The Effect of Number of Hops per Path on Remind Energy in MANETs Routing Protocols

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ABSTRACT

In mobile ad hoc networks (MANETs), routing protocol acting the most important role. In the last decade, Ad hoc On-demand Distance Vector (AODV) routing protocol becomes the attention of focused research on MANETs worldwide. AODV and most of the on demand ad hoc routing protocols use single route reply along reverse path. Rapid change of topology causes that the route reply could not reach to the source node. This increases communication delay and power consumption as well as decrease in packet delivery ratio. To avoid these problems, a Reverse AODV (RAODV) was proposed which tries multiple route replies. Remained energy in RAODV is higher than AODV; even it has sent more data packets to destination. A simulation study is presented to compare number of hops in selected path along rout reply of these two protocols. Results shows in RAODV the data packets meet fewer hops in chosen path and this will effect on remind energy in RAODV to be higher than AODV.

General Terms

Routing Protocols, Algorithms, Ad hoc Networks.

Keywords

Number of hops in path, remind energy, AODV routing protocol, RAODV routing protocol.

1. INTRODUCTION

MANET's consist of mobile platform which communicate with each other through wireless links, without infrastructure base stations. Each node not only is a host but also as a router that maintains routes to and forwards data packets for other nodes in the network that may not be inside direct wireless transmission range. Topology of a mobile ad-hoc network will often change rapidly; this behavior needs some management and solving problem of this type of networks. If source and destination nodes are not within the transmission range of each other, intermediate nodes are needed to serve as intermediate routers for the communication between the two nodes [1].On-demand routing protocol don't exchange routing information periodically. They discover a rout only when it is needed for the communication between two nodes [1, 2]. Moreover, mobile platform moves autonomously and communicate via dynamically changing network. Thus, frequent change of network topology is a main challenge for many important topics, such as routing protocol robustness, and performance degradation [3, 4]. Outline of this paper is as follows: In next section the Ad-hoc On-Demand Distance Vector (AODV) [1] and an optimized version of this algorithm namely Reverse AODV (RAODV) routing protocols are introduced. (R)AODV uses demand-driven route establishment procedures but remind energy in RAODV is higher than AODV; even it has sent more data packets to destination [5]. In third section to find out the reason of this, we provide simulation study. This simulation study compares the total hop count and max hop count of two protocols. The result of compression shows that RAODV has lower total hop count and lower max hop count. It means RAODV chooses shorter path and the data packet from source to destination meet less hop in this between which it can be the cause that RAODV has better performance of AODV on average energy remind. Finally, some conclusions will present in forth section.

2. WIRELESS AD HOC ROUTING PROTOCOLS

This section briefly discuss about properties of Ad-Hoc routing protocols, classification of routing protocols and illustrate the protocols that we investigate. Aexhaustive discussion and comparison of most popular wireless ad hoc routing algorithms is available in B. R. Arun Kumar et al. ,(2008) [6].

2.1 Properties of Ad-Hoc Routing protocols

The properties that are desirable in Ad-Hoc Routing protocols are [7]:

2.1.1 Distributed operation

The protocol should be distributed. It should not be dependent on a centralized controlling node. This is the case even for stationary networks. The dissimilarity is that the nodes in an ad-hoc network can enter or leave the network very easily and because of mobility the network can be partitioned.

2.1.2 Loop free

To improve the overall performance, the routing protocol should assurance that the routes supplied are loop free. This avoids any misuse of bandwidth or CPU consumption.

2.1.3 Demand based operation

To minimize the control overhead in the network and thus not misuse the network resources the protocol should be reactive. This means that the protocol should react only when needed and should not periodically broadcast control information.

2.1.4 Unidirectional link support

The radio environment can cause the formation of unidirectional links. Utilization of these links and not only the bi-directional links improves the routing protocol performance.

2.1.5 Security

The radio environment is especially vulnerable toimpersonation attacks so to ensure the wanted behavior of the routing protocol we need some sort of security measures. Authentication and encryption is the way to go and problem here lies within distributing the keys among the nodes in the ad-hoc network.

2.1.6 Power conservation

The nodes in the ad-hoc network can be laptops and thin clients such as PDA‘s that are limited in battery power and therefore uses some standby mode to save the power. It is therefore very important that the routing protocol has support for these sleep modes.

2.1.7 Multiple routes

To reduce the number of reactions to topological changes and congestion multiple routes can be used. If one route becomes invalid, it is possible that another stored route could still be valid and thus saving the routing protocol from initiating another route discovery procedure.

2.1.8 Quality of Service Support

Some sort of Quality of service is necessary to incorporate into the routing protocol. This helps to find what these networks will be used for. It could be for instance real time traffic support.

2.2 Classification of Routing Protocols

Classification of routing protocols in mobile ad hoc network can be done in many ways, but most of these are done depending on routing strategy and network structure [8] [9] [10]. The routing protocols can be categorized as flat routing, hierarchical routing and geographic position assisted routing while depending on the network structure. According to the routing strategy routing protocols can be classified as Table-driven and source initiated. The classification of routing protocols is shown in the Figure 1.

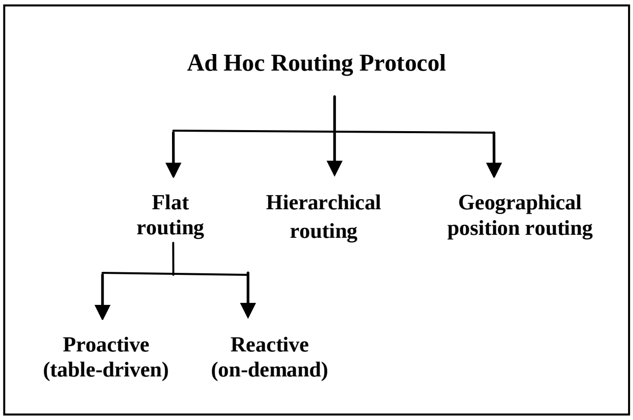

Fig 1: Classification of Routing Protocols in Mobile Ad-hoc Networks [9]

2.2.1 Flat Routing Protocols

Flat routing [9] protocols are divided mainly into two classes; the first one is proactive routing (table driven) protocols and other is reactive (on-demand) routing protocols. One thing is general for both protocol classes is that every node participating in routing play an equal role.

They have further been classified after their design principles; proactive routing is mostly based on LS (link-state) while on-demand routing is based on DV(distance-vector).

2.2.1.1 Pro-Active (Table Driven) Routing Protocols

Proactive MANET protocols are also called as table-driven protocols and will actively determine the layout of the network. Through a regular exchange of network topology packets between the nodes of the network, at every single node an absolute picture of the network is maintained. There is hence minimal delay in determining the route to be taken. This is especially important for time-critical traffic [9].When the routing information becomes worthless quickly, there are many short-lived routes that are being determined and not used before they turn invalid. Therefore, another drawback resulting from the increased mobility is the amount of traffic overhead generated when evaluate these unnecessary routes. This is specially altered when the network size increases. The portion of the total control traffic that consists of actual practical data is further decreased.

Lastly, if the nodes transmit infrequently, most of the routing information is considered redundant. The nodes, however, continue to expend energy by continually updating these unused entries in their routing tables as mentioned, energy conservation is very important in a MANET system design. Therefore, this excessive expenditure of energy is not desired. Thus, proactive MANET protocols work best in networks that have low node mobility or where the nodes transmit data frequently.

2.2.1.2 Reactive (On Demand) Routing Protocols

Portable nodes- Notebooks, palmtops or even mobile phones usually compose wireless ad-hoc networks. This portability also brings a significant issue of mobility.

This is a key issue in ad-hoc networks. The mobility of the nodes causes the topology of the network to change constantly. Keeping track of this topology is not an easy task, and too many resources may be consumed in signaling. Reactive routing protocols were intended for these types of environments. These are based on the design that there is no point on trying to have an image of the entire network topology, since it will be constantly changing. Instead, whenever a node needs a route to a given target, it initiates a route discovery process on the fly, for discovering out a pathway [11].

Reactive protocols start to set up routes on-demand. The routing protocol will try to establish such a route, whenever any node wants to initiate communication with another node to which it has no route. This kind of protocols is usually based on flooding the network with Route Request (RREQ) and Route reply (RERP) messages .By the help of Route request message the route is discovered from source to target node; and as the target node gets a RREQ message it send RERP message for the confirmation that the route has been established. This kind of protocol is usually very effective on single-rate networks. It usually minimizes the number of hops of the selected path. However, on multi-rate networks, the number of hops is not as important as the throughput that can be obtained on a given path [12].

2.2.2 Hierarchical Routing Protocols

As the size of the wireless network increases, the flat routing protocols may produce too much overhead for the MANET. In this case a hierarchical solution may be preferable[11].

2.2.3 Geographical Routing Protocols

There are two approaches to geographic mobile ad hoc networks:

1. Actual geographic coordinates (as obtained through GPS – the Global Positioning System).
2. Reference points in some fixed coordinate system.

An advantage of geographic routing protocols [11] is that they prevent network-wide searches for destinations. If the recent geographical coordinates are known then control and data packets can be sent in the general direction of the destination. This trim downs control overhead in the network. A disadvantage is that all nodes must have access to their geographical coordinates all the time to make the geographical routing protocols useful. The routing updates must be done faster in compare of the network mobility rate to consider the location-based routing effective. This is because locations of nodes may change quickly in a MANET.

2.3 AODV Protocol

AODV is a reactive routing protocol. In this protocol, the nodes use the sequence numbers to avoid loops and take the path information as updated as possible.

ALGORITHM 1. AODV Routing Protocol [1]

```
// S is the source node; D is the destination node
// RT = Routing Table
S wants to communicate with D
If RT of S contains a route to D
        S establishes communication with D
Else
  S creates a RREQ packet and broadcasts it to its
                        neighbors
//RREQ contains the destination Address
  //(DestAddr),
// Sequence Number (Seq) and Broadcast ID (BID)
For all nodes N receiving RREQ
If (RREQ was previously processed)
              discard duplicate RREQ
End if
If (N is D)
  send back a RREP packet to the node sending the
                        RREQ
Else if (N has a route to D with SeqId >
              = RREQ.Seq)
              send back a RREP packet
Else
  record the node from which RREQ was received
                  broadcast RREQ
End if
End for
While (node N receives RREP) and (N != S)
           forward RREP on the reverse path
  store information about the node sending RREP
                      in the RT
End for
S receives RREP
```

When a source node wants to transmit information to a destination node, it sends a RREQ (Route Request) packet in broadcast mode to request a route. If a node sees that it is in the destination field of a RREQ, first it checks that this packet has not been received yet by means of a RREQ register. If it was not registered, it sends the message back and increases the number of hops and creates the route reverse replying with a RREP (Route Reply) packet to confirm the path. For the maintenance of the routes can be used 2 methods: a) ACK messages in MAC level or b) HELLO messages in network.

AODV routing protocol is developed as an improvement to the Destination-Sequenced Distance-Vector (DSDV) routing algorithm [13]. The aim of AODV is to reduce the number of broadcast messages sent throughout the network by discovering routes on-demand instead of keeping complete up-to-date route information. It reduces number of broadcast by creating routes on demand basis, as against DSDV that maintains routes to each known destination [14,11,15]. When source requires sending data to a destination and if route to that destination is not known then it initiates route discovery. AODV allows nodes to respond to link breakages and changes in network topology in a timely manner.

Routes, which are not in use for long time, are deleted from the table. Also AODV uses Destination Sequence Numbers to avoid loop formation and Count to Infinity Problem.

A source node seeking to send a data packet to a destination node checks its route table to see if it has a valid route to the destination node. If a route exists, it simply forwards the packets to the next hop along the way to the destination. On the other hand, if there is no route in the table, the source node begins a *route discovery* process. It broadcasts a *route request* (RREQ) packet to its immediate neighbors, and those nodes broadcast further to their neighbors until the request reaches either an intermediate node with a route to the destination or the destination node itself. This route request packet contains the IP address of the source node, current sequence number, the IP address of the destination node, and the sequence number known last. Figure 2 denotes the forward and reverse path formation in the AODV protocol. An intermediate node can reply to the route request packet only if they have a destination sequence number that is greater than or equal to the number contained in the route request packet header. When the intermediate nodes forward route request packets to their neighbors, they record in their route tables the address of the neighbor from which the first copy of the packet has come from. This recorded information is later used to construct the reverse path for the route reply (RREP) packet. If the same RREQ packets arrive later on, they are discarded. When the route reply packet arrives from the destination or the intermediate node, the nodes forward it along the established reverse path and store the forward route entry in their route table by the use of symmetric links. Route maintenance is required if either the source or the intermediate node moves away. If a source node becomes unreachable, it simply reinitiates the route discovery process. If an intermediate node moves, it sends a *link failure notification* message to each of its upstream neighbors to ensure the deletion of that particular part of the route. Once the message reaches to source node, it then reinitiates the route discovery process.

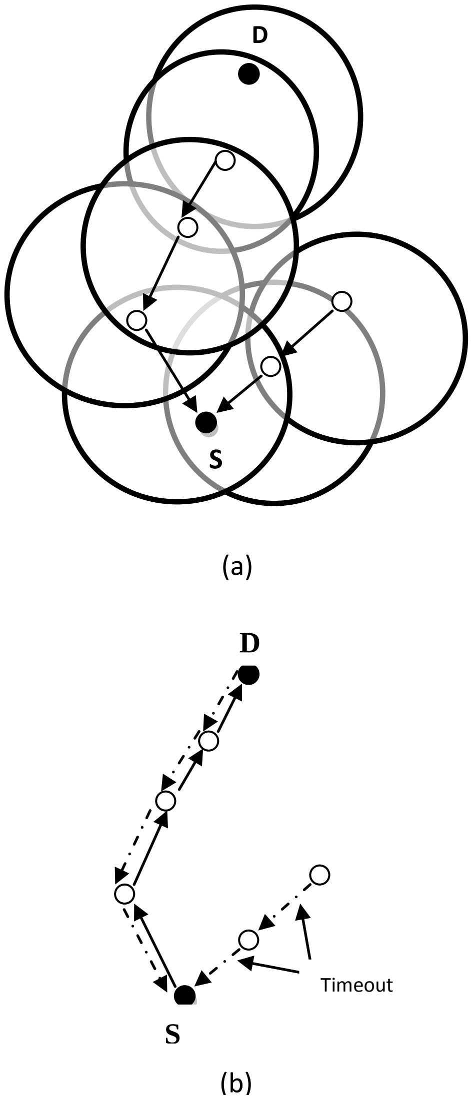

Fig 2: (a) Reverse Path Formation. (b) Forward Path Formation [1]

Local movements do not have global effects, as was the case in DSDV. The stale routes are discarded; as a result, no additional route maintenance is required. AODV has a route aging mechanism; however, it does not find out how long a link might be alive for routing purposes. The latency is minimized due to avoidance of using multiple routes. Integration of multicast routing makes AODV different from other routing protocols. AODV combines unicast, multicast, and broadcast communications; currently, it uses only symmetric links between neighboring nodes. AODV provides both a route table for unicast routes and a multicastroute table for multicast routes. The route table stores the destination and next-hop IP addresses and destination sequence number. Destination sequence numbers are used to ensure that all routes are loop free, and the most current route information is used whenever route discovery is executed. In multicast communications, each multicast group has its own sequence number that is maintained by the multicast group leader. AODV deletes invalid routes by the use of a special route error message called Route Error (RERR).

An important feature of AODV is the maintenance of timer based states in each node, regarding utilization of individual routing table entries. A routing table entry is expired if not used recently. A set of predecessor nodes is maintained for each routing table entry, indicating the set of neighboring nodes which use that entry to route data packets. These nodes are notified with RERR packets when the next-hop link breaks. Each predecessor node, in turn forwards the RERR to its own set of predecessors, thus effectively erasing all routes using the broken link. Route error propagation in AODV can be visualized conceptually as a tree whose root is the node at the point of failure and all sources using the failed link as the leaves [14].

2.4 RAODV Protocol

AODV routing algorithm builds a single loop-free path to each other node on the network [14]. One disadvantage of AODV and most on-demand routing protocols is a route reply message loss. In reverse AODV algorithm this problem concerned and one efficient approach proposed. AODV and most of ondemand routing is based on single route reply message. The lost of route reply message may cause a significant degradation of performance. In rout discovery phase, a route reply message (RREP) of AODV obtains by the spending cost of flooding the entire network or a partial area. RREP loss leads to source node reinitiate route discovery process which causes degrade of the routing performance, like high power consumption, long end-to-end delay and inevitably low packet delivery ratio. In RAODV algorithm, loss of RREP messages considered. In RAODV, destination node uses reverse RREQ to find source node [16]. It reduces path fail correction messages and can improve the robustness of performance. Therefore, success rate of route discovery may be increased even though high node mobility situation.

TYPE	RESERVED	HOP COUNT
Broadcast ID		
Distination IP Address		
Dsitination Sequence Number		
Source IP Address		
Source Sequence Number		
Request Time		

Fig 3: RREQ Message Format

TYPE	RESERVED	HOP COUNT
Broadcast ID		
Distination IP Address		
Dsitination Sequence Number		
Source IP Address		
Reply Time		

Fig 4: R-RREQ Message Format

Route request packet in RAODV like AODV contain following fields where, the source and destination addresses, together with the broadcast ID, uniquely identify this RREQ packet.

When the destination node receives first route request message, it generates reverse request (R-RREQ) message and broadcasts it to neighbor nodes within transmission range. The reverse request packet contains these fields which show in the figure 4.

When broadcasted reverse request packet arrives to intermediate node, it will check for redundancy. If it already received the same message, the message is dropped, otherwise forwards to next nodes and when the source node receives first reverse request message, then it starts packet transmission, and late arrived RRREQs are saved for future use. The alternative paths can be used when the primary path fails communications [11].

3. PREFERENCE RESULT

This section, first describe the simulation environment used in our study and then discuss the results in detail.

3.1 Simulation Environment

Our simulations are implemented in Network Simulator (NS-2) [17]. The simulation parameters are as follows:

- Number of nodes: 10, 20, 30, 40, 50, 60, 70, respectively;
- Testing area: 1000m x 1000m;
- Mobile speed: uniformly distributed between 0 and MAXSPEED (we choose MAXSPEED = 2, 5, 10, 25, 30, 40, 50, 60, 70, 75m/s, respectively);
- Mobility model: random way point model (when the node reaches its destination, it pauses for several seconds, e.g., 1s, then randomly chooses another destination point within the field, with a randomly selected constant velocity);
- Traffic load: UDP, CBR traffic generator;
- Radio transmission range: 250 m;
- MAC layer: IEEE 802.11 and
- Each simulation is run for 100 seconds and repeated for 10 times.

We compare AODV with RAODV.

3.2 Result

To evaluate comparison of RAODV with that of AODV protocol based on number of hops in paths, we compare them

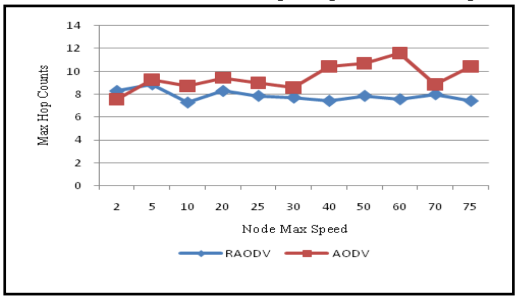

Fig 5: Total Hop Counts, when number of nodes varies

using two metrics:

- Total Hop Counts: sum of all hops which data packets meet from source to reaching destination in paths.
- Max Hop Counts: number of hop in longer path from source to destination.

We can see comparison in two cases: increasing number of node and increasing node max speed.

Figure 5 shows total hop counts of each protocol when number of nodes varies and figure 6 shows total hop counts of each protocol varying node speed.On both of this figure we can see total hop counts in RAODV is less than AODV.

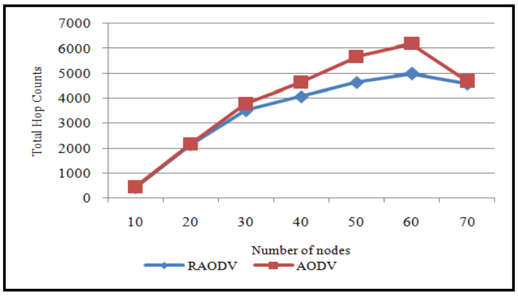

Fig 6: Total Hop Counts, when node speed varies

Figure 7 shows max hop counts where maximum speed of node varies and figure 8 shows max hop counts, when number of node varies.

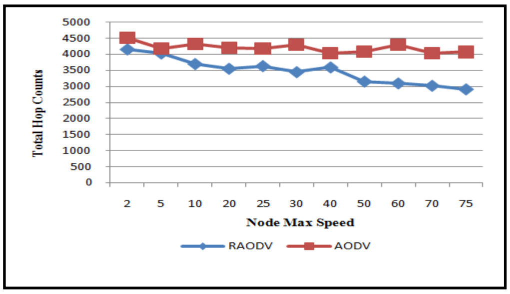

Fig 7: Max Hop Counts, when node speed varies

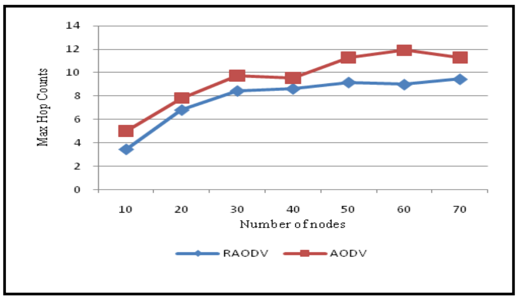

Fig 8: Max Hop Counts, when number of node varies

We can see RAODV has fewer max hop counts than AODV. The reason is AODV chooses route earlier, RAODV chooses recent rout according to reverse request. As fast node mobility causes high topology changes, recently selected path may have better consistency and shortest path, contain fewer hops.

4. CONCLUSION

This paper study the effect of number of hops per path on reminds energy in MANETs routing protocol. We investigate this effect by comparison of the AODV and RAODV routing protocols based on number of hops in path. Result of simulation demonstrates that number of total hops, in chosen paths and number of hops in longer path, in RAODV is less than AODV. In RAODV the data packets meet fewer hops in chosen path and this will effect on remind energy in RAODV to be higher than AODV; even it has sent more data packets to destination. As a future work, researchers may find out the shorter and more stable pathway of communication. This idea capable us to reserve more energy and enhance network transmission speed.

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