OPTIMIZING TCP FOR RADIO
RAN CHARACTERISTICS

› Congestion
  – Increasing number of users and/or increasing traffic in a cell
  – Lower possibility of overprovisioning than in fixed networks

› Reduced signal strength
  – when the device moves towards the edge of the cell, the Signal to Interference plus Noise Ratio (SINR) decreases

› Handovers
  – Between cells
  – Between radio technologies

› Varying channel conditions mean that it makes sense to wait.
Keep the RNC/eNB scheduler queues non-empty.
  - Unnecessarily empty buffers may reduce throughput.

Keep the scheduler queues short.
  - Bloated buffers decrease responsiveness, increase waste when flows are abandoned and add delay to handovers.

Balance flow rates to optimise user experience.
  - Higher throughputs for interactive flows than for background flows.
THEORY AND MODELS

• ↑Users in a cell → ↓Individual capacity per user → ↑Queues in RNC/eNB
• ↑Distance from a base station → ↓Signal Strength → ↑Queues in RNC/eNB
• ↑Queue length → ↑RTT per individual flow

Small queue → low RTT

Large queue → high RTT
TCP TRANSMISSION RATE

› TCP is designed to "fill the pipe".
  - Filled pipe $\rightarrow$ packet drops $\rightarrow$ TCP reduces transmission rate

› TCP losses are "feared" by router designers
  - Modern equipment often comes with large buffers – including RNC/eNB

› TCP fills those buffers with packets.
  - Buffer bloat problematic for new or interrupted flows and handovers.
TCP optimization helps to mitigate congestion by protecting the network from aggressive traffic.

During low to medium cell load, it is in general beneficial to push data fast.

But when there are limitations in the radio network, aggressive TCP behavior can fill the buffers, provoke large loss rates and make TCP slow down considerably.

End user pays for retransmitted data.
RADIO OPTIMIZED HYBRID CCA

› Treats both packet loss and increased RTT as congestion signal

› Separate back-off factors for loss and increased latency

› Sensitivity to RTT increase and back-off factors configurable per flow

› Configurable ICW
SINGLE POINT OF CONTROL

› Hybrid or delay sensitive algorithms typically yield to pure loss based flows.

› A single point of in the operator network that performs congestion control can ensure that overall fairness between flows.

› Initial window size can be auto-tuned based on knowledge about current conditions for specific user. TCP needs less time to probe the network.

› Simple to deploy
CCA EFFECTS ON RTT

Artificial example without proper AQM

New Reno

Ericsson Hybrid CCA

Note different scales!
Data collected at large site of Tier 1 operator in emerging market. Up to 70% reduction of retransmissions after introducing new CCA.
DYNAMIC ICW – RESULTS

Well dimensioned LTE network, European Operator.

Measurements on page load times for most popular sites in the country

Page load times reduced by 5 - 15% by using dynamic ICW.
RELATION TO ENCRYPTION & WAY FORWARD

- Current best practice is to deploy a “transparent” proxy outside the packet gateway.
- Transport protocols are being encrypted basically bypassing the PEP in its current form.
- Can we make a PEP explicit, how would we go on doing that?
  - Reverse proxy, origin consent?
  - Forward proxy, client consent?
- A PEP is deployed within an operator domain, thus simplifying the trust relationship, potentially allowing richer signaling.