ABSTRACT

Computer networks connect different computer systems which are called nodes in the network. Computer networks are essentially needed to a great extent in today's world which depends on information sharing. Computer networks become very essential for day to day life as they provide a wide range of applications. A computer network also known as data network is basically a telecommunication network that allows computers to interchange data. Networked computing devices provide data to each other through data connections. Different connecting media such as; wired or wireless are used to establish connections or network links between network nodes. The Internet is one of the renowned computer network which exchange data information from one geographical location to the other throughout the world. Networked computer devices that create, route and terminate the data are called as nodes of the network. Nodes also referred as hosts can be personal computers, laptop computers, microcomputers, computer servers, and networking hardware etc. Devices are said to be networked when they able to exchange information with each other. Computer networks support applications such as; access to the World Wide Web, (www) shared use of applications, storage servers, printers, fax machines, use of electronic mail (e-mail) and instant messaging applications etc.

Computer networks differ in the physical media used to transmit their signals, the communication protocols to organize network traffic, network size, network topology and organizational intent. Nowadays, computer networks are the core media of contemporary data communication. All latest aspects of the public switched telephone network (PSTN) are computer controlled. The scope of communication has improved significantly over the past decade. This progression in data communications would not have been achieved without the increasingly advancing computer network technologies. Computer network technologies continue to drive computer hardware, software, and peripherals industries. The growth of associated industries is reflected by growth in the numbers of people using networks, from the scientific user to the home user. Different computer networks are able to connect with each other by means of the devices called routers. Network routers use routing protocols for their IP (Internet

Protocol) address switching. Routing protocols are developed based on various routing algorithms. The growing usage of computer networks requires improvements in network technologies and management techniques to provide users high quality of service (QoS). As more users transmit data through a computer network, the quality of service received by the users begins to degrade.

The key aspect of computer networks that is vigorous to the quality of service is data routing. The effective method for routing data through a computer network can support with the new problems being met with today's emergent networks. Operative routing algorithms use various methods to determine the most appropriate route for transmitting data. Determining the best route through a wide area network (WAN) needs the routing algorithm to obtain information regarding all of the nodes, links, and devices existing in the network. Wireless networks are playing a key role in the communication field. Deployment of wireless networks in military applications, industrial applications and even in personal area networks is common today. Earlier, the key difference between wireless and wired networks was an only communication channel. Wired networks require a physical medium such as optical fiber or copper, whereas wireless networks do not require the physical medium instead they use wireless channels through radio frequencies. Wireless networks became very popular in diverse applications in view of factors like; ease installation, reliability, cost, bandwidth, the total required power, security, and performance of the network. All the wireless networks, however, require fixed infrastructures. Most common infrastructure oriented wireless networks are; cordless telephone, cellular networks, Wi-Fi, Microwave communication, Wi-MAX, Satellite communication and RADAR etc.

New advancements in wireless networking technologies have proposed a new kind of next- generation wireless networks called mobile ad-hoc networks (MANETs). Mobile ad hoc networks are playing a noticeable role in the fast deployment of self-governing mobile users, efficient and dynamic communication for emergency and rescue operations, disaster relief efforts, and military networks. Ad-hoc networking is an important concept in wireless communications, users intended to communicate with each other to create a temporary network without the help of any centralized controlling infrastructures such as; access points or base stations. In order to establish quicker and easier wireless communication, ad-hoc networks can be deployed as and when

required. Deployment of MANETs is easy and economical. Mobile ad-hoc networks do not possess fixed centralized infrastructures, every node in the network have to act as host and the router. Nodes of mobile ad-hoc networks assume mobile nature, which reasons these networks to acquire dynamic topologies. Such topologies may change dynamically and randomly at any point of time. Traditional routing protocols normally used for internet-based wireless networks cannot be applied directly into ad-hoc wireless networks. It is because, some common norms are not effective in all the cases for such dynamically changing networks and may not be true for mobile nodes. Mobile ad-hoc networks use specialized routing protocols which ensures path discovery between a source and the destination nodes.

Mobile ad-hoc networks are one of the categories of the wireless networks, that uses multi-hop radio relaying and it has the capacity of operating without having the support of any kind of fixed infrastructure or central control setup. MANETs are also called as infrastructure less networks. Mobile ad-hoc networks experience breakage of links due to movement of nodes from one place to another. This pours major challenges in performances of the routing protocols. Several routing protocols were proposed for MANETs by the research communities which are normally categorized as; topology and position based routing protocols. Simulation-based mobility models create node movements closely relates to the movements like in a real network. Several such models were proposed by the research community in order to test the performances of the routing protocols in various node mobility scenarios. Realistic motion scenarios of the nodes are complex natured that is why these scenarios vary from one mobility model to another. This poses challenges in analyzing mobile ad-hoc network routing protocols. Node mobility is shown to have a greater impact on average control overhead than any other factor. This would suggest that the designing algorithms that adapt to node mobility would have the greater impact on network performance.

Several factors affect the performance of the mobile ad-hoc networks some of them include; node transmit power, node pause time, node velocity, node density, mobility models, transmission region, number of source/sink pairs, type of traffic demands and the core routing protocol parameters. These factors along with the inherent characteristics of the mobile ad-hoc networks may result in impulsive variations in the overall performance of the MANET. Quantifying the effects of these

factors will help the new design choices and trade-offs. The Functionality of routing is integrated into every host of the ad-hoc network. Thus, mobile ad-hoc networks are characterized as having a dynamic, multi-hop and constantly changing topology. Different traffic generators are helpful in testing performances of routing protocols as they model the traffic in a predefined structure and scheduled manner. Traffic generators deliver the communication demands of traffic consignments regardless of the position of an agent which is attached at a particular interval and time. Mobile ad-hoc networks require solutions for some restrictions and inadequacies that include numerous factors such as; the characteristics of wireless links which are time-varying natured. There are some transmission obstructions such as; fading, path loss, blockage, and interference. Such obstructions prompt vulnerable behavior in wireless channels. Different issues resist the reliability of the wireless transmission. MANETs face a limited range of wireless transmission including the limited radio bands that result in lesser data rates.

In order to achieve optimum usage of bandwidth in mobile ad-hoc networks, routing overheads must be reduced. The major issues that affect the design, deployment, and performance of MANETs are; deployment considerations, routing scalability, multicasting transport layer protocol, pricing schemes, provisioning of QoS (Quality of Service), self-organization security energy management and addressing and service discovery. Routing protocols designed for mobile ad-hoc networks face the key challenges like the mobility of nodes, resource restrictions, and error-prone channel state, hidden and visible terminal problems. These challenges are required to be addressed for better performances of the mobile ad-hoc networks. Above discussed challenges can be put under control by means of effective management and control over them. Mobile ad-hoc network routing protocols must possess certain ideal characteristics by which the performance of the routing protocols may be compared. The ideal routing protocol must have completely distributing characteristics and it must be adaptive to frequent topology changes. A restricted number of nodes must take part in route maintenance and computation; every network node should have quick access to the accessible routes. During stable topology, the ideal routing protocol must converge to optimal routes. An ideal routing protocol must have the ability to deliver some QoS (Quality of Service) level according to demands made by the applications.

MANET routing protocols can be generally classified into four categories based on the mechanisms such as; topology of routing, consumption of specific resources, mechanism of routing information and usage of time-based information for routing. Based on Mechanism of Routing Information, routing protocols can be classified as; proactive or table driven, reactive or on-demand and hybrid routing protocols. In the past, many routing protocols were proposed for MANETs, among them some well-known are; AODV (Ad hoc On-Demand Distance Vector), DSDV (Destination Sequenced Distance Vector), OLSR (Optimized Link State Routing) and DSR (Dynamic Source Routing). Most of the previous works were focused on comparative performance analysis of some standard MANET routing protocols using NS2 (Network Simulator-2). In previous works, performances of the standard routing protocols were compared with one another considering some general network parameters. Researchers who have devoted towards performance analysis of MANET routing protocols were used a different set of standard MANET routing protocols for their analysis. These works can only justify the best performing standard routing protocol in a particular network scenario. In brief, there is enough scope for carrying out a systematic study of the analysis on mobile ad-hoc network routing protocols. Works in this thesis were focused on performance analysis of AODV, DSDV, OLSR and DSR routing protocols using NS3 (Network Simulator-3). As compare to NS-2, NS-3 has enhanced simulation capabilities and it gives more accurate results.

Initially, comparative performance analysis was carried out on standard AODV, DSDV and OLSR routing models considering different node densities and node pause times as variable network parameters. Later, comparative performance analysis on the same set of routing protocols was studied considering different node velocities and node transmit power as variable network parameters. In both the cases, as compared to AODV and DSDV routing protocols, performances of the OLSR routing protocol was concluded better. Performances of the routing protocols were evaluated by the help of standard performance evaluation metrics such as; the throughput, packet delivery ratio, an end to end delay, packet loss and normalized routing load. In order to strengthen performances of the AODV and DSDV routing protocols, many experiments were conducted on their routing parameter attributes for possible performance enhancements. Finally, performance enhancements in attribute revised models of

AODV and DSDV routing protocols were concluded by comparing their performances with the performances of the standard AODV and DSDV routing models. This analysis was completed considering different node density as variable network parameter.

Similarly, comparative performance analysis on the standard and revised routing models of OLSR and DSR protocols were also studied and performance enhancements in revised models were concluded for different node densities. Further, comparative performance analysis on attribute revised routing models of AODV, DSDV and OLSR protocols were also studied. Conclusion of this study reveals better performances of the revised OLSR routing protocol. A study on different security attacks associated with the routing in mobile ad hoc networks was also conducted to take these research works ahead on security issues.

Chapter-1, titled as 'Introduction' has some introductory and general aspects of computer networks which are discussed in detail that includes basics of computer networks, wired networks, local area networks, metropolitan area networks, wide area networks, wireless networks, system interconnection, wireless local area networks, wireless wide area networks, network hardware and software, different transmission media, types of various computer networks, mobile ad-hoc networks, core issues in routing, routing protocols and media access control protocols in ad-hoc networks, issues and challenges in ad-hoc networks and characteristics of an ideal mobile ad-hoc network routing protocol. This chapter also includes the scope of the thesis.

Chapter-2, titled as 'General Review and the Tools Used' includes some of the major works in the related area of mobile ad-hoc network routing protocols. Various state-of-the-art technologies as available in the literature are discussed in brief in this chapter. The latest trends in the field of development of various techniques of performance improvements in MANET routing protocols and their applications in various fields have been reviewed in detail. Security issues associated with the routing in mobile ad hoc networks were also discussed in this chapter. Various performance measuring metrics have been debated in detail along with the details of the simulation tools used also discussed in this chapter. Based on the literature survey carried out in this chapter, the motivation behind the present study is outlined at the end of this chapter.

Chapter-3, titled as 'Study and Analysis of Different Node Density and Pause Time Effects' is devoted to studying and comparative performance analysis of different node density and node pause time effects on standard AODV, DSDV, and OLSR routing protocols. Node density refers to the network models comprising of a different set of nodes and node pause time refers to the halt position of a mobile node. Networks of different sets of nodes were created to test the behaviour and performances of the routing protocols. Similarly, different node pause time intervals were considered for examining the performances and deeds of the routing protocols. There were two scenarios fixed for each effect; simulation scenario - I and simulation scenario - II. For these scenarios, many network parameters were taken into consideration. For simulation scenario - I, different set of nodes used were 30,40,50,60,70,80,90 and100. Simulation time was fixed to 150 seconds with no pause time. Wi-Fi mode was set to the ad-hoc mode with a rate of 2Mbps (802.11b). Transmit power was set to 7.5dBm with 10 number of fixed source/sink connections. Random waypoint mobility model was used for a rectangular region of 300 × 1500 m to ensure node mobility at a speed of 20 m/s. Transmission data rate was fixed to 2.048 Kilobits per second along with the data packet size of 64 Bytes using friss loss model. For simulation scenario - II, different node pause times considered were 5, 10, 15, 20, 25, 30 seconds with 50 numbers of network nodes and rest network parameters were set as in simulation scenario - I. In this chapter, various performance measuring metrics were analyzed and the obtained results were discussed with suitable comments along with tables and graphs.

Chapter-4, titled as 'Investigations on Diverse Node Velocity and Transmit Power Effects' is involved with the study and analysis of diverse node velocity and transmit power effects on standard AODV, DSDV, and OLSR routing protocols. Node velocity refers to the speed at which mobile nodes travels. Transmit power refers to the transmission power by which a source node transmits the data packets to the destination node. Random waypoint mobility model was used for the simulation-based node mobility with different speeds. Study and analysis of different node velocity and transmit power effects were conducted in two cases. In the first case, analysis of varied node velocity effects was taken into account and in the second case, analysis of diverse transmit power were considered. Different values of node velocities were; 10 m/s, 20 m/s and 30 m/s and 3.5dBm, 4.5dBm, 5.5dBm, 6.5dBm, 7.5dBm, 8.5dBm and 9.5dBm

were considered as different transmit power values. Other network parameters were kept similarly as in chapter-3 in order to maintain the same test platform for testing performance and behavior of the standard AODV, DSDV and OLSR Routing protocols for different varying parameters. Different network parameters were set for simulation-based experiments in a 300 x 1500 m rectangular simulation region. Separate experiments were conducted for each value of node velocity and the transmit power. Obtained packet data was used for analyzing different performance evaluating metrics. At the end of the chapter, results were tabled and plotted with appropriate comments.

Chapter-5, titled as 'Performance Analysis on Standard and Revised Routing Models of AODV, DSDV and OLSR' includes investigations on performances of the standard and attributes revised routing models of AODV, DSDV, and OLSR routing protocols in different node density scenarios. These analyses were carried out in three different sections; section 'A' deals with the AODV routing protocol, section 'B' deals with DSDV routing protocol and section 'C' deals with the OLSR routing protocol. In every section, the performance of the revised routing model was compared with the performance of the standard routing model in order to check performance improvements. Routing attributes of the standard routing protocols were altered to test possible performance improvements. Attributes of the parameters associated with each routing protocol were tested for different values according to their functions and to achieve performance enhancements in the routing protocols. In chapter-5, comparative performances of the attribute revised routing models were also discussed in section 'D'. Obtained packet data was utilized for analyzing various performance calculating metrics such as; the throughput, packet delivery ratio, end-to-end delay, packet loss and normalized routing load. At the end of this chapter, results were discussed in detail with graphs.

Chapter-6, titled as 'Performance Analysis of Standard and Revised DSR Routing Models' includes investigations on performances of the standard and attribute revised routing models of DSR routing protocol in different node population scenarios. Routing attributes of the standard dynamic source routing (DSR) protocol were altered in order to obtain a new DSR protocol design namely, the REV.DSR (Revised DSR). Performances of the REV.DSR was tested and compared with the performances of the STD.DSR (Standard DSR) to check possible performance improvements in different

node densities. Suitable network parameters and attributes revised dynamic source routing parameters were set for this analysis. Like in previous chapters, obtained packet data was employed for analyzing various performance evaluating parameters namely, the throughput, packet delivery ratio, end-to-end delay, packet loss and normalized routing load. In this chapter, various performance measuring metrics were analyzed and the obtained results were discussed with suitable comments along with tables and graphs.

Chapter-7 concludes some major outcomes and findings of the thesis. This chapter presents the overall conclusions drawn from the results presented in chapters 3 to 6 of the thesis. Finally, based on the constraints and limitation of the present study, an outline regarding the future scope of the works in the related area of research has been presented at the end of this chapter followed by useful references and list of research papers at the end.

This work is a humble attempt to initiate the study and analysis of various performance affecting parameters and revising up of routing attributes in some standard algorithmic protocol models to achieve better performances in terms of various performances measuring metrics. In order to strengthen mobile ad hoc networks in terms of effective connectivity, a better performing routing protocol is needed. This study will empower scientists and engineers to test and select effectively performing routing protocols while designing protocol suits for mobile ad hoc networks. Work initiated in the thesis will open extensive investigation opportunities for further research with a collaborative effort from industries and academia.