

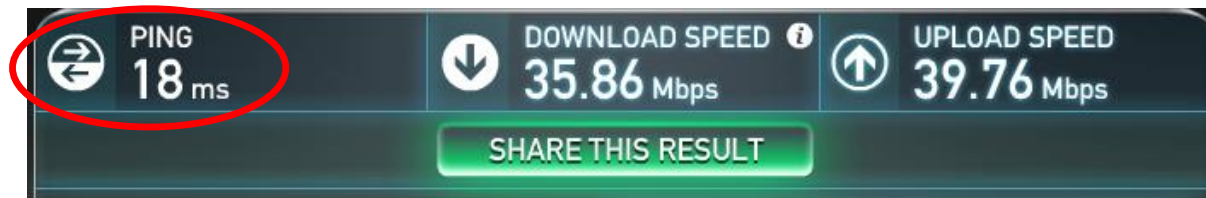
STUDY ON LATENCY REDUCTION TECHNIQUES FOR LTE

RP-150310 - Motivation for new proposed SI

LATENCY REDUCTIONS



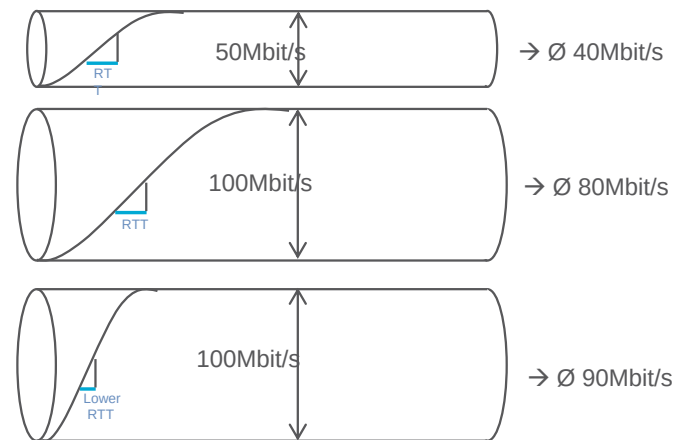
- › Latency is one key performance indicator
 - Differentiator between 3G and 4G, between operators and between wireless systems
 - Key requirement for 5G systems
- › No major work on latency improvements in 3GPP since Rel-8!
 - Meanwhile, data rates have increased from 300 Mbit/s to 4 Gbit/s
 - Latency (RTT) is dominating the end user throughput for TCP-based apps
- › Pre-scheduling techniques are offered by the vendors and are deployed in commercial operation
 - But those drain UE battery and cause heavy uplink interference (coverage problems)



WHY IS LATENCY IMPORTANT?

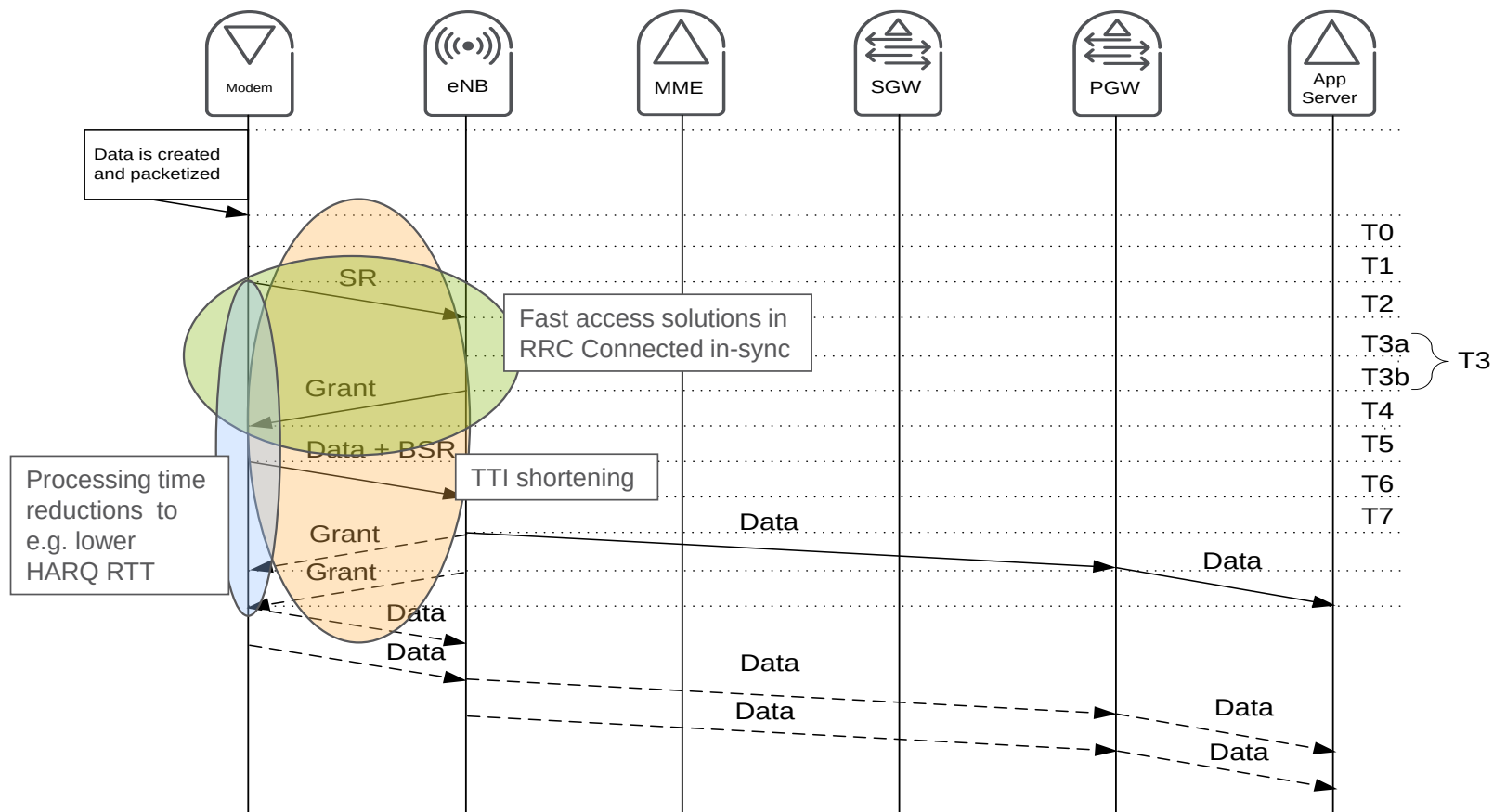


- › Low latency gives higher TCP throughput
 - Both DL and UL latency (round trip time **RTT**) matters for TCP DL!



- › Quality of experience for real-time services is directly related to latency
- › Low latency opens up for new applications
 - car-to-car, critical MTC
- › UE buffer requirements can be set lower

WHAT 3GPP COULD ADDRESS



STUDY ITEM OBJECTIVES



- › Study enhancements to the E-UTRAN radio system in order to:
 - Significantly reduce the packet data latency over the LTE air interfaces (UL/DL) for an active UE
 - Significantly reduce the packet data latency for UEs that have been inactive for a longer period (in connected state).

- › The solutions should consider resource efficiency, including air interface capacity, battery lifetime and control channel resources.

PROPOSED STUDY AREAS



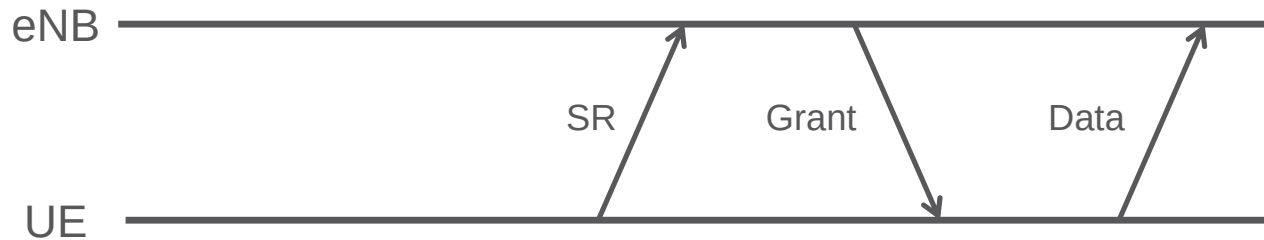
- › L2 protocol solutions for fast uplink access:
 - for active UEs and UEs that have been inactive a longer time, but are kept in RRC Connected, focus should be on getting a more resource efficient solution, compared to the pre-scheduling solutions allowed by the standard today;

- › TTI shortening and reduced processing times:
 - Re-timing of the system to significantly reduce all latencies involving RAN transport, while preserving backwards compatibility (thus allowing normal operation of pre-Rel 13 UEs);

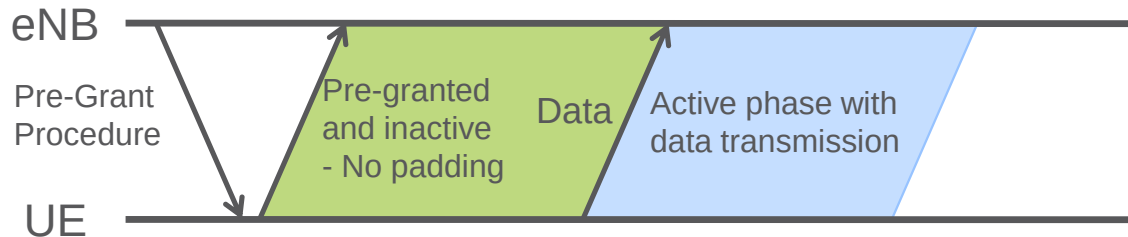
L2 PROTOCOL SOLUTION EXAMPLE



› Current uplink transmission procedure:



› Enabling instant uplink access



L2 PROTOCOL SOLUTION EXAMPLE

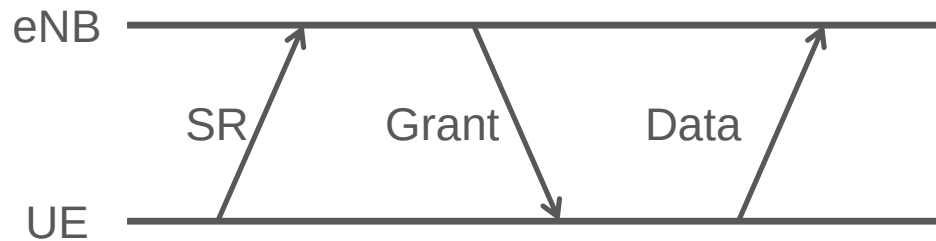


- › Pre-grant → fast uplink access but with limited throughput
 - Resources can be allocated with (modified) SPS
- › Remove the requirement to send padding when no data is in buffer → saves battery resources when inactive
 - Good throughput per watt statistics
- › Switch to dynamic scheduling when entering active phase
 - optimizing throughput when having lot of data in send buffer

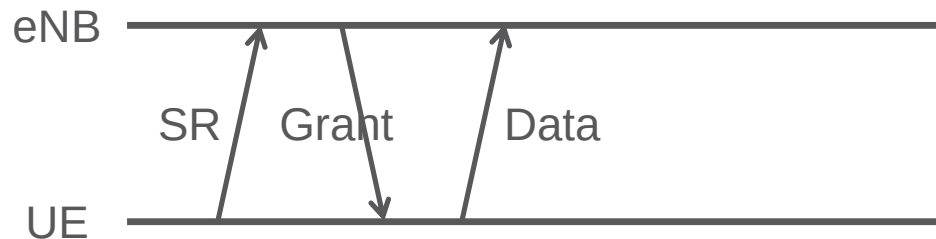
TTI SHORTENING IN UL



- › Current uplink transmission procedure:



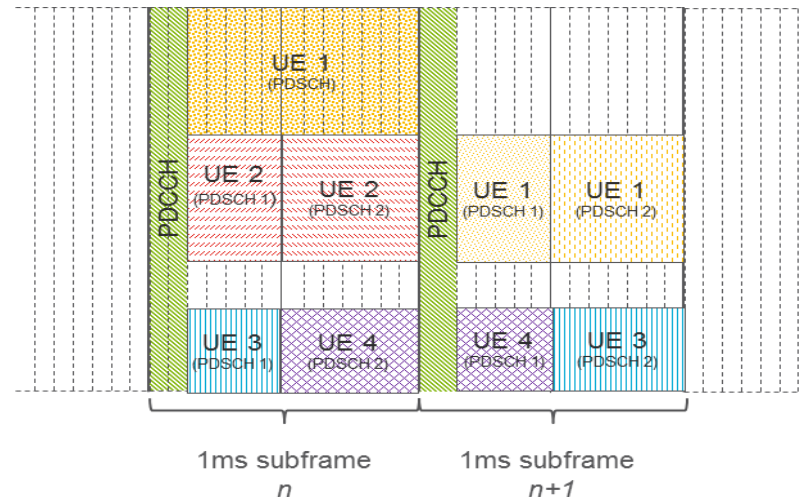
- › Improved uplink latency via TTI shortening



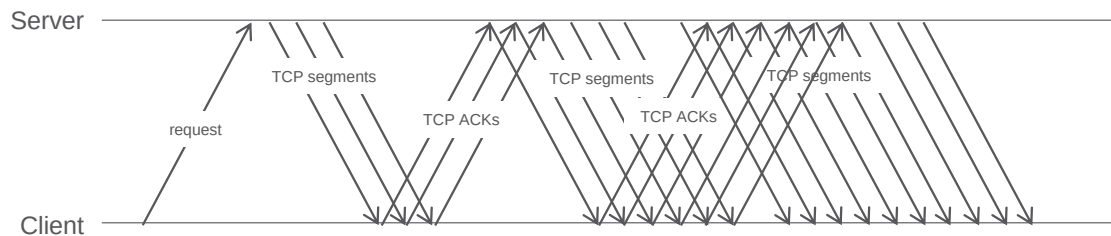
TTI SHORTENING IN DL



- › Backward compatible scheduling of shorter PDSCH assignments
- › Users scheduled with shorter assignments are able sent UL HARQ ACK/NACK earlier



LATENCY IMPACT ON TCP



- › TCP (especially slowstart) performance depends on LTE round trip time
 - Matters for downloads of small files, which currently dominate internet traffic (webpages, Whatsapp, Twitter etc.)
- › The self-clocking property of TCP means that both LTE uplink and downlink latency improvement will improve TCP downlink performance

POTENTIAL GAINS (TCP THROUGHPUT)

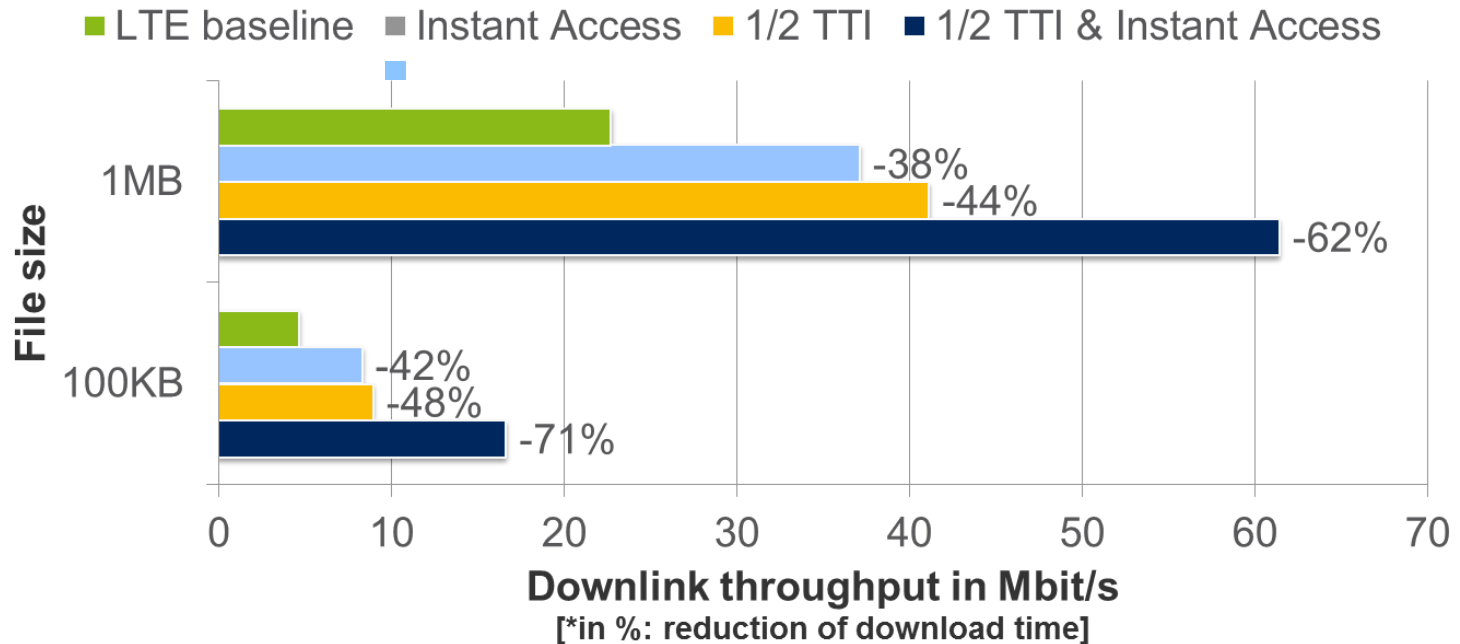
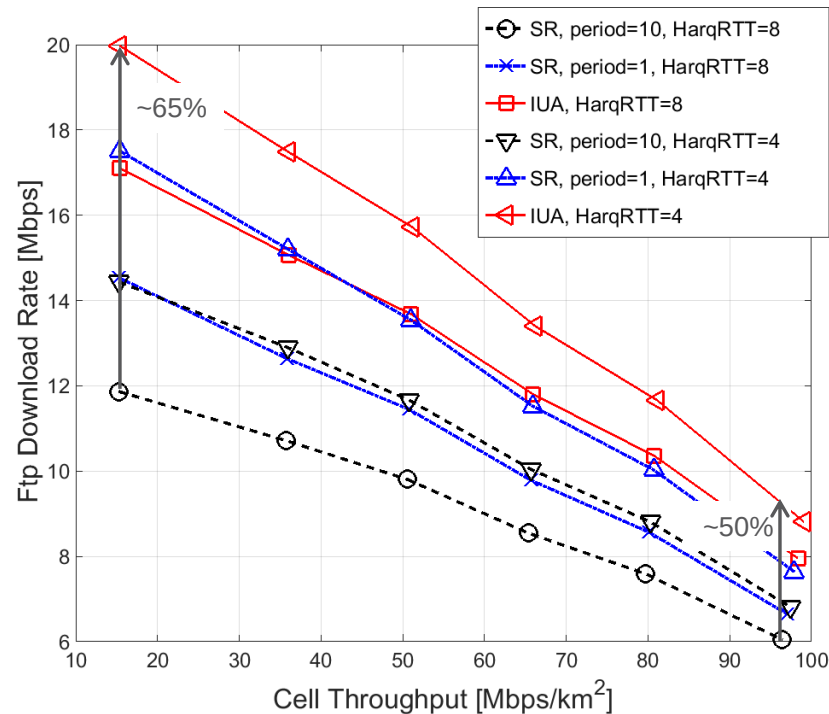


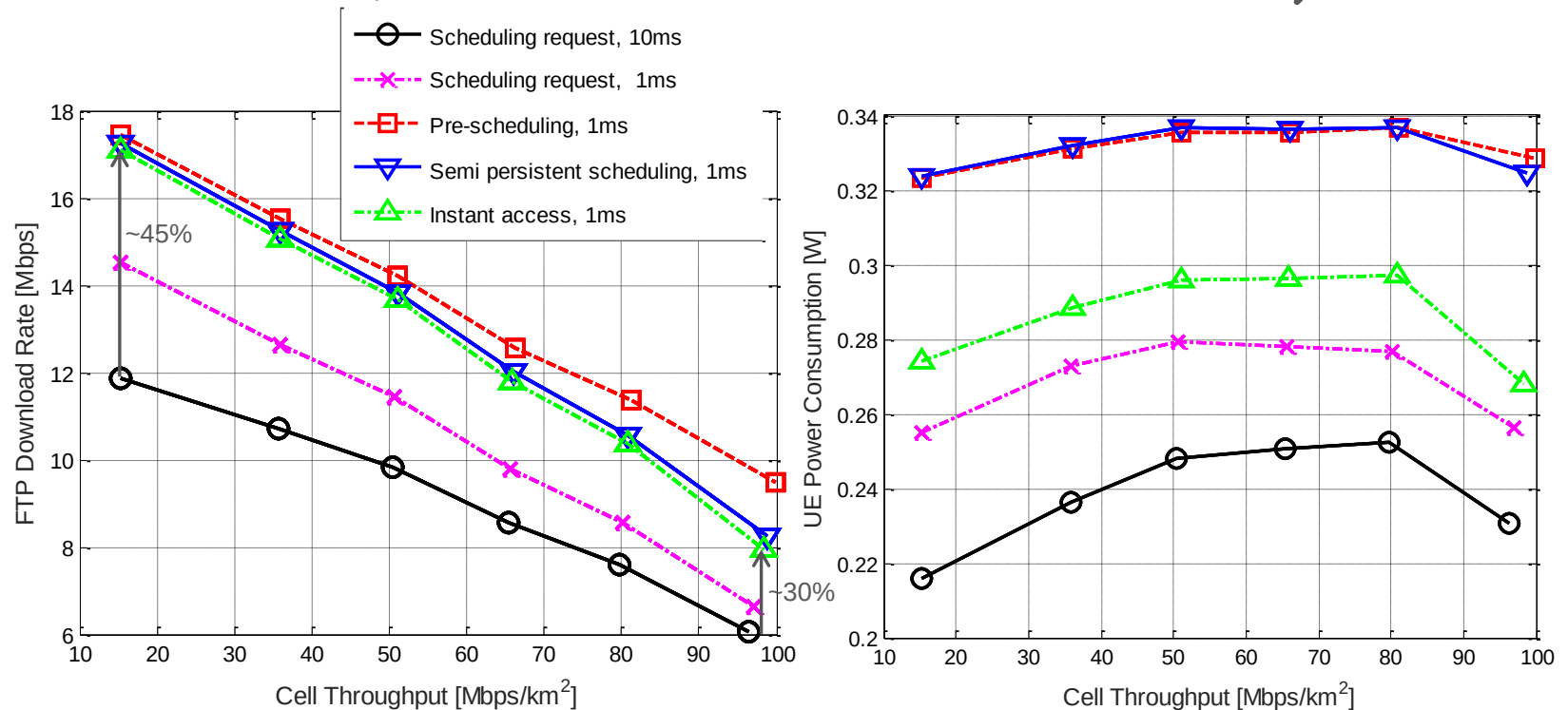
Figure 1: FTP download speed (x-axis in Mbit/s) and relative reduction in download time (as %) for different FTP filesizes and latency reduction techniques.

POTENTIAL GAIN (SYSTEM LEVEL, TCP THROUGHPUT)



- › Shorter HARQ RTT increases download throughput in all schemes
- › Highest download throughput when Instant Uplink Access (IUA) and shorter HARQ RTT combined together

POTENTIAL GAIN (SYSTEM LEVEL, TCP THROUGHPUT)



- › Higher download throughput with Instant Access
 - Comparable with performance of “always-UL-granted” access
 - However, with significantly less UE power consumption

CONCLUSION



› Latency matters!

- For typical web events such as end-user page/file downloads
- For real time services and new applications and use cases

› Significant gains observed in LTE

- L2 protocol enhancements
- TTI shortening
- Note: L2 protocol enhancements and TTI shortening gains are additive.



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