5. INTEGRATION OF IMPROVED PACKET SCHEDULING STRATEGY IN LM-PSAODV FOR INTER-PACKET DELAY REDUCTION

5.1 INTRODUCTION

The performance analysis carried out to verify the efficiency of the Loop-Free Multipath in Probabilistic Scheme Based AODV routing algorithm with an objective of packet drop reduction discussed in chapter 4. The Inter-Packet Delay (IPD) is the major issue in transmitting the multimedia applications from any ad hoc node to any other node and therefore it is required to propose an efficient packet forwarding strategy. Low IPD is especially essential for applications requiring timely delivery of packets, e.g. multimedia applications, video etc. In this chapter, an Enhanced Round Robin Packet Scheduling Strategy (ERR-PSS) is proposed as an Improved Packet Scheduling (IPS) Strategy and is implemented as an integrated component to the modified AODV (LM-PSAODV) for the reduction of IPD while transmitting the multimedia applications from source to destination. The hybrid packet scheduling approach (ERR-PSS) and the existing packet scheduling strategies namely First-In-First-Out Packet Scheduling Strategy (FIFO-PSS) and Round Robin Packet Scheduling Strategy (RR-PSS) are implemented and integrated with the modified AODV (LM-PSAODV) in a simulated environment on varying number of connections and pause times. The Improved Packet Scheduling (IPS) Strategy is meticulously examined and analyzed with the FIFO-PSS and RR-PSS. The methodology of enhanced round robin packet scheduling strategy for multimedia transmission, results and analysis are described in this chapter.

Topology design is to choose links among network nodes to be installed and determine the link capacity so that the cost of the overall network is minimized. In the process of enhancing real-time video streaming over mobile ad hoc networks using multipoint-to-point communication, the UDP is used as the transport layer protocol. The unique features of an effective Cross-layer Packet Scheduling and Routing Algorithm for delay-sensitive media transmission over MANET is that packet scheduling algorithm at the MAC layer and routing algorithm at the network layer are tightly-coupled to improve end to end QoS.

5.2 ASSUMPTIONS AND METHODOLOGY OF ENHANCED ROUND ROBINPACKET SCHEDULING STRATEGYFOR MULTIMEDIA TRANSMISSION

Providing QoS in MANETs for the transmission of real-time applications requires the high packet delivery ratio with minimum delay. Performance enhancement in routing and end to end delivery to support multimedia applications in MANET with the available limited resources is one of the challenging tasks. The delay may happen due to various reasons such as nodes mobility, routing, scheduling of packets etc. In this work, the scheduling of packets for transmissions is carried out, so as to improve the MANET performance. The ERR-PSS strategy is 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.

5.2.1 Methodology for Packet Scheduling

The main objective of the ERR-PSS is to reduce the Inter-Packet Delay (IPD) in mobile ad-hoc networks for multimedia applications. Firstly, set the parameter values for transmission range, bandwidth, simulation time, packet size, packet rate, topology size, number of mobile nodes, pause time, traffic type, MAC protocol, routing protocols, transport protocol, mobility model and type of service for the experimentation of ERR-PSS in MANET. In a network, there may be ‘N’ number of mobile ad hoc nodes. Let ‘S’ be the source node and it transmits ‘m’ packets to the ‘k’ destination nodes given by the set D = {D_1, D_2, D_3 … D_k} with available bandwidth ’B’ is shared by ‘k’ destination nodes as B= {b_1, b_2 … b_k}.

The ERR-PSS schedules the packets prioritywise and forwards the time-critical information efficiently in a round-robin manner among the multiple source-destination pairs in the ad hoc network. This enhanced packet scheduling algorithm 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 ERR-PSS uses the methodology that identifies each flow through flow id for every source and destination pair; each flow is allowed to send one packet at a time in round-robin way based on the time slice and priority metrics. The packets are scheduled to forward to the succeeding nodes based on the priority metrics such as packet priority, node priority and route priority and thereby minimizing the Inter-Packet Delay.

The packet priority is determined based on the packet urgency value at each node. The node priority can be computed as the sum of packet priority of all packets in the buffer. The route priority is the sum of node priority of all the nodes in the route. The packets are transmitted to a next node based on route's priority in a round-robin manner. The packet priority ($P_{pkt}(t)$) can be determined by the Equation (5.1).

$$P_{pkt}(t) = D_{max} - d_j(t) \tag{5.1}$$

Where,

- $P_{pkt}(t)$ is the packet priority at time 't',
- D_{max} is the maximum tolerable end to end delay and
- $d_j(t)$ is the residual delay for node 'j' at time 't'

The node priority $P_{node}(t)$ can be computed using the Equation (5.2). It is the sum of packet priority of all 'm' packets in the buffer.

$$P_{node}(t) = \sum_{i=1}^{m} (p_{node}(t)) \tag{5.2}$$

The route priority P_{route} (t) can be calculated using the Equation (5.3). It is the sum of node priority of all the 'j' nodes in the route R.

$$P_{route}(t) = \sum_{i=1}^{j} (P_{node(i)}(t)) \quad (5.3)$$

The hybrid packet scheduling approach (ERR-PSS), First-In-First-Out Packet Scheduling Strategy (FIFO-PSS) and Round Robin Packet Scheduling Strategy (RR-PSS) are implemented and integrated with the modified AODV (LM-PSAODV) in a simulated environment on varying number of connections and pause times.

5.2.2 ERR-PSS over Multimedia Traffic

This work investigates the use of ERR scheduling algorithm for MANET by analyzing the various scheduling algorithms in delay-sensitive applications. The purpose of ERR-PSS is to forward the packets efficiently from source to multiple ad hoc nodes with minimized Inter-Packet Delay and routing overhead in transmitting the multimedia applications. The proposed packet scheduling strategy is analyzed in the multimedia traffic using AODV and LM-PSAODV routing protocols.

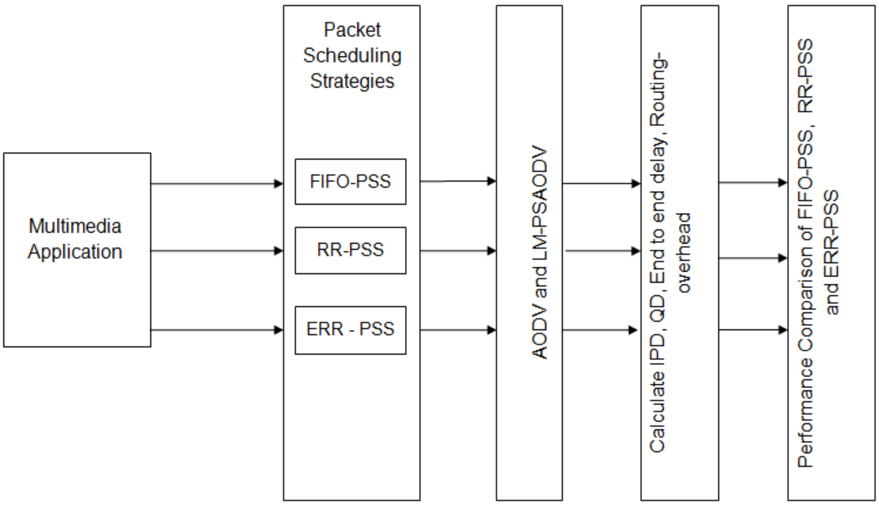

Figure 5.1: Flow Diagram for performance comparison of Packet Strategies over Multimedia Applications

Figure 5.1 illustrates the flow of the performance comparison of packet scheduling strategies over the transmission of multimedia applications. The LM-PSAODV strategy is evaluated for data traffic. The ERR-PSS strategy is analyzed for delay sensitive applications.

5.3 SIMULATION ENVIRONMENT

Simulation environments were run for 600 seconds on five different scenarios on varying number of source-destination connection pairs as 5, 10, 15, 20 and 25. In this work, the User Datagram Protocol (UDP) is used as the transport protocol for the end to end delivery of multimedia files. The performance of the scheduling techniques is compared in terms of Inter-Packet Delay, queuing delay, end to end delay and routing overhead for the delivery of delay-sensitive applications from source to destination. Table 5.1 shows the simulation Parameter values for the experimentation of ERR-PSS in MANET environment. With the assumption of video conferencing chat for the Farmers' Awareness Application the values to the parameters have been set.

Table 5.1: IPS - Simulation Parameters

PARAMETERS	SETTINGS
Transmission Range	250 m
Bandwidth	2 Mbps
Simulation Time	600 s
Packet Size	512 Bytes
Packet Rate	5 Packets / Sec.
Topology Size	1000 m X 1000 m
Number of Mobile nodes	200
Pause Time	0 s
Traffic Type	VoIP (Voice over Internet Protocol)
MAC Protocol	IEEE 802.11
Routing Protocols	AODV, LMPSAODV
Transport Protocol	UDP

Mobility Model	Random Waypoint
Service	Video Transmission

5.4 RESULTS AND ANALYSIS

The performance of the ERR-PSS has been studied and analyzed with the existing scheduling algorithms FIFO-PSS and RR-PSS. In the existing packet scheduling algorithms, the forwarding of packets to the succeeding nodes either in FIFO or in RR scheduling algorithm leads to more Inter-Packet Delay. The ERR-PSS using LM-PSAODV routing protocol reduced the IPD and routing overhead compared with the existing packet scheduling algorithms namely FIFO-PSS and RR-PSS. In this strategy, the Inter-Packet Delay is the most important performance metric for the evaluation of the strategy.

5.4.1 Varying Number of Connections and Pause Times with Different Scheduling Algorithms

The sensitivity analysis is carried out to verify the efficiency of the ERR-PSS. In this performance analysis, the proposed packet scheduling strategy is compared with the existing scheduling algorithms using AODV and LM-PSAODV routing protocols to evaluate the performance metrics such as Inter-Packet Delay, Queuing Delay, End to End delay and Routing Overhead on varying number of connections and pause times.

5.4.1.1 Inter-packet delay using AODV

Low IPD is especially important for applications requiring timely delivery of packets. The IPD is evaluated on varying pause time for proposed and existing packet scheduling strategies which are presented in Table 5.2 and Table 5.3 using AODV and LM-PSAODV respectively as the routing protocols.

Table 5.2: IPS - Effect of Inter-Packet Delay on varying Pause Time using AODV Routing Protocol

Pause Time (Sec.)	Inter-Packet Delay (Sec.)		
	FIFO	RR	ERR-PSS(IPS)
20	0.08	0.07	0.04
40	0.09	0.07	0.05
60	0.09	0.07	0.06
80	0.1	0.08	0.06
100	0.1	0.08	0.07

As the pause time increases, the IPD also increases in FIFO, RR and IPS strategies. However, this increase is proportionately lower, in the case of IPS, because in the Improved Packet Scheduling strategy the packets are scheduled to forward to the succeeding nodes based on the priority metrics such as packet priority, node priority and route priority which reduce the Inter-Packet Delay. In FIFO it schedules the packets to the succeeding nodes simply based on arrival time of the packets and RR follows round robin fashion for forwarding the packets. In these existing strategies no priority metrics are used.

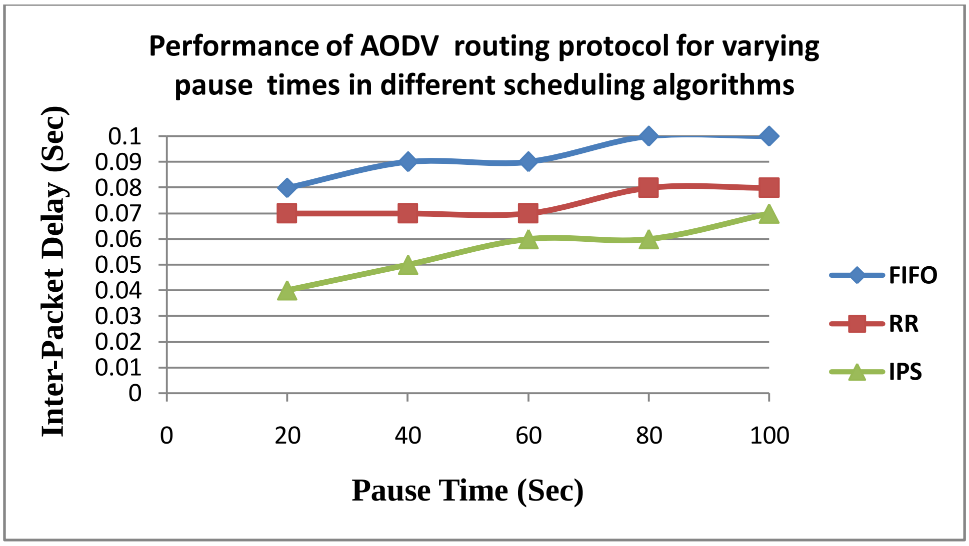

Figure 5.2: IPS - Effect of Inter-Packet Delay on varying Pause Time using AODV Routing Protocol

The ERR-PSS improves the performance by 30% and 13% reduction in the IPD compared to the FIFO-PSS and RR-PSS for the sample pause time of 100 Sec. using AODV as the routing protocol.

5.4.1.2 Inter-packet delay using LMPSAODV

The effect of Inter-Packet Delay among three different packet scheduling strategies on varying pause time as shown in Figure 5.2 and Figure 5.3 using AODV and LM-PSAODV respectively as routing protocol. The ERR-PSS improves the performance by 38% and 29% reduction in the IPD compared to the FIFO-PSS and RR-PSS for the sample pause time of 100 Seconds using LM-PSAODV as the routing protocol. In this performance comparison, the IPD for LM-PSAODV is less compared with AODV, the reason because the LM-PSAODV routing algorithm establishes the loop-free multipath and can reduce data transmission delays.

Table 5.3: IPS - Effect of Inter-Packet Delay on varying Pause Time using LM-PSAODV Routing Protocol

Pause Time (Sec.)	Inter-Packet Delay (Sec.)		
	FIFO	RR	IPS
20	0.05	0.05	0.02
40	0.06	0.05	0.03
60	0.07	0.06	0.04
80	0.07	0.07	0.04
100	0.08	0.07	0.05

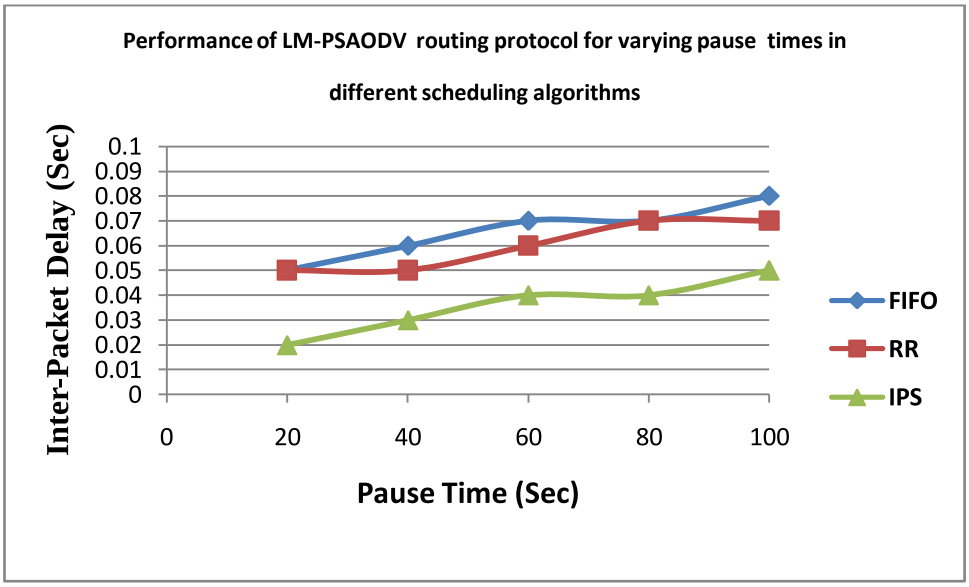

Figure 5.3: IPS -Effect of Inter-Packet Delay on varying Pause Time using LM-PSAODV Routing Protocol

5.4.1.3 Queuing delay using AODV

A network requires reduced queuing delay is a vital need in the data transmission particularly for delay-sensitive applications. The queuing delay is evaluated on varying pause time for proposed and existing packet scheduling strategies is elucidated in Table 5.4 and Table 5.5 using AODV and LM-PSAODV respectively as the routing protocols.

Table 5.4: IPS - Effect of Queuing Delay on varying Pause Time using AODV Routing Protocol

Pause Time (Sec.)	Queuing Delay (ms)		
	FIFO	RR	IPS
20	0.06	0.04	0.02
40	0.18	0.1	0.05
60	0.2	0.17	0.09
80	0.26	0.2	0.18
100	0.27	0.24	0.21

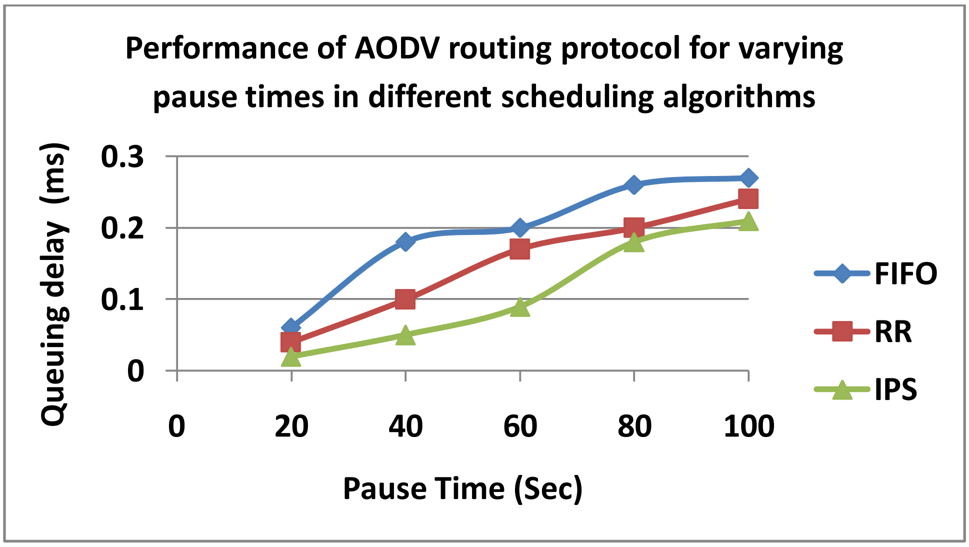

Figure 5.4: IPS -Effect of Queuing Delay on varying Pause Time using AODV Routing Protocol

When the pause time increases proportionally, the queuing delay also increases in FIFO, RR and IPS strategies due to the node's mobility, speed and routing. However, this increase is comparatively lesser, in the case of IPS, the reason because in the Improved Packet Scheduling strategy the packets are scheduled to forward to the succeeding nodes based on the priority metrics. The node priority can be computed as the sum of packet priority of all packets in the buffer. Due to consideration of the buffer capacity of the node to forward the packets the queuing delay is lower. The ERR-PSS improves the performance by 22% and 13% reduction in the queuing delay compared to the FIFO-PSS and RR-PSS for the sample pause time of 100 Seconds using AODV as the routing protocol.

5.4.1.4 Queuing delay using LM-PSAODV

The effect of queuing delay between three different packet scheduling strategies are compared on varying pause time is illustrated in Figure 5.4 and Figure 5.5 using AODV and LM-PSAODV respectively as routing protocol. The ERR-PSS improves the performance by 27% and 21% reduction in the queuing delay compared to the FIFO-PSS and RR-PSS for the sample pause time of 100 Seconds using LM-PSAODV as the routing protocol. In this performance comparison, the queuing delay for LM-PSAODV is less compared with AODV, because the LM-PSAODV routing algorithm establishes the disjoint multipath and hence able to reduce transmission delays.

Table 5.5: IPS - Effect of Queuing Delay on varying Pause Time using LM-PSAODV Routing Protocol

Pause Time (Sec.)	Queuing Delay (ms.)		
	FIFO	RR	IPS
20	0.04	0.03	0.02
40	0.14	0.12	0.05
60	0.18	0.15	0.09
80	0.2	0.2	0.14
100	0.26	0.24	0.19

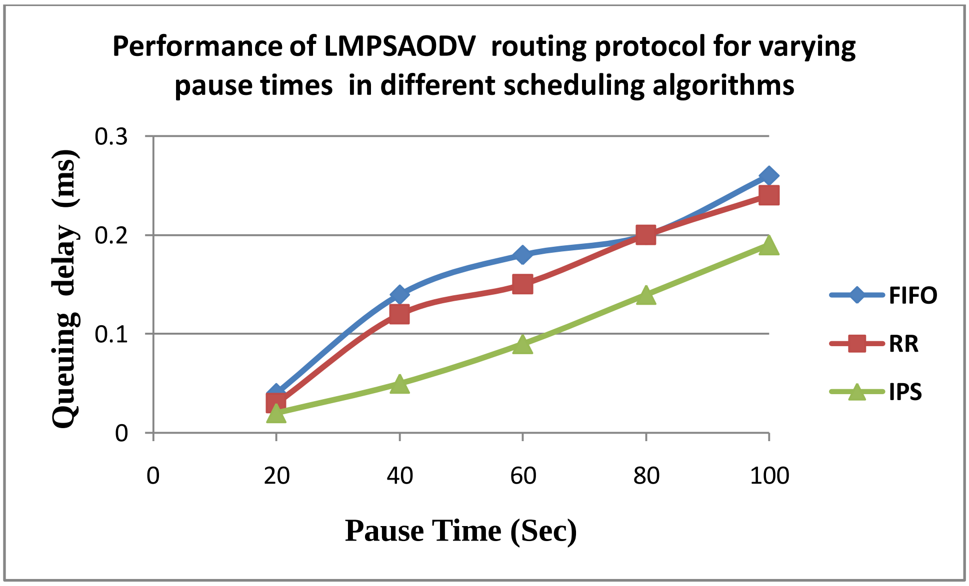

Figure 5.5: IPS -Effect of Queuing Delay on varying Pause Time using LM-PSAODV Routing Protocol

5.4.1.5 End to end delay using AODV

The minimized end to end delay is the significant need for the better performance of the multimedia application transmission in a network.

Table 5.6: IPS - Effect of end to end Delay on varying Pause Time using AODV Routing Protocol

Pause Time (Sec.)	End to End Delay (Sec.)		
	FIFO	**RR**	**IPS**
20	0.14	0.11	0.06
40	0.27	0.17	0.1
60	0.29	0.23	0.15
80	0.27	0.24	0.2
100	0.27	0.26	0.22

The end to end delay is evaluated on varying pause time for proposed and existing packet scheduling strategies are shown in Table 5.6 and Table 5.7 using AODV and LM-PSAODV respectively as the routing protocols.

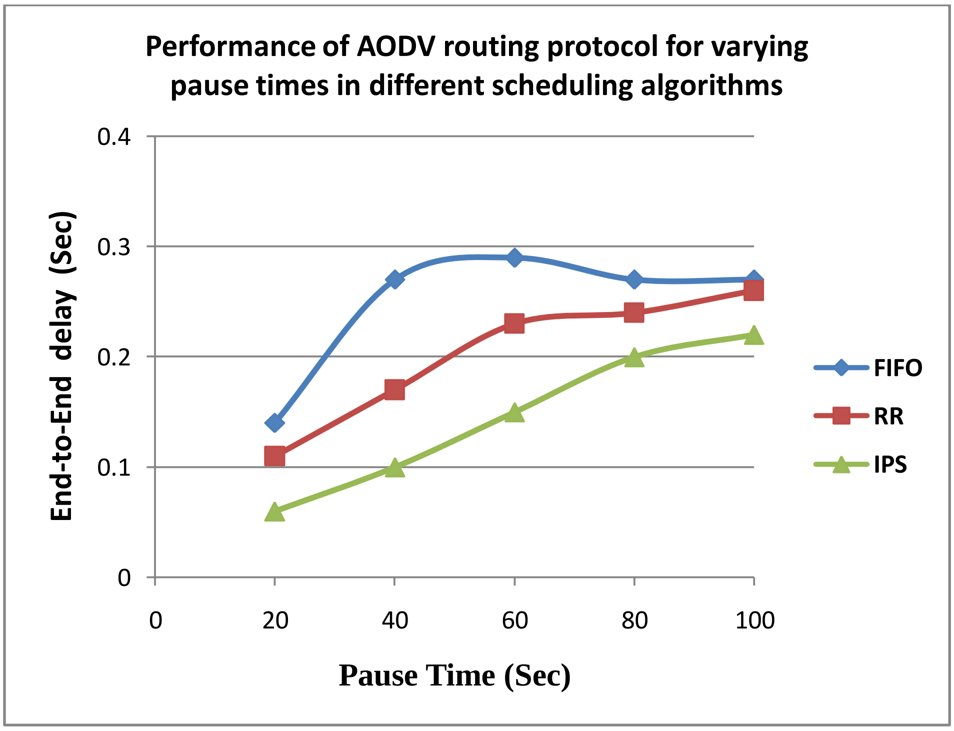

Figure 5.6: IPS -Effect of end to end Delay on varying Pause Time using AODV Routing Protocol

As the pause time increases occasionally queuing delay also increases in FIFO-PSS due to the node's mobility, speed and number of packets. However, this increase is lower in case of IPS. The reason is that the proposed scheduling strategy has minimal Inter-Packet Delay and Queuing delay compared with FIFO and RR strategies. The end to end delay is a delay incurred by the packets between their generation time and their arrival time at the destination and hence these minimal IPD and queuing delay that in turn leads to reduced end to end delay. The ERR-PSS improves the performance by 19% and 15% reduction in the end to end delay compared to the FIFO-PSS and RR-PSS for the sample pause time of 100 Seconds using AODV as the routing protocol.

5.4.1.6 End to end delay using LM-PSAODV

The effect of end to end delay between three different packet scheduling strategies is compared on varying pause time as shown in Figure 5.6 and Figure 5.7 using AODV and LM-PSAODV respectively as routing protocol.

Table 5.7: IPS - Effect of end to end Delay on varying Pause Time using LM-PSAODV Routing Protocol

Pause Time (Sec.)	End to End Delay (Sec.)		
	FIFO	RR	IPS
20	0.09	0.08	0.04
40	0.2	0.17	0.08
60	0.25	0.21	0.17
80	0.27	0.27	0.18
100	0.34	0.31	0.24

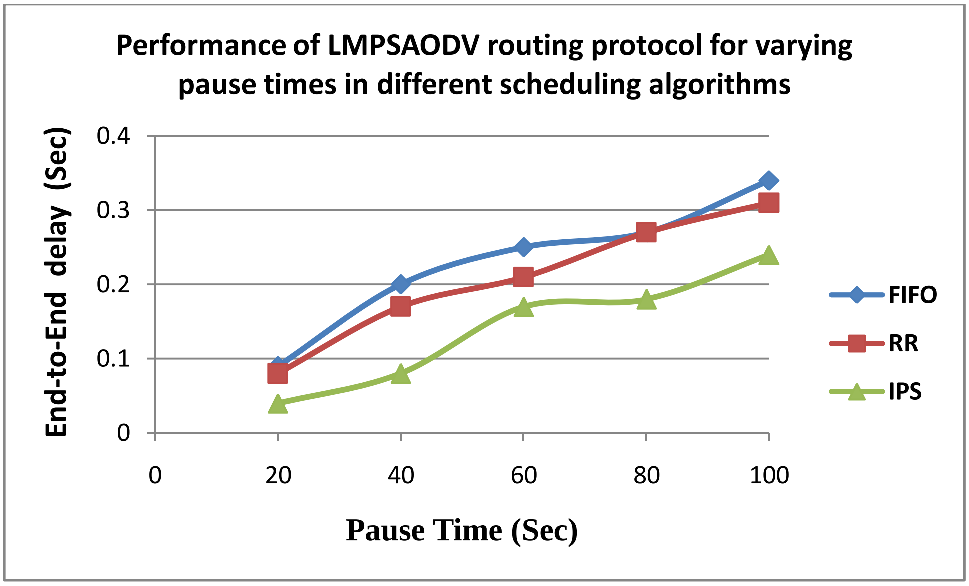

Figure 5.7: IPS -Effect of end to end Delay on varying Pause Time using LM-PSAODV Routing Protocol

The ERR-PSS improves the performance by 29% and 23% reduction in the end to end delay compared to the FIFO-PSS and RR-PSS for the sample pause time of 100 Seconds using LM-PSAODV as the routing protocol. In this performance comparison, the end to end delay for LM-PSAODV is less compared with AODV, because the LM-PSAODV routing protocol establishes the multipath and hence the LM-PSAODV routing protocol is able to decrease various kind of delays.

5.4.1.7 Routing overhead using AODV

The better way of route establishment is through broadcasting less number of control packets (routing overhead). The routing overhead is evaluated on varying number of connections for proposed and existing packet scheduling strategies is presented in Table 5.8 and Table 5.9 using AODV and LM-PSAODV respectively as the routing protocols.

Table 5.8: IPS - Effect of Routing Overhead on varying number of Connection using AODV Routing Protocol

Number of Connections	Total No. of Routing overhead packets		
	FIFO	RR	IPS
5	34000	33700	33600
10	42000	41500	41200
15	63000	62000	61100
20	72000	70000	69000
25	89000	88000	86000

As the number of connections increases, the routing overhead also increases in FIFO, RR and IPS strategies. The reason is that, if the number of source-destination pair increases, then to establish the routes between them requires more broadcasting of routing overheads. This increase is proportionately lower, in the case of IPS compared with FIFO and RR scheduling strategies.

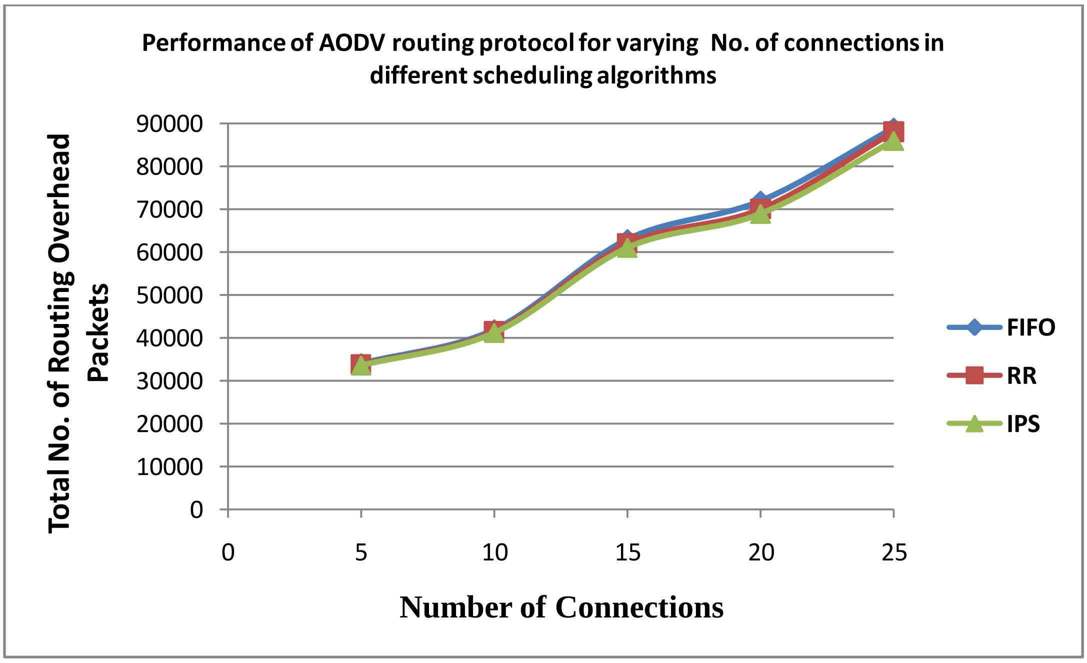

Figure 5.8: IPS -Effect of Routing Overhead on varying number of Connection using AODV Routing Protocol

The ERR-PSS improves the performance by 3% and 2% reduction in the routing overhead compared to the FIFO-PSS and RR-PSS for the sample of 25 numbers of connections using AODV as the routing protocol.

5.4.1.8 Routing overhead using LM-PSAODV

The effect of routing overhead among three different packet scheduling strategies on varying number of connections as shown in Figure 5.8 and Figure 5.9 using AODV and LM-PSAODV respectively as routing protocol. The ERR-PSS improves the performance by 3% and 2% reduction in the routing overhead compared to the FIFO-PSS and RR-PSS for the sample of 25 numbers of connections using LM-PSAODV as the routing protocol.

Table 5.9: IPS - Effect of Routing Overhead on varying number of Connection using LM-PSAODV Routing Protocol

Number of Connections	Total No. of Routing overhead packets		
	FIFO	RR	IPS
5	27500	27400	27030
10	34200	33900	33270
15	51780	51290	50980
20	60000	59180	58650
25	77800	76400	75200

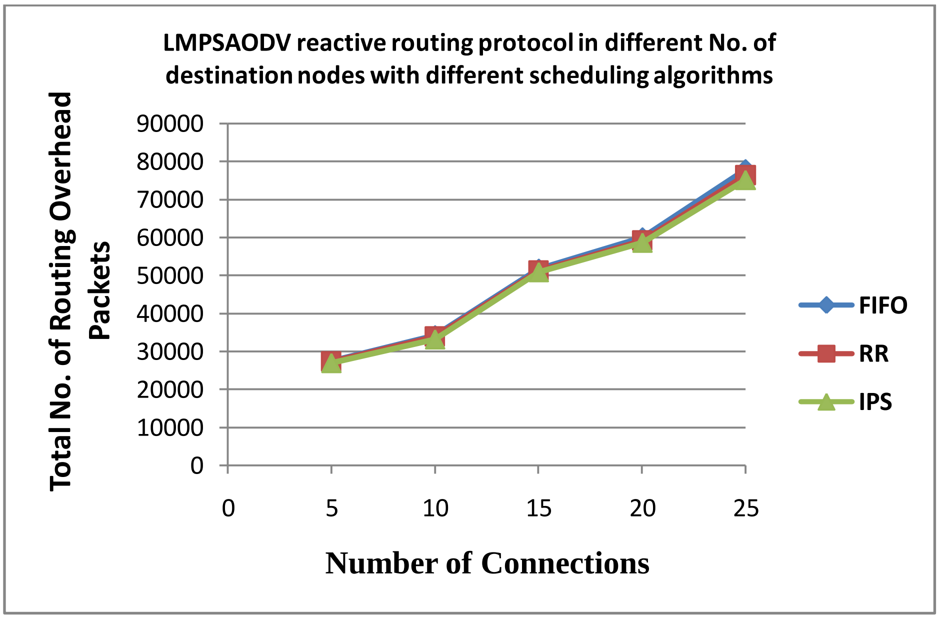

Figure 5.9: IPS -Effect of Routing Overhead on varying number of Connection using LM-PSAODV Routing Protocol

The ERR-PSS with LM-PSAODV routing protocol improves the performance by 13% reduction in the routing overhead compared to ERR-PSS with AODV routing protocol for the sample of 25 numbers of connections. In this performance comparison, the proposed packet scheduling strategy is not reduced more routing overhead than the existing packet scheduling strategies, but it yields more reductions in the delays comparatively with the existing packet scheduling strategies.

The proposed packet scheduling strategy with LM-PSAODV routing protocol performs better in the reduction router overhead than with AODV routing protocol. The reason is that, in LM-PSAODV algorithm the route request packets are rebroadcasted based on probability value instead of simple flooding of control packets. The ERR-PSS with LM-PSAODV considerably minimizes the routing overhead.

5.5 CONCLUSION

In this chapter, an improved packet scheduling strategy (ERR-PSS) is introduced for packet forwarding along with the Loop-free Multipath 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 both the round robin and priority scheduling algorithms as a hybrid packet scheduling approach for better scheduling of packets to reduce inter-packet delay.

The ERR-PSS along with LM-PSAODV on varying pause times performs better than the existing techniques namely FIFO-PSS and RR-PSS in terms of reduction in IPD by 38% and 29%, in terms of queuing delay 27% and 21% and in terms of end to end delay by 29% and 23% and respectively. The ERR-PSS with LM-PSAODV routing protocol improves the performance by 13% reduction in the routing overhead compared to ERR-PSS with AODV routing protocol for the sample of 25 numbers of connections. It illustrates that the ERR-PSS with LM-PSAODV considerably minimizes the routing overhead. From the results found, it is concluded that ERR-PSS with LM-PSAODV routing protocol yields the significant reduction in routing overhead.

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. The requirement of good channel conditions for smooth video transmission and the occurrence of congestion when a link is carrying more data than its capacity demand a queue management algorithm for congestion control and queue delay reductions while delivering time-critical multimedia applications in MANET.A Fuzzy-based Random Early Detection Queue Management technique is proposed as the fourth strategy in the following chapter for congestion control and reduction of queuing delay.