4. LOOP-FREE MULTIPATH IN PROBABILISTIC SCHEME BASED AODV ROUTING WITH TCP VARIANTS FOR PACKET DROP REDUCTION AND PACKET DELIVERY IMPROVEMENT

4.1 INTRODUCTION

The sensitivity analysis carried out to verify the efficiency of the Probabilistic Scheme Based AODV (PSAODV) Routing algorithm with an objective of control-overhead reduction is discussed in chapter 3. In this chapter, the proposed Loop-free Multipath in Probabilistic Scheme based AODV routing (LM-PSAODV) aims to reduce the occurrence of packet drops in routing loops and suggests a suitable selection of TCP variant for more accurate data delivery from source to destination in data traffic. The problem considered in the LM-PSAODV strategy is to reduce the packet drops due to the occurrences of routing loops between same two nodes while selecting the next neighbour node for rebroadcasting. A few numbers of packets are locked in the network for random time periods may lead to the possibility of packet drops due to the occurrences of routing loops between same two nodes while selecting the next neighbour node for rebroadcasting. The packets may stay longer time period in the routing loop and hence it is essential to establish the disjoint routing. The LM-PSAODV, PSAODV and AODV routing protocols are experimented with different TCP variants namely TCP Tahoe and TCP SACK in a simulation environment on varying node density. LM-PSAODV is thoroughly examined, compared and analyzed with the PSAODV and AODV routing protocol. The methodology of LM-PSAODV routing, analysis of the existing and proposed routing with TCP variants, results and analysis are described in the rest of the sections of this chapter.

Scalability of a lot of on-demand routing protocols is limited because of nodes' movement. Scalability for wireless routing protocols basically depends on extra routing messages. SACK is a type of selective acknowledgements for the TCP to provide the sender with sufficient information to recover quickly from multiple packet losses within a single transmission window.

The multipath routing scheme is called Multipath On-demand routing in order to minimize the route break recovery overhead. This scheme provides multiple routes on the intermediate nodes on the primary path to the destination along with source node. The Routing On-demand Acyclic Multipath (ROAM) algorithm maintains multiple loop-free paths to destinations. Each router maintains entries only for those destinations for which data flows through the router, which reduces storage space requirements and the amount of bandwidth needed to maintain correct routing tables. It is proved that monotonically increasing sequence numbers by themselves do not guarantee Loop Freedom and thus AODV Can Yield Routing Loops.

4.2 METHODOLOGY OF LM-PSAODV ROUTING AND ANALYSIS OF THE TCP VARIANTS

The objective of the proposed Loop-free Multipath in Probabilistic Scheme based AODV (LM-PSAODV) routing algorithm is explored for reduction of packet drops and selection of a suitable TCP variant in MANET. The routing algorithm is also analyzed with TCP variants to identify a TCP variant for more accurate data delivery from source to destination. Whenever the routing loop occurs, the proposed strategy establishes an alternate path from the current node to the destination node by calling the route repairing mechanism in AODV, based on the TTL value of the packet. Figure 4.1 is the scenario for a loop formed between the intermediate nodes ‘B’ and ‘C’ in an established route from a source ‘S’ to destination ‘D’ of a sample network.

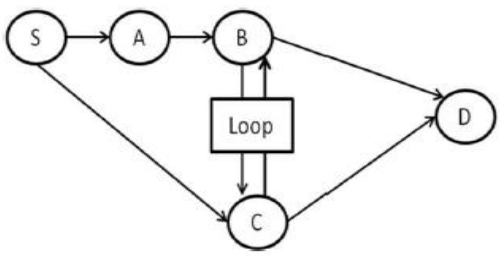

Figure 4.1: Routing Loop between intermediate nodes

The packets are transmitted from the source node 'S' and they are expected to reach the destination node 'D'. But, the packets are forwarded indefinitely between the intermediate nodes 'B 'and 'C' due to the formation of a routing loop between these nodes while selecting the same node again and again as the next node. The LM-PSAODV strategy reduces the reduction of packet drops along with routing overhead.

4.2.1 Methodology for Route Discovery

Set the parameter values for transmission range, bandwidth, simulation time, packet size, packet generation rate, topology size, number of nodes, traffic type, MAC protocol, routing protocol, source type and mobility model for the experimentation of LM-PSAODV routing in MANET. In this strategy, if the number of occurrences of the same pkt-id appeared more than three times within the T_{max} duration ($T_{max}$is allowable threshold TTL value of the packet which is equal to $3/4^{th}$ of the actual TTL value) of the packet in the routing table of looping node, then the route repairing mechanism is called by propagating the route error (RERR) message to inform the unreachable destination for the establishment of an alternate path from source to destination with partial disjoint of the looping nodes before the lapse of the TTL period. With the assumption of T_{max} duration for the number of occurrences of the same pkt-id appeared in the routing table of a node was restricted to at most three, if a situation occurs where next hop becomes unreachable, then RERR message is initiated and an alternate route is provided immediately by the proposed routing without initiating a route request procedure. Hence the network resources, such as bandwidth are saved and reconstruction times are also minimized.

LM-PSAODV establishes multiple routes between source and destination nodes. When one route fails due to path break, source nodes can maintain connections by using other routes. Hence, the routing algorithm not only reduces data losses but also the delay times that are caused by route disconnection. Multipath routing protocols search node-disjoint, link disjoint or non-disjoint routes during the route discovery process.

- Node-disjoint routes have completely disjoint routes where there are no nodes or links in common.
- Link-disjoint routes have no links in common but may have nodes in common.
- Non-disjoint routes may use nodes or links in common. If a node or link fails and it is used by the main and backup route in non-disjoint and link-disjoint routes, then the main and backup routes will be disconnected at the same time.

However, in node disjoint routes, main routes and backup routes use completely different nodes or links. Therefore, whenever the primary path disconnected, data transmission may be available through the backup route in the multipath. In single-path routing protocols, route maintenance has to be done as and when it fails. Therefore, data transmission will be stopped till the new route is established, which causes data transmission delay. On the other hand, multipath routing protocols perform the route maintenance process even if one route fails among the multiple routes. To perform the route maintenance process before all routes fail, the network must always maintain multiple routes. The LM-PSAODV routing algorithm establishes the loop-free multipath and can reduce data transmission delays.

4.2.2 LM-PSAODV Routing with TCP Tahoe and TCP SACK

The LM-PSAODV, PSAODV and AODV routing protocols are experimented with different TCP variants namely TCP Tahoe and TCP SACK in a simulation environment on varying node density. The performance of the protocols is compared in terms of Packet Delivery Ratio, Number of Packets Dropped, Routing Overhead and End to End delay for accurate data delivery in the established loop free multipath routing from source to destination.

Packet drop is used as the primary metric for the performance analysis of LM-PSAODV strategy.

4.3 SIMULATION ENVIRONMENT

The simulation settings for the experimentation of LM-PSAODV routing algorithm for the establishment of loop-free multipath in terms of the parameter values are shown in Table 4.1. Simulations ran on networks of 50,100,150,200 and 250 nodes in topology size of 1000m x 1000m. During the simulation, nodes were free to move anywhere within the area according to the Random Waypoint mobility model. The transport protocols namely TCP Tahoe and TCP SACK were analyzed with AODV, PSAODV and LM-PSAODV routing protocols.

Table 4.1: LM-PSAODV Simulation Parameters

PARAMETERS	SETTINGS
Transmission Range	250 m
Bandwidth	2 Mbps
Simulation Time	300 s
Packet Size	512 Bytes
Packet Rate	5 Packet / Sec.
Topology Size	1000 m X 1000 m
Number of Mobile nodes	200 Nodes
Pause Time	20 Sec.
Traffic Type	CBR
MAC Protocol	IEEE 802.11
Routing Protocols	AODV, PSAODV, LMPSAODV
Transport Protocols	TCP Tahoe, TCP SACK
Mobility Model	Random Waypoint

The Simulation Parameters for the LM-PSAODV strategy are transmission range, bandwidth, simulation time, packet size, packet rate, topology size, number of mobile nodes, pause time, traffic type, MAC protocol, routing protocols, transport protocols and mobility model. These are the key parameters used in this approach. Based on the type of traffic the appropriate values are set to the parameters. In this approach, the data traffic is analyzed for testing and hence TCP is used as the transport protocols, whereas while testing the real time traffic the UDP is used as the transport protocol.

4.4 RESULTS AND ANALYSIS

The performance analysis of LM-PSAODV is done with the AODV and PSAODV considering the following metrics. The performance metric considered for this comparative analysis are Packet Delivery Ratio, Number of Packets Dropped, Routing Overhead and End to End delay.

4.4.1 LM-PSAODV with TCP Tahoe and TCP SACK in Varying Number of Nodes

The performance evaluations of LM-PSAODV is done with the AODV and PSAODV routing protocols are measured for the Effect of Packet Delivery Ratio using TCP-Tahoe and TCP-SACK, Effect of Packet Drop using TCP-Tahoe and TCP-SACK, Effect of routing overhead using TCP-Tahoe and TCP-SACK, Effect of end to end delay using TCP-Tahoe and TCP-SACK on varying node density.

4.4.1.1 Packet delivery ratio

The packet delivery ratio of AODV, PSAODV and proposed LM-PSAODV in terms of variation in number of nodes with TCP-Tahoe and TCP-SACK is elucidated in Table 4.2 and Table 4.3 respectively.

Table 4.2: LM-PSAODV - Effect of Packet Delivery Ratio on varying node density using TCP-Tahoe

Number of Nodes	Packet Delivery Ratio (%)

	AODV	PSAODV	LM-PSAODV
50	75	85	86
100	81	88	90
200	85	92	94

Table 4.3: LM-PSAODV - Effect of Packet Delivery Ratio on varying node density using TCP-SACK

Number of Nodes	Packet Delivery Ratio (%)		
	AODV	PSAODV	LM-PSAODV
50	75	85	88
100	81	88	91
200	85	93	95

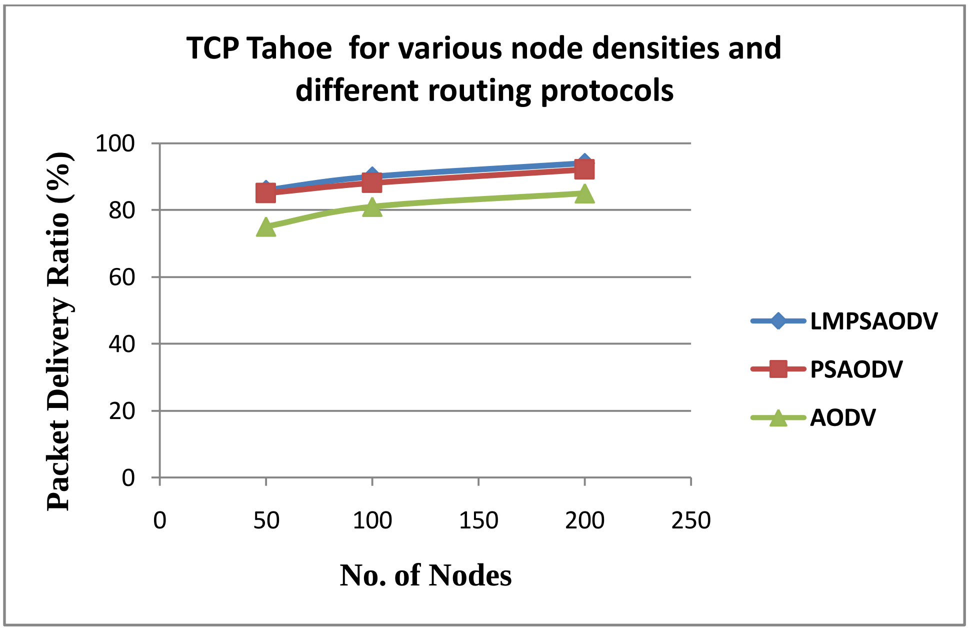

Figure 4.2: LM-PSAODV - Effect of Packet Delivery Ratio on varying node density using TCP-Tahoe

The effect of Packet Delivery Ratio on varying node density using TCP-Tahoe and TCP SACK are shown in Figure 4.2 and Figure 4.3 respectively.

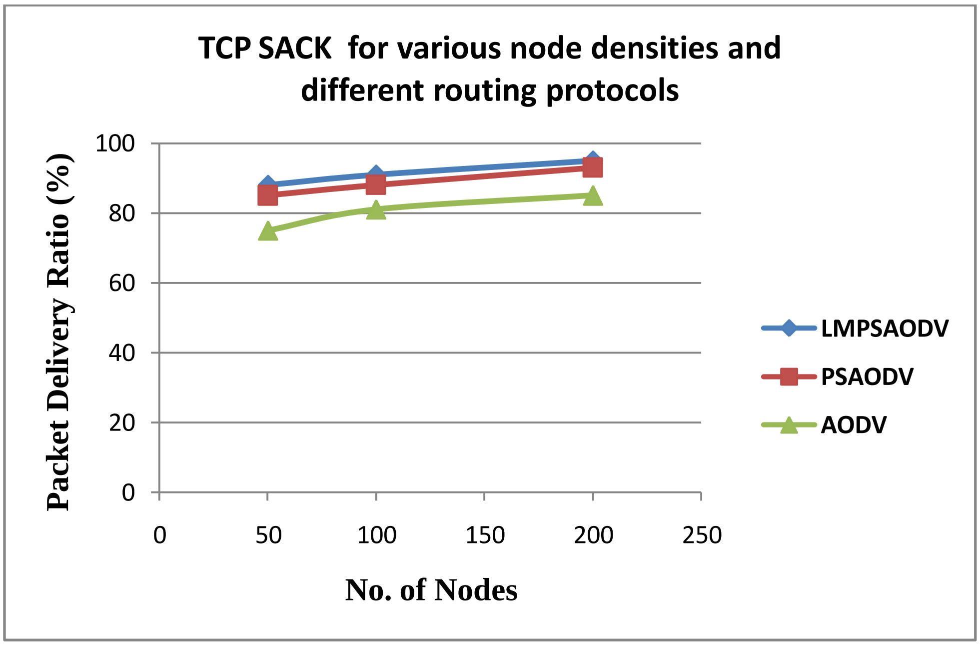

Figure 4.3: LM-PSAODV - Effect of Packet Delivery Ratio on varying node density using TCP-SACK

The Packet Delivery ratio desires to be high for successful performance of routing. The LM-PSAODV routing achieves 9% and 10% improvement in the packet delivery ratio than the AODV routing algorithm for the sample node density of 200 using TCP Tahoe and TCP SACK respectively as the transport protocol. The LM-PSAODV gives a significant impact in PDR,because the AODV does not consider the number of times rebroadcasting the RouteRequest (RREQ) packet and hence the network resources are inefficiently utilized; so AODV leads to less PDR compared with PSAODV and LM-PSAODV.

4.4.1.2 Number of packets dropped

The total dropped packets of AODV, PSAODV and LMPSAODV in terms of variation in the number of nodes with TCP Tahoe and TCP SACK is presented in Table 4.4 and Table 4.5 respectively. The dropped packets need to be low for good performance of routing.

Table 4.4: LM-PSAODV - Effect of Packet Drop on varying node density using TCP-Tahoe

Number of Nodes	No. of packets dropped		
	AODV	PSAODV	LM-PSAODV
50	65	61	53
100	72	66	58
150	92	84	72
200	104	101	92
250	122	115	103

The LM-PSAODV routing algorithm improves the performance by 16% reduction in packet drops when compared to the AODV routing and 10% reduction in packet drops when compared to the PSAODV routing for the sample node density of 250 using TCP-Tahoe as the transport protocol. The LM-PSAODV routing algorithm improves the performance by 19% reduction in packet drops when compared to the AODV routing and 15% reduction in packet drops when compared to the PSAODV routing for the sample node density of 250 using TCP-SACK as the transport protocol.

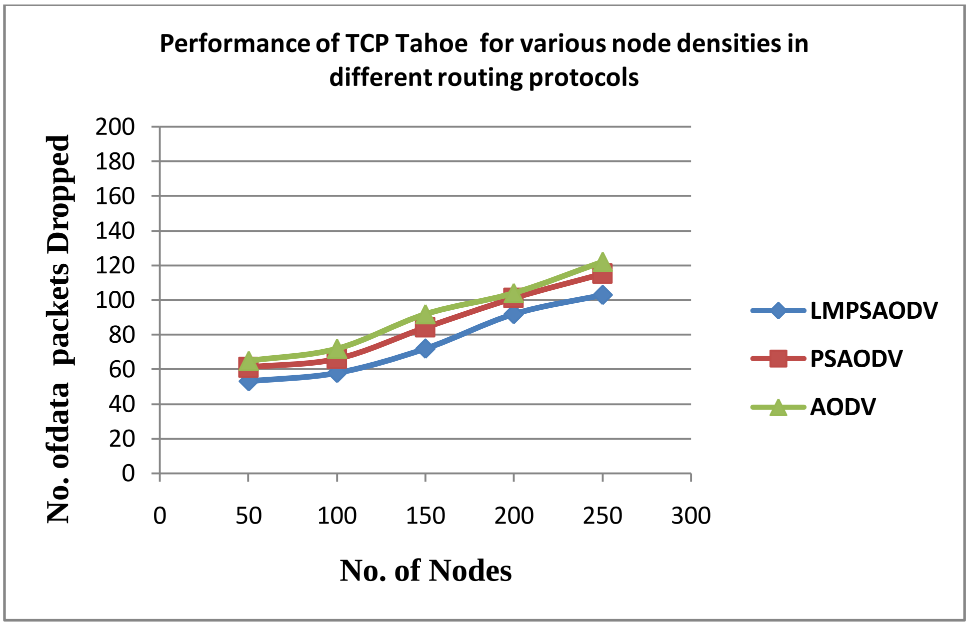

Figure 4.4: LM-PSAODV - Effect of Packet Drop on varying node density using TCP-Tahoe

Table 4.5: Effect of Packet Drop on varying node density using TCP-SACK

Number of Nodes	Number of data packets dropped		
	AODV	PSAODV	LM-PSAODV
50	52	50	42
100	63	57	48
150	76	72	59
200	96	86	71
250	107	102	87

The number of packets dropped in the LM-PSAODV routing algorithm is comparatively lower than PSAODV and AODV routing protocols, because in LM-PSAODV routing, whenever the routing loop occurs, it establishes an alternate path from current node to destination node by calling the route repairing mechanism in AODV, based on TTL value of the packet. Hence, in the proposed routing the packet drops due to routing loops are reduced.

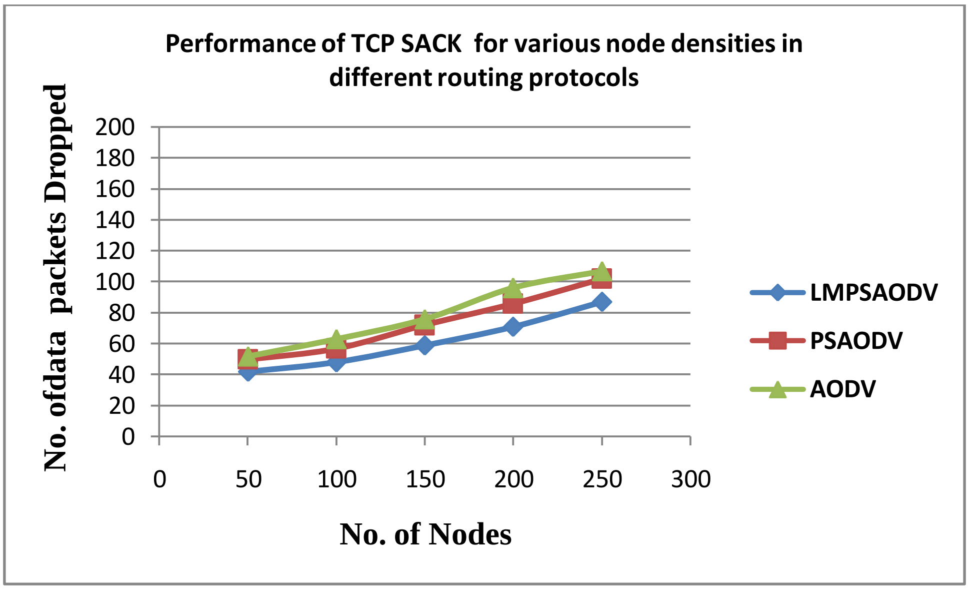

Figure 4.5: Effect of Packet Drop using TCP SACK on varying node Density

1.4.1.3 Routing overhead

The performance comparison of LM-PSAODV, PSAODV and AODV routing algorithms based on routing overhead on varying node density with TCP Tahoe and TCP SACK are shown in Table 4.6 and Table 4.7 respectively.

Table 4.6: LM-PSAODV - Effect of routing overhead on varying node density using TCP Tahoe

Number of Nodes	Total number of Routing overhead packets		
	AODV	PSAODV	LM-PSAODV
50	17312	14100	13900
100	38678	35987	35190
200	59673	54890	53807

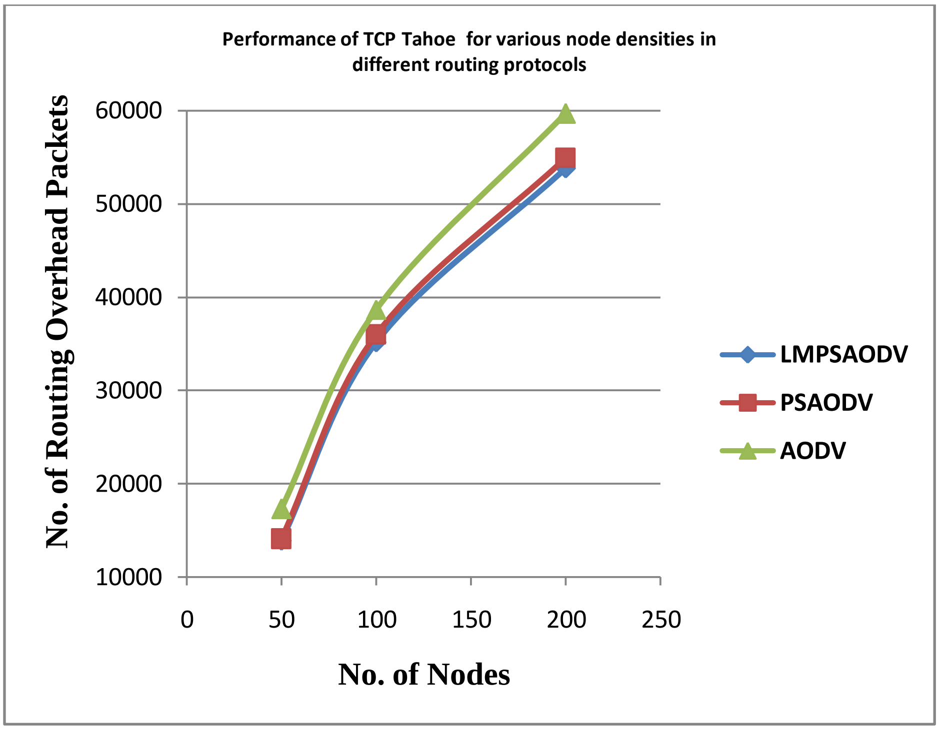

Figure 4.6: LM-PSAODV - Effect of Routing overhead on varying node density using TCP Tahoe

Table 4.7: LM-PSAODV - Effect of Routing overhead on varying node density using TCP SACK

Number of Nodes	Total number of Routing overhead packets		
	AODV	PSAODV	LM-PSAODV
50	14614	14112	14012
100	34372	30283	30217
200	56098	47980	45880

The effect of Routing overhead on varying node density using TCP Tahoe and TCP SACK are presented in Figure 4.6 and Figure 4.7 respectively. The LM-PSAODV routing algorithm improves the performance by 10% and 18% reduction in routing overhead when compared to the AODV routing for the sample node density of 200 using TCP Tahoe and TCP SACK respectively as the transport protocol. As the number of nodes increases, the control packets also increase in the three routing algorithms. However, this increase is proportionately lower, in the case of LM-PSAODV and PSAODV, because in these two routing algorithms the route request packets are rebroadcasted based on probability value instead of simple flooding of control packets, hence it considerably minimizes the routing overhead.

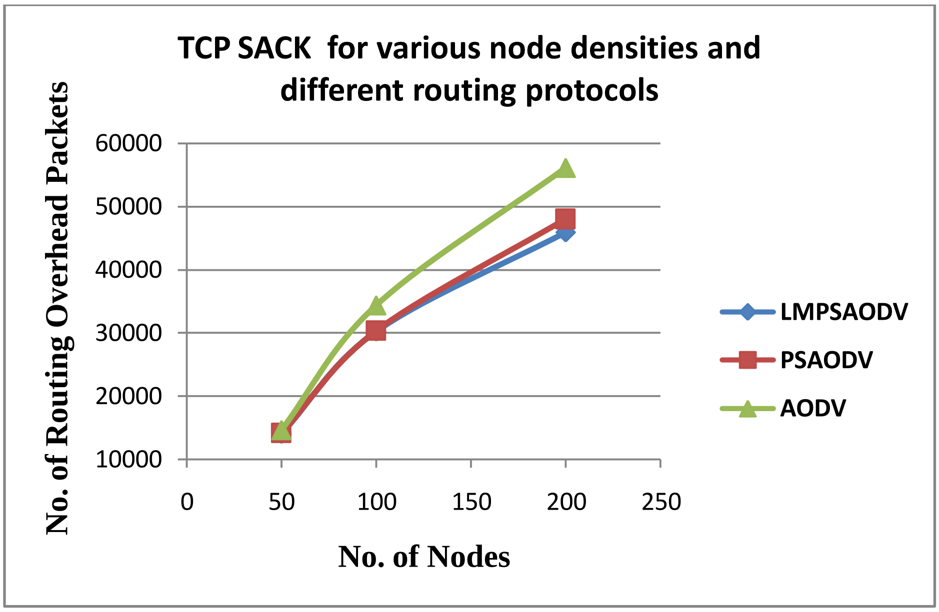

Figure 4.7: LM-PSAODV - Effect of Routing overhead on varying node using TCP SACK

4.4.1.4 End to end delay

The end to end Delay is a significant parameter for evaluating a protocol which must be low for good quality performance. The end to end delay in variation with the number of nodes for different reactive routing protocols is shown in Table 4.8 and Table 4.9 with respect to TCP Tahoe and TCP SACK respectively as the transport protocol.

Table 4.8: LM-PSAODV - Effect of End to End delay on varying node density using TCP Tahoe

Number of Nodes	End to End Delay (s)		
	AODV	PSAODV	LM-PSAODV
50	0.06	0.05	0.04
100	0.2	0.15	0.09
200	1.45	1.32	1.15

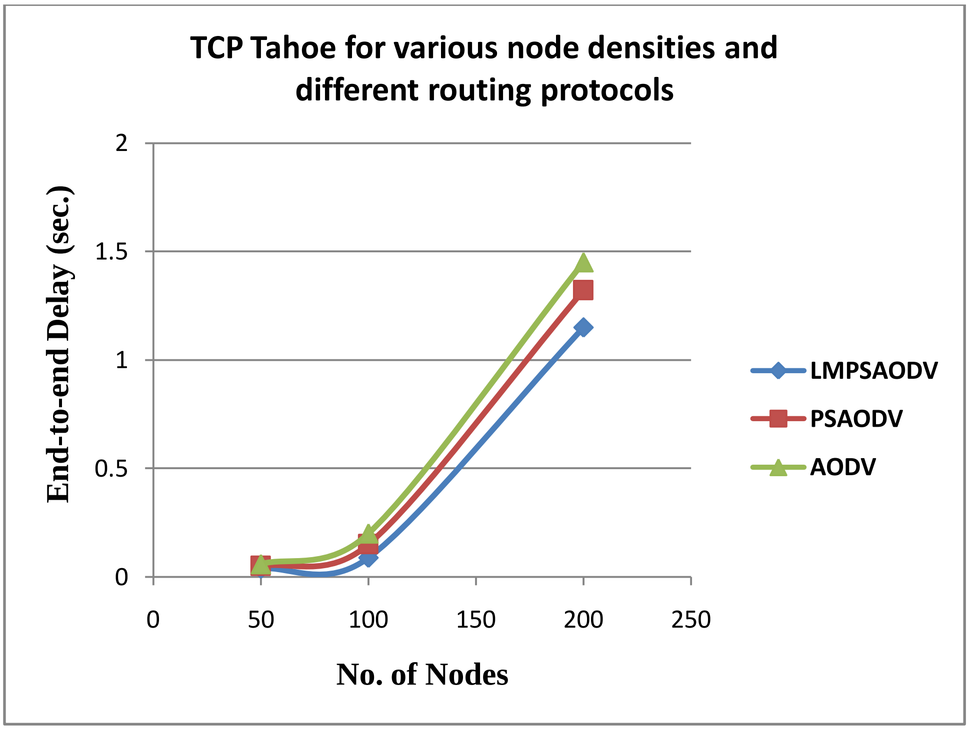

Figure 4.8: LM-PSAODV - Effect of End to End delay on varying node density using TCP Tahoe

If the number of nodes increases, the end to end delay also increases. This is due to different reasons like mobility speed, number of packets travels in the route and path break. The end to end delay is evaluated for three different reactive routing protocols namely LM-PSAODV, PSAODV and AODV with varying number of nodes as shown in Figure 4.8 and Figure 4.9 with respect to TCP Tahoe and TCP SACK respectively as the transport protocol.

Table 4.9: LM-PSAODV - Effect of End to End delay on varying node density using TCP SACK

Number of Nodes	End to End Delay (s)		
	AODV	PSAODV	LM-PSAODV
50	0.05	0.05	0.03
100	0.18	0.12	0.09
200	1.39	1.26	0.98

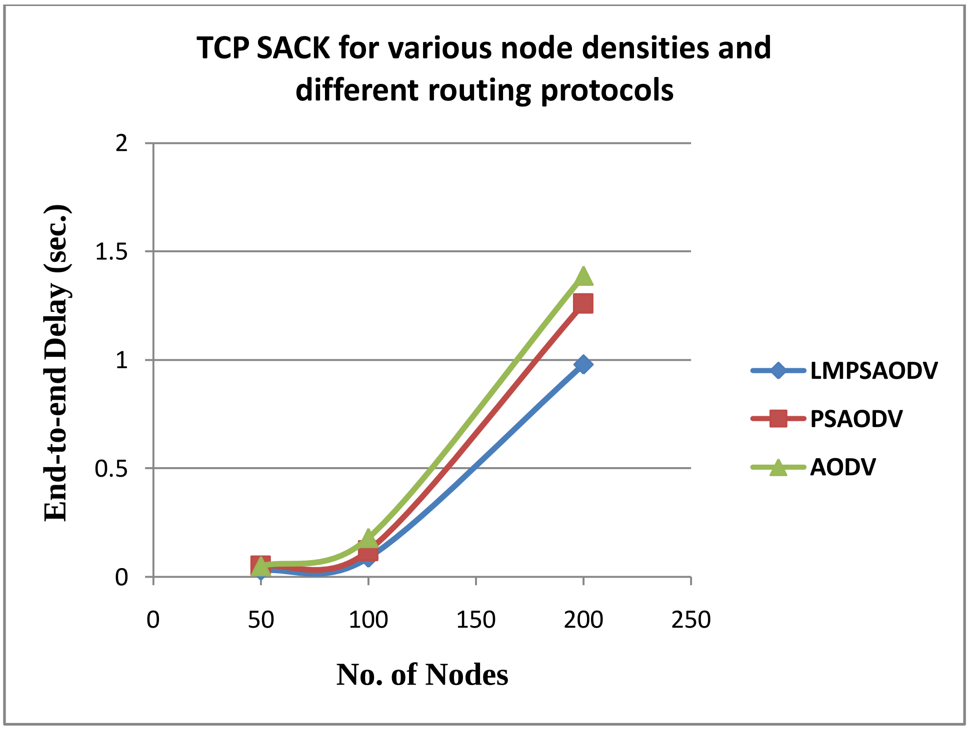

Figure 4.9: LM-PSAODV - Effect of End to End delay on varying node density using TCP SACK

When the number of nodes increases, the packet delay from source to the destination also increases. The LM-PSAODV routing algorithm improves the performance by 21% and 29% reduction in the end to end delay compared to the AODV routing for the sample node density of 200 using TCP Tahoe and TCP SACK respectively as the transport protocol. In this performance comparison, the end to end delay for LM-PSAODV is less compared with PSAODV and AODV, the reason because the LM-PSAODV routing algorithm establishes the loop-free multipath and can reduce data transmission delays. Using the multi-paths the reconstruction times are also minimized.

4.5 CONCLUSION

In this chapter, an Integrated Loop-Free Multipath in Probabilistic Scheme Based AODV routing algorithm has been introduced to reduce the packet drop and to improve the packet delivery ratio. 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 Loop-free Multipath AODV (LM-PSAODV) routing strategy established the disjoint route from source to destination, which resulted in more reduction of packet drops than PSAODV routing strategy.

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. It is concluded that 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 accurate end to end delivery of data-traffic applications and performs better to the changing network sizes.

Thus, the results illustrate that the interaction between the transport layer and network layer protocol that has a significant impact on the achievable packet delivery ratio, end to end delay and routing overhead in ad hoc networks. Since this algorithm is not able to reduce the Inter-Packet Delay (IPD) for multimedia applications in MANET environment, an Enhanced Round Robin packet scheduling technique is proposed as the third strategy in the following chapter to handle time-critical applications.