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Improving TCP performance by congestion window adaptation MANET

Abstract

An ad hoc network is a dynamically forming temporary network with a collection of wireless mobile nodes. It does not use any centralized administration or existing network infrastructure. In wireless networks, improving TCP performance largely depends on congestion window size. Both contention and congestion affect the TCP performance. A contention problem occurs in network when adjacent nodes shared channel to transmit packets. Channel contentions cause network congestion because of a lack of coordination between the transport layer and the medium access layer. Due to the channel interference the Bandwidth Delay Product cannot reach to maximum value as in wired network. Packet loss occurs at MAC layer due to congestion. In ad hoc networks, both contention and congestion can severely affect the performance of TCP. In our work, we show that the over-injection of conventional TCP window mechanism results in severe contentions, and medium contentions cause network congestion. The idea is to dynamically adjust the congestion window to improve TCP performance by reducing the congestion window overshooting problem. We study the network performance such as throughput, Packet delivery ratio, and end-to- end delay when congestion control mechanism is used.

Keywords: Congestion Control, Contention Detection, Bandwidth Delay Product, RTT, MANET.

1. INTRODUCTION

All Mobile Ad Hoc Network (MANETs) consists of wireless mobile node with no pre-existing infrastructure. As TCP has been optimized for running over wired networks, the performance of TCP degrades in MANET. Conventional TCP mechanisms encounter several problems and yield poor performance in ad hoc network environments [1]. TCP maintains a congestion window (CWND) which keeps increasing until a packet loss is detected. In this way, the conventional TCP mechanisms attempt to chock up the channel and perform well in wired networks. However, they are too aggressive in 802.11-based ad hoc networks. The greedy property of TCP causes severe contentions in MAC layer and results in packet losses

and degradation in the network performance. Xinming Zhang, Nana Li, Wenbo Zhu, and Dan Keun Sung, introduce two metrics, channel utilization (*CU*) and contention ratio (*CR*), to characterize the MAC layer status. They propose a TCP transmission rate control mechanism based on channel utilization and contention ratio (TPCCC) in ad hoc networks. TPCCC mechanism controls traffic load to an appropriate level by adapting the congestion window size dynamically based on the *CU* and *CR* values [3]. Many researchers have been focused on improving TCP performance in the MANET. Main reason of poor performance of TCP over 802 MAC protocol is that, the excessive number of medium accesses caused by large congestion window of TCP. This is caused not only by the ACK packets that compete with the TCP data packets for the medium, but also by the retransmissions performed by TCP then reacting to packet loss or retransmission timer out (RTO). If there exists a big difference between the transmission rates of MAC and TCP, it may cause network congestion and retransmissions. In order to solve this problem, we need to take advantage of the feedback information from MAC layer to adjust the window in TCP properly.

In this paper, we propose a congestion window adaptation mechanism. This proposed scheme is compared with TCP and TCP-congestion control mechanism to get more meaningful results. The results have confined that in static multihop wireless networks, the TCP-CWACD outperforms all the other schemes in terms of throughput, delay and packet delivery ratio. In our work, we show that the over-injection of conventional TCP window mechanism results in severe contentions, and medium contentions cause network congestion. The idea is to dynamically adjust the congestion window to improve TCP performance by reducing the congestion window overshooting problem. We study the network performance such as throughput, Packet delivery ratio, and end-to- end delay when congestion control mechanism is used.

The rest of the paper is organized as follows. Section II presents the Congestion Window Overshooting Problem. Section III discusses the proposed CWA-CD mechanism. Section IV discusses the simulation setup for performance evaluations, and the simulation scenarios, results and analysis are reported in Section IV. Section V concludes the paper.

2. CONGESTION WINDOW OVERSHOOTING PROBLEM

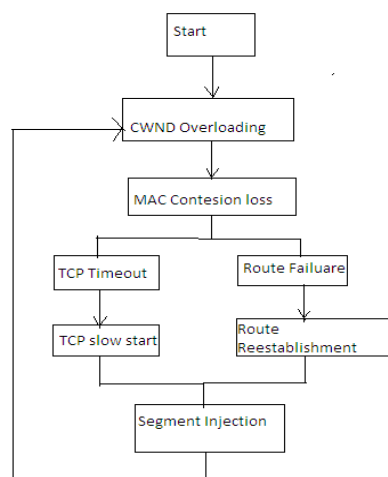


Fig.1 cycle of the TCP cwnd overshooting problem

Fig. 1 shows a cycle of the TCP *cwnd* overshooting problem it. Due to *cwnd* overshooting significantly degrades the network performance. During normal data transfer step, in first

phase *cwnd is overshooting* it causes phase two i.e. a TCP network to be overloaded. In this situation, a large number of data segments need to be transferred, and severe MAC contentions may accordingly occur. In phase three As a result, many segment losses may occur, in fourth phase these segment losses trigger retransmission timeouts and subsequent slow start phase 5 at the TCP source node. With lower transmission rate Data segments again start to be injected into the network.

To decrease this *cwnd overshooting* problem we divide the Round Trip Time i.e. RTT into two parts. we consider this two parameters congestion RTT and contention RTT. The contention RTT is the sum of contention delays through the path, which is a specific but essential factor in multihop ad hoc networks. On the other hand, the remaining part in RTT is the congestion RTT, which is made up of the end-to-end transfer delay of all the links through the path. Note that this end-to-end transfer delay of link contains queuing delay, transmission delay, and processing delay but no contention delay, and we will call it the link transfer delay in this paper. The duration of continuous segment flow in the pipe is determined by the only congestion RTT

3. TCP CONGESTION WINDOW ADAPTATION – CONTENTION DETECTION MECHANISM

To dynamically adjust the congestion window we propose the mechanism called Congestion Window Adaptation-Contention Detection (CWA-CD). For this purpose the new parameter is used called Variance of Contention RTT per Hop (VCRH).

1. Algorithm:

- a. Define parameter *v_rtt*.
- b. The value of contention RTT is gathered through packet forwarding.
- c. In MAC agent value of contention RTT is measured as interval between packet arrival at head of line of queue and delivery time at physical layer.
- d. Set time stamp in fragment to keep track of contention delay of current node.
- e. The contention delay is measured hop by hop and recorded in fragment and TCP destination copies the sum from the segment into ACK.
- f. Depending on the value of ack decide to increment /decrement or unchanged the value of congestion window.

2. CWA-CD Mechanism:

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Set a threshold parameter ssthresh
If (v_rtt > ssthresh)
{
Degree of contention in the network is severe.
}
When TCP source receives a new ACK
Updates the value of the v_rtt before checking whether this value is larger
than or equal to the ssthresh value.
If (v_rtt >= ssthresh)
{
Decrease CWND .
}
    
```

If the RTO expires,
 Then the network is in a bad congestion or contention status.
 Else the contention status of the network is not so bad, and just halve the *cwnd*.

We should notice that the *v_rtt* sampling should be reset after an RTO, and thus, the subsequent slow start of *cwnd* is not affected by the low value of *v_rtt* obtained before the RTO expires.

First, upon reception of a new ACK, the *v_rtt* result indicates how we can adjust the value of *cwnd*, and even if the estimation on contention is different from reality, the resulting *cwnd* is just slightly modified.

Second, if a packet loss occurs, determine whether we can minimize the *cwnd*, depending on the contention situation. If the contention status is not severe, it is beneficial for alleviating the large variation of *cwnd* and increasing the throughput by just halving the congestion window.

4. PERFORMANCE EVALUATION

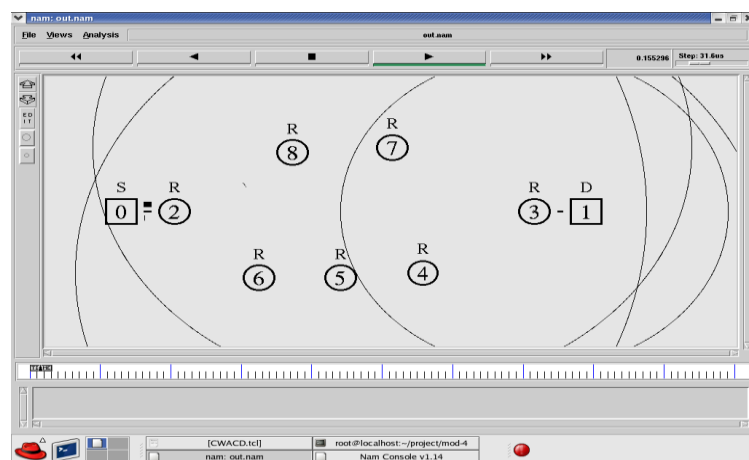
1. Simulation Results:

We implement the original TCP, the conventional TCP with contention control mechanism, and our proposed TCP CWA-CD mechanism in the ns-2 network simulator, and we compare the performance of these three mechanisms. We analyze the network performance and characterize the congestion window among these three mechanisms.

Experimental Parameters

Routing Protocol	AODV
Maximum Packet size	500
Maximum number of nodes	10
Simulation Time	10 μ s
Antenna Type	Omni antenna
Distance to adjusting nodes	150

Table 1: Experimental parameters



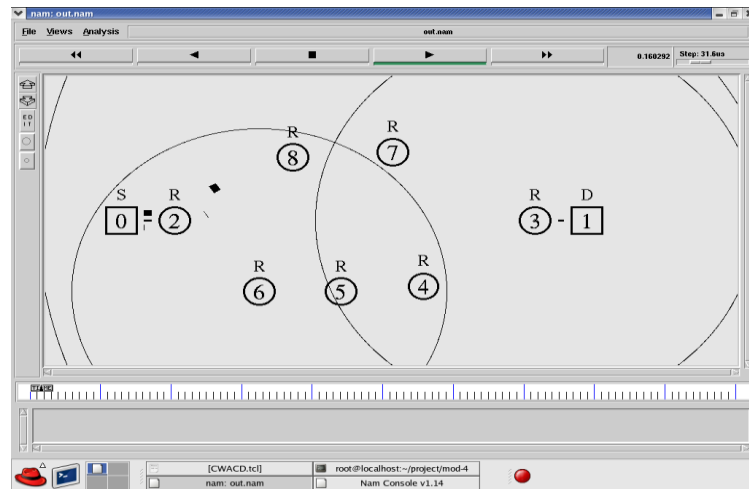


Fig 2. Simulation results

Time (μs)	TCP Throughput	Time (μs)	TCP-CON Throughput	Time(μs)	CWACD Throughput
0	0	0	0	0	0
1.5	1286.96	1.7	74.97	2	6700.04
3.5	1094.09	3.7	77.87	4	6902.72
5.5	852.92	5.7	78.65	6	6973.07
7.5	945.25	7.7	79.01	8	7006.49
9.5	1030.86	9.7	321.92	10	7027.41

Table 2: Throughput Comparison

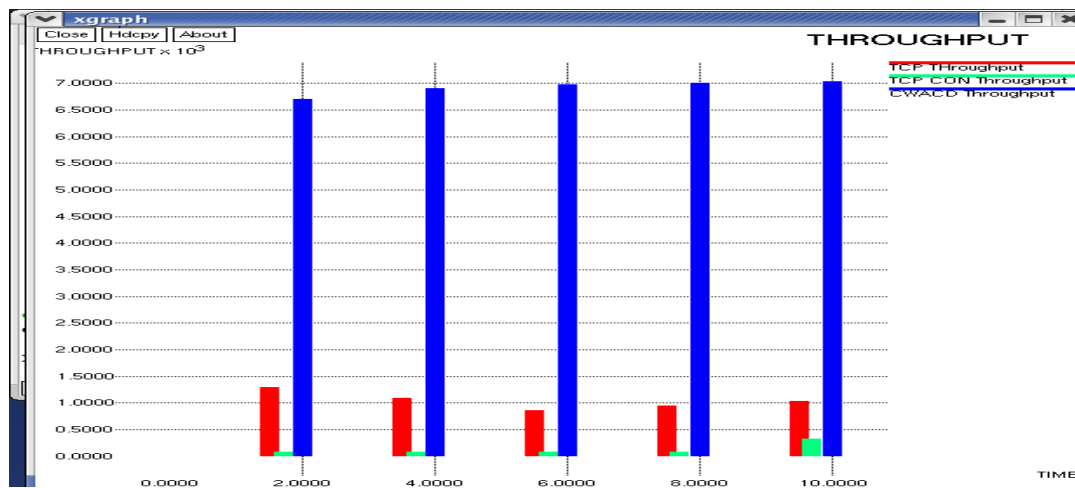


Fig.3 Throughput comparison

Time(μ s)	TCP Delay	Time(μ s)	TCP-CON Delay	Time(μ s)	CWACD Delay
0	0	0	0	0	0
1.5	993.97	1.7	339.97	2	973.80
3.5	1441.77	3.7	583.86	4	1857.39
5.5	1949.03	5.7	832.31	6	2736.99
7.5	3401.48	7.7	1081.59	8	3616.94
9.5	4622.96	9.7	6656.02	10	4496.14

Table 3: Average Delay Comparison

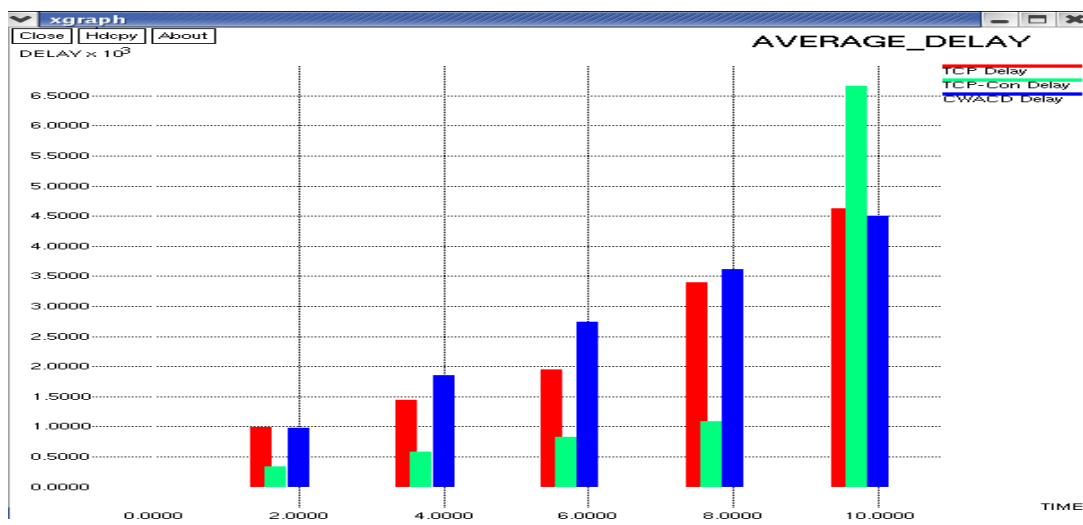


Fig.4 Average Delay Comparison

Time (μ s)	TCP PDR	Time (μ s)	TCP-CON PDR	Time(μ s)	CWACD PDR
0	0	0	0	0	0
1.5	0.1804	1.7	0.5182	2	0.9953
3.5	0.1641	3.7	0.0584	4	0.9976
5.5	0.1988	5.7	0.9447	6	0.9984
7.5	0.1801	7.7	0.8923	8	0.9988
9.5	0.1652	9.7	0.3128	10	0.9991

Table 4: Packet Delivery Ratio Comparison

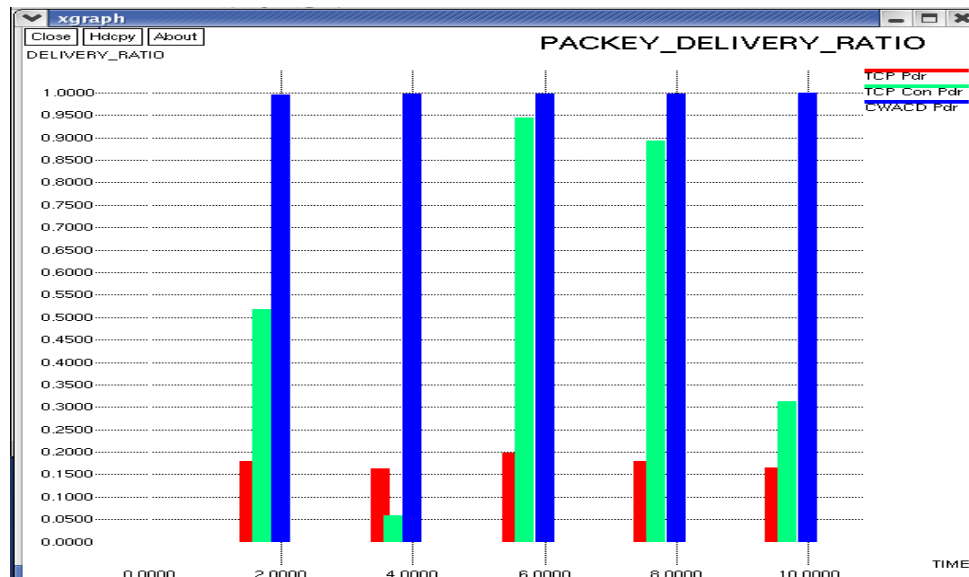


Fig.5 Packet Delivery Ratio Comparison

Fig.3 show that the *throughput* value of the TCP with CWA-CD is more stable. Also fig.5 shows that packet delivery ratio is also gives better performance by using our proposed mechanism.

5. CONCLUSION

In order to achieve high end-to-end throughput, there is need for coordination between TCP and MAC layer. Congestion control mechanisms, such as those in transmission control protocol (TCP), regulate the allowed source rates so that the total traffic load on any link does not exceed the available capacity. Any packet loss is due to network congestion is no longer valid in wireless networks, TCP performs poorly in such networks. From above algorithms it is clear that more solutions are needed to overcome congestion problem. Congestion metrics still remains a great challenge for the future work. To set the congestion window to its optimal value to utilize the whole bandwidth and reduces congestion ratio new algorithms are to be introduced. So the idea is to dynamically adjust the congestion window to improve TCP performance. The mechanism which we proposed does not consider mobility factor. It mainly focuses on link contentions. The main source of link unreliability in mobile adhoc network is link failure due to mobility. To improve the network performance of the network we give the collective considerations of these factors in our future work.

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