CHAPTER 3

PERFORMANCE ENHANCEMENT OF ADHOC DYNAMIC SOURCE ROUTING USING NETWORK CODING

3.1 INTRODUCTION TO MANET

MANET is a group of wireless nodes that communicate with each other without a pre-defined infrastructure such as an Access point or base station. The topology is dynamic in nature due to node mobility. Each node acts as a router. Terminals take care of the management and control of the network. These wireless nodes that form the network have low CPU processing capacity, have a small memory footprint and operate on low power. Such networks are useful when fixed infrastructure isn't easily available, when it is expensive or impractical. They are also used for military applications, rescue and home networking. The nodes in the network have self-configuring capability. The figure 3.1 shows the structure of mobile adhoc network. Host movement is frequent and so the topology is dynamic topology. Links between the source and destination is multihop links and data must be routed via intermediate routes [46].

Figure 3.1 Structure of MANET
The major challenges of MANET are:

- Restricted transmission range
- Link characteristics are time varying.
- Wireless medium’s broadcast nature
- Transmission errors due to packet loss.
- Route changes due to Mobility
- Packet loss due to Mobility
- Power/Battery constraints
- Network partitions are potentially frequent
- Routing
- Quality of Service
- Security

The types of routing protocols for mobile adhoc network is listed below.

- Table driven or Proactive routing protocol
- On-demand or Reactive routing protocol
- Hybrid routing protocol.
**Proactive routing protocol**

A routing table is maintained by every node in table-driven/proactive routing protocol and this information is exchanged periodically with neighbouring nodes [47]. When a mobile node wants to transmit data, the route details to the destination can be selected from the table maintained without delay. The whole network is flooded with routing information. When a node requires a path to destination, it runs an appropriate path-finding algorithm, as the examples are WRP, DSDV and OLSR.

**Reactive routing protocol**

No network topology information or routing table is maintained in On-demand / Reactive routing protocol. When a node is required to communicate with a destination, then the path finding process is initiated and exchange of routing information takes place. A route request containing a unique identifier and destination address are broadcasted whenever a mobile node wants to forward data. Examples are TORA, AODV and DSR.

**Hybrid routing protocol**: The best features of proactive and reactive routing protocol are combined called as hybrid routing. Example- ZRP

### 3.2 NETWORK CODING

Ahlswede et al. [18-19] introduced the concept of network coding technique and it is a major breakthrough in the field of communications and an innovation in the network layer. Generally, in Computer networks store and forward method is used i.e. from the source node it goes through number of intermediate node to reach the destination.
In the concept of network coding an intermediate node called as relay node can combine two or more incoming packets into a single outgoing packet called as encoding. The receiver node can decode the received packet to get the data. The concept of network coding increases throughput, robustness, reduces network complexity and number of transmissions. Figure 3.2 shows the comparison between traditional method and using network coding.

XOR is one of the simplest form of data coding [22]. The number of transmissions is reduced when network coding is applied.

3.3 IMPLEMENTATION OF NETWORK CODING IN DSR

In this research, we implement coding concept in DSR which is an ad-hoc network routing protocol for improving the network throughput and enhancing different network parameters, is used.
3.3.1 Need for DSR routing:

Network coding was applied to Dynamic source routing (DSR) to achieve network gain and enhance the performance of the network. The reason for choosing DSR is as follows

- DSR does not perform well in higher-mobility scenarios.
- High MAC overhead degrades the performance of DSR.
- Mechanism of DSR is source routing based.
- Cache staleness.

3.3.2 DSR Protocol

The Dynamic Source Routing protocol [48], is a wireless adhoc network based reactive routing protocol. It is a link state routing protocol which is source-initiated. The protocol has two basic mechanisms i.e. “Route Discovery “and “Route Maintenance “.

Route Discovery Mechanism

To transmit data, the source node S, starts by initiating a process of route discovery by flooding all its neighbouring nodes, a Route Request (RREQ) message. Every mobile node on receiving RREQ message append their address to the received message and forwards it. As soon as the first RREQ is received by the destination node D, it sends a RREP. All other duplicate RREQ messages received are discarded. By reversing the routes appended in the RREQ messages, Route Reply can be sent from D back to S. Route Reply has the route from Source to Destination included, on which the Route Request message was received by the node D (destination node). Data is routed by the source node S using “source route” mechanism.
Route Maintenance

The routes are cached and because of frequent host movement and dynamic topology the route information stored in cache becomes stale over a period of time. In case if the original route breaks it finds an alternate route.

The two mechanisms, Route Discovery and Route Maintenance, operate entirely on demand. Any periodic route advertisement, link state sensing and neighbour packet detection is not used by Dynamic Source Routing. It does not rely on functions from any of the underlying protocols in network.

3.3.3 Network coding Model

Consider a network with 4 nodes A, B, X & Y. as shown in the figure 3.3. The network coding that is applied is a simple XOR operation. Let the data packet generated by node ‘X’ and ‘Y’ be b1= 10011011 and b2= 11011011. Node A acts as an intermediate or relay node. Encoding is done at node A. The output from node A will be Packet (b1) XOR Packet (b2) = Packet (C) = 10011011 (XOR) 11011011 = 01000000

Figure 3.3 Network Model
If node B wants only b1, it performs decoding. B receives C= 01000000. Decoding is C(XOR)b2=b1 ie 01000000 XOR 11011011 =b1. The number of transmission is reduced from 4 to 3. If the packet size is not equal then, it is padded with zeros to make it equal.

**Proposed Algorithm**

Input: p1, p2  Output: p1 (xor) p2

// p1 and p2 are packets sent from source node1 and source node 2

{ 

If size of p1 =size of p2

Then

{

Perform network coding on p1 and p2 (p1 XOR p2).

Transmit data obtained by encoding.

}

Else

{

Add trailing zeros to packet of shorter length

Perform network coding and transmit

}
3.4 SIMULATION

The simulation environment is set up and the performance metric is described as follows: OMnet++ simulator was used to carry out the simulation.

Adhoc network module is established and a network containing 9 wireless nodes is created and IP addresses are assigned to each of the nodes. The area is specified as 900 x 900 m and nodes have a communication range of 250m. The source nodes and destination nodes are considered as Node A and G respectively, while the relay/forwarder node is considered as Node D. By applying the properties of network nodes, the network is initialized. DSR is implemented. To move along X and Y axes, mobility is provided to the nodes. The MANET routing module controls RREQ, RREP & DSR. Each of the initialized nodes have a minimum transmission rate of 4 packets/s. The mobility speed assigned is 5Mbps and this speed varies from 0-10 Mbps. Various network parameters such as throughput, packet delivery ratio & delay are measured by changing the speed and with the observed readings, graphs were plotted. As an independent module, Network Coding concept is implemented. However, the module only handles the data packets whereas the other packets such as RREQ & RREP are only control messages in DSR. After applying network coding, the protocol is named Network coded -Dynamic source routing. As mentioned above, by varying the speed of mobility, different parameters, were measured.

Performance metric:

For evaluating the effect of our proposed Network Coded DSR (NC-DSR) protocol, the below metrics were used.

Average throughput: “It is defined as the ratio of total packets received to the simulation time”.

Average end to end delay: “This is the average overall delay for a packet to traverse from a source node to a destination node”. It takes into account the queuing delay, transmission time, propagation time in the wireless channel in addition to the route discovery time.
**Packet delivery ratio:** It is defined as the ratio of total number of packets received by the destination node to the total number of packets sent.

**Packet overhead:** The number of packets transmitted by all the nodes including data and other encoded packets is called as the overhead.

### 3.4.1 Performance analysis

A comparison of the performance of the existing DSR protocol is made with the proposed NC-DSR. The figure 3.4 shows the packet overhead as a function of the node’s mobility for DSR as well as NC-DSR. Network Coded – DSR, when compared to DSR, reduces the routing overhead by 19 - 26% on an average.

![Figure 3.4 Node Mobility vs Packet Overhead](image)

The figure 3.5 implies Network Coded- DSR, has lesser packet loss compared to DSR due to the consequence of lower latency in route discovery. While calculating the packet loss, the losses at the network layer are also taken into account.
Figure 3.5 Variable node mobility vs Average Packet Loss

The figure 3.6 displays the “throughput” of Network Coded- DSR & DSR. The graph shows that NC-DSR improves the throughput by 20-24% over DSR when the Mobility speed is varied from 0 - 10m/s.

Figure 3.6 Node Mobility vs Throughput

The figure 3.7 depicts the “Average End-to-End Delay”. It is observed that, a longer time is required to setup the route if the node mobility is high because the probability of packet loss increases. We observed that the delay in NC-DSR is lesser than that of DSR.
We performed a simulation study of the use of network coding in DSR and observed how it enhances the performance of adhoc network. The results clearly indicate that, while the delay has been minimized, the average throughput of the network has improved. In future, Network Coding can be further improved to analyse various other parameters like energy saving, load balancing etc.

**Figure 3.7 Node Mobility vs Average Delay**

![Graph showing node mobility vs average delay](graph.png)