Intelligent Routing Protocol for Ad Hoc Wireless Network

Chaorong Peng Chang Wen Chen
cpeng@fit.edu cchen@fit.edu
Dept. of ECE, Florida Institute of Technology, Melbourne, FL 32901

ABSTRACT

A novel routing scheme for mobile ad hoc networks (MANETs), which combines hybrid and multi-inter-routing path properties with a distributed topology discovery route mechanism using control agents is proposed in this paper.

In recent years, a variety of hybrid routing protocols for Mobile Ad hoc wireless networks (MANETs) have been developed. Which is proactively maintains routing information for a local neighborhood, while reactively acquiring routes to destinations beyond the global. The hybrid protocol reduces routing discovery latency and the end-to-end delay by providing high connectivity without requiring much of the scarce network capacity. On the other side the hybrid routing protocols in MANETs likes Zone Routing Protocol still need route "re-discover" time when a route between zones link break. Sine the topology update information needs to be broadcast routing request on local zone. Due to this delay, the routing protocol may not be applicable for real-time data and multimedia communication.

We utilize the advantages of a clustering organization and multi-routing path in routing protocol to achieve several goals at the same time. Firstly, IRP efficiently saves network bandwidth and reduces route reconstruction time when a routing path fails. The IRP protocol does not require global periodic routing advertisements, local control agents will automatically monitor and repair broke links. Secondly, it efficiently reduces congestion and traffic "bottlenecks" for ClusterHeads in clustering network. Thirdly, it reduces significant overheads associated with maintaining clusters. Fourthly, it improves clusters stability due to dynamic topology changing frequently.

In this paper, we present the Intelligent Routing Protocol. First, we discuss the problem of routing in ad hoc networks and the motivation of IRP. We describe the hierarchical architecture of IRP. We describe the routing process and illustrate it with an example. Further, we describe the control manage mechanisms, which are used to control active route and reduce the traffic amount in the route discovery procedure. Finial, the numerical experiments are given to show the effectiveness of IRP routing protocol.

Keywords: Hybrid, multi-routing path, ClusterHead, Routing protocol, ad hoc wireless.

1. INTRODUCTION

Ad hoc wireless networks consist of peer-to-peer wireless mobile nodes that capable of communication with each other without fixed infrastructures. The intermediate nodes often change dynamically and arbitrarily. If a sender, who wants to communication with another node, is outside the radio communication range, the sender must utilize one of routing protocols to discovery routing path and the intermediate nodes act as router forwarding data packets to the destination nodes. Frequent information exchanges occur to consume communication resources including bandwidth and power.

Various design choices are available for designing routing protocols for ad hoc wireless network [1] including: (1) flat vs. hierarchical (2) proactive vs. reactive vs. hybrid. In the flat networks, each node can be used to forward packets between arbitrary source and destination. Therefore, the flat networks reduce congestion and eliminating possible traffic "bottlenecks" in the network. However, they do not have organization for network comparing with hierarchical network. In the hierarchical networks, such as CGSR [3], nodes are divided into group. The major advantage of hierarchical routing is the drastic reduction of routing table storage in each node and the flooding algorithm. However, the disadvantage is its possible congestion and traffic "bottlenecks" in network.

In proactive routing protocol, such as DSDV [2], CGSR [3], routes to all destination nodes are maintained in a routing table and updated during a period of time. The advantage is its reliability and low delay in communication. The disadvantage is its increased overhead. In reactive routing protocol, such as AODV [4], CBRP [8], a route to a specific destination is computed "on demand". In hybrid routing protocol, it employs both proactive and reactive properties by maintaining inter-cluster information proactively and intra-cluster information reactively. For example, in ZRP [5], DST [6], and DDR [7], a node wants to communication with another node in a routing table, this process is proactive. However, a nodes needs to discover a route for intra-cluster communication, this process is reactive. The advantage of these hybrid protocols is the reduction of overhead comparing with pure proactive protocol and the reduction of delay

Wireless Sensing and Processing, edited by Raghuveer M. Rao, Sohail A. Dianat, Michael David Zoltowski,
Proc. of SPIE Vol. 6248, 62480R, (2006) · 0277-786X/06/$15 · doi: 10.1117/12.665681

Downloaded From: http://proceedings.spiedigitallibrary.org/ on 05/01/2017 Terms of Use: http://spiedigitallibrary.org/ss/termsofuse.aspx

time for searching route time on demand comparing with pure reactive protocol. All this routing schemes for ad hoc networks usually employ single-path routing.

Recently, the research multi-routing path protocol [10, 11] based on the AODV and DSR protocols were developed. Multi-routing path schemes try to reduce route discovery packets so that the communication between source and destination will be continue when a link broken.

Employ a set of paths from source to destination so that the total volume of traffic may be divided and communicated via selected multi-routing path. Also source can perform balance load forwards packets and reduce congestion in network.

In this paper we present a novel Intelligent Routing Protocol (IRP) that is efficient and suitable for multi- routing path in the mobile ad-hoc networks (MANETs). The main ideas of IRP are as follows: A network is divided into clusters with inter-cluster communication and intra-cluster communication controlled by their ClusterHeads. A ClusterHead reply a RREP message to be Intelligent ClusterHead Agent (ICHA). Active multi-inter routing paths are established and controlled by their ICHA. The corresponding ICHA maintains active multi-inter route in its routing table and each active routes maintain its route table for entry routing path information into packets. Thus, IRP will provide flexible and active multi-inter routing paths utilizing a hybrid routing protocol. Each intermediate ICHA will be used to reply path to exchange routing information in network. The ICHA automatically reconstruct active inter route if a link fails. So that it reduces the number of route reconstructions Request and Reply messages for the source to destination. The source flexibly chooses multi-inter routing path to efficiently gain fault tolerance routing path and reduce route discovery latency.

The remainder of this paper is organized as follows. In Section 2, details on the initialization and cluster definition algorithm for IRP are described. In Section 3, full description of the Intelligent Routing Protocol Algorithms is presented. In Section 4, Experimental results based on Glomosim simulation showing reduced delay time comparing with AOMDV [10] is presented. Section 5 summarize the proposed IRP protocol and present our plans for future.

2. PRIMARY

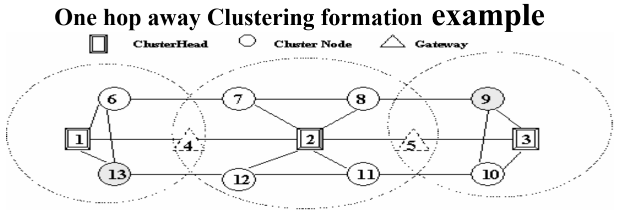
Cluster-based Hierarchical protocol has been known to handle the scalability issue in the ad hoc network (e.g.CBRP, CGRS). ClusterHead need to known topology information from Hello message in an ad hoc network and find the destination's location, computing multi-inter routing path. IRP uses a lowest ID algorithm to choose a node to be ClusterHead and format cluster-based one hop away hierarchical routing scheme.

2.1. Hello Message with Role

Especially here, each node in cluster has different property for IRP routing protocol. We distinguish them with different role which is determined in order of the receiver Hello message from its neighbor nodes.

Initially, each node with undecision role broadcasts its hello message. Utilizing lowest node address to be ClusterHead algorithm and gain a node to be ClusterHead role. Each node listens Hello message from its neighbor node. Receiver ClusterHead message of an undecision node is to be cluster node and broadcasts its hello message with cluster node role. A cluster node received more than one ClusterHead hello message with different address, then; Cluster Node is to be Gateway and broadcasts its hello message with Gateway role.

One hop away Clustering formation example



ClusterNode 8 NTable I.

Nbr_address	Nbr_role	Nbr_CH	NbrTime_out
7	CN	2	Ts
9	CN	3	Ts
2	CH	0	Ts

Note: CN=ClusterNode; CH=ClusterHead

Figure 1: illustration one-hop away Clustering formation and Neighbor Table maintaining example.

For example in Figure 1: the node 1,2,3 received initial Hello message and compared with sender address to obtain their address lowest in their clustering to be ClusterHead, so they issues Hello message with ClusterHead role to its neighbor, the node 4 received Hello messages from the two ClusterHead 1 and 2 to be gateway. Node 5 received Hello messages

Downloaded From: http://proceedings.spiedigitallibrary.org/ on 05/01/2017 Terms of Use: http://spiedigitallibrary.org/ss/termsofuse.aspx

from the two ClusterHead 2 and 3 to be gateways. Other nodes who received Hello messages of one ClusterHead are to be ClusterNode in network.

2.2. Neighbor Table (NTable) Maintains

Each node knows its neighbor information from neighbor Hello message and maintain neighbor table.

♣ The Node Neighbor Table (NTable) includes < Nbr_Address; NbrRole; NbrCH_Address; NbrTime out>

Where: Nbr_Address = Neighbor node address; NbrRole = Neighbor node with its role. NbrCH_Address = the ClusterHead Address of Neighbor node. The NTable is updated by the periodic Hello messages. A node receives a Hello message from its neighbor nodes and scans through the message's list of entries to obtain one-hop away neighborhood information and two-hop away ClusterHeads of neighbor. If the NbrTime expires, the node did not received Hello message, then, it deleted this neighbor node. For example ClusterNode 8 maintains its Neighbor Table I shown in Figure1.

3. INTELLIGENT ROUTING PROTOCOL

First, to distinguish source node and destination node that is actually different from the Target node and Shooter node as we discussed below. And also Definition control agents in IRP protocol:

(1): A node that wants to communication with another node is called Shooter. And another node is called Target

(2): A ClusterHead send reply request route (RREP) message to its source ClusterHead is called Intelligent ClusterHead Agents (ICHA).

(3): ClusterHead sends a RREP message is called destination ICHA. And received RREP message of ClusterHead is called source ICHA.

3.1. Mechanism Architecture Overview

The proposed IRP can be considered to consist of a collection of five mechanisms: "Table management mechanism" "Reply path discovery mechanism, Multi routing path discovery mechanism, Reply path control mechanism, Routing path control mechanism". The mechanisions are operated by **Intelligent ClusterHead Agents (ICHA**) in IRP protocol. The mechanism architecture diagram shown in Figure 2:

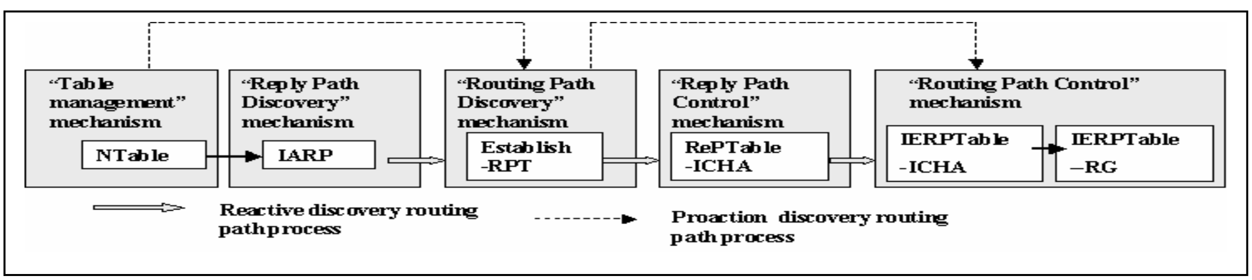


Figure 2: Mechanism Architecture Overview

.

❖ In the" Table management mechanism" includes one neighbor table: each node maintains its neighbor nodes information with their role to provide its neighbor nodes information and knows the topology network changing frequently .The ICHA will maintain one-hop neighbor nodes, two-hop away adjacent nodes information for establishing multi routing path in network.

❖ In the "Reply Path Discovery Mechanism" includes an Intra Routing Path Protocol (IARP) which include two phase: route request route path phase (RREQ), route reply request route phase (RREP), utilizing the route request message to obtain reply path. Destination utilizes reply path to deliver reply route request packets (RREP) with appending its routing information to source ICHA via reply path. Also the reply path will be used to exchanging information between the ICHA if new routing path information is generated by ICHA.

❖ In the "Multi Routing Path Discovery Mechanism" includes an Establishing Route Path Protocol (Establish-RTP) to determine multi routing path. The Establish-RTP protocol includes two phases: Request Inter Route Message (ReqIER) and Reply Inter Route Message (RepIER) to discovery multi inter routing path in ICHA dominating clustering. And utilizing multi routing path properties to determine multi routing path which is from the Shooter to Target in network.

Downloaded From: http://proceedings.spiedigitallibrary.org/ on 05/01/2017 Terms of Use: http://spiedigitallibrary.org/ss/termsofuse.aspx

❖ In the “Reply Path Control mechanism”, utilizing IARP to maintain a reply path table (RePTable-ICHA) in each ICHA to ensure communication between ICHAs when they need to exchange routing information.

❖ In the “Routing Path Control mechanism” includes two tables: Inter Route Path Table in ICHA (IERPTable-ICHA) which ICHA maintains active routing in its dominating clustering to monitor and control active route. Another table is an Inter Route Path Table (IERPTable-RG) which entries its IERPTable-RG into packets and ensure that packets will be delivered throughout in ICHA’s dominating clustering.

3.2. Shooter Query Routing Information

Initially, if Shooter node is not a ClusterHead and it needs to communicate with a Target node without routing information, then it will send an Ask message to its ClusterHead to query the routing information. Shooter’s ClusterHead scans its NTable, if the Target is out of the Shooter’s ClusterHead clustering, then, using Establish-RTP and IARP to discovery target and establish multi routing path shown in Figure 2 with reactive determine routing path process. Otherwise, Shooter’s ICHA uses Establish-RTP to establish multi routing path in its dominating clustering from Shooter to Target shown in Figure 2 with proactive discovery routing path process.

♣ The ASK message contains follows field:

<ASK_ID; ASK_#; ShooterCH_Address; Target_Address; Shooter_Address; ASK_Timeout>

Three parameters <Shooter_Address; ASK_ID; Target_Address> uniquely identify a ASK message. ASK_ID is incremented whenever the Shooter node issues a new ASK message with a new Target address. Each time, a ASK message is issued to its ClusterHead, since timeout for the ASK message is reset to the current time plus ASK_Timeout. The ASK # is fresh number of Shooter sending Ask message with same Target_Address. When Shooter’s ClusterHead receives a ASK message from Shooter node, it checks whether Target node is in its NTable. If the target in its NTable, then the Shooter’s ClusterHead just discovery multi routing path in its clustering, otherwise it broadcasts route request message to query route.

3.3. Intra-Routing Path protocol (IARP)

The intra-routing path protocol is a reactive routing process that is divided into two phases: The ClusterHead Route Request phase and the ClusterHead Route Reply Phase. If the Target is outside the Shooter’s ClusterHead, then the Shooter’s ClusterHead broadcast RREQ message to query routes in network.

3.3.1. The ClusterHead Route Request Phase:

In the ClusterHead route request phase, the source ClusterHead broadcasts a route request packet (RREQ) to its peripheral ClusterHeads. If the receiver route request packet of destination ClusterHead knows the Target in its NTable, it responds by sending a route reply back to the source ClusterHead. Otherwise, it continues the process by broadcasting route request packets. In this way, the ClusterHead route request packets spreads throughout whole network. If destination ClusterHead receives several copies of source ClusterHead route request packets, they considered as redundant and are discarded.

♣ The RREQ message contains as follow as

< Broadcast_ID; broadcast_#; ReplyHop_cont#; Target_Address; Shooter_Address; my_Address; RREQ_time out>

The parameters < Broadcast_ID; Target_Address; Shooter_Address; > uniquely identify a RREQ message. When a Shooter or a Target is changed, a new RREQ message generated by the Shooter ClusterHead’s, and Broadcast_ID is incremented whenever the Shooter ClusterHead issues a new RREQ.

The destination ClusterHead obtains RREQ message from the source Gateway broadcasting RREQ message after increasing the ReplyHop_cont#. If destination ClusterHead satisfies the RREQ, it will send a reply packet (RREP) back to the source ClusterHead via source Gateway. Otherwise, it will continue to broadcast the RREQ to its own neighbor nodes after increasing the ReplyHop_cont#.

The reply path information must be accumulated when the ClusterHead request route message is sent through the network. The reply information is recorded in ClusterHead route request packets .The source ClusterHeads and source Gateway forwarding a route request packet appends their address to RREQ packet to reach destination ClusterHead and are maintained in RePTable of destination ClusterHead (detain in 3.3.3). When the RREQ time expire, the Shooter’s ClusterHead re-broadcast RREQ message with increasing broadcast-# number if the Shooter still needs to communicate with Target.

Note: receiver RREQ message of cluster node deleted it. This way is to avoid RREQ message flooding in network.

Downloaded From: http://proceedings.spiedigitallibrary.org/ on 05/01/2017 Terms of Use: http://spiedigitallibrary.org/ss/termsofuse.aspx

3.3.2. The ClusterHead Route Reply Phase

In RREQ message we know that the destination ClusterHead recodes source address which forwards RREQ packets to destination ClusterHead. When the ClusterHead receives and satisfy RREQ message to reply message. By the definition (2,3), the ClusterHead who prepares to reply a message is to be destination ICHA, and receiver reply message of ClusterHead is to be Source ICHA.

♣ The RREP message contains .as follow:

<Reply_ID; Reply_#; ReplyHop_cont#; SrcGN_Address; SrcICHA_Address; myICHA_Address; Shooter_Address; Target_Address; myRouteInfor; Reply_time out >

Where: SrcGN= receiver RREP message of Source Gateway Node; SrcICHA= receiver of RREP message of Source ICHA; myICHA_Address = sender RREQ message of ICHA Address; myRouteInfor= sender Route Information which is provided by the sender RREP of ICHA (detail in 3.4.4)

The parameters <Reply_ID; Target_Address; Shooter_Address > uniquely identify a RREP message. Reply_ID is incremented whenever the destination ICHA issues a new RREP since generated new Target. And the sender ICHA replies message with increasing Reply_# number due to change sender routing information. The ReplyHop_cont# (detail in 3,3,1) is used to determine TTL for reply path.

3.3.3. ICHA Maintains Reply Path Table (RePTable)

Traditional routing protocol uses reply path to be route path. However, In IRP, each ICHA maintains its source ICHA address and destination ICHA address to maintains reply Path for communication between ICHAs. Destination ICHA delivers RREP packets with appending its reply table entries in packets to source ICHA via reply path.

ICHA replies RREP message and maintains a reply path table (RePTable) to provide route information for establishing multi inter routing path in source ICHA dominating clustering.

♣ The Reply Path Table (RePTable) contains as follow:

<Reply_ID; Reply_#; ReplyHop_cont#; SrcGN_Address; SrcICHA_Address; DestICHA_Address; DestGN_Address; Shooter_Address; Target_Address; DestRouteInfor; Reply_time out >;

Where: SrcGN address= receiver RREP message of gateway address; SrcICHA address =receiver RREP message of Source ICHA address; DestICHA address= sender RREP message of destination ICHA address; DestGN address= sender RREP message of gateway address; DestRouteInfor =Destination Routing Information in destination ICHA dominating clustering (more detail in 3.4.4).

This reply path table update depends on ICHA receiving RREQ and RREP message. This reply path table maintains for at least enough time for the Shooter and Target communication in the network. If the ClusterHeads did not receiver RREP message during reply time expiry, then they delete this reply path table.

3.4. Establish Inter Route Path Protocol (Establish-RTP)

In Establish-RTP protocol, we first definition routing path properties for multi inter routing path in ICHA dominating clustering. The Establish –RTP include Request inter Route Phase and Reply Inter Route Path to determine routing path property in each ICHA dominating clustering. And given example to illustration each step about establishing multi routing path process in network.

3.4.1. Request Inter Route Phase

ClusterHead received and satisfy RREQ message, then it needs to reply RREP message and to be ICHA (definition 2,3). Before delivering RREP message, ICHA needs to know one-hop away neighbor nodes information, two-hop away adjacent nodes information and three-hop away ClusterHead of adjacent nodes information. This information will be provided to ICHA determining routing properties in its dominating clustering. ICHA broadcasts Request Inter Route (ReqIER) message and its Cluster nodes received ReqIER message and reply Inter Route (RepIER) packets with appending their NTable entries to ICHA.

Note: receiver ReqIER message of gateway discards it to avoid being active route.

♣ ReqIER message contains as follow:

ReqBroadcast_ID; ReqBroadcast_#; SrcICHA_Address; myRole; my_Address; Reqbroadcast_time out>

The three parameters < ReqBroadcast_ID; SrcICHA_Address; my_address> uniquely identify a ReqIER message.

ReqBroadcast_ID is incremented whenever the ICHA issues a new ReqIER message with a new source ICHA address. Each time, a ReqIER message is issued to its ClusterNode, since timeout for the ReqIER message is reset to the current

Downloaded From: http://proceedings.spiedigitallibrary.org/ on 05/01/2017 Terms of Use: http://spiedigitallibrary.org/ss/termsofuse.aspx

time plus ReqIER_Timeout. The ReqBroadcast # is fresh number of ICHA sends ReqIER message with same Source ICHA Address if the ICHA still need to determine its routing properties.

3.4.2. Reply Request Inter Route Phase:

The receivers ReqIER message of ClusterNodes reply Request Inter Route (RepIER) message with summary their neighbor information in its NTable to its ICHA.

♣ RepIER message includes shown in Figure 3 RepIER message -ClusterNode: this message provide neighbor nodes with their ClusterHeads information of sender of ClusterNodes.

Where: myICHA_Address = ICHA Address which is ClusterNode receive ReqIER message from this ICHA. myNTable_entry = appending my neighbor table entries into RepIER message. (Detail NTable in 2.2). The parameters < RepIER_ID; myICHA_Address; my_Address > uniquely identify a RepIER message uniquely identify a RepIER message. RepIER_ID is incremented whenever ICHA issues a new RepIER new with new NTable entry.

RepIERTable –ICHA (II)	**RepIER message -ClusterNode**
IntNbr_Address =	my_Address
IntNbrRole =	myRole
IntNbrCH_Address =	myICHA_Address
IntAdj_Address =	Nbr_Address
IntAdjRole =	NbrRole
IntAdjCH__Address =	NbrCH_Address
RepIER_ID; =	RepIER_ID;
RepIER_#; =	RepIER_#;
RepIER_time out =	RepIER_time out

Figure 3: ICHA maintains RepIERTable from the RepIER message of ClusterNode sending

Source ICHA maintains Destination Routing Information Illustration.

Source ICHA maintains DestRouteInfor	Destination ICHA sends DestRouteInfor
DestRG =	actDestSuggestRG
DestSrcRG =	actSrcRG
DestPath _ID =	Path_ID
DestPath_# =	Path_#

Figure 4: Destination ICHA sends its routing information to Source ICHA which maintains them in its RePTable.

Each time, a RepIER message is issued to its ICHA, since timeout for the RepIER message is reset to the current time plus RepIER_time out. The RepIER # is fresh number of ClusterNode sends RepIER message with same neighbor table entry.

♣ ICHA Maintain Reply Inter Route Table (RepIERTable):

To illustrate that ICHA will re-build relationship with its neighbor node and adjacent nodes which are obtained from the RepIER message of neighbor nodes. So the ICHA maintains its RepIERTable with given name by ICHA shown in Figure 3 RepIERTable-ICHA (II) and correspondent to RepIER message which is sent by ClusterNode.

The Reply Request Inter Route Table (RepIERTable) contains shown in Figure 3 RepIERTable-ICHA (II). This table update depends on ICHA receiving RepIER message. This RepIERTable maintains for at least enough time for the Shooter and Target communication in the network .If the ICHA did not receiver RepIER message during RepIER time expiry, then this ICHA delete this reply request inter route table.

In particular, whenever ICHA receives a RepIER message from its ClusterNode and scans through the message's list of entries to obtain one-hop away neighborhood cluster nodes, two-hop away adjacent cluster nods and three-hop away ClusterHead of adjacent node.

3.4.3. Definition Multi Routing Path Properties:

ICHA will determine routing path property from the ReqIER and RepIER message to establish multi routing path. Definition multi routing path property contains as follow:

(4): IntNbr node with ICHA address connects with IntAdj node which has a Source ICHA addresses, then this IntAdj nodes is called Destination Suggestion Route Gateway (DestSuggestRG), and this IntNbr node is called Source RG (SrcRG);

(5): IntNbr node with ICHA address is connected between SrcRG and DestRG, this IntNbr node is called Inter Route (IntRoute).

Downloaded From: http://proceedings.spiedigitallibrary.org/ on 05/01/2017 Terms of Use: http://spiedigitallibrary.org/ss/termsofuse.aspx

(6): The ICHA calculates the min route hop number of inter routing path from the DestRG to SrcRG; and determine the disjoin link inter routing path to be active inter routing path. More than one active inter routing path in ICHA dominating clustering is called multi inter routing path.

(7): The each multi inter routing path is located in different ICHA dominating clustering and between two multi inter routing path are connected by the multi route gateways to obtain whole routing path from Shooter to Target in network, this routing path is called multi routing path.

(8): The SrcRG lays on the active inter routing path is called active Source RG (actSrcRG); and connected with DestSuggestRG is called active DestSuggestRG (actDestSuggestRG);

(9): IntRoute lays on active inter routing path is called active IntRoute (actIntRoute).

(10): All nodes lay on the multi routing path are called active routes.

(11): Each active inter routing path has own Path Identify is called (Path_ID).

(12): The number of multi inter routing path is called (Path_#).

(13): The IntRouteHop _cont# in each destination ICHA,

(14): Determine Routing Information:

Each ICHA determine their multi routing path properties in its dominating clustering, the destination ICHA needs to provide suggestion route gateways information which are located in Source ICHA to be used. But, the Source ICHA determines which route gateway is to be active route gateway. Also, the destination ICHA provided active source route gateways and Path_ID, Path_# which are located in Destination ICHA for assisting Source ICHA to determine multi inter routing path in source ICHA dominating clustering.

In 3.2 detain Source ICHA receives RREP message which includes Destination Routing Information (DestRouteInfor). We want to disquisition destination routing information and source routing information which are used in Source ICHA, then, Source ICHA change DestRouteInfor name and maintain them in its ReRPTable shown in Figure4.

3.5. Determine multi inter routing path property and establish multi routing path in network:

ICHA utilizes RePTable and RepIERTable to determine multi routing path properties and then utilizing the definition to obtain multi routing path. We use example to describe this section.

Example In Figure 1 shown that the shooter 13 wants to communication with Target 9 without routing information. In order to IRP protocol, first shooter sends ASK message to its ClusterHead 1 for query routing path information. However, Target-9 is outside NTable of Shooter's ClusterHead-1. Then ClusterHead-1 broadcasts RREQ message to its peripheral ClusterHeads. The destination ClusterHead-3 discoveries Target-9 in its NTable, then it needs to determine its multi inter routing path before reply a RREP message to source ICAH-2. By definition (2,3), the Target's ClusterHead-3 to be ICHA-3, and Source ClusterHead-2 to be ICHA-2 and the ClusterHead-1 to be ICAH-1.Each ICHA determines its multi inter routing path process with example show as follow:

3.5.1. Target's ICHA-3 determines its multi inter routing path:

TStep_1: By Establish-RTP protocol, first, the ICHA-3 broadcasts ReqIER message to its ClusterNode, the cluster node 9 and 10 receive ReqIER message and summary their neighbor information. Then they send RepIER packets with appending NTable entries to ICHA–3. The gateway–5 deleted ReqIER message. The ICHA-3 receives RepIER messages and maintains message information in its RepIERTable-ICHA to obtain neighbor node and adjacent node with their ClusterHeads shown in Figure 5:

TStep_2: By the definition (4): IntAdj-8 with a source ICHA-2 is to be destSuggestRG. And connected with IntNbr-9 is to be SrcRG-9. Similarly. IntAdj-11 is to be destSuggestRG-11 and IntNbr-10 is to be SrcRG-10.

TStep_3: By the definition (6): ICHA-3 calculates the min hop between the SrcRG and DestRG. Due this ICHA is Target's ICHA, in this case, the SrcRG= DestRG=9, the min hop =1; and the DestRG-9 to SrcRG-10 has min hop=2. Since destSuggestRG (9 and 10) is located in source ICHA 2 dominating clustering separately. So the ICHA-3 determine two active inter routing paths (9 and 9->10) and obtain multi inter routing path in its dominating clustering.

TStep_4: By the definition (8): ICHA-3 obtain active route include actSrcRG (9,10); actDestSuggestRG (8; 11).

TStep_5: By the definition (10): ICHA-3 determine active inter routing path 9 has own Path_ID=A; and active inter routing path 9->10 has own Path_ID=B.

TStep_6: By the definition (11): ICHA-3: determines the multi inter routing Path#=2. Then it obtains its routing information including shown in Figure 6 (ICHA 3 obtains routing information including as follow).

From the above each step, The ICHA 3 obtains routing information containing shown in Figure 6 (ICHA3 obtains destination routing Information) and delivers RREP packets with appending its routing information to Source ICHA 2 via

Downloaded From: http://proceedings.spiedigitallibrary.org/ on 05/01/2017 Terms of Use: http://spiedigitallibrary.org/ss/termsofuse.aspx

reply path, the destination routing information of ICHA 3 is sent contains shown in Figure 7(ICHA 3 sent destRouteInfor to ICHA2). The finally, multi inter routing path is determined in ICHA 3 shown in Figure 8.

ICHA3 received RepIER message of ClusterNode 9 And maintains them in its RepIERTable (III)		**ICHA3 received RepIER message of ClusterNode 10 And maintains them in its RepIERTable (IV)**	
RepIERTable –ICHA 3	RepIER message -ClusterNode 9	RepIERTable –ICHA 3	RepIER message -ClusterNode 10
IntNbr_Address = 9	my_Address=9	IntNbr_Address = 10	my_Address=10,
IntNbrRole =CN	MyRole=CN	IntNbrRole =CN	MyRole=CN
IntNbrCH_Address = 3	myICHA_Address=3	IntNbrCH_Address = 3	myICHA_Address=3
IntAdj_Address =8	Nbr_Address=8,	IntAdj_Address =11	Nbr_Address=11
IntAdjRole =CN	NbrRole=CN	IntAdjRole =CN	NbrRole=CN
IntAdjCH__Address =2	NbrCH_Address=2	IntAdjCH__Address =2	NbrCH_Address=2
RepIER_ID; =	RepIER_ID;	RepIER_ID; =	RepIER_ID;
RepIER_#; =	RepIER_#;	RepIER_#; =	RepIER_#;
RepIER_time out =	RepIER_time out	RepIER_time out =	RepIER_time out

Figure 5: ICHA 3 maintains its RepIERTable illustration

ICHA3 obtains destination routing Information including as follow:			ICHA2 obtains destination routing Information including as follow:			ICHA1 obtains destination routing Information including as follow:		
Path_ID	A	B	Path_ID	A	B	Path_ID	A	B
actDestSuggestRG	8	11	actDestSuggestRG	6	13	actDestSuggestRG	0	0
actSrcRG	9	10	actSrcRG	7	12	actSrcRG	13	13
IntRouteHop_cont#	1	2	IntRouteHop_cont#	2	2	IntRouteHop_cont#	1	0

Figure 6: illustration ICHA obtains its destination routing information from routing path properties in example.

ICHA 2 maintains destRouteInfor of ICHA3			ICHA 3 sent destRouteInfor to ICHA2			ICHA 1 maintains destRouteInfor of ICHA2			ICHA 2 sent destRouteInfor toICHA1.		
DestPath_ID	A	B	Path_ID	A	B	DestPath_ID	A	B	Path_ID	A	B
DestRG	8	11	ActDest SuggestRG	8	11	DestRG	6	13	ActDest SuggestRG	6	13
DestSrcRG	9	10	ActSrcRG	9	10	DestSrcRG	7	12	ActSrcRG	7	12

Figure 7: Illustration Source ICHA maintains destination routing information with changing

3.5.2. Intermediate ICHA-2 determines its multi inter routing path:

IStep_1. By the definition (14), The ICHA-2 receives RREP message of ICHA 3 and obtains destination routing information to maintain in its RePTable-ICHA. The destRouteInfor party of RePTable is maintained shown in Figure 7(ICHA 2 maintains destRouteInform of ICHA3)

IStep_2. Repeat Tstep_1 and 2: ICHA-2 determines DestSuggestRG-13; SrcRG-12; DestSuggestRG-6; SrcRG-7;

IStep_3. Repeat Tstep_3: obtain min hop from the DestRG-8 to SrcRG-7 is 2 and DestRG-11 to SrcRG-12 is 2; So determine two disjoin link path (7→8) and (12→11).

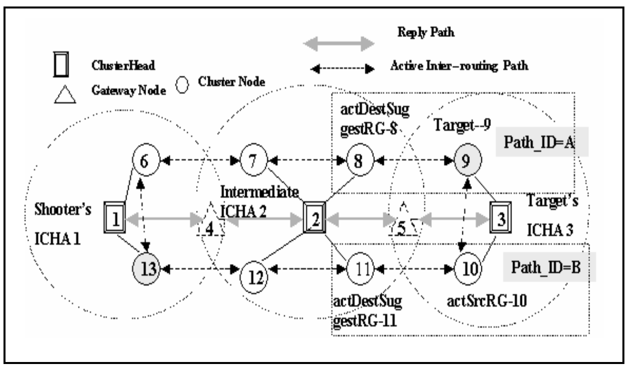
IStep_4. Repeat Tstep_4: to obtains active routes include actDestRG-8; actSrcRG-7; actDestSuggestRG-6; actDestRG-11; actSrcRG-12; actDestSuggestRG-13;

Downloaded From: http://proceedings.spiedigitallibrary.org/ on 05/01/2017 Terms of Use: http://spiedigitallibrary.org/ss/termsofuse.aspx

IStep_5. Repeat Tstep_5: due to obtain actDestRG-8 is located in Path_ID=A; so the actSrcRG-7 and actDestSuggestRG-6 belong to the Path_ID=A and including active route (7,8). Similarly the Path_ID=B includes active routes (11,12).
IStep_6. Repeat Tstep_6 to obtains routing information which includes shown in Figure 6(ICHA 2 obtain routing information including as follow)
IStep_7. RREP message with appending destRouteInfor of ICHA 2 is sent to ICHA 1, the appending DestRouteInfor of ICHA 2 includes shown in Figure 7(ICHA 2 sent destRouteInfor to ICHA 1).
The finally, multi inter routing path of ICHA 2is denoted in Figure 9.

3.5.3. Shooter's ICHA determines its multi inter routing path.

Similarly, the Shooter's ICHA-1 maintains "destRouteInfor of ICHA 2" in its RePTable which shown in Figure 7(ICHA1 maintains destRouteInfor of ICHA 2). Repeats Istep_1 to 7 to obtain routing information shown in Figure 6(ICHA 1 obtains routing information including as follow). The finally, multi routing path is denoted in Figure 10.
Path_ID=A: 13→6→7→8→9; Path_ID=B: 13→12→11→10→9]



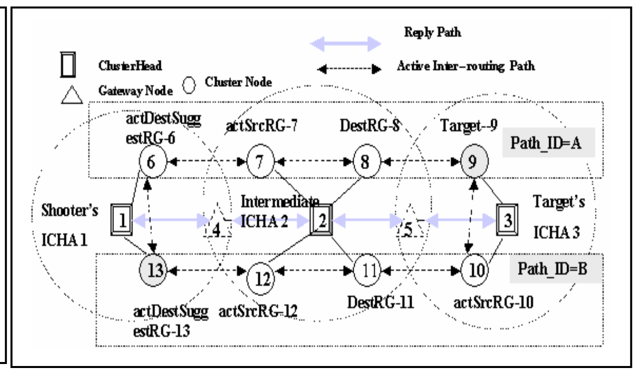


Figure 8: Target's ICHA-3 received RREQ and determined multi inter routing path

Figure 9: Intermediate's ICHA-2 received RREQ message and determined multi inter routing path.

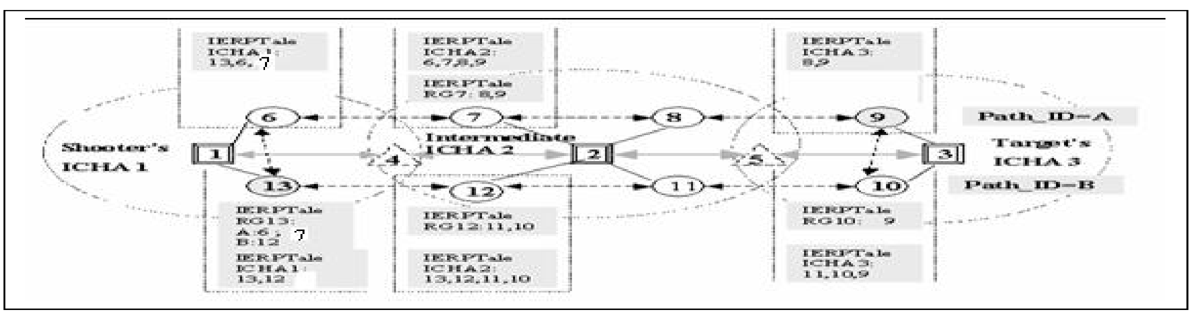


Figure 10: illustration each ICHA and their RG maintains IERPTable example

3.5.4. Maintaining IERPTable-ICHA and IERPTable-RG:

In IRP protocol, multi route gateway are obtained to connect with multi inter routing path to be multi routing path (by definition 7). And the multi inter routing path is maintained by their ICHA separately.
Each ICHA determines active route to maintain Inter Routing Path table (IERPTable-ICHA) contains as follow:
actDestRG_address; actDestSrcRG_address; Path_ID; Path_#; IntRouteHop_cont#;Order_ID ;OrderRG_ID; OrderRG_#;>.
The IERPTable-ICHA is updated by active route in ICHA dominating clustering. Whenever a active route is generated by the ICHA and scans throughout list of table, if this active route existed, then just discards, otherwise adding this active route with correspond to its role in IERPTable-ICHA. For the active route move out active inter routing path, the

Downloaded From: http://proceedings.spiedigitallibrary.org/ on 05/01/2017 Terms of Use: http://spiedigitallibrary.org/ss/termsofuse.aspx

ICHA delete this active route with its role from the table list. For example in Figure 11, the ICHA 2 determines its multi routing path and obtains active route to maintain in its IERPTable-ICHA2.

IERPTable-ICHA 2(IV)
ActSrcRG_address =12
ActIntRoute_address
ActDestRG_address=11
ActDestSrcRG_address=10
IntRouteHop_cont_#=3
Path_ID=B
OrderRG_ID;OrderRG_#
Path_#=2; Time out;

Figure 11: IERPTable-ICHA2 maintains IERPTable

IERPTable-RG12 (VII)
ActSrcRG_address =12
ActIntRoute_address
ActDestRoute_address=11
ActDestSrcRG_address=10
OrderRG_ID; OrderRG_#
IntRouteHop_cont#=3
myICHA_address=2
Order_time out

Figure 12: IERPTable-RG12 maintains IERPTable.

When the ICHA maintains its IERPTable-ICHA and issues an OrderRG message to its active source route gateway (actSrcRG) to maintains inter routing path in IERPTable-RG.

♣ OrderRG message contains as follow: < OrderRG_ID; OrderRG_#; actSrcRG_address; actIntRoute_address; actDestRG_address; actDestSrcRG_address; myICHA_address; IntRouteHop_cont#; OrderRG_time out>.

The parameters <OrderRG_ID; myICHA_address; actSrcRG_address> uniquely identify an OrderRG message and active source route gateway (actSrcRG) receives OrderRG message from its ICHA and maintains list of OrderRG message in its IERPTable-RG. Whenever adding or deleting active route in IERPTable-ICHA, ICHA will issues new OrderRG message with increasing OrderRG identify to its active source route gateway. The OrderRG_time expired, the ICHA re-send OrderRG message with increasing Order_# number. This IERPTable maintains for at least enough time for the Shooter and Target communication in the network .If the ICHA deleted RepIERTable, then this ICHA also deletes its IERPTable-ICHA.

The active source route gateway (actSrcRG) received OrderRG message and maintains all information of OrderRG message in its IERPTable-RG. To propose a guarantee of packets which will be delivered by each active route throughout clustering of each ICHA dominating in network, each active source route gateway (actSrcRG) with source ICHA delivered packets with appending its IERPTable-RG table entries to destination active source route gateway (actDestSrcRG) with destination ICHA. Each packet will be obtained active inter routing path which is located in source ICHA dominating clustering in order of this table entries and packets forwards route table to arriver destination active route.

♣ The IERPTable contains as follow: <actSrcRG_addess; actIntRG_address; actDestRG_address; actDestSrcRG_address; ICHA_address; OrderRG_ID;OrderRG_#; IntRouteHop#; Time out>

This table update depends on actSrcRG receiving OrderRG message. This IERPTable-RG maintains for at least enough time for the Shooter and Target communication in the network .If the actSrcRG did not receiver OrderRG message during OrderRG time expiry, then this actSrcRG delete this inter routing path table.

In particular, whenever actSrcRG receives an OrderRG message from its ICHA and scans through the message's list of entries to active inter routing path which is located in ICHA dominating clustering.

For example Figure 12 actSrcRG 12 received OrderRG message from the ICHA 2 and maintains its IERPTable-RG12.

In Figure 10 illustrated that IERPTable-RG-13 contains active route (6,7, 12); and IERPTable-ICHA-1 contains active route (13,12;6,7); IERPTable-RG-12 contains active routes (11, 10); IERPTable-RG-7 contains active route (8, 9) and IERPTable-ICHA-2 contains active route (13,12,11,10; 6,7,8,9); IERPTable-RG-10 active route (9) and IERPTable-ICHA-3 contains active route (11,10; 8,9)

3.5.5. ICHA Repairs Broken Link Automatically:

By the definition 7, each multi inter routing path is located in its ICHA dominating clustering and two multi inter route path are connected by the multi route gateways shown in Figure13. ICHA selects ClusterNode to be active routes in its clustering. So each ICHA monitors and determines active multi inter routing path in its location.

Downloaded From: http://proceedings.spiedigitallibrary.org/ on 05/01/2017 Terms of Use: http://spiedigitallibrary.org/ss/termsofuse.aspx

The ICHA receives RepIER message of active route and discoveries neighbor member of active route changing, which mean that active route move out or in active inter routing path. Then, the ICHA will find suitable cluster node to instead of this active route role., then It sends a OrderRG message to its actSrcRG for new route table entries. If the actSrcRG changed, then the ICHA must detectors new actSrcRG and actDestSuggestRG and repeat "determine multi inter routing path process for each step" (detail in 3.2) to obtain new multi inter path with min hop in its clustering. And also generated new destination routing information and appended them into RREP packets to deliver this RREP message with increasing RREP_# to source ICHA via reply path. The source ICHA received RREP message and re-determined its multi routing path to obtain new multi inter routing properties in order of new destination routing information to match with destination routing information.

In special case, if the ICHA could not find suitable ClusterNode to be active route, then, it sets itself to be active route and deliver packets until it find other ClusterNode instead of active route which move out multi inter routing path.

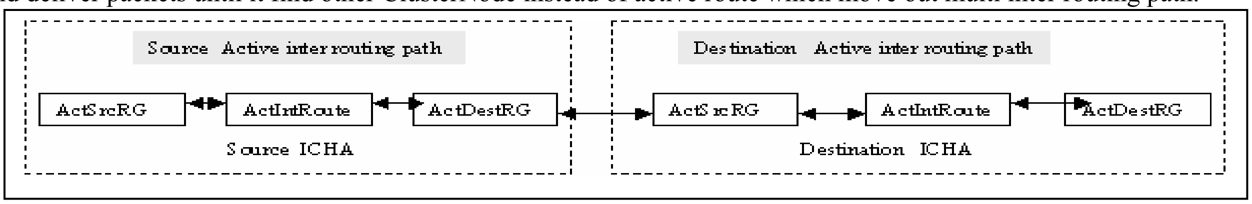


Figure 13: Illustration the two active inter routing path are connected by route gateway (actDestRG and actSrcRG).

4. SIMULATION AND ANALYSIS

4.1. Simulation Environment

Simulations were performed on the Glomosim simulator with wirelesses components that were developed by the Global Mobile Information System Simulation Library [9]. Many protocols used in ad hoc networks have been implemented including the IEEE 802.11 standard wireless LAN MAC protocol. A mobile ad how network is generated as follows: 100 mobile nodes move within a square region of size 1000 x 1000 m^2 according to random waypoint mobility model. The transmission range of a node is 250m. Constant bit-rate traffic sources were used and data packet size was 512 bits. All simulations were run for 300 seconds. The speed of the movement follows a uniform distribution between 0 and the maximal speed v =5, 10,15,20,25 m/s are generated.

4.2. Performance metrics

a. Packet delivery fraction –ratio of the data packets delivered to the destination
b. Average end to end delay: include all delays caused by buffering during route discovery, queuing delay at the interface, retransmission delay at the MAC, propagation and transfer times.
c. Route discovery frequency: the aggregate number of route requests generated by all source per second.

4.3. Simulation discussion

There is a tremendous reduction in the average end-to-end delay with AOMDV as shown in Figure 14. Since the DHMRP is hybrid multi routing path protocol which includes proactive and reactive. The proactive will reduce the route request discovery latency, And also utilizes Intelligent ClusterHead Agents (ICHA) establish multi routing path and automatically repair link broken in ICHA dominating clustering to improve stabilization multi routing path in network, more data packets will be delivered to destinations without waiting for route discovery latency of sourer nodes (shown in Figure 15). So that the average end-to-end delay is reduce in IRP, especially when the mobility speed increase. In other words, the packets drop at intermediate routes due the link broken at high speed, the hybrid IRP protocol with automatically repairing routing path property, so that its reroute request packets less then reactive routing protocol AOMDV, then, with the mobility speed increases, much more available routes will be broken. And AOMDV increases the number of source –initiated route discoveries more than IRP (shown in figure 16)

Downloaded From: http://proceedings.spiedigitallibrary.org/ on 05/01/2017 Terms of Use: http://spiedigitallibrary.org/ss/termsofuse.aspx

5. CONCLUSION

In this paper, we presented a novel routing scheme for mobile ad hoc networks (MANETs). The proposed routing combines hybrid and multi-routing path properties with a distributed topology discovery route mechanism. We completely utilize the advantages of a hybrid clustering organization and multi-routing path in routing protocol to achieve several performance goals at the same time Extensive numerical experiments have been carried out to show the enhanced performance of the proposed IRP routing protocol.

This protocol is scalable to large networks. The performance of IRP certainly depends on the distribution of the mobile nodes in the network. The optimal inter-intra cluster trade-off depends on a number of factors, including node velocity, ClusterHeads lifetime, node density and network span. However, based on the evaluations presented in this paper, we can conclude that this novel IRP routing protocol with hybrid and multi-routing path indeed can deliver the desired performance for mobile ad hoc network applications.

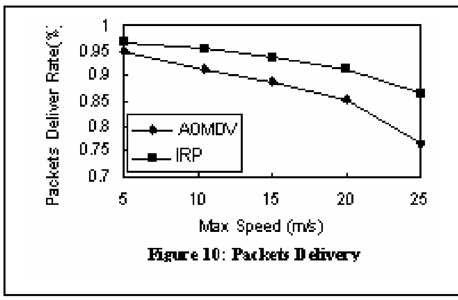


Figure 14: End-to-End Delay

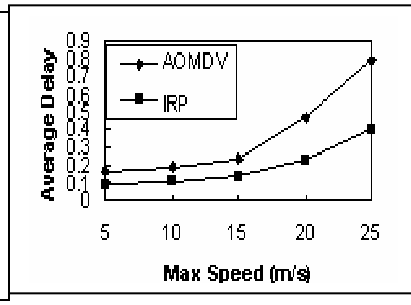


Figure 15: Packets delivery

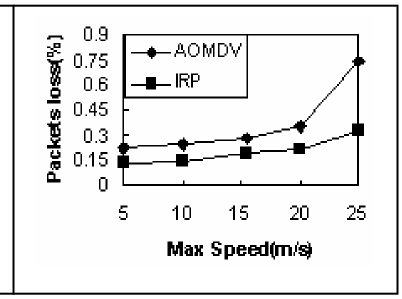


Figure 16: Route Discovery

6. REFERENCE

1. Royer, E. M.; Chai-Keong Toh; " A review of current routing protocols for ad hoc mobile wireless networks" Personal Communications, IEEE Volume 6, Issue 2, April 1999 Page(s): 46 – 5
2. C.E. Perkins, T. J. Watson, "Highly dynamic destination Sequenced distance vector routing (DSDV) for mobile comers", in ACM SIGCOMM'94 Conference Architectures, London, UK, 1994.
3. C. -C. Chiang, "Routing in clustered multihop mobile wireless networks with fading channel", in: Proceedings of IEEE SICON, April 1997, pp.197-211.
4. S. Das, C. Perkins, E. Royer, "Ad hoc on demand distance vector (AODV) routing", Internet Draft, draft-ietf-manet-aodv11.txt, work in progress, 2002.
5. Z. J. Hass, R. Pearlman, "Zone routing protocol for ad-hoc networks", Internet Draft, draft-ietf-manet-zrp-02.txt, works in progress, 1999.
6. S. Radhakishnan, N.S.V Rao, G.Racherla, C.N.Sekharan, and S.G.Batsell, "DST-A routing protocol for ad hoc networks using distributed Spanning trees", in IEEE Wireless Communications and Networking Conference, New Orleans, 1999.
7. N.Nikaein, H.Laboid, C.Bonnet, " Distributed dynamic routing Algorithm (ddr) for mobile ad hoc networks", in: Proceedings of the MobiHOC 2000:
8. M.Jiang, J. Ji, Y.C. Tay, " Cluster based routing protocol", Internet Draft, draft-ietf-manet-cbrp-spec- 01.txt.work in progress, 1999.
9. Glomosim home page. World Wide Web, http://www.pcl.cs.ucla.edu/projects/glomosim.
10. YuHua Yuan: HuiMin Chen; Min Jia; "an optimized ad –hoc on-demand multipath distance vector (AOMDV) Routing Protocol" communications, 2005 Asia –Pacific Conference on 03-05.
11. Loscri V; De Rango, F, Marano, S.; "a correction for ad hoc on demand multipath distance vector routing protocol" vehicular technology conference 2005. VTC-2005-Fall. 2005 IEEE 62nd.

Downloaded From: http://proceedings.spiedigitallibrary.org/ on 05/01/2017 Terms of Use: http://spiedigitallibrary.org/ss/termsofuse.aspx