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xMIDURR: A Quality of Service Technique to Save Energy in Mobile Ad hoc Networks

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ABSTRACT

A Mobile Ad-hoc Network (MANET) is a cluster of wireless mobile hosts forming a temporary network without any fixed infrastructure or centralized control.MANET isself-organizing and easily deployable networks. They are mainly suitable for emergencies, natural disasters, military and rescue operations. Energy efficient is one of the key issues in MANET because of highly dynamic and distributed nature of nodes. Since every mobile node has limited power supply, energy depletion has become one of the main threats to lifetime of the MANET. Obviously, it is necessary to send HELLO messages from source node for identifying the neighboring nodes. The source node initiates the Route Request(RREQ) after identifying its nearest neighbors. Energy is wasted in the process of duplication of RREQ and Route Reply (RREP)packets that are sent from source to destination. A technique named MIDURR (Minimize the Duplication of Route Request) is already proposed in the previous work. This paper proposes aExtended MIDURR (xMIDURR) technique and a mathematical model for the same. The mathematical result proves that xMIDURR sends fewer RREQ compared to AODV. In turn, it saves energy in MANET.

Keywords: *MANET, RREQ, RREP, AODV, MIDURR and Energy.*

1. BACKGROUND

Mobile Ad-hoc Network (MANET) is a group of mobile nodes and it has dynamic topology in nature. Due to the mobility of the nodes MANET has nofixedinfrastructure or centralized access points.The node in the network not only acts as hosts but also routers. The main limitation of Ad-hoc system is the availability of Energy. The life of a node is directly relative to the battery power in that node. The key challenge in MANET is to save energy of the nodes and prolong lifetime of a network. In a network, when nodes are establishing the connection,it consumes more energy in route discovery process if the node is out of communication range.From the past decades, a set of Ad-hoc routing protocols are proposed by the Internet Engineering Task Force (IETF). Routing protocols are classified into three types such as proactive, reactive and hybrid.Building suchrouting algorithms poses significant challenges, since the devicesaredistinguished by their restricted resources like battery power, bandwidth, processing delay and memory. MANET has high mobility, where all the mobile nodes are allowed to move in different directions which results in frequent topology changes. The energy is one of the main issues in routing protocol of MANET. Already one technique is proposed in the name of MIDURR for saving the energy which can be found in [1].

This paper is organized as follows. Section 1 explainsthe background ofMANET. Section 2 describes theproposed xMIDURRtechnique, section 3 describes a mathematical model for xMIDURR and Section 4 as conclusion.

2. XMIDURR: A PROPOSED WORK

Ad-hoc On Demand Distance Vector Routing is an expansion of AODV protocol which comes under Reactive protocol. It establishes the route on-demand basis. HELLO messages are sent periodically to identify neighbors. Nodes maintain

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the routing table and use destination sequence numbers for each route entry. The route discovery process is initiated by broadcasting RREQ, when a node wants to send data packets to destination.

Likewise, on receiving RREQ, each node forwardsthem to their neighbors until the destination is reached. Once the RREQ reach the destination, it sends RREP to all the nodes that has sent the RREQ.Route Error packets (RERR) are raised to notify about the broken links during data transmission.Figure 1 shows the RREQ message format of AODV is given below:

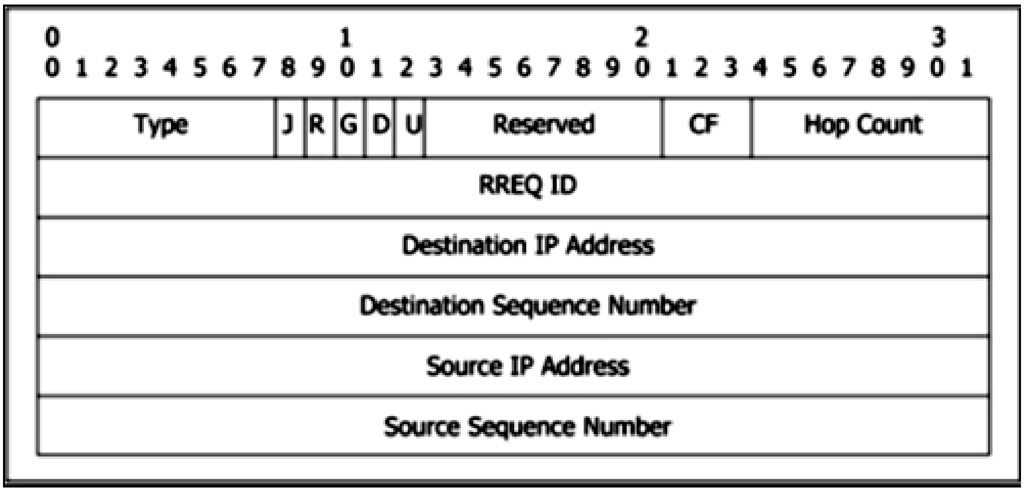

Figure 1: AODV RREQ Message Format

J → Join flag; reserved for multicast.
R → Repair flag; reserved for multicast.
G → Gratuitous RREP flag; indicates whether agratuitous RREP should be unicast to the node specified in the Destination IP Address field.
D → Destination only flag; indicates only the destination may respond to this RREQ.
U → Unknown sequence number; indicates the destination sequence number is unknown.
Reserved → Set as 0; ignored on reception.

2.1 Overview of Proposed xMIDURR Technique

xMIDURRinnovates the existing AODV protocol by introducing a new field called '*Neighbors ID'*by replacing the *Reserved* field.The objective of xMIDURR is to conserve energy of nodes in the network by avoiding broadcast of duplicate RREQ. The authors do not consider the control overhead caused byhosting 'Neighbors ID'. Figure 2 shows the enhanced RREQ message format ofxMIDURR.

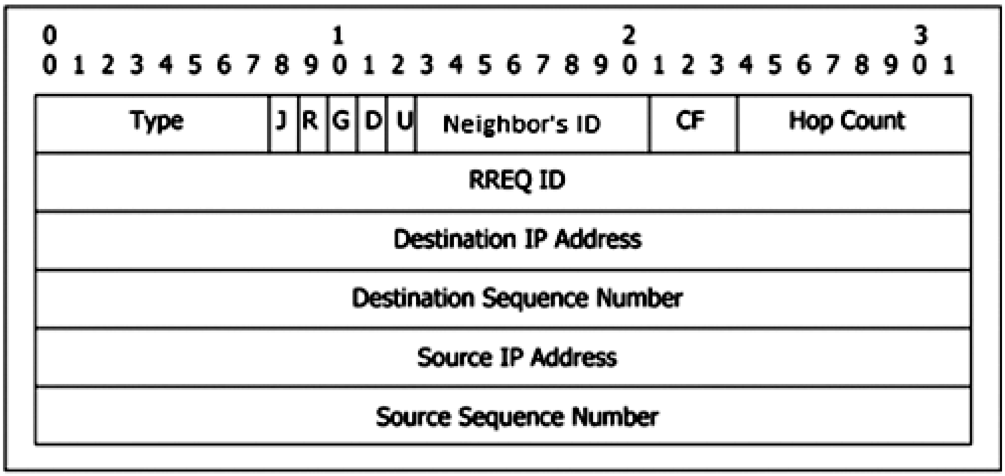

Figure 2: xMIDURR RREQ Message Format

To justify that xMIDURR outperforms AODV the following mathematical model is presented. Figure 3 shows an example network scenario.It has seven nodes A, B, C, D, E, F and G whereA is source node and G isdestination node. Available energy ofevery node is denotedin joules.Nodes B,C and D receive RREQ from the source node A. Nodes E and G receive the RREQfrom node B. Nodes F and G receive RREQ from node D. Unlike AODV, xMIDURR does not allow Nodes C, E and F tosend RREQ, since the RREQ has already been broadcasted by its sibling nodes.

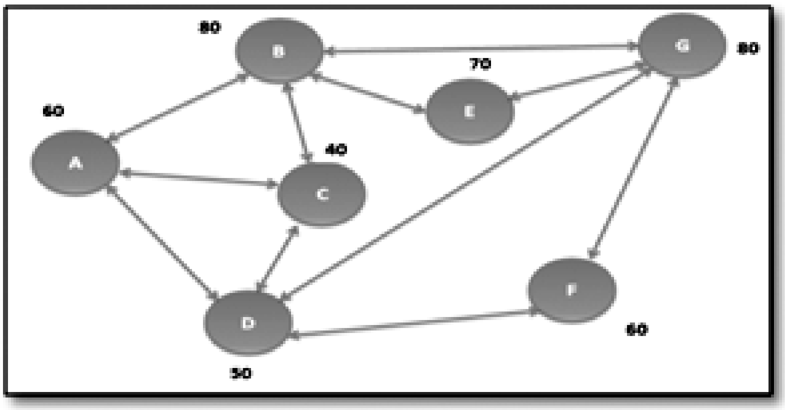

Figure 3: Example Network Scenario

2.2 Existing Protocol (AODV)

In AODV protocol**,** the source node (A) broadcast the RREQ to its neighbors (B, C and D). Likewise, all the nodes send the RREQ to their neighbor nodes until RREPis received from destination node. The set-wise route formulation is shown in Table 1.

Table1.Number of RREQ and Number of Path(s) available in Existing Protocol (AODV)

S.No.	*Sender (s)*	*NeighborsNode(s)*	*RREQReceived*	*No. ofRREQ*	*No. of Path(s) Available*
1	A	B,C,D	B,C,D	3	A→B→G
2	B	A,C,E,G	E,C,G	3	A→B→E→G
3	C	A,B,D	B,D	2	A→C→B→E→G
4	D	A,C,F,G	C,F,G	3	A→D→C→B→E→G
5	E	B,G	G	1	A→D→G
6	F	D,G	G	1	A→D→F→G
7	—	—	—	—	A→C→D→F→G
8	—	—	—	—	A→B→C→D→F→G
9	—	—	—	—	A→C→D→G
10	—	—	—	—	A→B→C→D→G
			Total =	**13**	

xMIDURR tries to reduce the duplication of RREQ and thus overcomes nodes broadcasting the same RREQ again and again. xMIDURR identifies the siblings of each node and intelligently understands the availability of RREQ in the sibling nodes.

The set-wise route formulation of xMIDURR is shown in Table 2.Here, the source node (A) broadcasts the RREQ to its neighbors (B, C and D). B sends RREQ to its neighbors except C because B knows that C is one of its siblings. Similarly, all the nodes check their siblings and forwards RREQ accordingly.

Table 2: No. of RREQ's and No. of Path(s) available in Proposed Technique (xMIDURR)

S.No.	*Sender (s)*	*NeighborsNode(s)*	*RREQReceived*	*No. ofRREQ*	*No. of Path(s) Available*
1	A	B,C,D	B,C,D	3	A→B→G
2	B	A,C,E,G	E,G	2	A→D→G
3	C	A,B,D	—	0	—
4	D	A,G,F,C	F,G	2	
5	E	B,G	—	0	—
6	F	D,G	—	0	—
			Total =	7	

3. MATHEMATICAL MODEL

While xMIDURR is an extended version of MIDURR technique, it is momentous to prove the efficiency of the technique with respect to traditional methods. In this view, a mathematical model is proposed to justify the performance of xMIDURR.

3.1 Basic Preliminaries

The following sets are used to calculate the number of RREQ in AODV protocol

A = {B, C, D}
B = {E, C, G}
C = {B, D}
D = {C, F, G}
E = {G}
F = {G}

The following sets are used to calculate the number of RREQ in xMIDURRtechnique

A = {B, C, D}
B = {E, G}
D = {F, G}

An important principle in power control protocol design is that receive Energy consumption CANNOT be ignored. In this respect we need to consider the researches in [21], [22] to give more detailed Energy consumption discussion. The Energy consumption of broadcasting RREQ can be explained with the below simple scenario shown in figure 4: [23]

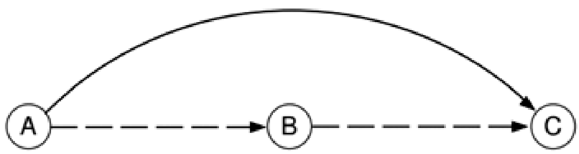

Figure 4: Scenario for RREQ Broadcasting

In broadcasting to a single hop from A to C the consumed Energy P_{AC} can be denoted as

$$P_C = P_{tx:A-C} + P_{rx}$$

Where P_{rx} is the constant Energy (0.68 Joules) taken by the receiver [23]

While Broadcasting to B and C, the Energy consumed by the link A-B and A-C is

$$P_{BC} = P_{tx:A-B} + P_{rx} + P_{tx:A-C} + P_{rx} [23]$$

The optimal position of B is at the middle point between A and C. If we assume that the path loss factor of radio propagation $\alpha = 4$, i.e.,

$P_{tx:A-B} = P_{tx:B-C} = (½)^4 P_{tx:A-C}$, and $P_{rx} = 0.68P_{max}$

the following Energy consumed is intended:

$P_{AC} = 1.68P_{max}$ [23]

3.2 Energy Calculations

Based on the preliminary presented in 3.1, the following mathematical model is presented for xMIDURR to check its performance. Considering the scenario presented in Figure-3, the Energy consumption is calculated for AODV and xMIDURR.

3.2.1 Energy Consumption in AODV

$P_{BCD} = P_{tx:A-B} + P_{rx} + P_{tx:A-C} + P_{rx} + P_{tx:A-D} + P_{rx} = 1.68 + 1.68 + 1.68 = 5.04$ Joules

$P_{ECG} = P_{tx:B-E} + P_{rx} + P_{tx:B-C} + P_{rx} + P_{tx:B-G} + P_{rx} = 5.04$ Joules

$P_{BD} = P_{tx:C-B} + P_{rx} + P_{tx:C-D} + P_{rx} = 3.36$ Joules

$P_{CFG} = P_{tx:D-C} + P_{rx} + P_{tx:D-F} + P_{rx} + P_{tx:D-G} + P_{rx} = 5.04$ Joules

$P_{G} = P_{tx:E-G} + P_{rx} = 1.68$ Joules

$P_{G} = P_{tx:F-G} + P_{rx} = 1.68$ Joules

Total Energy Consumption by AODV = 21.84 Joules.

3.2.2 Energy Consumption in xMIDURR

$P_{BCD} = P_{tx:A-B} + P_{rx} + P_{tx:A-C} + P_{rx} + P_{tx:A-D} + P_{rx} = 1.68 + 1.68 + 1.68 = 5.04$ Joules

$P_{EG} = P_{tx:B-E} + P_{rx} + P_{tx:B-G} + P_{rx} = 3.36$ Joules

$P_{FG} = P_{tx:D-F} + P_{rx} + P_{tx:D-G} + P_{rx} = 3.36$ Joules

Total Energy Consumption by xMIDURR = 11.76 Joules.

The comparison chart is shown in Figure-5.

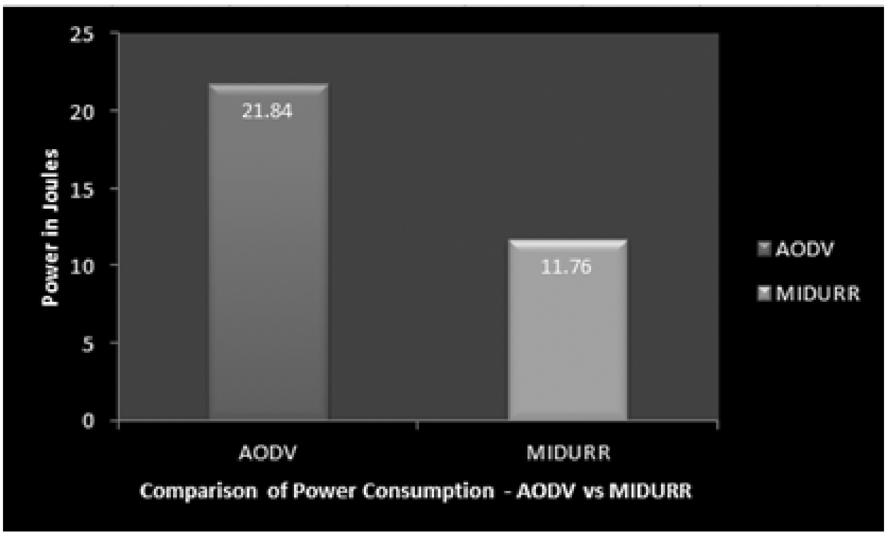

Figure 5: Comparison of Energy Consumption

It is seen from the above chart that xMIDURR uses less Energy compared to AODV protocol. This is achieved by avoiding broadcast of duplicate RREQ.

4. CONCLUSION

Nodes are broadcasting RREQ to all its neighbors for establishing connection from source to destination**.** Energy consumption is one of the main issues in MANET routing protocol. The energy depletion is more when nodes are sending duplicate RREQ and RREP. In order to overcome this issue, xMIDURRtechniqueis proposed to save energy in MANET. The Mathematical model proposed in this paper justifies the fact thatxMIDURR consumes less Energy than AODV. Certainly, the Quality of Servicein Mobile Ad hoc Network is enhanced.

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