CHAPTER 7

CONCLUSIONS AND FUTURE ENHANCEMENTS

7.1 SUMMARY

Emerging group communication applications, such as multiparty conferencing, emergency rescue operations etc. have made the design and development of efficient optimized multicast routing protocols in ad hoc environments a necessity and not just a desire. In this thesis, first the concepts related to MANETS, multicast routing and optimization are described. Then the analyses and recent advancements in the area of our research are summarized. The main design issues and challenges that multicast routing protocols face are identified, and a brief overview of the current optimization techniques in MANETs, is provided.

The first step in the literature survey is to classify the multicasting techniques into Multicast routing in wired and wireless networks, QoS multicasting, Multimedia multicasting and then to MANET multicasting protocols. From the literature it is learnt that, in MANETs, node mobility results in frequent link breaks, packet collisions, transient loops and problems in resource reservation. Also, MANET faces many challenges in supporting multicast communication because of the node mobility, energy and bandwidth consumption, control overhead, packet losses, end-end delays, reliability and scalability. Hence, designing protocols, which should support high delivery with minimum overhead, is a dire need.
MANET multicasting protocols are then classified into tree and mesh based protocols based on their underlying data forwarding mechanisms. Finally, a qualitative comparison of MAODV, ADMR and ODMRP candidates for tree and mesh based protocols are explored, according to several distinct features and performance parameters. From the study it serves as motivation to optimize the protocol, the MAODV as a representative of tree based protocols against the ODMRP, a mesh based protocol using the heuristic techniques of the GA and PSO.

Next, a GA based optimization approach that can be applied in reactive multicast routing protocols is proposed, in order to facilitate the implementation of finding a minimum cost multicast tree to forward data packets. The proposed architecture is an enhancement of the existing protocol in which the routing procedure is modified, so that the new optimal multicast tree (or) minimum cost tree is found using the steps of topology encoding, topology crossover and node mutation used in the heuristic approach of the GA. The main features that the GA-MAODV and GA-ODMRP have introduced find a minimum cost multicast tree to forward data packets in GA-MAODV and minimizing the number of forwarding nodes in the GA-ODMRP. Thus, a forwarding mesh is built upon the resultant tree which has a lower data overhead than the forwarding mesh built upon shortest path trees. Moreover, it is observed that, when large number of sources is in transmission, almost no additional redundancy is required and when the number of sources is small, a larger number of forwarding links might be used to cope with high mobility.

The performance evaluation of the protocols demonstrated that the proposed strategy improves the performance of the MANETs by improving the packet delivery ratio and by decreasing the control message overhead in an acceptable time limit of latency. The proposed architecture provides a very
stable multicast tree to forward the data packets by optimizing the number of forwarding nodes which are cost effective and not easily disrupted by mobility.

A PSO based multicast routing strategy for supporting optimal multicast tree construction is presented in MANETs. The basic motivations of the proposed routing model stem from the cost incurred in multicast routing and the node mobility observed in location uncertainty in MANETs. Based on the underlying structure, the PSO-MAODV and PSO-ODMRP, which are suitable for highly dynamic environment MANETs, have been proposed.

The PSO-MAODV considerably improves the efficiency of the protocol by managing to offer higher performance than the MAODV at a lower cost in terms of forwarding efficiency. The minimum cost tree is obtained by following the PSO procedure fitness evaluation, cost and route updation. The lower cost allows the proposed approach to support a higher overall traffic load. The PSO-ODMRP has been introduced to reduce the data overhead of the mesh based ODMRP. The modified version of the ODMRP reduces the number of forwarding nodes when there is enough reliability in the forwarding mesh, which in turn, reduce the data overhead and can concentrate on effective increase in packet delivery.

Finally, the realistic scenarios of emergency rescue operation and video conferencing are used to compare the performance of optimized multicast routing protocols. Among the two basic classifications of mesh and tree based optimized protocols, the tree based protocols propagate data over a tree spanning all multicast group members; these are bandwidth efficient and do not always offer sufficient robustness. This inherent property of these protocols makes them suitable for video conferencing where the loss of data can be compromised. In mesh based protocols, on the other hand, a subset of
network nodes (the mesh) is responsible for forwarding the data to all the multicast receivers, and thus address robustness and reliability requirements with path redundancy inherent to meshes, and make them all suitable for critical environments like emergency rescue operations. From the summary of simulation results it is observed that the robustness, optimality and reliability of these protocols proved their suitability to these kinds of real time applications.

The analysis and comparisons show that the advantages and disadvantages of the protocols reside mainly in the aspects of overhead, delay and packet delivery ratio. The performance evaluation of the proposed protocols is accomplished via modeling and simulation. The simulation results demonstrate that the proposed protocols provide an accurate and efficient approach of estimating and evaluating the multicast routing strategy in MANETs.

7.1.1 Multicasting Routing Protocols as a Function of Optimization

The reactive protocols of MAODV and ODMRP as candidates for mesh and tree based protocols are evaluated, and it is found that the MAODV does not perform as well as the other protocols in terms of packet delivery ratio, but has the lowest routing overhead, whereas the ODMRP performs considerably better than previous protocols in terms of delivery ratio but it suffers from excessive overhead.

In this work, optimized tree and mesh based multicast routing protocols for MANETs have been developed by applying heuristic techniques like the GA and PSO. The concept of optimized routing strategy relies on finding a minimum cost multicast tree to forward data packets in reactive multicast routing protocols, and enhance their performance. The design
approach adopted in this thesis is generic in nature and the choice of protocol depends on its proven performance and on its applicability to the scenarios and environment, where the protocol is deployed. With regard to optimality, the protocols attempt to benefit from the higher efficiency of improving the packet delivery ratio in tree based protocols and reducing the control overhead offered by mesh based protocols.

When compared to the MAODV and ODMRP, the GA-MAODV, GA-ODMRP, PSO-MAODV and PSO-ODMRP clearly outperform in most situations. Their superiority lies in the fact that, in the long run, the optimized protocols are able to deliver large number of packets with minimum control message overhead, while keeping minimum latency at acceptable levels. This is also clearly evident from typical MANET scenarios, such as video conferencing and emergency rescue operations which are used to explore the performance of these optimized protocols. By means of simulation it is demonstrated that the optimized protocols perform very well, particularly as the number of multicast senders and receivers increases. The results show that the efficiency of the routing strategy goes up and down depending on the number of sources, number of receivers and status of MANETs.

Simulation results show that even though the performance of all multicast protocols degrade in terms of packet delivery, as node mobility increases, mesh based optimized protocols perform considerably better than tree based optimized protocols in almost all the scenarios considered, because of their redundant broadcast mechanism. Tree based optimized protocols possess only the lowest routing overhead compared to mesh based optimized protocols exhibiting a considerably good packet delivery ratio. One among the conclusions from this research is that, the optimization of routing strategy yields better results than the existing protocols and greatly improves the performance of the MANETs.
The resultant optimized multicast protocols are simple and efficient, robust and form loop free minimum cost multicast trees. The thesis presents a detailed study of the effects of varying the number of multicast senders to varying number of multicast receivers on the performance of reactive optimized multicast routing protocols.

7.1.2 GA vs PSO based Multicast Routing Protocols

Through the various parameters, the efficiency of GA based multicast protocols and PSO based multicast protocols have been discussed. The results obtained from the various network scenarios demonstrate that multicast routing optimization, in general, can greatly improve network performance. It is experimentally shown that the PSO is superior to other heuristics with respect to result, quality and runtime. But, GA based algorithms compare favorably with other multicast routing protocols in terms of success rate in finding minimum cost trees.

From the results, it is seen that the proposed PSO based optimized protocols have a much stabilized packet delivery curve than that of the genetic algorithms. Moreover, these optimized protocols find optimal routes faster. Although the latency curve of the PSO based protocols vibrate more in the beginning, it stabilizes with time in most cases.

The thesis quantifies the performance differences of the GA based optimization and PSO based optimization for multicast routing strategy in MANETs. The simulation results show that the PSO based multicast routing offers significantly better performance to multicast data flows than the GA based multicast routing. The average packet delivery ratio given by the PSO based multicast routing is higher by up to 10 percent, and the average latency is up to 12 percent lower in the experiments conducted.
7.2 FUTURE WORK

Multicasting in MANETs faces many challenges due to the mobility of the nodes, unreliable transmission medium, lack of dedicated routers and fixed infrastructure, limited transmission range of the devices, and limited available bandwidth. The concept of polymorphic hybrid protocols constitutes future trends in the design of efficient optimized multi behavioral multicast routing protocols for power constrained networks such as MANETs.

In future, it is possible to extend the proposed protocols to solve some QoS issues, such as power and bandwidth. The mobile devices are equipped with a low power battery, so it is very important to reduce the number of packet transmissions. Moreover, the bandwidth consumption is important for supporting real time and multimedia service. Meanwhile, in this set of experiments, the node mobility is varied from 0-20 m/s. In future, in order to deploy mission critical applications, the node mobility may be increased so that the efficiency of the protocols at high speed can be explored. Further work can focus on combining other efficient heuristic algorithms with these reactive multicast routing protocols to reduce computation time and embed it into an energy aware multicast routing protocol.

The other performance metrics such as energy-based mobility, link stability, forwarding efficiency and mean delivery latency can be used to evaluate the proposed protocols. Designing a new protocol with different group mobility models suitable for multicast applications, can also be considered for future work.