PBE-CC: Congestion Control via Endpoint-Centric, Physical-Layer Bandwidth Measurements

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This paper suggests PBE-CC, end-to-end (E2E) congestion control algorithm that makes use of bandwidth/capacity measurement at PBE-CC mobile users' side through the decode of the control channel from PBE-CC senders in downlink scenarios. PBE-CC is a cross-layer design (unlike previous TCP congestion control algorithms we covered) where the control channel information-based bandwidth measurement at the physical layer feedbacks to the sender and thus the sender controls its sending rate at the transport/application layer accordingly. This measurement/feedback occurs at every subframe (i.e., every 1ms), and this is very fine-grained measurements/feedback compared to other end-to-end congestion control algorithms, which is desirable for wireless networks, since wireless channel quality is highly dynamic and unpredictable in general. PBE-CC can immediately increase network throughput when the bottleneck is the wireless hop where the sender cannot make full use of available PRB (cf. the bottleneck is the internet). According to the paper, nearly 70% of bottleneck happens at the wireless hop. Indeed, PBE-CC achieves 6.3% higher throughput while it reduces delay by 1.8x, compared to other state-of-the-art comparison schemes.

There were interesting discussions on the paper during the class.

1. Impact of Latency due to the E2E mechanism: While the capacity measurement and feedback transmission at mobile users' side are fine-grained and immediate, there exists inevitable latency for the feedback to reach the senders since it is a E2E-based algorithm. This latency might cause critical problems when users are on quite fast vehicles, where the measurement might be no longer valid when the feedback reaches the sender.

2. Expansion to Uplink Scenarios: Continuing from 1, while the measurement feedback is required at the sender for downlink scenarios, the mobile users themselves are senders for uplink scenarios. This implies that the previous E2E latency issues do not exist for the uplink since users can immediately control their sending rate based on the capacity measurement. Considering the need for high throughput in the uplink due to new applications such as video telephony, wireless data backup, and IoT, PBE-CC for the uplink seems particularly promising.

3. Expansion to Wireless Local-Area Network (WLAN or Wi-Fi): The use of PBE-CC for WLAN was discussed. Unlike cellular networks, open-source (OS/firmware/driver) Wi-Fi routers are available, so the PBE-CC implementation on the router might be immediately available. However, one pointed out that recent Wi-Fi routers are also closed-source, and the information available might be different from the one in the control channel of cellular networks.

4. Resource Allocation Fairness Issues: Whenever PBE-CC mobile users find idle PRB, the PBE-CC sender assigns available unused PRB to every user evenly. This allocation might not be desirable for cellular networks, since required capacity per user varies in general, depending on services/applications they are using. It seems that various PRB assignment rules towards the best network throughput is worth to be explored (which requires simple modifications).

The use of control channel information of cellular networks at the mobile user side is intriguing and is likely to motivate many other ideas, not just for congestion control, since independence in layer design causes various bottlenecks for the next-level performance network architectures. Furthermore, it seems that PBE-CC can play an important role in 5G, since PBE-CC mobile users can obtain multi-cell information and more dense deployment of cells is expected in 5G networks (e.g., for carrier aggregation, cell-free MIMO, mmWave, and/or frequency reuse).