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# Adaptive TCP Optimization is Key to Improve Quality of Experience in Mobile Networks

As network operators enter an age of intense competition, maintaining subscribers' quality of experience (QoE) holds the key to success. As mobile networks have become more advanced in an effort to deliver a wider variety of new services to customers, data connection speeds have been put under more strain than ever before. Failing to effectively optimize network speed leads to slow data transfer, disgruntled subscribers and fewer profits for the operator.

TCP congestion control technologies were originally developed in the early days of the Internet to deal with congestion in the network. These technologies performed well for fixed-line networks. However, the transition to using the same techniques in mobile networks hasn't been quite so simple. The environment has proved a far more challenging arena for TCP protocols when it comes to achieving the same success.

This is partly because a mobile network throws up several situations and challenges not often seen in fixed-line networks. The available bandwidth in a modern mobile network changes far more frequently because of variables such as environmental factors and mobility. In addition to this, weather changes, electronic interference and poor coverage inside buildings can all cause random packet losses. The link layer protocol is also complicated; it may possess its own retransmission which can cause jitter and deliver packets out of sequence.

Table 1 illustrates the TCP performance gap in mobile networks. In this study[1] of a LTE network, TCP throughput was measured by downloading large files in several locations with different signal strength and signal/noise ratio. The maximum achievable application layer UDP throughput (i.e., Goodput) was also recorded. The results show that TCP achieves substantially lower throughput than what the network is capable of supporting. There is significant potential to apply TCP optimization technologies to speed up TCP performance in mobile networks and close the gap.

TCP optimization uses a TCP proxy that acts as a transparent 'relay' between the mobile network and the Internet. On the mobile side, it uses TCP algorithms specifically formulated to address the challenges in mobile networks. The TCP proxy receives data as soon as possible from the content server on the Internet and then attempts to deliver this data to the handset in a way that matches the current network conditions in the most adaptive fashion possible. In this way data connection speeds can be dramatically improved, resulting in a higher QoE for the subscriber.

LTE networks substantially increase the speed that mobile networks can operate at. However, such networks must use TCP optimization in order to reach their full potential. This is because TCP uses a windowing mechanism to determine how much data can be transferred before it stops and waits for acknowledgements of received packets. The dynamic range of windowing that TCP has to manage is represented by the so-called Delay-Bandwidth Product (DBP), the product of the available bandwidth and the latency [2]. The DBP in LTE networks might be 100X higher than that of previous generation networks.

**Table 1: TCP Performance Gap**

| Location Signal Condition RSRP, SINR values represent signal strength and signal/noise ratio | Excellent -64, 27 | Good -90, 27 | Fair -110, 15 |
|---|---|---|---|
| Maximum Achievable UDP Goodput (Mbps) | 81 | 55 | 50 |
| Actual TCP Throughput (Mbps) | 34 | 30 | 27 |
| TCP Speedup Potential | 138% | 83% | 85% |

**Figure 1: Delay-Bandwidth Product (DBP) is significantly higher in LTE Networks**

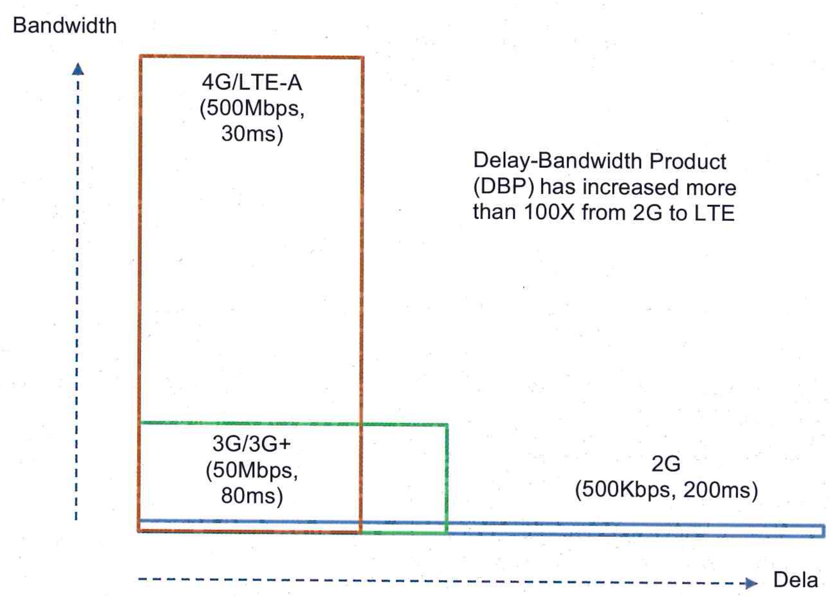


Figure 1 shows the DBP of different types of mobile networks. The area of the rectangle represents the DBP (product of delay and bandwidth) for a type of network. In a 2G network with bandwidth of 500Kbps and delay of 200ms, the DBP is about 12.5KB. In contrast, a LTE or LTE-Advanced network may have throughput over 500Mbps with a delay in the region of 30ms. The DBP in this case would be around 1.88MB, more than 100X increase compared with that of a 2G network. If 2G is like riding a bicycle at 5mph, LTE is like piloting an aircraft at 500mph. By using TCP optimization, mobile-specific TCP technologies can be enabled and TCP settings can be tuned to manage this much larger dynamic range of TCP windowing accurately.

One challenge for TCP optimization is that most mobile networks will have some form of 3G, 4G, LTE and LTE-A technologies co-existing for many years to come. Depending on the location of subscribers, they may move between different types of mobile networks, for example from LTE to 3G.

TCP optimization technologies must be adaptive so that it can determine the types of network a subscriber is using upon and apply the appropriate TCP algorithms and settings best suited for those conditions.

There are different ways that this might be achieved. In many mobile networks, the information about the type of network that a subscriber is currently using can be passed onto the TCP proxy through a control channel via PCRF or Radius. TCP optimization technologies also have built-in self-adapting capabilities to sense the type of network based on observing the dynamics of the TCP connection to the subscriber.

Over 90% of traffic on a mobile network today is TCP based; TCP optimization can help mobile operators have a positive impact across the board. Of the TCP traffic, 60% today is video and the number is expected to increase to 80% in the next a few years. Additional video optimization technologies can complement TCP optimization to further enhance network speed and efficiency.

To sum up, carefully designed adaptive TCP optimization can help operators to reach the full potential of their networks. It can speed up file download, reduce webpage load time and video startup time, resulting in a higher QoE and increased levels of satisfaction for the subscribers.

*References*
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