Chapter 1

Introduction

1.1 Introduction

The rapid change in technologies time to time causes the existing system to become obsolete in a short duration. A communication network is a set of equipment and provides service between users located at various geographical points. The basic service provided by computer network is the transfer of messages from one computer connected to the network to any other computer connected to the network. The three most common types of computer networks are Local Area Network (LAN), Metropolitan Area Network (MAN) and Wide Area Network (WAN). The main difference among these classifications is their area of coverage. For small distances between computers, LAN is used and it provides very high speed, relatively error-free communication and also economical. WAN is also referred to as internet which links millions of LANs. To alleviate the problems of incompatibility and ensure that hardware and software components can be integrated into any network, IEEE developed and approved network standards. A standard that outlines characteristics of how two network devices communicate is called a protocol. A protocol would define packet format, coding scheme, error handling, and sequencing techniques.

The communication link between two network devices can be either wired or wireless. Wired networks needs the infrastructure such as i) need to run cables in difficult environments and ii) cables need to be run from computer to computer and switch to switch. The other major problem in a wired network is disconnection of cable link or loose cables which is the single most common and annoying source of failure.
During disasters, telecommunications infrastructure failures occur through a variety of mechanisms. Investigation reveals mainly three categories of causes: i) physical destruction of network components, ii) disruption in supporting network infrastructure, iii) network congestion and overload. The risk associated with communication failures remains serious because of growing dependence upon these tools in emergency operations. For example, the Indian Ocean tsunami of December 2004 highlighted the human cost of communications breakdowns during disasters. While seismic monitoring stations throughout the world detected the massive sub-sea earthquake that triggered the tsunami, a lack of procedures for communicating these warnings to governments and inadequate infrastructure in the regions at risk delayed the transmission of warnings.

The primary solution for the mobile users in the disaster environment is the Mobile Adhoc Networks (MANETs), which is a wireless network standard under IEEE 802.11. MANETs provide high speed data connectivity, cheap voice communication and is also more efficient in terms of flexible installation. MANETs allows all wireless devices within the range of each other to discover and communicate in peer-to-peer fashion without involving the central access points.

However, the performance of MANETs is affected by several errors such as link error, link delay, traffic control, inefficient congestion control mechanism and unreliable data transfer. The main aim of this research work is to carry out the performance analysis of the existing MANETs routing protocols and development of a new Hybrid Reliable Data Transmission technique with bandwidth, congestion control and energy efficient mechanism.

The IEEE 802.11a, b Media Access Control (MAC) and Physical layer (PHY) standards are used for data transmission. The performance of these layers are analyzed for
various modulation techniques, routing protocols (AODV, TORA, DSR, and DSDV) under various mobility conditions and transmission channel models (AWGN, Rayleigh and Rican fading channels). In this thesis, the performance analysis of various Mobile Adhoc Networks routing protocols is carried out and three new algorithms are developed for developing a new ARA based EEMCC Protocol with HRDT technique for Disaster Risk Management.

The first algorithm namely **Energy Efficient Multicast Congestion Control (EEMCC) protocol** is proposed to identify the particular routing in MANETS. The development of this protocol involves three phases. They are: i) construction of multicast tree, ii) admission control scheme and iii) adjustment of multicast traffic rate at each bottleneck of a multicast tree. It is a self congestion control protocol. The second algorithm is the ARA Technique for bandwidth and QoS parameters improvement. It uses forward and backward agents to collect the bandwidth information of intermediate nodes and confirms the allocation and feeds the bandwidth information to the source for real-time traffic flow in forward and backward phases respectively. The third one is Hybrid Reliable Data Transmission (HRDT) technique developed by combined interleaving of Automatic Repeat Request (ARQ) and Forward Error Correction (FEC). This algorithm is useful for retrieving the off-line data or dropped packets during the disaster like situations.

The proposed algorithms are implemented using the NS-2 simulator. The NS-2 simulator is used for simulating routing protocols and adhoc network research. It also supports popular network protocols for wired and wireless networks. NS-2 was built in C++ and provides a simulation interface through OTcl, an object-oriented dialect of Tcl. The user describes a network topology by writing OTcl scripts, and then the main NS-2 program simulates that topology with specified parameters. In this thesis, twelve
simulation parameters are considered for the analysis. The proposed algorithms are validated and compared with the existing protocols. The throughput achieved using the proposed EEMCC protocol is 50% higher and the bandwidth observed in ARA Technique is 80% more than the earlier AODV protocol. Also the energy consumption observed to be much less in the proposed HRDT as compared to MAODV protocol.

1.2 Aim of the Thesis

To carry out the performance analysis of various MANETs routing protocols and to develop of ARA based EEMCC protocol with HRDT technique for disaster risk management the following tasks are carried out.

i) The IEEE 802.11a, b WLAN networks performance is analyzed by considering various PHY layer transmission techniques (DSSS, IR, FHSS and OFDM) and transmission models.

ii) Suitability of existing MANET routing protocols (AODV, DSDV, DSR and TORA) and mobility models are investigated for disaster environments.

iii) Probability of BER analysis over (i) different fading channel models (AWGN, Rayleigh fading and Rician fading channels) and (ii) various modulation techniques with different data transmission rates are carried out to find the suitability for disaster risk management applications using MANETs.

iv) A three phase Energy Efficient Multicast Congestion Control (EEMCC) algorithm is developed for self congestion control based on a multicast tree.

v) A new Ant Resource Allocation (ARA) technique is developed for efficient bandwidth reservation in real-time multicast applications and to enhance the QoS parameters. It is also used to detect the QoS changes, congestion and route breakages.
vi) An error control scheme called Hybrid Reliable Data Transmission (HRDT) technique is developed using ARQ and FEC approaches for MANETs which suits disaster situations.

1.3 Literature Survey

To fulfill the objectives of the thesis, fundamental concepts of wireless communications, MANETs and their routing protocols, various channel models, data rates of IEEE 802.11 standards and modulation techniques are essential. In mobile adhoc networks, the provision of QoS is more challenging because of lack of central coordination, node mobility, multi-hop communications and contention for channel access. These issues are dealt by several authors (Hua Chen, Baolin Sun, 2009; Tolga Numanoglu and Wendi Heinzelman, 2009; Guojun Wang, Jiannong Cao, Lifan Zhang, Keith C. C. Chan, et. al. 2005) and suggested the mesh network approach for determining the routes in mobile and multicast environment. For estimating and evaluating the route stability in a mesh network approach, the QoS parameters to be considered are redundancy, availability, regularity and load balancing according to the current link conditions for real time traffic scenarios. But due to the absence of infrastructure in MANETs, the mesh network approach leads to heavier traffic loads with fixed access points/base stations. This causes more energy consumption as every mesh node is connected to each other node in the network even though data transmission is highly reliable in mesh networks. Another aspect to be considered in MANETs is that all the nodes are battery powered which is a precious energy source to be utilized scarcely. These aspects are not considered in the previous works that are proposed by several authors as mentioned above. Therefore, energy efficient design needs to consider the trade-offs between different network performances criteria particularly in the disaster like situations such as Tsunami, earthquakes, floods. For this purpose, a self congestion
control protocol called Energy Efficient Multicast Congestion Control (EEMCC) Protocol for Mobile Adhoc Networks is proposed in this thesis. It uses proactive, reactive and hybrid routing protocols. The proposed EEMCC protocol overcomes the disadvantages of existing multicast congestion control protocols which depends on individual receivers to detect and adjust their receiving rates by using the threshold values.

As there are increasing demands in wireless technology, bandwidth and delay plays a crucial part in disaster recovery scenarios. Several authors (Vida Lashkari B. O, Mehdi Dehghan, 2007; Zeyad M. Alfawaer, GuiWei Hua, and Noraziah Ahmed, 2007; Ya-Ju Yu et.al, 2009; De-Nian Yang and Ming-Syan Chen, 2008; A. Sabari and K. Duraiswamy, 2009; Juan Liu et.al, 1999; Emy E. Egbogah et.al., 2008) proposed protocols to improve the path/route discovery by using Swarm Intelligence and Dijkstra’s algorithm in multicast environment. These protocols are also used to decrease the end-to-end delay between the nodes with the reserved bandwidth on per chosen flow and also for efficient multicast connectivity. Also to overcome the problem of traffic load and to increase the efficiency of bandwidth in multicast communications an Ant Based Multicast routing is introduced for real time traffic. In this thesis, for improving the bandwidth a new Ant Resource Allocation (ARA) technique is developed based on EEMCC protocol. This particular algorithm is useful and reliable during disaster environments.

While transmitting the data in MANETs there may be loss of data and errors may be encountered in real time traffic scenarios. This is due to lack of joining the nodes in a multicast group in an optimum time. To reduce the dropping of packets, reliable multicast transport protocols were developed (Mehdi Effat Parvar et.al 2007; Dimitrios Koutsonikolas and Y.Charlie Hu 2007; Erik M.Ferragut 2009; Ali Alsaih and Tariq Alahda 2007) over combined networks using sub-casting called RMSS. These algorithms are based on a hierarchical structure where the receivers are grouped into local regions.
The sub-casting in these algorithms is used to retransmit the data only to the requested receivers. As different from the previous work, in this thesis a new hybrid error control technique namely Hybrid Reliable Data Transmission (HRDT) technique is proposed to reduce the errors and data losses which occur in MANETs by combined interleaving of Forward Error Correction and Automatic Repeat Request techniques. This hybrid error control scheme gives less packet loss rate and less data transmission delay and energy consumption compared to the existing Reliable Multicast data Distribution Protocol (RMDP) and MAODV algorithms.

1.4 Technical Approach

Literature survey reveals that existing multicast congestion control protocols used in MANETs are having severe drawbacks such as more link delay, link error and ineffective traffic control. These drawbacks affect the performance of the MANETs particularly during the disaster like situations such as Tsunami, earthquakes and floods.

The wireless LAN standards (IEEE 802.11a, b) consists of two important basic layers at the bottom of the network model and these two layers offers critical services to the network operation. They are: Physical Layer (PHY) and Medium Access Control (MAC) layer. The MAC layer is responsible for providing a multiple access scheme to allow more than one user at a time and the PHY layer is responsible for transmitting and receiving data over the air. For transformation of data in all IEEE802.11 standards, the physical layer uses Physical Layer Convergence Protocol (PLCP) for sending as well as receiving of data using a scrambler at both ends.

The IEEE 802.11a, b standards PHY layer and MAC layer performance is analyzed with respect to frequency, data rate, modulation technique and FEC parameters. The modulation techniques used in the performance comparison at the physical layer are
BPSK, QPSK, OFDM and the different multiple access control techniques used in the performance comparison are DSSS, IR, FHSS and OFDM.

In MANETs, the data transmission is through wireless radio links from one node to another. Therefore, routing determination for sending and receiving of information in MANETs plays a crucial role particularly in disaster like situations because of MANETs are infrastructure less networks. In this thesis, different routing protocols are investigated to design an optimum protocol that suits the disaster like situations.

Even though several routing protocols are available, table driven (DSDV) and reactive (AODV, TORA, DSR) protocols are considered in this thesis because these are suitable for small networks, maintains fresh lists of destinations and their routes by periodically distributing routing tables throughout the network and to control the overhead. The performance metrics of these routing protocols are compared by computing the packet delivery ratio, throughput, dropped packets and standard deviation under various transformation channel models (AWGN, Rayleigh and Rician fading channels) and different mobility models i.e. Manhattan, Freeway, Random-way point, and Group mobility models.

Based on the analysis, a new routing protocol namely “Energy Efficient Multicast Congestion Control (EEMCC) Protocol” is developed for the disaster like situations. The development of this protocol involves three phases. In the first phase, a multicast tree route will be identified at the source based on determination of the nodes having higher residual energies towards the receivers by their corresponding threshold energy levels. In the second phase, it deals with the admission control scheme that depends on the output queue size, which is used to analyze the flow admission or rejection of the node. The third phase of this routing protocol adjusts the multicast traffic rate at each bottleneck of a multicast tree.
To improve the bandwidth of Energy Efficient Multicast Congestion Control in real time data applications and also to improve the QoS parameters of the EEMCC protocol a new technique known as “Ant Resource Allocation (ARA)” technique is developed. In this technique, the forward and backward agents are used in forward and backward phases. In the forward phase, the source sends a Forward Ant Agent (FAA) which collects the bandwidth information of intermediate nodes. In the backward phase, the Forward Ant Agent (FAA) which acts as a Backward Ant Agent (BAA) that confirms the allocation and feeds the bandwidth information to the source along with reserving a bandwidth for real-time flow for each backward node.

Also to reduce the congestion in data transmission and to retrieve the off-line data from the source nodes, a new and third technique namely “Hybrid Reliable Data Transmission (HRDT)” is proposed. This algorithm is useful for retrieving the dropped real-time data packets during the disaster environments. This algorithm is a hybrid error control technique by combined interleaving of Automatic Repeat reQuest (ARQ) and Forward Error Correction (FEC). It is a two phase technique, where in the initial step the data services among the real time and non-real time data services are differentiated. These techniques are helpful for finding out the better data transmission where the off-line data or dropped situations that usually occur in disaster like situations.

1.5 Applications of the Thesis

- In offices and banks high data transfer between various nodes or terminals is required. One can establish WLAN with high speed data rate by using IEEE802.11 a/b communication networks
- Establishment of adhoc networks with good data delivery ratio can be used for forest search operations.
In disaster environments to transmit or receive the data without any loss of information the IEEE802.11a/b communication networks are useful.

The proposed EEMCC protocol is useful in the battle fields where no power supply is available to transfer or receive data from various locations with less congestion and to retain long time in the network.

The developed ARA technique in this thesis is used for the real time data transmission or reception where high bandwidth is required.

In disaster moments like Tsunami, floods, earthquakes, battle fields etc., the proposed Hybrid Reliable Data Transmission (HRDT) technique in Mobile Adhoc Networks (MANETs) is used to retrieve the off-line data or dropped packets.

1.6 Organization of the Thesis

This thesis is organized into eight chapters including Introduction and Conclusions. Chapter 2 presents the Wireless LAN architecture and data transmission procedures of IEEE 802.11a, b physical layers. It also discusses the importance of inter frame space, CW time, frequency, FEC rate and data rate parameters in the data transmission. Chapter 3 presents the fundamentals of mobile adhoc networks and their routing protocols (AODV, DSR, TORA, DSDV etc.) performance using different mobility models (Free way, Manhattan, Random-way point and Group Mobility models).

In Chapter 4, the Probability of bit errors for different modulation techniques are estimated and their performances are compared for IEEE 802.11a, b standards under AWGN, Rayleigh fading and Rician fading channels. Chapter 5 presents a new Energy Efficient Multicast Congestion Control (EEMCC) Protocol. This algorithm is implemented in three phases. The first phase involves construction of energy efficient tree and nodes residual energy estimation. The second phase consists of multicast admission
control. Third phase involves adjustment of traffic rate. In Chapter 6, a new Ant Resource Allocation (ARA) technique for real time traffic scenario is proposed. This algorithm is implemented in two phases known as forward and backward phases, where Forward Ant Agent (FAA) collects the intermediate nodes bandwidth information and Backward Ant Agent (BAA) confirms the bandwidth allocation and feeds the information to the source respectively. In Chapter 7, a new Hybrid Reliable Data Transmission (HRDT) technique is presented for reliable data transmission using FEC and ARQ and is validated with the RMDP methods. Chapter 8 presents the overall conclusions of the thesis along with the future scope of the work.