A Review of Congestion Control with TCP Friendly Rate Control and Queue Management on MANET

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***Abstract*— The Mobile Ad hoc Network (MANET) constructs the limited range wireless communications model in which nodes construct a temporary network and communicate with each other. It's communication completely depends on the intermediate nodes and the bandwidth they can provide. As the resources, routes, and bandwidth are limited MANET finds difficulties for communication when high traffic occurs and cause congestion. Congestion is one of the essential problems being identified in MANET as it reduces the network performance. The real-time data transmission in MANET is relying on the traditional TCP protocol which does not manage the congestion efficiently. However, congestion control techniques utilized through TCP are insufficient for this kind of networks due to node mobility and dynamic topology changes. In this paper, we present a review of the congestion control technique of MANET and how effective TCP congestion control and queue management are in managing and maintaining network congestion. We also explore the existing approaches and their approaches in congestion control over MANET.**

***Index Terms*— Wireless, Congestion Control, TCP, Rate Control, Queue Management, MANET.**

I. Introduction

The characteristic of a wireless network which constructs a temporary network on demand through self-configured parameters over a group of a wireless device in its communication range defines the Mobile Ad Hoc Network (MANET). They communicate each other through a wireless mode by discovering dynamic routes and without any centralized control. In essence, the infrastructure is low and inexpensive, and the quick process characteristics of MANET provide a commitment to use in a variety of areas. Due to the dynamic topology of MANET, it is difficult to maintain the current path to improve network performance. Mostly congestion causes packet loss and it takes place because of the "number of packets sent" into the network is additional than the bandwidth competence within the network. There are other factors that cause packet loss, for instance, the "mobility", "link failure", "interference", etc. However, if proper congestion control is not executed, the network collapses and data is not transmitted. To solve this problem, a lot of congestion control algorithms comprise of being proposed for MANET [1], [2], [18]. In the rest of the paper we follow the naming convention for "Wireless Network as *WNet*", "Routing Tables as *RTab*, "Queue Management as *QMgmt*", "Congestion Control as *CCtrl*", Congestion Window as *CWin,* "Packet Loss as *PL*oss", "Rate Control as *RCtrl"* , *"*Wireless Link as *WLink",* and "Routing Protocols as *RPrt*".

Currently, MANET utilizes several routing approaches and the entire of these algorithms are largely categorized into two types as, " Proactive Routing" and "Reactive Routing" approaches. The routing protocol that retrieves and stores above single route in the *RTab* for every destination node is called a "multipath routing protocol". In wireless scenarios, the roaming of the roots because of node movement and the *WLink* used for data communication is naturally unpredictable and leads to error. Consequently, we use the multi-path route protocol [3], [4] to minimize the disadvantages of the routing protocol. The "Multipath routing protocols" are utilized to improve dependability through guarantee the accessibility of supported routes at any time through transfer the identical packet and fault tolerance on everyone path. It can, in addition, be utilized to make available "load balancing", in this manner it reducing the congestion of a single path caused due to heavy network traffic.

TCP *CCtrl* is well appropriate for the Internet, and for MANET, the similar TCP does not apply because of node mobility due to certain properties such as "node mobility" and "shared wireless multihop channel" [5], [6], [9]. Data delivery through an unreliable shared media can resulting in transmission and *PL*oss. The delay in packet transmission or *PL*oss is originated with the routing changes that have to be not misinterpreted as congestion.

Congestion on the Internet typically concentrates on a particular router, but the collective medium of MANET congestion does not overload the mobile node, however, it affects the entire coverage area. Packet loss that is not basis through network congestion because of packet routing changes should not be mistaken for TCP congestion. This is able to initiate an incorrect response to TCP *CCtrl* [10]. In addition, it is more difficult to monitor *PL*oss due to changes in its transmission time and round-trip times. MANET differs from wired networks in features, for instance, the "half-duplex links", "channel noise", "mobility", and

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"hidden terminal" issues. Thus, these differentiate the *RPrt* utilized over MANET.

Everyone node in the MANET can use "TCP" or "UDP" as their transport protocol supporting on the category of application. On the other hand, TCP has been enhanced to create it appropriate for functioning in a wireless situation. TCP-enhanced surveys [6], [7], [8] in *WNet* have established that TCP is influenced through mobility and low-level protocols. Dissimilar TCP that regulates the delivery rate according to traffic, "UDP" is believed a "greedy protocol". So various people at rest think that TCP can transmit its multimedia traffic to keep the immovability of the Internet [12], [13]. Nevertheless, due to TCP in the dynamic changes in the network does not respond smoothly, especially in the wireless environment where TCP-hosted multimedia applications which generate high traffic rate shows low-quality services.

This paper is categorized as follows. Section-2 presents the "Congestion Control Mechanism" in MANET. Section-3 gives a comprehensive review of "TCP-Friendly Rate Control" for congestion control and section-4, we provide the review on "Queue Management" and its role in *CCtrl* in MANET. We conclude in a review of congestion control in Section-5.

II. Congestion control Mechanism In Manet

The majority of the earlier researchers considered and estimated the performance of the transport protocol separately commencing for the routing protocol of MANET [13]. Recent researchers have begun to look at interactions among transport protocols and other networking layers [15], [16]. There have been various attempts to study [16], [17] the correlation between TCP and other MANET routing protocols, however, there is still congestion problem because of a large number of traffic.

Adjusting the data rate utilized through everyone sender is necessary to avoid network overload, where multiple senders contend for link bandwidth. After the packet arrives at the router and it cannot be moved then it dropped. Several packets are discarded when too many packets arrive at network bottlenecks. Thus, discarded packets will travel for long distances, and other lost packets will usually trigger retransmission. This means that additional packets are forwarded to the network. Network throughput also deteriorates because of network congestion. If there is no proper *CCtrl*, then the chances of network collapse are almost no success in data transmission [18], [19].

A. Impact of TCP Congestion Control Scheme on MANET

MANET is a wireless dynamic network that communicates with nodes "without a fixed infrastructure" and " dynamic topology". The "Routing protocols" and "Congestion Control techniques" considered for wired networks not able to be functional to MANET. To maintain the real-time data communication with minimal delay, the center of attention on congestion and routing of MANETs. TCP is the mainly excellent preference for dependable data transfer. However, the difficulty is that congestion control method exploited through TCP not able to be useful to MANET. TCP not able to make different among packet losses because of congestion from the losses caused by connection errors. When *PL*oss happens, it believes it to be because of the overload and reduces its overload window [20], [21], [24]]. This leads to a degradation of the MANET performance. There are several topics that necessitate additional research. Several of these topics consist of "security", "topology control", "QoS", "routing", "power management", "traffic control", etc.

TCP is the most widespread protocol on the Internet developed specifically for *WNet*. In the *WNet* the performance of TCP is additionally significant since in such networks the likelihood of the error rate is extremely more. After *PL*oss happens, the sender TCP directly reduces the congestion overload window exclusive of examining the explanation for *PL*oss. When a *PL*oss happens because of the connection errors, the decline in the *CWin* outcomes in a decline in the data transfer rate. This function influences the throughput of the network. Because of this difficulty in TCP, the existing AODV protocol does not work well if it is run using the past TCP version, such as "TCP Reno", "TCP-Vegas", etc [22], [23]. For this reason, MANET's performance is concentrated. In order to get better the concert of MANET, we require designing an intellectual congestion control scheme for TCP that identifies the motivation for *PL*oss and then decides whether or not the window is to be reduced.

B. Congestion Control Approaches in MANET

As the congestion overload origins a huge loss for the network in conditions of "throughput" and "energy consumption", the beneficiaries are focusing on avoiding congestion in MANET. It can be classified as follows into the following category.

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(a). Prevention for Congestion Control

The data *RCtrl* scheduling is a fraction of a node specifically activated to monitor the receiving and delivering packets throughout the communication. It also acquires occupied dependability for the dynamic *QMgmt* at the time of the necessitate, that is the executing the process for "ordering of packets", "controlling of packet drop mechanisms", "maintenance of the priority of the packets" and others when changing the priority dynamically in the network.

Predictive *CCtrl* will be additional effective if this can be identified extremely early. There are a number of mechanisms for distinguishing mechanisms, for example, "queue length-based congestion detection", "throughput-based congestion detection", and "round-trip time-based congestion detection". This is the second action in congestion detection and avoidance mechanisms. In subsequent to congestion detection, how we notify congestion to the transmitting node is the most important issue. Two measurement techniques are "implicit and explicit", are recognized techniques for "congestion notification". Implicit techniques can diminish the congestion overhead of data communication, although for a while an explicit mechanism executes enhanced when evaluated to implicit mechanisms.

The process of detecting congestion is completed at several nodes, a "congestion avoidance algorithm" is executed at the source node. It mostly focuses on the rate modification of the flow of the transient solution of the transport layer. However, in some cases, it is possible for the source to switch packets in the other direction, if potential, through maintaining the similar flow rate sustained by means of changing the routing algorithm. However, because repeated congestion has a significant impact on network throughput, you will not get better results.

Grundy et al. [17] proposed an algorithm facilitate detects congestion in the network and moves traffic to fewer congested areas. This technique consists of the "social, delay" and "buffer metrics" of the node and the self-network [38]. Their adaptive forwarding protocols are "dynamic" and "flexible". It functions as a clean "contact-based protocol" in short congestion situations except as a high supply in high congestion situations. This explanation is not effectual while the network is congested.

Kelly et al. [25] primary established mathematical impressions and process of functional studies for example "shadow pricing" and "proportional fairness" in *CCtrl* research. The authors build an innovative hypothetical framework that believes together "fairness" and "stability" for *RCtrl* problem investigation. Everyone algorithm for rate control in this framework be able to be seen as a solution to the problem of most favorable rate allotment of usefulness functions. These algorithms are classified into two classes as, "basic algorithms" and "dual algorithms", which can be understood as explicit ratios based on congested display feedback signals and shaded pricing. The terminal *RCtrl* algorithm of TCP and the packet discard algorithm of ATM are examples of "primal algorithm" and "dual algorithm", respectively. This effort makes available a common prototype for the design of *RCtrl* plans that it be able to be effectively pursued wireless network.

D. A. Tran et al. [26] proposed a work as "Congestion Adaptive Routing in Mobile Ad hoc Networks". In the study, it proposes a "congestion adaptive multipath routing protocol" to raise throughput and decline congestion in MANET. If the standard load on an existing link enhances ahead of the characterized threshold and the offered bandwidth and remaining battery energy falls underneath a described threshold, it is scattered over the dependable multipath to diminishing traffic load during traffic congestion.

(b). End-to-End Congestion Control

For an "end-to-end congestion control" approach [27], [28], the network layer does not make available explicit maintain for the transport layer. Also, the being thereof network congestion overload necessity be experiential through the end system on the basis of "network behavior", "packet loss", "packet arrival delay", "jitter", and so on.

When a TCP connection is initiated, the *CWin* is typically assigned a value of 1. The bandwidth available for the connection can be a lot outsized than the "Maximum segment size (MSS) " for every "Round trip time (RTT) ". The TCP Sender carry on to increase the "baud rate exponentially" pending a loss happening occurs. Later than the loss notice from the receiver, the transmitter node executes the flow control mechanism. The "Additive Increase and Multiplicative Decrease (AIMD)" mainly utilized the approach. This is a united approach of two components of the algorithm as, "Additive Increase to achieve better throughput" and "Multiplicative Decrease to detect congestion". Additive growth supervises the *CWin* in such an approach that the effectiveness of the network is taking the full advantage. It also tries to improve the throughput rate by growing the *CWin* size with unchanging additional elements. This part of the algorithm is executed until convenient is no congestion notice command received from the caller region.

III. TCP-Friendly Rate Control For Congestion Control

Congestion control in the wired network is performed by means of a "one-to-one" and "network-layer mechanism". The Rate control of a *WNet* is similar in some respects to *RCtrl* of a wired network, but with distinctive requirements and limitations. First, nodes in a wireless channel cannot transmit or receive at the similar instance. Second, there is no essential situation to identify and notify congestion. As an alternative, all nodes have comparable privileges to handle congestion. Third, *WNet* nodes severely limit capacity and energy. The "Pervasive communications" are progressively additional being transmitted through mobile devices and individual digital supporters. This inclination is now experiential by mobile phone provision suppliers who have determined considerable increases in multimedia traffic. To enhanced communicate multimedia traffic, the IETF has normalized the innovative "TCP Friendly Rate Control (TFRC) protocol" [29].

The "TCP-Friendly Rate Control" is a congestion control mechanism for unicast flows that participate with TCP traffic in the best-effort Internet environment [13], [30]. This mechanism has been integrated into one of the possible congestion control methods, DCCP [2]. The main characteristic of TFRC is that it uses a TCP equation model with much less throughput change over time than TCP. This makes it further appropriate for multimedia applications for example, "audio/video streaming" or "voice over IP". TFRC retransmits the "TCP-based congestion control mechanism" all the way through an "equation model" from TCP computing. The flat rate variation, due to this load control mechanism, constitutes a superior candidate for the liberation of an efficient transportation provision to client and server multimedia applications. Nevertheless, in a media streaming situation, if multimedia servers are influential handing out and communication mechanism, this is usually not the situation for mobile customers. In fact, these consumers have restricted resources limited resources and are very perceptive to the processing of communications and systems when focusing on application layers.

The TFRC algorithm, in addition to the travel time and throughput estimation, requires the estimation of the rate of

*PL*oss. This loss estimation is calculated on the receiver's side and transmitted to the sender in a rate controlled manner. The initial loss estimation is important because it consents to the sender to calculate the send rate, which, as described in [31], and starts the receiver to correctly initialize the lost history events. In fact, subsequent estimates of the *PL*oss rate are based on the weighted average of the masses used from this event. As a result, initializing this structure has an effect on the transmission throughput and overall performance of the TFRC.

P. Dalal et al. [6] mitigate the problems of "cross-layer collaboration" among "802.11 ARQ link layer retransmission" and "TCP congestion control". The simulation is carried out for "AP-based WLANs" using various "error rates", "Automatic-Repeat-Request (ARQ)" repeat limits, and "multiple TCP flows". Even though, they concluded that ARQ successfully blocked the wireless loss of TCP to an assured level of error. Alternatively, ARQ enhances the RTT and can obstruct with TCP *CCtrl* variants based on RTT estimates. In addition, ARQ cannot avoid wireless loss in excessive network situations with congestion and requires congestion overhead. In general, in order to avoid duplicate retransmissions in common layers and to take advantage of ARQ competence, a cross-layer mechanism must be followed.

T. Issariyakul et al. [8] illustrates a "phase-type discrete-time Markov chain" for obtained a "probability density function" for the quantity of ARQ reiterate essentially for flourishing TCP segment transmission more than a multi-hop *WNet*. The authors explore the likelihood of success for dissimilar ARQ procedure and link error rates. Barman et al. [31] proposed an investigation by amendment the broadcasting power and ARQ reiterate limits. They wind up that all mechanisms should lower the loss rate but find a negotiation among the cost and benefit.

S. Choudhury et al. [12] consider the consequence of "payload length" and "ARQ reiterate limit changes" on reachable TCP throughput. Common infrastructure is the co-survival of voice and data traffic in a WLAN is appraised for various noise stages through the "QualNet simulator". The authors finish off that loss protective due to high ARQ retry limits results in reduced throughput. For networks with high loss counts or high contention for the number of nodes, ARQ retransmission is essential for many applications where the loss is not acceptable, but multimedia applications can often tolerate high loss rates.

Zhai et al. [22] proposed a "Rate-Based Congestion Control (RBCC)" adopting a "leaky bucket algorithm". In this method, the subtitle is additional along through the path as an original response field used through everyone intermediate node. This node provides information about the maximum flow rate on every node. The study of the channel utilization, the occasion interval during which the media is not inoperative. This information is used to transform the recently additional response field. This will assist the source to determine the baud rate. All intermediate nodes maintain the particulars of the flow from beginning to end which they in a while calculating the convergence of equality.

Subramanian et. al. [32] proposes "MAC layer modification" and "loss-tolerance modification of TCP". It argues that "ARQ" can go ahead to setback fluctuations and condensed TCP throughput, rigorously limiting ARQ repeat and commence "Forward Error Correction (FEC)", most important to high-quality outcomes with TCP variants. Conversely, it does not want to change the TCP and instead try to adjust the ARQ repeat boundary as above as possible exclusive of "RTO" of the "TCP" flow.

IV. Queue Management For Congestion Control

The nature of network *CCtrl* is that the sender regulates its transfer rate in relation to the possible measurement of the underlying networks. It can be worked based on utilizing the two modules. One of the source algorithms that dynamically regulates the transfer rate in reaction to the density. Another one is the "link algorithm" that wholly or clearly transmits information concerning measuring present densities to resources that use this link. On the existing Internet, the "source algorithm" is performed by TCP, and the "link algorithm" is achieved by "active queuing management schemes (AQM)" on routers. Few illustration of AQM are, "RED" [33], "REM" [34], "AVQ" [35] and "Yellow" [36] . The TCP describes how the source transmission rate is set while the AQM plans define how to define and update probable measurements.

In "queue-based approach" the congestion occurs with a "standard or instant queue length" and the "control objective" is to become constant the "queue length". The disadvantage of queuing formats is that a necessary necessity. Projections based on the rate of use of the link, the determination of the level of transportation, and measures derived from the closing *RCtrl*. The "Rate-based designs" can make available initial response for freight [11], [19], [20], [22]. Other AQM initiatives combine queue lengths and input rates to determine congestion and accomplish a trade among queue constancy and accountability.

The existing "TCP / AQM algorithms" [5] suppose that the *PL*oss is because of network congestion. Nevertheless, this "TCP /AQM algorithm" for both kinds of networks is not enough. In *WNets*, the communication comprises inherent features that influence the concert of transport protocols together with "variable bandwidth", "corruption", "channel allocation delay", and "asymmetry".

The entire of these basis makes a severe non-congestion *PL*oss. The nonspecific TCP protocol informs the source to diminish the communication rate simply as soon as *PL*oss because of network congestion occurs. As a result, the TCP protocol of both kinds of the hybrid network should not simply detect *PL*oss, excluding also detect the cause of *PL*oss. Also, the "degree of statistical multiplexing" more than a *WLink* is dissimilar beginning the number of wired links. For example, a *WLink* has multiple flows instead of hundreds of flows through a wired link. Conventional "TCP/AQM schemes" are fine-tuned for wired links with high-level statistical multiplexing, but may perhaps not work fine for *WLinks* with multiple flows [37].

RED is the most common "queue-based AQM technique" [33]. In RED, packets are arbitrarily dropped earlier than the buffer is fully populated, and the likelihood of dropping enhances as the regular queue length increases. As the source rate increases, the queue length increases and additional packets are dropped. This will reduce the source rate. The RED arrangement has been a difficulty ever since it was primary proposed, and several researchers encompass endeavor to solve it in [6]. At the same time the occurrence of determined queues represents congestion, the length provides modest information about the strictness of congestion. As a result, there are several advantages to separating queue length from congestion management.

Li Qiang Tao et al. al [24] is described in the proposal as "ECODA: Improved congestion detection and avoidance for multi-class traffic in sensor networks". They proposed a new "energy-efficient congestion control scheme" for sensor networks called "ECODA - Enhanced congestion detection and avoidance" consisting of three mechanisms as, 1) "use double buffer thresholds and weighted buffer differences for congestion detection", 2) "a flexible queue scheduler for packet scheduling", and 3) "Bottleneck-Node-based source rate control scheme".

S. Athuraliya et al. [34] proposed REM, which works around the "queuing and rate-based scheme". The goal of REM is that together inputs around the "link capacity" and "queue lengths" approximately a determined intention, in spite of the number of consumers who have the link are stable. In REM, every output line holds a rate action as a possible measurement. The rate is restructured supported on the non-compliance of the rate i.e. the difference among the "input rate" and the "link capacity" and the lack of coordination of the queue, for example, the dissimilarity among the queue length and the preset goal. Similarly, the REM uses a possible markup function. REM is calculated from the performance measurement such as "packet loss", "queue length", or "latency". From the time when REM tries to continue the zero-number length in spite of the quantity of recent and it restrictions capability to manage the explosion of traffic.

The "Rate-based marking" make available initial reaction and take actions quickly if convenient rate difference among "input rate" and "link capacity". The improvements of this method are studied in [22], [25], [31]. Initial feedback is stronger in the existence of very little flows or in the variability of extended flows in the network. If exploitation is nearby to 100%, dispersion caused by little flows can lead to unattractive transients with exceptionally extended queue lengths that last for extensive periods. The "Queue Metrics" are not affected by the current queue reach and drainage ratios because queue length is a collective dissimilarity importance of the rate mismatch.

T. Henderson et al. [21] believe the relationship among *WLinks* and transport protocols and model the rules suitably for *WLinks*. The wireless links experience important loss of packets because of "bit errors" and "handoffs". The TCP stream can simply diminish its transmission loss due to network congestion, not in the case of wireless achieves. The innovative "AQM algorithms" are specifically anticipated for the wireless network.

Sagfors et al. [39] utilizes momentary queue lengths to measure congestion, and proposes a "deterministic drop strategy" for the packet throw away anticipation counter determined by "pipe capacity" and "TCP's rate half-policy estimates". Li and Liu [40] proposed an explicit "feedback scheme with AQM" to grip large-capacity delay products over *WLinks* and burst *PL*oss. A major problem with these scenarios is preventing a slow start exceed of the TCP connection. The exceeded occurs since TCP detects buffer congestion up to the maximum RTT after the buffer is filled and the first packet is dropped [38]. At this point, the transmission rate of TCP can be twice as much as the available bandwidth of the path, resulting in a lot of *PL*oss.

V. Conclusion

In MANET, group communication is a unique characteristic of various proposed functions, it is added to this transmit medium. Therefore, it is significant to keep away from congestion disintegrate in wireless multihop networks to achieve proficient congestion control. Congestion is a major problem in MANET that show the ways to packet loss and network performance humiliation. In all of the above mechanisms, congestion prevention technology shows that it only starts after congestion being occurred. However, some algorithms also implement congestion prevention mechanisms. However, congestion due to the buffer pool is not fully controlled, so we can see that TCP performance is lowered by motivating researchers to design algorithms that can overcome this problem. This review concludes in order to construct a resourceful congestion control on the basis of the queuing technique using the multipath routing mechanism in the mobile ad hoc network so that decrease congestion overloading of the network additionally as the forwarding of the overhead of the network and increase the packet delivery proportion the network.

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