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Cross Layer Dependencies and Solution for Mobile Ad Hoc Networks

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Abstract: In MANETs, routing protocols uses wireless links and access to this links are controlled by MAC layer and end to end communication support is provided by TCP protocol. If there is any change in network topology, Information at different layer is needed to be updated otherwise, it may interrupt smooth network operations. Frequent changes in different network parameters may cause unnecessary routing over load, contention, congestion etc. thus results huge packet loss. All these facts show the protocol dependency over the intermediate layers and its impact over the network performance. In this paper, a cross layer solution is proposed for ad hoc networks using different routing protocols under the various performance constraints.

Keywords: MAC, TCP, AODV, DSDV, MANET.

I. INTRODUCTION

In a network, there are multiple layers which are used to perform some specific operations. Output of a layer may be used as Input to another layer. Data processing delay at one layer may interrupt the smooth operation of upper or lower layer. Information flow between various layers raises the need of a control scheme, called cross layer solution which can define some common rules for each layer, in order to maintain the performance of entire network.

For designing a cross layer solution, there is need to investigate the dependencies of each layer over routing protocols. If developers just consider only one layer, there may be chances that modified operations of that layer may degrade the performance of other layer or it can also introduce the extra control overhead. Cross layer solution must consider the data exchange and data flow between various layers. MAC layer defines the channel access rules. It uses backoff timers to manage the contention window. If network topology changes, there is need to update the routing information but if any node is waiting for channel access, it is not possible to send the routing updates to that node. If some nodes are using dedicated end to end communication links but due to dynamic topology, these nodes suffer from frequent link breaks. Routing protocol also suffers from the same issue as it has to maintain the routing table. Following figure: shows the information flow and data exchange between various layers [8][11][12.]

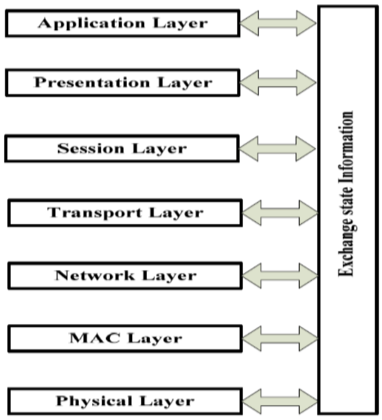


Figure: Data Flow between multiple layers [8]

II. LITERATURE REVIEW

Q. T. Hoang et al. [1] proposed a cross layer reliable communication solution for ad hoc networks by introducing the signals having shorten length which can reduce the control overhead for routing protocol. It can also reduce the probability of possible collision and latency ratio while enhances the overall network performance in terms of higher Throughput. Proposed work can be extended to provide the cross layer support over multi hop networks.

D. Sunithat et al. [2] identified the impact of MAC layer over TCP congestion and developed a method which can determine the Threshold value, if shared medium is busy, in order to trigger the congestion control algorithm. Congestion control scheme manages the congestion level under constraints of Delay and available bandwidth. Simulation results show that it uses fair resource allocation and maintains the network performance under QoS constraints.

Y.S. Lim et al. [3] examined the TCP protocol that does not perform well over wireless networks as it is unaware from the operations of MAC layer, to overcome from this issue and proposed a solution for transmission using multi paths over wireless networks, in order to maximum utilization of the medium. Multi-path TCP exploits the data transmission information from MAC layer and regulates the RTO according to the flow over MAC layer. Proposed solution was implemented over Linux/Android pate form and results show that it suffers little bit from Time Out stage but still it is able to maintain the data flow and sub flows.

P. S. Kalshetti et al. [4] investigated the issues related to real time video transmission over wireless networks that suffers from unfair bandwidth utilization, jitter and delay etc. and developed a cross layer solution based on MAC and PHY layer. Adaptive retry limit (ARL) is used for MAC layer to vary the transmission rate and Enhanced Adaptive Forward Error Correction for PHY layer to reduce the overall Delay factor. Results show that cross layer support enhances the real time data delivery by reducng the Delay in transmission over wireless networks.

J. Jang et al. [5] did a survey of routing layer, MAC layer and Transport layer and the cross layer solutions which were developed to enhance the overall performance of the entire network. Survey shows that if upper layers don not cooperate with lower layer than, network performance may suffer. Researchers designed the cross layer solutions for MAC layer, Transport Layer, Routing Layer and PHY layer. Layer Survey shows that selection of layer to design a cross layer solution is also very important as solution based MAC and PHY layers could not perform well whereas combination of TCP with PHY did not perform well.

A. Cammarano et al. [6] developed a cross layer framework which supports scheduling and rate control for routing protocol. It operates in a distributed environment and manages the congestion over Cognitive Radio Ad Hoc Networks. Network Utility Maximization method uses the backoff algorithms for MAC layer and access to medium is granted by spectrum sensing and it can fully utilize the channel.

U. F. Abbasi et al. [7] developed a cross layer solution for Body Area Network which select nodes using a timer for Received Signal Strength and residual energy. If any intermediate node has the highest value for these parameters, thus selected as relay node. Simulation re4sults show the variations in payload and Delay as per the selection criteria and it can also improves the network performance as well as its life time.

K. N. Quang et al. [8] observed the behavior of MAC layer and its impact over routing information and resolved the issues related to fair resource allocation over wireless networks. It utilizes orthogonal frequency division multiple accesses techniques for communication purpose and avoid the channel interference to overcome from Hidden/Exposed terminal issues and maintains the network performance. Simulation results show that cross layer scheme also work for ad hoc networks as well as for multi hop networks under the constraints of mobility.

S. H. Lee et al. [9] proposed a cross layer solution to overcome the form the issues related to control packet overhearing at MAC layer. This method enables the nodes to estimates the control packets from UP/Down streams and finally it finds an optimal path for transmission without depending upon the control packets. Simulation results show that proposed method improves the resource utilization and the power efficiency by resolving the dependency over control packets while it also performs path optimization as compared to the other methods.

J. Park et al. [10] developed a cross layer scheme to transmit the H.264 video stream over wireless channel. It uses a modulation method for MAC layer, error correction at application layer and channel optimization at PHY layer. Simulation results show that it can maintain the quality of video transmission under the constraint of fading channel.

III. Proposed Scheme

<u>Basic TCP congestion control method</u>

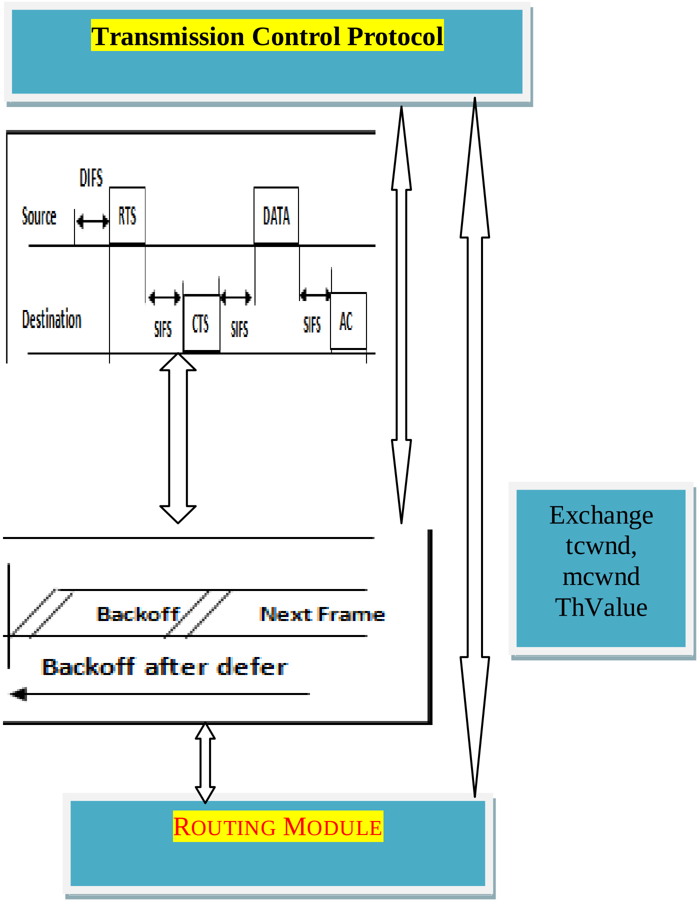
```
Switch (state)
{ Case: Success
If (tcwnd <sstresh)
{ tcwnd += Const_Val
}
else {
tcwnd += Const_Val / tcwnd
}
Case : retransmission
ssthresh = half(tcwnd)
tcwnd = Const_Val
}
```

Basic MAC Back off control Method

```
Channel_state(s)
While (mcwnd< MAX
{
Mcwnd++
```

```
If mcwnd> MAX;

Mcwnd=MIN;

}

Proposed MAC Back off control Method

Channel_state(s)

While (mcwnd< MAX

{

MACCWND =( CURRENT_ MACCWND * constant ) * CONST_val;

If MACCWND > MAX;

{

MACCWND =MAC->min(CONST_MACCWND);

}

If (MACCWND -> Reset-Th_Val> mTh_Val

{

Reset (TcpCWND);

}

}
```

In normal routine, backoff method is called, a idle time is set for any node, after that, node reattempts to access the medium again, but this idle state can cause the extra control overhead over routing protocols, because, if any node is performing roué discovery operation but node at next HOP can't respond because it is in idle state, so node at previous HOP should wait for while. If at large scale, nodes become idle during backoff time, then routing protocol suffers a lot and all nodes get the access to the shared medium, mean while if there is any change in network topology , then route discovery and maintenance phase is retriggered, and at the same time, if some nodes are using TCP connections, TCP will switch to the retransmission phase, so if we intercept the a backoff timer value , in such a way that, on the behave of that value, if we set the TCP congestion window by indicating the Time Out state, then after regaining the access to channel, transmission can be restarted and we can avoid the packet loss, routing overhead and transmission delay etc.



IV. PERFORMANCE ANALYSIS AND RESULTS

Simulation Setup

Simulation Parameters	Parameter Values
Multicast Routing Protocol(s)	AODV, DSDV
Terrain	1000x1000
Node Density	50
MAC Protocol	MAC 802.11
Transport Layer Protocol	TCP
Traffic Type	CBR
Packet Size	512
Sampling Interval	0.1 seconds
Simulation Time	10 seconds
Network Simulator	NS-2.34
Simulation Scenario(s)	nCls a/d: No Cross Layer solution for AODV/DSDV wCls a/d: With Cross Layer solution for AODV/DSDV

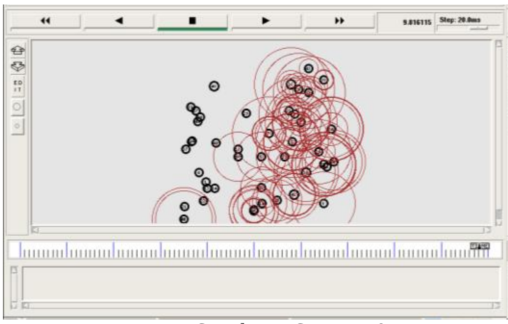


Figure 1: Simulation Scenario-0

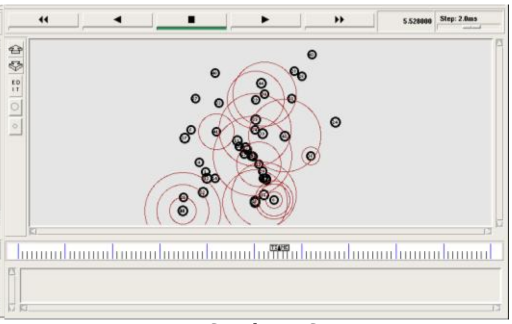


Figure 2: Simulation Scenario-1

Performance Analysis

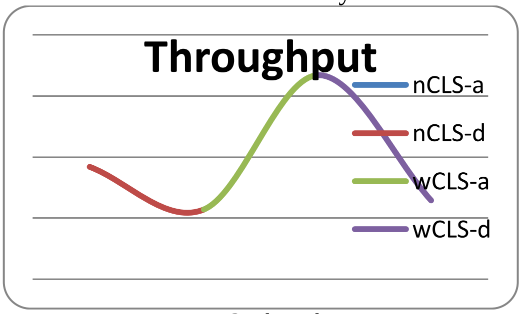


Figure 3: Throughput

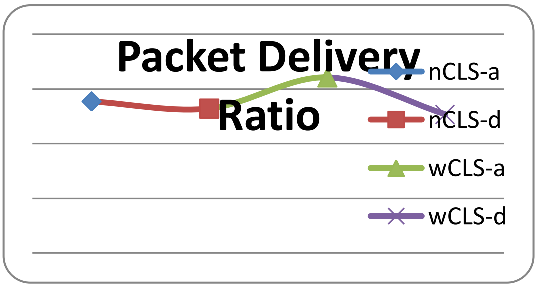


Figure 4: Packet Delivery Ratio

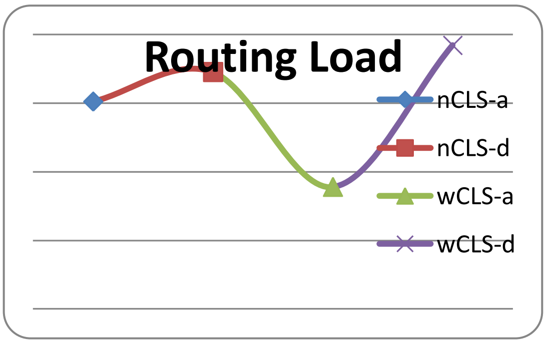


Figure 5: Routing Load

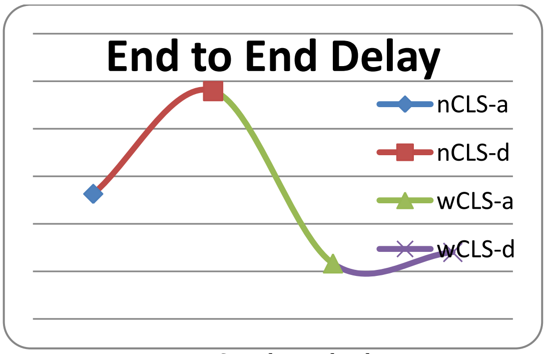


Figure 6: End to End Delay

Without using proposed scheme, Throughput of AODV is 36.8, PDR is 55.42168675, Routing Load is 2.804347826 and End to End Delay is 131.5ms. Throughput of DSDV is 22.9, PDR is 52.88683603, Routing Load is 2.890829694 and End to

End Delay is 240.108ms. It can be observed that without using proposed scheme, AODV has the highest Throughput and Packet Delivery Ratio. It has minimum Routing Load and Delay as compared to DSDV protocol.

Using proposed scheme, Throughput of AODV is 66.9, PDR is 64.26512968, Routing Load is 2.556053812 and End to End Delay is 58.2665ms. Throughput of DSDV is 25.8, PDR is 50.78740157, Routing Load is 2.968992248 and End to End Delay is 70.0908ms. It can be observed that

Using proposed scheme, AODV improves the Throughput and Packet Delivery Ratio. It reduces the Routing Load and Delay as compared to DSDV protocol.

Cross Layer performance Analysis of Reactive and Proactive Routing Protocol

In case of nCLS-a, RTS packets are dropped with few variations but using wCLS-a, there are lot of variations in packet RTS-drop and it can be observed that it is a managed packet drop,

Using nCLS-a , RTR packets are dropped in continues manner and at the end of simulation, it is increasing randomly while using wCLS-a, it grows and shrinks rapidly.

In case of nCLS-a, TCP packets and ACK both are dropped with frequent variations, in the end of simulation whereas, wCLS-a tries to manage the packet drop in smoothly.

In case of nCLS-d, it can be observed that there are lot of frequent variation is packet drop for RTS, RTR, TCP and ACK but wCLS-d slightly controls all the relevant variations.

Cross Layer Analysis: AODV

Without using Proposed Scheme

MAC Layer

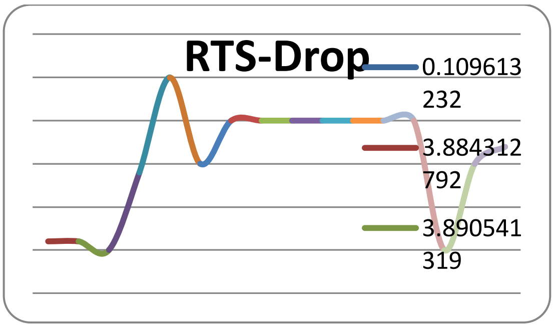


Figure 7: RTS-Drop-AODV

TCP Layer

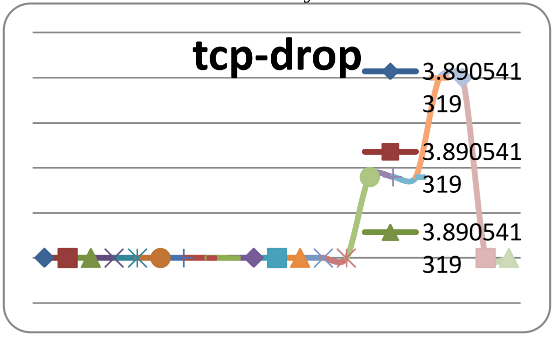


Figure 8:TCP-Drop-AODV

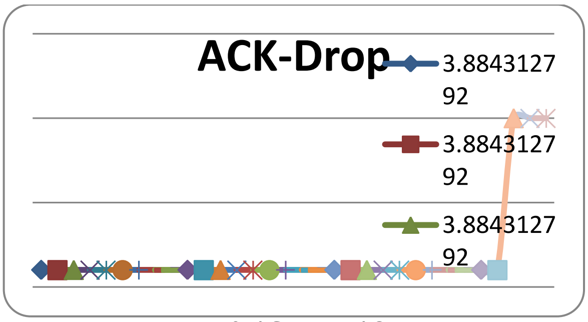


Figure 9: ACK-Drop-AODV

Routing Layer

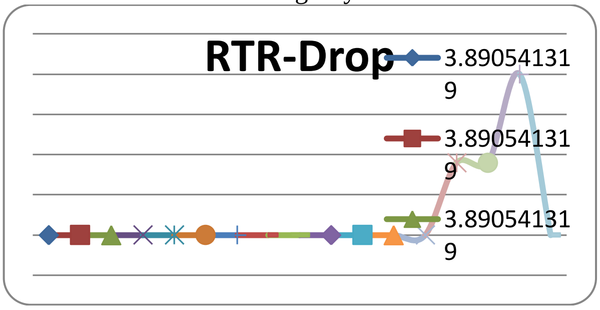


Figure 10: RTR-Drop-AODV

Using Proposed Scheme

MAC Layer

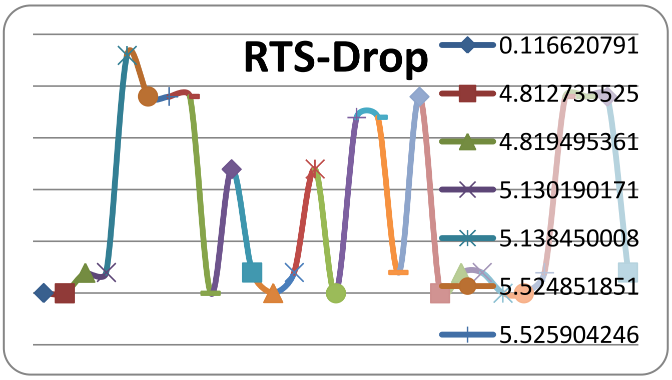


Figure 11: RTS-Drop-AODV

Routing Layer

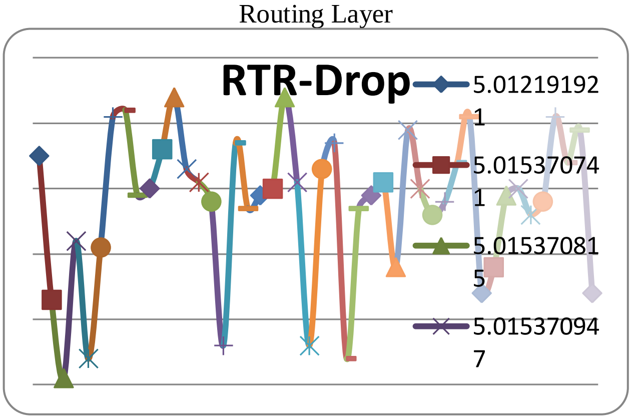


Figure 12: RTR-Drop-AODV

Tranaport Layer

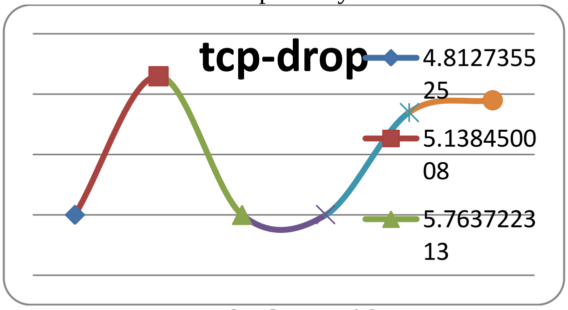


Figure 13: TCP-Drop-AODV

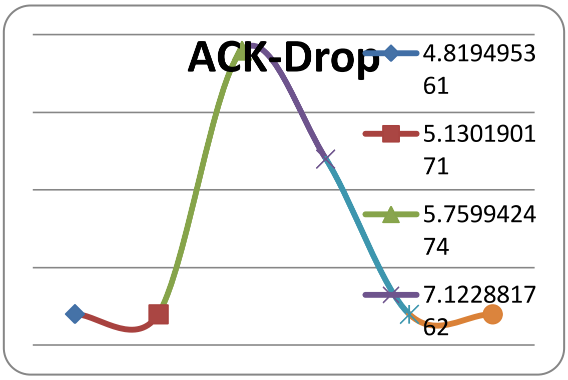


Figure 14: ACK-Drop-AODV

Cross Layer Analysis: DSDV

Without using proposed scheme

MAC Layer

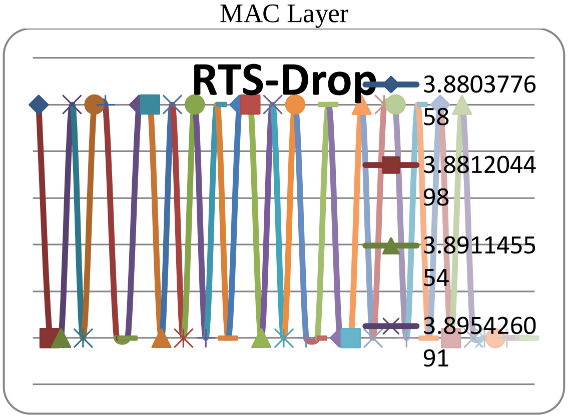


Figure 15: RTS-Drop-DSDV

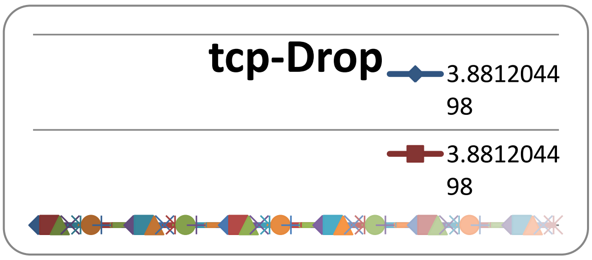


Figure 16: TCP-Drop-DSDV

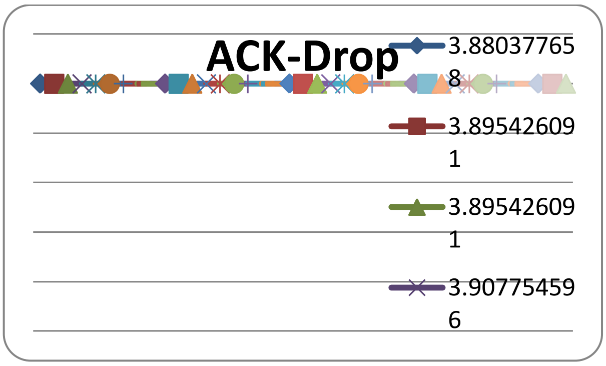


Figure 17: ACK-Drop-DSDV

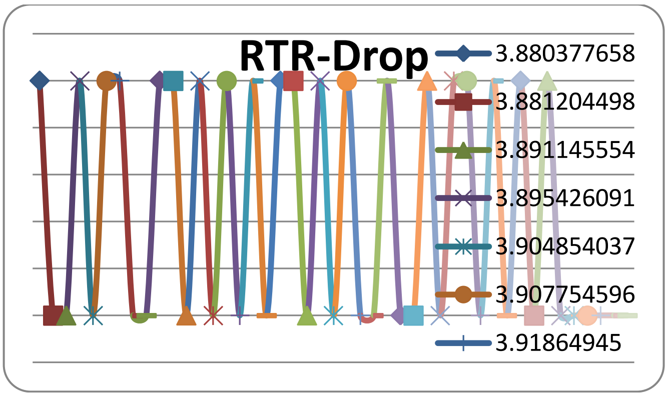


Figure 18: RTR-Drop-DSDV

Using proposed scheme

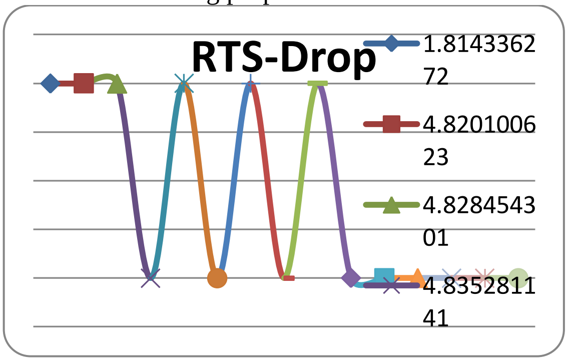


Figure 19: RTS-Drop-DSDV

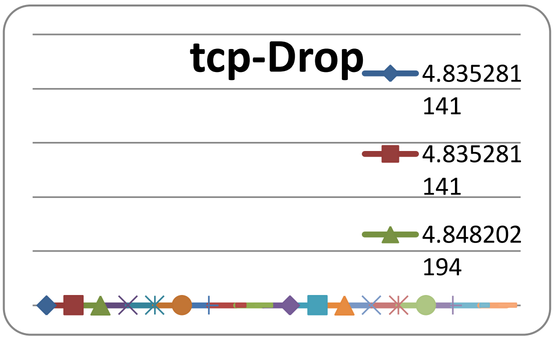


Figure20 : TCP-Drop-DSDV

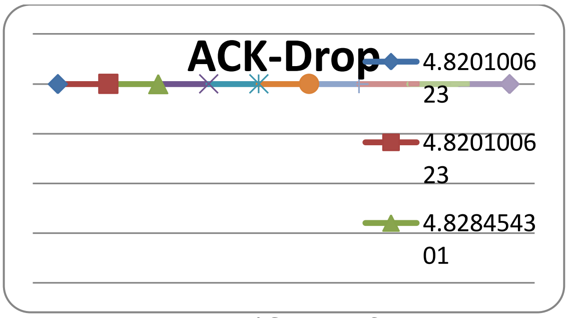


Figure 21: ACK Drop-DSDV

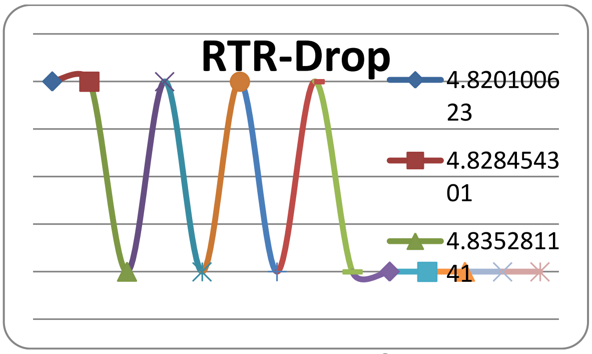


Figure 22: RTR-Drop-DSDV

V. CONCLUSION

In this research work, we explored the dependencies of various layers over each other. We used Reactive (AODV) and proactive (DSDV) protocols with MAC 802.11 and TCP protocol. For Simulation purpose, we used NS-2, open source network simulator and developed various simulation scenarios i.e.

nCLS-a, nCLS-d, wCLS-a and wCLS-d etc. Simulation results show that without using proposed scheme, Throughput of AODV is 36.8, PDR is 55.42168675, Routing Load is 2.804347826 and End to End Delay is 131.5ms. Throughput of DSDV is 22.9, PDR is 52.88683603, Routing Load is 2.890829694 and End to End Delay is 240.108ms. It can be observed that without using proposed scheme, AODV has the highest Throughput and Packet Delivery Ratio. It has minimum Routing Load and Delay as compared to DSDV protocol.

Using proposed scheme, Throughput of AODV is 66.9, PDR is 64.26512968, Routing Load is 2.556053812 and End to End Delay is 58.2665ms. Throughput of DSDV is 25.8, PDR is 50.78740157, Routing Load is 2.968992248 and End to End Delay is 70.0908ms. It can be observed that Using proposed scheme, AODV improves the Throughput and Packet Delivery Ratio. It reduces the Routing Load and Delay as compared to DSDV protocol.

In case of cross layer performance analysis, Using nCLS-a, RTS packets are dropped with few variations but using wCLS-a, there are lot of variations in packet RTS-drop and it can be observed that it is a managed packet drop, Using nCLS-a , RTR packets are dropped in continues manner and at the end of simulation, it is increasing randomly while using wCLS-a, it grows and shrinks rapidly. Using nCLS-a, TCP packets and ACK both are dropped with frequent variations, in the end of simulation whereas, wCLS-a tries to manage the packet drop in smoothly. Using nCLS-d, it can be observed that there are lot of frequent variation is packet drop for RTS, RTR, TCP and ACK but wCLS-d slightly controls all the relevant variations.

Finally, it can be concluded that this research work identified the dependencies of different layer over each other and how the overall performance of routing protocol can be enhanced. It can be observed that reactive protocol preformed well as compared to proactive protocol but our proposed scheme still improves the performance of proactive protocol.

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