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A Review on Improvement in TCP Congestion Control Mechanism in MANET

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***Abstract*— Congestion control is a key problem in mobile ad-hoc networks. The standard TCP congestion control mechanism is not able to handle the special properties of a shared wireless channel well. In particular the frequent changes of the network topology and the shared nature of the wireless channel pose significant challenges. In MANET nodes have forward each others packet through the network without any fixed communication 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, Medium 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 can't reach to its maximum value as in wired network. Packet loss occurs at MAC layer due to congestion.**

So the idea is to dynamically adjust the congestion window to improve TCP performance. We studied congestion aware parameters like end to end delay, packet loss, Throughput and network overload.

***Keywords*— Bandwidth delay product, Congestion Control, Contention detection, , channel utilization , Mobile Adhoc network**

I. Introduction

A wireless ad hoc network is usually defined as a set of wireless mobile nodes dynamically self-organizing a temporary network without any central administration or existing network infrastructure. **C**onventional TCP mechanisms encounter several problems and yield poor performance in Ad Hoc network environments. 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. Mobile nodes have limited transmission capacity, large number of packets flooded in the network degrades the network performance , network congestion occurs. More packet loss occurs because of congestion in network.

Congestion is the dominant cause of packet loss in MANET. Many problems occur in transmission due to congestion in MANET [II]. To answer those challenges, many congestion control algorithms in MANETs were proposed[III].

II. Problems Due To Congestion

Wireless nodes communicate with each other over shared media. The number of packets sent to the network is greater than the capacity of network. When too many packets are present in a part of a subnet, the performance degrades this situation is called as congestion. Many problems occur due to congestion in network.

A. Hidden Terminal Problem

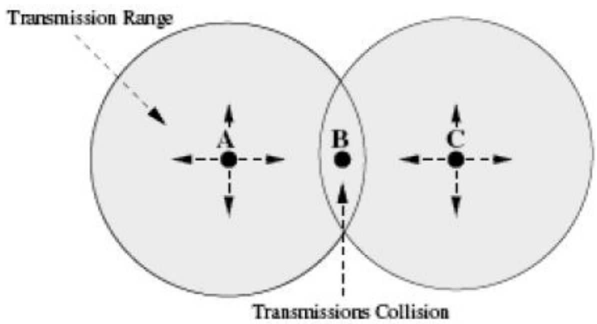

Fig. 1 Hidden Terminal Problem

A typical hidden terminal situation is depicted in Figure. Stations A and C have a frame to transmit to station B. Station A cannot detect C's transmission because it is outside the transmission range of C. Station C (resp. A)is therefore "hidden" to station A (resp. C). Since A and C transmission areas are not disjoint, there will be packet collisions at B. These collisions make the transmission from A and C toward B problematic.

B. Window Overshooting Problem

During a cwnd upgrade and normal data transfer step, cwnd overshooting (phase 1) causes a TCP network to be overloaded soon (phase 2). In this situation, a large number of data segments need to be transferred, and severe MAC contentions may accordingly occur. As a result, many segment losses may occur (phase 3), and these segment losses trigger retransmission timeouts (RTOs; phase 4) and subsequent slow start (phase 5) at the TCP source node. Data segments again start to be injected into the network (phase 6), with a lower transmission rate. However, soon, an increase in the cwnd will exceed an appropriate level in accordance with the *real* BDP, and it causes a return to phase 1. The TCP cwnd value overshoots and frequently resets in the problem cycle, and a large variation in the cwnd significantly reduces the throughput.

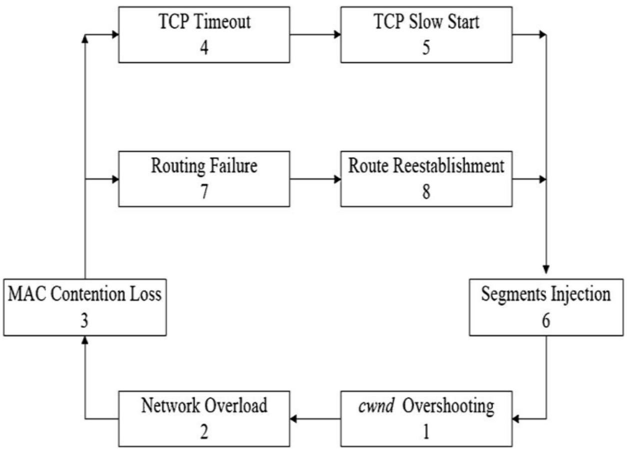

Fig. 2 Window Overshooting Problem

C. Network Interference problem

Reduction in signal strength causes network interference . Since communication over the wireless links takes place in a shared medium, interference can occur at a node if it is within transmission range of more than one station. In order to prevent such collisions, coordination among the conflicting stations is required.

D. Network Partition

The main reason to network partition is nodes mobility. Nodes mobility is energy constraint operation. Ex. As shown in fig. Suppose dotted lines are links between nodes .

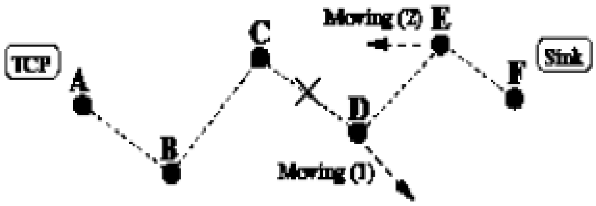

Fig 3. Network Partition

If node D moves away from node C then the network is partition into two parts and two separate network components are form.

E. Power constraint

Batteries carry by mobile nodes has limited power supply,so they require additional power to store and forward packets.

III. Available Solutions

By examining TCP performance on MANET it is identified that TCP can not distinguish between packet loss occurs due to route failure and network congestion.

A. TCP Congestion Window Adaptation-contention detection Mechanism(CWA-CD Mechanism)

Problem Identified: Xin Ming Zhang, Wen Bo Zhu, Na Na Li, and Dan Keun Sung [1] propose a solution on TCP window overshooting problem.
Solution Proposed: They split the real round-trip time (RTT) into two parts: 1) congestion RTT and 2) contention RTT. the contention RTT has nothing to do with the BDP and that the BDP is determined by only the congestion RTT if a link with the worst contention status does not lead to link breakage. An inadequate use of the contention RTT causes a TCP congestion window overshooting problem. 2) define a variable, variance of contention RTT per hop (*VCRH*), to evaluate the degree of link contentions. First, it can represent the degree of link contention. Second, the variance is a random variable that reflects the contention situation

observed during the recent observation window. Third, the variance can also reflect the status of a bottleneck. 3)make a modification of the TCP congestion window adaptation mechanism. The CWA–CD adapts the *cwnd* value based on not only RTO and acknowledgement (ACK) but also the *VCRH*. It is timely and accurate, and thus, it is effective in limiting the congestion window size from overshooting.

They set a threshold parameter *VCRH_th*, and if the *VCRH* exceeds this threshold, the degree of contention in the network is regarded to be severe. Whenever a TCP source receives a new ACK, it updates the value of the *VCRH* before checking whether this value is larger than or equal to the *VCRH_th* value. If it is larger, *cwnd* is decreased by one MSS instead of an increase in the congestion window. This approach could effectively restrain the congestion window from overshooting. If the RTO expires, which implies that the network is in a bad congestion or contention status, we need to check whether the *VCRH* is larger than or equal to *VCRH_th* before halving the congestion window threshold(*ssthresh*) . If the *V CRH* is larger, the network status is regarded to be very bad, and they reset the *cwnd* to 2 ∗ MSS and enable the slow-start step.

But in this mechanism they does not consider the mobility factor. It does not totally fix the number of packet losses.

B. TCP Rate Control Mechanism Based on Channel Utilization and Contention Ratio(TCPCC Mechanism)

Xinming Zhang, Nana Li, Wenbo Zhu and Dan Kenu Sung proposes a TCPCC mechanism to improve TCP performance in MANET.

Problem Identified: The greedy property of TCP causes severe contentions in MAC layer and results in packet losses and degradation in network performance[2].

Solution Proposed: The CU (Channel Utilization) and (CR) Contention Ratio values are monitor at each node. The CU and CR values inserted into the packet header of data packet. When sender generates the data packets the CU and CR values are set to maximum (1.0) and minimum(0.0) respectively. After receiving data packet the node compares its own metrics with the values kept in packet header. If the CU value of any node is smaller than that in the packet header and CR is larger than packet header ,the node replace the corresponding fields in packet header by it's own value, then those fields are copied to ACK in destination . then the channel busy status is estimated through the CU and CR values in the ACK and adjust the congestion window size accordingly.

C. On Setting TCP's Congestion Window Limit in Mobile Ad Hoc Networks

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Problem Identified:

Setting TCP's congestion window limit (CWL) to a small value would increase TCP performance in mobile ad hoc networks (MANET). In this paper we address the problem of how to properly set this limit for TCP to achieve its optimal performance. To this end, they turn the problem of setting TCP's optimal CWL into identifying the bandwidth-delay product (BDP) of a path in MANET[3].

Solution Proposed:

In this paper, apply the adaptive CWL setting strategy according to a TCP flow's current path, in a dynamic MANET.

They claim that the achievable BDP obtained in a chain topology is higher than that of a path with same length in a dynamic MANET, because it has been obtained a) by separating the nodes as far as possible, and b) with no competing cross traffic. Since these conditions cannot be guaranteed in a dynamic MANET, a lower (and better) BDP bound may exist. However, it is extremely difficult to quantify such conditions in a highly dynamic and variable network. Therefore, they can only use the achievable BDP obtained in a chain topology as an approximation of the BDP upper bound of a path in a dynamic MANET.

Two added benefits of using adaptive CWL can also be observed in our simulations: 1) shorter outgoing queue length and 2) fewer packet drops due to queue overflows.

simple adaptive CWL setting strategy is useful in preventing TCP's congestion window overshoots. Adaptive CWL rule is generally applicable to *any* path in MANET, and its performance is usually better than that of a small fixed CWL setting.

D. TCP-CDR: An End-to-End Scheme for TCP over Mobile Ad hoc Networks:

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Problem Identified:

End-to-end scheme require the modification of TCP/IP protocol stack at the end node, which poses a serious limitation for their deployment[4].

Solution Proposed:

This paper propose a true end-to-end scheme that does not mandate
any modification on the TCP/IP stack at any node. This scheme is TCP-CDR, to reflect means three enhancements in TCP- Congestion
window limit, Delayed ACK and maximum RTO limit. This proposed scheme is compared with Few and TCP-AP as well as a few other state-of-the-art schemes.

A. Congestion window limit:

In mobile ad hoc network the routing path changes swiftly so RTEC of the path cannot be obtained immediately when nodes are moving fast. In addition, the value of RTHC may not be available if the routing protocol is not DSR. Therefore, this paper purpose to use a constant value of congestion window limit

B. Delayed ACK

Dynamically adjusting delayed threshold is not suitable for MANET, because in these environment location of nodes alter swiftly. The signals can not track the current status of network. Moreover, this feedback control requires additional processing in TCP protocol stacks, wlhich has a negative impact on the energy performance of the mobile nodes and makes protocol stack deployment more difficult. Therefore, in this mechanism delayed ACK value kept as constant.

***C.* Maximum RTO limit:**

In this mechanism limit the Retransmission Time Out to low threshold for fast recovery invoked by link failure, packet loss or network congestion.

The TCP timeout value is obtained by calculating RTT(Round Trip Time) value of previously transmitted TCP packets.

E. Cross Layer Congestion Control in AdHoc Wireless Network:

Dzmitry Kliazovich, Fabrizio Granelli *Department of Information and Communication Technologies, University of Trento, Via Summarise 14, I-38050 Trento, Italy Received 18 February 2005; accepted 5 August 2005 Available online 31 August 2005[5].

Problem Identified:

The paper presents the problem of performance degradation of transport layer protocols due to congestion of wireless local area networks. Congestion occurs when the amount of data sent to the network exceeds the available capacity. Such situation leads to increased buffer space usage in intermediate nodes over the data path,
leading to data losses in case of shortage of resources. Transmitted data start to be dropped when available buffer resources, which are physically limited, are exhausted. Such situation decreases network reliability in the sense of service provisioning for data communications. Transport-level protocols improve reliability by implementation of different error recovery schemes. However, they could lead to excessive data retransmissions, reducing an important parameter such as network utilization, while at the same time increasing latency in data delivery.

Solution Proposed:

This paper targets the core reason for network congestion—the amount of traffic emitted to the network. For such reason, the proposed solution for congestion avoidance is to control (and possibly optimize) the amount of traffic being sent onto the network, considering limited availability of network resources.

C3TCP- Cross layer Congestion Control in TCP:

Sender node N1 initiates the transmission by sending a TCP data packet to node N4 over the string topology.

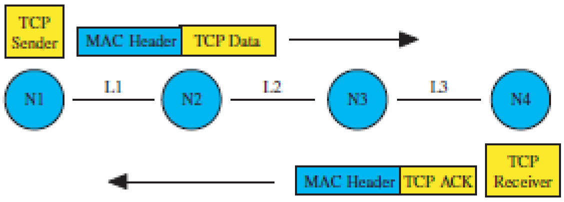

Fig.1 C3TCP usage scenario: TCP connection over 3-hop Wireless network.

Upon reception of the TCP data packet, the link layer of node N1 performs bandwidth and delay measurements for link L1. Then, it includes the measured information into the corresponding optional fields inside the MAC header. Node N2, after the reception of the data frame from node N1, performs the same measurements for link L2. Then, it takes the minimal value for the measured bandwidth of links L1 and L2 and updates the bandwidth option in the MAC header. Delay experienced by the data on the link L2 is summed with the delay on the link L1.
When the TCP data packet reaches the destination node N4, its MAC header contains bandwidth and delay experienced by the packet on the path through links L1–L2–L3. TCP receiver in N4 replies with TCP ACK back to the sender indicating successful data packet reception. This TCP ACK is also encapsulated by link and physical layer headers, including the bandwidth–delay information obtained by N4 during TCP data packet reception. Such information is simply echoed back using the appropriate optional fields. Upon the reception of the TCP ACK packet, sender node N1 will have the bandwidth and the delay for both transmitted TCP data and TCP ACK packets. Based on the obtained information, the sender can adjust the outgoing traffic using calculated bandwidth–delay product. The bandwidth is taken only from TCP data packet propagating in forward direction, while the delay is obtained as a sum of propagation delays of TCP data and TCP ACK packets.

Conclusions

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. Given the reasons, almost all the proposed schemes attempt to achieve better TCP performance with either of the two ideas: TCP should be capable of distinguishing non congestion- related packet losses from congestion caused packet losses such that corresponding actions can be taken to deal with the losses; or non-congestion-related losses should be reduced such that TCP can work normally without any modifications. Interestingly enough, there seems little study attempting to combine these two ideas.

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. It is quite important to obtain an optimal approach that combines related parameters collected from physics layer, MAC layer, even higher layer to measure the congestion status. Congestion control mechanisms will improve the performance of wireless ad hoc network greatly though the performance of network is poor. To set the congestion window to its optimal value to utilize the whole bandwidth and reduces congestion ratio new algorithms are to be introduced.

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