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Various versions of TCP over LTE networks: A Survey

Pooja Kumari, Dr. Yogesh Chaba

Abstract— **This review paper is about various versions of Transmission Control Protocols (TCP) used in LTE networks.TCP is used for congestion control in 4G networks. Now-a-days number of users of mobiles are increasing tremendously. Mobile has become an indifferent member of our lives. To manage such huge number of users we need a network that runs smoothly, without congestion.**

Index Terms— **Congestion Control, LTE, TCP, 4th Generation.**

I. Introduction

Wireless communication has seen tremendous development in last decade. Wireless communication dates back to the end of nineteenth century when the Maxwell equations proved that transmission of information can be carried out without the need of a wire [1]. A few years later, scientists such as Marconi proved that wireless transmissions may be a reality even for long distances. During the twentieth century, electronic and propagation discoveries gave way to many wireless transmission systems. Today a large number of wireless transmission technologies exists, while others are still under development.

The 4G has been developing with the goal of providing speed up to 20 mbps while supporting Quality of service (QOS) features [2]. The aim of 4G will be to replace the entire cellular network with a single cellular network worldwide which is completely standardized based on IP for audio, video and multimedia services. 4G systems will be developed with software defined radios, which allows the equipment to be upgraded to new services and protocols via software upgrades only [3].

4G can be implemented using 2 techniques-

1. Long Term Evolution (LTE)
2. Worldwide Interoperability for Microwave Access (Wi-MAX)

II. LTE

LTE is a standard for wireless communication of high speed data. It is based on GSM/EDGE and UMTS/HSPA network technologies leading to increased capacity and speed using a different radio interface together with the core network evolution [4]. LTE is developed by 3rd Generation Partnership Project (3GPP) and is specified in its release 8 Document series, with minor improvements defined in release 9. Features of LTE are

- Uses OFDM for downlink and single carrier FDMA for uplink to save power.
- Supports peak download rates up to 299.6 mbps and upload rates up to 75.4 mbps.
- Improved support for mobility.
- Supports packet switched radio interface.
- Simplified architecture.
- Supports both FDD and TDD.
- Increased spectrum flexibility.

Pooja Kumari, *M. tech (Computer Science), Guru Jambheshwar University of Science & Technology, Hisar, Haryana*

Dr. Yogesh Chaba, *(Professor) CSE Dept, Guru Jambheshwar University of Science & Technology, Hisar, Haryana*

III. Congestion control using TCP

Congestion is a state in which performance degrades due to the saturation of network resources such as communication links and memory buffers. As a result a network will experience a long delay, waste of system resources, or even network collapse. Network congestion has been well recognized as a resource sharing problem [5]. Congestion can be handled by employing a principle of physics: the law of conservation of packets. The idea is that do not inject a packet into the network until an old one leaves. TCP tries to achieve this goal by dynamically calculating the window size.

Congestion control using TCP consists of : Slow Start (SS), Congestion Avoidance (CA), and fast retransmit/fast recovery. The end point nodes detect congestion by increase in end to end delay. Retransmissions can further worsen the situation as more number of packets is injected into the network [1]. In the slow start phase, TCP sender gradually increases the congestion window (cwnd) size by one packet when an acknowledgment is received, until congestion is detected in the network. After detecting congestion, cwnd is reduced to half of the current window and the slow start process begins again. Congestion avoidance is employed in order to prevent excessive losses due to an exponentially increasing sending rate. Packets are eventually dropped when offered load increases above network capacity leading to reductions in congestion window by half which is called fast retransmit and fast recovery.

TCP assumes that all packet losses, or unacknowledged packets, or delays are caused by congestion in the network which is not valid for a wireless network, where packet loss are frequent and caused by poor channel conditions. Standard TCP does not work if the errors are not caused by congestion. Rather it reduces the throughput unnecessarily.

IV. VERSIONS OF TCP

TCP protocol has been extensively used in traditional wired networks to give a good performance at the transport layer. But TCP in its current form does not perform well in modern wireless networks where packet loss due to lost path can create performance problems.

A. TCP Tahoe

Early TCP implementations followed a go-back-n model using cumulative positive acknowledgment, requiring a timer to expire to resend the lost data. The TCP Tahoe added a number of refinements to the earlier implementations. The new algorithm include Slow Start (SS), Congestion Avoidance (CA) and Fast retransmit. In the SS algorithm, the reception of an ACK is considered as an invitation to send double the amount of data that has been acknowledged [6]. CA is triggered when congestion is detected. With fast retransmit, after receiving a number of duplicate ACK's, the packet is considered to be lost and retransmitted without waiting for retransmit timer to expire.

B. TCP DUAL

TCP Tahoe has delivered a great service to the internet community by controlling congestion. However, this solution has a drawback of straining the network with high amplitude periodic phases [6]. Wang and crowcroft [7] proposed TCP DUAL which enhances Congestion Avoidance algorithm. DUAL uses proactive congestion detection algorithm. It uses the queuing delay as a prediction parameter of the network congestion.

C. TCP Reno

TCP Reno incorporated the enhancements of Tahoe and modified the Fast Retransmit module to include Fast recovery. This enhancement prevents the communication pipe to go empty after Fast Retransmit. Therefore avoiding the Slow Start phase after a single packet loss. Fast Recovery works by assuming that each duplicate ACK represents a single packet delivery.

D. TCP New-Reno

One drawback of the TCP Reno's Fast Recovery is when multiple packet losses occur in a single congestion event [6]. The TCP New-Reno implements a small change in the Reno algorithm at the sender that removes the Reno's wait for a retransmit timer when multiple packets are lost from the window. This change manipulates the sender's behavior during Fast Recovery when a partial ACK is received that acknowledges some but not all the packets that were sent at the start of Fast Recovery. In New-Reno, partial acknowledgement does not take out TCP from Fast Recovery algorithm.

E. TCP Westwood

It is a sender side only modification of TCP New-Reno that is implemented to better handle large bandwidth delay product path, with packet loss due to transmission or other errors. TCP Westwood relies on extracting information from ACK stream to better set the congestion control parameters: Slow Start threshold and Congestion Window. This algorithm uses a variable "Eligible Rate" which is estimated and used by the sender to update the SS threshold and cwnd after a packet loss.

F. TCP SACK

SACK is abbreviated for Selective Acknowledgement. Adding SACK to TCP does not change the basic underlying algorithm. TCP SACK preserves the properties of Tahoe and Reno of being robust when multiple packet loss occurs. During Fast Recovery, SACK maintains a variable called pipe that represents the estimated number of outstanding packets. The sender sends only the new or retransmitted data when the estimated number of packets in the path is less than cwnd. When the sender sends s new packet or retransmits an old packet, variable pipe is incremented by one and is decremented by one when the sender receives a duplicate ACK with a SACK option. Use of variable pipe determines when to send a packet and which packet to send. The sender maintains a scoreboard for the packets which are delivered, lost or outstanding.

G. TCP FACK

FACK stands for Forward Acknowledgment. SACK provides the receiver with extended reporting capabilities but it does not define any particular congestion control algorithm [6]. FACK uses recovery procedures which use additional information available in SACK to handle error recovery and the number of outstanding packets in two separate mechanisms. The error recovery part of FACK uses selective ACKs to indicate losses and it has a direct means for calculating the number of outstanding packets using information extracted from SACK.

H. TCP Vegas

TCP Vegas uses the packet delay as an indicator of congestion. When a duplicate ACK is received , the timestamp of the acknowledgement is compared with a timeout value. If the timestamp value is found to be greater than the timeout value, then it will not wait for three duplicate ACKs, rather it will retransmit the packet immediately.

I. TCP CUBIC

CUBIC is an implementation of TCP for high bandwidth networks with high latency. It is a derivative of BIC TCP, in which window size is a cubic function of the time since the last congestion occurred. Another difference between CUBIC and other standard TCPs is that it does not depend on the arrival of ACKs to increase the window size. Its window size is dependent only on the last congestion event.

V. CONCLUSION

In this paper, we review about various versions of Transmission Control Protocol (TCP) in LTE networks. There are various versions of TCP available with minor modifications, out of which we have tried to list out many. Each version is better than the other in one way or the other. A lot of research has been performed so far in order to implement TCP in 4G for congestion control. Future scope of this paper is to implement TCP in a better form such that it gives better performance in 4G. Various versions of TCP can be combined together to perform this task or research can be done to implement altogether a new version of TCP.

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Pooja Kumari M. tech (Computer Science), Guru Jambheshwar University of Science & Technology, Hisar, Haryana

Dr. Yogesh Chaba (Professor) CSE Dept, Guru Jambheshwar University of Science & Technology, Hisar, Haryana