Toward Optimal Performance with Network Assisted TCP at Mobile Edge

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Problem Statement

- TCP performs poorly in cellular networks mainly because of two fundamental issues:

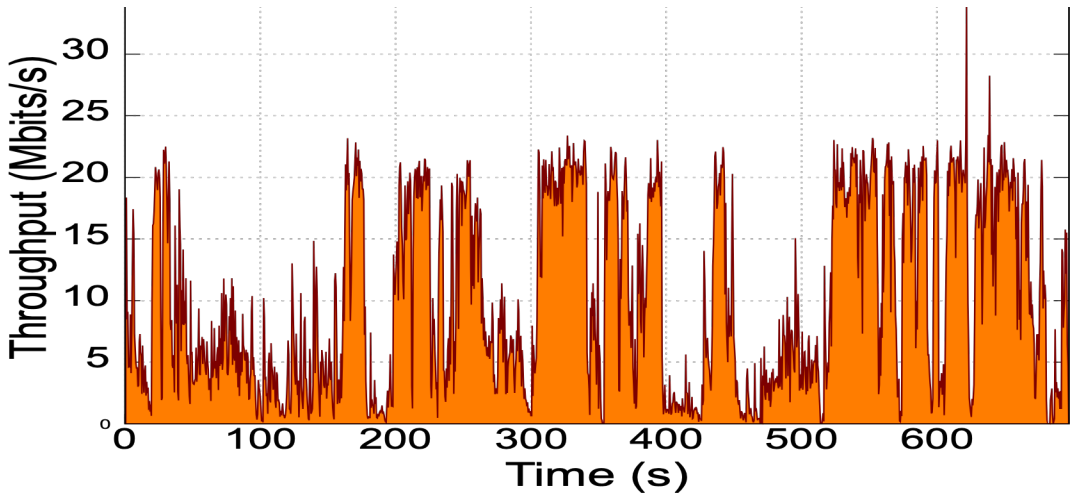
1. Generalization issue: Most of the TCP designs are Intended to be general solutions
   - TCP becomes **Jack of all trades, master of none**!

2. Having a distributed nature:
   - Distributed measurements downgrade the overall performance of TCP

TCP: Jack of all trades, master of none!

Cellular networks differ significantly from their general wired counterparts, which impacts the performance of a TCP designed as a general solution:

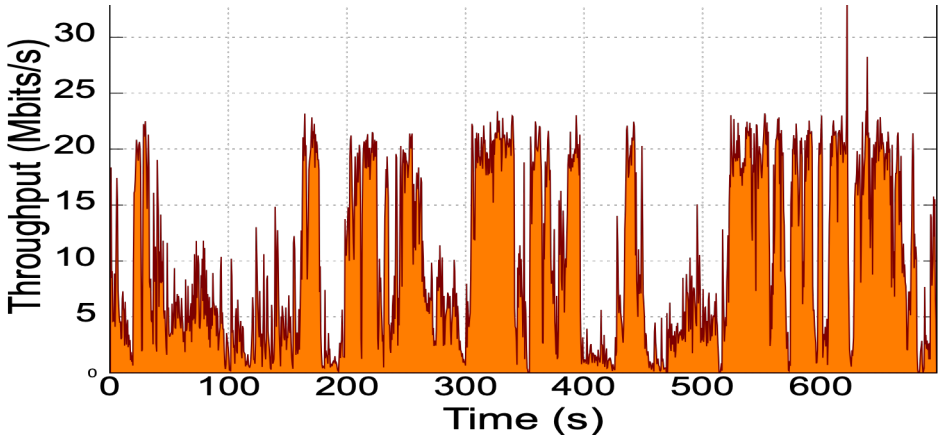
1. Multiple order of magnitude faster capacity fluctuations (at millisecond timescale)
   - TCP either underutilizes the links or causes bufferbloat
2. Higher non-congestive packet loss rates
   - TCP has no means to differentiate congestive pkt loss from non-congestive ones
3. Deep per-user buffers at BTS
   - Potentially can cause large self-inflicted packet delays
4. Schedulers/Resource-manager at BTS
   - Extra uplink/downlink scheduling delays

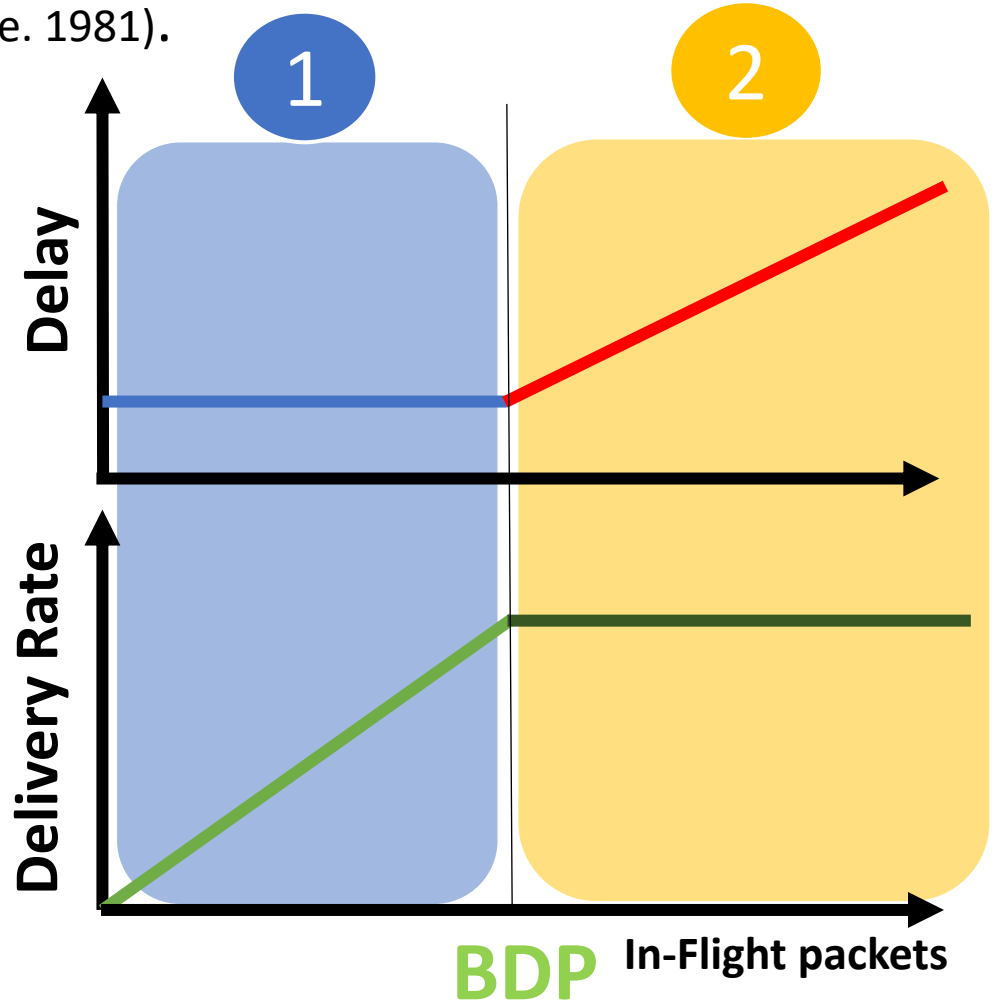


Distributed Measurement Paradox

- It is impossible to create a **distributed algorithm** that converges to the point where (any form of) $Power = \frac{Throughput}{Delay}$ is maximized (Jaffe. 1981).
- Intuition:
  - A Measurement Paradox!

Problem becomes even worse when link bandwidth is **not** a **flat** and **stable one**!

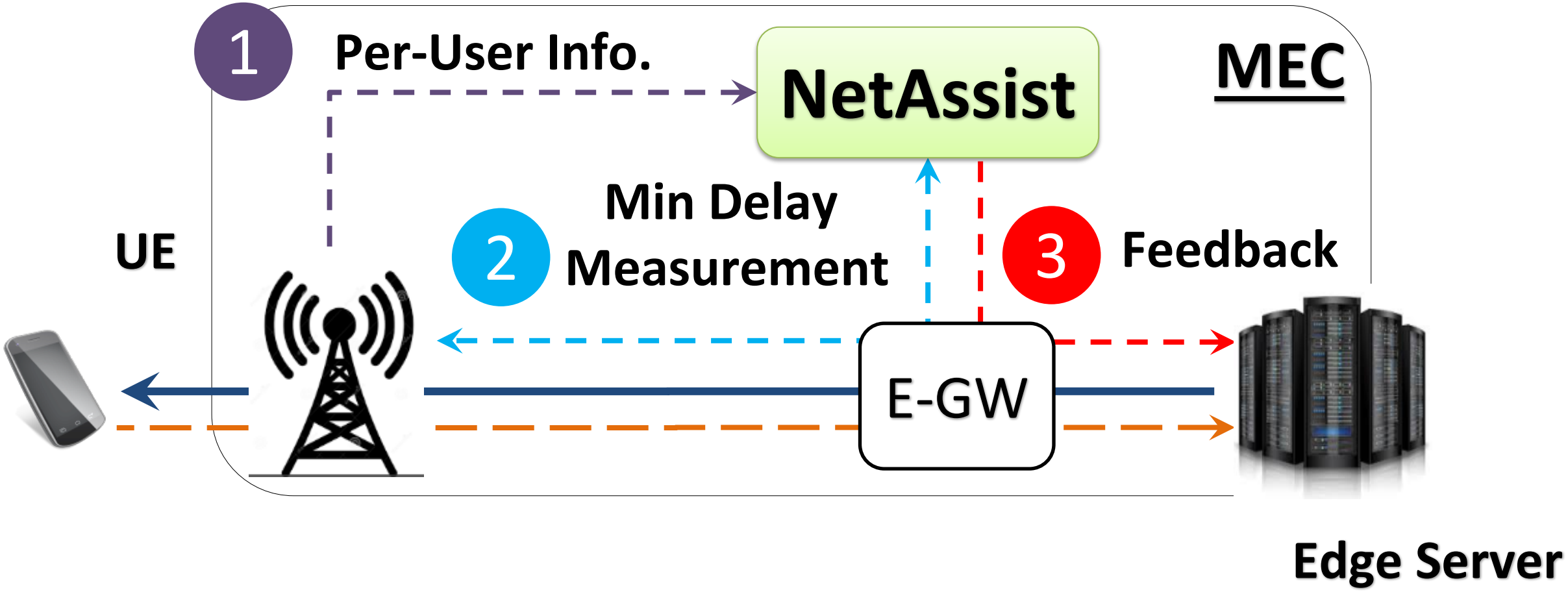




Overview of the solution

1. A domain-specific design:
   - Consider the unique properties of the network to design a better congestion control
     - Servers are located very close to the RAN
     - Single authority manages the network and servers, …
2. Employ Centralized measurements:
   - Cellular networks already have a notion of centralized measurements
   - Abandon the distributed measurement approach and use a centralized one.
   - Let the network do the measurements!
     - The wireless scheduler (at BTS) knows per-user quality of channel, queue occupancy, etc. in a fine-grain timescale (1ms timeframes)

Network-Assisted TCP



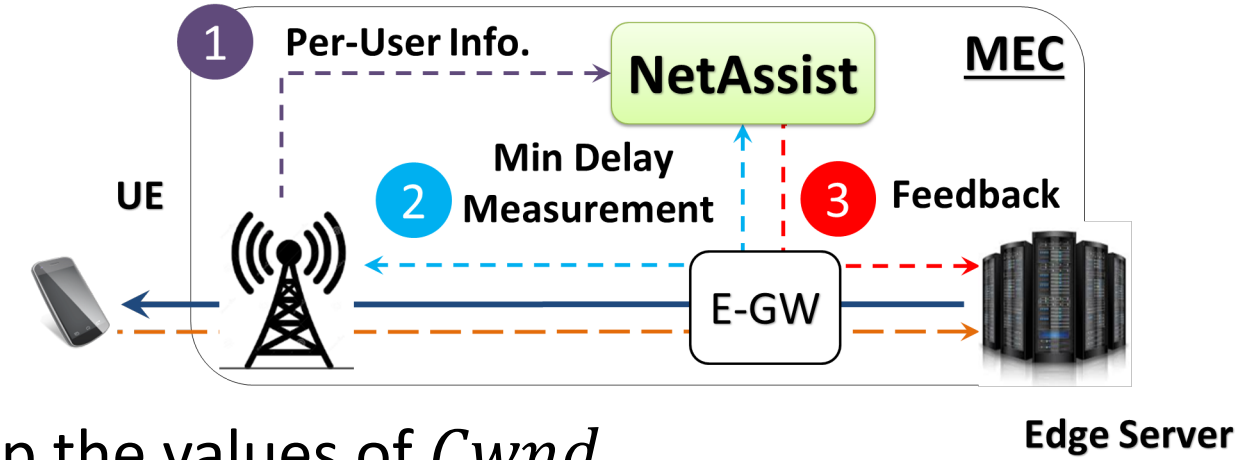
Two versions: a **clean-slate** & a **backward-compatible**

NATCP:

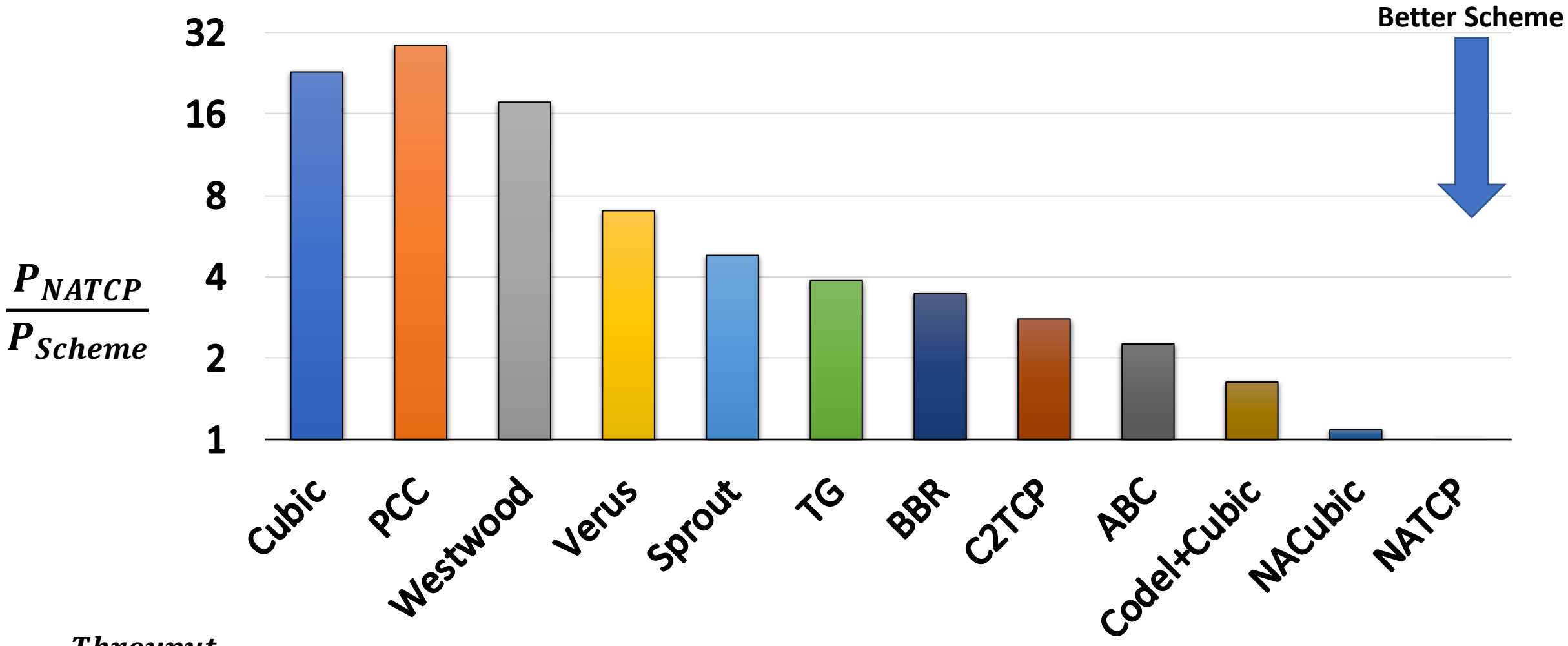
- A clean-slate design replacing the TCP at end-hosts
- Periodically, receives feedback information (avg. Bw and $Delay$):
  - $Cwnd = \alpha \times \boldsymbol{Delay} \times \boldsymbol{Bw}$
  - $Pacing_{rate} = \boldsymbol{Bw}$

NACubic:

- A backward compatible design
- Underlying TCP still calculates the $Cwnd$
- The feedback from NetAssist is used to cap the values of $Cwnd$
  - $Cwnd_{Max} = \alpha \times \boldsymbol{Delay} \times \boldsymbol{Bw}$
  - $Cwnd = Min(Cwnd_{Max}, Cwnd)$
  - $Pacing_{rate} = \boldsymbol{Bw}$



Overall results (averaged over more than 15 cellular traces)



$\{P = \frac{Throuput}{Delay}\}$

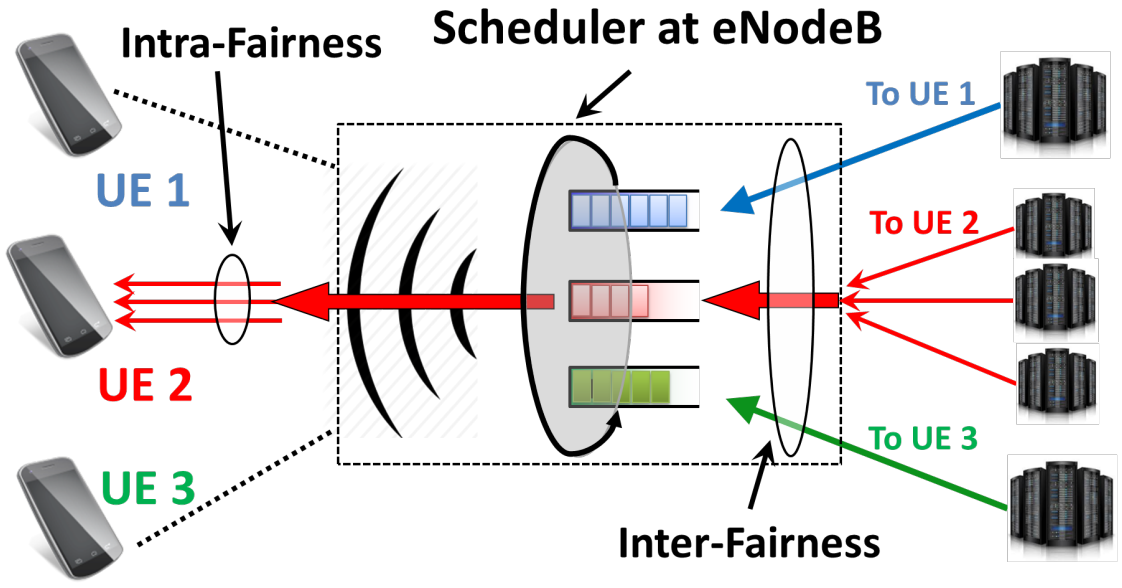
Conclusion

- The controversial points of the paper
  - Exploring new design space and philosophy for designing TCP for MobileEdge
- What kind of feedback you are looking to receive
  - Any feedback on the implementation of NATCP!
- Under what circumstances the whole idea might fall apart
  - If components dealing with the measurements are providing wrong feedback
- The open issues the paper does not address
  - How to provide security for communications among different entities?
  - The standardized/detailed protocols for communication among various component

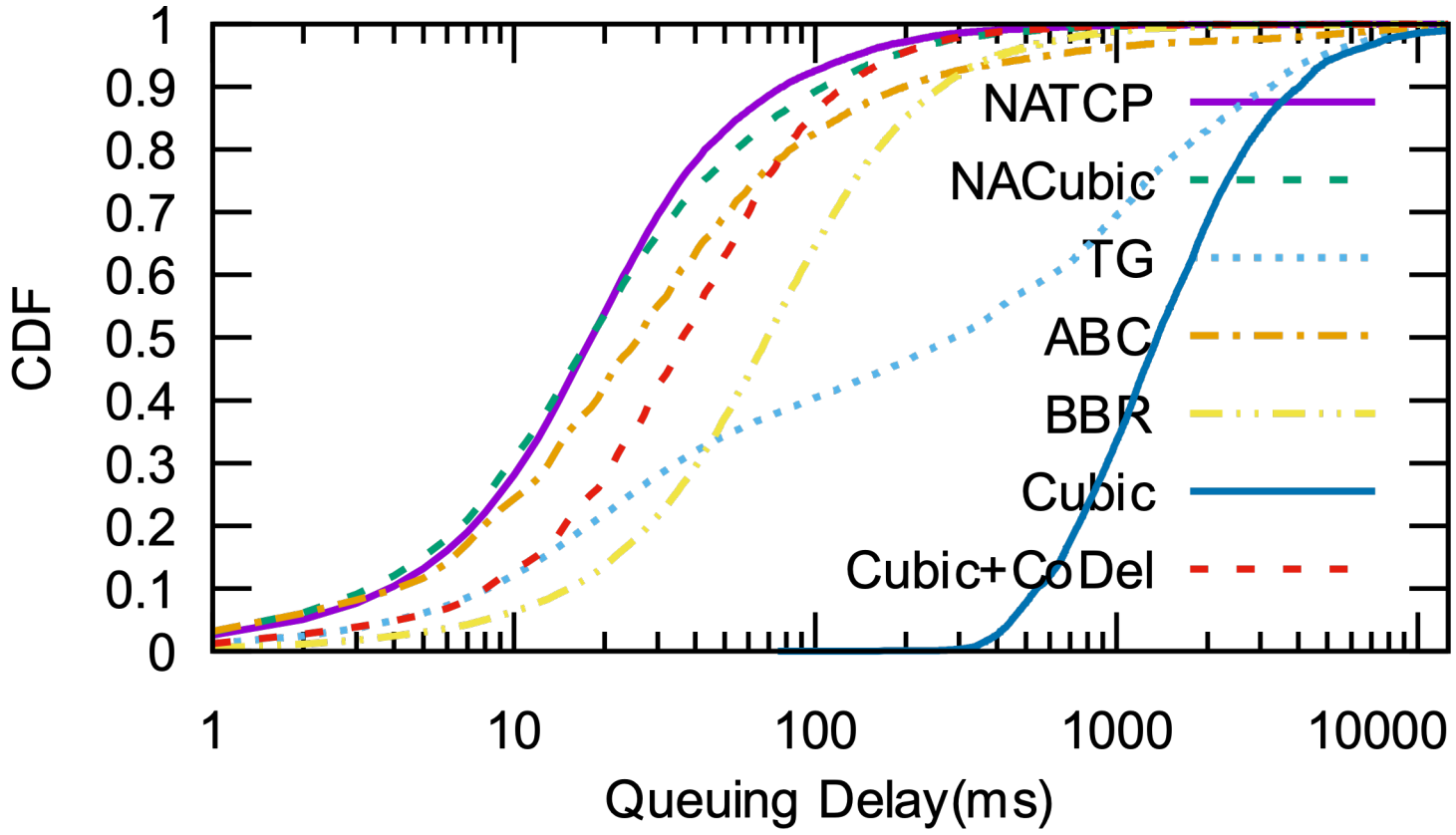
BKP Slides

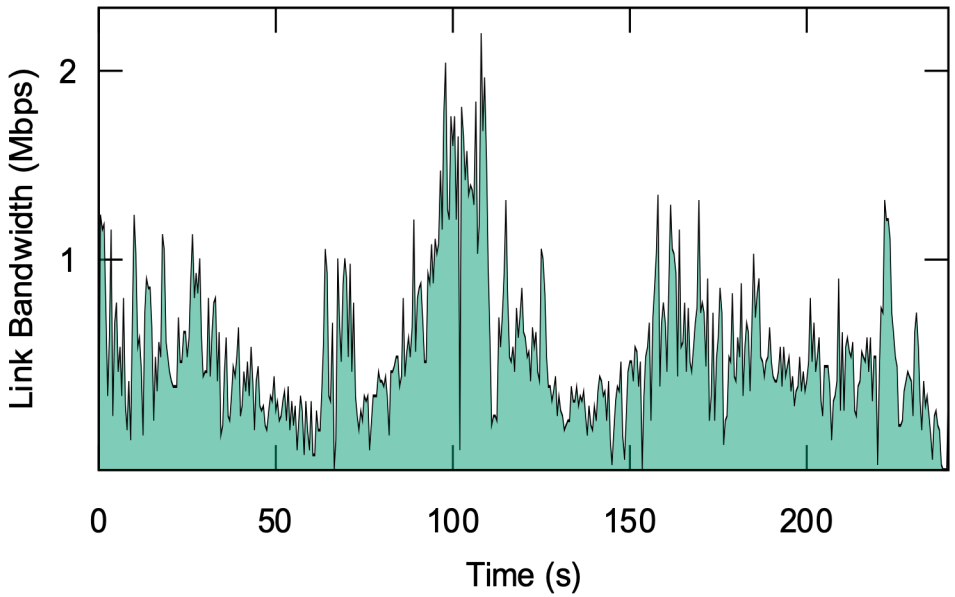
NATCP: Fairness

- In a general network number of competing flows is not known, but this is not the case in cellular networks!
- Per-User buffers at BTS:
  - Number of competing flows is known by client!
- Inter-Fairness
  - Wireless scheduler handles it
- Intra-Fairness
  - The client sends fairness info. to the server



Do we really need the delay feedback?





TG[23] is a scheme based on providing only Bw feedback in an in-band manner

In-Band vs. Out-of-Band Signaling

- Comparison between In-Band (IB) and Out-of-Band (OoB) signaling when feedback only consists of Bw and the time it has both Bw & delay (NATCP):

Table 1: Normalized P_{95} for various schemes

Scheme	Bw (IB)	Bw (OoB)	NATCP (IB)	NATCP (OoB)
P_{95}	1×	3.47×	7.32×	9.31×