

# Cellular Network Delay: Measurements in Four Swedish HSDPA+ and LTE Networks

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# Delay Measurements

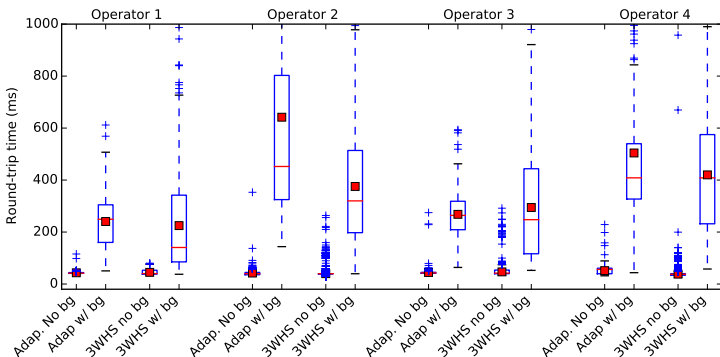
## Why have we focused on delay

- Delays typically directly impact user service perceptions
- Most TCP flows in cellular networks are short (90% < 36KiB)
- Per-user queuing are employed in cellular networks, but concurrent user flows can interact

## Measurements for HSPA+ and LTE

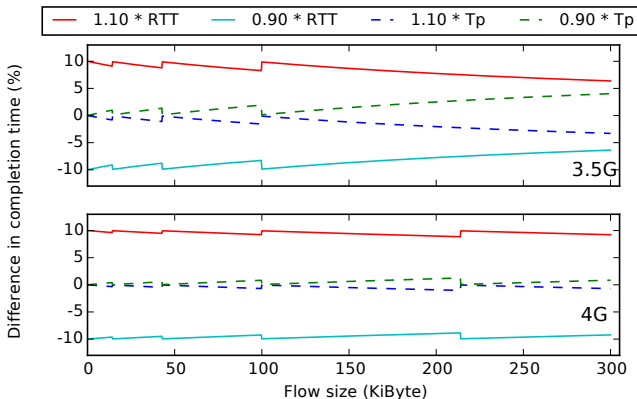
- Networks of 4 main Swedish providers for 3+ years
- Different approaches to measure network layer delay
- Impact of concurrent traffic on measured delay and application performance
- Impact of congestion control
- Modeling and analysis of short flow performance

# Effect of Single Background Flow for HSPA+



Delays are considerably increased when a background TCP flow is present

# Relative Impact of Throughput and RTT on Short Flow Completion Time



Mean values for RTT and throughput from our measurements are used as baselines. The figure shows the relative impact of a 10% change in RTT and throughput.

The completion time is much more sensitive to variation in RTT than throughput.