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Energy Efficient Landmark Selection for Group Mobility Model in MANET

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Abstract

Background: Mobile Ad hoc Network (MANET) has its application in tough terrains such as battle fields, disaster recovery, emergency rescue operations etc. The usage of MANET in these areas are very critical for communication. Energy is an important criterion in MANET for the successful communication of nodes without a link failure. The most of the mobile nodes are powered by battery. The nodes does routing which transfers the packets from source to destination. The consumption of energy by routing nodes arises the need for energy aware routing. **Methods:** In this work, an energy efficient LANDMARK selection process for E-LANMAR routing protocol in group mobility for a moderate networks size is proposed. In the proposed work, energy efficiency of a header node (LANDMARK) can be achieved by minimizing the frequent header selection process. This work is modelled and simulated in QUALNET 5.0.2 Simulator. The LANDNARK acts as a cluster head, the cluster head selection is based not only on the number of neighbours but also residual energy of a node. **Results:** The results shows that throughput and Packet Delivery Ratio (PDR) for E-LANMAR is better compared with LANMAR routing protocol. The reduction of frequent LANDMARK selection process in E-LANMAR routing protocol reduces the energy consumption of nodes further in group mobility. **Application:** The proposed work can be applied wherever the nodes in MANET moves in a group such as an emergency rescue operations, army battle field communication etc.

Keywords: E-LANMAR, Group Mobility, LANDMARK Selection, MANET, Residual Energy

1. Introduction

The wireless mobile nodes in Mobile Ad hoc Network (MANET)[1] moves in random which form dynamic topology and it is an infrastructure less network as shown in Figure 1. A topology change in MANET also occurs due to the unstable connection, restricted energy capacity and absence of fixed infrastructure. These are the limitations of MANET which differentiated it from other networks[2]. The main idea behind this MANET routing protocols is to maximize the network throughput and energy efficiency. The increase in network throughput is calculated by packet de-livery ratio which will contribute to manage energy efficiency[3].

MANETs, find several applications in various areas. Some of them are: Tactical networks, Emergency services Commercial and civilian environments, Home and enterprise networking, Sensor networks, Context aware services, and hybrid Wireless network architectures[4].

Optimization of Energy in MANET can be attained by using an efficient metric for route selection process considering cost, node energy, and battery level. The efficiency is not only regard to consumption of less power but to focus on increasing the network life time, whereby the node can maintain its long connectivity with all other nodes by routing the packets to the destination.

1.1 Energy Consumption Issues in MANET

Energy is a scarce resource in mobile ad hoc networks. In MANET all nodes are energized by battery with limited capacities. So only nodes uses energy efficient method in MANET for power management and increase in network life time. Thus the failure of node in the network will impact on the data transmission from source to

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destination or network failure. Energy of the nodes must also be taken into consideration for energy efficiency in MANET. In flat based routing protocol all the nodes consumes same amount of energy but in cluster based routing protocol, more energy is consumed by cluster head than cluster member. Energy management[2] can be categorized into battery power management, system power management and transmission power management. The energy efficiency of a routing protocol is decided by the four energy cost metrics namely residual energy capacity, transmission power, approximated node lifetime and integrated energy metrics.

2. Protocol Overview

2.1 Ad Hoc Routing Protocols

The Ad-hoc routing protocols are categorized into three groups[5], they are Proactive (Table driven) routing protocol, Reactive (On demand) routing protocol and Hybrid routing Protocol. Shown in Figure 2.

Figure 1. Architecture of MANET.

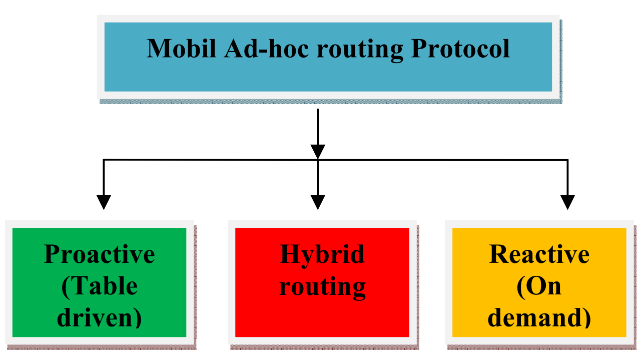


Figure 2. MANET Routing Protocols.

2.1.1 Proactive (Table Driven)

In proactive routing protocol[5], a node reserve routing information of other nodes in the network. The routing information is usually reserved in a table called routing table. This table is updated periodically and/or if the network topology changes.

2.1.2 Reactive(On-Demand)

Reactive routing protocol[6] do not reserve the network topology information, they will obtain necessary information of a path when required, by the process of connection establishment. For this reason these protocols periodically do not interchange the routing information.

2.1.3 Hybrid Routing (Zone Based)

Hybrid routing protocol[6] are a new generation protocol, which combine the nature of both proactive and reactive protocol. These protocols increase the scalability by allowing nodes with close vicinity to work together to form some sort of a backbone to reduce the frequent route discovery process.

2.2 LANMARK Protocol

The idea of logical subnets in which the members are likely to move as a group is the concept we adopt here from LANDMARK Protocol[7]. Every logical subnet has one header node (LANDMARK header), which serves for that subnet. Such LANDMARK header has the information about all nodes in its subnet. The LANMAR protocol uses Fisheye State Routing (FSR) protocol for routing scope that is measured in hop distance as shown in Figure 3. The scope of covering the majority of the subnet members depends upon placement of Landmark header. If the form of a subnet is likely to be a round, all members of the subnet is covered by the scope of the center node. By electing this central node as landmark requirement of the protocol is fully satisfied[7]. Then the scope elected as landmark uses a destination sequence number to make sure its routing entry is updated. The landmarks are disseminated in a distance vector mechanism. All nodes preserve a distance vector for headers in all scope. The number of entries in distance vector table is equal to the number of logical subnets in the network. If a landmark does not found at the center of the scope, some members will drift off from its scope. The landmark will keep a trace of the nodes in distance vector which drifters from the group. By periodical routing update mechanism, the distance

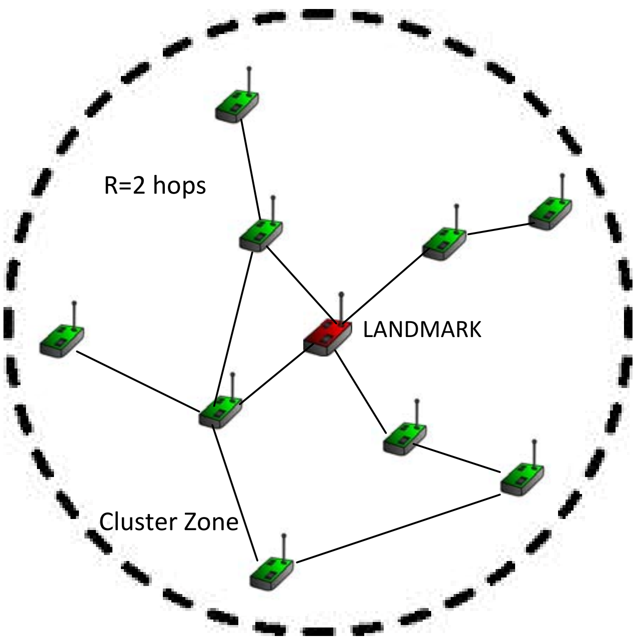


Figure 3. Size of the Scope.

vectors for landmarks and drifters are swapped among their neighbours.

The LANMAR is a proactive routing protocol that has the necessary routing information of the nodes within the scope. For routing inside the scope, each node periodically interchanges the routing information to its one hop neighbours. In each update, the node includes all the routing table entries and sent it to the members within the scope.

2.2.1 LANDMARK Protocol

LANMAR routing protocol[8] is a cluster based routing protocol. It is used for large-scale ad hoc network that exhibit group mobility. LANMAR is a proactive routing protocol, each node will maintain the accurate routing information about immediate neighbor and as well as to its header nodes. When a node needs to transmit a packet and the destination is within its scope as indicated in the routing table, the packet will be forwarded directly by Fisheye State Routing (FSR) protocol. A landmark is dynamically elected in each group. Each node in scope uses FSR to route packets to the landmark header. The landmark header by receiving this packet will direct the packet to the corresponding landmark of the destination scope. The transmission between the landmark headers is carried out by Landmark routing protocol with respect to scope ID.

2.2.2 LANDMARK Election

In landmark, election[7] and re-election of landmark is an important factor. Each node in a group tracks other nodes of the group and computes its weight. LANMAR protocol uses host protocol functionality. At the beginning no landmark exists in a group. If any node in a group finds that it has more number of group members (greater than threshold value T)[9], it declares itself as landmark to its group and adds itself in landmark distance vector table. Winner competition occurs between the two nodes when two nodes declares themselves as landmark in same group and one of the node will be elected as landmark based on its node weight

Due to mobility, selected landmark node will lose its member and the new landmark is selected by taking its weight into concern i.e. (weight of the current elected winner is twice the weight of the old node). When more than one node declares itself as a landmark in same group, simple solution is to find the node with largest number of group members that wins the election as shown in Figure 4. To use hysteresis in replacing the existing landmark, we assume competing node's number of members is M, existing landmark members as N and factor value as S (constant value 1.3). When M is greater than N∗S, competing node replaces the existing node. Sometimes N reduces smaller than threshold value T; it gives up the landmark role. If tie occurs between the nodes, M falls within an interval [N∗1/S, N∗S], then node with large member wins the election. If tie again occurs with equal number, it is broken using lowest id (i.e. address of the node is used as id).

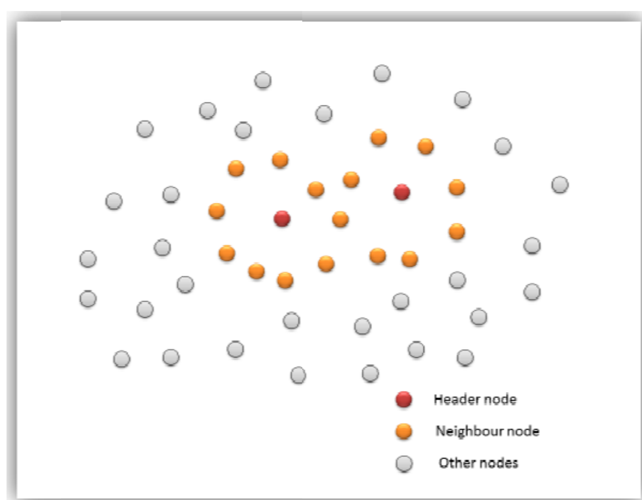


Figure 4. More than one node competing in same cluster.

3. Energy Efficient LANMAR Protocol

Since energy is an important criterion for mobile nodes, it will impact on network lifetime. In normal LANMAR routing protocol, header selection depends only on its number of neighbor nodes, which is greater than threshold T. In this proposed methodology, we are not only considering its number of neighbor nodes but also its energy level of header node. Consider if there are more than one node proclaims itself as a Landmark, header selection process take place and both satisfies the header selection criteria as per the normal LANMAR routing protocol. Now the residual energy levels of competing nodes are taken into consideration. With the help of minimum energy routing protocol, selects the node which has higher residual energy level than the other competing nodes to be selected as the LANMAR header.

3.1 Energy Efficient Routing

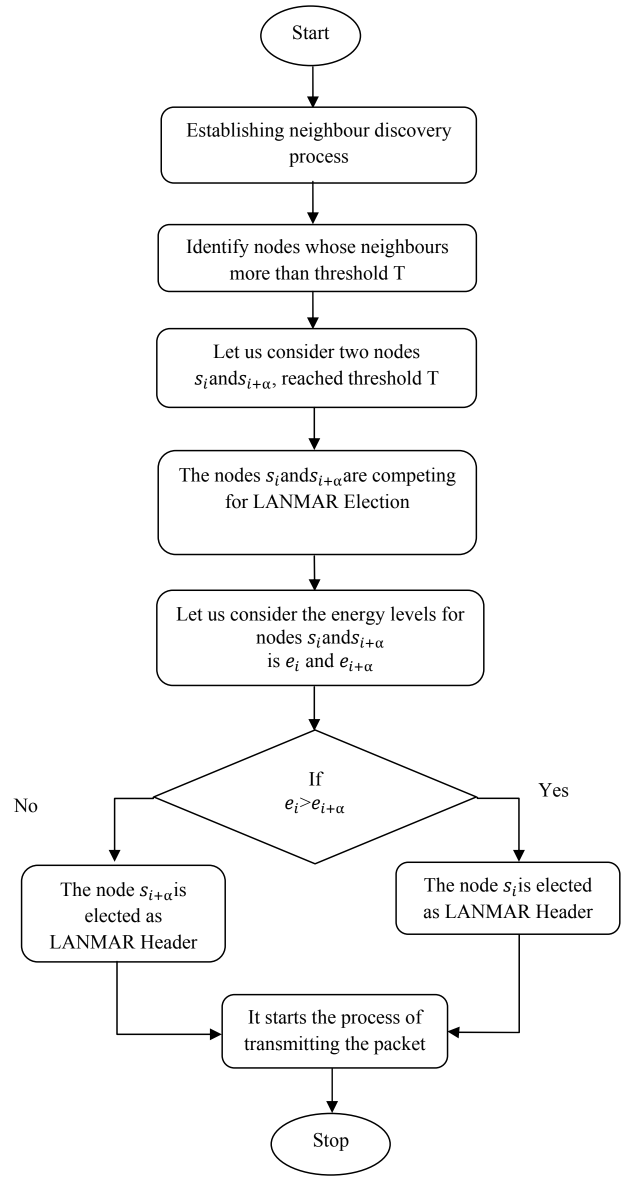
In a scope two or more number of nodes competes landmark selection process, the process can let the node with maximum number of neighbours as member win the election and in case of tie the lowest ID breaks the tie. But in energy LANMAR (E-LANMAR), when more than one nodes declare itself as header in same group, the energy of those competing node are calculated, and the node with maximum energy is selected as a landmark for that group, for which energy efficient method to find out the node with higher energy level of those nodes is proposed which is described in flow chart 1.

3.2 Group Mobility Model

Group movements are based on the path traveled by a logical center for the group. Each group has a logical "center". The location, motion behavior, direction, speed, and acceleration of the entire groups are defined by the center's motion. Thus, the group course is determined by providing a path for the center. For example, consider two groups of firefighters in a fire rescue operation, the task assigned to them is to rescue peoples trapped in the building. As the two group moves by front and back side of the building, to analyze this scenario a group mobility model is simulated.

4. Performance Analysis

The scenario is built using QualNet 5.0.2; a software that provides scalable simulations of Mobile Ad hoc network.



Flow Chart 1. Energy Efficient LANMAR protocol.

The proposed system is adopted with linear battery model which supports simulation time of 200 seconds to analyze the performance metrics of LANMAR and E-LANMAR protocols in group mobility model.

4.1 Software Resource

The software resource used here is QualNet 5.0.2[10] simulator. QualNet is a complete suite of tools for modeling large wired and wireless networks. Figure 5 shows the basic functional diagram to simulate scenarios using QualNet 5.0.2. It uses simulator and emulator to predict

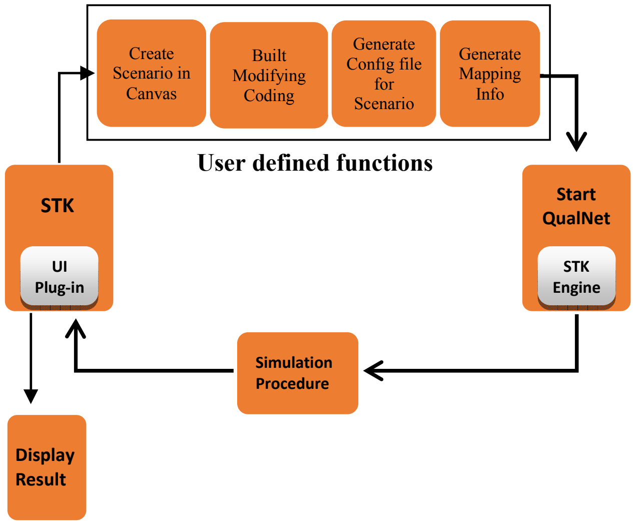


Figure 5. Functional diagram of QualNet.

the behavior and analyze the networks and to improve their operation performance, design and management.

The steps associated with simulation in QualNet are[11]:

- The first phase is to create and prepare the simulation scenario based on the system description and metrics of interest.
- Implementation of algorithm for working of energy based landmark selection
- Next phase is to implement and posturize the created scenario and to collect respective results
- The result analysis of simulation is the final phase.

4.2 Simulation Parameters

Simulation is done using the discrete event simulator QualNet5.0.2. Constant Bit Rate (CBR) traffic sources are used. The source-destination pairs are stretch random in a rectangular field with 1500 × 1500m² field whereas network size is varied as 20, 40,50, 60, 70, 80, and 160 nodes as shown in Figure 6. The mobility of nodes follows group mobility model[12], where the nodes move in group with other nodes in the network. The pause time, which affects the Relative speeds of the mobile hosts, is kept constant at 30s.Maximum speeds varied at 0-10m/s. This work uses a linear battery model to study the performance of LANMAR and E-LANMAR protocols. The performance metrics namely throughput and packet delivery ratio are considered. The scenario parameters and their values are shown in Table 1.

Table 1. Scenario properties

Simulation Parameters	Value
Terrain	1500 × 1500 m²
Nodes	20, 40, 50, 60, 70, 80, 160.
Simulation time	200s
Mobility model	Group mobility model
Min.speed	0 m/s
Max. speed	10 m/s
Pause time	30s
Mac layer	IEEE 802.11
Application layer traffic	CBR
Battery model	Linear
Routing protocol(s)	LANMAR, E-LANMAR

Figure 6. Node placement in terrain.

- Linear battery model[13]

The voltage E and internal resistance R are a function of state of discharge of other parameters represented as

$$E = E_0 - k \cdot f \quad (1)$$

$$R = R_0 - k_R \cdot f \quad (2)$$

Where, E_0 is no load voltage when fully charged.
f is the state of discharge.
R_0 is internal resistance when fully charged.
k, k_R are constants.

4.3 Performance Metrics

- **Throughput:** Throughput is the measure of the number of packets successfully transmitted to their final destination per unit time.
- **Packet Delivery Ratio (PDR):** Packet Delivery Ratio is defined as the ratio of the number of data packets successfully delivered to those generated by the source.

$$PDR = \frac{Received\ packet}{Sent\ packet} * 100 \quad (3)$$

4.4 Throughput

It can be observed from Figure 7, that the proposed scheme in single group mobility model leads to an increase in throughput as the number of node increases. However for the scenario with 80, and 160 numbers of nodes, the throughput reduces to a greater extent in the E-LANMAR and LANMAR. It could be overcome by splitting the total number of nodes into several groups.

4.5 Packet Delivery Ratio

The packet delivery ratio is shown in Figure 8, for the single group of nodes both E-LANMAR and gives better performance as the number of node increases. There is sudden fall in packet delivery ratio, when the number of nodes increases to 80, 160. The performance could be increased by eliminating redundant messages in the network.

5. Conclusion

In this paper, the energy efficient LANDMARK selection process for E-LANMAR routing protocol in group

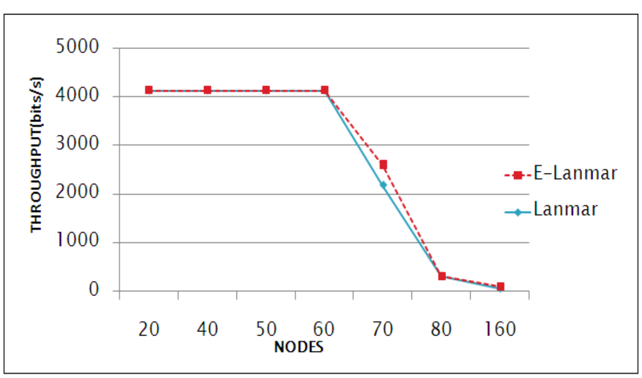


Figure 7. Throughput.

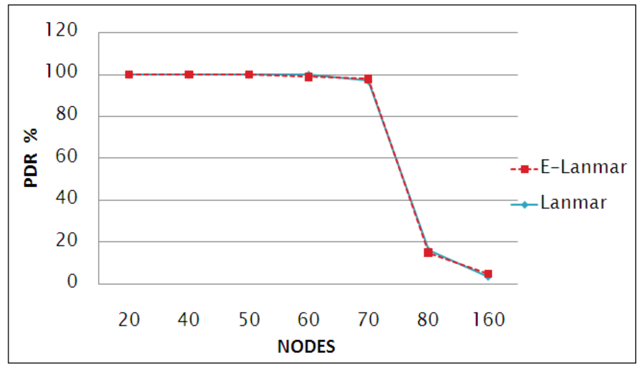


Figure 8. Packet Delivery Ratio.

mobility is presented. The proposed scheme in Group mobility gives better performance in throughput and packet delivery ratio in moderate networks size. Since the need of frequent cluster head (LANDMARK) selection process is not required in group mobility, this model is energy efficient and increases network lifetime. The performance analysis of LANMAR and E-LANMAR protocol in group mobility shows that throughput and PDR for E-LANMAR is better compared with LANMAR routing protocol.

The enhancement of E-LANMAR routing protocol in such a way that it can operate with less overhead and implementable for large area networks is considered as future work.

6. Acknowledgement

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