ISSN:0975-9646

Multicast Opportunistic Routing Protocol "TOMR" Based on Trust and Link Quality Matrix for Wireless Networks

Mrs.Sanafarin Salim Mulla
Department of Electronics Engineering,
P.VP.I.T Budhgaon, Shivaji University
Sangli, India

Prof.J.A.Shaikh
Associate Professor & Head,
Department of Electronics Engineering,
P.VP.I.T Budhgaon, Shivaji University
Sangli, India

ABSTRACT : A new paradigm of opportunistic routing (OR), is able to improve network throughput in multi-hop wireless networks, by effectively utilizing such a shared wireless broadcast medium. In opportunistic routing protocols, all neighboring nodes that are closer to the destination may overhear a data packet, and may be a candidate for forwarding the packet to its destination. For forwarding packet we are going to use E2TX metric that is an idea of implementing high throughput path metric ETX for routing in multi-hop wireless network was proposed in [4], and the same is extended to derive new metric E2TX in multi-hop opportunistic routing proposed in TOR [1]. TOR uses the trust value and ETX to derive E2TX which is used for in multi-hop OR

In this Paper we are extending an idea of implementing multicast routing in opportunistic networks using E2TX metric proposed in TOR [1].

Keywords— Opportunistic Routing; Trust value ; link Quality, candidates Selection ,forwarder nodes; Multicast

I. INTRODUCTION

In Opportunistic Routing protocol packet is broadcasted to the all adjoin nodes of sources and all the candidates that successfully receive it will coordinate with each other to determine which one will actually forward it, while the others will simply discard the packet. Leveraging the nodes' ability to overhear a broadcast packet, it differs from traditional routing in that forwarders are selected among the packet recipients after its transmission. The set of candidates which each node uses and priority order of them have a significant impact on the performance that OR can achieve. Therefore, using a good metric to select and order the candidates is a key factor in designing an OR protocol. In this paper Candidates in OR can be prioritized based on Expected Transmission Count (ETX) and trust value associated with each node in the network. and further opportunistic multicast routing protocol (TOMR) uses E2TX to select candidate relay sets and their prioritization.

To implement multicasting we have used technique to divide a network into four multicast regions. We have used Pythagoras Theorem to select longest multicast destination in each region. After selection of multicast destinations we have used a candidate selection algorithm for selection of candidate to forward a packet to destinations. We have used multicast send algorithm to send multicast packet and multicast receive algorithm to receive multicast packet.

II. RELATED WORK

Different opportunistic routing protocols have been proposed recently for wireless networks. Candidate selection and prioritization are the two key issues that need to be addressed by any opportunistic routing scheme. Solving these issues needs to consider routing efficiency, protocol overhead, and compatibility with existing MAC protocols, use of network state information, location information, and use of coding function.

By taking these factors as well as different design strategies into consideration various OR protocol are their i.e Extremely Opportunistic Routing Protocol ExOR [1] uses the ETX to choose a candidate forwarder set , Mac Independent Opportunistic Routing Protocol MORE [6] randomly mixes packets before forwarding them which ensures the routers that overhear the same transmission will not forward the same packets, Simple Opportunistic Adaptive Routing SOAR [3] was proposed as an improvement to the ExOR protocol. SOAR support multiple flows. Like unicast OR there are various Multicast Routing Protocal also presents i.e Ad-hoc Multicast Routing (AMRoute) AMRoute [8] is a tree based proactive multicast routing protocol. It connects multicast group members by using unicast tunnels. There is at least one core in each multicast group, other one is Node state multicasting (NSM) [13] which is built directly on top of node state routing (NSR) . NSR uses two different routing construct called as node and wormhole. Node construct is modelled as point in space and wormhole as directed path. And last one is Robust and Scalable Geographic Multicast Protocol (RSGM) It provides robust packet transmission in a dynamic MANET. Protocol uses several virtual architectures for more robust and scalable membership management and packet forwarding in unstable wireless network.

III. DESCRIPTION OF COMPONETS

A. Topology

As in [2], Let G = (V, E) denotes the topology of the network, which is a undirected graph with wireless nodes set V and link set E (communication links that join the nodes).

B. Modeling of E2TX metric

As in [2], E2TX is a metric of the wireless link; trust value is used to indicate the trustworthiness of the transmission behaviours over the link.

C. Trust Calculation

As mentioned in [7] let us assume node *j* is one of the node *k's* neighbours. Trust value assigned by node *k* on node *j* is denoted by *T(k,n)* after the n^{th} topology update. This trust value is calculated as ratio of number of packet transferred to the number of packet that has been received correctly. Statistical model used is

$$T_j(k,n)=R_{kj}(n)/F_{kj}(n) \quad ....(1)$$

Where R_{kj} (n) and F_{kj} (n) are the number of packet that have been received by *k* and forwarded from *j* at time *t* respectively, and $0 \leq T(k, t) \leq 1$.

D. Trust Updation

After every topology change node updates its trust value which is calculated by moving average model. At n^{th} topology updating cycle,

$$T_j(k, n) = \alpha . T_j(k,n-1)+(1-\alpha).T_j(k, n) \quad ....(2)$$

Where, $T_j(k,n)$ is node $j^{'s}$ trust value measured during n^{th} topology updating cycle.

$0<\alpha<1$ is a weighting factor used to trade off between current measurement and previous estimation.

E. ETX and E2TX Calculation

The E2TX [1] is an integrative metric, which model the various transmission behaviors which are associated with the trustworthiness of forwarding packets and link quality over the link. OR uses ETX metric [4] to weigh the link quality and to select the unpredictable next-hop. We also retain the ETX metric in this paper, a state-of-the art routing metric proposed by De Couto et al. A link's ETX metric measures the expected number of transmissions (including retransmissions) required to send a single packet across the link. Let P_f and P_r denote the loss probability of the link in the forward and reverse directions, respectively. Each node measures loss rate of its links to and from its neighbours (i.e., Pf and Pr) by broadcasting one probe packet every second and counting the number of probes received in the last 10 seconds.

Then, the link's ETX [4] metric is calculated as:

$$ETX = 1/(1-p_f).(1-p_r) .... (3)$$

Assuming independent packet losses, each node in the network maintains an exponentially weighted moving average of ETX samples. Considering both the trustworthiness and link quality requirements, a relay node that is less trusted and link quality must be rejected in our objective, thus a combined routing metric function can be designed as:

$$E2TX(n)_j = (1- T_j(n)). ETX_{j.....} \quad (4)$$

Where, $E2TX(n)_j$ denotes the combined metric of node j ,when the network lies in the n^{th} topology.

The combined routing metric value of node j holds true, only if node j satisfies a precondition: $T_j(n) \geq T_{threshold}$. Where $T_{threshold}$ is the trust threshold value of the whole network, definition5 means if the node j is not a trustworthy node, namely, it may be a selfish and malicious node, so, we disregard the node and don't allow its joining in the network, when perform the operation of TOMR.

IV. PROPOSED MULTICAST ROUTING PROTOCAL

1. Overview of TOMR

Trust opportunistic multicast routing protocol (TOMR): Trust opportunistic multicast routing protocol is developed for multi-hop opportunistic wireless network. Protocol is used for hop to hop packet transmission for reliable packet delivery from source to group of destinations. TOMR uses intermediate candidate for transmission of packet.

Here we can explain the concept of TOMR with help of following block diagram. Here the firstly TOMR at each node measures the trust and ETX value for each neighbouring node in the network.Once the trust and ETX values are measured TOMR then calculates the E2TX depending upon these two values. Once the E2TX

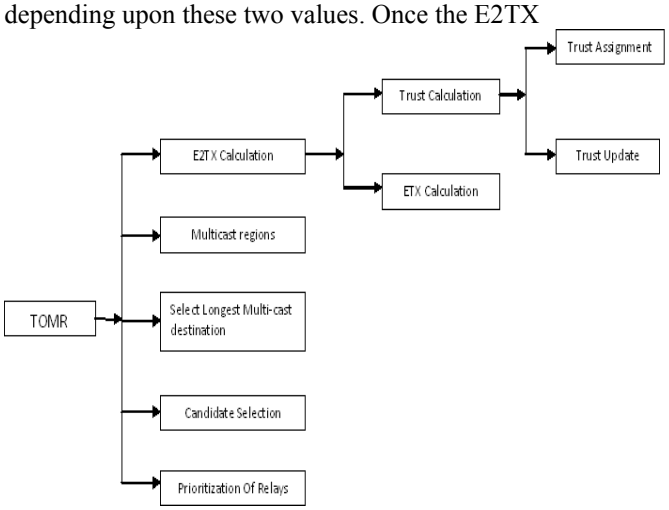


Figure a: Frame work of TOMR

for each neighbouring node is calculated then the E2TX values are used in the next step i.e. candidate selection. But before candidate selection TOMR divides the whole network into four multicast regions. After creation of multicast region protocol detrmines the longest possible node in all multicast region. Then for longest possible node the candidate selection is done using E2TX values . Now these selected relays are prioritized depending upon the E2TX values. Nodes with less E2TX values are given the first prefference and so on.After every topology change the Trust values are updated and then the new E2TX values are calculated.

2. Maintain Multicast Region

In proposed multicast routing protocol we have made some assumptions.

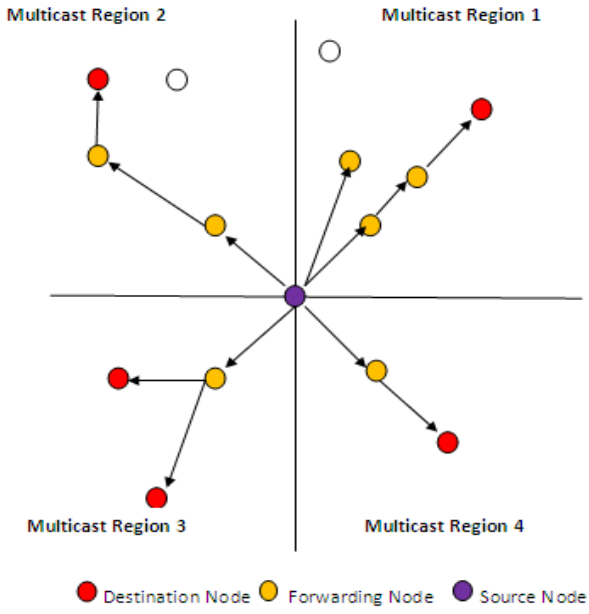
1. All nodes in the wireless network are present in the two dimensional space.
2. We also assume that the location service module is present inside the protocol stack which returns the (x,y) co-ordinates of the members present in the network.

Protocol creates the "multicast region" centred at the node. Also we assume that each multicast region corresponds to the one quadrant of the network, for a grid centred at the source node.

In the network topology shown in Fig b, where the source node or forwarding candidates are located at that point the whole network is divided into the quadrants called as multicast regions. The location service module calculates the (x,y) co-ordinates of each node present in the multicast group. By using those co-ordinates protocol calculates the distance of the longest possible multicast member belonging to each multicast region using the Pythagoras Theorem.

Let S(x1,y1) be source or forwarding node in the network, x1 and y1 are the co-ordinates of the node S. Let D (x2,y2) be any node from the network. TOMR determines the location of the node D by using its co-ordinates,

F $$\frac{(x2-x1)}{(y2-y1)} = \frac{x}{y}$$ …….. *(5)*



After determining the location of node depending upon its location nodes are added to the newly created list of nodes i.e $r_i.nodes$ which creates the four multicast regions of a network where $1 \le i \le 4$. $r_i.nodes$ contains the nodes which belongs to region r_i . The above table represents the values of (x,y) co-ordinates and quadrants to which the nodes can belong. Table also shows that nodes added to $r_i.nodes$ will not be malicious because the nodes added to the list will have their trust values greater than the $T_{threshold}$.

If either co-ordinate is '0' the node will not be in a quadrant, but it will lie on an axis. All nodes with x=0 are on y-axis and all nodes with y=0 are on x-axis.

3. Create Multicast Destination List

Upon receiving a multicast packet, TOMR on forwarding node retrieves the list of multicast destinations. Now the next task of the protocol is the determination of the multicast region to which multicast destination belongs. Protocol determines the location of the multicast destination and creates different lists for each multicast region using above equation.

$$\frac{(x2-x1)}{(y2-y1)} = \frac{x}{y}$$

Here in above equation (x1,y1) are the co-ordinates forwarding node, (x2,y2) are the co-ordinates of any multicast destination. Then using these values protocol determines the values of (x,y) as shown in equation. Depending upon values of (x,y) the following decisions are made,

1. If *x<0 and y>0* then Multicast destination is added to the *r1.list.*
2. If *x>0 and y>0* then multicast destination is added to the *r2.list.*
3. If *x<0 and y<0* then multicast destination is added to the *r3.list.*
4. If *x>0 and y<0* then multicast destination is added to the *r4.list.*

Here, r_i *.list* represents the list of multicast destinations belonging to the four multicast regions. Where, $1 \le i \le 4$.

4. Selection of Longest Multicast Destination in Each Multicast Region

Once the r_i list are prepared for each multicast region r_i . Protocol gets the co-ordinates of the all nodes belonging to each multicast list and then calculates the distance by using following mathematical equation

$$(SM)^2 = |(x2-x1)|^2 + |(y2-y1)|^2 \quad ....(6)$$

SM is the distance of a forwarding node to multicast any destination. After calculating the distances of each multicast destination protocol compares these calculated distances and determines the longest possible node in that region. In further steps candidate selection is done for the longest possible node.

5. Candidate selection Algorithm

For each region r_i in R
Select longest possible multicast destination in r_i.longest from r_i
End for
//Generate potential candidate set for $r_i.longest$
$W^i_{x,d} = \phi$
For each j $\in$ r_i
If j $\neq$ x & E2TX (x,d) > E2TX (j,d) then
$W^i_{x,d} = W^i_{x,d} \cup \{j\}$
End if.
End for
// generate actual candidate set $C^i_{x,d}$ from $W^i_{x,d}$
$C^i_{x,d} = \phi$
For each $r_i \in R$
While no new candidate is added to $C^i_{x,d}$
For each candidate in $W^i_{x,d}$ do
If j $\in$ $W^i_{x,d}$ and E2TX (x,d) – λ > E2TX (j,d) then

$C^{i}_{x,d} = C^{i}_{x,d} \cup \{ j \}$
End if
End for
End for
Return

Where, in above algorithm,
r_i = It represent the multicast region belonging to R.
R = Set of multicast regions r_i, where $1 \leq i \leq 4$.
r_i.longest = Represents the longest possible node in region r_i .
$W^{i}_{x,d}$ = Set of potential forwarding candidate for source x and destination d belonging to region r_i .
$C^{i}_{x,d}$ = Set of actual forwarding candidate for source x and destination d in region r_i .
λ = Configurable parameter.

6. Prioritization of selected relays

After the procedure of candidate selection of relay set, we can drive a optimal potential relay set, Subsequently, how to select a next-hop relay node in this relay set to forward packets? Namely, we should utilize a new solution to order the priorities of each node in this relay set. We assume that each node of the network is judged its trustworthiness as explained in 7.4.2, so the network isn't compromised of selfish and malicious nodes to satisfy the security for forwarding packets, in the optimal potential relay set, we compare the E2TX of each node to order their priorities.

V. User Interface Description

Trust opportunistic multicast routing protocol provides user interface using network animator (nam). It will give user complete idea of nodes in simulation. It will show packets traversing through nodes, dropped packet. It will also show graphs achieved by increase in throughput, packet delivery ratio for the number of packets transferred Figure c shows the screenshot of TOMR network topology.

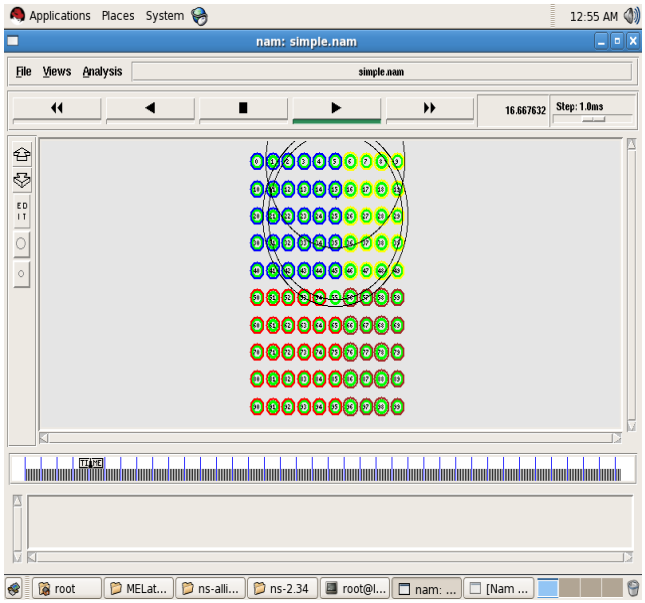


Figure c: TOMR topology with multicast region

VI. Preparations Work Of Tomr

(1) If a node joins the network or as soon as it is turned on, its trust value is set to an initial value 0.5 or calculated during first topology (this means the node is a benevolent node at the beginning).
(2) Each node then calculate the link quality metric ETX by sending the probe packet to its neighbor node, which the node locates within the transmission range of the sending node.
(3) After procedure (1) and (2), each node can drive the combined metric E2TX by using the formula (4);
(4) TOMR creates the four multicast region by using the location service module.
(5) A source node collects all E2TX of its neighbor nodes for candidate selection and prioritization of selected relay nodes as in TOR.
(6) When the mentioned above procedure is finished or network topology changes, the trust value of each node can be updated by formula (1) and (2), and moreover, trust judging phrase unfolds.
(7) If trust value of a node is less than $T_{threshold}$, this node will be elicited as a selfish or malicious node, so it will be omitted in next routing phase from security of network point of view.

VII. Simulation Result

A wireless network of 100 node is created and for the simulation of implemented protocol, TOMR, we have used following parameters.
1. End to end delay
2. Packet loss ratio
3. Packet delivery ratio
4. Throughput
5. Routing overheads

1. End To End Delay:

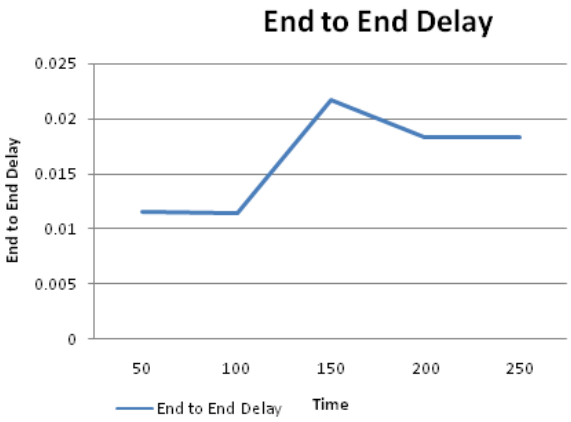


Figure shows Graph of end to end delay for network of 100 nodes.
Graph shows time on X axis and end to end delay on Y axis. From this graph we can see that the delay is consistent from start to end of simulation (250 s).

2. Packet Loss Ratio:

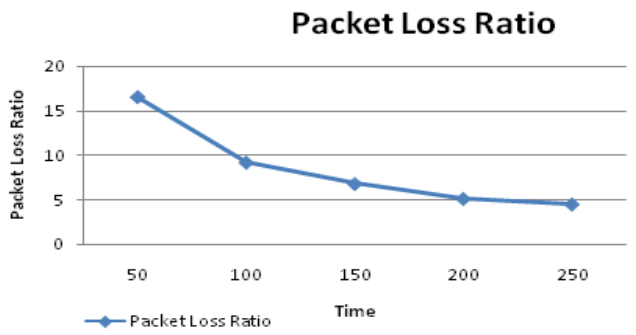


Figure shows the graph of packet loss ratio for network of 100 nodes.
Graph shows time on X axis and packet loss ratio on Y axis. Here PLR is continuously decreasing with the increasing time. We have simulation for 250 s.

3. Packet Delivery Ration:

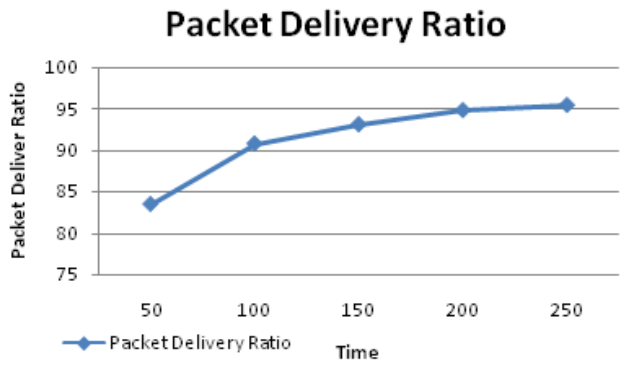


Figure shows the graph of packet delivery ratio for network of 100 nodes.
Graph shows time on X axis and packet delivery ratio on Y axis. Here PDR is also consistent from start to end of the simulation. (250 s).

4.Throughput:

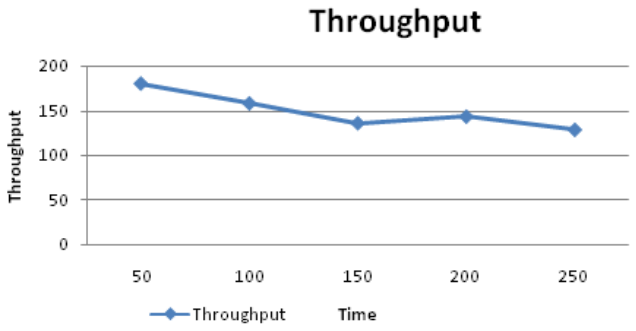


Figure shows the graph of throughput of network for 100 nodes.Graph shows time on X axis and throughput on Y axis. From this graph we can see that the throughput is consistent from the start to end of simulation (250 s)

5. Routing Overheads :

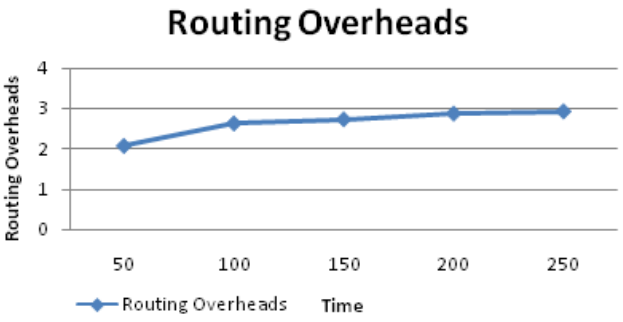
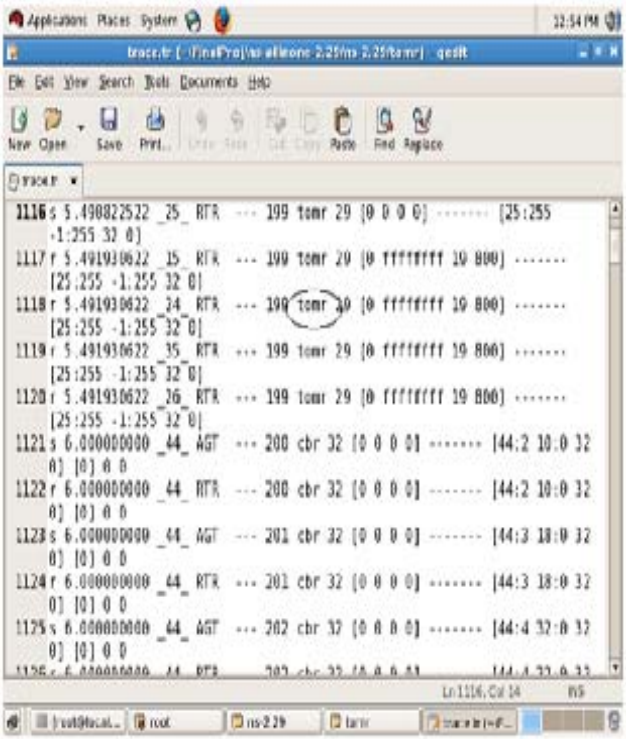


Figure shows the graph of routing overheads of network for 100 nodes. Graph shows time on X axis and routing overheads on Y axis. Here, graph shows increasing overheads with increasing time till the end of simulation (250 s).

6. Trace File:



VIII. CONCLUSION

In this paper , we have proposed and implemented an idea of trust opportunistic routing in a multi-hop wireless network. TOMR uses the E2TX metric for candidate selection and prioritization of relays. TOMR takes the advantage of broadcast nature of wireless medium to forward packets. We have also tried to keep routing overheads within tolerable limit. We have successfully implemented the algorithm for multicasting using E2TX metric. Lastly we have discussed the performance of TOMR in terms of packet delivery ratio, packet loss ratio, throughput, end to end delay and routing overheads.

REFERENCES

[1] WangBo, HuangChuanhe ,YangWenzhong , WangTong," Trust Opportunistic Routing Protocol in Multi-hop Wireless Networks", in Proceedings of ACM SIGCOMM, pp.563-567,2010.

[2] S. Biswas and R. Morris, ExOR: Opportunistic multi-hop routing for wireless networks, in Proceedings of ACM SIGCOMM, 2005, pp.133-144.

[3] E.Roznor,J.Seshadri,YMehta,L.Qiu, Simple Opportunistic Routing Protocol for Wireless Mesh Networks, 2nd IEEE Workshop on Wireless Mesh Networks,2006.

[4] D. S. J. De Couto, D. Aguayo, 1. Bicket, and R. Morris, A high throughput path metric for multi-hop wireless routing, in Proceedings of ACM MOBICOM, 2003, pp. 134-146.

[5] C.Zouridaki,B.L.Mark,M .Hejmo,R.K. Thomas,Hermes: a quantitative trust establishment framework for reliable data packet delivery in MANETs ,Journal of Computer Security I 5(1) (2007)3-38.

[6] "MORE protocol", April 2011[html], http://en.wikipedia.org/wiki/MORE_protocol.

[7] Sanchez J.A., Ruiz P.M., Stojmenovic I. GMR: Geographic Multicast Routing for Wireless Sensor Network, In Proceeding in Sensor, Meshand Ad-hoc Communication and Network, IEEE, Secon 06, 2006,Virginia, USA.

[8] Liu, M.; McAuley, A.; and Talpade, R.; "AMRoute: Ad-hoc Multicast Routing Protocol", Mobile Networks and Applications 7, 429-439, 2002 @2002 Kluwer Academic Publishers.

[9] Wu, C. W.; Tay, Y. C. and Toh, C.-K.; .Ad hoc Multicast Routing protocol utilizing Increasing id-numbers (AMRIS) Functional Specification., Internet Draft, draft-manet-amris-spec-00.txt, November 1998, Work in progress. http://tools.ietf.org/id/draft-ietf manet-amris-spec-00.txt

[10] J.J.Garcia-Luna-Aceves and Ewerton L. Madruga "The Core-Assisted Mesh Protocol Selected Areas in Communications, IEEE Journal on Volume 17, Issue 8, Aug 1999 Page(s):1380 – 1394.

[11] Lee,S.-J.; Gerla, M.; Chiang, C.-C; "On Demand Multicast Routing Protocol" Wireless adaptive http://www.cs.ucla.edu/NRL/wireles.

[12] Prasun Sinha, Raghupathy Sivakumar, Vaduvur Bharghavan "MCEDAR: Multicast Core-Extraction Distributed Ad hoc Routing" In Proc. of the Wireless Communications and Networking Conference http://timely.crhc.uiuc.edu/Papers/wcnc99.2.ps.gz.

[13] John A. Stine,McLean, "Node State Multicasting In Wireless Ad hoc networks" Military Communications Conference, 2005. MILCOM 2005. IEEE ,pages 2030 - 2036 Vol. 4.

[14] Chen-Hsiang Feng, Yuqun Zhang, Ilker Demirkol, Wendi B. Heinzelman, "Stateless Multicast Protocol for Ad Hoc Networks" IEEE transactions on mobile computing, vol. 11, no. 2, february 2012.

[15] Sunil Kumar Soni, Trilok Chand Aseri "A Review of Current Multicast Routing Protocol of Mobile Ad Hoc Network". Second International Conference on Computer Modeling and Simulation 2010.