CHAPTER 1

INTRODUCTION

1.1 GENERAL

Mobile ad hoc network is a dynamic network formed by a large number of nodes. Ad hoc network is an autonomous network and it works without the aid of any centralizing authority. Due to the mobility of the nodes, routing is quite a challenging task. The dynamic topology of the ad hoc network leads to the frequent breakup of routes. Route failure affects the connectivity of the network. Moreover the nodes are dependent on the limited battery power. Power shortage in any node may result in the network partitioning (Sachin 2012).

Due to infrastructure less and self-organizing nature of ad-hoc networks, it has several applications in the area of commercial sector for emergency rescue operations and disaster relief efforts. MANETs provide a solution in the field of defense to detect movement of enemies as well as to exchange information between military headquarters. Also, the MANET provides an enhancement to cellular based mobile network infrastructure. Nowadays, it is an inexpensive alternative for data exchange among cooperative mobile nodes (Kavita 2011).

For communication among two nodes, one node has to check whether the receiving node is within the transmission range of source (Range of a node is defined with the assumption that mobile hosts use wireless RF transceivers as their network interface). If yes, then they can communicate directly, otherwise, with the
help of intermediate nodes communication will take place. Each node will act as a host as well as a router. All the nodes should be cooperative so that exchange of information would be successful. This cooperation process is called as routing (Kavita 2011). Several Routing Protocols have been proposed in the past and their performance comparison has been analyzed. Chapter 2 provides an overview of these protocols and their past work. In MANET, each node acts both as a router and as a host. The key challenges faced at different layers of MANET are shown in Figure 1.1. It represents layered structure approach to ad hoc networks (Sunil Taneja 2010).

Investigating MANETs is achievable by resorting either to software-based simulators or to experimentation networks (test beds). Most researchers favor simulators at the expense of test beds. What prevents (or at least hinders) the use of real-size test beds is their cost and their inherent lack of flexibility. This becomes particularly impeding as the size of the experimented network grows. Software-based simulation then turns out to be a viable alternative and a widely used solution (Stuart Kurkowski). Chapter 2 provides an overview of the MANET simulators and simulation.
Routing is the key functionality for directing communication over large networks. The primary task of any routing protocol is to discover and maintain routes to needed network destinations. The routing protocols for ad hoc networks can be divided into two groups, proactive and reactive. Proactive routing refers to the condition that whenever a node has some data for a particular destination, it can be transmitted immediately. On the other hand, reactive routing protocol determines the routes as and when it is required by a node in the network.

With proactive routing protocols, such as Optimized Link State Routing (OLSR) and Open Shortest Path First with MANET Designated Routers (OSPF-MDR), a link is maintained by the exchange of control packets. A link break is normally not detected until either a certain number of HELLO packets have been lost, or the lack of periodic updates results in a link timeout (Larsen 2009). (Some implementations might let the link layer detect link breaks and signal this information to the routing protocol. Such cross-layer optimizations are outside the scope of this research. Here, the common layered approach where HELLO packets are necessary for the detection of link breaks is exclusively explored.

Link break is a common characteristic of MANET due to dynamic topology. In such cases routing protocol has to find alternative paths. The time period before new paths are found is referred to as the rerouting interval, and the duration of rerouting interval is referred as rerouting time. During the rerouting interval, the network layer at the node upstream to the broken link might try to forward data packets over the broken link. Instead, these packets are accumulated in the output queue. Due to the layered design, the link layer (L2) will keep trying to transmit the queued data traffic already designated to the broken link, even after the network layer (L3) has timed out the link. This does not only consume scarce radio
resources but also blocks the MAC layer. Thus the network layer is not able to announce that the link is broken, and the rerouting time increases correspondingly.

Finally, when all the stale data packets designated to the output queue have been dropped, the MAC layer is ready to transmit the link state announcement to establish new routes throughout the network and to serve packets waiting in the output queue designated to the respective receivers. In summary, the rerouting time due to link breaks depends on the time to carry out the following processes:

- Detection of a link break
- The emptying of all stale packets from the output queue
- Network-wide link-state announcement to establish new paths.

For a good routing protocol, throughput and packet delivery ratio should be high whereas average delay or rerouting time should be less. While there has been already a solution proposed to overcome queuing problem that occurs during MANET routing, surprisingly little focus has been directed to the enhancement or extending this approach. Indeed, the main contribution of this research is the proposal of an implementation specific solution to address the gaps of adaptive retry limit approach. The key idea is to perform the adaptive retry limit approach in asynchronous fashion where it is performed in synchronous way today. As a result of this solution the queuing problem is eliminated to reduce the rerouting time and increase the performance of MANET.

The Nodes available in MANETs are lacking in energy and bandwidth. These limitations end up in posing a set of intractable issues; in specific routing and flow control. With regard to such energy constrained operations, it is significant to save energy that result in the advancement of the network’s lifetime. It works in
such an, effective way, in energy constrained applications (Pham 2007). The existing zone routing algorithm pays less attention to this constraint.

The transmission area of a node is divided into a safe zone close to the node, and an unsafe zone (i.e. buffer zone) near the end of the transmission range in the buffer zone algorithm. The probability is high that link breaks occur with neighboring nodes located in the buffer zone, while links to neighboring nodes in the safe zone are expected to be more stable. Thus, neighbors in the safe zone are preferred as relay nodes, while neighbors in the buffer zone are only used if necessary, to avoid network partitioning (Larsen 2009).

While there has already been a solution proposed, with the transmission buffer zone, to reduce rerouting time and avoid link breaks, surprisingly little focus has been directed to the enhancement or extension of this approach. Indeed, one of the contributions of this research is the proposal of a mechanism to reduce the disadvantages of buffer zone routing. The key idea is to divide the safe zone into multiple virtual zones based on the distance, energy and transmission range of the nodes. In the current approach, the unsafe or buffer zone is not considered.

One of the fundamental tasks that an ad hoc network should perform is congestion control. The main objective of congestion control is to limit the delay and buffer overflow caused by network congestion, and to provide better performance of the network (Duc 2006). There is another dimension for categorizing routing protocols: congestion-adaptive routing versus congestion un-adaptive routing. We note that the existing routing protocols are congestion un-adaptive (Li VOK 2004). When establishing a new route, it remains the same until mobility or failure results in disconnection. During packet transfer between the source and the destination, congestion may happen; this is not handled by the existing routing
protocol. It may lead to the following problems: (i) long delay, (ii) many packet losses and (iii) low throughput. The above problems become more visible in large-scale transmission of traffic intensive data, such as multimedia data probable, and the negative impact of packet loss on the service quality is of great significance (Duc 2006).

It is expensive in terms of time and overhead, to recover from congestion in a dynamic network like MANET. But in well-established networks such as the internet, it is not that expensive. The main aim of congestion control is to lower the end-to-end delay, and reduce the packet loss because of network congestion and offers comparatively a better performance of the network (Corson 1999) As far as the wire line networks, congestion control is employed at the transport layer, and it is independent of the functionality of other layers. However, these congestion control techniques do not apply directly to ad hoc networks, because the ad hoc network is challenged by a limited wireless bandwidth, power constraints and route failures, due to node mobility and limited buffer size. The final result is a high packet-loss rate, re-routing instability, loss of energy, bandwidth and retransmission of lost packets, which imply that more packets are transmitted in the network. These delays and packet losses are not originated by network congestion, but this can be misinterpreted as congestion losses (Johnson 2001).

The objective of this research is to resolve and clear that congestion, which is the major cause, for packet loss in MANETS. Usually reducing packet loss involves congestion control running on top of mobilizing and failure adaptive routing protocol, at the network layer. A new perspective of this problem might be to understand congestion control in the MAC or network layer. After all, it might make sense to tackle the problem from where it emerges. An exceedingly high
network load is a problem closely associated with medium access and packet forwarding (Christian 2007).

There are three main methods for investigating MANETs: theoretical analysis, simulations and experiments. Theoretical analysis can give fundamental knowledge about investigated mechanisms and systems. Simulations, on the other hand, enable the investigation of the dynamics occurring when the distributed interaction is too complex to model using theoretical analysis, especially in combination with mobility. Even though simulations provide an easy way to investigate the distributed properties of algorithms, simulators cannot simulate the world in its entirety, but have different areas where they are strong and weak. The simulator employed in this thesis work is not very good at abstracting the physical world. In cases where attributes of the physical layer (i.e., real world properties) are defining for the system performance or other investigated features, experiments with real equipment in the desired conditions should be preferred. However, performing experiments with more than a few nodes requires a great effort from participators in the experiment, especially in order to support realistic mobility. The work load prior to the experiment is high, since the equipment must be prepared with the correct software versions and charged batteries etc. Thus, the infrastructure required to perform large experiments makes it more cost effective to perform research using simulators and theoretical analysis. The objective of the thesis work was to improve performance of MANET routing by tuning rerouting time. This was to be achieved through:

- Building up expertise on ad hoc protocols, QoS and how typical emergency scenarios evolve in general
Investigating and analyzing models for providing QoS at different OSI layers in an ad hoc setting

Developing models for QoS provisioning within the link and the network layers, in addition to a working admission control

The performance results presented in this thesis were obtained using simulations. The issues with rerouting time were investigated further in the simulator, which gave much easier access to the inner workings of the MAC protocol. In the subsequent chapters, larger topologies were investigated, and these topologies would have required considerable resources to perform investigations using experiments rather than simulations. Therefore, the work for the thesis was performed mainly using simulations as the preferred method of research.

1.2 MOTIVATION FOR THE PRESENT WORK

A good deal of literature is available pertaining to routing procedure that lead to performance with regard to mobile Ad-hoc Network’s. As far as these mobile Ad-hoc networks are concerned, the data forwarding between nodes is a challenging task due to high mobility of wireless nodes and rapid change of topology. Many research papers have been reported delineating proactive, reactive, position based routing, opportunistic forwarding, hybrid routing (Karp and Kung 2000, Sachin Dhahia 2012, Kavita Pandey 2011, Sunil Taneja and Ashwani Kush 2010, Pham and Larsen 2007, Chenna Reddy 2006, Perkins and Royer 1999, Stuart Kurkowski, Luc Hogie 2006, Kamal Kant, Baumann2007 and Michele 2009) approaches for selecting the forwarding node to carry data packets to destination. But still addressing the challenge of multihop information dissemination in MANET is mandatory. In spite of a good deal of publications in this area, it is felt that there is a
need for research enhancements and development of algorithms that are tuned to dynamically changing network topology.

Mobile Ad hoc NETworks (MANETs) have the potential for increasing the information flow in emergency and rescue operations. Rapid response in areas without existing infrastructure is currently limited to single hop technologies, primarily voice communication using "walkie-talkies". MANETs can offer voice communication, situational awareness through position sharing and geographically mapped events, access to maps and construction drawings, and support for other types of improvised communication. The use of such services can increase the effectiveness of an operation. While MANETs are able to offer multi-hop broadband communication for emergency and rescue operations, there are challenges that currently limit their usefulness. These challenges are linked to aspects such as capacity, density, collisions and mobility, all of which affect the Quality of Service (QoS) and Quality of Experience (QoE) offered by the MANET. Techniques such as Adaptive Retry Limit (ARL), Buffer Zone Algorithm and Early congestion detection with adaptive routing were made in the past to improve the rerouting time in MANETs but still there are gaps in the available methods and algorithms such as these approaches are synchronous and reactive in nature.

1.3 OBJECTIVES

Keeping the background in mind and the contributions made so far in the area of MANET routing techniques, the main aim of this research is to focus on rerouting time that enhances the efficiency of packet-forwarding between source and destination by addressing the routing issues. The thesis suggests new routing techniques for MANET that ensures reduced average number of hops, high payload
delivery ratio, minimized end-to-end delay and reduced control overhead. The problems considered are:

a. The exploration of MANET routing protocols, metrics and simulators to identify key elements of MANET routing.


c. The introduction of virtual zones to extend buffer zone routing algorithm to reduce rerouting time within the buffer zones.

d. The implementation of a proactive routing algorithm “Proactive Routing with Early Congestion Detection (PRECD)” to avoid congestion.

1.4 SCOPE OF THE THESIS

This thesis entitled, “Rerouting Time Strategies for MANET Routing” provides strategies for improving MANET Routing by tuning Rerouting time as the performance metric. This dissertation is divided into six chapters including the introduction.

Well established and the very important MANET routing protocols have been reviewed in Chapter 2. The characteristics and design factors of MANET simulators are discussed elaborately. The classifications of MANET routing protocols are presented, describing concisely their advantages and disadvantages. Taxonomy of MANET performance metrics is provided with details of each metric.
Asynchronous Invocation of Adaptive Retry Limit (AARL) is explored for evaluating the performance of rerouting time in Chapter 3 which proposes parallel execution of ARL. Asynchronous invocation is an implementation variation of the adaptive retry limit solution. The efficiency of AARL with respect to rerouting time is demonstrated comparing the existing ARL approach. This solution restricts the adaptive retry limit to only successive packets with same MAC address.

Extended Buffer Zone Algorithm (EBZA) is introduced in Chapter 4, where virtual zones are introduced within the buffer zone. The overall objective of the algorithm is to forward the packet as soon as possible when link break occurs. Whenever the nodes become live, they communicate among themselves and update their respective routing tables. This phase is known as the neighbour discovery phase. After this, each node is aware of its single, double and multiple hop neighbours. Along with the neighbour information the node’s virtual zone information is updated in the routing table. This information is then used, while making a routing decision. Virtual Zones are formed dynamically, based on the similarity of the nodes. A Virtual zone formation could be performed whenever there is a change in the initial topology or it could be done on a periodic basis. The comparison of the performance of EBZA approach with the existing Buffer Zone Algorithm (Larsen 2009) and OLSR(Clausen 2003) protocol is illustrated to reveal its superiority in terms of RET Loss, TTL Loss, Average number of hops and Goodput with varying node velocity in different network load.

A proactive routing algorithm that routes packets ahead of the congestion occurrence is described in Chapter 5, which forwards packets in the direction of destination with improved rerouting time. In Early Congestion Detection and Optimal Control Routing (EDOCR), the network is divided into sparse and dense regions, by using average neighbours, to find a non-congested alternative path with
the help of dense nodes. EDAODV techniques have been proposed to detect the congestion well in advance and find a non-congested alternative path bi-directionally. A technique for self-curing the congestion was proposed and called as the Early Detection Congestion and Self Cure Routing (EDCSCAODV). In EDAPR, techniques have been proposed for preventing congestion by using the NHN (Noncongested2 hop neighbours list). To utilize the concepts of EDAODV and EDAPR, the research proposes the PRECD routing procedures for mobile ad hoc networks. PRECD detects congestion by using early congestion detection techniques, and it can easily choose a non-congested alternative node from the two hop lists and establish a route to the destination immediately. The new protocol can reduce broadcast packets and find a non-congested path. The exemplified performance of PRECD over EDAODV (Senthil Kumaran 2010) and EDAPR (Sankaranarayanan 2011) in terms of payload delivery ratio, end-to-end delay and routing overhead is established.

In Chapter 6, the review of work reported, major conclusions reached and contributions made are dealt with recommendations for further research are stated.