7. CONCLUSION AND FURTHER RESEARCH

7.1 INTRODUCTION

This chapter reviews the significance of the proposed framework and provides suggestions for future research. This research offers fresh motivation for providing QoS in MANETs for the end to end delivery of time-critical multimedia applications in the context of MANET routing and queue management. With the objective of improving the performance in MANET environment, the core functions which are taken into account are competent routing mechanism, successive forwarding of packets to the nodes with minimum delay and managing the link queue size effectively. The various performance metrics are evaluated for the proposed strategies and compared with the traditional reactive routing protocol namely AODV. The simulation results reveal that the proposed algorithms perform better than the existing routing, scheduling and queue management strategies in terms of routing overhead, packet drops, packet delivery ratio, inter-packet delay, queuing delay and end to end delay which in turn has improved the MANET performance. The introduction of various routing protocols, packet scheduling strategy and queue management technique enables for the successful end to end delivery of time-critical multimedia applications in the challenging environment of high mobility and network sizes. In the remainder of this chapter, the contributions of the research carried out and the areas for further work are sketched out.

7.2 HIGHLIGHTS OF THE WORK DONE

This work has proposed a set of routing, packet scheduling and queue management strategies that focus on enhancing packet delivery ratio and reducing end to end delay for the delivery of time-critical multimedia applications in MANET. A brief survey of broadcasting schemes in route discovery, disjoint multipath routing schemes, packet scheduling schemes

over multimedia traffic and queue management schemes available in the literature is discussed in the introductory chapter and the motivation for the present work also brought out. Keeping in the background the contributions made so far in the area of routing techniques and the objective of developing routing, scheduling and queue management algorithms are proposed and simulated in Network Simulator NS 2.34. Based on the investigations made and the results obtained, the following conclusions are arrived at:

i.   A new Probabilistic Scheme based AODV (PSAODV) routing as a modified AODV routing is specially designed for reduction of routing overhead and selection of a suitable TCP variant in MANET. The introduction of PSAODV as a first routing strategy has minimized the rebroadcasting of route request packets in ad hoc nodes, which resulted in the reduction of routing overhead. The simulation results reveal that the proposed routing strategy has enhanced the existing AODV routing protocol performance in terms of packet delivery ratio and routing overhead as a significant improvement on delivering the data packets in MANET environment. On comparison of the performance of the PSAODV protocol with the existing AODV routing protocol in TCP Vegas, TCP Tahoe and TCP SACK the performance of PSAODV is found better than the AODV routing protocol in TCP-SACK in terms of packet delivery ratio.

ii.   A Loop-free Multipath in Probabilistic Scheme based AODV (LM-PSAODV) routing as a modified AODV is introduced for reduction of packet drops and selection of a suitable TCP variant in MANET. The Loop-free Multipath AODV (LMPSAODV) as the second routing strategy established the disjoint route from source to destination, which resulted in more reduction of packet drops than PSAODV routing strategy and identified TCP SACK as a suitable TCP variant for an accurate end to end delivery of data-traffic applications. The strategy is implemented and evaluated to provide a disjoint path with reliable delivery in MANET environment. The LM-PSAODV routing algorithm avoids the

packet looping, reduces the packet drops and increases the packet delivery ratio by the establishment of the partially disjoint alternate route while looping occurs. The simulation results confirm that the proposed strategy performs better than the PSAODV and AODV routing algorithms in terms of Packet Delivery Ratio, Packet Drop, Routing Overhead and End to End Delay. Thus, the results illustrate that the interaction between transport layer with the network layer protocol has a significant impact on the achievable packet delivery ratio, end to end delay and routing overhead in ad hoc networks.

iii. As a third strategy, the improved packet scheduling strategy (ERR-PSS) is introduced for packet forwarding along with the Loop-free Multipath in Probabilistic Scheme based AODV (LM-PSAODV) routing strategy, which minimized the IPD when transmission of multimedia applications. The strategy is implemented and evaluated to forward the packets to the succeeding nodes in an efficient manner. It uses the features of round robin and priority scheduling algorithms as a hybrid packet scheduling approach for better scheduling of packets to reduce inter-packet delay. The simulation results confirm that the proposed packet scheduling strategy performs better than the existing scheduling strategies namely FIFO-PSS and RR-PSS in terms of Inter-Packet Delay, Queuing Delay, End to End delay and Routing Overhead on varying number of connections and pause times. The implementation of hybrid packet scheduling approach (ERR-PSS) in LM-PSAODV has improved the routing performance in terms of Inter-packet delay, end to end delay and routing overhead as a vital improvement on delivering multimedia applications in MANET environment.

iv. The Fuzzy Logic-based Random Early Detection (FL-RED) technique as a queue management scheme is deployed for congestion control and reduction of queuing delay in delay sensitive applications. The FL-RED queue management technique is developed as a fourth strategy to control the

congestion at the link level and has reduced the queuing delay. The proposed queue management strategy is implemented and evaluated to manage the link queue size in an an efficient manner, it estimate the packet dropping probability 'p' for every packet based on the size of the queue q(t), the rate of enqueue (e_q) and the rate of dequeue (d_q) to reduce the queuing delay. The simulation results have revealed that the proposed strategy performs better than the existing queue management strategy in terms of queuing delay by varying number of nodes over delay sensitive applications in MANET environment.

v. The Integration of LM-PSAODV, ERR-PSS and FL-RED algorithms is proposed as an improved routing and queue management framework for better performance achievement in MANET. As a highlighting fifth strategy, IRQM-framework is suggested to reduce the delays while the delivery of delay-sensitive applications and enhanced the performance of the MANET. From the results obtained, it is observed that the IRQM framework performs better in the reduction of an average end to end delay than "AODV routing with RED queue management" and "LM-PSAODV routing with RED queue management" over delay sensitive applications. Hence, it is concluded that the IRQM framework confirms the suitability of support for video traffic applications in the challenging MANET environment.

These enhancements for the routing, packet scheduling and queue management algorithms developed. The results and the comparison of results were reported.

7.3   FURTHER RESEARCH

There are many ways in which this research can be taken forward. This research work has modified the AODV reactive routing protocol with five different strategies for routing, scheduling and queue management enhanced

the performance in MANET. Application of these strategies into Dynamic Source Routing (DSR) and Location-Aided Routing (LAR) protocols for identification of the location information of ad-hoc nodes in Global Positioning applications would be the future work. In this research, the Random Waypoint Mobility model has been used to examine the movement behaviour of mobile nodes. Experimentation using other mobility models such as Group Mobility model in MANET environment would be the extension of this work. In this work the proposed methods are simulated and the nodes are distributed randomly over the two-dimensional grid. The implementation of the video conferencing chat for the farmers' awareness application in real-time is considered as the future scope of the work. This research can further be extended to provide the secured routing between ad hoc nodes for the data transmission in military applications.