CHAPTER 5

RELIABLE AND EFFECTIVE LOAD BALANCING
TECHNIQUE

This chapter is divided into 6 sections. Section 5.1 provides the need for Reliable and Effective Load Balanced Routing (RELBR) Technique. Section 5.2 gives the overview of the RELBR technique. Section 5.3 discusses about the calculation of the combined weight function which is used to find the stability of the route. Section 5.4 illustrates the load balancing technique for the RELBR. This technique discusses how the load is distributed to the multiple routes in an effective manner. Section 5.5 provides the simulation results for the RELBR by varying the load and pause time using the NS2 simulator. Section 5.6 presents the summary for this chapter.

5.1 NEED FOR RELBR

MANETs have been evolving to serve a growing range of applications that rely on multi-hop wireless infrastructureless which can be deployed quickly. The potential applications include emergency disaster relief, battlefield situations, mine site operations, and wireless classrooms or meeting rooms in which participants wish to share information or to acquire huge amount of data.

A critical challenge in the design of Ad hoc networks is the development of efficient routing protocols that offer high quality communication (Bharadwaj et al 2011). Currently, Ad hoc routing protocols
lacks in load balancing techniques. A major negative aspect of all existing ad
hoc routing protocols is that they consider the path with minimum number of
hops as optimal path to any given destination (Guérin & Orda 2002), (Rani &
Dave 2009). However, this strategy does not have provision for conveying the
load and quality of path during route setup. This leads to congestion at
medium access control layer (MAC) in these nodes, which in turn lead to high
packet delays, since some nodes may carry excessive loads (Saigal et al 2004),
(Lee and Riley 2005). This leads to the problem of link breakage. To avoid
this problem, the load balance issue is considered in this chapter.

5.2 OVERVIEW OF RELBR

In Reliable and Effective Load Balanced Routing Technique (RELBR) the load is uniformly distributed among two or more computers
network links i.e., multipath is used to achieve the fairness in load balancing.
Thus it utilizes the resources in an optimal manner. Multipath routing
establishes the multiple paths between the single source and single destination
pair. This multipath routing designed in order to maximize the reliability or to
provide the load balancing.

In this technique, initially, a combined weight function is calculated
based on the signal strength, length, traffic load and energy level. Based on
these values the routes are stored in the route cache in the descending order.
Select the best n paths from these routes based on the combined weight value.
Then the traffic is distributed over these paths using network diversity coding.
On the receiving side, the original message is reconstructed if at least L blocks
out of M blocks reach the destination using diversity coding. This improves
the performance of RELBR in terms of overhead, end-to-end delay, packet
delivery ratio and energy consumption.
5.3 ESTIMATION OF COMBINED WEIGHT FUNCTION

The combined weight function for each route in the route cache is calculated for reliable and effective load balancing technique using the following parameters

- **Length**: Length of the route to transfer the data from source to destination
- **Traffic Load**: Traffic load across the route.
- **Energy Level**: Indicate the residual battery energy for the route to transfer the data
- **Signal strength**: Indicates the received signal strength

Best n paths are selected based on their combined weight value among the selected paths in the route cache. Then traffic is distributed over these paths using network diversity coding.

- **The Received Signal Strength**

  Signal strength in the wireless medium plays vital role in communication between the nodes. As the distance between the node increases the signal gets weakened and sometimes the reception of signal is not possible (Lin, 2004). When the node is within the radio range, then it is within the communication range else it is not able to communicate.

  The IEEE 802.11 is reliable MAC protocol. It assumes the fixed maximum transmission power in order that the received signal strength must attain every exposed node. During the transmission of RTS packet by sending node, it attaches its transmission power. While receiving the RTS packet, the signal strength received for free-space propagation is measured by the receiving node (Vadivel & Bhasakaran 2010).
\[ P_R = P_T \left( \frac{\lambda}{4\pi d} \right)^2 G_T G_R \]  

(5.1)

where, \( \lambda \) is wavelength of the carrier,
\( d \) is distance between sender and receiver.
\( G_T \) and \( G_R \) are unity gain of transmitting and receiving omni directional antennas, respectively.

➢ **Length**

Length which indicates the priority of route \( i \) regarding the length of the route is defined as,

\[ \text{Len}_i = \frac{\text{ALen}_i}{\text{MLen}} \]  

(5.2)

\( \text{ALen}_i \) is the actual length of route \( i \) (i.e. number of hops in route \( i \))
\( \text{MLen} \) is the maximum length that a route can take in DSR routing protocols.

➢ **Traffic Load**

In the routing process, a route with a lower traffic cost has a higher priority. The traffic of the route nodes causes the total traffic which can affect a route. Traffic of each node is linked to the number of routes through it. The total traffic of route \( i \), \( \text{TL}_i \) is given by:

\[ \text{TL}_i = \frac{\sum_{n=1}^{N_i} \text{R}1_n + \sum_{k=1}^{NH_n} \text{R}2^k_n}{\text{NH}_i \times C_{\text{max}}} \]  

(5.3)

where \( \text{R}1_n \) = number of routes via node \( n \)
\( N_i \) = number of nodes in route \( i \).
\( \text{NH}_n \) = number of neighbours for node \( n \),
\( \text{R}2^k_n \) = number of routes through \( k \)th neighbour of node \( n \),
\( NH_i = \text{number of neighbours of nodes in route } i \text{ which has } N_n \text{ nodes} \) (repetitive neighbour is taken into account once),
\( C_{max} = \text{maximum connection which a node can establish in a network} \) (which is set to the same value for all nodes).
Packet delay is caused from both traffic load at the current node and traffic load at neighbouring nodes.

\section*{Residual Energy}

A perfect route regarding energy level is the route with a maximum residual battery power in its nodes. Sometimes route have a high residual energy level and some nodes are with low energy levels. For these cases, it results in failure in hot spots which further causes nodes and routes pass through them in an undesirable way. The priority of route \( i \) related to residual energy level \( (\text{Energy}_{i}) \), is termed as,

\[
\text{Energy}_i = \frac{\text{Energy}_{res} \,(i)}{N_i \times \text{Energy}_{initial}} \tag{5.4}
\]

Where \( N_i = \text{number of nodes in the route} \)
\( \text{Energy}_{initial} = \text{node’s energy in the beginning of simulation} \) (which is set to the same value for all nodes),
\( \text{Energy}_{res} \,(i) = \text{total of the remaining energy in the nodes of route } i \),
Combined Weight Function

Finally the Combined Weight Function (CWF) is formed by using the equations (5.1), (5.2), (5.3) and (5.4) as

\[
CWF = \frac{a \cdot \text{Energy}_i + b \cdot P_R}{c \cdot \text{Len}_i \cdot d \cdot TL_i} \quad (5.5)
\]

Energy\_i - residual energy of the route given by the equation (5.4)

P\_R - received signal strength given by equation (5.1)

Len\_i - length of the route given by equation (5.2)

TL\_i - total traffic of the route given by equation (5.3)

Where a, b, c and d are constants used to normalize the metrics.

5.4 LOAD BALANCING TECHNIQUE

Most of the on demand routing protocol for MANET consider the shortest path with minimum number of hop count as the optimal route. The hop metric is easy to implement and reliable in the dynamic environments. The shortest path may sometimes incur a higher end-to-end delay than other paths. Routing protocols based on shortest path cannot fairly distribute the routing load among mobile hosts. Unbalanced distribution of load may lead to increase in packet loss rate and depletion of battery power on certain nodes.

In this technique the dynamic source routing protocol is improved by considering the load balancing as one of the issue. Initially the routes are added into the route cache. For each routes the combined weight function is calculated and it is sorted based on the descending order of CWF value. Based on these values it selects the best n paths from the route. The load is distributed over these paths in order to get optimal utilization of resources which upgrades the DSR routing protocol.
The Figure 5.1 clearly illustrates the visual representation and logical view of the RELBR technique for mobile ad hoc networks.

Add route in cache

For each route, find, Energy_i, Len_i and TL_i.

Determine $P_R$ combined weight function

Sort $\{R_i\}$ in descending order of CWF

If $P_{R_i} > \text{MinTh}$, $P_{R_i} < \text{MaxTh}$

Select route $R_1$ from $\{R_i\}$ and Reroute traffic

If CWF < MinCWF

Remove $R_i$

Apply load balancing technique

Alternative path is not needed

No

Yes

Yes

No

R_i is not removed

Figure 5.1 Flowchart for RELBR Technique
Consider \( w_{\min} \) to be the probability of minimum combined weight function (CWF) of a path which is indexed as \( k \) where \( k=1,2,...p_{\max} \) and \( p_{\max} \) is the total number of available paths, \( w_{\max} \) is the probability of maximum combined weight function (CWF) of the path and \( w_{op} \) is the probability of weight function of other paths.

- \( w_{\min} \) implies no information reaches to the destination.
- \( w_{\max} = 1 - w_{\min} \) implies all the information reaches correctly to the destination.
- The probability \( w_{\max} \) or \( w_{\min} \) of a path is independent of the probability \( w_{op} \), since there are no common nodes for these paths.
- A packet containing \( T \) bits of information is to be transmitted in such a way that the probability \( w_{\max} \) of the path \( p_{\max} \) must be maximized.
- Extra \( U \) bits are added to the original information of \( T \) bits for enhancing reliability of message transmission with the help of source coding technique.
- Hence, \( S = T + U \) is treated as one network layer packet.
- Original \( T \) bits are split into \( L \) blocks of equal size \( b \) and \( U \) bits are split into \( M \) blocks of same size \( b \) as of \( T \) bits.

The original message can be reconstructed if at least \( L \) blocks out of \( M \) blocks reach the destination using \( L \) for \( M \) diversity coding. This is achieved by using Lagrange interpolation and secret sharing scheme (Shamir, 1979). The blocks of \( S \) bits information can be judiciously distributed over the available paths.
An allocation vector is defined as $A_v = [A_{vj}]$, where, $A_{vj}$ is the number of equal size blocks distributed over the path $j$.

If $p$ is the number of paths available, then the allocation vector has the form as

$$A_v = (A_{v1}, A_{v2} \ldots A_{vp}) \text{ where } p \leq p_{\text{max}}, \quad (5.6)$$

Since the block size is $b$, it can write,

$$S = b \sum_{j=1}^{n} A_{vj} \quad (5.7)$$

If $b_j$ is the number of blocks that reaches the destination through the path $j$, then

$$p(b_j = A_{vj}) = w_{\text{max}} \quad (5.8)$$
$$p(b_j = 0) = w_{\text{min}} \quad (5.9)$$

Assuming for $w_{\text{max}}$, all the allocated blocks over the path will reach to the destination successfully and in case $w_{\text{min}}$, all the blocks sent over the path is lost.

The $w_{\text{max}}$ in terms of $p$ and $A_v$ is given by

$$w_{\text{max}}(p, A_v) = p \left\{ \sum_{j=1}^{n} A_{vj} \geq \frac{S}{r} \right\} \quad (5.10)$$

where $\sum_{i=1}^{n} A_{vj}$ total number of blocks by which the information $S$ bits is fragmented.

The probabilities of combined weight function whether minimum or maximum is not same for all paths.
The paths with maximum probability cannot be assigned with fewer blocks than a path with a minimum probability,

Therefore, $W_{\text{min}} \leq w_{\text{min}} + 1$ follows $A_v \geq A_v + 1$ \hspace{1cm} (5.11)

Assume the uniform $A_v$ without the loss of generality i.e. all the paths will be assigned with equal number of blocks though they have different probability.

In this RELBR technique, it makes use of the combined weight function to calculate the combined weight value to find the robustness of the route. CWF value is based on the distance between the nodes, traffic load, energy level of the route and the signal strength of the link. If the route has minimum combined weight value i.e., $w_{\text{min}}$ then the data transferred through this route won’t be received by the receiver correctly. If the route has maximum combined weight value $w_{\text{max}}$ then the data forwarded through this route will be received by receiver correctly.

In order to achieve the fairness in load balancing, the original data $T$ is added with the extra $U$ bit. The information $T$ and $U$ is split up in to $L$ and $M$ equal size block $b$ with the help of source coding technique. The goal of source coding technique is to have the source data and make it smaller. On the receiver side, the original message can be reconstructed using network diversity coding. In this network diversity coding, the transmitted data is encoded and decoded to increase the network throughput, reduce delay and make the network more robust. Every route in the route cache have different probability of combined weight function i.e., the route may have minimum or maximum probability value. The paths with maximum probability cannot be assigned with smaller amount of blocks than a path with minimum probability.
In this reliable and effective load balancing technique, all the routes will be allocated with equal number of blocks for the path which has the probability greater than that of Wmin. So the data send will be received by the receiver. The performance of the DSR routing protocol is upgraded by reducing the utilization of resources i.e., battery power, overhead, delay time and increases the packet delivery ratio.

5.5 RELBR SIMULATION RESULTS

This section presents the simulation model and parameter, performance metrics, tables and charts for the Reliable and Effective Load Balanced Routing protocol. It also shows the experimental result for this RELBR by varying the load and pause time for 50 nodes.

5.5.1 Simulation Model and Parameters

A detailed simulation model based on NS-2 used in the evaluation of proposed technique called Reliable And Effective Load Balanced Routing Protocol (RELBR). Consider a network topology with 50 mobile nodes moving randomly placed over a 1500 meter X 300 meter region for 100 seconds simulation time. The simulated traffic is a Constant Bit Rate (CBR). The node transmits the packet at a constant rate and the entire data packets have a constant size as 512 bytes.

The channel capacity of mobile host is set to the same value: 2Mbps. RELBR make use of the distributed coordination function (DCF) of IEEE 802.11 for wireless LANS as the MAC layer protocol. It has the functionality to notify the network layer about the link breakage. The mobility model adopted for this RELBR technique is a random waypoint model in a rectangular field area. Here, each packet in the network starts its journey from
a random location to a random destination with a minimal speed of 5 m/s. Each mobile node in the network initialized with the energy of 5.1 joules. All nodes have the same transmission range of 250 meters. The pause time is varied as 10, 20, 30, 40 and 50 sec.

Table 5.1 provides the simulation settings and parameters used for the Reliable and Effective and Load Balanced technique.

<table>
<thead>
<tr>
<th>Table 5.1: Simulation Parameters (RELBR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Nodes</td>
</tr>
<tr>
<td>Area Size</td>
</tr>
<tr>
<td>Mac</td>
</tr>
<tr>
<td>Radio Range</td>
</tr>
<tr>
<td>Simulation Time</td>
</tr>
<tr>
<td>Traffic Source</td>
</tr>
<tr>
<td>Packet Size</td>
</tr>
<tr>
<td>Mobility Model</td>
</tr>
<tr>
<td>Rxpower</td>
</tr>
<tr>
<td>Txpower</td>
</tr>
<tr>
<td>Idlepower</td>
</tr>
<tr>
<td>Initial energy</td>
</tr>
<tr>
<td>Load</td>
</tr>
<tr>
<td>Speed</td>
</tr>
<tr>
<td>Pause time</td>
</tr>
</tbody>
</table>
5.5.2 Performance Metrics

The Reliable and Effective Load Balanced Routing (RELBR) protocol is evaluated and compared with the conventional DSR protocol. The evaluation of RELBR mainly depends on the performance according to the following metrics: Control overhead, Average end-to-end delay, Average Packet Delivery Ratio and Average Energy consumption.

- **Control overhead**: The control overhead is defined as the total number of routing control packets normalized by the total number of received data packets.
- **Average end-to-end delay**: The end-to-end delay is averaged over all surviving data packets from the sources to the destinations.
- **Average Packet Delivery Ratio**: Packet delivery ratio is measured by dividing the number of packets received by the destination to the total number of packets originated by the source. This also specifies the packet loss. The better delivery ratio enhances the routing protocol.
- **Average Energy**: It is the average energy consumption of all the nodes involved in sending, receiving and forward operations.

5.5.3 Results Based on Load

This section presents a number of table and charts for the Reliable and Effective Load Balanced Routing Technique by varying the traffic load from 50, 100, 150, 200 and 250 kb and the pause time for 50 nodes.

In this experiment, the performance of both the DSR and RELBR techniques are measured by varying the load from 50 to 250 kb, keeping the pause time as 10 seconds for 50 nodes.
Table 5.2: Load Vs Delay (RELBR)

<table>
<thead>
<tr>
<th>Load (kb)</th>
<th>Delay (Secs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DSR</td>
</tr>
<tr>
<td>50</td>
<td>0.379451</td>
</tr>
<tr>
<td>100</td>
<td>0.369852</td>
</tr>
<tr>
<td>150</td>
<td>0.391812</td>
</tr>
<tr>
<td>200</td>
<td>0.370659</td>
</tr>
<tr>
<td>250</td>
<td>0.361453</td>
</tr>
</tbody>
</table>

Table 5.2 provides the end-to-end delay time for the RELBR and the DSR routing protocol by varying the load with constant pause time. It clearly illustrates that the end-to-end delay time for the RELBR is reduced greatly because the data are transmitted using multiple paths, when compared with the conventional DSR routing protocol.

Figure 5.2: Load Vs Delay (RELBR)

Figure 5.2, shows the average end-to-end delay for the proposed RELBR technique. Delay time is reduced in a huge manner when compared to the DSR protocol.
Table 5.3 Load Vs Delivery Ratio (RELBR)

<table>
<thead>
<tr>
<th>Load (kb)</th>
<th>Delivery Ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DSR</td>
</tr>
<tr>
<td>50</td>
<td>0.804704</td>
</tr>
<tr>
<td>100</td>
<td>0.803373</td>
</tr>
<tr>
<td>150</td>
<td>0.798942</td>
</tr>
<tr>
<td>200</td>
<td>0.802269</td>
</tr>
<tr>
<td>250</td>
<td>0.812436</td>
</tr>
</tbody>
</table>

Table 5.3 provides the packet delivery ratio for the proposed RELBR technique and the conventional DSR routing protocol. It clearly shows that the packet delivery ratio for RELBR is improved considerably when compared with the DSR protocol. Because, it selects the optimal routes and the load is distributed over these routes.

Figure 5.3: Load Vs Delivery Ratio (RELBR)

Figure 5.3, clearly shows the packet delivery ratio for RELBR increases when compared to DSR, since it utilizes robust links. The delivery ratio is increased because the traffic is distributed over the multiple paths.
Table 5.4: Load Vs Energy (RELBR)

<table>
<thead>
<tr>
<th>Load (kb)</th>
<th>Energy (J)</th>
<th>DSR</th>
<th>RELBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>4.191098</td>
<td>3.94147</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>3.902425</td>
<td>3.843377</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>3.651296</td>
<td>3.419156</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>3.387354</td>
<td>3.12873</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>3.35486</td>
<td>2.960989</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.4 provides the average energy consumed by the DSR and RELBR. The energy consumed by the RELBR is minimized when compared with the DSR routing protocol.

Figure 5.4: Load Vs Energy (RELBR)

Figure 5.4 clearly illustrates the results for energy consumption of the RELBR protocol and DSR protocol. It shows that energy consumed by the
RELBR is less when compared against the DSR protocol, since it has energy as a routing metric.

Table 5.5 Load Vs Overhead (RELBR)

<table>
<thead>
<tr>
<th>Load (kb)</th>
<th>Overhead (pkts)</th>
<th>DSR</th>
<th>RELBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>845</td>
<td>575</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>1677</td>
<td>1130</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>2507</td>
<td>1673</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>3406</td>
<td>2239</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>4160</td>
<td>3345</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.5 presents the control overhead for the RELBR technique and DSR routing protocol. The control overhead for the RELBR is reduced significantly when evaluated against the DSR. The overhead is reduced by means of distributing the load over the multiple paths.

Figure 5.5: Load Vs Overhead (RELBR)

Figure 5.5 shows control overhead of the protocols RELBR and DSR. Since RELBR make use of HELLO packets for cost estimation, the
values are considerably less in RELBR when compared with DSR. The overhead is reduced by choosing the robust routes from the route cache and then the data are forwarded through the path, which avoids the link failure caused by the traffic load.

5.5.4 Results Based on Pause Time

In this experimentation, the performance of DSR routing protocol is measured using the metrics end-to-end delay, average overhead, average delivery ratio and the energy consumption against the RELBR technique by varying the pause time from 10 – 50 secs with the interval of 10 seconds. The load 250 kb is kept as constant for 50 mobile nodes.

Table 5.6 Pause Time Vs Delay (RELBR)

<table>
<thead>
<tr>
<th>Pause Time (Secs)</th>
<th>Delay (Secs)</th>
<th>DSR</th>
<th>RELBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.035001</td>
<td>0.015325</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0.033621</td>
<td>0.013563</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>0.029864</td>
<td>0.013027</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>0.026748</td>
<td>0.010133</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>0.024262</td>
<td>0.004152</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.6 presents the average end-to-end delay for the RELBR is calculated by varying the pause time with constant traffic load as 250 kb for 50 nodes. The end-to-end delay for the RELBR is minimized greatly when compared with the DSR routing protocol.
Figure 5.6, shows the plot for the average end-to-end delay versus pause time of the RELBR technique and DSR. It shows RELBR delay time is minimized in a considerable manner. The delay time is reduced because the packets are distributed over multiple routes which has the value greater than the minimum combined weight value.

Table 5.7: Pause Time Vs Delivery Ratio (RELBR)

<table>
<thead>
<tr>
<th>Pause Time (Secs)</th>
<th>Delivery Ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DSR</td>
</tr>
<tr>
<td>10</td>
<td>0.662362</td>
</tr>
<tr>
<td>20</td>
<td>0.693721</td>
</tr>
<tr>
<td>30</td>
<td>0.735362</td>
</tr>
<tr>
<td>40</td>
<td>0.751427</td>
</tr>
<tr>
<td>50</td>
<td>0.793262</td>
</tr>
</tbody>
</table>

Table 5.7 provides the values for the packet delivery ratio for both the RELBR and DSR. It is clear from the table that the packet delivery ratio of the RELBR is increased considerably.
Figure 5.7, clearly shows that the packet delivery ratio for RELBR increases when compared to DSR, since it utilizes robust links and the data are travelled through multiple paths.

Table 5.8: Pause Time Vs Energy (RELBR)

<table>
<thead>
<tr>
<th>Pause Time</th>
<th>Energy (J) DSR</th>
<th>Energy (J) RELBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>4.221328</td>
<td>3.232813</td>
</tr>
<tr>
<td>20</td>
<td>4.440523</td>
<td>3.523926</td>
</tr>
<tr>
<td>30</td>
<td>4.631483</td>
<td>3.753631</td>
</tr>
<tr>
<td>40</td>
<td>4.863162</td>
<td>3.967362</td>
</tr>
<tr>
<td>50</td>
<td>5.023833</td>
<td>4.137675</td>
</tr>
</tbody>
</table>

Table 5.8 shows that energy consumed by the DSR and RELBR. Energy is the resource utilized by the nodes in the network which is used to send and receive the packet. So the energy consumed by the DSR protocol is
high when compared with the RELBR technique because it chooses the most reliable paths from the route cache.

Figure 5.8: Pause Time Vs Energy

Figure 5.8 shows the result for energy consumption. From the results, the performance of the RELBR consumes less energy than the DSR protocol, since it has the energy as a routing metric.

Table 5.9: Pause Time Vs Overhead (RELBR)

<table>
<thead>
<tr>
<th>Pause Time (Secs)</th>
<th>Overhead (pkts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DSR</td>
</tr>
<tr>
<td>10</td>
<td>2828</td>
</tr>
<tr>
<td>20</td>
<td>2481</td>
</tr>
<tr>
<td>30</td>
<td>1959</td>
</tr>
<tr>
<td>40</td>
<td>1563</td>
</tr>
<tr>
<td>50</td>
<td>1292</td>
</tr>
</tbody>
</table>

Table 5.9 provides the control overhead for the RELBR and DSR protocol. It is clear from the table 5.9 that the RELBR overhead is reduced when compared with the DSR protocol.
Figure 5.9 shows the control overhead of the protocols DSR and RELBR. Since RELBR make use of HELLO packets for cost estimation, the values are considerably decreased in RELBR when compared with DSR.

5.6 CHAPTER SUMMARY

This chapter discusses about the working of reliable and effective load balancing technique for DSR routing protocol in mobile ad hoc networks. In this technique, initially, combined weight function is based on the route length, traffic load, energy and the signal strength is estimated for each route. The estimated routes are stored in the route cache. Select the best n paths based on their combined weight value from the route cache. The traffic load is distributed over these paths using the source coding technique. On the receiver side, the receiver reconstructs the received messages using network diversity coding. So that the performance of the Reliable and Effective Load Balancing Technique increases the packet delivery ratio, reduces end-to-end delay, overhead and energy consumed by the network with DSR routing protocol.
In the next chapter, the routing overhead is considered to optimize the RELBR routing protocol by means of improving the scalability of the DSR routing protocol. The overhead occurred during the time of route setup creates the flooding of route request and cached route reply can overload the network to a bad extent. Due to the source routing, the intermediate route addresses along with the address of the source and destination is stored in the data packet header. The performance of the DSR routing protocol is degraded, when the data is carried through the entire path and when the number of nodes in the network is increased.