Cross Layer Congestion Control in Cellular Networks

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Outline

- Problem Definition
- Background
- Proposed Design
- Progress
- Existing Studies

Motivation

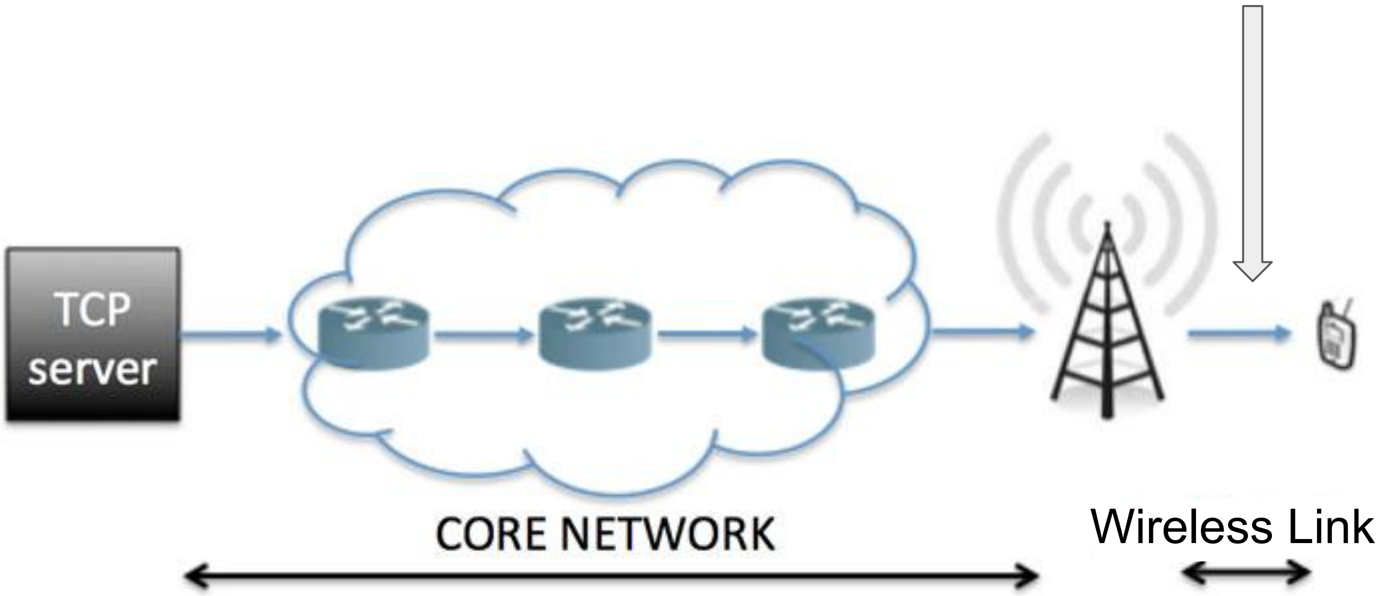
- Last hop cellular link is often the bottleneck in end-to-end delays [1].
- TCP often under utilize the available bandwidth in wireless links [2].
- Emerging edge computing

[1] BARANASURIYA, N., NAVDA, V., PADMANABHAN, V. N.,AND GILBERT, S. Qprobe: Locating the bottleneck in cellular communication. In Proceedings of the 11th ACM Conference on Emerging Networking Experiments and Technologies (New York, NY, USA,2015), CoNEXT '15, ACM, pp. 33:1–33:7

[2] HUANG, J., QIAN, F., GUO, Y., ZHOU, Y., XU, Q., MAO, Z. M., SEN,S.,ANDSPATSCHECK, O. An in-depth study of lte: Effect of network protocol and application behavior on performance. In Proceedings of the ACM SIGCOMM 2013 Conference on SIGCOMM (New York, NY,USA, 2013), SIGCOMM '13, ACM, pp. 363–374.

Background

TCP often misinterprets
link-layer packet losses



Hypothesis

Leveraging physical layer information at the base station, achieves better **bandwidth utilization** and increased throughput.

What are some possible options in eNB:

- Resource allocations for each UE
- CQI values for each UE
- MIMO modes

Progress

Currently, testbed is set up, consisting of

- Core network (EPC)
- Base station (eNB) - Skylark IRIS SDR hardware
- Smartphones (UE) and programmable SIM cards

Next:

Profile the basic end to end communication performance using existing congestion control algorithms such as TCP - Cubic, TCP - BBR.

Improve congestion control by incorporating physical layer information.

Evaluation

Compare with existing TCP congestion control algorithms.

- Cubic
- BBR

<u>Metrics:</u>

- Bandwidth utilization
- Throughput

Related work: Bottleneck in cellular network

QProbe: Locating the Bottleneck in Cellular Communication (CoNEXT '15)

- 642 participators, 51 cellular providers and 15 servers around 33 countries;
- 2 months data collection and 8116 runs;
- About ⅓ of the bottleneck situations are attributed to wireless bottlenecks.

Table 2: `QProbe` runs for different radio technologies

Technology	Runs	Wireless Bottlenecks	WAN Bottlenecks
3G	2573	215 (8.4%)	97 (3.8%)
LTE	5480	441 (8.1%)	837 (15.3%)

Related work: Bottleneck in cellular network

Understanding Bufferbloat in Cellular Networks (CellNet '12)

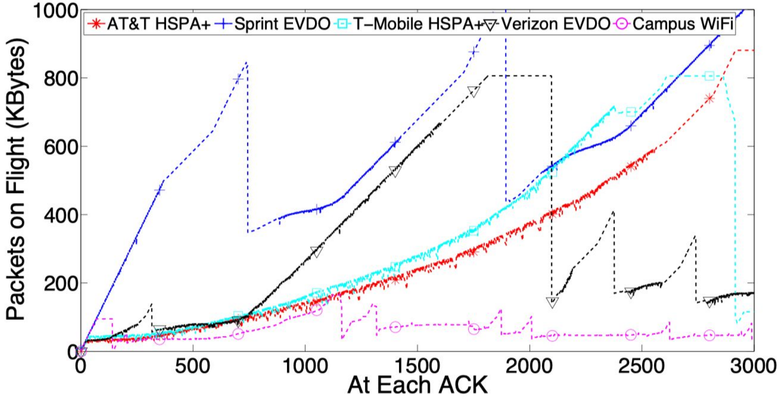


Figure 1: Surprisingly, we observed a fat pipe in all four major U.S. carriers. This observation verifies the prevalent bufferbloat problem in cellular networks.

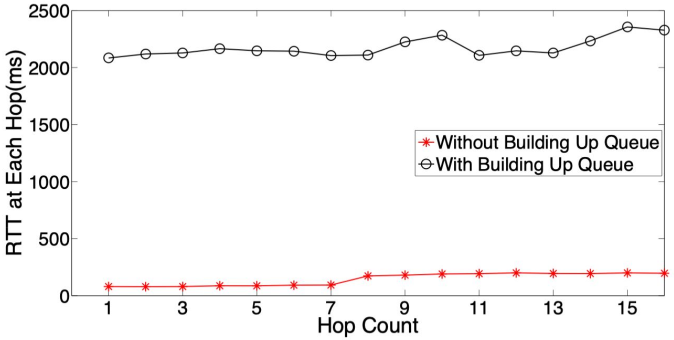


Figure 2: We verify that the bottleneck is within the cellular network (the first IP hop).

Related work: Cross-Layer End-to-End Congestion Control

CQIC: Revisiting Cross-Layer Congestion Control for Cellular Networks (HotMobile ‘15)

- T-ms time slot;
- Collect CQIs(Channel Quality Index) and DTXs(Discontinuous Transmission) over the time slot;
- Combine the average CQI and DTX over the previous time slot together to estimate the link capacity in the current time slot.

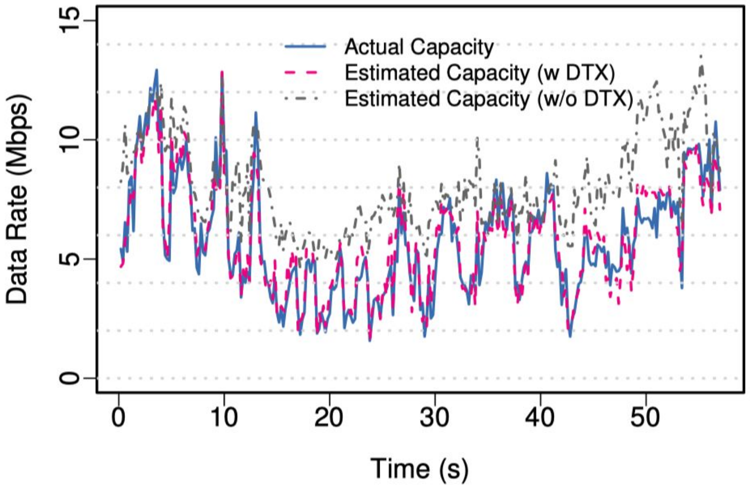


Figure 3: Capacity estimation based on CQI alone (estimated capacity w/o DTX), and based on both CQI and DTX (estimated capacity w/ DTX).

Conclusion

Summary

- We believe that one of the critical bottlenecks of end-to-end delay and bandwidth in cellular network is located at the last hop;
- It will be effective and efficient if cross-layer information(especially in physical layer) can be leveraged to tackle the bottleneck.

Questions?