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Trust Opportunistic Multicast Routing (TOMR) Protocol In Multihop Wireless Network

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***Abstract*— Multicasting The traditional idea in designing routing protocols treats a wireless link as a point-to-point link, and utilizes a single predetermined path to transmit data packets from source to destination. The opportunistic routing is new technology for designing routing protocols in multi-hop wireless network. Opportunistic routing takes the benefit of broadcast nature of wireless communication medium to forward packets opportunistically by using set of intermediate nodes. Due to unreliable and unpredictable nature of the wireless communication medium, many scholars consider network security as key research topic in wireless network. In this paper we are giving a new solution for secure multicast packet transmission using existing trust metric called E2TX (Trustworthiness and ETX). Using E2TX we also consider two issues for a new routing protocol called TOMR: candidate selection and prioritization in classical opportunistic routing.**

***Keywords*— Opportunistic Routing, Trust, Multicasting, Multihop Wireless Network..**

I. INTRODUCTION

The traditional idea in designing routing protocols treats a wireless link as a point-to-point link, and utilizes a single predetermined path to transmit data packets from source to destination. The infrastructure-less property and unstable nature of wireless medium raises problem of unreliable communication. Opportunistic routing is capable to increase the network throughput by utilizing broadcast nature of wireless network. In OR routing intermediate nodes act as candidate to forwarding the packet to its destination. Network security is also a hot research topic in wireless networks; many scholars do pay their attention to secure routing in multi-hop wireless networks to protect it against malicious and selfish behavior.

Existing traditional ad hoc routing protocol uses minimum hop-count as link metric. In [5] author gives a new solution, ETX path metric to determine link quality of wireless network. The ETX of a link is the predicted number of data transmissions required to send a packet over that link, including retransmissions. The ETX of a link is calculated using the forward and reverse delivery ratios of a link. , The expected number of transmissions is:

$$ETX = 1/DR_f \times 1/DR_r$$

DR_f is the measured probability that a data packet successfully arrives at recipient and the reverse delivery ratio, DR_r , is the probability that the s ACK packet is successfully received.

In addition to the ETX author of [2] added an idea of trust and developed a new metric called E2TX to detect the malicious and selfish node in the network. Author has also discussed use of E2TX for candidate selection and prioritization of the relays. In this paper we have retained an idea of E2TX metric for selection of the candidates to forward a packet to its destination. As well as we are extending our work to add multicasting in the trust based opportunistic routing in multi-hop wireless network. This is our main contribution to this paper.

In section 2 we discuss different opportunistic routing protocols and multicast routing protocol in wireless network. Section 3 explains an idea of trust metrics, in section 4 we have discussed an idea of multicasting. In section 5 we will discuss the algorithms related to protocol. Section 6 and 7 addresses the important issues: candidate selection and prioritization of relays respectively.

II. RELATED WORK

To take advantage of the broadcast nature of the wireless network different opportunistic routing protocols have been put by various authors. Opportunistic routing takes the benefit of broadcast communication medium to forward the packets form source to destination in wireless network. Opportunistic routing also considers two main issues: candidate selection and prioritization of the relays.

A. Extremely Opportunistic Routing Protocol

ExOR [1] uses ETX to choose a candidate forwarder set. ExOR provide better performances over traditional routing protocols. But a major problem associated with ExOR is after a transmission; all the nodes in the candidate set needs to wait for forwarding of the nodes with higher priority. Multicast is also not implemented.

B. Trust Opportunistic Routing Protocol

The ETX metric in [1] calculates the quality of link to make the forwarding decision. But in paper [2] in addition to the link quality metric author has added the trust value associated with each node in the network. By combining these two, link quality metric ETX and trust value of a node in the network, author has developed a new metric E2TX (ETX and Trustworthiness) for candidate selection and prioritization of relays. Each node in the networks derives the E2TX value for all its neighbors and depending upon E2TX value the candidate set is determined. TOR out performs classic routing ExOR in terms of packet delivery ratio, delay and routing overheads. But multicast is not implemented.

C. Multicasting Protocols

Multicasting is a major phenomenon which is missing in all of the above mentioned opportunistic routing protocol in multi-hop wireless network. Major work we are introducing in this paper is combining the idea of multicasting in trust opportunistic routing in multi-hop wireless network. Numbers of multicast protocols are in existence for the wireless network. Most of the multicast protocols for WSN and MANET uses a tree based structure to connect to the multicast member such as[10] GMR, [9] ADMR which uses common broadcast flooding for multicasting. Also multicast algorithms rely on routing tables maintained at intermediate node for constructing and maintaining multicast tree. RBMulticast [4] is a completely stateless protocol which uses only location information for multicasting without creating tree or maintenance or even neighbor table maintenance, which makes it ideally suited for wireless network. In this paper we have also proposed a new multicasting idea which will make our protocol stateless and gives relief from the creation of multicasting tree and costly state maintenance table at each node. Due to these properties our protocols will be well suited for the wireless networks.

III. EXISTING METRIC

We describe our problem with following definitions.

A. Definition I

As in [2] $G=(V,E)$ denotes the topology of network, which is directed graph with wireless nodes set V and link set E (communication links joining the nodes).

B. Definition II

As in [2] as a metric of wireless link, trust value is used to indicate trustworthiness of transmission behaviors over a link.

C. Definition III

As mentioned in [11] let us assume node j is one of the node i's neighbors. Trust value assigned by node i on node j is denoted by $T(i,n)$ 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

$$T(i,n)=R_{ij}(n)/F_{ij}(n) \quad (1)$$

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

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

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

Where, $T_j(i,n)$ 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.

D. Definition IV

In [3] opportunistic routing uses the ETX metric to weight the link quality for selection of next hop relay. ETX measures the *Expected Number of Transmissions* required to send a single packet across the link by broadcasting one probe packet every second and counting number of probes received in last 10 seconds.

$$ETX=1/(1-P_f).(1-P_r) \quad (3)$$

P_f and P_r denote the loss probability of link in forward and reverse direction. E2TX metric in [2] is derived from the both values from equation (2) and (3) as follows

$$E2TX(n)_j = (1-T_j(n)) . ETX_j \quad (4)$$

Where, E2TX denote the combined metric of node j, when network lies in n^{th} topology.

E. Definition V

The combined routing metric $E2TX_j$ holds true value only if the trust value of node is greater than the threshold trust value.

$T_j \geq T_{threshold}$

Where, $T_{threshold}$ is the trust threshold of entire network.

IV. PROPOSED MULTICASTING

In proposed routing protocol we have made some assumptions.

- All nodes in the wireless network are present in the two dimensional space.
- 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 multicast group.

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

In the network topology shown in Fig. 1, 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 following mathematical equation (Pythagoras Theorem).

$$|SM_1|^2 = |(x_2-x_1)|^2 + |(y_2-y_1)|^2 \quad (5)$$

Where, SM_1 is the distance of source node $S(x_1,y_1)$ from the multicast member $M_1(x_2,y_2)$.

Using formula (5) the distance of longest possible destination is calculated for each multicast quadrant.

V. PROTOCOL OVERVIEW

As we know that the major challenge in any opportunistic routing is candidate selection and prioritization of the selected relay nodes. When, node wants to send a single packet to multiple destinations. Packet headers are configured with the multicast member present in respective regions. Using formula (5) longest possible multicast members are determined and candidate selection is done for each of them in their respective regions. After prioritization of selected relays the packets are forwarded to the multicast members. The decision of packet splitting and forwarding is done at each forwarding candidate in that region by using the following algorithm,

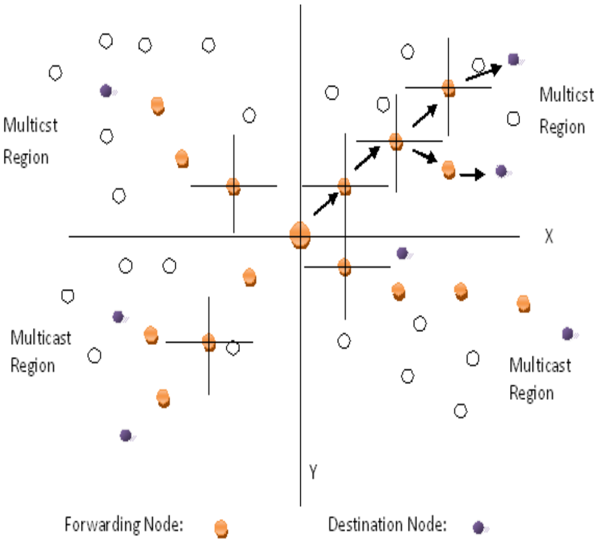

Fig 1 Multicast decision and packet splitting

- *Multicast Send Algorithm*

```
Get the multicast group list N.
for node i in N do
        for multicast region r in 4 quadrants R do
                if i Є r then
                add i to r.list
                end if.
        end for.
end for.

for r Є R do
        If r.list is not empty then
        Replicate packet, add r.list in to packet header.
        After candidate selection for longest possible
        node in that region, broadcast the packet.
        end if
end for
```

Fig 2 Multicast send algorithm

When the packet is received by the intermediate selected relay nodes then following algorithm is used to receive and process the packet

- *Multicast Receive Algorithm*

```
Get the destination list 'D' from the packet header do

for all members of 'D' do
        if I am 'd' then
        remove d from list D.
        replicate packet.
        end if
end for
if check destination list is not-empty then
Call the send algorithm.
End if
```

Fig 3 Multicast Receive Algorithm

VI. CANDIDATE SELECTION

Unlike candidate selection in TOR, proposed protocol uses different strategy. Once the multicasting module locates and calculates the distance of longest possible multicast group member in each quadrant. Candidate selection for the longest possible destination is done in each quadrant using following algorithm

```
For node x selecting the candidate set Cx,d.
While no new candidates are added in Cx,d do
/* find the next new candidate */
for each node j in r do
        If j Є r and E2TX(x,d)- λ > E2TX(j,d) then
        Cx,d = Cx,d U {j}
        End if
End for
Return.
```

Fig 4 Candidate Selection Algorithm

VII. PRIORITIZATION OF RELAYS

After completion of selection of candidate relay set, the another issue needs to be noticed in OR is prioritization of the selected relays. We compare the E2TX of each node to assign priorities using theorem in [2].

Theorem : (Priority rule for relays) For any node, once its relays have been determined, there lays should be prioritized in the decreasing order of their corresponding E2TX in order to provide the assurance that each node has a higher trustworthiness and less number of retransmission.

CONCLUSION

In this paper, we have put the idea of multicasting in trust based opportunistic routing. Also we have used optimum algorithm for candidate selection using existing E2TX metric. We have also tried to reduce overheads by selecting candidates for limited multicast group member instead of doing it for all members in one multicast region. We have also put the algorithm for multicasting using E2TX metric. Future scope in this paper is to reducing the routing overheads to more extent and minimizing the energy consumption during routing.

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