CHAPTER-7

Conclusions and Future Scope

The current chapter is dedicated to conclude and summarize the key conclusions drawn from the results gained in the previous chapters of this thesis. As research is an incessant process of knowledge, a summary of the future scope in the areas associated to the current investigations have also been accomplished.

7.1 Conclusion

The current dissertation is focused to explore achievements in performance enhancement of the routing protocols in mobile ad-hoc networks. With recent advancements in performance progressions of computer and wireless communication technologies, use of cutting-edge mobile wireless computing is increasing day by day. Mobile wireless computing involves IP (Internet Protocol) usage; the idea of mobile ad-hoc networking is to provide efficient, error free and robust operation in mobile wireless networks by including routing features into the mobile nodes. Due to mobility of nodes, mobile ad-hoc networks acquire dynamic topologies.

In order to co-op with the advanced technologies of computing and communication, mobile ad-hoc network protocols are required to enrich their performance abilities.

Initially, three well-known standard routing protocols of mobile ad-hoc networks were considered for the investigations; AODV (Ad hoc On Demand Distance Vector), DSDV (Destination Sequenced Distance Vector) and the OLSR (Optimized Link State Routing). Primarily, effects of different node density and node pause times were analysed in all the three routing protocols. Later on, effects of different node velocity and transmit power were also investigated in the se routing protocols. These performance investigations conclude better performances of the standard OLSR routing protocol as compared to the AODV and DSDV routing protocols. Performances of the routing protocols were evaluated by the help well-known metrics namely, the throughput, packet delivery ratio, end to end delay, packet loss and the normalized routing load.

Further, investigations were conducted towards achieving performance enhancements in AODV and DSDV routing protocols. After conducting many experiments on standard parameter attributes of the AODV and DSDV routing protocols, new attribute revised designs of AODV and DSDV protocols were obtained. Performances of the new attribute revised models were tested and compared with the standard protocol models in different node density scenarios. It is concluded that the attribute revised models of AODV and DSDV were shown improved performances as compare to their standard versions.

In addition, performance investigations on standard and attribute revised routing models of OLSR were also conducted in different node density scenarios. It is concluded that the revised OLSR model has shown better performances as compared to its standard version. Comparative performance analysis on attribute revised models of the AODV, DSDV and OLSR routing protocols was also studied. Conclusion of this study reveals better performances of the revised OLSR routing protocol as compared to revised AODV and DSDV routing models.

Taking these research works ahead, comparative performance analysis on standard and revised models of the DSR routing protocol was also conducted in different node density scenarios. Conclusions of this study also reveal improved performances in the revised DSR routing model. Performance evaluation of all the standard and revised routing protocol models were carried out by the help of above discussed well-known performance evaluation metrics available for MANET routing protocols. A study on different security attacks associated with routing in mobile ad hoc networks was also conducted for further research on routing attacks.

7.1.1 Effects of Different Node Density and Node Pause Time

In chapter-3, different node density and node pause time effects on standard AODV, DSDV and OLSR routing protocols were studied and analysed. Node density refers to the network models comprising of 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. Various factors affect the performances of the MANET routing protocols. Some of them include; transmit power, number of fixed source/sink connections, node density, node velocity, node pause time, transmission region, transmission range, type of traffic (offered load), Wi-Fi rate and packet size etc. Out of these factors, node density and node pause time were opted for examining their effects on behaviour and performances of the standard AODV, DSDV and OLSR 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 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.

Simulation results of both the scenarios conclude better performances of the OLSR routing protocol for all the metric calculations as compare to AODV and DSDV routing protocols. Results of simulation scenario-I conclude; better performance of the standard OLSR routing protocol in terms of network throughput. As far as AODV and DSDV are concerned, initially throughput of the AODV was found better, but after some point of time, it was degraded. As compare to AODV protocol, DSDV has performed well in terms of throughput. The standard OLSR routing protocol has also shown better performances in terms of other metrics namely, the packet delivery ratio, end to end delay, packet loss and normalized routing load when it was compared with the performances gained by the AODV and DSDV protocols. Comparison results of AODV and DSDV conclude that; in some cases, AODV has performed better and in some other cases, DSDV protocol has better results. Simulation scenario-II also concludes better performances of the OLSR routing protocol in terms of all the metric calculations when it was compared with performances of the AODV and DSDV protocols.

As far as AODV and DSDV are concerned, in some cases, DSDV routing protocol has shown better results and in some other cases, the AODV routing protocol has shown better performances for varied values of node densities and the node pause times. These conclusions are based on the version of the network simulator used and the network parameters set for the experiments. However, performance of the MANET routing protocols depends on many other technical parameters associated with the network and wireless technologies. Finally, it is concluded that; performances of the standard OLSR routing protocol were better in terms of all the metric calculations as compared to performances of AODV and DSDV routing protocols for different node densities and node pause time.

7.1.2 Effects of Diverse Node Velocity and Transmit Power

In chapter-4, diverse node velocity and transmit power effects on standard AODV, DSDV and OLSR routing protocols were studied and analysed. 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 first case, analysis of varied node velocity effects were taken into account and in second case, analysis of diverse transmit power was considered. Different values of node velocities used 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 same test platform for testing performance and behavior of standard AODV, DSDV and OLSR Routing protocols for different varying parameters. Analysis of varied node velocities conclude better performances of the OLSR routing protocol as compare to AODV and DSDV, in terms of performance metrics; the throughput, packet delivery ratio, end to end delay, packet loss and normalized routing load.

Comparison of AODV and DSDV concludes that; for some values of node velocity, performances of the AODV routing protocol were found better and in some other values of node velocity, performances of the DSDV routing protocol were enhanced. Analyses of varied transmit power effects also conclude better performances of the OLSR protocol when it compared with the performances of AODV and DSDV. Performance comparison of AODV and DSDV protocols concludes that; for some values of transmit power, performances of the AODV routing protocol were better and in some other values of transmit power, performances of the DSDV routing protocol were recovering. Finally, it is concluded that; performances of the standard OLSR routing protocol were better in terms of all the metric calculations as compared to performances of AODV and DSDV routing protocols for different node velocities and transmit power.

7.1.3 Performance Analysis of Standard and Revised AODV, DSDV and OLSR Models

In chapter-5, performance comparison of the standard and attributes revised routing models of AODV, DSDV and OLSR routing protocols were studied and analyzed for 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, performance of the revised routing model was compared with 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. As per experimental results and metric calculations; the throughput, packet delivery ratio, end to end delay, packet loss and normalized routing load of the attributes revised AODV, DSDV and OLSR routing models were shown better and enhanced performances as compare to the default or standard AODV, DSDV and OLSR routing models. These performance enhancements were made possible by the help of simulation platforms used, selection of suitable general network parameters and protocol attributes.

In chapter-5, comparative performances of the revised routing models were also discussed in section ‘D’. Where, the revised OLSR model has shown better performances in terms of network throughput, packet delivery ratio, end to end delay, packet loss and normalized routing load metrics. Attribute revised routing models are helpful in gaining maximum efficiency of the MANETs in various deployment scenarios. Revised versions of the AODV, DSDV and OLSR routing protocols can be utilized as MANET routing protocols in real networks comprising of small or large set of nodes.

7.1.4 Performance Analysis on Standard and Revised Routing Models of DSR Protocol

In chapter-6, performance analysis on standard and revised routing models of DSR routing protocol were studied and analyzed. According to simulation results and performance calculations, the revised DSR routing model has shown improvements in its performances as compared to the standard DSR routing model. The revised DSR model has improved throughput, better packet delivery, least end-to-end delays, minimum packet losses and lesser routing overheads. These results were obtained for suitable network parameters and attributes revised dynamic source routing parameters set for these analysis. Attributes of dynamic source routing parameters were altered for testing and research based study purposes.

Further research on standard and revised DSR routing models can be taken ahead for large network node sets, different simulation scenarios comprising of different network and protocol parameters with different attribute values and QoS (Quality of Service) concerns. Routing protocols are considered as most important protocols in mobile ad hoc networks because; they establish paths between network nodes for effective and error-free communication. Due to infrastructure less nature of mobile ad hoc networks, they are very helpful at locations where network infrastructure does not exist. Some applications of these networks include; military operations, emergency rescue operations (during flood, earthquake etc.) etc. In order to strengthen mobile ad hoc networks in terms of effective connectivity among nodes, a better performing routing protocol is quite essential. This study will empower scientists and engineers to test and select effectively performing routing protocols while designing protocol suits for mobile ad hoc networks. This study will help researchers for further improvements, critical analysis on DSR routing protocol.

7.2 Future Scope of Research

Further research on performance comparison and performance enhancement in mobile ad-hoc network routing protocols could be taken ahead considering various other parameters pertaining to the network simulation scenarios and protocol parameters. Still there is lot of scope to research on mobile ad-hoc network routing protocols, added research can be taken ahead for larger number of network nodes, diverse simulation scenarios including different parameters (different geometrical regions) of the transmission region, transmission range, varied number of source/sink pairs, different mobility models, different Wi-Fi rates, dissimilar type of offered load, different traffic generators, QoS (Quality of Service) considerations etc. Further research can be taken ahead on security concerns associated with the routing protocols. Revised models of AODV, DSDV, OLSR and DSR routing protocols can further be studied for higher values of node pause time, node velocity, transmit power and the other performance affecting factors discussed above.

There are various routing protocols available for mobile ad-hoc networks other than the AODV, DSDV, OLSR and DSR. Further research can be taken ahead considering other routing protocols of mobile ad-hoc networks such as; WRP, CGSR, STAR, FSR, HSR, GSR, ABR, SSA, FORP, PLBR, CEDAR, ZRP, ZHLS, PAR, LAR etc. Mobile ad-hoc networks require overcoming from some restrictions and inefficiencies that include several factors like characteristics of the wireless links. There exist some barriers in wireless transmissions like; fading, path loss, blockage and interference which add to vulnerable behaviour of wireless channels. Different factors resist the reliability of the wireless transmission, these barriers needs to be addressed. Mobile ad-hoc networks face inadequate range of wireless transmission including the limited radio bands that results in inferior data rates. In order to achieve optimal usage of bandwidth in mobile ad-hoc networks, routing overheads must be reduced.

In ad-hoc networks, transmission inaccuracies results in higher packet losses, the key factors that cause these packet losses are: collisions of hidden terminals, high bit error rate of wireless channels, interference, frequent path breaks triggered due to mobility of the nodes and enlarged collisions due to the existence of unidirectional links and hidden terminals. Nodes in mobile ad-hoc networks experiences path changes due to their mobility. Frequent path break occurs due to dynamic nature of network topology. Mobile ad-hoc networks faces frequent network partitions, random mobility of nodes often lead to network partitions. This affects the performances of the intermediate nodes. The key issues that distress the design, deployment and performances of mobile ad-hoc networks are; deployment reflections, routing processes, scalability, multicasting, behaviour and performance of transport layer protocols, pricing schemes, provisioning up of quality of service, self-organization, security, energy management and addressing. Service discovery needs to be addressed further to achieve better performances.

The organization of mobile ad-hoc networks involves good amount of planning and estimation of future growth of traffic over data links of the network. The routing protocols are responsible for exchanging the routing information and finding a feasible path from a source to the destination nodes based on the criteria like; hop length, minimum power required, life time of the wireless link, fetching information about path breaks, mending the broken paths, expanding processing power and bandwidth. The density of nodes in an ad-hoc network does not grow in the way by which today's Internet but the operation of huge number of nodes in ad-hoc mode is not far away. Multicasting plays very important role in the typical mobile ad-hoc network applications such as; emergency search and rescue operations and military communications. In such cases, network nodes for groups to carry out certain tasks require point-to-multipoint and multipoint-to-multipoint voice and data communications. The transport layer protocols are responsible in setting up and maintaining end-to-end connections, reliable end-to-end delivery of data packets, flow control and congestion control. There is still much scope in addressing transport layer protocols.

Pricing schemes incorporate service compensation or service reimbursement. Mobile ad-hoc networks that deployed for some special tasks like; military missions, rescue operations and law enforcement do not require such pricing schemes. Some commercial deployment of mobile ad-hoc networks requires billing and pricing. Provision of quality of service is the performance level of services offered by a service provider to the user. Provisioning of quality of service often requires negotiation between the host and the network, priority scheduling, resource reservation schemes and calling admission control. In mobile ad-hoc networks, rendering quality of service can be on per flow, per link, or per node basis. These qualities of service issues required to address in such a manner that the users must get error free and efficient network services and the associated applications that transport over the mobile ad-hoc network. Self-organization and maintaining the network itself are the very essential properties of mobile ad-hoc networks. The major activities that these networks required to accomplish for self-organization are; neighbour discovery, topology organization and topology reorganization.

In mobile ad-hoc networks, communication security is very important, especially in military applications. The lack of any central coordination and shared wireless medium makes them more vulnerable to attacks than wired networks. Therefore, more research should be focussed over security concerns of the mobile ad-hoc networks. Energy management can be defined as the process of managing the sources and consumers of energy in a node or in the network as a whole for enhancing the lifetime of the network. Determining the energy discharge pattern of a node's battery is a major requirement to enhance the battery life and finding routes that result in minimum total energy consumption in the network. More research focus is required to address energy issues in the nodes of mobile ad-hoc networks.

Addressing and service discovery undertake significance in mobile ad-hoc networks due to the absence of centralized controller. An address that is globally unique in the connected part of the ad-hoc network is required for a node in order to participate in communication. Auto configuration of addresses is required to allocate non-duplicate addresses to the nodes. Further research could address the issues related to the media access control protocols involved in communication of mobile ad-hoc networks, quality of service related issues and 'addressing and service discoveries' in mobile ad-hoc networks.