Packet-oriented QoS management model for a wireless Access Point

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Why this Internet-Draft?

- Internet mobile traffic grows rapidly… but **no model for packet-based QoS management over the radio segment** has been documented
  - without such models taking into account the IP layer in the wireless Access Point for QoS management, some of the mechanisms involving the IP layer (AQM, ECN, …) are irrelevant to cellular networks
  - common models for simulation activity are useful

- Overview of the I-D is provided here, as well as initial simulation results (based on NS-3)
- Objective: initiate discussion on the mailing list!

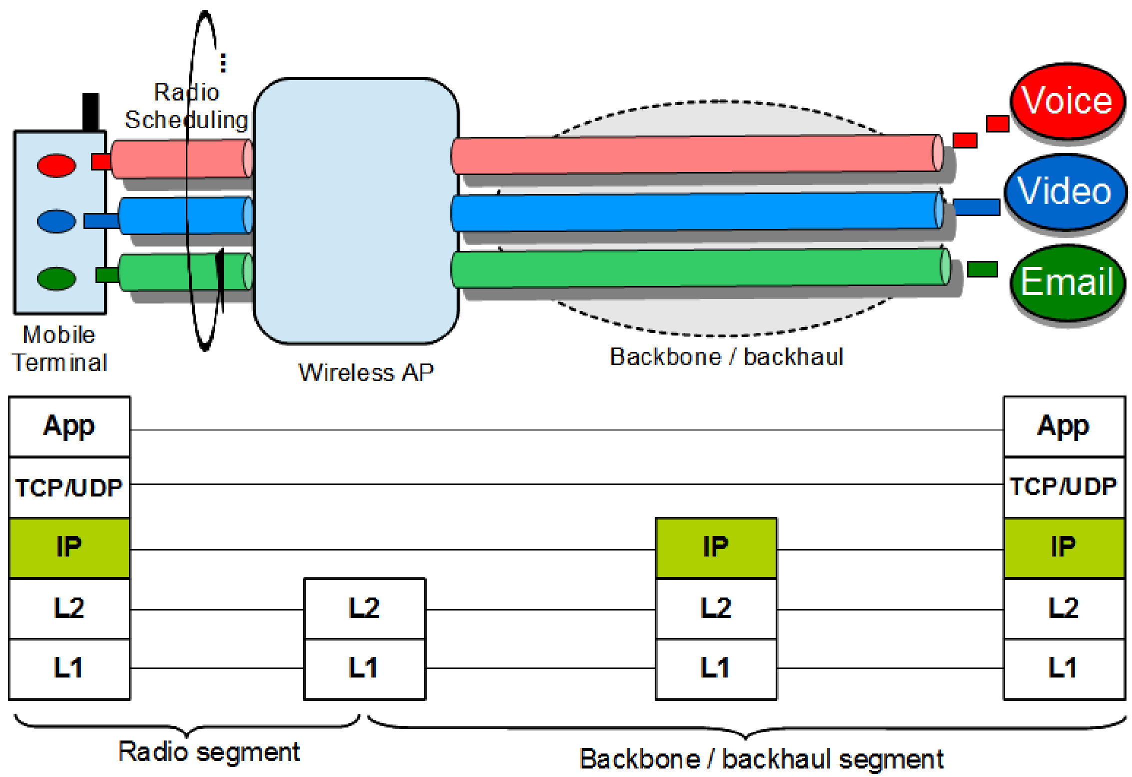
Current QoS model in Mobile Cellular Networks

Connection-oriented QoS management in mobile networks

- Several bearers per terminal (one per QoS level); traffic oriented at bearer endpoints
- Bearers setup via control plane signaling protocols, including input to the radio scheduler
- IP layer normally not treated by the (e)NB, which acts as a relay
- Multi-bearer QoS model is very similar to access architectures proposed in the late 90s for residential fixed services on ADSL

In the current context, this model raises issues in terms of:

- Scalability (number of bearers)
- Efficiency (signaling load)
- Performance (bearer establishment delay)



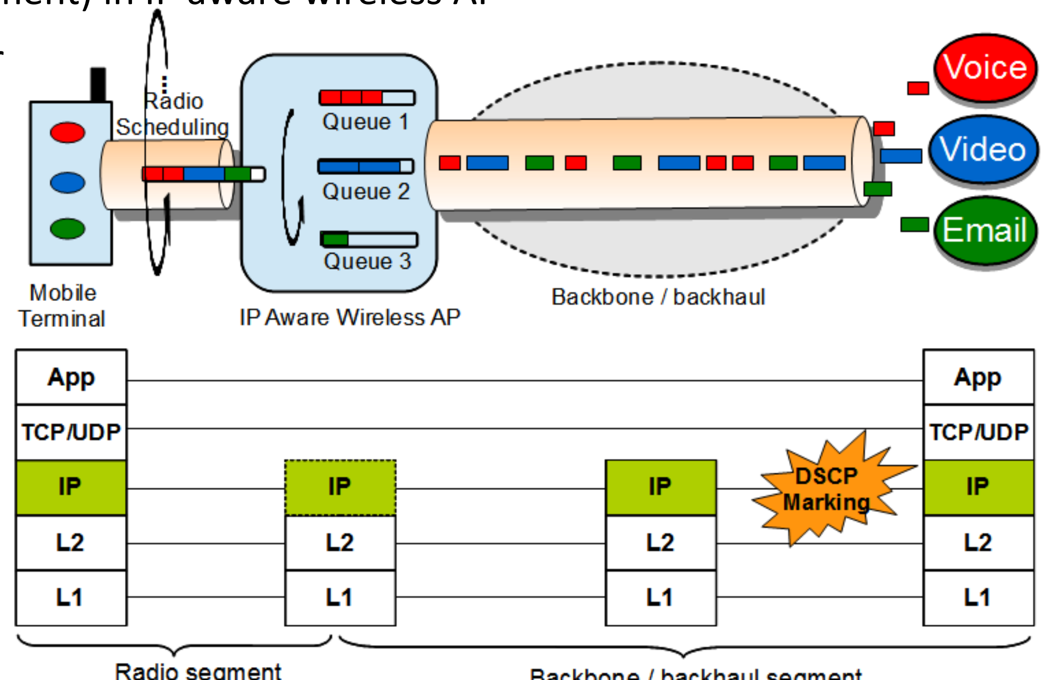
Packet-oriented QoS model for Mobile Networks

IP basis features

- IP networks natively operate packets, commonly conveyed in connectionless mode
- IP QoS naturally managed on a packet by packet basis (DSCP/ToS field)

IP aware model

- Mobile terminal connectivity may still be operated in connection-oriented mode through a bearer
- But QoS management is performed in packet mode: DSCP/ToS field controls the QoS in the bearer
- DSCP taken into account when scheduling packets on radio interface
- Addition of an IP stage (queue management) in IP aware wireless AP
- QoS management inside a single bearer



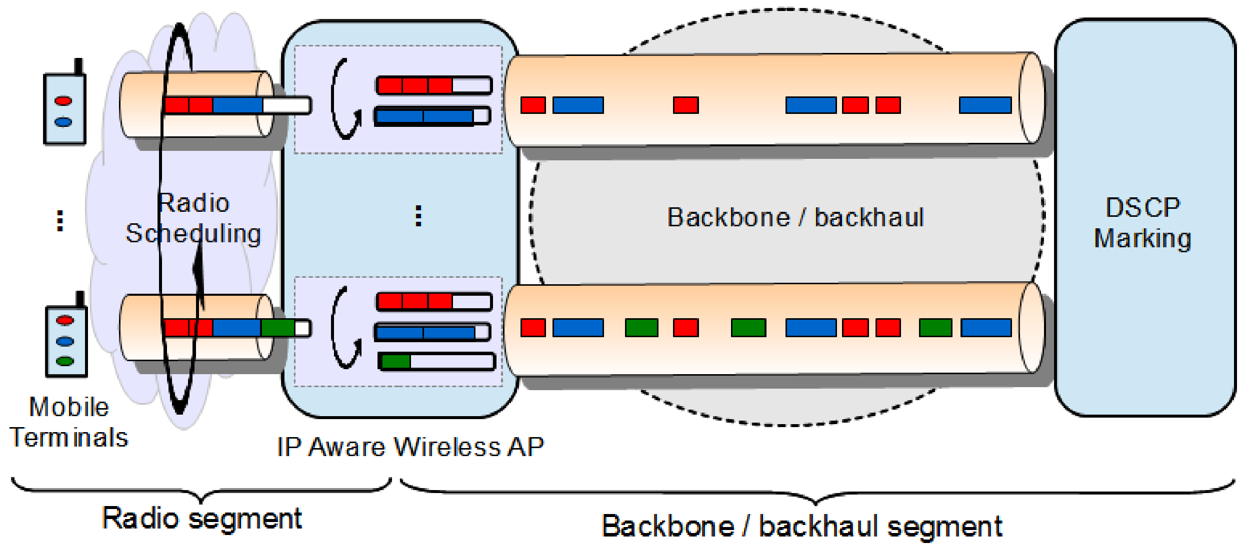
Advantages:

- Solves previous issues (scalability, efficiency, performance)
- Easy deployment/operation
- Allows implementation of IP mechanisms as AQM, ECN, etc
- Leads to a graceful fixed/mobile functional convergence

Possible models (intra-bearer/inter-bearer)

Model for intra-bearer arrangement

- Addition of an IP queuing stage per user prior to the radio scheduler, without changing the overall radio resources allocation between the various mobile terminals (intra-bearer arrangements only)
- Prioritization of the sensitive packets transmitted on the radio interface based on the DSCP marking



Models for inter-bearer arrangement

- Radio resource allocation depends on the traffic mix offered to the mobile terminal
- More radio resources to users operating high priority traffic (inter-bearer arrangements)

Conclusions and next steps

IP aware model

- It is in line with usual Internet paradigms, based on connectionless packet-oriented QoS management
- It is easy to deploy and operate
- It allows the activation of IP mechanisms discussed in ICCRG (AQM, ECN, etc) in the IP aware wireless AP, because the IP layer is now treated by the (e)NB in this model
- It leads to a graceful fixed/mobile functional convergence

Next steps

- Intra-bearer model has been presented in this version of the draft
  - Initial simulations results are provided in annex of this presentation
  - More advanced simulations on radio segment, based on LENA NS-3 module, on-going
  - Investigations on-going about implementation issues
- Inter-bearer model(s) will be provided later
- Feedback from IRTF/IETF community is welcome!

Thanks You

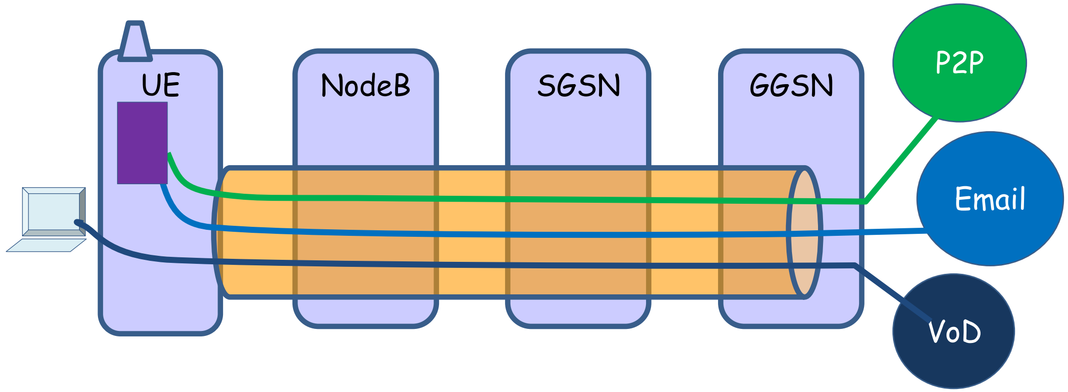
Annex: initial simulation results based on NS-3

(intra-bearer model)

QoS policies in mobile networks of today

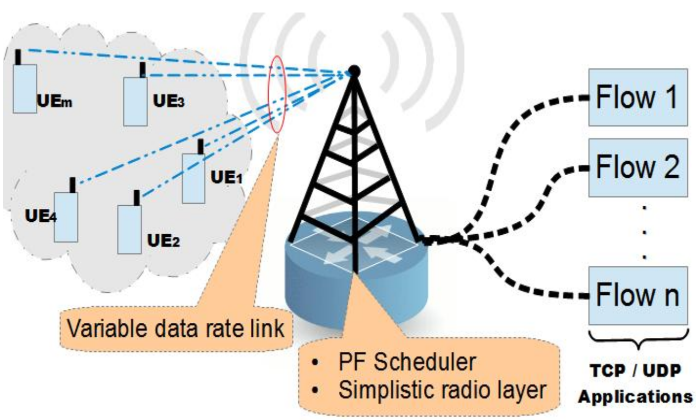
Current 3G deployment

- A “Best Effort for all” policy within one bearer per UE
- No QoS differentiation per service
  - multibearer not available in most UEs; no strong marketing request
- Blind FIFO multiplexing within this bearer: poor customer experience



Simulation: Model for intra-bearer arrangement

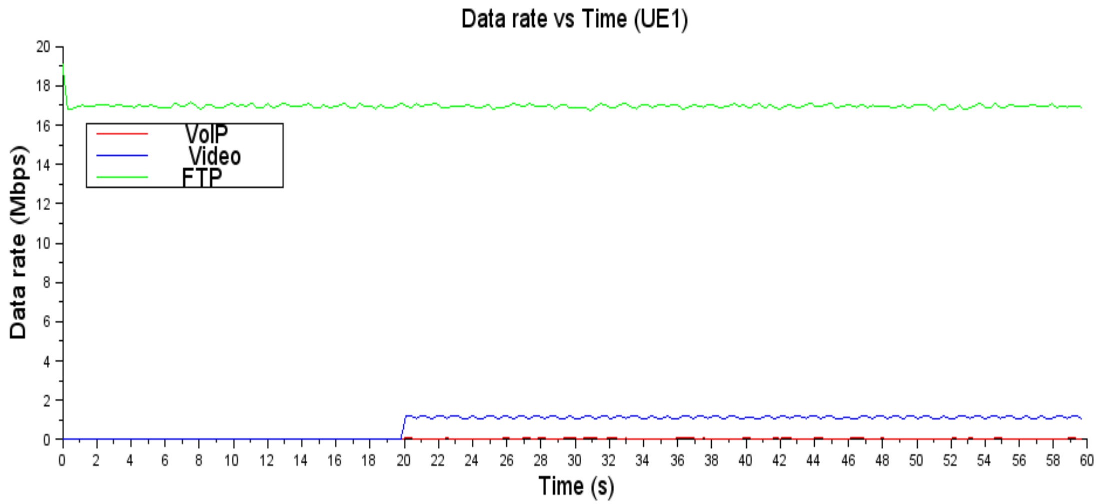
- LTE network configuration: frequency band = 20MHz (100 Physical Resources Blocks), no radio loss
- Radio scheduling algorithm: Proportional Fair
- IP non-preemptive Priority Queuing system added before this radio scheduler, without influencing it. 3 finite queues per UE: highest priority queue with strict priority, and two other queues in Round Robin
- Three independent application streams: Best Effort BE/FTP (TCP cubic), Medium AF/Video (TCP cubic) and Premium EF/VoIP (UDP). FTP starts first, then Video and VoIP (at time t = 20s).
- One terminal in good radio conditions **UE_1** (CQIs vary uniformly in [10, 15])
- One terminal in bad radio conditions **UE_2** (CQIs vary uniformly in [1, 5]) – NB: full CQI range is [1-15]



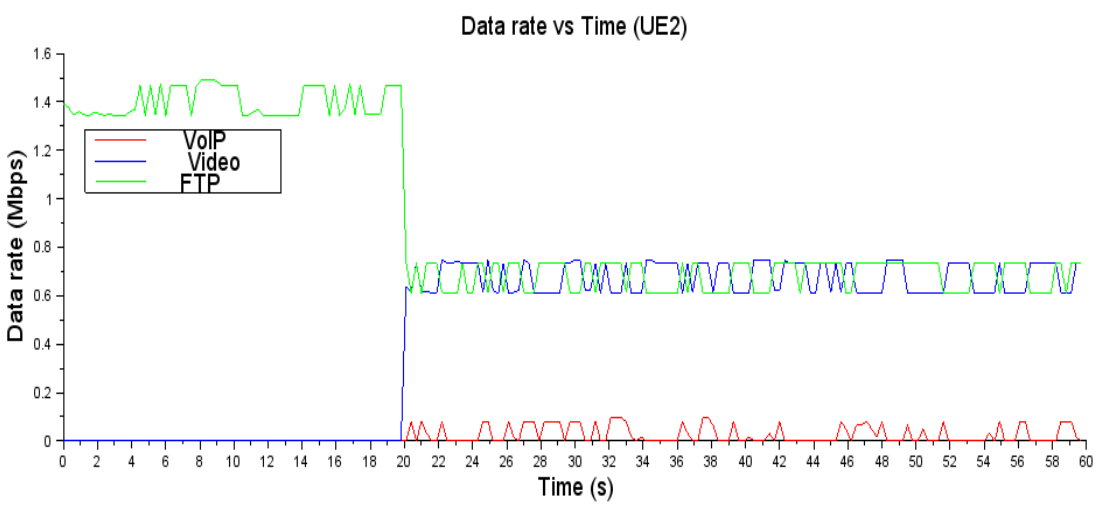
Number of terminals	2
Transmission Time Interval (TTI) duration	1 ms
Data rate of VoIP traffic (UDP) (EF) ($t_0 = 20s$)	68.8 kbps
Data rate of Video (TCP) (AF) ($t_0 = 20s$)	Application rate: 1 Mbps
Data rate of FTP (BE) ($t_0 = 0s$)	Application rate: 15 Mbps
Packet size of VoIP traffic	172 bytes
Packet size of Video traffic	1460 bytes
Packet size of FTP traffic	1460 bytes
Queue size (prioritized and non-prioritized)	15 000 Packets
Simulation time	60 seconds

Simulation: Data rate UE1 vs UE2
With IP-aware

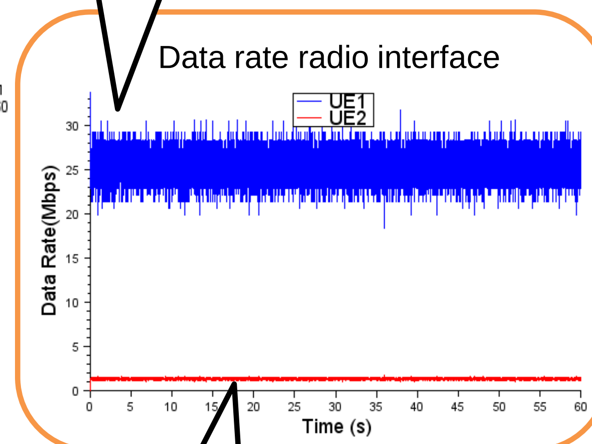
UE1
good radio conditions



UE2
bad radio conditions



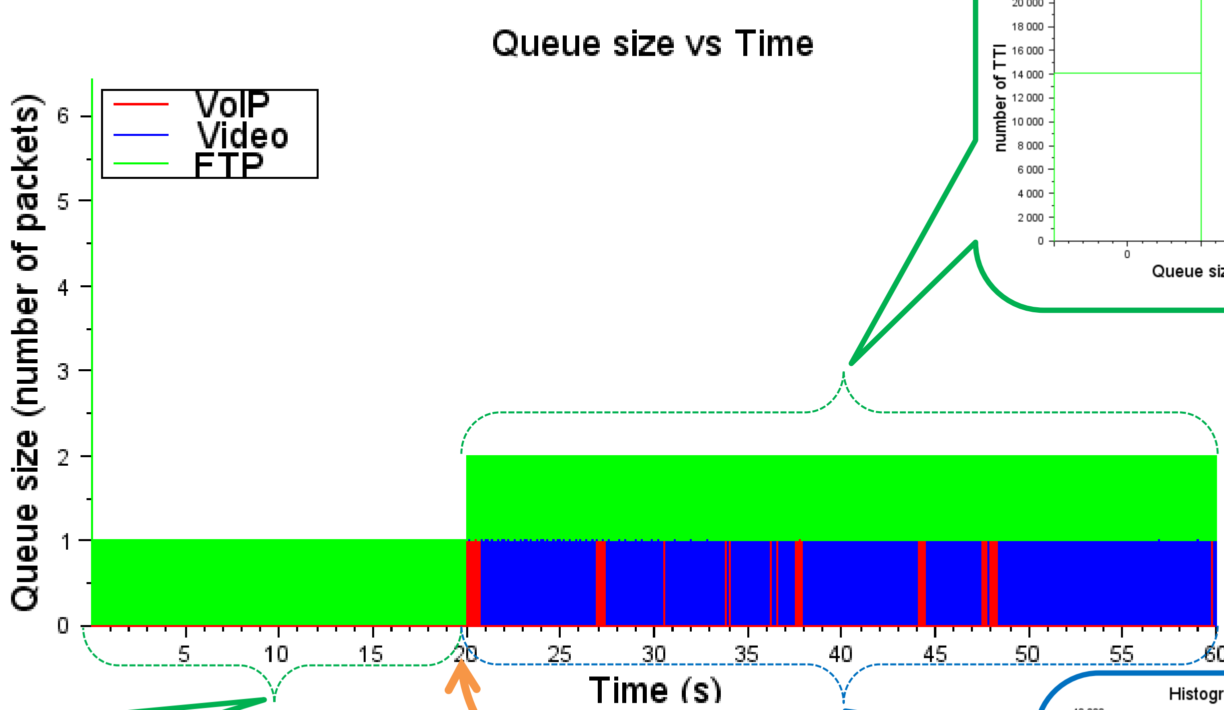
UE1 has enough throughput (≈25 Mbps) to serve all its flows at the application rate

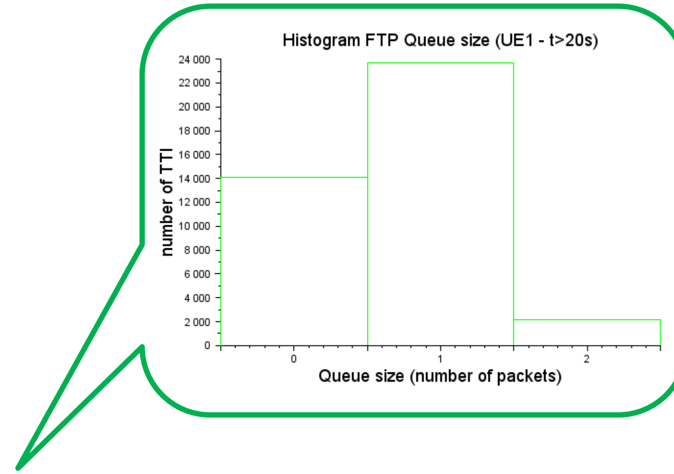


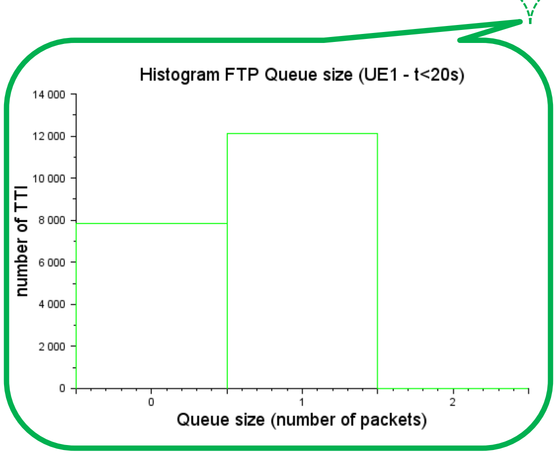
UE2 has not enough throughput (≈1.4 Mbps) to serve all its flows at the application rate

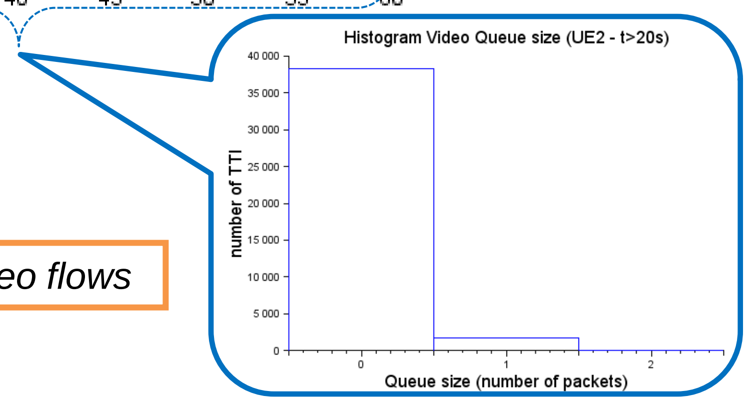
Simulation: Queue state UE1

With IP-aware



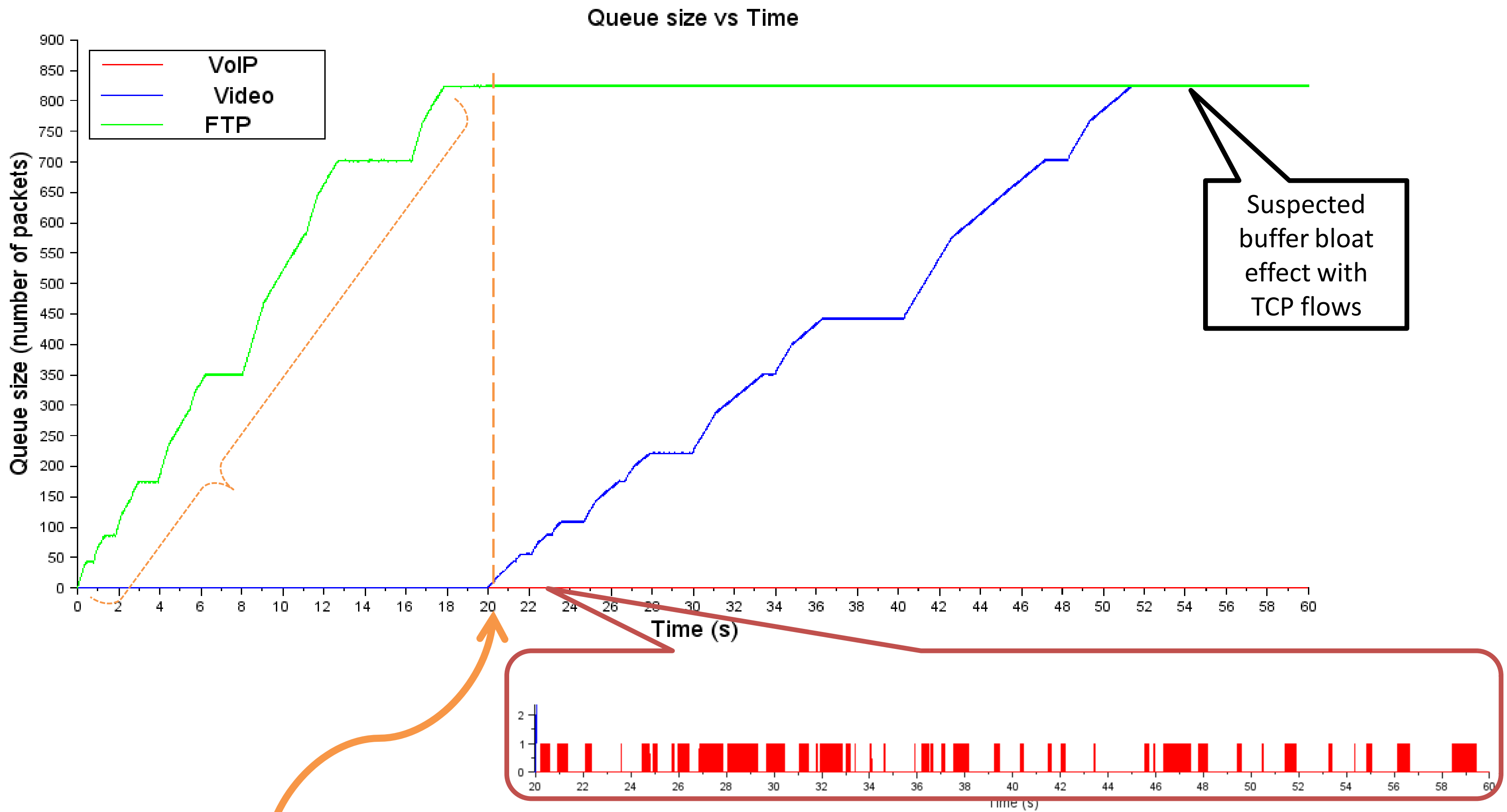






t=20s : Start of VoIP and video flows

Simulation: Queue state UE2
With IP-aware



t=20s : Start of VoIP and video flows

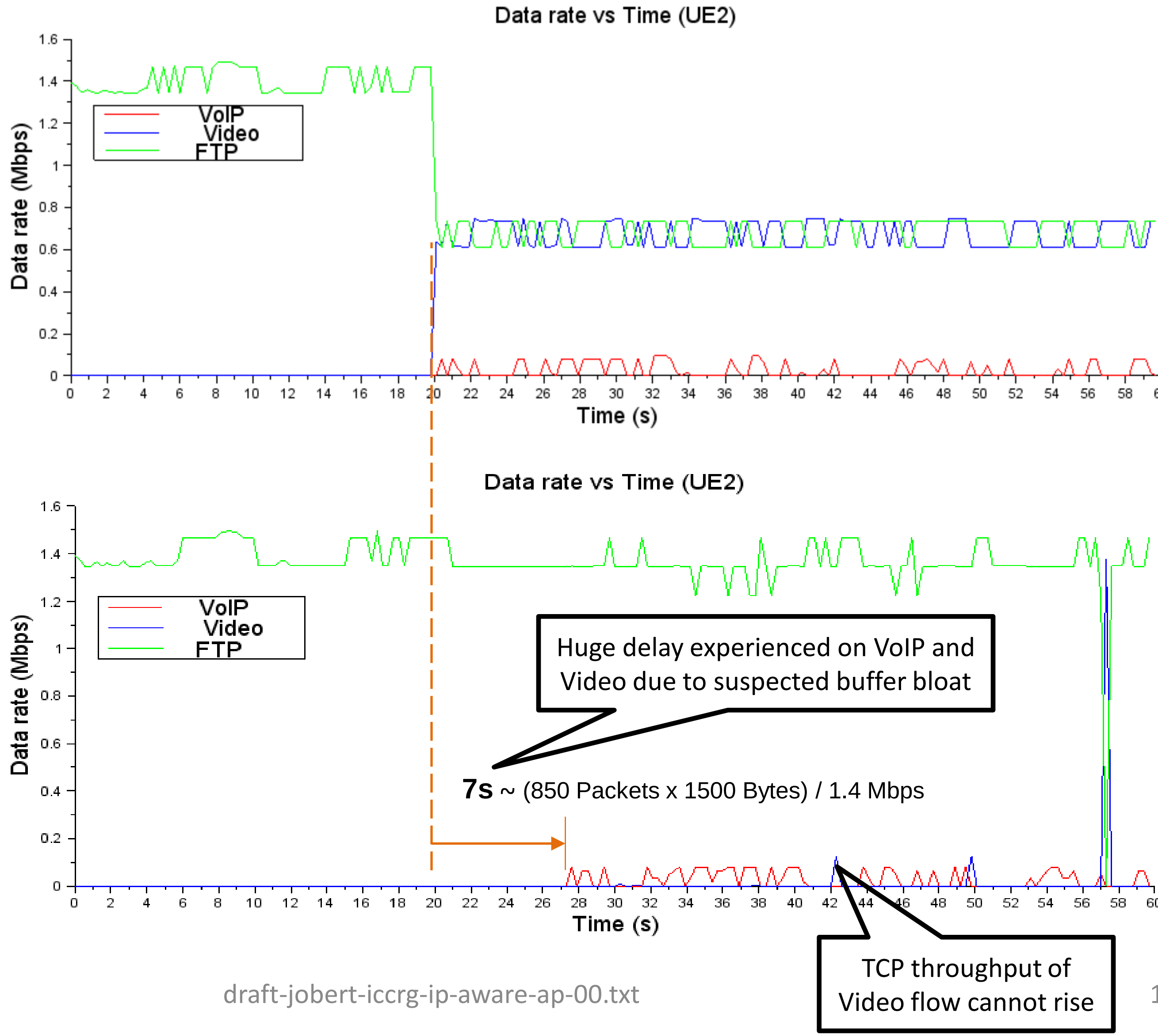
Simulation: Data rate UE2
With IP-aware vs Without IP-aware

UE2

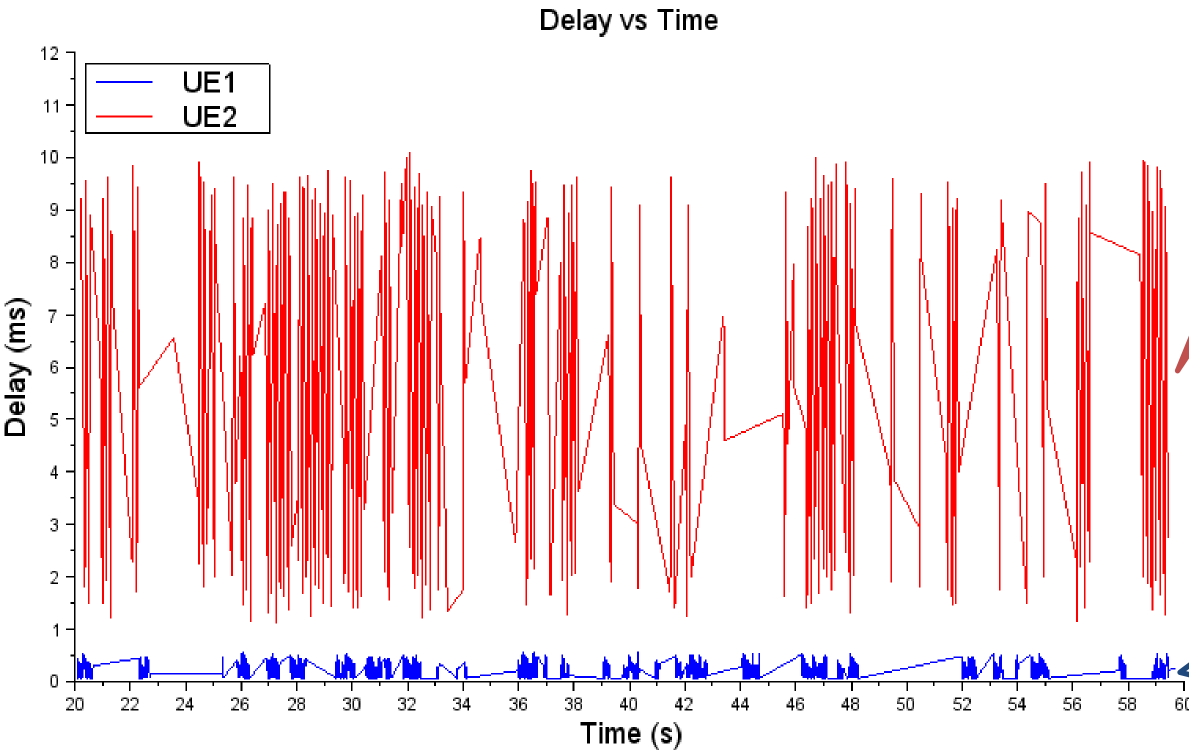
With IP-aware
(3 IP queues,
one for each app)

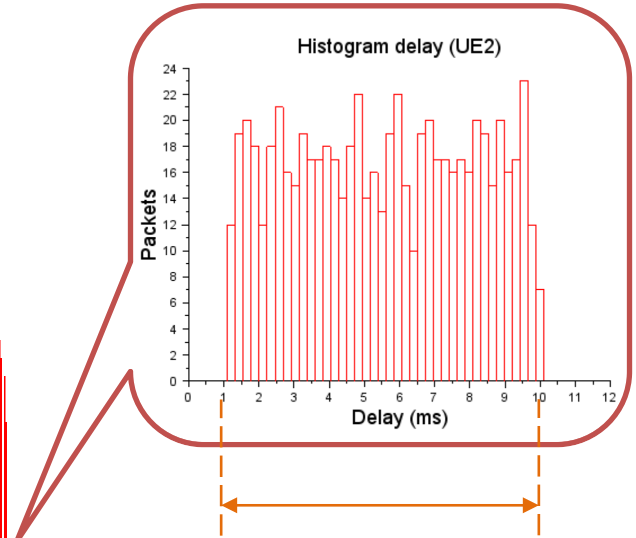
UE2

Without IP-aware
(1 single queue,
shared by all apps)



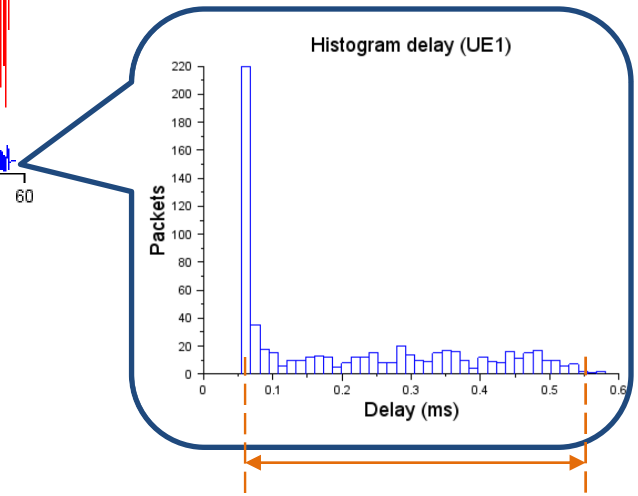
Simulation: VoIP Delay UE1 vs UE2
With IP-aware





9ms ~ (1 Packet x1500 Bytes) / 1.4 Mbps

(VoIP d*elay spread due to non preemptive configuration*)

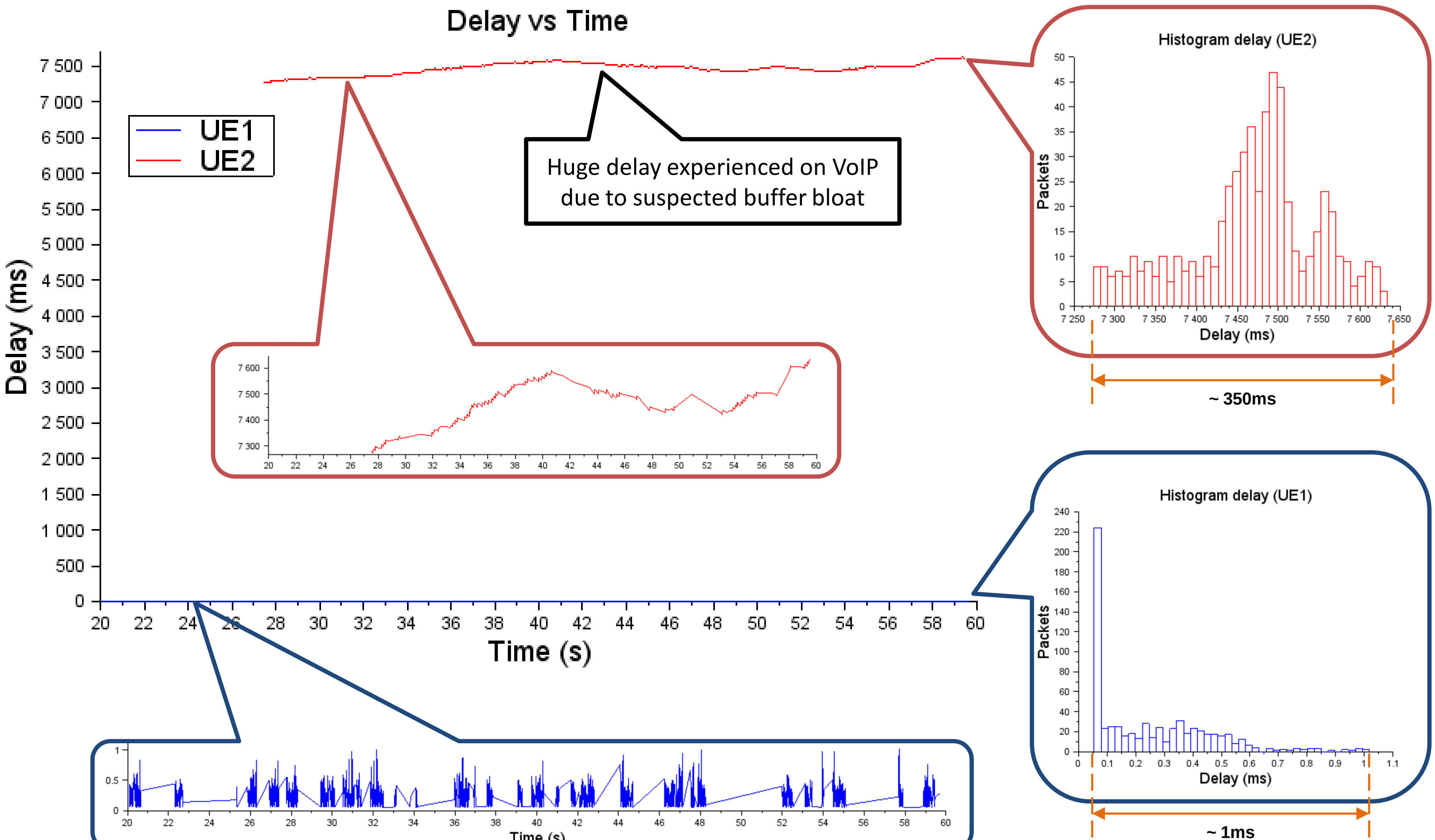


0.5ms ~ (1 Packet x1500 Bytes) / 25 Mbps

<u>Propagation delay VoIP packets</u>:

UE1: **0.06ms** ~ (1 Packet x 200 Bytes) / 25 Mbps
UE2: **1ms** ~ (1 Packet x 200 Bytes) / 1.4 Mbps

Simulation: VoIP Delay UE1 vs UE2
Without IP-aware



(VoIP delay spread due to probability of more than one packet in the queue at the same time)

Quick reminder on radio schedulers

Radio resource allocation

- Achievable throughput depends on UE radio conditions (Modulation and Coding Schemes)
- Popular Proportional Fair is an opportunistic algorithm

QoS aware scheduling (GBR, weights)

- Prop. Fair behavior is modified
- Maintaining a GBR requires more resources in bad radio conditions (less efficient coding schemes)
- Impacts depends on the commitment’s harshness; potentially, all radio resources to a premium UE in very bad conditions

QoS differentiation between bearers is not “rob Peter to pay Paul”

- Impact on cell overall capacity and risk of starvation