Enhanced Expanding Ring Search Algorithm for AODV

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ABSTRACT
Reactive routing protocols like AODV and DSR uses Expanding ring search algorithm for route discovery in MANET. This paper presents enhancement in basic TTL sequence based ERS. This results into faster route discovery, lesser routing traffic and efficient energy operation in MANET. We have considered circular network area with equal node density in entire network. Source and destination nodes are randomly distributed.

General Terms
AODV, MANET, ERS, ROUING TRAFFIC

Keywords
Enhanced Expanding Ring Search

1. INTRODUCTION
A wireless Ad Hoc network is a collection of mobile nodes that form a dynamic, autonomous network. Nodes communicate with each other without depending on any infrastructure (e.g. access points or base stations) [1]. Hence, in these networks each node acts as a host and as a router.

2. AD HOC ROUTING
Network topology in Ad Hoc networks, changes frequently and unpredictably. Such a highly dynamic nature of network, makes routing difficult and complex between mobile nodes. As routing is very important in communication between mobile nodes, study of routing protocols has become area of interest for many. Based on Routing information update mechanism, routing protocols in wireless ad-hoc networks are divided into three groups of proactive (Table-Driven), reactive (On-Demand), and hybrid routing protocols. [1]

In reactive routing protocols, the nodes obtain the necessary path only when it is required using connection establishment process. The main advantage of such protocol is less routing traffic being generated in network and faster route discovery which is very essential in Ad hoc networks. The disadvantage is that the node has to initiate route discovery process before sending the data if it does not have prior information about the same.

3. AD HOC ON-DEMAND DISTANCE VECTOR (AODV) ROUTING PROTOCOL
Ad-Hoc On-Demand Distance Vector (AODV) routing protocol is one of the most popular reactive routing protocols. AODV routing algorithm is very suitable for dynamic self-starting network as needed by users who want to use ad hoc networks. AODV uses an on demand approach for finding routes i.e. route is only established when it is required for sending data by a source. It employs destination sequence number to identify the most recent path. AODV ensures loop-free routes even while repairing broken links. Because the protocol does not require global periodic routing advertisements, the overall bandwidth available that is needed for the mobile nodes is considerably less than in those protocols that do necessitate such advertisements [1].

AODV defined RREQ, RREP, and RERR message types. These messages are received via UDP, and normal IP header processing applies. AODV sends RREQ and gets the RREP as the answer.

AODV uses expanding ring search technique for Controlling Dissemination of Route Request Messages.

In this paper, we describe a method which makes the Expanding Ring Search based route discovery in reactive routing protocol like AODV to be more efficient in terms of route discovery. This method reduces the number of re-transmitting request messages in the route discovery process which results into reduced network overhead.

4. EXPANDING RING SEARCH
Expanding Ring Search (ERS) is used for making the route discovery process be more efficient. The source node is the center of the search ring. ERS successively searches a larger area until the node having needed information being searched is found. To start the discovery of route instead of flooding that sets the TTL value to network diameter, the following steps are followed.

1. The originating node initially uses a TTL = TTL_START in the RREQ packet IP header. Now the originating node waits for the RREP for RING_TRAVERSAL_TIME (2 * NODE_TRAVERSAL_TIME *(TTL_VALUE + TIMEOUT_BUFFER) milliseconds. If the RREP doesn't come, destination is not within the TTL no of hops.

2. The originator broadcasts the RREQ again with the TTL = TTL + TTL_INCREMENT.

3. This continues until the TTL= TTL_THRESHOLD set in the RREQ. After that TTL = NET_DIAMETER is used for each attempt.

Example:

The distance between source and destination is 3 hops.

Steps for sending Route Request

1.
- Using TTL=1 send RREQ
- Wait for RING_TRAVERSAL_TIME

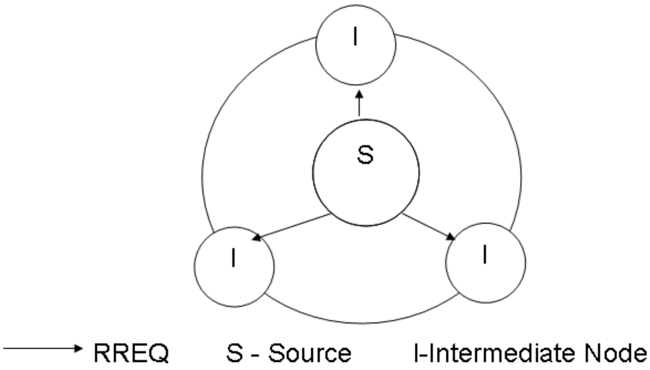

Figure 1 Network with one ring.

2. **No Replay**
- Using TTL=2 send RREQ
- Wait for 2 * RING_TRAVERSAL_TIME

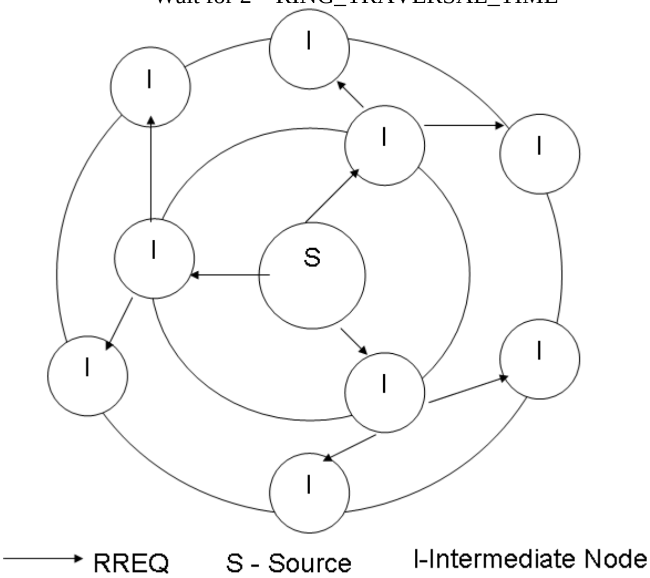

Figure 2 Network with two ring.

3. **No Replay**
- Using TTL=3 send RREQ
- Wait for 3 * RING_TRAVERSAL_TIME

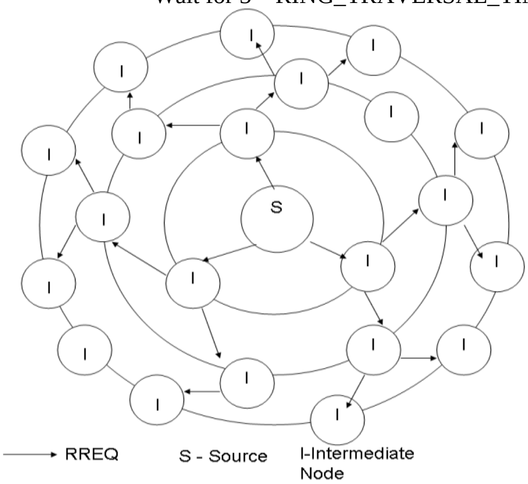

Figure 3 Network with Three ring.

5. ENHANCED ERS

We propose an alternative ERS scheme to support reactive routing protocol such as DSR and AODV and it is called Enhanced Expanding Ring Search (EERS – in short).

Basic route discovery structure of EERS is the same as TTL based ERS protocol but with fixing the initial TTL parameters according to diameter of network. In basic TTL based ERS, route discovery starts with TTL value 1 and then increases as per TTL increase. Once the source sends RREQ it waits for corresponding RREP till a round trip time of the packet i.e. time to travel RREQ from source to node and RREP to travel back from node to source. Node traversal time is the time taken by control packet to reach from one node to other node in its transmission range of the network. So in this case, the round trip time will be 2* Node Traversal time. In this way when TTL is set as 1, the sender will send RREQ to all the nodes which are reachable in its radio range. If we consider the antenna used by sender is unidirectional, this range will be a circle with radius equal to source radio range which we will call as *unit radius*. This makes the first circle in ERS. Now after waiting for RREP as above, if the source not getting any reply, it will send another RREQ with increased wait time which is double the earlier wait time and this continues till RREP is received. This makes the ring expanding each time the radius increased by one unit.

Here we have considered a network as a circle whose radius is in multiple of radio range of the nodes i.e. *unit radius*. Network Nodes in this circle are distributed evenly with same density in entire network. Any node can become source / destination at any time.

While using ERS in route discovery, generating a ring with *unit radius*, there exist various expenses attached to it in terms of delay, routing / control traffic and energy dissipation. We will call this all expenses as unit expense individually i.e. unit delay, unit routing traffic and unit energy dissipation. . Out of these expenses delay is one dimensional i.e. it depends on linear distance between source and destination. Here we have considered delay only as transmission delay and not the other delays like queuing delay, processing delay etc. Routing / control traffic and energy dissipation are proportional to the area of the ring. As we have considered uniform density of nodes throughout the network, as the radius increases i.e. distance from source increases, number of intermediate nodes also increases which will in turn increases generated routing traffic and energy dissipation. Now the area of a ring is proportional to square of its radius, as the radius increases its area increases in square of the radius and routing traffic and energy dissipation expenses will also increase to square of the radius i.e. ring count. So in ERS with first ring there will be total expense of one unit. If the destination is not found in first ring, second search with doubled unit radius. We have assumed TTL initial vale as 1 and TTL increment is also taken as 1. So for every search attempt, radius of the ring will increase by unit radius. Thus the distance doubles and area covered will be 4 times the earlier one. This will make the delay 1 + 2 = 3 units and routing traffic and energy expenses 1 + 4 = 5 units for searching a destination in second ring. In this way for third ring delay will be 1+2+3=6 units and routing traffic and energy expenses will be 1+4+9 = 14units and so on. Table 1 shows delay expense and routing traffic and energy expenses in ERS for ring count from 1 to 10.

ERS	Linear Distance	Delay	Area	Routing Traffic	Energy Dissipation
1st Ring	1	1	1	1	1
2nd Ring	2	3	4	5	5
3rd Ring	3	6	9	14	14
4th Ring	4	10	16	30	30
5th Ring	5	15	25	55	55
6th Ring	6	21	36	91	91
7th Ring	7	28	49	140	140
8th Ring	8	36	64	204	204
9th Ring	9	45	91	295	295
10th Ring	10	55	100	395	395

Table1. Various expenses in Units in ERS

We have suggested an enhancement into the above scheme by deciding initial value of TTL depending on the diameter of network. The name of EERS is based on the initial TTL value set e.g. for initial TTL value 2 it is called as EERS – 2. In this new scheme, instead of setting initial TTL value as 1, diameter of network is measured in multiple of unit radius and depending on this value, initial TTL value is selected. After initializing TTL, source sends RREQ with RREQ propagating till TTL times unit radius. If corresponding RREP is not found in waiting time, TTL is incremented by one and process continues further.

For example in EERS 2, initial TTL value is taken as 2 and accordingly waits time is selected. If RREP is not received within this wait time, TTL is incremented by TTL Increment which is 1in this case. This goes on from ring 3 to ring 10. Similarly for EERS 3 TTL initial value is set as 3, for EERS 4 it is 4 and so on.

Table 2 shows delay expense for various EERS schemes

	ERS	EERS2	EERS3	EERS4	EERS5	EERS6	EERS7	EERS8	EERS9	EERS10
1st Ring	1	2	3	4	5	6	7	8	9	10
2nd Ring	3	2	3	4	5	6	7	8	9	10
3rd Ring	6	5	3	4	5	6	7	8	9	10
4th Ring	10	9	7	4	5	6	7	8	9	10
5th Ring	15	14	12	9	5	6	7	8	9	10
6th Ring	21	20	18	15	11	6	7	8	9	10
7th Ring	28	27	25	22	18	13	7	8	9	10
8th Ring	36	35	33	30	26	21	15	8	9	10
9th Ring	45	44	42	39	35	30	24	17	9	10
10th Ring	55	54	52	49	45	40	34	27	19	10

Table 2 Delay expenses in units for different EERS

Table 3 shows routing traffic and energy dissipation expenses for various EERS schemes.

	ERS	EERS2	EERS3	EERS4	EERS5	EERS6	EERS7	EERS8	EERS9	EERS10
1st Ring	1	4	9	16	25	36	49	64	81	100
2nd Ring	5	4	9	16	25	36	49	64	81	100
3rd Ring	14	13	9	16	25	36	49	64	81	100
4th Ring	30	29	25	16	25	36	49	64	81	100
5th Ring	55	54	50	41	25	36	49	64	81	100
6th Ring	91	90	86	77	61	36	49	64	81	100
7th Ring	140	139	135	126	110	85	49	64	81	100
8th Ring	204	203	199	190	174	149	113	64	81	100
9th Ring	295	294	290	281	265	240	204	155	81	100
10th Ring	395	394	390	381	365	340	304	297	181	100

Table 3 Routing traffic & Energy dissipation expense in different EERS

We can see that by selecting initial TTL value higher than 1, we incur higher unit cost initially but the same results into benefit as the number of ring traversed by RREQ increased. This will offset the initial cost incurred and will result into better performance.

As shown in the table 2 and 3 for Ring – 5 case i.e. where radius of network is five times the unit radius. In this situation the best scenario will be destination is in radio range of the source and can directly communicate with destination. While the worst scenario will be the destination is in outer most circle i.e. farthest to source. Data will transfer from source to destination in five hops. The linear distance between source and destination can be minimum one ring to maximum five rings. Here we have considered equal distribution and density of nodes in each direction so the probability of finding a destination node in any of the five ring will be same and equal i.e. 0.20. In such situation ERS will incur delay of 35 / 5 = 7 units and hops routing traffic and energy expenses of 105 / 5 = 21 units on average. In the same situation if we employ EERS 3 i.e. for initial TTL value of 3, delay cost will be 28 / 5 = 5.6 unit and routing traffic and energy expenses will be 102 / 5 = 20.4.

On this basis for different radius of the network, various EERS schemes can be proved batter then ERS. Table 4 shows the best suitable EERS schemes for Delay expense.

Radius of Network	**Recommended EERS**	**Benefit over ERS in Unit Delay**
1 Ring	ERS	0
2 Ring	EERS 2	1
3 Ring	EERS 2	1
4 Ring	EERS 3	6
5 Ring	EERS 4	14
6 Ring	EERS 5	26
7 Ring	EERS 6	43
8 Ring	EERS 7	67
9 Ring	EERS 8	98
10 Ring	EERS 9	140

Table 4 Recommended EERS for various networks with amount of benefit over ERS

Similarly for routing traffic and energy expenses, table 5 shows the recommended EERS.

Diameter of Network	**Recommended EERS**	**Benefit over ERS in unit routing traffic & energy dissipation**
1 Ring	ERS	0
2 Ring	ERS	0
3 Ring	ERS	0
4 Ring	EERS 2	6
5 Ring	EERS 3	14
6 Ring	EERS 4	26
7 Ring	EERS 5	43
8 Ring	EERS 6	67
9 Ring	EERS 7	98
10 Ring	EERS 9	140

Table 5 Recommended EERS with various network size.

6. SIMULATION AND RESULTS

To support the above logic of enhanced ERS we have created various scenarios in OPNET [2].

Distance between source and destination node kept changing from one hop to six hops i.e. from 600 meters to 3600 meters. Two sets of scenarios were created. One set of six scenarios used ERS with distance between source and destination increasing from 600 meters to 3600 in the interval of 600 meters and the other set with six scenarios used EERS. In ERS based scenarios, TTL parameters were set as – TTL Start = 1, TTL Increment = 1 and TTL Threshold = 10. Destination can only reply to RREQ was enabled. In EERS based scenarios all the details were similar except the TTL start time was set according to the distance between source and destination as suggested in section V.

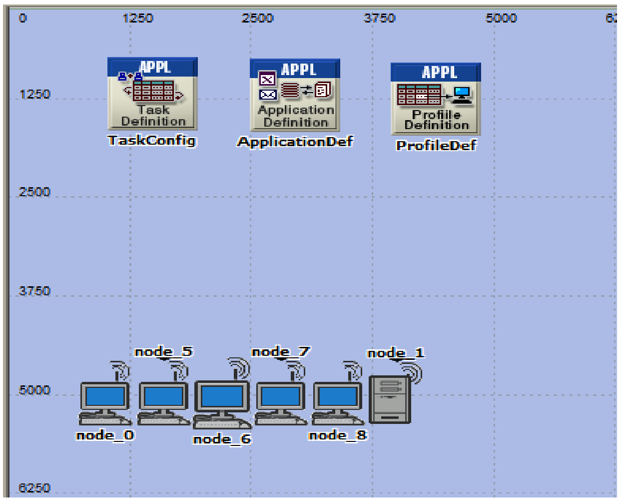

Figure 4 Network topology.

We have selected routing traffic received and sent in entire network as a parameter to observe. Figure 5 shows three pairs of routing traffic received for ring 4, ring 5 and ring 6 in both EERS and ERS scenario. For better understanding different start time for application is chosen in OPNET. It is very clear from the figure that the routing traffic received in EERS is less compared to that received in corresponding ERS.

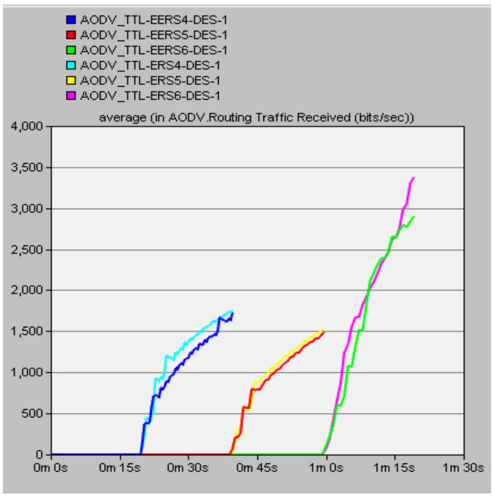

Figure 5 Routing traffic received. (Bits/second)

Similarly for delay we have selected route discovery time as a parameter to observe. Figure 6 clearly shows that delay in all three scenarios is less in EERS compared to ERS.

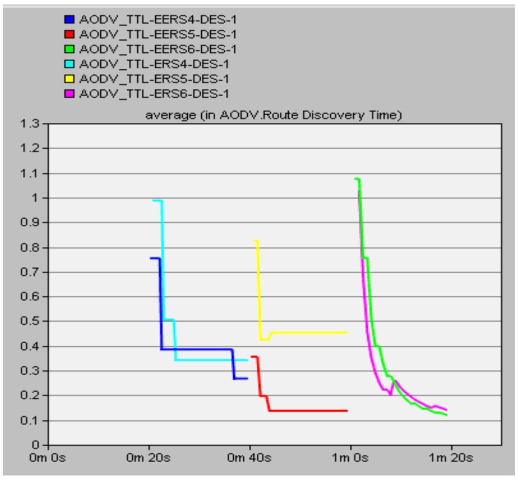

Figure 6 Route discovery time

Both of the above results support our argument presented in section V.

7. CONCLUSION

Here we have presented a modification into famous Expanding Ring Search algorithm. Selecting initial ring size by setting TTL initial value in accordance with diameter of network, various expenses in terms of delay, routing traffic and energy dissipation can be reduced. Above calculations and observations are made considering a circle like network with uniform node distribution and density which may not resemble the actual situation in practice. In future more network shapes and node distributions can be examined.

8. REFERENCES

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