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A Study the Mobility's Influence on Mobile Ad Hoc Networks Routing Protocols & Energy Consumption

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Abstract- MANET is a self-configuring network of wireless mobile nodes. Since the nodes in a MANET run on batteries, power is a precious commodity. Both the routing technique & mobility model are crucial to MANET performance. A node's mobility, as represented by a mobility model, is a significant factor to consider when assessing an effectiveness of routing protocol. For MANETs to function, it is essential that energy consumption be restricted. The focus of this investigation is on how different mobility models effect the amount of energy consumption by different MANET routing methods. Using NS2, we simulate the energy consumption of various mobility models to compare their relative efficiency.

Keywords- MANET, Routing protocols, Energy Consumption, Mobility Models

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INTRODUCTION

Mobile devices with wireless network interfaces will be crucial to infrastructured and infrastructure-less mobile networks [1]. A wireless local area network based on IEEE 802.11 technology connects a mobile node to a stationary base station through a single-hop wireless link in the most popular infrastructured mobile network. MANET nodes can communicate directly or through intermediaries. A MANET's routing system makes all nodes mobile routers. MANETs are infrastructure-less, self-organizing, fast-deployable wireless networks that are excellent for outdoor events, emergencies, natural disasters, and military operations [2, 3]. Routing in dynamic, scattered MANETs is difficult. Energy-efficient routing may be the most important MANET design parameter since mobile nodes are powered by limited batteries. Mobile nodes can no longer relay packets or serve as nodes if they lose power. This study examines energy use and mobility. MANET simulations often use the Random Waypoint model [4], nodes travel autonomously to a random determined destination with a random set velocity. The Random Waypoint model's popularity in simulations may be attributable, in part, to the relative ease with which it may be implemented. Nonetheless, MANETs have potential in a variety of contexts where complicated mobility patterns are present. As a result, this study employs a variety of mobility models to examine how mobility affects energy use during routing.

ROUTING PROTOCOLS IN MANET

Routing protocol establishes the routing path between source & destination nodes to send data. The various routing methods can be categorized as follows:

Reactive (on-demand) routing protocol

When a node initiates communication with another node, the routing path is determined via reactive routing protocols. The routing table is not updated by these techniques. As a result, it has longer delays [5] but lower communication overheads.

On-demand routing can be achieved with the assistance of ASDSR, a method offered by Natoureah et al. [6]. Since nodes only send control packets when they're needed, control overheads are reduced and battery life is extended. AODV is a loop-free routing approach introduced by Perkins et al. [7]. It can reduce costs and fix the failure paths. The algorithm's efficacy is conditional on the total round-trip delay and the available bandwidth. The scalable & flexible routing method TORA [8] was implemented by Park & Corson. It can function in a extremely variable mobile setting.

Associativity-based routing (ABR) was created by Tohn [9] and is a straightforward example of distributed routing. The identification upkeep of the route in this protocol are based on associativity & stability. This method eliminates the possibility of deadlocks and loops and eliminates the transmission of duplicate data. Signal stability-based adaptive routing (SSBR), which takes into account both location stability & signal strength for distributed routing, was studied by Dube et al. [10]. When numerous routes lead to the same destination, it can pick the one that's going to be the most efficient. Using an ant colony optimization (ACO) algorithm, Gunes et al. [11] presented a novel routing strategy to reduce network overheads.

Proactive (table driven) routing protocol

Table-driven routing protocols store routing information in each node's tables. DSDV, developed by Perkins and Bhagwat [12], is a table-driven routing technique that borrows ideas from the Bellman Ford routing strategy. OLSR was introduced by Clausen et al.[13], which made advantage of link states to do proactive routing. Quantitative OLSR (QOLSR) was first presented by Munaretto & Fonseca [14].

The OLSR-based hierarchical proactive routing system (HOLSR) in MANETs was studied by Gonzalez et al. [15]. It addresses the problems of limited transmission range & bandwidth that plague flat routing. WRP, introduced by Murthy et al. [16], is a form of distributed Bellman-Ford algorithm. Choosing the neighboring node with the lowest cost establishes this route. The STAR was created by Luna & Spohn [17] to define the best routing path in a MANET. Every node in the tree was responsible for determining & saving the best path to all possible destinations. ORA & LORA are both components of STAR. When compared to LORA, the ORA has fewer packet overheads. The hierarchical and decentralized cluster head gateway switch routing protocols (CGSR) were proposed by Chiag et al. [18]. For reliable cluster head selection & channel allocation, it employed least cluster change (LCC).

Hybrid routing protocols

To improve the efficacy of routing, Hybrid routing protocol combines proactive and reactive routing mechanisms. Samer et al. [19] looked into the inter- and intra-zone routing protocol-based ZRP approach. Taking into account the sensor nodes' geographic locations, Joa-Ng & Lu [20] devised a hierarchical link state routing protocol called Zone based hierarchical link state routing protocol (ZHLS). Pei et al. [21] looked into how landmarks and FSR work together during the development process. That one-participant action is misinterpreted as a collective one. Loop-free, scalable, adaptable, & efficient hybrid technique, RDMAR was investigated by Aggelous [22]. There was a phase of finding and keeping your course. The routing mechanism of distributed spanning trees (DST) was investigated by Radhakrishnan et al. [23]. The routing between the source & destination modules made use of DST & hybrid tree flooding. The distributed dynamic routing (DDR) method employed by Nikaein et al. [24] is tree-based but requires no root node. This method relies on frequent beacon communications between neighboring nodes to build a tree structure. Providing route quality information & accurate distance between node and its adjacent node, scalable FSR was proposed by Pei et al. [25]. Hybrid ant colony optimization (HOPNET) was introduced by Wang et al. [26]. In the event of a route failure, it can automatically reroute itself. Collaboration between FSR & ZRP was studied by Yang [27] to boost routing efficiency. In order to adapt to topology changes, Xiaochuan et al. [28] investigated Link reliability based hybrid routing (LRHR), which can move between proactive & reactive routing phenomena. The routing technique proposed by Bamis et al. [29] takes into account the mobility of sensor nodes throughout the routing establishment process.

Hierarchical routing protocols

This section provides various hierarchical routing techniques implemented for mobile networks. Sivakumar et al. [30] used CEDAR that consist of the node group as the MANET to improve network quality. Iwata et al. [31] proposed multi-level, distributed, dynamic cluster based routing technique namely hierarchical state routing (HSR). The HSR routing mechanism resulted in low routing overheads and resourceful exploitation of radio channels to increase the network performance. Eriksson et al. [32] presented an improved scalability aware dynamic addressing in MANET using geo-graphical information of the sensor nodes. Xu et al. [33] investigated hierarchical landmark routing (H-LANMAR) to enhance the scalability of networks where the nodes are categorized in multi-hop clusters.

Multipath routing protocols

Multipath routing techniques establish multiple paths for the routing information from source to target which can be used during routing failure. Data caching technique & shortest multipath routing form the basis of CHAMP, a protocol described by Valera et al. [34]. It has been found to decrease packet loss caused by route failures. On-demand multipath secure multipath routing (secMR) was introduced by Mavropodi et al. [35] to improve routing mechanism security. The rogue node was identified with the help of a key. Liang [36] looked at a system called energy and mobility aware geographical multipath routing (EM- GMR) that takes into account the location, mobility, battery life, & power of individual sensor nodes. They have used 27 rule base for the fuzzy system to establish the connection between two hopes. Ganesan et al. [37] explored Braided multipath routing (BMR) which is capable of finding the alternate path for the established routing path from source to node. Wang et al. [38] presented truth multipath routing protocol (TMRP) to tackle the problem of the non-cooperative nodes during routing. Marina et al. [39] explored loop free AOMDV. The technique is founded on “advertise hop count” which considers maximum allowable hops in the path considered at the sensor node.

Multicast Routing Protocols

Using either a tree-based or a mesh-based strategy, the protocol's source node sends data to numerous receivers. The tree based approach uses the available resources efficiently whereas mesh based approach creates the redundant paths to improve the network throughput.

Jetchera and Johnson [40] presented on-demand Adaptive demand-driver multicast routing (ADMR) that used forwarding trees based on source to monitor the traffic pattern. Ji and Corson [41] proposed a differential destination multicast (DDM) routing protocol in which every node has control over its group sensors. Further, Das et al. [42] proposed DCMP to improve the scalability, efficacy, and to decrease the network overheads. Bur and Ersoy [43] investigated Ad-hoc QoS multicasting (AQM) in which QoSis obtained by maintaining and monitoring the neighbouring nodes. Layuan and Chunlin [44] developed QoS multicast routing protocols for clustering MANET (QMRPCAH) to enhance scalability and flexibility.

Location-aware routing protocols

Using GPS, the position of neighboring nodes can be determined with location-aware routing. The scalability of the network is enhanced as a result.

The nodes' GPS coordinates and transmission rates are gathered via the distance routing effect algorithm (DREAM) described by Basagni et al. [45]. To determine if a node is within the request zone, Ko & Vaidya [46] implemented LAR based direct flooding technique. The wireless MANET proposed by Liu et al. [47] uses a region based routing protocol (REGR) that may set up dynamic regions between the source & destination nodes. It included both the initial setting up of the route & subsequent maintenance. MER, which relies on GPS coordinates, was investigated by Kwon & Shroff [48]. In order to solve the triangular routing problem & blind detouring problem, Kim [49] introduced GLR.

Power-aware routing protocols

The power consumption of nodes in MANETs determines the lifetime & performance of the sensor node. As a result, creating power-aware routing protocols is both important & difficult. Device & energy aware routing (DEAR) was introduced by Avudainayagam et al. [50] for networks with a mix of nodes that run on different energy sources. Three different power-aware algorithms, including CLUSTERPOW, tunneled CLUSTERPOW, & MINPOW, were implemented by Kawadia et al. [51]. Each hop in the path obtained using these methods makes use of its full transmission power potential. The source-originated routing technique that forms the basis of lowest energy hierarchical dynamic source routing (MEHDSR) was developed by Tarique [52].

Table 1 gives the comparative analysis of various major algorithms based on routing type, scalability, reliability, control overheads, presence of loop, and bandwidth.

Table 1: Comparative analysis of various algorithms

Protocol	Routing Type	Scalability	Reliability	Control Overheads	Loop Free	Bandwidth
ASDSR	Reactive (on-demand)	No	Yes	Low	Yes	Limited
AODV	Reactive (on-demand)	No	Yes	Low	Yes	Limited
TORA	Reactive (on-demand)	Yes	Yes	Low	Yes	Limited
ABR	Reactive (on-demand)	No	Yes	Low	Yes	Limited
DSDV	Pro-active	No	Yes	High	Yes	High
OLSR	Pro-active	No	No	High	No	Extremely High
ZRP	Hybrid	Moderate	Yes	Low	Yes	Limited
FSR	Hybrid	Good	No	Low	Yes	High
DREAM	Location aware	No	No	High	Yes	Limited
LAR	Location aware	No	No	High	Yes	Limited
REGR	Location aware	Yes	No	Moderate	No	Moderate
MER	Location aware	No	Yes	High	Yes	Moderate
GLR	Location aware	Yes	No	Moderate	No	Limited
DEAR	Power aware	No	Yes	Moderate	Yes	Limited
CLUSTERPOW	Power aware	Yes	Yes	Moderate	Yes	Limited
MEHDSR	Power aware	Yes	No	High	Yes	Limited

MANETS MOBILITY MODELS

In order to simulate MANETs, mobility models are crucial, actually it gives realistic scenarios to the simulation in terms of location, movement pattern, acceleration, speed, direction. Nowadays, many mobility models are available to carry out the performance of MANET.

Random Waypoint

In this mobility model, a single location is selected at random during simulation, and from that point on, nodes move towards it at varying speeds before stopping for a predetermined amount of time [53]. The simulation runs indefinitely with nodes pausing at predetermined intervals. This mobility model has fixed parameters, such as starting point, node speed, and halt duration, which remain in place until the simulation is terminated. Case study of random waypoint model [54] is depicted in Fig 2.

Random Direction

When a node in this mobility model hits the edge or border of the network, it will stop for a predetermined length of time before continuing to move at a new angle, as demonstrated in Fig.2 [55][56].

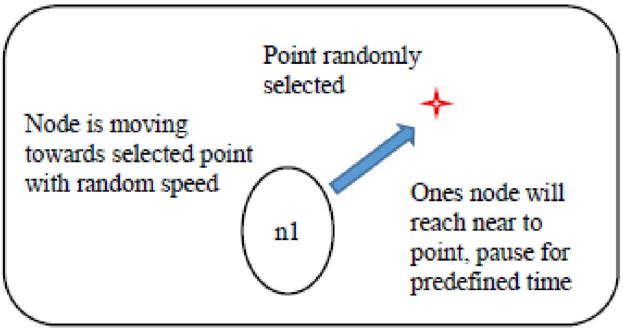

Fig 1: Random Waypoint

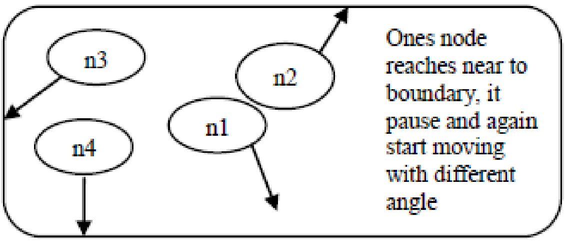

Fig 2: Random Direction Model

Random Walk

The nodes in this model randomly change their speed & direction of movement. In this, a node travels from its present position to the next position by arbitrarily choosing the way and speed with which the node has to travel. In this mobility model ones node reaches near to boundary of network in simulation it will pause for predefined time and bounce back with the angle which depends upon the direction in which it is coming [57][58].

Manhattan Grid Model

This mobility model depicted in Fig. 3 requires nodes to follow a predetermined path in the shape of a grid. The additional parameter added in Manhattan Grid is minimum speed of node, if node is not moving for a specified amount of time then that node is in pause mode. In this model map is used which includes horizontal and vertical lines like a grid. Mobile nodes move on this map, when a node comes across any junction point, it has to wait for a specific amount of time then it will move either in right or left direction or move in a straight way, it depends upon probability. This mobility model is mainly used for vehicles, because it moves either in right, left or straight direction [59][60].

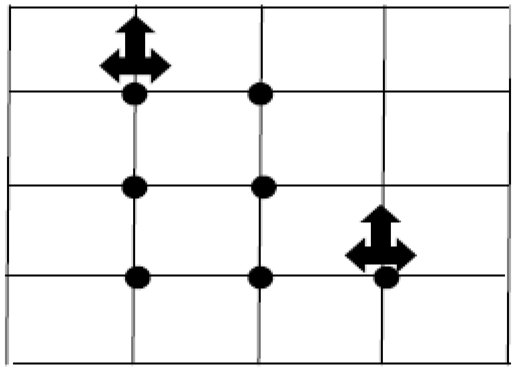

Fig 3: Manhattan Grid Mobility Model

Gauss Markov

Nodes in this mobility model are subject to a random function that determines both their velocity and their heading. The current speed & direction of the node are passed to the random function, which then uses those values to determine the node's future speed & direction. When the direction & velocity of a node are unknown, a random function is used instead [61, 62].

Disaster Mobility Model

In this mobility model disaster area is divided in a grid of hexagonal shapes after that path finder method is used to find the safest path in the disaster area. Some path finder algorithms are Breadth First Search, Dijkstra's Algorithm. In this mobility model in grid each cell has weight value, higher the weight value means that path is safer as compared to other. The weight value is depend on ability to use grid cell effectively [63][64].

INVESTIGATIONAL ANALYSIS & RESULTS

The routing protocols are tested with NS-2 [65], version 2.34 of the network simulator. Spread out over a 1000m*1000m area at a constant 20m/s in speed, the network is made up of a wide variety of nodes. Information is provided in Table 1. Bonn-Motion [66] is another tool utilized to create node motions for various mobility models.

Table 1 Simulator factors

Mobility Model	RWP, RPGM, Manhattan Grid, Gauss Markov
Queue Length	50
Interface Queue	Drop Tail/Priori Queue
Traffic Type	CBR
Number of Connection	70% of the nodes
Packet Rate	8 packets/second
Pause Time	10 seconds
Speed of Nodes	20 m/s
Antenna	Omni directional
Simulation Area	1000m x 1000m
Number of Nodes	10, 20, 30, 40, 50
Initial Node Energy	1000 joules
Simulation Time	900 seconds

Routing protocols' energy consumption behavior has been studied using the following performance measures.

Transmission energy: A network node's packet transmission energy. By adding up the energy each node expends during packet transmission, the total network energy consumption may be determined. The equation characterizes the typical amount of energy transmitted.

$$\text{Average Transmission Energy} = \frac{\text{Total Transmission Energy}}{\text{Total number of nodes}}$$

Receive energy: To receive data from other nodes in a network, a node must expend energy. The amount of the energy used by each node in the network to receive packets from other nodes is the total energy used by the network to receive the packets. The equation defines the average receiving energy consumption.

$$\text{Average Receiving Energy} = \frac{\text{Total Receiving Energy}}{\text{Total number of nodes}}$$

Idle energy: While the network nodes are not actively transmitting or receiving, they are nevertheless using energy. The amount of the energy used by all the nodes in the network while they are doing nothing is known as the idle energy.

$$\text{Average Idle Energy} = \frac{\text{Total Idle Energy}}{\text{Total number of nodes}}$$

Remaining energy: The network nodes' energy at simulation's finish. All the network nodes' remaining energies are added together to get the total remaining energy. If there is a lot of energy left over, the network will likely last longer. In general, the amount of energy that is still available can be calculated using equation.

$$\text{Average Remaining Energy} = \frac{\text{Total Remaining Energy}}{\text{Total number of nodes}}$$

Results for different combinations of nodes, transmission rate (in m/s), and transmission distance are obtained by simulating the routing protocols in NS-2. Metrics for success include total energy used, total energy left over, and averages of both.

Average energy use across four different mobility models is summarized in Figures 4, 5, 6, & 7. Manhattan's mobility model was found to be the most efficient of the four examined for the Average Consumed Energy on the AODV Protocol for Different Models.

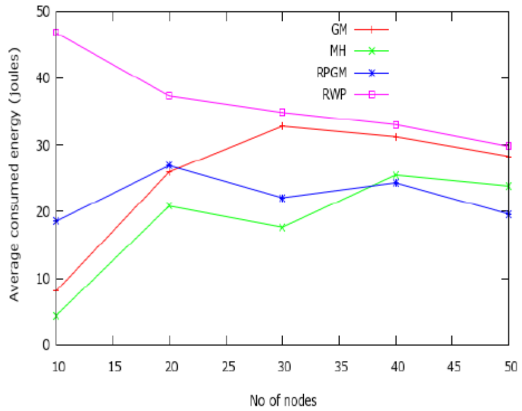

Fig 4 Transmission energy consumption

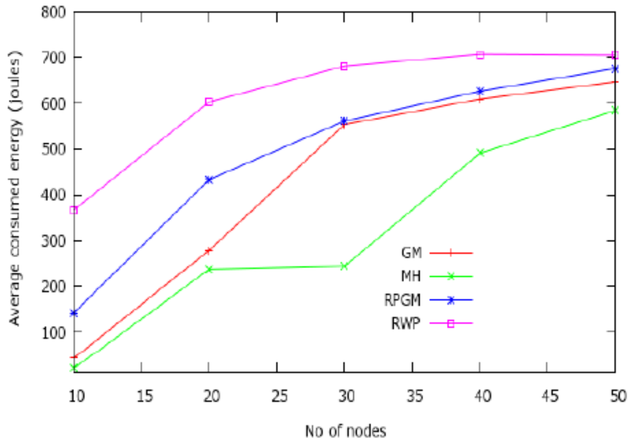

Fig 5 Receive Energy Consumption

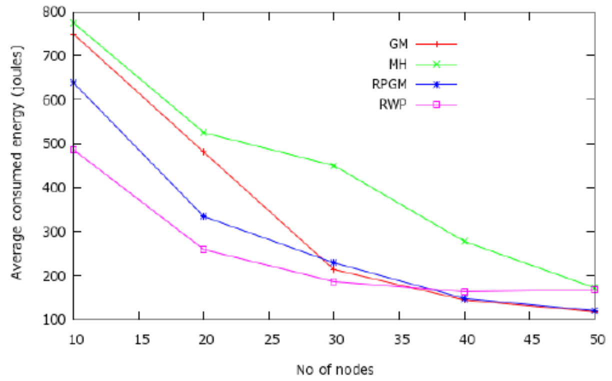

Fig 6 Idle Mode Energy Consumption

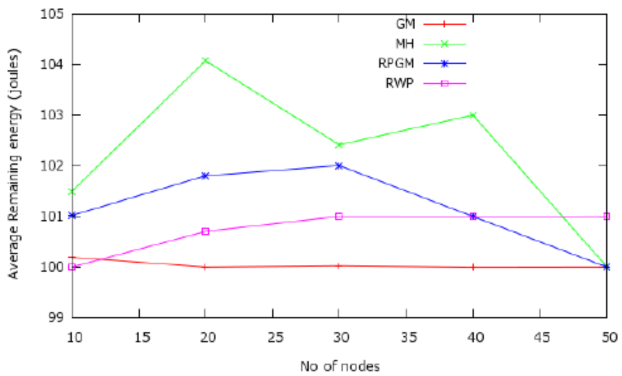

Fig 7 Remaining Average Energy

CONCLUSION

This paper discusses numerous routing protocols, including proactive, reactive, hybrid, hierarchical, multipath, location-based, & geographical protocols. DSR and other reactive routing protocols. Proactive routing methods, such as DSDV & OLSR, make better use of available bandwidth but can be difficult to scale due to their significant control overheads. Energy consumption of routing protocols in MANET has been analyzed in this work by running extensive simulations. The AODV routing protocol has been tested on the RWP, RPGM, Gauss Markov, & Manhattan Grid mobility models, as well as with variable densities of nodes. For this purpose, we used the NS-2 network simulator & Bonnmotion program to produce node movements for various mobility models. In a 1000 by 1000 meter simulated domain, altering the node density from 10 to 50 nodes yielded results for various energy consumption modes. Overall, the Manhattan mobility model is the most successful of the four models examined. It follows that the mobility model used has a significant impact on energy usage, and that the Manhattan grid is the most energy effective mobility model.

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