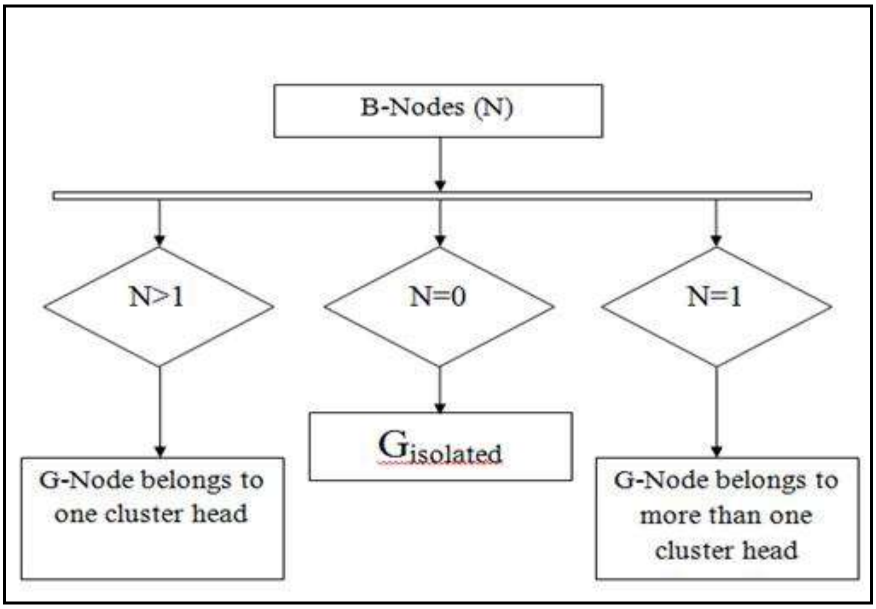

Fig 3: Cluster head selection

V. Routing Components in LRPH

It includes route discovery and route maintenance.

Route Discovery Procedure includes 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 so '*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

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.

VI. Results and Discussions

Experimental results demonstrate that the performance ofLRPH outperforms other two routing protocols over power heterogeneousMANETs. In addition, we can find that, althoughthe performance trend of the three protocols matches the simu- lation results well, the experimental data of the three protocolsare much worse than the simulation results. This is because, under the realistic network environment, the wireless linksbecome fragile and of low quality. Fortunately, all mechanismsand transmissions in LRPH are based on the bidirectional links.However,MCand DSR do not consider this issues; all strategies(e.g., clustering and route discovery) almost fail.

Fig 4: Average Energy ratio (Existing vs proposed)

Fig 5: Average delay ratio (Existing vs proposed)

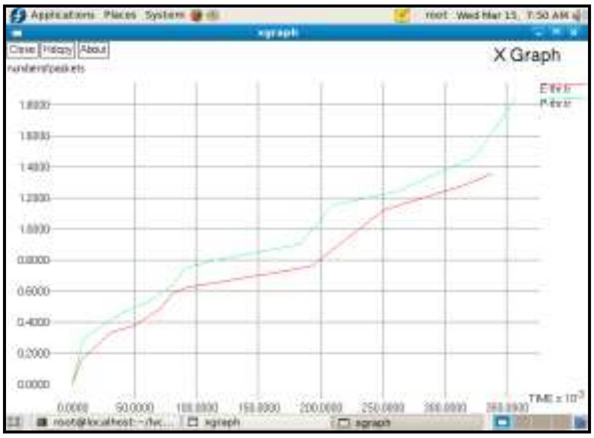

Fig 6: Average throughput ratio(Existing vs proposed)

VII. Conclusion

Static WSNs are limited in achieving tasks for supporting certain domain applications. Using mobile sinks improve the capability of hybrid *WSNs*, where mobile sinks traverse along pre-specified sink locations for gathering sensory data by static sensors. Prolonging the network lifetime, while ensuring the network region coverage, is a challenge. This project proposed a method to mitigate this problem. Specifically, the network region is divided into grid cells, which are grouped into clusters while considering the energy consumption of data gathering. 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. Thereafter, mobile sinks are similar in energy consumption for both data gathering and sink movement. Consequently, the network lifetime is prolonged.

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