International Journal of Scientific & Engineering Research, Volume 4, Issue 10, October-2013
ISSN 2229-5518

A Survey on Congestion Control Mechanisms In Mobile Adhoc Networks

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Abstract— Due to highly dynamic nature of Mobile ad hoc networks (MANET), predictability and design of efficient protocols and methodology to handle congestion proves to be a tedious task. Since issues and architecture of mobile ad hoc networks are very much different from their counterparts, so are its congestion control strategies due to frequent changes in network's topology. A noted congestion control mechanism is to notify source for the congestion in the network so that either it may pacify the transmission rate or look for an alternative option. It must be noted down that all the existing methodologies are capable to tell the source about the congestion problem as they use TCP. But in case of MANET, the packet losses due to link failure (due to its dynamic nature) are misinterpreted as packet losses due to congestion, and in the snapshot of a timeout, backing-off its RTO. This results in needless reduction of transmission speed due to which throughput of the whole network degrades. In this paper, we compare various congestion control mechanism used in MANET such as TCP Tahoe, TCP-Reno,TCP New Reno, TCP SACK, TCP FACK, TCP Vegas. Along with the above specified APCC, RED and strategical RED approach to handle congestion is also illustrated. The same is tried to resolve by using concept of explicit congestion Notification (ECN) which is an extension to transmission control protocol (TCP) and allows end to end notification of network congestion without dropping packets which is done conventionally in TCP/IP networks with a bit difference of additional bit and other methodologies available for the same have been discussed.

Index Terms— Explicit Congestion Notification (ECN), Mobile ad hoc Networks (MANET), Congestion control, RED, TCP, MANET, ECN.

1 Introduction

A Mobile ad hoc network (MANET) is a temporary self-organizing network of wireless mobile nodes without any existing infrastructure. It allows various devices to form a network in the areas where no needed infrastructure exists. Albeit, there are many problems and challenges that need to be resolved prior a large-scale establishment of a MANET, small and medium-sized MANETs can be easily established [4].

In this paper the problem of congestion control in MANETs is considered. In most wireless scenarios used, the devices communicate through some networking backbone in the form of base stations. On the contrary, an ad-hoc network does not have any infrastructure. Mobile ad-hoc networks are used in scenarios where no infrastructure is available, of which a very common example is, disaster relief scenario

Much research effort has been put into the ad-hoc network area. Various approaches have been proposed to perform routing in MANETs. It has also been noticed that the functions of transport layer needs to be adapted to the specific properties of MANETs. In particular the congestion control method implemented in the transport protocol used nowadays, i. e., TCP; do not deal properly with the specific effects occurring in MANETs [2].

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As a result, suitable congestion control is considered to be a key issue for mobile ad-hoc networks. Many congestion-related problems identified, includes drastic throughput downfall and other problems. They have been shown to evolve from the Medium Access Control layer, network, and transport layers, as discussed, in [2], [3] and [4]. There is a large variety of ideas on how to overcome the difficulties. In this survey paper, we provide a brief of existing attempts to solve the congestion problem in mobile multi-hop ad-hoc networks. There is no attention paid towards approaches aimed at improvising congestion control or TCP performance.

2 Congestion Control in Manet

Congestion control works very well in TCP over Internet. But ad hoc network exhibit some properties that highly affects the design of appropriate protocols in general, and of particularly congestion control mechanism. Due to the dynamic behavior, mobile ad-hoc network is highly problematic for standard TCP. Primary amongst the differing properties of MANETs is the frequent mobility of nodes and a shared, wireless multi-hop channel. Route changes due to dynamic nature as well as the inherently unreliable medium result in abrupt delay packet delivery and packet losses. These delays and losses must not be misunderstood as congestion losses. The usage of a wireless multi-hop channel permits only single data transmission at a time within the range of one node. Thus close links are not independent from each other. This influences the way network congestion revealed itself. Routers are dedicated hosts connected by high bandwidth channels. When congestion occurs on the network, it is usually concentrated on a router. On the contrary, congestion in ad-hoc networks affects a complete area because of the shared medium. Even though, it

International Journal of Scientific & Engineering Research Volume 4, Issue 10, October-2013
ISSN 2229-5518

depends on the network, the same happened with other reasons can lead to misinterpretation of TCP congestion control. Besides, noticing packet losses is much difficult, as transmission delay and thus also RTTs vary much more. The effect of a traffic flow on the network condition can cause severe unfairness between flows. Thus wireless multi-hop networks are much more intended to overload problems than traditional wired networks like the Internet. Therefore an appropriate congestion control is needed for network satisfiable performance.

In MANET, since there is no fixed infrastructure, there are no routers, and hence the mobile nodes themselves act as the routers. Congestion control methods [5] can be deployed on routers or node. In existing methodologies, the source is told about the congestion so that, either it may pacify the packet transmission rate or find an alternative which may not necessarily be an optimal route. TCP, one of the popular transport layer protocols, employs congestion control methods (time out) to inform the source about the congestion control problem.

3 Congestion Control Mechanism: Related Works

In this section we try to subjectively identify some of the current trends in the research for congestion control mechanisms.TCP optimization in MANETs have been investigated in several studies. TCP does not have any mechanisms that are designed to handle link failures. From the point of view of TCP, link failure and network congestion are same things. As a consequence, when portion of the network lags and some segments are dropped, Transmission control protocol assume that there is congestion in the network, and start dealing with the segment loss. TCP congestion control mechanisms have improved over time. The main versions of TCP are Tahoe TCP, Reno TCP, New Reno TCP and SACK TCP. Tahoe TCP is the first one and less frequently used. New Reno TCP and SACK TCP are widely implemented. We point the attention on other two TCP flavors, TCP FACK and TCP Vegas because they are the new flavors and are being implemented.

As discussed in [8], different variants of TCP are discussed which are illustrated here briefly-

3.1 TCP TAHOE

In Tahoe, whenever a TCP connection starts after a packet loss or starts normally, it should go through a process called slow-start. The cause for this process is that burst might overpower the network and the connection might not get initialized again. Most importantly that Tahoe detects packet losses by timeouts. Usually, repeated interrupts are costly so we have not fine grain time-outs which not usually checks for time outs [8].

3.2 TCP RENO

This RENO is based on Tahoe, such as slow starts and the coarse grain retransmit timer. It also adds some logic over it so that lost packets are detected sooner and the pipeline is not evacuated every time a packet is lost. RENO performs very well over TCP when the packet losses are minor. But when we have many packet losses in single window then RENO doesn't perform too well [8].

3.3 New RENO

New RENO is a slight modified version, over TCP-RENO. It is able to check multiple packet losses and thus is much better than RENO in the event of multiple packet losses. New-RENO also enters into fast-retransmit, when it receives numerous duplicate packets. It differs from RENO in that, it doesn't leave fast-recovery till all the data which was standing at the time it entered fast recovery is acknowledged. When the acknowledgement for the first retransmitted segment is received then we deduce which other segment was lost. New Reno consumes one RTT to detect each packet loss.

3.4 TCP SACK

TCP with Selective Acknowledgments is a modification to TCP RENO. It works on the problems face by TCP RENO and TCP New-RENO that is detection of more than one lost packets, and retransmission of numerous lost packet per RTT. SACK deters the slow-start and fast retransmits parts of RENO.

3.5 TCP FACK

Forward Acknowledgement is an algorithm that works on the SACK options, and activates at congestion controlling. FACK uses datum provided by Selective Acknowledgement to add better control to the inject data into the network while recovery, and is accomplished by counting the bytes of data in the network explicitly. FACK amplify congestion control by recovering data therefore obtaining exact control over the data flow in the network.

3.6 TCP VEGAS

Vegas detects congestion at an preliminary steps based on rising Round-Trip Time values of the packets which is not seen in other variants of TCP. Vegas is an implementation which is a modification of RENO. It builds on the principle that proactive method to tackle congestion is better than reactive counterpart [8]. It is tried to resolve the hurdle of coarse grain timeouts by suggesting a methodology which checks for timeouts at a very effective schedule. It also surmounts the problem of requiring enough duplicate acknowledgements to detect packet loss, and also propounds a modified slow start algorithm which prevents it from creating congestion in the network.

Apart from these approaches, in another work discussed in [1], an explicit congestion notification (ECN-based) access point congestion control algorithm called APCC (AP congestion control) is proposed. The main properties of APCC are: (i) Usage of wireless channel load and buffer queue length as congestion indicator parameters, APCC ascertains low

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packet loss rate, high throughput and low queue delay; (ii) APCC guarantees the up/down TCP fairness by marking the ECN bit in TCP DATA and ACK packets; (iii) Considering the wireless channel rate of each TCP flow, AP Congestion Control sets different ECN marking probability for each flow to achieve the time fairness and high network efficiency.

Similarly in an effort tried in [6], a new queue management approach is proposed on the RED (Random Early Detection) algorithm by monitoring the global congestion situation of an autonomous system. In order to observe the congestion situation of the system, traffic is generated between routers and a centralized unit. Routers are order to send packets regarding current output queue levels to the central unit which produces a overall view of congestion. The routers update their Random Early Detection parameters according to the congestion notification of the control unit [6].

In [7], a work proposed by author, very similar to former one specified, a modified approach is proposed to modify queue parameters in accordance with existing queue parameters and mitigate the delay and improves the throughput. Delay time can be reduced substantially if network length is more and sender and receiver are at sufficient distance and increase the throughput.

Furthermore, a comparative study of different variants of TCP used in MANET on the basis of Throughput v/s number of nodes for 5 and 25 connections in low mobility scenario as well as 100 and 200 nodes in high mobility scenario is available in [9] and illustrated below.

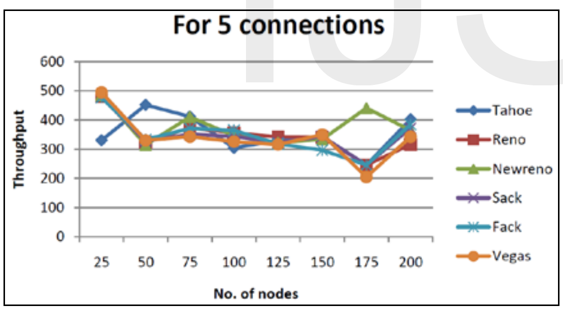

Figure1: Comparison of TCP variants with 5 connections in low mobility [9]

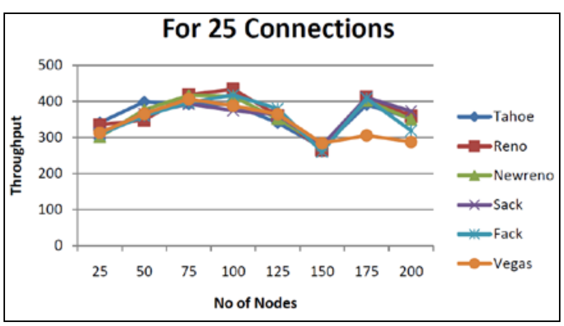

Figure 2: Comparison of TCP variants with 25 connections in low mobility [9]

Figure 1 and 2 are graphs of Throughput v/s Number of nodes for 5 connections and 25 connections respectively. As mentioned in [9], large variations are observed in the graph because TCP's performance in Mobile Ad hoc Networks is affected due to non-uniform network. Also the behavior of the underlying routing protocol used affects the performance of TCP.

Figure 3 and 4 are graphs of Throughput v/s Number of connections for 100 nodes and 200 nodes with high mobility. It is observed that approximately all the variants of TCP have similar performance except TCP Vegas. The performance of Vegas is similar to other flavors of TCP initially but later when, in the work illustrated in [9], it increases the number of connections, the performance degrades at an unexpected pace. When author in [9] increase the number of connections in a network (keeping number of nodes fixed) more packets are dropped in the network due to contention. Due to this behavior, it regulates the amount of data that it transmits in the network. Hence, Vegas achieve lower throughput as compared to other flavors.

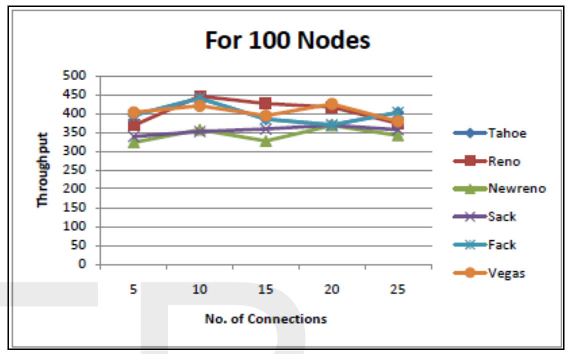

Figure 3: Comparison of TCP variants with 100 connections in high mobility [9]

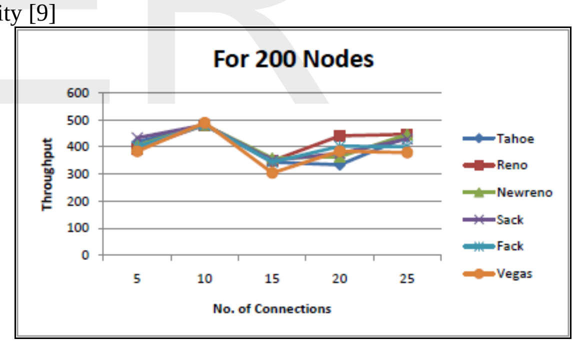

Figure 4: Comparison of TCP variants with 200 connections in high mobility [9]

4 CONCLUSION

Congestion control mechanisms discussed so far have their own pros and cons along with its complexities. Perspectives proposing improved transport layers for MANETs show two major trends, firstly, there are large numbers of protocols which try to improve, wide spread protocols, mainly with TCP. On the other hand many approaches willingly sacrifice compatibility to gain more freedom in protocol design and hence to even better fit the specific needs of MANETs. In this paper we presented a survey of, different approach as to handle congestion in MANET along with an approach presently deployed in wireless networks using concept of ECN. ECN

International Journal of Scientific & Engineering Research Volume 4, Issue 10, October-2013
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employs extra bits to avoid misinterpretation of packets but due to link failure as congestion. In our future work, we intend to use extra bits (ECN) to notify the sender of the severity of congestion. The sender, then based on severity of congestion would resize its congestion window by smaller or larger factor.

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