1. Introduction

1.1 Research Motivation

The recent trends in mobile technology have become an important part of our life [1]. Mobile devices can be connected *anytime, anywhere and anyhow* which has lead towards the development of wireless networks [2]. This emerging area of mobile computing [3] requires the routing protocols to effectively manage the communication.

Multicasting is the transmission of data to a group of hosts recognized by means of a single destination address [4]. Multicasting is proposed for group-oriented computing. When there are more applications in use, multicasting is required. The use of multicasting in a network has many benefits. Multicasting reduces the communication costs for applications to send the same data to multiple recipients. Unlike multiple unicasts, multicasting reduces the consumption of link bandwidth, sender and router processing and delivery delay [5].

Maintaining the group membership information, creation of multicast trees and mesh structures are challenging even in wired networks. A challenging environment for multicasting is mobile ad-hoc network (MANET). It consists of dynamic set of nodes and rapidly changing multi-hop topologies which composes of comparatively low-bandwidth wireless links. As every node has a limited transmission
range, all the messages may not reach all the intended hosts. For the communication of the entire network a source-to-destination path can pass through the number of intermediate neighbor nodes.

The major applications of MANET technology are in the field where fast deployment and dynamic reconfigurations are essential [6], which comprises of military battlefields, emergency search and rescue sites etc. These applications lead to multicast operation and it is even more crucial to reduce the transmission overhead and power consumption. Multicasting can improve the efficiency of the wireless link while sending multiple copies of messages by utilizing the inherent broadcast property of wireless transmission. Still ad-hoc routing protocols and wireless mobile multicast routing protocols faces several Quality of Service (QoS) challenges.

In multicasting, QoS is a popular research topic due to the increasing popularity of multimedia applications, the commercial usage of mobile ad hoc networks in supporting group communications which is rapidly gaining popularity [7]. As such there is a need to support QoS multicast applications in mobile ad hoc networks. Routing in MANETs is more challenging as compared to the traditional wired networks.

The main objective of multicast routing protocols in MANETs is to deliver the data packets among the nodes efficiently without any fixed topology or centralized control. In MANETs each and every node behaves
as a host as well as a router in addition the changes of network topology are distributed among the nodes [8]. In this the design of efficient and reliable multicast routing protocols are challenging. On demand routing protocols are better than proactive routing protocols because they consume less bandwidth [9]. In MANETs the topologies are dynamically changing as the nodes are dynamically changing. For this reason we concentrate on multicast topology. The two most widely studied tree based routing protocols are Multicast Ad hoc On demand Distance Vector (MAODV) [10] routing protocol and Adaptive Demand Driven Multicast Routing (ADMR) [11] protocol and two most widely studied mesh based routing protocols are On-demand Multicast Routing (ODMR) [12] protocol and Protocol for Unified Multicasting through Announcements (PUMA) [13]. The limitation of the above protocols is that they build and relay on a single path for each data session. Whenever a link break on the active route, the above protocols have to reinitiate the route discover process. On demand multipath routing protocols can improve the above problems by establishing multiple paths between a source and destination pair in a single route discovery [14]. A new discovery is invoked only when its entire routing path fails.

This thesis proposes a practical Multiple Path Discovery (MPD) algorithm which computes both the primary path as well as an alternate paths (maximally node disjoint) [15], Group Discovery (GD) algorithm which computes the grouping the multiple paths [16], Load Distribution
algorithm which distributes the data in the groups and also two reliable protocols named as Node Disjoint Split Multipath Multicast Ad hoc On demand Distance Vector (NDSM-MAODV) [17] and Node Disjoint Split Multipath Protocol for Unified Multicasting through Announcements (NDSM-PUMA) [18] which has novel feature as compared to other On-demand protocols in terms of more packet delivery ratio, less end to end delay and more throughput.

Most of the existing routing protocols build and utilize a single route used for every source and destination pairs. Because of the node mobility, link failures and the dynamic characteristics of the radio channel, links inside a route might be temporarily unavailable and hence making the route invalid [19]. This problem can be reduced by using the multipath route addresses which provides more than one route to a destination node. Source node knows how to use these routes as primary and alternate paths [15]. Alternatively source node uses both of these for distributing the data among these multiple routes to enhance the transmission reliability and also to reduce the congestion in the network. The proposed methodology developed in this thesis has been evaluated by designing and implementing simulation experiments using network simulator -2 (NS-2) [20].
1.2 Research Objectives

The objective of this thesis is to design and develop routing protocols for MANETs, which can provide reliable data transmission along with high packet delivery ratio, less end to end delay and more throughputs within the limited bandwidth.

This thesis proposes Some Path Discovery Algorithms. In this we proposes a practical Multiple Path Discovery algorithm which computes both the primary path as well as the alternate paths by using the maximally node disjoint approaches [15]. After computing the multiple paths, grouping the paths is done by using the Group Discovery [GD] algorithm [16] and data is sent to the source through these groups. There by the source node divides the data by using the Load distribution algorithm. By using this, the data packet is distributed to the groups according to the priority given to the groups. In the group, it has many paths, the first path is a primary path and the remaining all are alternate paths which carries the same data packet. Therefore the source node sends the data to the group by duplicating them. If one path fails then data can be passed successfully by the alternate path. As a result of this, source node need not reinitiate the route discovery process except when both paths fail. By this reason the frequent flooding of RREQ packets are reduced by the source for route discovery. The duplication of each data packet, grouping the paths and finding the multiple paths in the proposed protocol, it may cause slight increase in load on the network
when compared to other protocols. But in MANETs “Reliability” is particularly important in multicasting and it is also challenging to distribute the reliable data towards the group members whose topology varies.

The goal of this thesis is to design efficient multicast routing protocols for MANETs. In this thesis to improve the efficiency of multicast routing protocols we proposed the concept of multipath protocol. In this we have taken two tree based routing protocols i.e. MAODV and ADMR and two mesh based routing protocols i.e. ODMR and PUMA. Simulation result shows that MAODV has a better performance as compared to ADMR [107] and PUMA has a better performance as compared to ODMR [108]. To improve the MAODV and PUMA we proposed the concept of Node Disjoint and Split Multipath. We presented two novel routing protocols i.e. Node Disjoint Split Multipath Multicast Ad hoc On Demand Distance Vector routing protocol and Node Disjoint Split Multipath Protocol for Unified Multicasting through Announcements. The operation and performance of these protocols are evaluated through the simulation. Simulation result shows that the proposed protocols exhibit better performance when compared to the other.

1.3 Thesis organization

The chapter provides an introduction to the research topic namely “A Novel Enhanced Split Multicast Routing Protocols in
MANETs”. The research objectives and methodologies adopted to achieve the goals of research are also described.

Chapter 2 provides an overview of MANET, Routing in MANETs, Classification of ad hoc routing protocols, Multicasting in MANETs, Issues and challenges of multicasting, Classification of multicast and multipath routing protocols and brief description about the Network simulator (NS-2).

Chapter 3 provides a schematic way of design and experimentation of NS-2 configuration for critical analysis. Here we considered two protocols MAODV and ADMR of the tree based category and another two protocols PUMA and ODMRP of the mesh based category for illustrating protocol ranking/ordering process. However this contribution has a technological value and not having much philosophical nature. The performance of above mentioned protocols are considered for the QoS parameters which are essential for evaluating the worthiness of new routing protocols which are developed in this thesis.

Chapter 4 presents Some Path Discovery Algorithms i.e. Multiple Path discovery algorithm, Group discovery algorithm and Load distribution algorithm. Multiple path discovery algorithm is a mathematical tool developed as Multiple Path Discovery for arriving at a new protocols which will address the limitations of some of the existing multicast routing protocols which are explained in chapter 2. To enhance
the efficiency and throughput the discovered paths are grouped by developing the Group Discovery strategies. Multi-path routing allows the route establishment of multiple paths between the source to destination. To improve the performance of the multipath routing protocols, load balancing is a must because load balancing deals with improving the performance of the system by transmitting the data from over loaded nodes to under loaded or idle nodes. Using the load balancing strategies the total time to process all data may reduce considerably and also makes it sure that no node sits idle while some data are waiting to be processed.

Chapter 5 describes the proposed multicast tree based routing protocol that aims at improving the packet delivery ratio and elongating the life time of the network. In this chapter we described about the proposed NDSM-MAODV routing protocol, mechanisms of the proposed protocol, phases of the proposed protocol, performance evaluation through simulation. This chapter also gives the simulation result and compares the performance of the proposed scheme in different scenarios with MAODV and NDSM-MAODV-ran, NDSM-MAODV-seq, NDSM-MAODV-opt.

Chapter 6 describes the proposed multicast mesh based routing protocol which improves the packet delivery ratio and extending the life time of the network. We described about the proposed NDSM-PUMA
routing protocol, mechanisms of the proposed protocol, phases of the proposed protocol, performance evaluation through simulation. This chapter gives the simulation results in different scenarios and compares the performance of the proposed scheme with PUMA and NDSM-PUMA-ran, NDSM-PUMA-seq, NDSM-PUMA-opt.

Chapter 7 presents the better simulation results of the chapter 5 i.e. NDSM-MAODV-opt and the better simulation results of chapter 6 i.e. NDSM-PUMA-opt, and Compares the performances of these protocols.

Chapter 8 concludes the thesis of the work and it discusses the directions for future research.