Modeling of Congestion Control Algorithms Based on Buffer Management for MANETS

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Abstract

Mobile Ad Hoc Networks (MANETs) are autonomously mobile nodes forming networks in an infrastructure less environment and have dynamic topologies, also called short lived networks. In order to facilitate communication within the networks, routing protocols are used to discover routes between them. In MANETs, temporary route changes and link failures happened rapidly. The assumptions are that all packets loss is due to congestion, TCP performs badly in such a Network. Different Transport Control protocol (TCP) variant has been developed for the improved output performance of TCP in MANETs. The performance comparison of two TCP reactive and proactive routing protocols for MANETs: Dynamic Sequence Distance Vector Routing (DSDV) and Optimized Link State Routing (OLSR). A detailed simulation model with the help of MAC layer and physical layer models are used to study the performance and interlayer interactions of their result implications. It is demonstrate that even though DSDV and OLSR share similar reactive and proactive behavior, the differences is only that the protocol reaction can lead to significant performance differentials. Here, it is observed that two on demand routing protocols OLSR and DSDV along with QoS management scheme namely RRED significant perform better than other TCP Variants in case of increasing Random Packet Loss as well as in case of Mobility.

Keywords: Manet Routing Protocols, TCP variants, OLSR, DSDV, Load Balancing, QoS, Mobility.

1. Introduction

Wireless ad-hoc networks are decentralized type of wireless networks (Balakrishnan & Padmanabhan, 1997). An ad-hoc wireless networks are collection of two or more devices build with wireless communications and networking capabilities. These devices can communicate with other nodes those are urgently within their radio range or another one that is outside their radio range. For this scenario, intermediate nodesare used to forward the packet from one source to another destination. Networks are ad hoc because the donot rely on an existing infrastructure, such as routers in wired networks. A mobile ad-hoc network (MANETs) is self-configured infrastructure less networks of mobile devices connected by wireless links.

All devices in a MANET are easy to move independently in every direction, and will, therefore, change the links to other devices frequently. Each node must forward traffic not

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related to its own use and, therefore, that be a router. The main challenges in building a MANETs are equipped every device to continuously manage the information required to properly route traffic. Those networks operate by themselves or may be connected to the larger Internet. Transmission Control Protocols (TCP) are connection oriented point-to-point protocols. This means, that for building a reliable communication streams on the top of the unreliable Internet Protocols (IP). TCPs are protocols those supports nearly all Internet applications. TCPs are used by a large number of IP applications, such as emails, Web services, and TELNETs. As connection-oriented protocols, TCPs ensures that data is transferred reliably from one source to another destination.

This paper presents a Modelling of Congestion Control Algorithms Based on Buffer Management for Manets (CCA) to increase the performance of throughput, packet delivery ratio and avoid congestion in MANETs employing simultaneous decreasing of the average delay and routing load using various TCP variants. An outline of this paper is as follows. Section 2 describes a review of MANET routing protocols, section 3 describes the TCP variants. Additionally, in section 4 and 5, the paper presents a detailed review of Routing Metric Calculation and CCA algorithm. Section 6 gives the simulation results. Finally in section 7, conclusion is presented.

2. MANET Routing Protocols

a. Optimized Link State Routing Protocol (OLSR)

Optimized Link State Routing is another pro-active link state protocol which is claimed to work best in large dense network. Optimized Link State Advanced Routing Protocol (OLSAR) each node selects a set of multipoint relays (MRP) from its neighbours. The radio range of the MRP set such that it should all to hops neighbours. Each node has the knowledge as to for which node it acts as a MRP. Thus Optimized Link State Routing Protocol (OLSR) requires bidirectional links to find the suitable routes for the nodes. Optimized Link state Routing Protocols is not suitable for high mobility nodes.

OLSR utilizes UDP to distribute routing packets .Each routing packet Contains one or more OLSR messages. Message exists for neighbour by the same originator as the route and sends its reply via the reversed hop list in the received request. OLSR (Zhou. H.) is a suitable for network where frequent communication takes place in collection of nodes rather than as a whole. It is not cleared what criteria nodes use to form Multipoint Relays (MRP). Each routing Packet in OLSR can have more than one message. Due to the nature of mobile ad-hoc network it is expected that network transmission would meet different types of error. OLSR use User Data Protocol (UDP) as communication medium.

b. Destination-Sequenced Distance-Vector Routing Protocol (DSDV)

The destination sequenced distance vector routing protocol (DSDV) is an extension of classical bellman ford routing mechanism (Zhou, 2003). DSDV maintains consistent network view via periodic routing updates. Routing information is stored inside routing tables maintained by each node. New route broadcasts contain the addresses of the destination, the multiple of hops to reach destination, the sequence number of the destination and a new sequence number unique to broadcast.

A route with a recent sequence number is considered as a fresh route. If sequence numbers are found to be the same then route with better metric will be selected. DSDV use distance vector shortest-path routing as the underlying routing protocol. It has a high degree of complexity especially during link failure and addition. Maximum setting time is difficult to determine in DSDV. DSDV does not support multi-path routing (Ali et al., 2012). DSDV protocol assumes that all nodes are trustworthy and cooperative.

3. TCP Variants

TCP New RENO is a slight modification over TCP-RENO. It is able to detect multiple packet losses and thus is much more efficient that RENO in the event of multiple packet losses. Like RENO (Tabash et al., 2010). New-RENO also enters into fast-retransmit when it receives multiple duplicate packets,

However it differs from RENO in that it does not exit fast-recovery until all the data which was out standing at the time it entered fast recovery is acknowledged. The fast-recovery phase proceeds as in Reno, however when a fresh acknowledgement (ACK) is received then there are two cases:

i) If it acknowledges all the segments which were outstanding when we entered fast recovery then it exits fast recovery and sets congestion window (CWD) to threshold value and continues congestion avoidance like Tahoe.
ii) If the ACK is a partial ACK then it deduces that the next segment in line was lost and it retransmits that segment and sets the number of duplicate ACKs received to zero. It exits Fast recovery when all the data in the window is acknowledged.

TCP Westwood variant of TCP (Wang et al., 2002) was a sender-side-only modification to new Reno that was intended to better large bandwidth-delay handle product paths, with potential loss of packet due to other errors or transmission and with load of dynamic nodes. TCP-W relies on mining the Acknowledgement stream for information to help this better setting of the CC parameters: slow starts thresh and congestion window (Wang *et al*., 2002). In TCP-W, estimation of an Agile and used by the sender to update slow start thresh and congestion window upon indication of loss, or during its phase of Agile Probing, a proposed modification to the well-defined SS (Slow Start) phase. In addition, a scheme that is called PNCD has been devised to lack of congestion detect persistent and an Agile Probing phase to utilize large dynamic throughput (Broch et al., 1998).

TCP CUBIC has an optimized congestion control algorithm; it comes as an improved version of BIC TCP. Presently, CUBIC is the default TCP algorithm in Linux (Kaushik, *et al*., 2012). CUBIC improves scalability of TCP and assures a fair utilization of the bandwidth thanks to the enhanced window growth function. TCP CUBIC combines both additive-increase and binary search-increase techniques to achieve good scalability. CUBIC performs good performance in wired network scenarios. In addition the window-growth function of CUBIC is defined in real-time instead of RTT, so that, window-growth rate is independent of RTT. The growth function of CUBIC is determined by Cubic Parameters:

$$W(t) = C(t - K) + Wmax \quad (1)$$

Here C is a CUBIC parameter; *t* is elapsed time from the last window reduction is shown. *K* is the time period that the above function takes to increase W to W_{max} when there is no further loss event and is calculated as:

$$\sqrt[3]{\frac{W_{max}}{C}}$$

TCP CUBIC is mainly conducted by simulation and real tested experiments. The window-growth function of CUBIC is a CUBIC function having a similar size to the growth function of BIC TCP.

4. Routing Metric Calculation

a. Calculation of Available Throughput

We use the mechanism for calculation of available throughput. Number of bits delivered successfully per second to the destination. It is the measure of effectiveness. It is rate of number of packets received at the receiver with respect to the time taken. Units are bytes/sec or bits/sec.

*Throughput = number of packets delivered * packet size * 8/total duration.* (2)

Throughput could be affected due to changing network topologies, unreliable n between nodes, limited bandwidth, and limited energy.

b. Average End-to-End Delay

The average delay a data packet takes to travel from the source to the destination node. Delay in the arrival of a packet is introduced due to queuing of packets at the interface of node, time of transmission, time of retransmission due MAC, delay due to buffering (find the correct route to destination) during route discovery. When particular packet 'i' is sent at s_i time and received at r_i time delayed due to all these delays. Average for all the packets sent is given by: Lesser delay means better performance for the protocol. Given equation 3 is used to calculate end to end delay.

$D=1/N\sum_{i=1}^{s} r_i - s_i.$ (3)

c. Routing Overhead

It is calculated as total number of control packets transmitted. The increase in routing message overhead reduces the performance of the ad-hoc network. Routing a Packet to its destination is done by network layer. When any packet arrives and its destination route is available, it is sent forward. Otherwise, the packet is buffered. The buffered packet could be dropped due to the following reasons:

i) When the buffer is full.
ii) When time of packet expires. We expect least packet loss from the routing protocol.

d. Packet Delivery Ratio

The ratio of packet of data delivered to the destination to those generated by the source. In other words, PDR is the ratio of number of packets received over connections to destination to the total number of packets sent over the destinations through these connections. This metric provides completeness and correctness measure of routing protocol used by connections, which helps in defining the reliability of the protocol.

Mathematically,

$P=1/c \sum_{f=1}^{e} R_f / N_f$ (4)

In given equation 4, where c is total number of connections to destination, f th connection is index to connection to it. R_f is no. of received packets by f th connection. N_f is no. of packets sent over to the destination through f th connection. Higher PDF value means better performance of the protocol.

5. CCA Algorithm

a. Algorithm

Multipath routing protocols, as previously mentioned is based on CAMRLB, to increase throughput and avoid congestion in MANETs. CAMRLB is a congestion adaptive multipath routing protocol considers available bandwidth, load and residual battery energy of nodes and distributes traffic through fail-safe multiple paths. In this paper our CCA algorithm performs a simulation for two different Proactive routing protocols namely OLSR and DSDV in a multi hop ad-hoc network environment. The impact of network size on the performance of DSDV and OLSR protocols (Goyel, 2012) under three different TCP variants TCP New-Reno, TCP Cubic, TCP Westwood with and without QoS management mechanism namely RRED is shown with the help of simulator NS-2 in terms of PDR, throughput, end to end delay, and routing load.

Algorithm 1

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Calculate the throughput (throughput) of a link using Eq (2).
Estimate the routing load using routing load formula,
Calculate Packet Delivery Ratio (PDR)                    using Eq (4).
Calculate the average end to end delay using Eq (3).
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In simulation, throughput of TCP CUBIC and TCP Westwood under QoS Management mechanism RRED gives better throughput than other TCP New-Reno against DSDV routing Protocols. Packet delivery ratio of TCP Westwood and TCP New-Reno against DSDV higher performance when network density is smaller. PDR of TCP Westwood is better than both TCP CUBIC and TCP New-Reno. The Average end-to-end Delay of TCP Westwood and TCP CUBIC gives better results than remaining TCP variant namely TCP New-Reno. Routing load of TCP CUBIC under QoS management mechanism namely RRED gives better results than TCP New-Reno and TCP Westwood for different network density scenarios.

b. The Traffic and Mobility Models

For traffic source and application, FTP is used above the agent TCP. The source-Destination pairs are spread instant over the network. The data generator is FTP. Mobility models were created for the simulations for different network density such as 40, 60, 80, 100 and 120 nodes and this model was set in such a way that all the nodes were provided with initial Location in the given rectangular topography field. The field configuration used is: $1500m * 1500m$ field. Then all the nodes move within their boundary by setting their final destination and the speed that each mode move with. All the simulation nodes are run for 150s simulation time in seconds. Same mobility and traffic scenarios are used across the protocol to collect fair results.

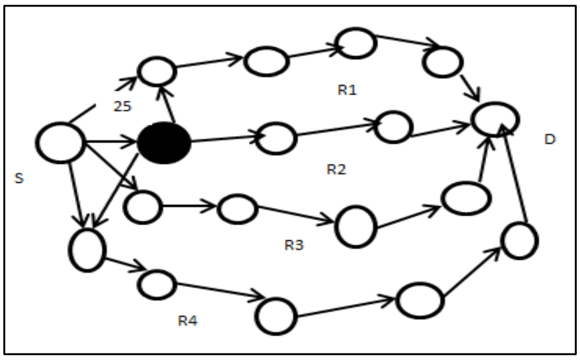

Fig 1: Multipath Load Distribution

In given fig 1, there are 4 paths R1, R2, R3 and R4 established between the source and destination.

6. Simulation Environment, Results and Analysis

NS2 (isi.edu, 2011) is used to simulate the Manet routing protocols under TCP variants. The channel capacity of mobile nodes was 2 Mbps. The simulation settings and parameters are summarized in Table 1.

Table 1: Important Simulation Parameters

Parameter	**Value**
Simulation time	150 Sec
Simulation area	1500m x 1500m
Antenna	Omni antenna
No. of nodes	40, 60, 80, 100, 120
TCP –Variants	TCP- New Reno, TCP- Westwood, and TCP-CUBIC
Routing protocols	DSDV, OLSR
Traffic	FTP
TCP segment size	1024 bytes
Mac	IEEE 802.11

Here is Comparison of DSDV and OLSR protocols under three different TCP variants TCP New-Reno, TCP Cubic, TCP Westwood with and without QoS management mechanism namely RRED. Simulation based on NS-2 has been used in the evaluation, and in order to perfectly evaluate the effect of out-of-order packet while multipath routing protocol is used in different simulation scenarios. IEEE 802.11 for wireless networks is used as the MAC layer protocol. Routing and all packets of data sent by the layers of routing are queued at the queue interface until the layer Mac can transmit them. The interface queues have maximum size of 50 packets and are worked as a priority queue at the layer.

The routing Protocol that have been chosen at the network layer are DSDV and OLSR under multipath route between base sender and receiver nodes.NS-2 simulator supports for simulating wireless networks consists of different network components including physical, data link and Medium Access Control (MAC) layer models. From channel type, a wireless channel model has been chosen.

Mobility models were created for the simulations for different network density such as 40, 60, 80, 100 and 120 nodes and this model was set in a way that all the nodes were provided with initial location in the given rectangular topography field.

Fig 2 and table 2 show the throughput of TCP-CUBIC and TCP-WESTWOOD under QoS management mechanism.

Table 2: Throughput versus no. of Nodes (TCP New-Reno, Cubic,Westwood)

No. of Nodes					
New-Reno	40	60	80	100	120
DSDV	452.626	588.106	627.113	699.265	309.127
OLSR	510.691	545.493	440.781	620.514	263.861
RRED+DSDV	485.477	560.22	630.134	680.751	319.034
RRED+OLSR	619.71	528.963	352.58	610.312	211.748
Cubic	40	60	80	100	120
DSDV	532.1	442.649	520.028	646.182	337.954
OLSR	601.946	492.485	473.063	565.385	229.746
DSDV+RRED	546.77	446.223	534.216	656.559	388.958
OLSR+RRED	490.494	542.809	444.537	530.593	244.82
Westwood	40	60	80	100	120
DSDV	494.948	528.646	502.905	624.88	337.03
OLSR	593.511	540.773	395.77	593.993	270.443
DSDV+RRED	583.769	517.692	603.527	650.194	347.795
OLSR+RRED	631.773	574.412	418.533	582.285	206.051

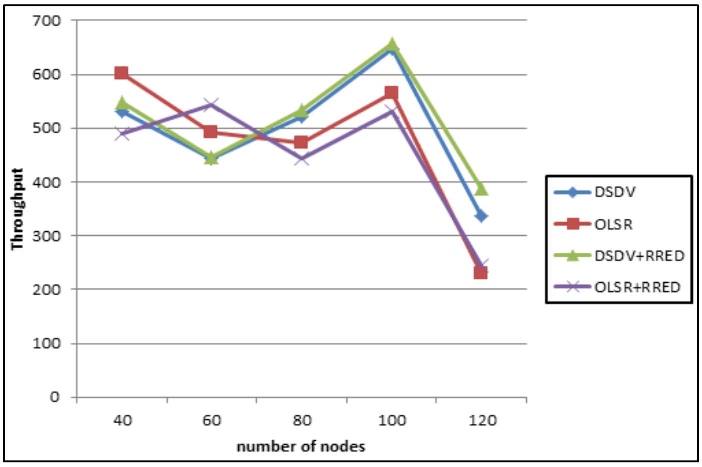

Fig 2: Throughput versus nodes (TCP-cubic).

RRED gives better throughput than otherTCP-New Reno against DSDV routing protocol. The throughput is representative of number of bits received per second.

Fig 3, 4 and table 2 shows the impact of network density on the throughput on TCP-New Reno and TCP-Westwood against DSDV and OLSR routing protocols.

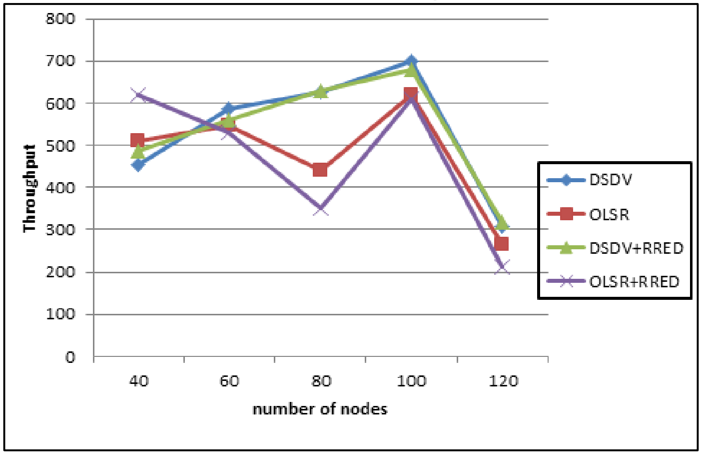

Fig 3: Throughput versus nodes (TCP-New Reno).

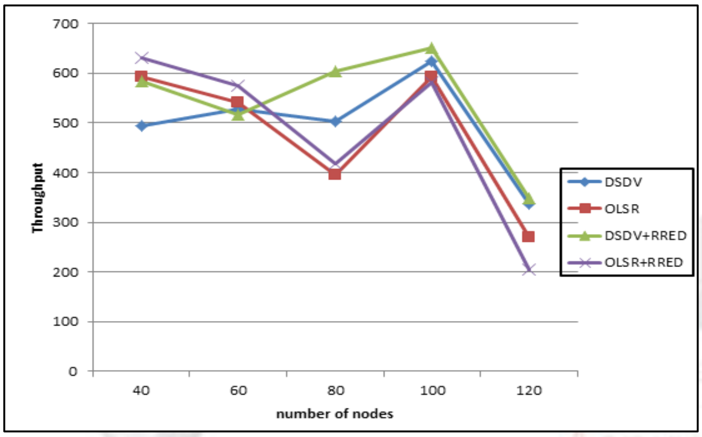

Fig 4: Throughput versus nodes (TCP Westwood).

Table 3: PDR verses no. of nodes (TCP New-Reno, Cubic and Westwood)

No. of Nodes					
New-Reno	40	60	80	100	120
DSDV	98.75%	98.02%	97.73%	97.66%	95.53%
OLSR	98.58%	97.43%	94.43%	97.16%	94.32%
RRED+DSDV	98.77%	97.87%	97.33%	97.96%	95.37%
RRED+OLSR	98.84%	97.32%	93.86%	97.12%	93.23%
Cubic	40	60	80	100	120
DSDV	98.90%	98.32%	97.71%	98.05%	95.98%
OLSR	98.78%	97.40%	95.01%	97.33%	93.08%
DSDV+RRED	98.85%	98.21%	96.35%	97.45%	96.27%
OLSR+RRED	98.51%	98.10%	94.69%	96.90%	94.57%
Westwood	40	60	80	100	120
DSDV	98.71%	97.78%	97.05%	97.72%	95.48%
OLSR	98.68%	97.46%	94.49%	97.53%	94.62%
DSDV+RRED	98.84%	97.75%	96.61%	97.40%	96.37%
OLSR+RRED	98.77%	97.47%	95.61%	97.28%	92.91%

Fig 5, 6 and 7 and table 3 shows the packet delivery ratio for three TCP variants namely TCP-New Reno, TCP-Westwood and TCP-CUBIC against DSDV and OLSR routing protocols when network density is varied. Simulation results shows TCP-Westwood and TCP-Newreno against DSDV protocol gives higher performace when network density is smaller. It is observed that the packet delivery ratio of TCP Westwood is better than both TCP-New Reno and TCP-CUBIC. Packet delivery ratio is representive in the form of Percentage.

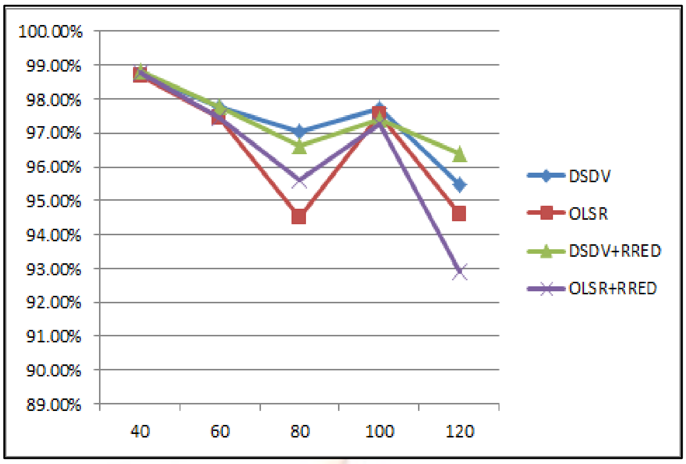

Fig 5: PDR versus nodes (TCP-Westwood).

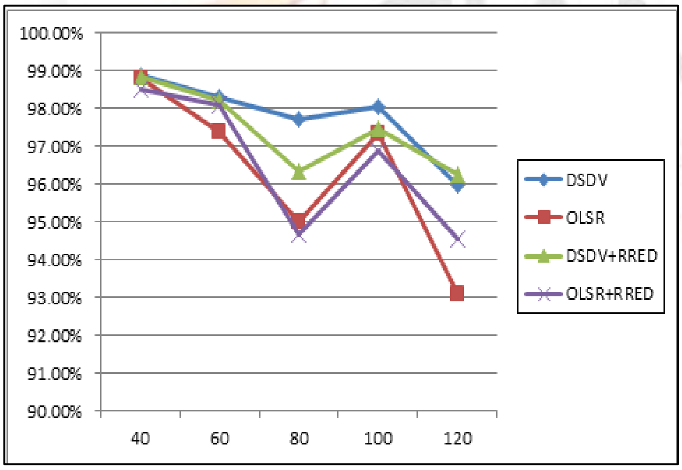

Fig 6: PDR versus nodes (TCP-Cubic).

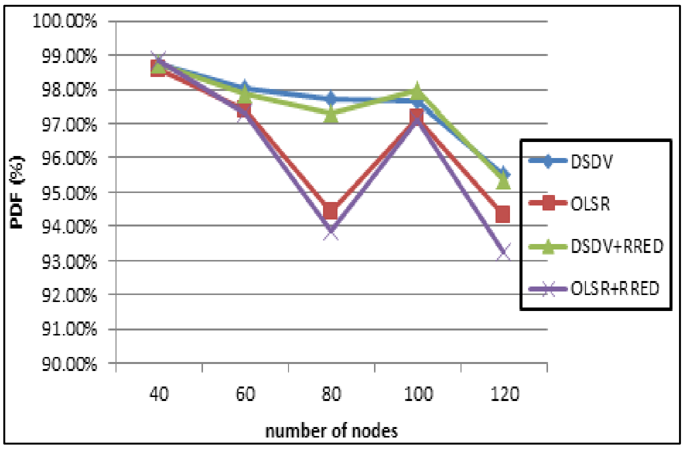

Fig 7: PDR versus nodes (TCP-New-Reno).

Table 4: Average delay vs nodes (TCP New-Reno, Cubic and Westwood)

No. of Nodes					
New-Reno	40	60	80	100	120
DSDV	0.18241	0.16281	0.1677	0.14393	0.19997
OLSR	0.19094	0.17146	0.1907	0.19793	0.24819
RRED+DSDV	0.15183	0.19499	0.21583	0.15546	0.14273
RRED+OLSR	0.14484	0.19395	0.18984	0.18852	0.27398
Cubic	40	60	80	100	120
DSDV	0.10714	0.11587	0.15869	0.14481	0.14493
OLSR	0.13911	0.15586	0.16508	0.19685	0.26945
DSDV+RRED	0.1511	0.11984	0.15007	0.14294	0.16234
OLSR+RRED	0.15861	0.16177	0.20378	0.18096	0.19886
Westwood	40	60	80	100	120
DSDV	0.17113	0.20575	0.28622	0.15928	0.14308
OLSR	0.17395	0.21224	0.22196	0.18674	0.2189
DSDV+RRED	0.15354	0.17875	0.16246	0.15964	0.20101
OLSR+RRED	0.15906	0.17945	0.198791	0.20202	0.24056

The fig 8, 9 and 10 and table 4 shows the impact of network density on average end-to-end delay for three TCP variants namely TCP-New Reno, TCP-Westwood and TCP-CUBIC against DSDV and OLSR routing protocols. The average end-to-end delay of TCP-Westwood and TCP-CUBIC gives better results than remaining TCP variant namelyTCP-Newreno. TCP-Westimating the networks bandwidth by properly averaging the returning rate of acknowledgment packets and low pass filtering per RTT. It then used this bandwidth estimated to adjust the slow start thresh and the congestion window to a value closed to it when a loss of packet is experienced as a result of which its end-to-end delay is comparatively smaller.

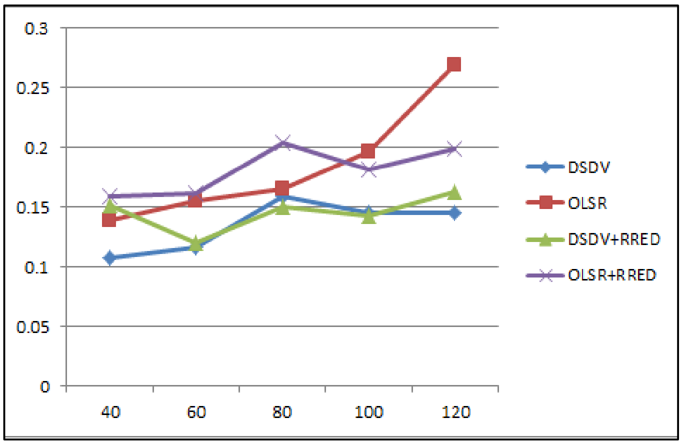

Fig 8: Average delay versus nodes (TCP-cubic).

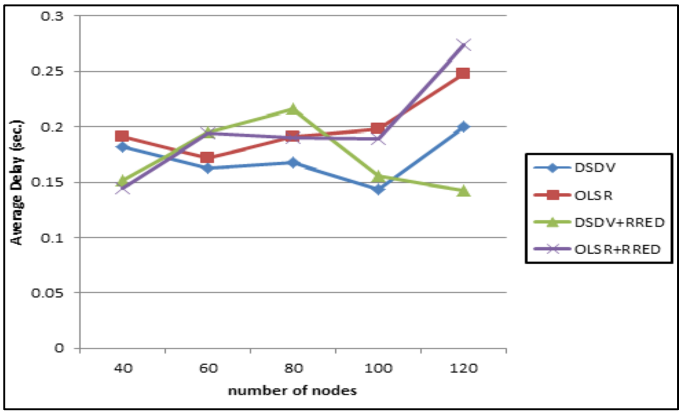

Fig 9: Average delay versus nodes (TCP New-Reno).

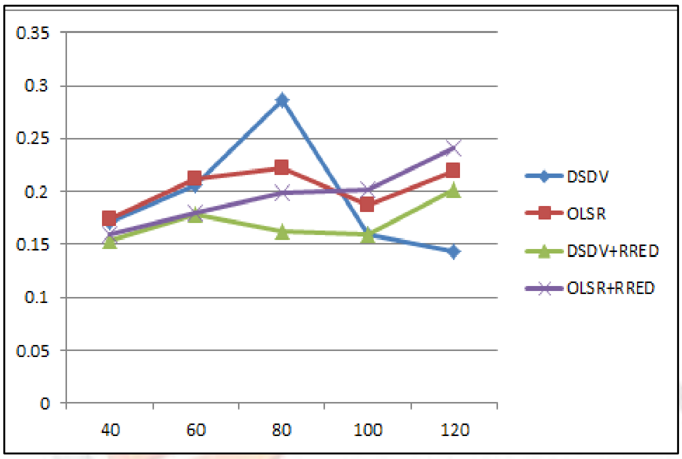

Fig 10: Average delay versus nodes (TCP Westwood).

Table 5: Routing Load vs nodes (TCP New-Reno, Cubic and Westwood)

No. of Nodes					
New-Reno	40	60	80	100	120
DSDV	5.282328	6.724085	7.328167	6.68782	9.128271
OLSR	6.054031	9.393585	12.20708	9.46707	18.70243
RRED+DSDV	5.314715	7.285511	7.934124	6.427699	7.836276
RRED+OLSR	5.902279	9.686223	13.01645	9.325472	21.12803
Cubic	40	60	80	100	120
DSDV	5.346259	5.820371	7.367748	6.441353	8.672125
OLSR	5.857564	9.504162	11.20815	9.461913	21.05544
DSDV+RRED	5.416348	6.471812	7.598686	6.530666	7.939993
OLSR+RRED	5.852653	8.47759	11.56525	9.636572	18.19408
Westwood	40	60	80	100	120
DSDV	5.425816	7.077896	7.469996	6.670808	7.543879
OLSR	5.85944	9.002061	11.49483	9.240364	17.77681
DSDV+RRED	5.385449	6.527463	7.898952	6.576457	8.008521
OLSR+RRED	5.791634	8.674752	10.72891	9.436408	21.04119

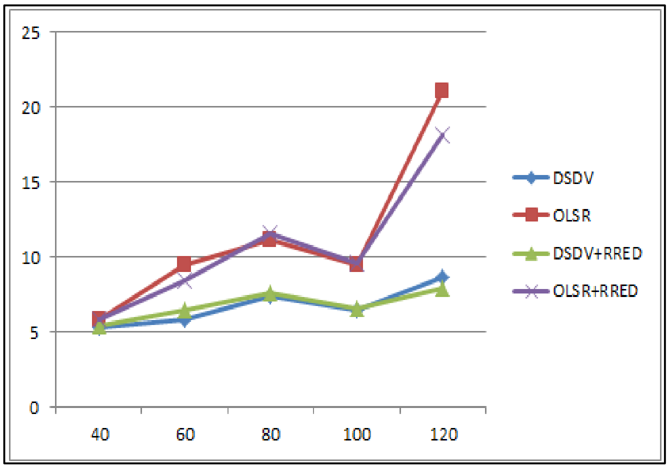

Fig 11: Routing Overhead versus nodes (TCP-cubic).

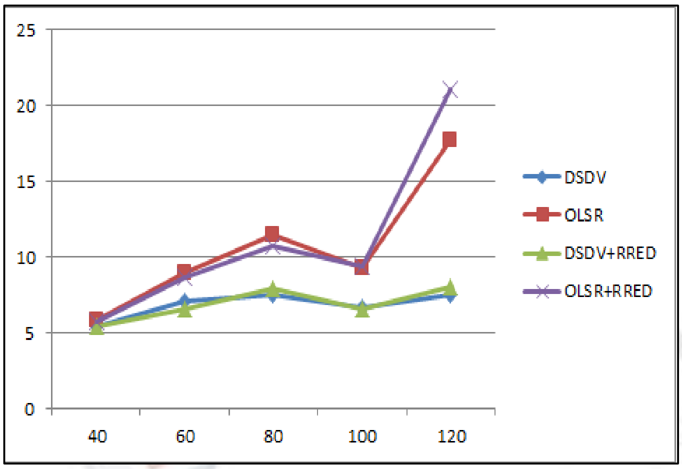

Fig12: Routing Overhead versus nodes (TCP-Westwood).

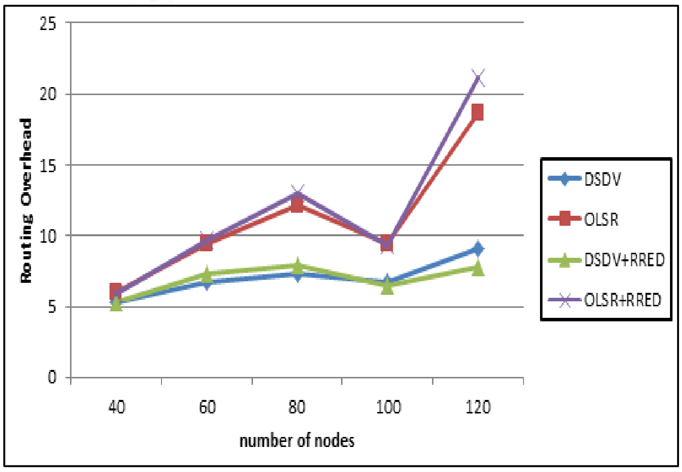

Fig13: Routing Overhead vs nodes (TCP New-Reno).

The fig 11, 12 and 13 and table 5 shows the impact of network density on the routing load. It is observed that the routing load of TCP-CUBIC under QoS management machanism namely RRED gives better results than TCP-New reno and TCP-Westwood for different network density scanrios.

VII. Conclusion and Future Scope

Through simulation, it is concluded that TCP throughput decreases significantly when node movement cases link failures. From the view of throughput, average delay and packet delivery ratio, TCP CUBIC is the best congestion control scheme out of selected TCP variants and RRED significantly improve its performance. From this analysis, it is found that TCP-CUBIC against DSDV routing protocol along with QoS management scheme namely RRED significant perform better than other TCP variants in case of increasing Random Packet Loss as well as in case of increasing mobility.

On the basis of the results obtained from simulation graphs in future this work could be extended by improving TCP-cubic performance over wireless multi-hop ad-hoc environment using other QoS management schemes.

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