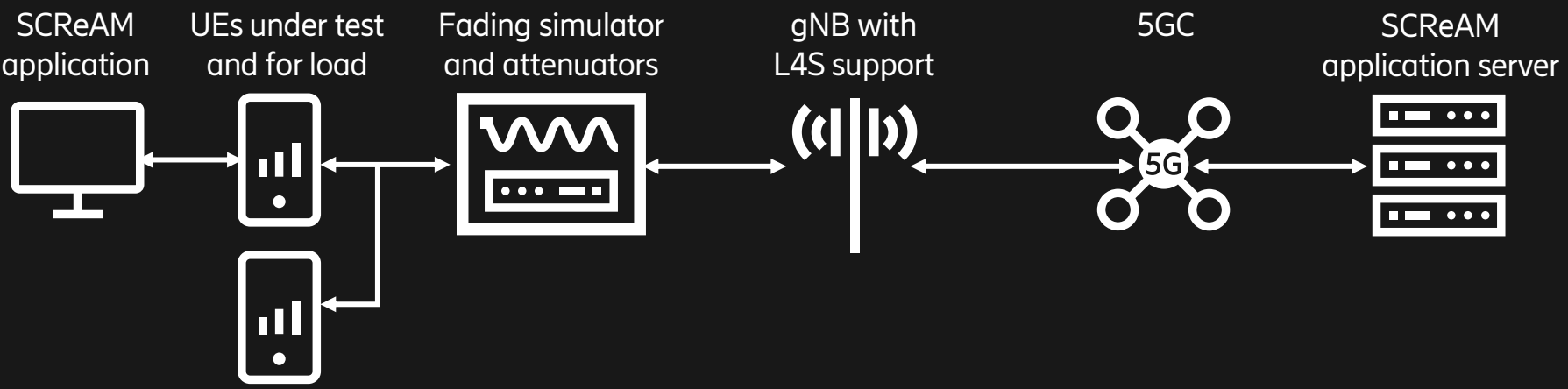
L4S Performance Results

Examples of proof points showing the benefit of the L4S technology

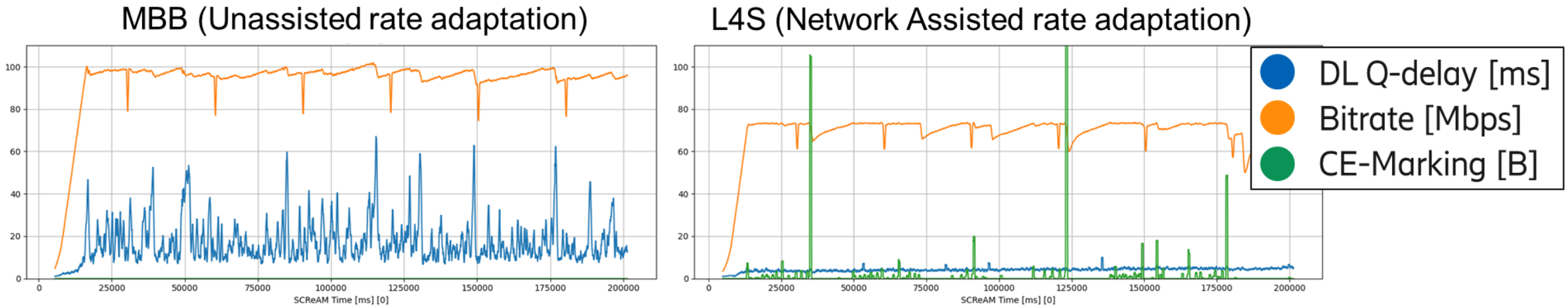
L4S Lab Results

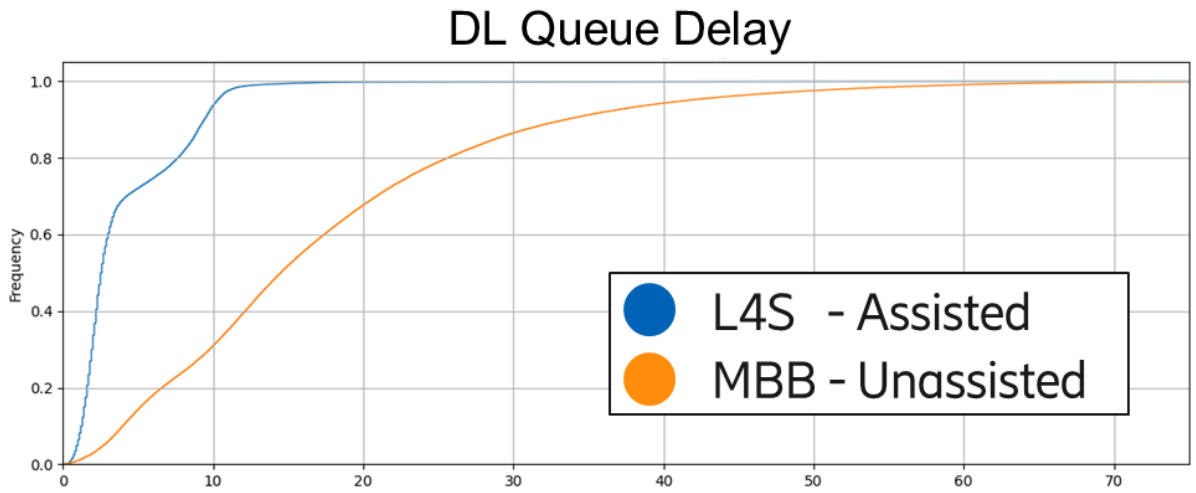
- Cabled RF



SCReAM reference:
https://github.com/EricssonResearch/scream

Results, "Mobile broadband, MBB" vs. L4S [Lab]

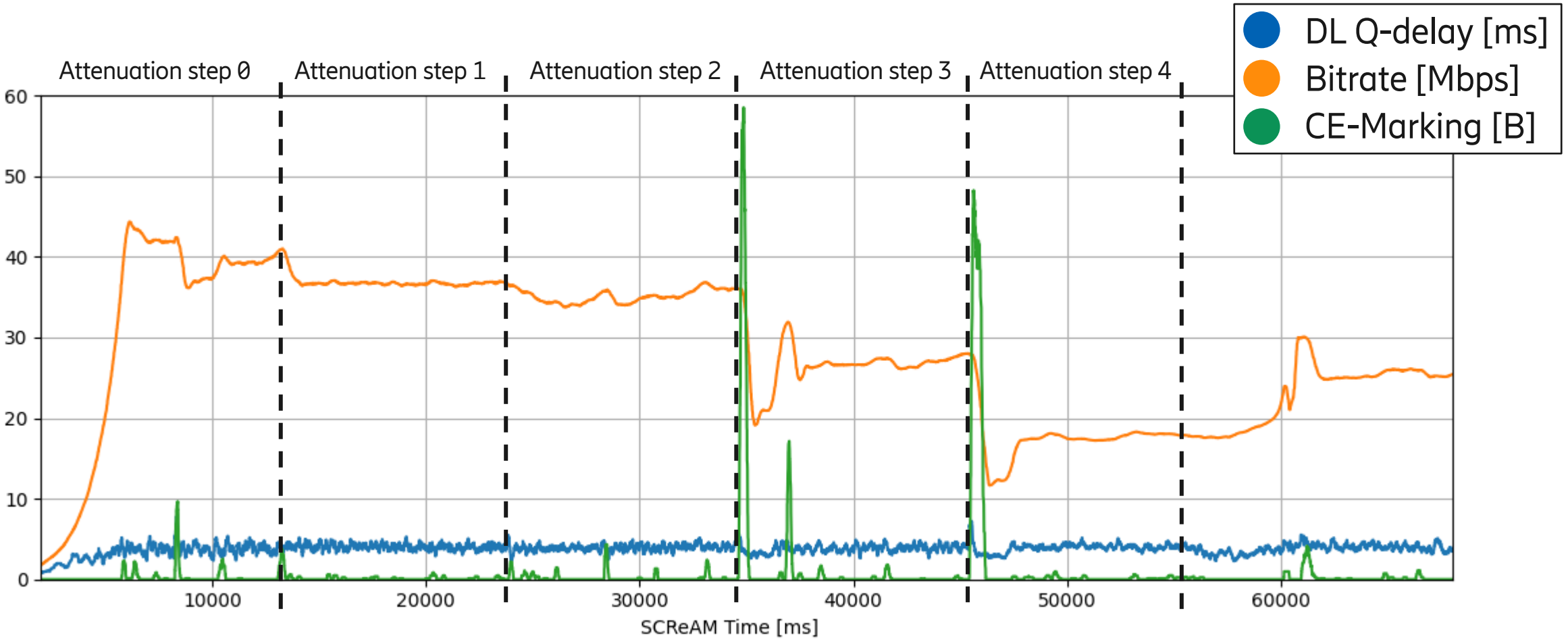




- High average latency level and more jitter using OTT rate adaption
- Significant lower average latency and low jitter with L4S assisted rate adaption
- Throughput is lower for L4S, a sacrifice to maintain the low level of latency
- L4S adapt rate well to shadow fading and keeps latency low

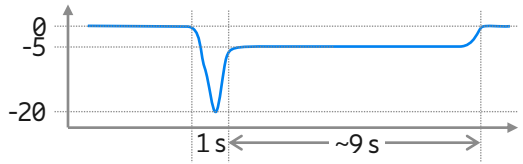
See also **White paper**

L4S lab results
- Varying attenuation, fast fading and background traffic

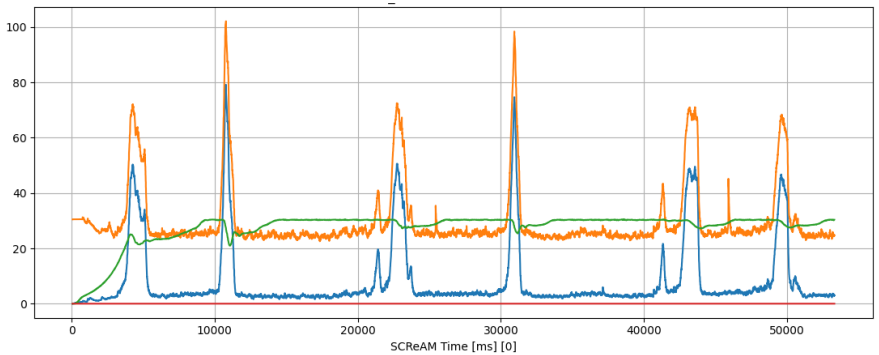


Mimic "City Busride" Testcase [Lab]

- Ramped drop (1s, 20dB), then 5dB attenuation, bursty background traffic

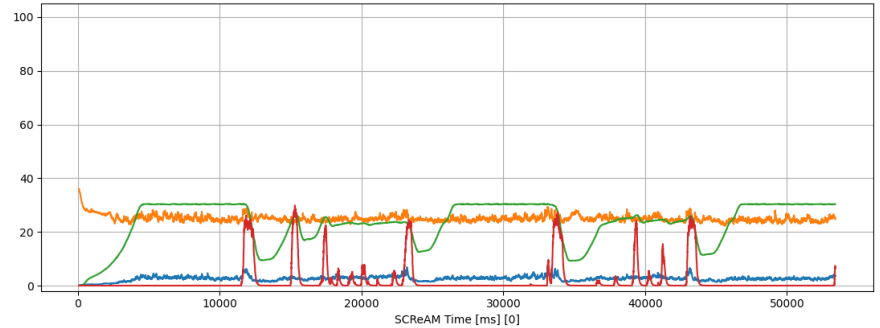


MBB (Unassisted rate adaptation)

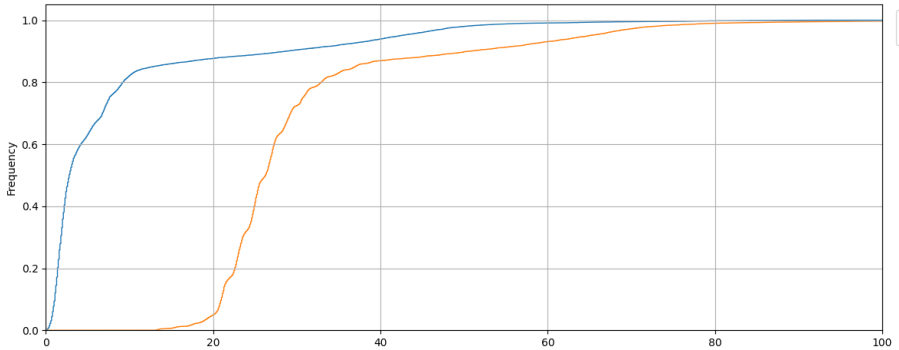


DL Q-delay [ms]
RTT [ms]
Bitrate [Mbps]
CE-Marking [B]

L4S (L4S Assisted rate adaptation)

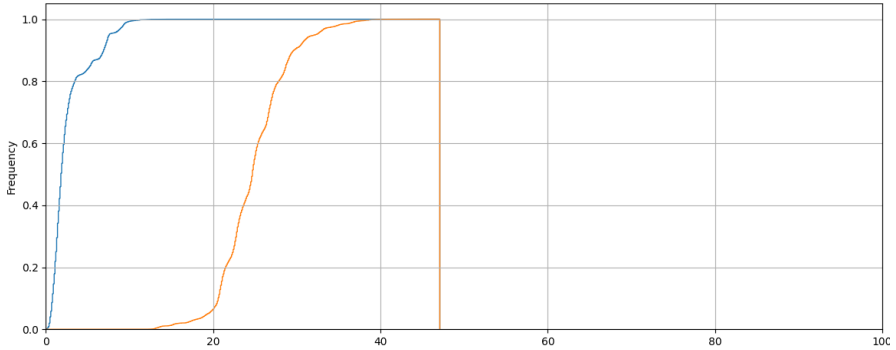


MBB (Unassisted rate adaptation) CDF

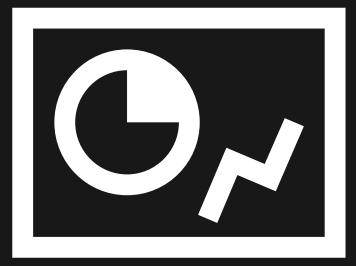


DL Q-delay [ms]
RTT [ms]

L4S (L4S Assisted rate adaptation) CDF

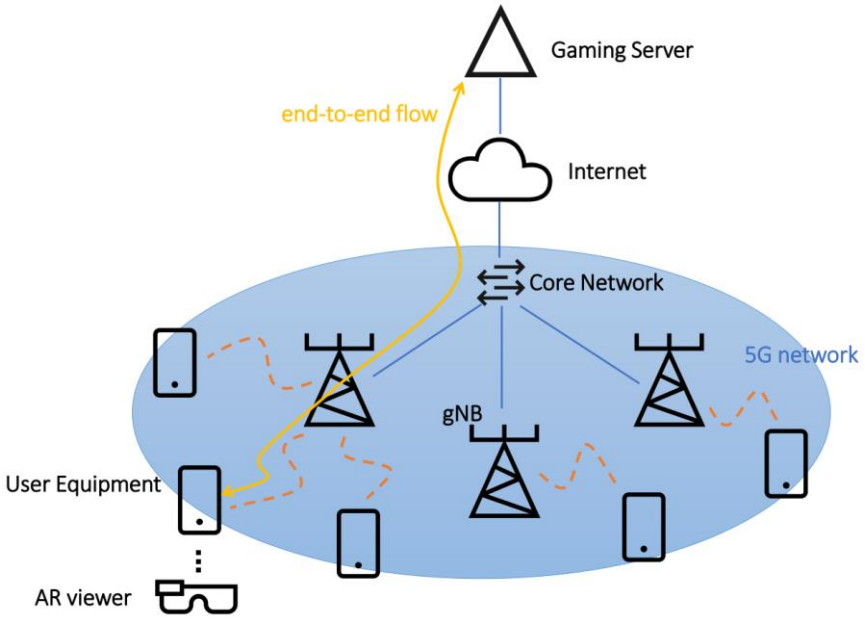


Simulations



Simulations

- Recommended reading: L4S in 5G networks (IEEE 2021)



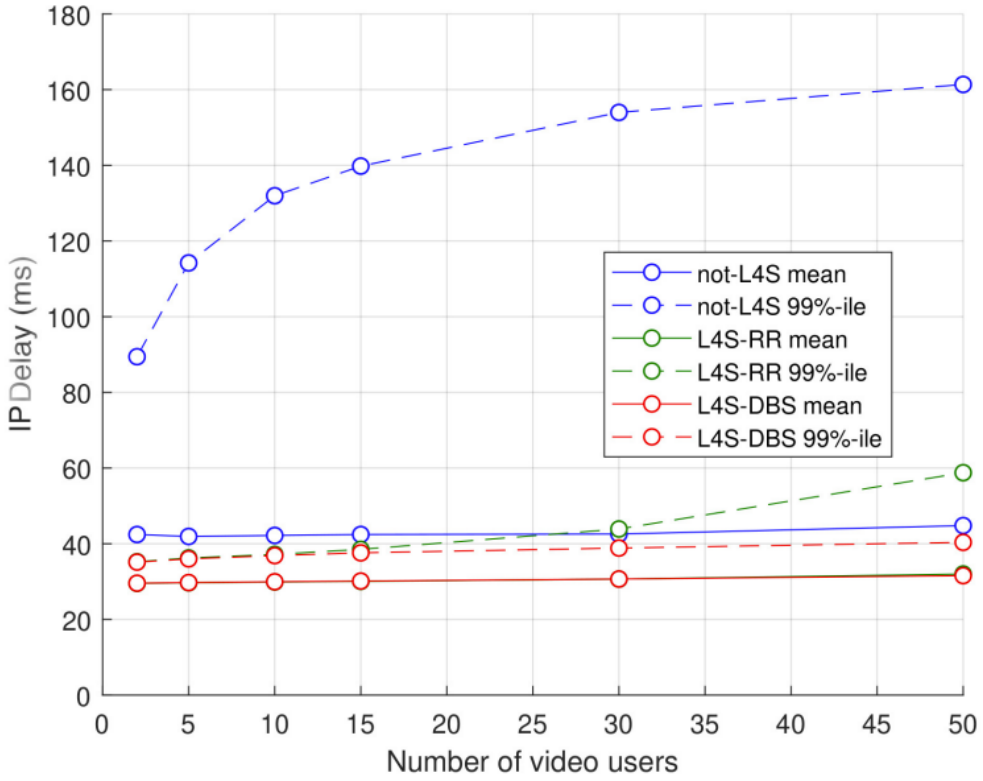
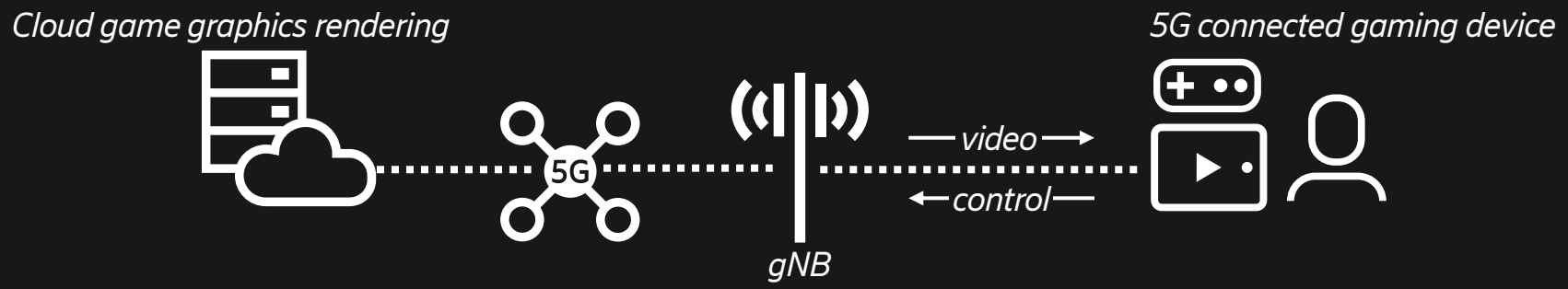


Fig. 3: IP delay vs. number of video users.

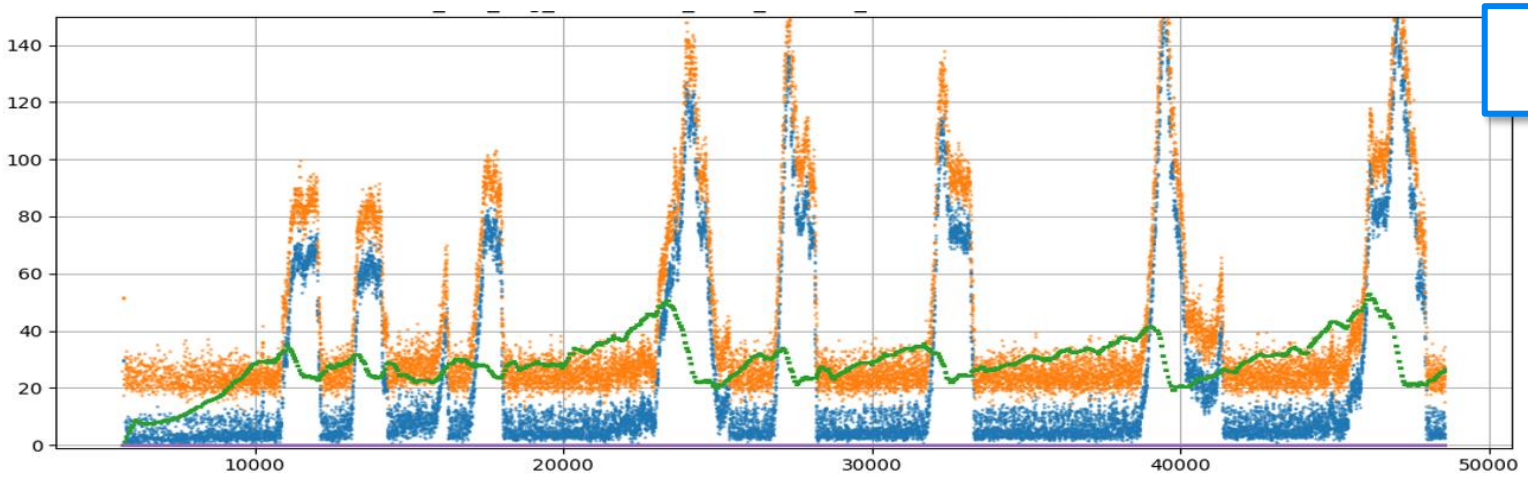
- 7 gNBs with 3 sectors each, for a total of 21 cells
- Low band (600MHz, FDD)
- Video (gaming) and Web users, [1:10]

NR Gaming
- Boat Attack, L4S downlink

[Ericsson and DT demo 5G low latency feature]

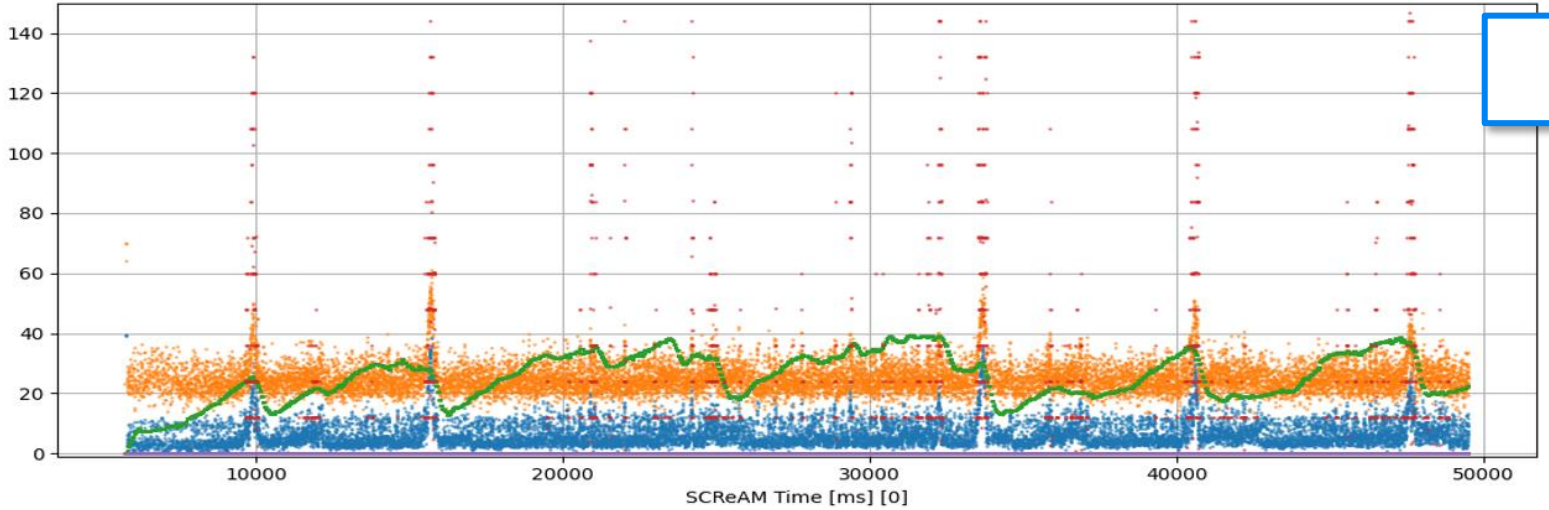


Bursty background 10 MB/5 sec on average
- Boat attack game with/without L4S



Baseline L4S OFF: Latency peaks

- Boat attack
- Bandwidth: 20 MHz
- TDD n40 (2.3 GHz)

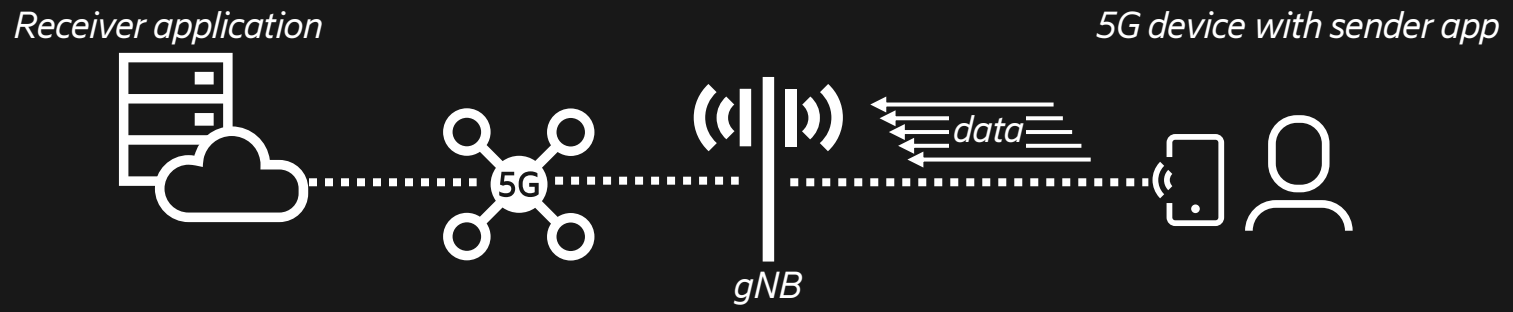


L4S ON: Rate adapted, stable low latency

- DL Q-delay [ms]
- RTT [ms]
- Bitrate [Mbps]
- CE-Marking [B]

Multiple (5) uplink flows

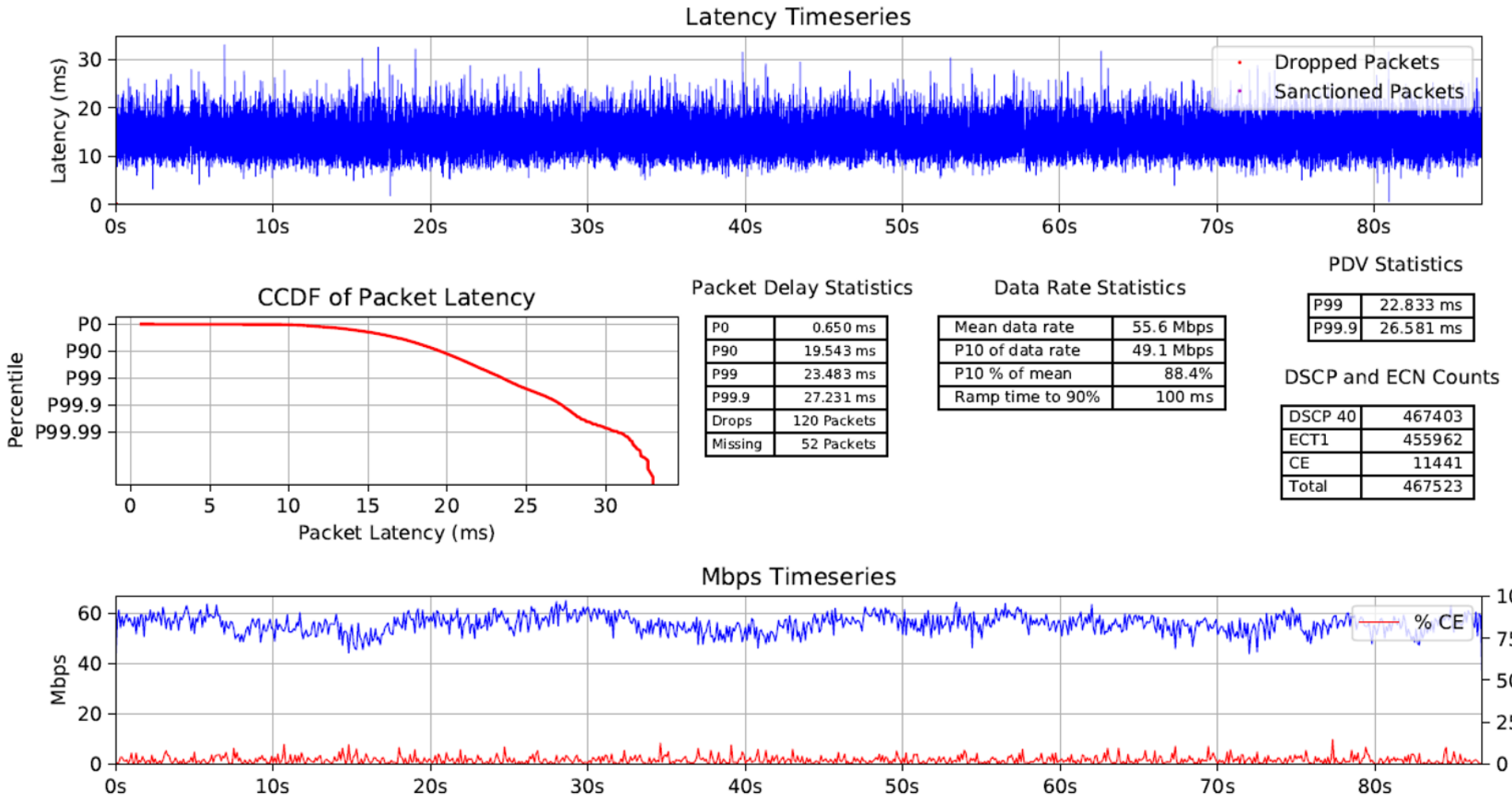
- TCP Prague [L4S]
- IETF Hackaton, London 2022



TCP Prague Uplink
- Link capacity

From IETF Hackaton, London 2022

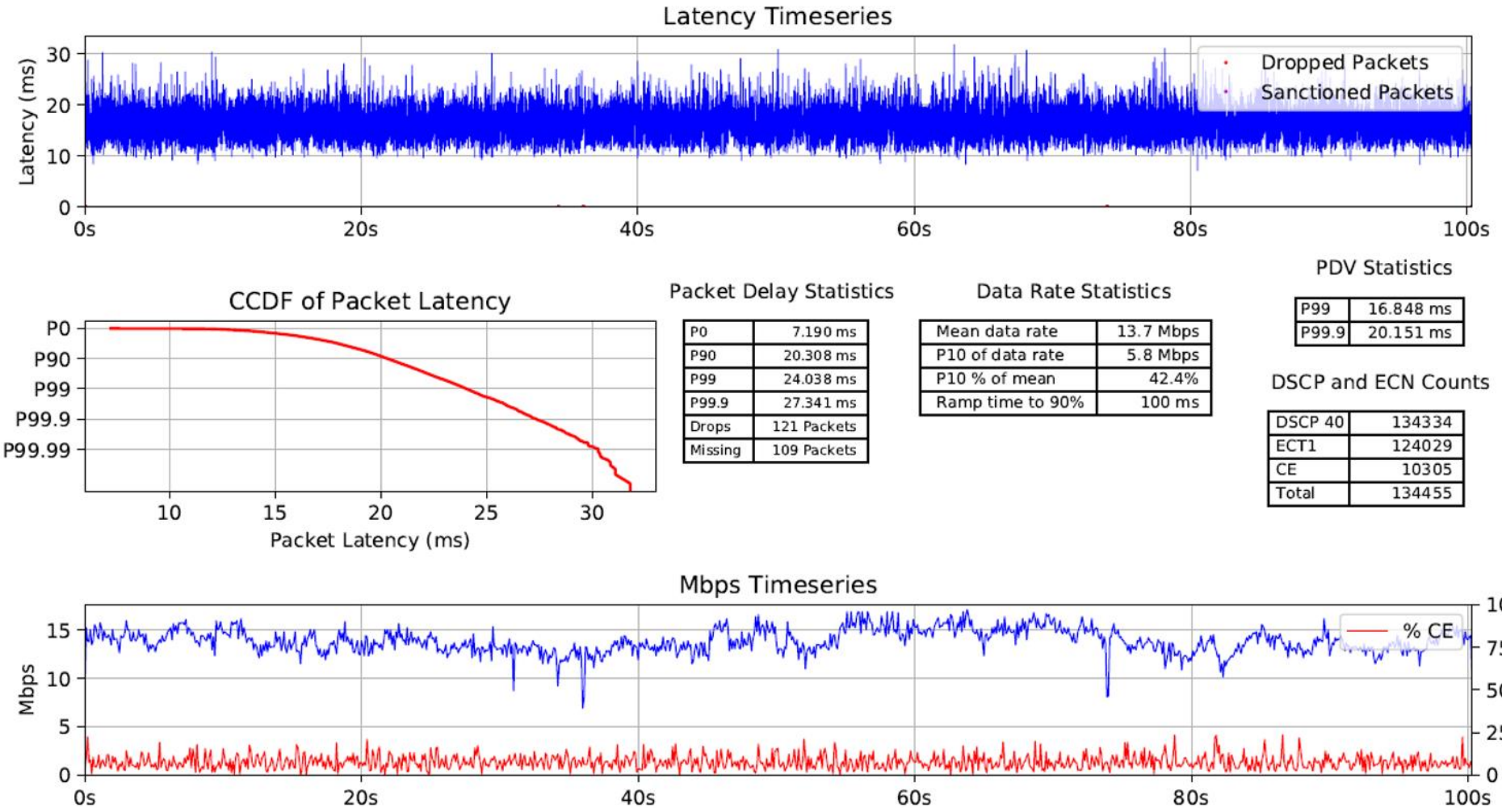
- Iperf or similar
- Bandwidth: 40 MHz
- TDD n78 (3.5 GHz)



TCP Prague Uplink
- 5 Streams
- Stream1 data

From IETF Hackaton, London 2022

- Iperf or similar
- Bandwidth: 40 MHz
- TDD n78 (3.5 GHz)

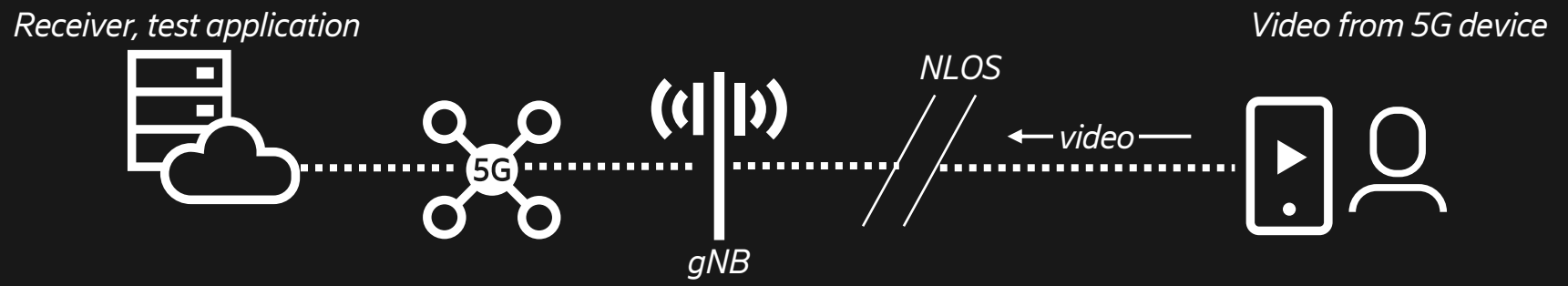


TCP Prague Uplink
- 5 Streams
- Aggregated rate

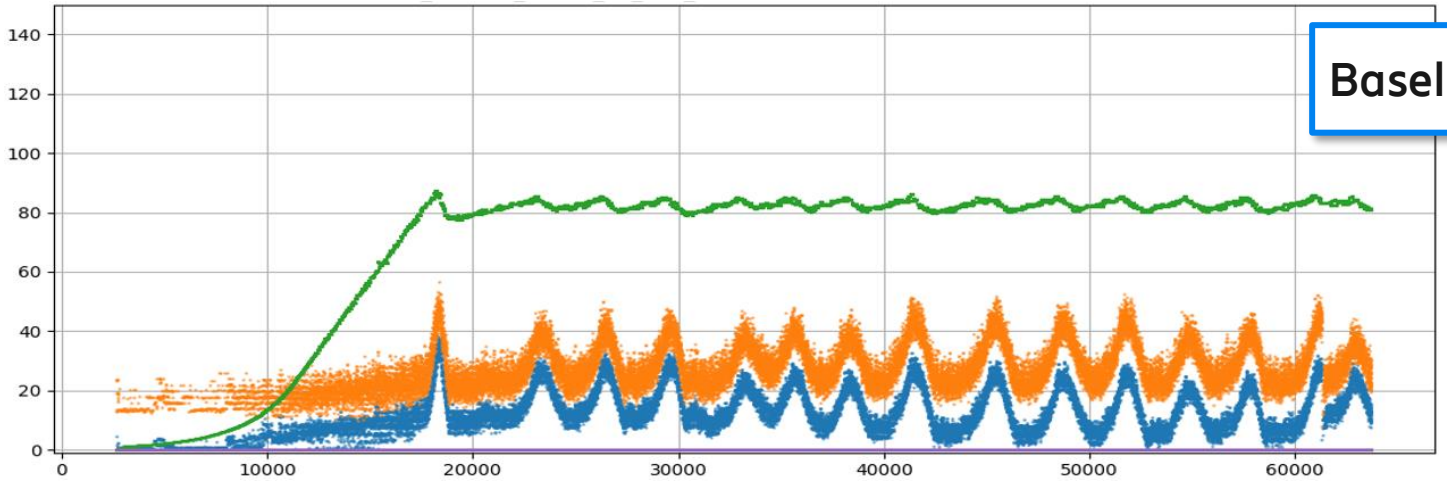
From IETF Hackaton, London 2022

- Iperf or similar
- Bandwidth: 40 MHz
- TDD n78 (3.5 GHz)

Static indoor, non line of sight
- L4S uplink

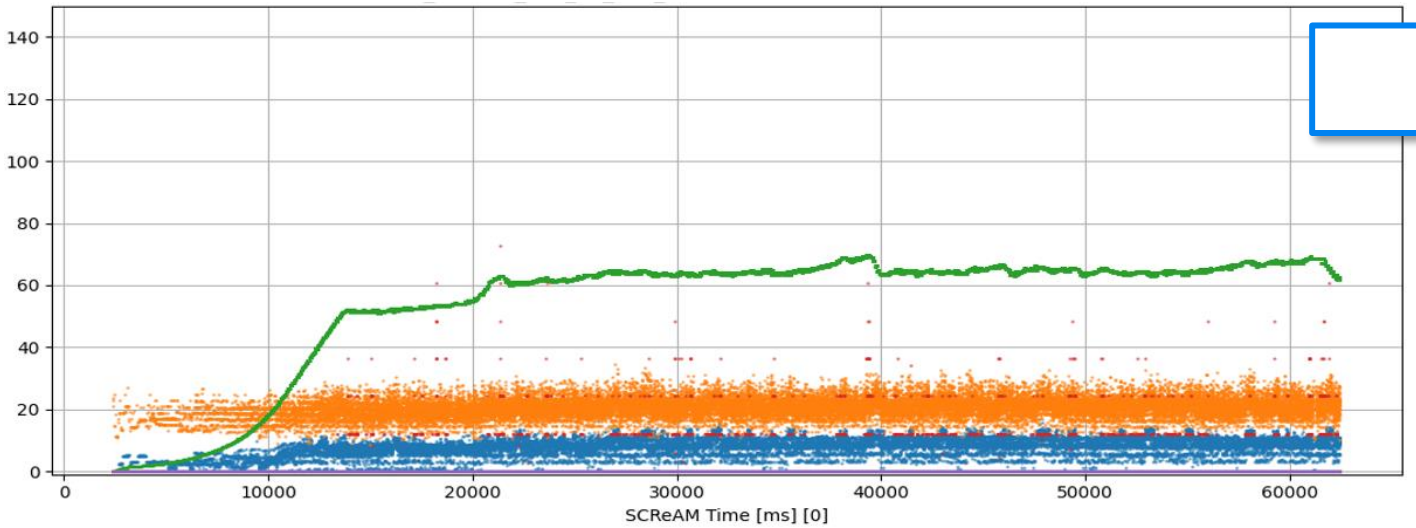


Static uplink, SCReAM test app
- L4S on/off. No background traffic



Baseline L4S OFF: Full buffer ⇔ UE link cap **~80Mbps**

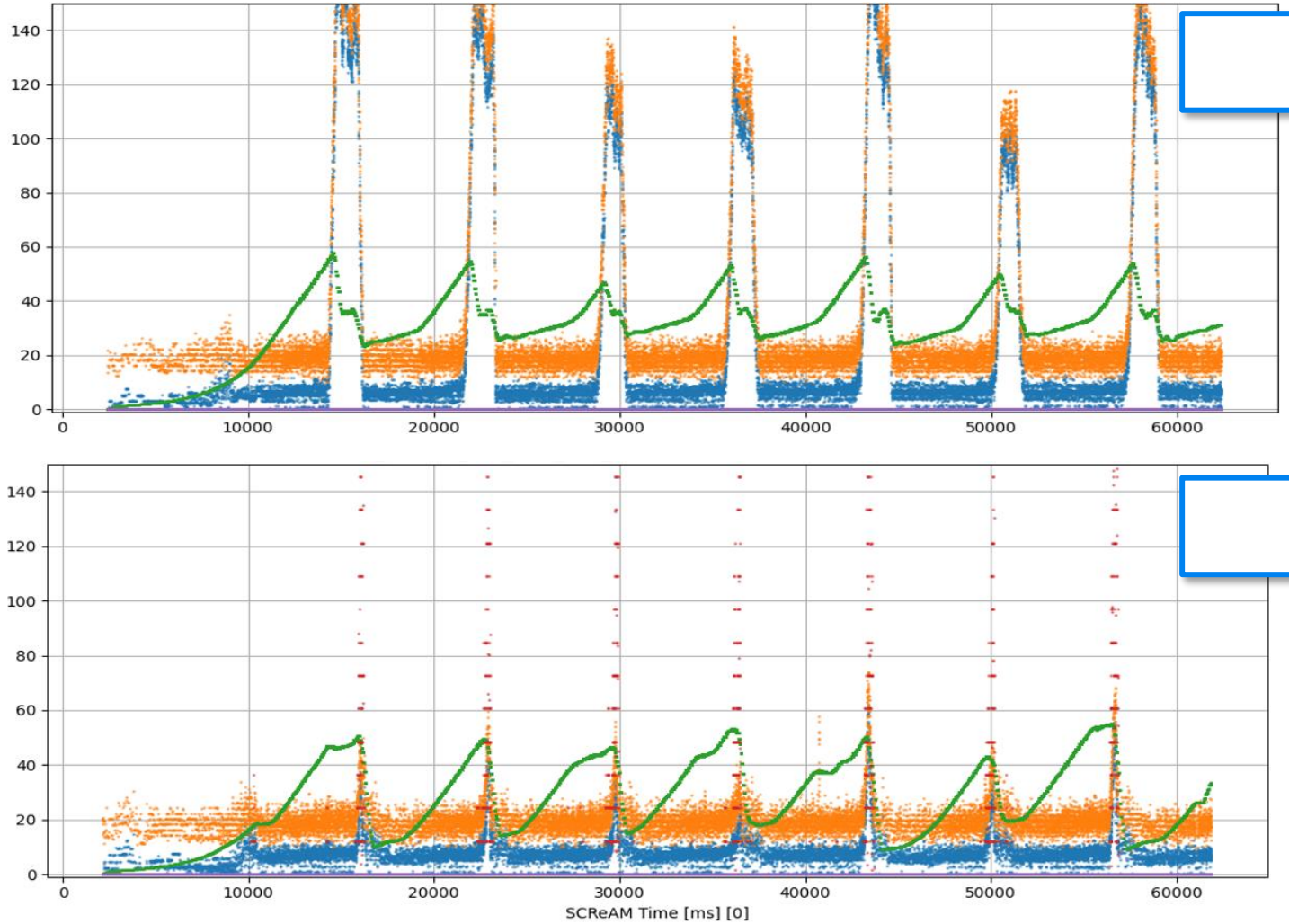
- Scream test app
- Bandwidth: 100 MHz
- TDD n78 (3.5 GHz)



L4S ON: ~60-70Mbps => ~75-85% of link cap

- DL Q-delay [ms]
- RTT [ms]
- Bitrate [Mbps]
- CE-Marking [B]

Static uplink, SCReAM test app
- L4S on/off. Background traffic (10 MB iperf bursts)



Baseline L4S OFF: Latency peaks

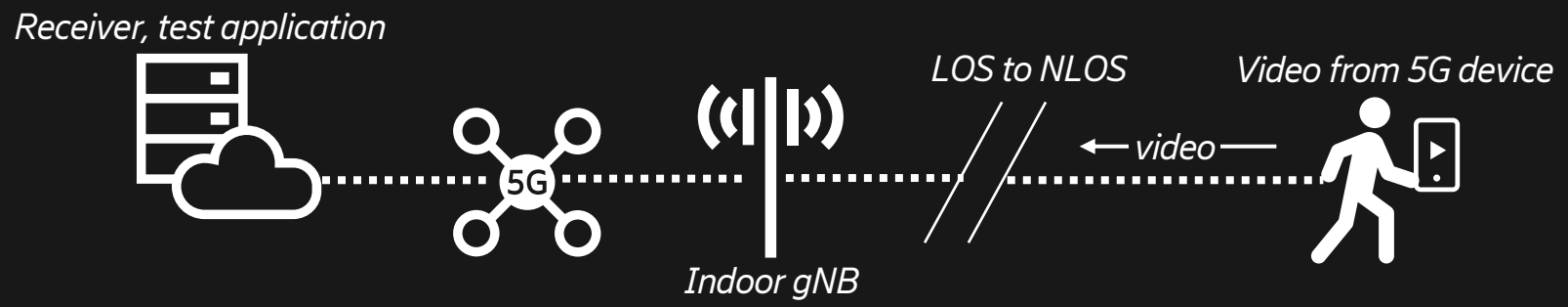
- Scream test app
- Bandwidth: 100 MHz
- TDD n78 (3.5 GHz)

L4S ON: Rate adapted, stable low latency

- DL Q-delay [ms]
- RTT [ms]
- Bitrate [Mbps]
- CE-Marking [B]

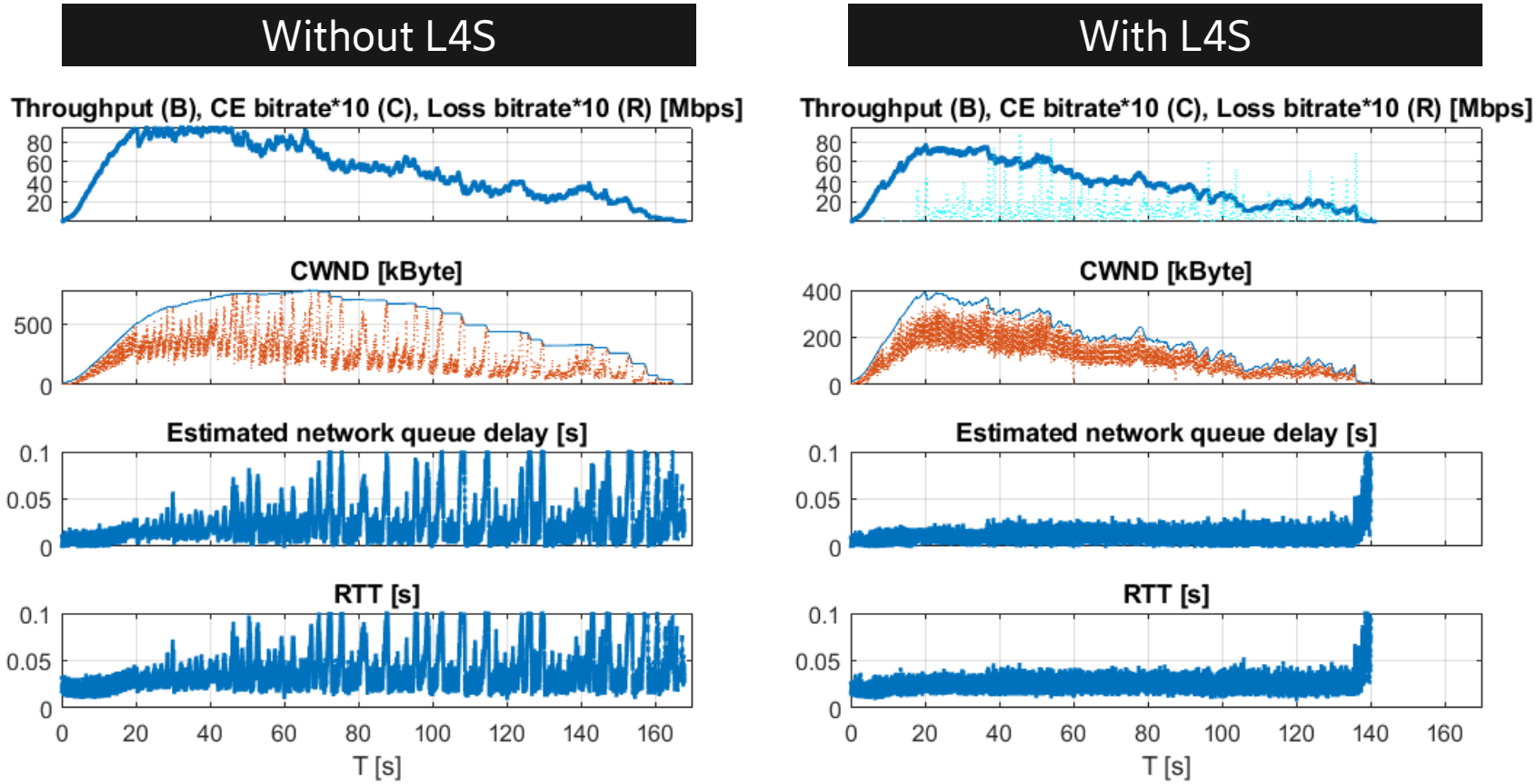
Indoor, no-L4S vs L4S

- Line of sight (LoS) -> Non-LoS



Comparison non-L4S vs L4S
- Pedestrian indoor

- Slow walk along corridor farther away from 5G radio*
  - L4S walk was a bit faster
- LoS until the last few seconds
- Fading causes the throughput to vary, i.e. not monotonically decreasing throughput
  - Even people passing by affects throughput



* Ericsson Radio Dot System

Abbreviations

5GC	5G Core net
App	Application
CDF	Cumulative Distribution Function
CE	Congestion Experienced
DL	Downlink
DRB	Data Radio Bearer
gNB	5G radio access network node
L4S	Low Latency Low Loss Scalable throughput
LoS	Line of Sight
MBB	Mobile Broadband
OTT	Over-the-Top
NLOS	Non-Line of Sight
RF	Radio Frequency
RTT	Round Trip Time
TDD	Time Division Duplex
UE	User Equipment
UL	Uplink