Evolution of 4G Communication Network Over 3G: Increasing wireless network speed by Coded TCP

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Abstract: - Wireless network is an emerging technology that allows user to access information and services electronically, regardless of their geographical position. Wireless carriers try to up sell customers on the new, improved technology; 3G provides greater range and therefore greater reliability for users. Currently only certain cities, states and carriers offer 4G coverage. So many customers find themselves with limited access when it comes to travel. Many wireless network Operators have invested massive sums of money in new frequency spectra and infrastructure development for 3G cellular networks then why 4G is capturing the users of 3G, there are lot more reasons but in this paper we are exploring the problem of packet loss/dropped and try to overcome it using the concept of Coded TCP.

KEYWORDS: 3G, 4G, Coded TCP

I. INTRODUCTION

A great deal of attention is currently being paid to the 2G, 2.5G, 3G, and 3G+ (4G) cellular networks. In particular, the 3G wireless technologies are in the limelight because they promise wide-area data rates of up to:

- 2 Mbps in stationary applications,
- 384 Kbps for slow moving users, and
- 128 Kbps for mobile users in vehicles.

Despite their appeal, resistance to 3G has built up over the past few years for several reasons. However, in future consumers will rollouts of 3G services for a variety of reasons. In this paper we are exploring the reason behind this. A limitation of 3G cellular networks is how they interface with wired TCP/IP networks.

Why TCP?
TCP is not suited for lossy links, as it treats a packet loss as a congestion signal Conventional TCP sends ACK after decoding an entire packet here, the notion of an ordered sequence of packets is missing. An Erasure Correction Scheme based on Random Linear Coding between TCP and IP has been developed

II. WHY 4G OVERCOME 3G

Due to the below reasons 4G is capturing the market of 3G

- Access mechanism
- Data Rate
- Practical Data Rate
- Cell shrinkage
- Lag
- Lower costs
- Band of frequencies
- Quality of signal
- Handoff
- Frequency utilization

- Global roaming capability
- Call drop
- QOS
- Large overhead associated with transmitting short messages

III. ADDITIONAL CONCERN ABOUT DATA TRANSMISSION OVER 3G NETWORK WHICH TRIES TO OVERCOME IN 4G

3.1What problem is solved-

A cellular network is how they interface with TCP/IP networks. TCP cannot easily distinguish between lost or dropped packets – resulting from wireless channels with significantly higher bit error rate (BER) than wired channels, and network congestion.

Coded TCP addresses a subtle problem deep in the internals of TCP itself. TCP implements reliable delivery through acknowledgement of received data, sending an ACK packet back to the sender. It's fairly smart about this, and has a number of internal timers and state machines which have been designed over time to address problems as they've been identified. Once such problem was "delayed duplicates," in which a network change would suddenly increase latency, delaying the delivery of either a packet or its ACK. The sender, unaware of the sudden change, would assume that its original packet had been lost, and re-transmit. However, if the receiver had already sent an ACK to the first packet, then the sender would assume that the ACK was in response to the re-transmission (rather than the original packet), and it would incorrectly assume that the network had gotten faster rather than slower. The incorrect time adjustment then locks the sender into a cycle of inappropriately rapid retransmissions for every packet, with corresponding false interpretation of the network timing. In response to this problem, TCP was re-engineered to be more patient in reacting to a missing ACK, to resume the transmission more slowly, and to require more frequent ACKs. This slow resume feature is now itself a problem in chronically lossy networks (such as cellular and Wi-Fi). A lost TCP packet can result in a significant delay in retransmission, often in the order of several seconds, and usually requiring reception of multiple duplicate ACKs. These delays are deadly to streaming media. When the primary concern for networking was low bandwidth and cost per packet, the caution in TCP made sense. Today, when bandwidth is cheap and the primary concern is rapid delivery, the caution leads to usability problems for users accustomed to real-time interactivity.

1.2 Where the change will happen-

Coded TCP introduces changes to the way TCP behaves. It therefore requires changes both on the client and on something upstream. Although the most obvious place to make the upstream change is on the server, the logistics of rolling out TCP stack changes to every server across the entire Internet suggest that it may be more effective to create in-line proxies to apply the TCP changes for transmission to the client. This is essentially a Layer 4 solution.

1.3 How the problem is solved-

Since details haven't been released, a lot of this section is speculation, but, assuming that the problem described above is the one being solved, it's probably accurate.

Coded TCP leverages the fact that TCP is a stream-based protocol, delivering large blocks of data that are artificially subdivided into packets. The stream nature means that the data can be divided and encoded (not encrypted, there's a very big difference) in a way that each packet contains not only its own payload, but also information about the packets before and after. Although there is likely going to be additional overhead per packet – which would historically have been derided as inefficient – the advantage is that a missing packet's payload can be re-created by the receiver, based on the context of the other packets. It's similar in concept to RAID 5: add the overhead of parity so that an array can lose a drive without losing any data. While it loses efficiency, it more than makes up for it in reliable delivery, as the stream can continue without the significant pauses that a dropped packet would normally create.

This problem can be overcome by Coded TCP i.e. a coding layer is there in between Transport layer and Network Layer is given in the figure 1. Coded TCP - boosting the performance of wireless networks by up to 10 times without increasing transmission power, adding more base stations, or using more wireless spectrum. In essence, the innovation called coded TCP — makes packet loss completely disappear. In wired networks, packet loss is incredibly rare, but in wireless networks it's one of the biggest issues affecting throughput

3.3 Model

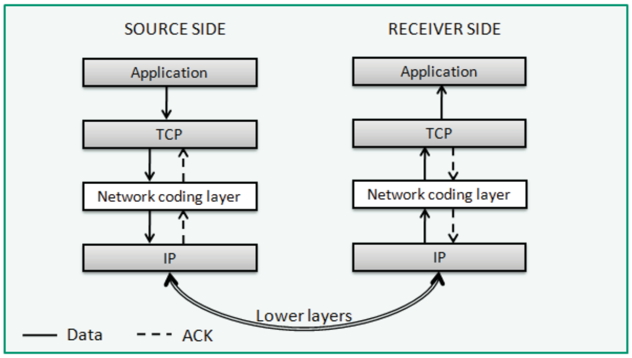

Figure 1. Protocol Stack

TCP was designed for wired networks, where lost packets are generally a sign of congestion. Wireless networks are in desperate need for forward error correction (FEC), and that's exactly what coded TCP provides is shows in below table.

ARQ	Network Coding
• Retransmit lost packets • Low delay, queue size • Streaming, not blocks • Not efficient on broadcast links • Link-by-link ARQ does not achieve network multicast capacity.	• Transmit linear combinations of packets • Achieves min-cut multicast capacity • Extends to broadcast links • Congestion control requires feedback • Decoding delay: block-based

Table -1 Comparing NC with ARQ

In ARQ - A common and important feature of today's protocols is the use of feedback in the form of acknowledgments. The simplest protocol that makes use of ACKs is the Automatic Repeat reQuest (ARQ) protocol. It uses the idea that the sender can interpret the absence of an ACK, and in this case, the sender simply retransmits the lost packet. Thus, ARQ ensures reliability. The ARQ scheme can be generalized to situations that have imperfections in the feedback link, in the form of either losses or delay in the ACKs.

With coded TCP or NC - Blocks of packets are clumped together and then transformed into algebraic equations that describe the packets. Coded TCP sends algebraic equations that describe series of packets instead of just sending the packets. This means that if a packet is dropped, the receiving device can use the equations to solve for the missing data instead of requesting it from the network. The equations involved are simple and linear which is shown below in figure 2.

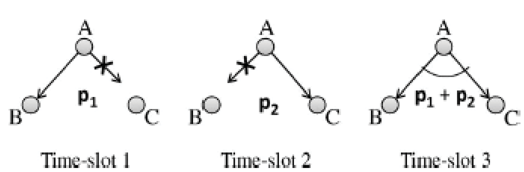

Figure 2. Network Coding

In above Figure node A broadcasts 2 packets to nodes B and C. In the first time-slot, only node B receives packet p1 and in the second slot, only node C receives packet p2. At this point, if instead of retransmitting p1 or p2, node A is allowed to mix the information and send a single packet containing the bitwise xor of p1 and p2, then both B and C receive their missing packet in just one additional time slot. This example shows that if we allow coding across packets, it is possible to convey new information simultaneously to all connected receivers.

By implementing Coded TCP

500 Kbps Connection —become→ 13.5 Mbps

1Mbps Connection —become→ 16 Mbps

Network congestion is one of the causes of packet loss, so it can cause a bit of a positive feedback loop, increasing packet loss and network congestion and therefore decreasing available bandwidth. Coded TCP seeks to break this loop and free up valuable bandwidth. With coded TCP, packet loss doesn't affect transmission rates. The receiver doesn't have to wait for the sender to resubmit the lost packet. In coded TCP Here a receiving device will be able to determine that a packet in the sequence is lost, and recreate it using the algebraic equation that is used to transmit the stream of packets. This reduces the need for re-transmission from the sender as the transmitter buffers several packets, encodes them and sends it as a single transmission, only requiring a single ACK rather than one per packet.

IV. FUTURE

Cellular networks however may see an improvement in implementing this technology, especially as installing more base stations can be expensive. The caveat to this technology is that it requires more processing power. The calculations are linear, only a moderate increase in processing power is needed, though more testing is required.

V. CONCLUSION

In this paper we are focus on how to prevent loss and dropped packet, where network coding can offer biggest benefits. In 3G cellular network the question is how they interface with TCP/IP networks. TCP cannot easily distinguish between lost or dropped packets. Loss-free wireless networks are incredibly rare for cellular networks, where installing more base stations is the very expensive solution to packet loss, coded TCP could be a big boon which is implementing in 4G to overcome the limitation of packet loss and dropped.

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