CHAPTER 6

ENHANCED DTV

6.1 OVERVIEW

Due to several issues in the mobile ad hoc networks traditional routing algorithms will not work efficiently in ad hoc network. Information from lower layers concerning connectivity or interference can help routing algorithms to find a good path. The major hindrance in existing routing protocols is routing overhead. One of the main reasons for routing overhead is large number of routing nodes. The Dynamic Triangular Vision algorithm is discussed which reduces the overhead by minimizing the routing nodes. But there is a chance of network failure if any node in the route is failed due to many reasons like battery limitations etc. If the proportions of relay nodes are large in a network, then it may lead to faster depletion of node’s battery power. Energy consumption in transmit state is higher than receiving state. Retransmission occurs due to collision, and this increases per packet energy consumption. Retransmission also affects other network parameters such as: end-to-end delay, jitter, throughput etc. To avoid these situations the DTV algorithm is enhanced to improve network lifetime, packet delivery ratio, save energy, increased throughput and reduce end-to-end delay by not only reducing the network region and also consider the optimal node for routing. Optimality of the nodes can be calculated based on their characteristics. Like DTV algorithm a virtual triangular request zone is created in Enhanced version also.
Within request zone only limited nodes can be elected based on weights of quality metrics.

6.2 METHODOLOGY OF ENHANCED DTV

This contribution aims to optimally use scarce resources such as bandwidth, computing power, memory, and battery power and routing to be adaptive with frequent topology changes caused by mobility of nodes. This enhanced version also proposed to provide an efficient route and a certain level of Quality of Service. In order to achieve these, each node in network maintains the DTV table, which consists of the node ID, Location, Grade Point (GP) of all neighboring nodes

\[
GP = W_1X_1 + W_2X_2 + W_3X_3 + \ldots \ldots \ldots (6.1)
\]

The dimensional values of weights \((W_i)\) and metrics used to qualify a node \((x_i)\) are given below:

\[
\begin{array}{c}
W1 \ W2 \ W3 \ldots \ WN \\
X1 \ x11 \ x12 \ x13 \ldots x1N \\
X2 \ x21 \ x22 \ x23 \ldots x2N \\
X3 \ x31 \ x32 \ x33 \ldots x3N \\
\ldots \ldots \\
\ldots \ldots \\
\ldots \ldots \\
XM \ Xm1 \ Xm2 \ Xm3 \ldots Xmn
\end{array}
\]
Where $W_i$ represents weights of a metric $i$ and $0 < W_i < 1$. $X_i$ represents the value of metrics $i$ which represents the node quality. The DTV table will be updated regularly and it is maintained in ascending order of GP values. The nodes which satisfying the constraints (within request zone) are considered as feasible nodes and top three nodes with highest GP values are treated as optimal nodes. The various metrics that are used in ranking the nodes are given below:

$X_1$. Packet Forwarding Ratio

The cooperative node can be identified by their previous Packet Forwarding Ratio (PFR). A selfish node that wants to save battery life for its own communication can endanger the correct network operation by simply not participating in the routing protocol or by not executing the packet forwarding. Current ad hoc routing protocols cannot cope with the selfishness problem and performances severely degrade as a result. Because of this each node should select cooperative neighbor node for better performance. To achieve this PFR can be calculated as below

\[
\text{Packet Forwarding Ratio (PFR)} = \frac{\text{No. of packets forwarded}}{\text{No. of packets received}} \quad \ldots \ldots (6.2)
\]

$X_2$. Link Alive Time (LAT)

This metric is used to find the approximate lifetime of a given wireless link using the mobility and location information of nodes. Link Alive Time between two nodes can be estimated using the information such as current position of the nodes, their direction of movement, and their transmission ranges [SU,99]. The wireless link between nodes a
and b with transmission range $T_X$, which are moving at velocity $V_a$ and $V_b$ at angles $T_a$ and $T_b$ can be estimated as below

$$\text{LAT} = \frac{- (pq+rs) + (p^2 + r^2)T_X^2 - (ps-qr)^2}{p^2+q^2} \quad \ldots \ldots (6.3)$$

Where $p= V_a\cos T_a - V_b\cos T_b$

$q=X_a-X_b$

$r= V_a\sin T_a - V_b\sin T_b$

$s=Y_a-Y_b$

$X_3$ - Average Throughput

Throughput is defined as the total amount of data a receiver actually receives from the sender $S$ divided by the time it takes for $R$ to get the last packet. The average throughput in Kbps can be computed by the formation as shown below:

$$\text{Average throughput} = \frac{(X*L)}{t} \quad \ldots \ldots (6.4)$$

Where $(X)$ denotes the number of the packets successfully received, $(L)$ is the packet size and $(t)$ is the simulation time. The node which improves the throughput will be selected for routing.

$X_4$ - Node buffer size

Every node need to store the data packets for particular time periods to recover it in case of any route failures. Each intermediate node should store the selected feasible nodes temporarily for future routing. So the node with highest buffer size will be given priority.
**X5 - Node mobility**

In MANET the network topology is highly dynamic due to the movement of nodes; hence routing suffers from frequent path breaks. Mobility of a node can be measured using the following formula

\[
M_v = \frac{1}{T} \sum_{i=1}^{T} \left( (X_t - X_{t-1})^2 + (Y_t - Y_{t-1})^2 \right)
\]

…… (6.5)

where \((X_t, Y_t)\) and \((X_{t-1}, Y_{t-1})\) are the coordinates of a node at time \(t\) and \(t-1\). The current time is \(T\). So the node with highest mobility will be given lower weight.

![Figure 6.1 Node mobility](image)

**X6 - Load on node**

Data packets will be buffered in the nodes when the routes are busy. Number of packets waited in the buffer queue for transmission is to be calculated in order to choose the node with minimum load.

**X7 - Energy**

In MANET power consumption by the nodes is a serious factor to be taken into consideration by routing protocols. The energy efficiency of a node is defined as the ratio of the amount of data delivered by the node to the total energy expended or using loss power using the distance [LI,01].

77
The remaining energy of the nodes can be calculated using

\[ E_R = E_T - t^*d(u,v)^n \] 

\[ \cdots \cdots (6.6) \]

Where \( E_R \) - Remaining energy

\[ E_T \] - Total energy

\( t \) – a constant

\( n \) – The path loss exponent indicating the loss power with distance from the transmitter

\( d(u,v) \) – distance between two nodes \( u \) and \( v \)

This algorithm includes Request zone creation, Route discovery and route maintenance phases. Request zone creation is similar to the one which is discussed in the previous chapter.

### 6.3 Route Discovery

If a source node \( S \) intends to send data to destination \( D \), first \( S \) has to find whether the location for \( D \) is available in location table, otherwise Location management is called to update the table. If the location is available, the source node checks whether the route for \( D \) is available in buffer or not. If there is a route, then it starts the communication. Otherwise it starts the route discovery. A request zone is created based on the location of \( S \) and \( D \). Only feasible neighbor nodes are selected for routing. Among the feasible nodes, three nodes with highest GP value is considered and stored in the buffer of \( S \). The node \( S \) transmits **Route Request packet** to one optimal node among these three nodes which is having the highest GP value. If the source is \( X \), then successive nodes may be named as \( X_1, X_2 \) and \( X_3 \). Suppose \( X_1 \)
is picked up, it consists of three nodes and that is indicated as $X_1Y_1$, $X_1Y_2$, and $X_1Y_3$ [AAN, 15c] and so on. The process continues until the destination is reached. A route reply is generated once the route request reaches the destination. After receiving Route Reply source starts the communication. The route discovery gives attention to the dynamic triangular view, so it majorly avoids route reply storms, and flooding attacks. The reply packet contains the route record yielding the sequence hops taken. If there is any failure in the route, the source selects the next optimal node which is in the buffer for communication. If any intermediate node or any intermediate link failure occurs in the discovered route, source need not reconstruct the route. Alternative node of three selected neighbor nodes (with highest GP values) of an intermediate node whose successor node or link failed is considered for routing. So the time taken to reconstruction is reduced.

An example route discovery is shown in Figure 6.2 in which the source node is S and destination is D. If source select the optimal node A for routing and the node A selects neighbor node E. But the node A stores nodes C and D in buffer. Because E, C and D are the three neighbor nodes of A with high GP values among them E is having the highest GP value, so it is the optimal node for routing. Similarly the node E selects the node F among its neighbor nodes and I chose node M and M can directly communicate with destination D. For example if the node I failed or link I→M is failed then route need not be reconstructed from the source instead F can construct the route from G or H based on their GP value. There is no need to reconstruct the packet also, because F is having the data packets in its buffer.
Similarly all the routes are having alternatives. This proves that the end-to-end delay of the proposed scheme is reduced and packet delivery ratio is increased.

![Figure 6.2 Route Discovery](image)

The following algorithm presents the process of discovering route in Enhanced DTV protocol systematically. Also the Figure 6.3 charts this process in a legible way.

### 6.3.1 Route Discovery Algorithm

**Step 1:** If a source node S intends to send data to destination D then S has to find whether the route for D is available in buffer or not.

**Step 2:** If there is a route then start communication.

**Step 3:** Otherwise start route discovery.

**Step 4:** A request zone is created based on the location of S and D.
Step 5: Only feasible neighbor nodes are selected for routing if \((X_{id} - X_s) > 0\) then intermediate nodes at \((X_k Y_k)\) are feasible only when \((X_s <= X_k <= X_{id})\) else nodes in the range \((X_{id} <= X_k <= s)\) are feasible. Likewise y coordinate constrains are considered \((Y_s <= Y_k <= Y_{id})\) or \((Y_{id} <= Y_k <= Y_s)\).

Step 6: Among these feasible nodes three nodes with highest GP value which is maintained in DTV table has been considered and stored in buffer of S.

Step 7: The S send **RouteRequest packet** to one optimal node among these three nodes which satisfies

\[
\text{Max } \sum_{i=1}^{n} W_i X_i \quad \ldots \ldots (6.7)
\]

Step 8: If the source is X then successive nodes may be named as \(X_1, X_2, X_3\). Suppose \(X_1\) has picked, it consists of three nodes and that is indicated as \(X_1 Y_1, X_1 Y_2, X_1 Y_3\) and so on.

Step 9: Repeat these until destination reached.

Step 10: Destination will send **Route-Reply**. After receiving **Route-Reply** source node starts communication.

Step 11: If any failure in the route the source node select next optimal node which is in the buffer for communication

Step 12: DTV model have 3 sides of degrees, they are powerfully changing upon the diverse entities. [AAN,16]
Case 1: Slow Moving Entity  
Larger Central Degree and Smaller Radius

Case 2: Fast Moving Entity
Smaller Central Degree and Larger Radius

Case 3: Unexpected Sharp Turn

---

Figure 6.3 Workflow model of Enhanced DTV
6.4 SIMULATION SETUP AND PERFORMANCE ANALYSIS

The enhanced DTV is simulated with NS2 and its performance is compared with existing protocols AODV, DSR and DTV which is proposed in the previous chapter. For this 1000mX1000m network is used with minimum of 80 nodes with simulation time 500secs.

There are a number of different simulation studies with NS2 environment have been taken place which are analyzing the behavior and performance of Enhanced DTV of DTVOSSP and comparing it to other existing routing protocols for ad hoc networks. Here only some of the basic results that indicate DTVOSSP's excellent performance are summarized. In the results presented here, all simulations were run in ad hoc networks of 80 mobile nodes moving according to the random waypoint mobility model within a flat squarer (1000mx1000m) area; all simulations were run for 500 seconds of simulated time. Data traffic was generated using constant bit rate (CBR) and mobile nodes acting as traffic sources generating 4 packets/second each; on the identical workloads. In the random waypoint mobility model, each mobile node begins at a random location and moves independently during the simulation. Each node remains stationary for a specified period that is known as pause time and then moves in a straight line to some new randomly chosen location at a randomly chosen speed up to some maximum speed. Once reaching that new location, the node again remains stationary for the pause time, and then chooses a new random location to proceed some new randomly chosen speed, and the node continues to repeat this behavior throughout the simulation run. This model can produce large amounts of relative node movement and
network topology change, and thus provides a good movement model with which to stress DTVOSSP or other ad hoc network routing protocols.

Table 6.1 listed down the simulation parameters that are used to evaluate the performance of Enhanced DTV.

**Table 6.1 Simulation Setup**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routing Protocols</td>
<td>Enhanced DTV, DTV, AODV and DSR</td>
</tr>
<tr>
<td>Simulation time</td>
<td>500 seconds</td>
</tr>
<tr>
<td>Traffic Type</td>
<td>CBR</td>
</tr>
<tr>
<td>Maximum Connections</td>
<td>10</td>
</tr>
<tr>
<td>Transmission Rate</td>
<td>4 packets per second</td>
</tr>
<tr>
<td>Packet Size</td>
<td>512 byte</td>
</tr>
<tr>
<td>Pause Time</td>
<td>0, 10, 20, 50, 100, 250 and 500 Second</td>
</tr>
<tr>
<td>Number of Nodes</td>
<td>80</td>
</tr>
<tr>
<td>Network Area</td>
<td>1000mX1000m</td>
</tr>
<tr>
<td>Maximum Speed of Nodes</td>
<td>20 m/s</td>
</tr>
</tbody>
</table>

**6.4.1 Performance metrics**

The following performance metrics are used to analyze the performance of Enhanced DTV and prove its effectiveness.
6.4.2. Analysis

Figure 6.4 and Table 6.2 summarize the performance of DTVOSSP as a function of pause time. The packet delivery ratio is the overall percentage of the UDP data packets originated by nodes that were successfully delivered by Enhanced DTV. It is compared with the packet delivery ratio of Enhanced DTV, DTV, AODV, and DSR with different pause time. These results prove that the packet delivery ratio of Enhanced DTV is higher than the existing protocols and even greater than the DTV which is proposed in the first contribution. Each point in the graphs represents the average of 10 random movement and communication scenarios for the given pause time.

Pause time basically determines the mobility rate of the model, as pause time increases the mobility rate decreases. Pause time is the amount of time taken by each of the moving nodes before they start transmitting packets. When the pause time is high, the wait time for the nodes is high and the mobility is low because the nodes are not continuously sending packets. When the pause time is low, the wait
time for the nodes is low and hence the mobility is high. It means the nodes are constantly sending packets without any wait time.

At a pause time of 0 (on the left hand-side of each graph), all nodes in the network are in constant motion, and as the pause time increases from left to right, the average node movement rate in the network decreases. At a pause time of 500 (on the right hand-side of each graph), all nodes are stationary, since each simulation was run for 500 simulated seconds of operation of the ad hoc network.

**Table 6.2 Packet delivery ratio of Enhanced DTV, DTV, DSR and AODV**

<table>
<thead>
<tr>
<th>Pause Time</th>
<th>Packet delivery Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enhanced DTV</td>
</tr>
<tr>
<td>0</td>
<td>0.98</td>
</tr>
<tr>
<td>10</td>
<td>0.99</td>
</tr>
<tr>
<td>20</td>
<td>0.88</td>
</tr>
<tr>
<td>50</td>
<td>0.89</td>
</tr>
<tr>
<td>100</td>
<td>0.97</td>
</tr>
<tr>
<td>250</td>
<td>0.9</td>
</tr>
<tr>
<td>500</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Enhanced DTV delivers almost all data packets, regardless of pause time, with packet delivery ratio between 85% and 98%. The
slight decrease at pause time 20 is due to the random generation of the
scenarios that used in the simulations. At the higher movement speed
of 20 meters/second, Enhanced DTV is able to deliver greater than 98% of
all packets, even at pause time 0 which is very high compared to
other protocols like AODV and DSR.

![Comparison of Packet Delivery Ratio of Enhanced DTV, DTV, AODV and DSR with different Pause Time](image)

**Figure 6.4 Comparison of Packet delivery ratio**

For the first time, when a node finished its own battery is defined
as network lifetime. The performance of the protocol is better when the
network life time is high. This can be proved from the Table 6.3 and
Figure 6.5 which shows that Network Life Time of Enhanced DTV is
better than all other protocols that compared.
Table 6.3 Performance of Enhanced DTV over Network Life Time

<table>
<thead>
<tr>
<th>Pause Time</th>
<th>Enhanced DTV</th>
<th>DTV</th>
<th>DSR</th>
<th>AODV</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>300</td>
<td>285</td>
<td>260</td>
<td>265</td>
</tr>
<tr>
<td>10</td>
<td>320</td>
<td>305</td>
<td>240</td>
<td>280</td>
</tr>
<tr>
<td>20</td>
<td>305</td>
<td>295</td>
<td>195</td>
<td>200</td>
</tr>
<tr>
<td>50</td>
<td>295</td>
<td>280</td>
<td>240</td>
<td>275</td>
</tr>
<tr>
<td>100</td>
<td>270</td>
<td>260</td>
<td>210</td>
<td>250</td>
</tr>
<tr>
<td>250</td>
<td>310</td>
<td>285</td>
<td>243</td>
<td>240</td>
</tr>
<tr>
<td>500</td>
<td>270</td>
<td>265</td>
<td>190</td>
<td>250</td>
</tr>
</tbody>
</table>

Figure 6.5 Comparison of Network Life Time
Network delay is the total latency experienced by a packet to traverse the network from the source to the destination. At the network layer, the end-to-end packet latency is the sum of processing delay, packet transmission delay, queuing delay and propagation delay. The end-to-end delay of a path is the sum of the node delay at each node plus the link delay at each link on the path. It is clear that from Figure 6.6 and Table 6.4 the end to end delay is very less in Enhanced DTV and it is decreased when the pause time increased that is when nodes mobility decreased.

<table>
<thead>
<tr>
<th>Pause Time</th>
<th>End to End Delay in Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enhanced DTV</td>
</tr>
<tr>
<td>0</td>
<td>0.18</td>
</tr>
<tr>
<td>10</td>
<td>0.17</td>
</tr>
<tr>
<td>20</td>
<td>0.1</td>
</tr>
<tr>
<td>50</td>
<td>0.1</td>
</tr>
<tr>
<td>100</td>
<td>0.08</td>
</tr>
<tr>
<td>250</td>
<td>0.05</td>
</tr>
<tr>
<td>500</td>
<td>0.02</td>
</tr>
</tbody>
</table>
As the speed of mobile hosts is increased, the number of routing packets begins to increase for all routing protocols. With higher speed, the frequency of route breaking increases, so routing overhead to discover new routes also increases. However, in DTV schemes 1 and 2 provide a lower rate of increase than flooding. This is because, with DTV, number of route requests is significantly reduced by limiting route discovery to a smaller request zone. This is shown in Table 6.5 and Figure 6.7 in which Routing overhead of Enhanced DTV is very low compared to existing protocols like DSR and AODV. For most speeds, Enhanced DTV clearly performs best in terms of the number of routing packets per data packet.

Figure 6.6 Performance of Enhanced DTV in terms of End to End Delay
### Table 6.5 Performance of Enhanced DTV over Routing Overhead with Different Pause time

<table>
<thead>
<tr>
<th>Pause Time</th>
<th>Routing Overhead</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enhanced DTV</td>
<td>DTV</td>
<td>DSR</td>
<td>AODV</td>
</tr>
<tr>
<td>0</td>
<td>0.5</td>
<td>0.7</td>
<td>1.3</td>
<td>0.98</td>
</tr>
<tr>
<td>10</td>
<td>0.5</td>
<td>0.8</td>
<td>1.4</td>
<td>1.2</td>
</tr>
<tr>
<td>20</td>
<td>0.3</td>
<td>0.8</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>50</td>
<td>0.25</td>
<td>0.6</td>
<td>1.8</td>
<td>1.2</td>
</tr>
<tr>
<td>100</td>
<td>0.25</td>
<td>0.6</td>
<td>1.5</td>
<td>0.95</td>
</tr>
<tr>
<td>250</td>
<td>0.25</td>
<td>0.5</td>
<td>2.5</td>
<td>1.5</td>
</tr>
<tr>
<td>500</td>
<td>0.2</td>
<td>0.3</td>
<td>1.3</td>
<td>1</td>
</tr>
</tbody>
</table>

**Figure 6.7 Routing Overhead of Enhanced DTV with various Pause Time**
6.5 SUMMARY

This chapter proposes an algorithm Enhanced DTV which introduces the qualities of node in the route selection process. Enhanced DTV also proves that geographical approaches can build on reactive techniques and in addition geographical information can be incorporated to aid in routing. The use of geolocation information can prevent network-wide searches for destinations, as either control packets or data packets can be sent in the general direction of the destination if the recent geographical coordinates for the destination are known. This reduces the control overhead generated in the network. And in this approach the Route Request is prevented from flooding the entire network because it is restricted to areas that are likely to be en route to the destination and also shortlist the nodes based on the weights of their qualities. This results in a reduction in both bandwidth and processing overhead.

The results show that the Enhanced DTV outperforms various routing parameters like packet delivery ratio, end to end delay, routing overhead and network life time etc. The next chapter enhances this approach by grouping the nodes in the network region when the size of the request region is very large by applying clustering concept.