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Implementation of Power Aware Routing Protocol for Ad-Hoc Network in Matlab

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ABSTRACT

Mobile Ad-hoc NET work (MANET) is an autonomous system of mobile hosts connected by wireless links. The nodes in these networks have several constraints such: limited bandwidth, transmission range and mobility. Another parameter that significantly affects the network performance is the limited battery power of the nodes. This paper proposes a novel routing protocol that considers two parameters: Hop count and Total Transmission loss. On the basis of these two route metrics an optimal path is proposed. The proposed protocol is implemented in MATLAB 2013a and our result also shows that our proposed protocol is better than other standard protocols such as MTPR (Minimum Total Transmission Power Routing) and AODV (Ad-hoc On demand Distance Vector routing).

Keywords: MANET, MTPR, AODV, Hop Count, Transmission loss, Routing Protocols, Power Saving.

1. INTRODUCTION

1.1. MANET "A mobile ad-hoc network (MANET) is a self-configuring network of mobile routers and associated hosts connected by wireless links." [1]. MANET is the new emerging technology which enables users to communicate without any physical infrastructure regardless of their geographical location, that's why it is sometimes referred to as an "infrastructure less" network. Ad hoc networking allows the devices to maintain connections to the network as well as easily adding and removing devices to and from the network. Due to nodal mobility, the network topology may change rapidly and unpredictably over time. The network is decentralized, where network organization and message delivery must be executed by the nodes themselves. Message routing is a problem in a decentralize environment where the topology fluctuates. While the shortest path from a source to a destination based on a given cost function in a static network is usually the optimal route, this concept is difficult to extend in MANET. MANET is more vulnerable than wired network due to mobile nodes, threats from compromised nodes inside the network, limited physical security, dynamic topology, scalability and lack of centralized management. Because of these vulnerabilities, MANET is more prone to malicious attacks

The traffic types in ad hoc networks are quite different from those in an infrastructure wireless network, including:

1) Peer-to-Peer: Communication between two nodes which are within one hop. Network traffic (Bps) is usually consistent.

2) Remote-to-Remote: Communication between two nodes beyond a single hop but which maintain a stable route between them. This may be the result of several nodes staying within communication range of each other in a single area or possibly moving as a group. The traffic is similar to standard network traffic.

3) Dynamic Traffic: This occurs when nodes are dynamic and moving around. Routes must be reconstructed. This results in a poor connectivity and network activity in short bursts.

1.1.2 MANET Features

MANET has the following features:

1) Autonomous terminal

2) Distributed operation

3) Multi-hop routing

4) Dynamic network topology

5) Fluctuating link capacity

6) Light-weight terminals

1.1.3 MANET Advantages

1. Independence from central network administration
2. Self-configuring, nodes are also routers
3. Self-healing through continuous re-configuration
4. Scalable: accommodates the addition of more nodes
5. Flexible: similar to being able to access the Internet from many different locations

1.1.4 MANET Disadvantages

1. Each node must have full performance
2. Throughput is affected by system loading
3. Reliability requires a sufficient number of nodes. Sparse networks can have problems
4. Large networks can have excessive latency

1.2. MANET Challenges

Regardless of the attractive applications, the features of MANET introduce several challenges [24] that must be studied carefully before a wide commercial deployment can be expected. These include:

1) Routing: Since the topology of the network is constantly changing, the issue of routing packets between any pair of nodes becomes a challenging task. Most protocols should be based on reactive routing instead of proactive. Multicast routing is another challenge because the multicast tree is no longer static due to the random movement of nodes within the network.

2) Security and Reliability: In addition to the common vulnerabilities of wireless connection, an ad hoc network has its particular security problems due to e.g. nasty neighbor relaying packets. The feature of distributed operation requires different schemes of authentication and key management. Further, wireless link characteristics introduce also reliability problems, because of the limited wireless transmission range, the broadcast nature of the wireless medium (e.g. hidden terminal problem), mobility-induced packet losses, and data transmission errors [10].

3) Internetworking: In addition to the communication within an ad hoc network, internetworking between MANET and fixed networks (mainly IP based) is often expected in many cases. The coexistence of routing protocols in such a mobile device is a challenge for the harmonious mobility management [10].

4) Power Consumption: For most of the light-weight mobile terminals, the communication-related functions should be optimized for lean power consumption. Conservation of power and power-aware routing must be taken into consideration.

5) Congestion: A critical issue for MANETs is that nodes are normally power constrained and leads huge congestion in the network. The power control problem in wireless ad hoc networks is that of choosing the transmit power for each packet in a distributed fashion at each node. The problem is complex since the choice of the power level fundamentally affects many aspects of the operation of the network [3]. It determines the range of a transmission. Thus determines the magnitude of the interference it creates for the other receivers which causes congestion.

1.3 MANET Applications

With the increase of portable devices as well as progress in wireless communication, ad-hoc networking is gaining importance with the increasing number of widespread applications. Ad-hoc networking can be applied anywhere where there is little or no communication infrastructure or the existing infrastructure is expensive or inconvenient to use. Typical applications include [10, 11]:

1) Military Battlefield: Ad- hoc networking would allow the military to take advantage of commonplace network technology to maintain an information network between the soldiers, vehicles, and military information headquarters.

2) Commercial Sector: Ad hoc can be used in emergency/rescue operations for disaster relief efforts, e.g. in fire, flood, or earthquake. Other commercial scenarios include e.g. ship-to-ship ad-hoc mobile communication, law enforcement, etc.

3) Local Level: Ad hoc networks can autonomously link an instant and temporary multimedia network using notebook computers or palmtop computers to spread and share information among participants at e.g. conference or classroom. Similarly in other civilian environments like taxicab, sports stadium, boat and small aircraft, mobile ad hoc communications will have many applications.

4) Personal Area Network (PAN): Short-range MANET can simplify the intercommunication between various mobile devices (such as a PDA, a laptop, and a cellular phone). Tedious wired cables are replaced with wireless connections. Such an ad hoc network can also extend the access to the Internet or other networks by mechanisms e.g. Wireless LAN (WLAN), GPRS, and UMTS.

2. ROUTING PROTOCOLS DEFINED

Routing is the most fundamental research issue in MANET and must deal with limitations such as high power consumption, low bandwidth, high error rates and unpredictable movements of nodes [22]. Generally, current routing protocols for MANET can be categorized as:

- Proactive (table-driven)
- Reactive (on-demand)
- Hybrid

2.1. Proactive (Table-Driven) Routing Protocols

In proactive routing, each node has one or more tables that contain the latest information of the routes to any node in the network. Each row has the next hop for reaching to a node/subnet and the cost of this route.

Advantage of Proactive protocols is that routes are readily available when there is any requirement to send packet to any other mobile node in the network.

Limitations are as Proactive routing tends to waste bandwidth and power in the network because of the need to broadcast the routing tables/updates. Furthermore, as the number of nodes in the MANET increases, the size of the table will increase; this can become a problem in and of itself.

2.2 Reactive (On-Demand) Protocols

Reactive routing protocols take a lazy approach to routing. They do not maintain or constantly update their route tables with the latest route topology. Instead, when a source node wants to transmit a message, it floods a query into the network to discover the route to the destination. This discovery packet is called the Route Request (RREQ) packet and the mechanism is called Route Discovery. The destination replies with a Route Reply (RREP) packet. As a result, the source dynamically finds the route to the destination. The discovered route is maintained until the destination node becomes inaccessible or until the route is no longer desired.

Advantage These are bandwidth efficient protocols. Routes are discovered on demand basis. Less Network communication overhead is required in this protocol.

Limitations These protocols have very high response time as route is needed to be discovered on demand, when there is some packet to be sent to new destination which does not lie on active path.

2.3 Hybrid Routing Protocols

Both the proactive and reactive protocols work well for networks with a small number of nodes. As the number of nodes increases, hybrid reactive/proactive protocols are used to achieve higher performance. Hybrid protocols attempt to assimilate the advantages of purely proactive and reactive protocols. The key idea is to use a reactive routing procedure at the global network level while employing a proactive routing procedure in a node's local neighbourhood.

The objective of the paper is to design and implement a routing scheme which chooses the most suitable for communication among all the possible paths between source and destination in the ad-hoc environment. The nodes are randomly distributed in the simulation region. The selection of the path is made on the consideration of following parameters.

1. Proper Hop_Count
2. Power optimization
3. Reduced congestion
4. Less end-to-end delay

3. ROUTING PROTOCOLS USED FOR ROUTING UNDER CONSIDERATION

3.1 Minimum Total Transmission Power Routing (MTPR)

Due to considerations such as radio power limitations, power consumption, and channel utilization, a mobile host may not be able to communicate directly with other hosts in a single-hop fashion. Ad hoc networks mostly operated on battery; so the power-efficiency becomes an important issue. To maximize the lifetime of ad hoc networks, the power consumption rate of each node must be minimized. MTPR protocol is the solution for less power consumption in multi-hop communication. We know that, transmission power is proportional to the transmission distance between two neighboring nodes, therefore MTPR protocol always selects a route with minimum total transmission power but with more hops, although the Dijkstra's shortest path algorithm was attempted to be used in MTPR protocol [9].

3.2 Ad hoc On-demand Distance Vector routing (AODV)

Ad hoc On-Demand Distance Vector (AODV) Routing is a routing protocol for mobile ad hoc networks (MANETs) and other wireless ad hoc networks. AODV is the routing protocol used in ZigBee. [23]. It uses shortest path scheme which is based on Dijkstra algorithm [6]. The AODV (Ad-Hoc On-Demand Distance Vector) routing protocol is a reactive routing protocol that uses some characteristics of proactive routing protocols. Routes are established on-demand, as they are needed. However, once established a route is maintained as long as it is needed. Reactive (or on-demand) routing protocols find a path between the source and the destination only when the path is needed (i.e., if there are data to be exchanged between the source and the destination). An advantage of this approach is that the routing overhead is greatly reduced. A disadvantage is a possible large delay from the moment the route is needed (a packet is ready to be sent) until the time the route is actually acquired. In AODV, the network is silent until a connection is needed. At that point the network node that needs a connection broadcasts a request for connection. Other AODV nodes forward this message, and record the node that they heard it from, creating an explosion of temporary routes back to the needy node.

When a node receives such a message and already has a route to the desired node, it sends a message backwards through a temporary route to the requesting node. The needy node then begins using the route that has the least number of hops through other nodes. Unused entries in the routing tables are recycled after a time. When a link fails, a routing error is passed back to a transmitting node, and the process repeats. Much of the complexity of the protocol is to lower the number of messages to conserve the capacity of the network. For example, each request for a route has a sequence number. Nodes use this sequence number so that they do not repeat route requests that they have already passed on. Another such feature is that the route requests have a "time to live" number that limits how many times they can be retransmitted. Another such feature is that if a route request fails, another route request may not be sent until twice as much time has passed as the timeout of the previous route request.

The advantage of AODV is that it creates no extra traffic for communication along existing links. Also, distance vector routing is simple, and doesn't require much memory or calculation. However AODV requires more time to establish a connection, and the initial communication to establish a route is heavier than some other approaches.

SOURCE ADDRESS	REQUIST ID	DESTINATION ADDRESS	SOURCE SEQUENCE NUMBER	DESTINATION SEQUENCE NUMBER	HOP COUNT

Fig 3.1: AODV Route Request Packet

3.3 Hybrid Routing Protocols

Hybrid protocols combine the features of reactive and proactive protocols. These protocols have the advantage of both proactive and reactive routing protocols to balance the delay which was the disadvantage of Table driven protocols and control overhead (in terms of control packages). Main feature of Hybrid Routing protocol is that the routing is proactive for short distances to shorten the routing discovery time and to Reduce the memory size whereas reactive for long distances to reduce the size of the routing table and overhead as long distance destination nodes do not maintain routing information due to large overhead.

Disadvantages

1. Large overlapping of routes.
2. Longer delay if route not found immediately.
3. Core nodes movement affects the performance of the protocol

4. IMPLEMENTATION OF PROPOSED ROUTING SCHEME

Mobile Ad-hoc NETwork (MANET) is an autonomous system of mobile hosts connected by wireless links. The nodes in these networks have several constraints such: limited bandwidth, transmission range and mobility. Another parameter that significantly affects the network performance is the limited battery power of the nodes. On the basis of these two route metrics an optimal path is proposed. Our proposed protocol is better than other standard protocols such as MTPR (Minimum Total Transmission Power Routing) and AODV (Ad-hoc On-demand Distance Vector routing). Here we also proposed a routing scheme which is hybrid of MTPR and AODV. We are of the opinion that MTPR strategy decreases total transmission power but at the same time introduces congestion that can be avoided by AODV routing protocol.

4.1 Proposed Routing Scheme- Here we will explain the concept of proposed routing scheme.

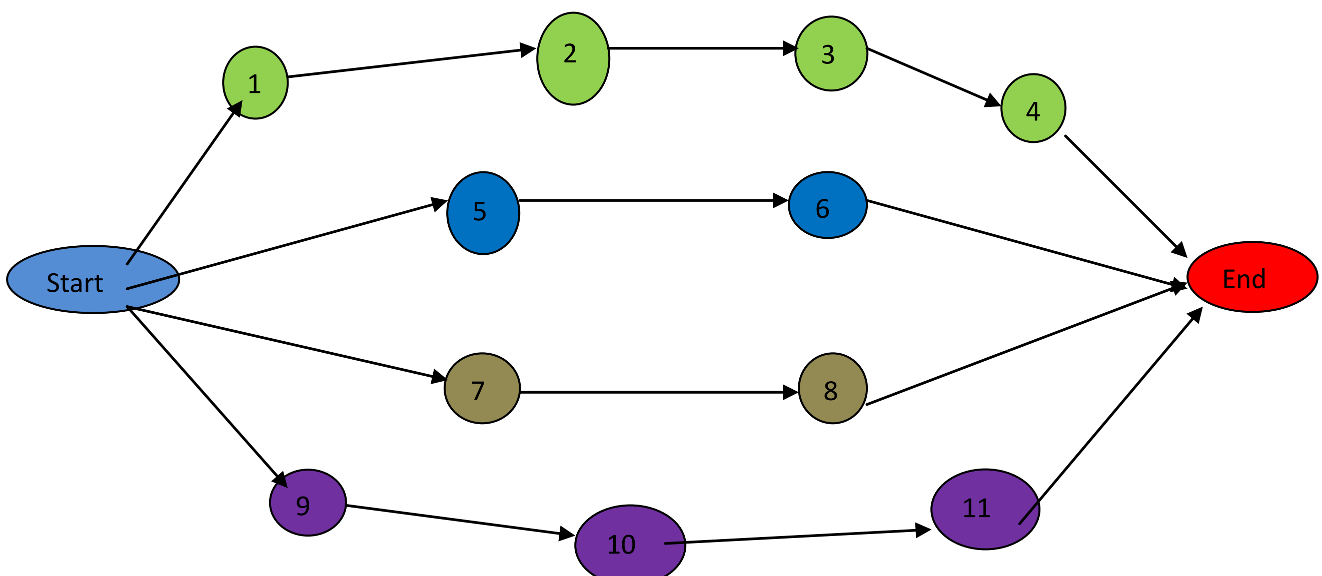


Fig.4.1: Various available paths between source and destination

Let us consider the above given diagram, here Start is SOURCE node and End is DESTINATION node where we want to forward the packet. All 1-2-3-4, 5-6, 7-8, 9-10-11 are various intermediate nodes for various possible paths. The distances between various nodes are given by a path matrix are shown in table 4.1.

Table 4.1: Path matrix for giving distances between various nodes

Nodes	Start	1	2	3	4	5	6	7	8	9	10	11	End
Start	0	20	--	--	--	20	--	10	--	20	--	--	--
1	--	0	15	--	--	--	--	--	--	--	--	--	--
2	--	--	0	15	--	--	--	--	--	--	--	--	--
3	--	--	--	0	15	--	--	--	--	--	--	--	--
4	--	--	--	--	0	--	--	--	--	--	--	--	15
5	--	--	--	--	--	0	5	--	--	--	--	--	--
6	--	--	--	--	--	--	0	--	--	--	--	--	10
7	--	--	--	--	--	--	--	0	20	--	--	--	--
8	--	--	--	--	--	--	--	--	0	--	--	--	5
9	--	--	--	--	--	--	--	--	--	0	20	--	--
10	--	--	--	--	--	--	--	--	--	--	0	20	--
11	--	--	--	--	--	--	--	--	--	--	--	0	5
End	--	--	--	--	--	--	--	--	--	--	--	--	0

It is well known that the total transmission power scales with transmitted distance as d^2 to d^4 depending on environmental conditions. Here we consider total transmission loss is taken as kd^2. The losses of selected paths from source to destination may be as follows:

The path1 (Start-1-2-3-4-End) has total transmission loss as =k (20 * 20 + 15 * 15 + 15 * 15 + 15 * 15+ 15 *15) =1300k units

The path2 (Start-5-6-End) has total transmission loss as =k (20 * 20 + 5 * 5 + 10 * 10) =525k units

The path3 (Start-7-8-End) has total transmission loss as =k (10 * 10 + 20 * 20 + 5 * 5) =525k units

The path4 (Start-9-10-11-End) has total transmission loss as =k (20 * 20 + 20 * 20 + 20 * 20 + 5 * 5) =1225k units

Here we will find mean between MTPR path and AODV path i.e. mean of a path with maximum number of intermediate hops and a path with minimum number of intermediate hops. Here MTPR path is path1 and AODV path is path2 and path3 (any one of them can be consider). Thus mean is given as [(4+2)/2] = 3

Now again difference between number of intermediate node for an adopted path and mean value calculated is considered to select the proposed optimal path. We can easily understand with a table as given below:

Table 4.2: To select optimized path with proper Hop_count and min. transmission loss

Path available	Number of intermediate nodes existed	Mean calculated	Required difference
Path1	4	3	| 4-3 |= 1
Path2	2	3	| 2-3 |= 1
Path3	2	3	| 2-3 |= 1
Path4	3	3	| 3-3 |= 0

Thus path4 (Start-9-10-11-End) with "0" calculated difference is proposed path with minimum power transmission loss as there is proper Hopcount. This path also reduces congestion problem of a network also.

4.2 Algorithm

Hybrid scheme based on MTPR and shortest path uses different performance metrics such as hop count comparision, packet delivery ratio and probability of reliability for all possible pair of source and destination. The algorithm shown under helps in calculating the above mentioned metrics. The nodes considered here are variable. A variable count is used to count the number of paths formed or are feasible. If path exists between Start-End pair the value of *count* variable is incremented by 1. If path exists between Start-End pair then determines all the feasible paths between source destination pair using MATLAB function *Fsible_paths (). Shortest_path (), MTPR_path () and Optimal_path ()* are the functions that are used to determine the Shortest path, MTPR path and optimal path from the feasible paths. Send the packets through each of the above mentioned paths using the function *Send_data ().*This process is repeated for all Start-End pairs. A variable called *Data_packet* is used to find cumulative value of packet received by destination through each of the paths. Finally determine the values of PDR and Average Hop Count values through each of the paths as discussed in the following algorithm:

To calculate various performance metrics

Total Nodes N = variable;

count = Hop_Count =0;

Data_packet_SP=0;

Data_packet_OP=0;

Data_packet_MP=0;

for i =1 to N-1

for j = i+1 to N

if (S-D path exists)

Fsible_paths ()

if Fsible_paths() == Nil

Continue

else

Count ++

end

```
        Shortest_path ()
        Optimal_path ()
        MPTR_path ()
        Data_packet_SP = Data_packet_SP+send_data ()
        Data_packet_OP = Data_packet_OP+send_data ()
        Data_packet_MP = Data_packet_MP+send_data ()
        Hop_Count1 = Hop_Count1+length (shortest_path)-2;
        Hop_Count2 = Hop_Count2+length (optimized_path)-2;
        Hop_Count3 = Hop_Count3+length (MTPR_path)-2;
        end
    end
end
   PDR1 = 2*Data Packets_SP / N / (N-1);

   PDR2 = 2*Data Packets_OP/ N / (N-1);

   PDR3 = 2*Data Packets_MP/ N / (N-1);

   PoR    = 2*Count / N / (N-1);

  Avg_Hop_ Count1 = 2*Hop_Count1/N/ (N-1);

  Avg_Hop_ Count2 = 2*Hop_Count2/N/ (N-1);

  Avg_Hop_ Count3 = 2*Hop_Count3/N/ (N-1);
```

4.3 MATLAB Simulation Parameters

Table4.3 Shows the values of various set up parameters used for simulation purpose in our paper

Table 4.3: MATLAB Simulation Parameters

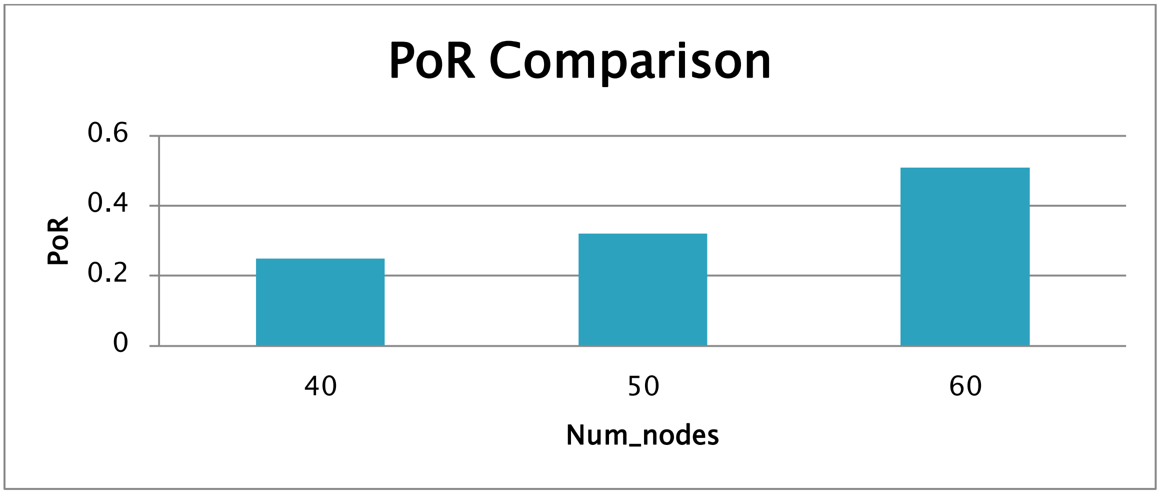
Parameter	Value
Nodes Location	Random
Nodes & Step Size	Varied from 40 to 60 Step size of 10
Routing Algorithm	Dijkstra's Shortest Path Algorithm
Packet transmission time	0.1sec
Mobility Model	Random Walk
Number of packet sent	50
Number of iteration	4
Routing Protocol used	MTPR, AODV,DSR,HYBRID

4.3 Simulation Results

1. **Probability of Reach ability (PoR):** Fig. shows the change in PoR with increase in the nodes concentration.

<u>Inferences</u>

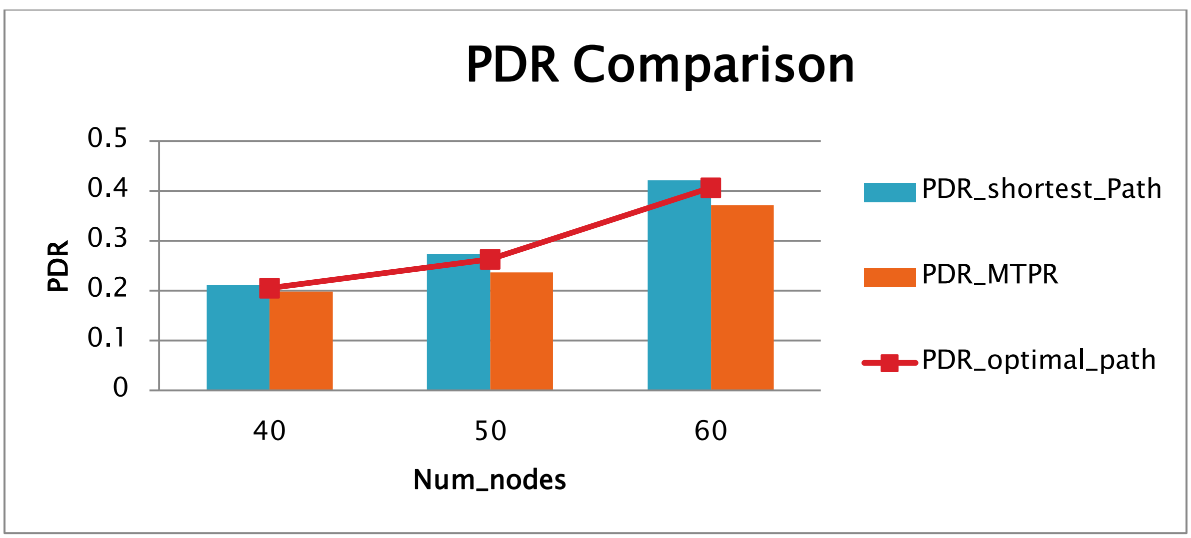
1. Value of PoR increases as the concentration of nodes increases in the simulation region.
2. As the number of nodes increases, the likelihood of path formation between the nodes those are largely separated increases.



Packet Delivery Ratio (PDR) comparison : Fig. shows the change in PDR values for different paths with the increase in the node concentration.

Inferences

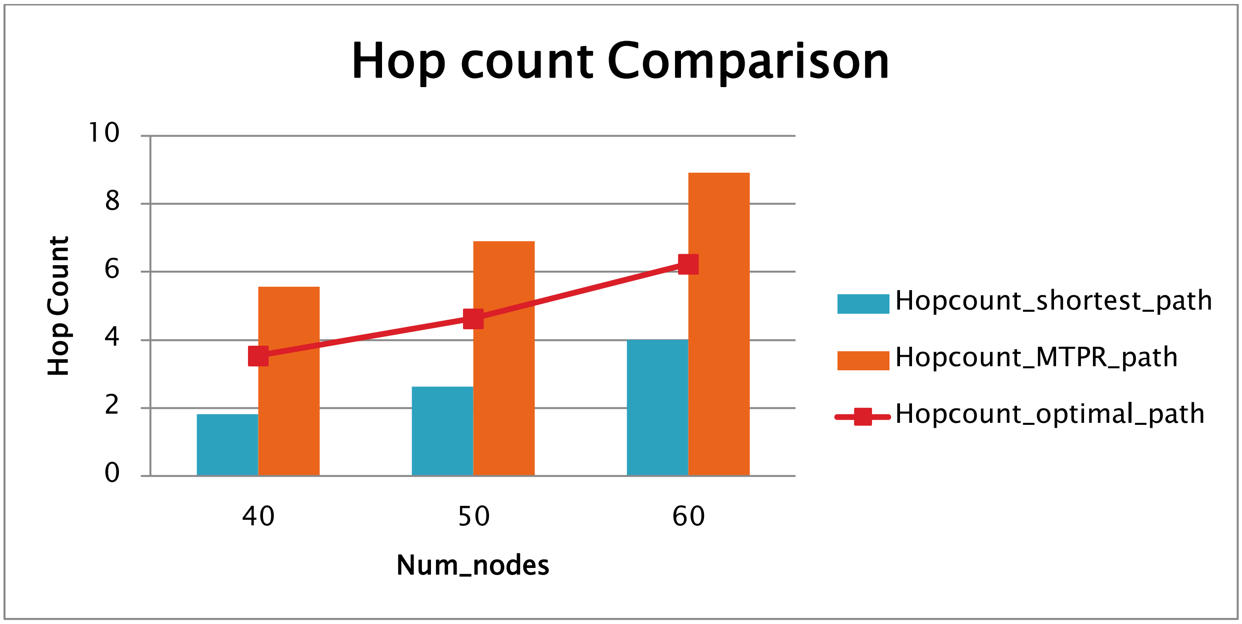
1. As the concentration of the nodes increases the PDR value enhances.
2. The PDR values for different paths are approximately same for node concentration equal to 40.
3. The difference in the PDR values for shortest path and optimal path is small in comparison to the difference in the PDR values of optimal path and MTPR path.



Hop Count Comparison Fig. shows the change in Hop Count values for different paths with the increase in the node concentration.

Inferences

1. Value of hop count for each node concentration is minimum for shortest path and highest in the case of MTPR path and hop count value for optimal path lies between the two.
2. With the increase in the node concentration the value of intermediate nodes (Hop count) involved in the path increases.



5. CONCLUSION AND FUTURE SCOPE

This paper contains two parts: one is *theoretical study* and other is *empirical study*. In theoretical part it is clear that due to the random mobility of node, routing becomes a complex issue. Till now many routing protocols are used in MANET. Each routing protocol has unique features. Based on network environments, we have to choose the suitable routing protocol. Proactive routing protocols are best suited in small networks. In large and dense network, reactive routing approach plays a major role. Reactive routing protocols use destination sequence number and feasible distance to ensure a loop free routing. Hybrid routing protocols use reactive and proactive approach in routing operations

In simulation part, we make a comparison among MTPR, AODV and our proposed scheme using various metrics such as Packet Delivery Ratio (PDR), Hop_Count, Probability of Reachability (PoR). As MTPR follow the path with maximum hops and leads to minimum loss of transmission power but leads to congestion. On the other hand AODV follows shortest path which maximize power loss but less congestion problem is introduced. Thus we proposes a hybrid scheme which follow an intermediate path among these two and leads to minimum transmission power loss along with the congestion problem

Future scope

Ad-hoc networks, the most provoke term in wireless technology, approach to be the emperor of future airs provided the vision of “anytime, anywhere” communications. At present, the general trend is toward mesh architecture and large scale. New applications call for both bandwidth and capacity, which implies the need for a higher frequency and better spatial spectrum reuse. Propagation, spectral reuse, and energy issues support a shift away from a single long wireless link (as in cellular) to a mesh of short links (as in MANET). Research on “multi-hop” architecture showed it a promising solution to the implementation of ad-hoc networks. As the evolvement goes on, especially the need of dense deployment such as battlefield and sensor networks, the nodes in MANET will be smaller, cheaper and capable. Till today there are various issues in MANET, but at what speed new routing strategies are growing, soon ad-hoc networks will reach to its advance stage.

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