CHAPTER 4

ENHANCED MULTIHOP ROUTING IN MANETS

4.1 INTRODUCTION

This Chapter describes about the critical parameters of opportunistic communication such as trust, mobility and energy in MANET. TME parameters computation over the individual nodes is used to find the efficient routing path in Mobile ad hoc Networks is discussed. The role of ALMN and compute nodes which are responsible to link the MANET and mobile networks is also addressed.

4.2 ROUTING ENHANCEMENT IN AODV

AODV is a pure on demand routing mechanism where routing is done only when a node wants to transmit data. The existing protocol selects the route based on minimum hop count and such a route may not be reliable and trust worthy. In the proposed modification all the incoming RREQs are analysed in order to select the best route.

4.2.1 Path Discovery

When a node source S wants to transmit data, it creates a RREQ packet and broadcasts it to the neighbouring nodes. A RREQ packet is uniquely identified using {node seqnum, broadcast_id} pair. The broadcasted RREQ packet gets rebroadcast through the network until it reaches the destination. Throughout the broadcast process the intermediate nodes keep
updating their routing tables whenever they receive a RREQ, so that a node knows all the paths existing to its neighbours. Such routing table entries are used to formulate the ‘reverse routes’.

4.2.1.1 Modification of RREQ

The additional fields added to the packet format are namely,

- Trust index
- Predicted mobility index
- Energy index
- QOS level

For the multiple routes identified, the destination calculates T-M-E index according to the QOS level required for the communication. Energy value is computed using the residual energy level of the nodes along the routes.

Additional fields are added in the RREQ packet in order to incorporate trust and mobility prediction during route discovery. These fields are as follows:

- Rq_c_trust – contains the cumulative trust index of the route discovered.
- Rq_m_life – minimum life expected by the route based on mobility prediction module.
- Rq_m_energy – minimum energy node along the discovered route.
- Rq_QOS – to specify the QOS level required for the route to be discovered.
4.2.2 Enhanced Route Discovery

The Enhanced TME based AODV routing is shown in Figure 4.1. Based on QoS requirement, weights are assigned to the three parameters of trust, mobility and energy and the TME index is computed whenever a node encounters RREQ packet. Instead of discarding the duplicate RREQs, our nodes are designed to handle more RREQs from the same source.

The node then computes TME index for each RREQ from same source but forwarded through different nodes. Then the node rebroadcasts only the RREQ that has high TME value. Thus at the end of route discovery process, the proposed system identifies a better route taking into consideration of the factors such as trust, predicted mobility and residual energy.
4.3 MODIFIED TME BASED ROUTING ALGORITHM

The modified TME based routing algorithm is explained as follows:

Step 1: For any node in MANET, proceed to step 2 if and only if the incoming packet is RREQ packet, else follow normal AODV.

Step 2: Retrieve the rq_QoS field from the packet and check the QoS level required for the packet transmission. Assign weights to the trust index, mobility index and energy index accordingly.

Step 3: Retrieve the rq_c_trust, rq_m_life and rq_m_energy from the packet and compute TME index for the RREQ packet (say new_TME).

Step 4: Look up for the values of trust, mobility and energy cached in the broadcast_id cache for the old values. Compute TME index for the old values (say old_TME).

Step 5: If new_TME > old_TME , update the routing table with a new reverse route to the node that sent the new RREQ and add broadcast_id with the new index values. Else discard the new RREQ packet.

The proposed Efficient TME based Ad hoc Routing (ETAR) protocol uses Trust, Mobility and Energy (TME) based modification in the existing AODV protocol.

4.4 MOBILITY PREDICTION ALGORITHM

The proposed synthetic mobility prediction algorithm (HCT-MM) predicts the real human mobility traces by considering the moving pattern in two halves of the day.
Step 1: Assignment of home location and roam location for community i

Step 2: Locate Initial Position of the nodes in Community i

Step 3: Assume T – Current time

T1 – First half of simulation time

T2 – Second half of simulation time

pr^i – Probability of node ‘i’ in roam location

ph^i – Probability of node ‘i’ in home location

If ((Simulation_Time mod T) < T1)

If node is in Home state;

Next movement – Home trip (1-pr^i) or roam trip pr^i

Next movement – Roam trip(1-ph^i) or home trip ph^i

If ((Simulation_Time mod T) = T1)

For node i;

Reset the home location to Hi (T2)

Reset the roam location to Ri (T2)

If (T1 <= (Simulation_Time mod T) < (T1 + T2))

If node is in Home state;

Next movement – Home trip (1-pr^i) or roam trip pr^i

Next movement – Roam trip (1-ph^i) or home trip ph^i

If ((Simulation_Time mod T) = (T1+T2))

For node i;
Reset the home location to Hi (T1)

Reset the roam location to Ri (T1)

4.5 TRUST COMPUTATION ALGORITHM

The Trust computation algorithm is explained as follows:

Step 1: Each node which is a part of MANET generates a POLL message packet containing its digital signature. (For ex: MD5 digest)

Step 2: All the nodes broadcast the POLL message to every neighbour within its transmission range.

Step 3: Any node upon receiving the POLL message must acknowledge its receipt and generates a POLL REPLY message of its own.

Step 4: The POLL REPLY message will encapsulate the key value sent by the source POLL message.

Step 5: The node then transmits the POLL REPLY message to the originator of the POLL message.

Step 6: In this way every node receives a POLL REPLY from all of its neighbours and obtains a trust opinion about its neighbours.

Step 7: Every node maintains two lists namely the local opinion list and Global opinion list. Upon receiving the POLL REPLY the node populates its local opinion list with a trust value for that node.

Step 8: If a malicious node tries to tamper with the packet the digest will not match with the returned message. If it is a selfish node it will not acknowledge with a POLL REPLY message.
Step 9: Based on the observed characteristics local opinion is calculated in each node for all its neighbours.

Step 10: Finally all nodes share their local view with their neighbours to obtain a more consolidated and precise global view of trustworthiness of all nodes.

The modified AODV for opportunistic communications is implemented as follows:

Receive request routine

{
If (id_lookup(rq_src address, rq_broadcast id)
{
	Old_trust = id_list->c_trust
	Old_m_life = id_list->m_life
	Old_m_energy = id_list->m_energy

If (rq_qos==1)
{
	Old_index = (0.5*old_m_life + 0.3 * old_m_energy + 0.2 * old_c_trust)/3
	new_index = (0.5*new_m_life + 0.3 * new_m_energy + 0.2 * new_c_trust)/3

}
If (rq_qos==2)
{
}
Old_index = (0.2*old_m_life + 0.1 * old_m_energy + 0.7 * old_c_trust)/3
new_index = (0.2*new_m_life + 0.1 * new_m_energy + 0.7 * new_c_trust)/3

} 
If(old_index < new_index) 
{ 
    Change routing table entry with new reverse route 
} 
Else 
{ 
    Discard the new RREQ 
}

4.5.1 Trust-Mobility-Energy (TME) Computation

The Trust-Mobility-Energy (TME) Computation algorithm is explained as follows:

Input:     Nodes’ route discovery packets

Output:    TME Index value

4.5.1.1 Trust Level Computation

1. Every node computes the trust level based on reply packets from neighbors (Local opinion).
2. The Local opinions from all of its neighbors are used to compute the Global trust value of the node (Global opinion).

3. Both Local and Global opinions are used to calculate the final trust value of the nodes in the MANET.

4.5.1.2 Mobility Pattern Computation

1. The mobility pattern is identified based on the intuitive observation made from the human mobility.

2. The mobility granularity of a node is defined with respect to various time slots in a day.

3. Nodes of similar localized mobility patterns are defined as “Community”. The various communities have different home locations, but may have the same roaming locations. The Nodes of different community won’t meet quiet often in the roaming location.

4.5.1.3 Energy Level Computation

1. Source Node floods the RREQ packet to its neighbours for selecting the energy efficient path.

2. The RREP packet is sent to neighbour which is having the maximum energy level until the source receives the RREP packet.

4.5.1.4 Opportunistic Path Computation (OPC)

Input : TME Index values and Application-type

Output : Optimal Path Selection
1. The weightage for TME parameters is assigned based on the type of application.

2. Path selection is based on the TME Index value.

3. Path maintenance is carried out by considering route caching.

### 4.6 OPPORTUNISTIC ROUTE COMPUTATION

Every node in the considered MANET will undergo the process of Neighbour Behaviour Observation. Every node has to respond to its neighbours based on the queries from them and reply with specific packets. All the nodes in the MANET maintain a Local Opinion list with entries for every neighbour. Based on the responses from various neighbours the list is populated to assess their trustworthiness.

![Figure 4.2 MANET Routing Path](image)

**Figure 4.2 MANET Routing Path**

Till now all the nodes have formed local opinions about their neighbours. This only provides a local opinion of trustworthiness of neighbours. But a global view is essential for making routing decisions, since malicious nodes may have spread conflicting opinions to other nodes. The work takes care of spreading the local opinion to all nodes to maintain a global view.

The global opinion formation phase helps to form a final trust opinion in all nodes. The global opinion list is populated with updated trust
values from neighbours. These global values are used in modifying the routing path.

In addition to the Trust and Mobility pattern parameters, the residual energy available in the nodes is also considered in making a decision on node suitability for the route. Finally by combining these three parameters viz-a-viz mobility, trust and energy as index called TME Index is computed during route discovery process. Based on this TME index value a node is chosen or eliminated for the routing process. MANET routing path computation is shown in Figure 4.2. The destination in TME based efficient path computation is either compute node or AMLN node. The AMLN in MANET then transfers the packets to wired/wireless networks such as Ethernet or WiFi / WiMAX networks.

4.7 SUMMARY

The TME parameters such as Trust, mobility and Energy are used to calculate the TME-index value which is used to establish the efficient route. The identified compute node or AMLN which will connect to wired/wireless networks were described. The efficient vertical handover decision is presented in Chapter 5.