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Further Enhanced IIoT/URLLC (FelIoT)

RAN Rel-18 Workshop

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RWS-210071

Nokia, Nokia Shanghai Bell

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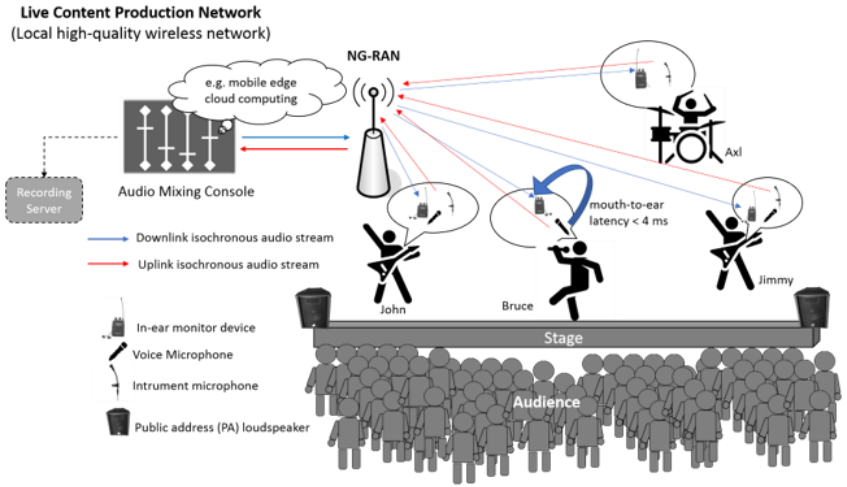
Further Enhanced IIoT/URLLC: Motivation

- URLLC is not anymore limited to transmission of small 32-byte payload with 1 ms latency!
- Focus on use cases requiring strict latency and reliability (≤1 ms, 99.99+%), and high (1-10 Mbps) throughput per link.
  - Examples: audio-visual production [TS 22.263, TR 22.827], factory automation (e.g. wired-to-wireless link replacement) [TS 22.104]
- **Exploiting FR2 spectrum is a must!** Even 5 Mbps/link with strict latency and reliability requirements is challenging with FR1 spectrum.



Example for audio-visual live production [TS 22.263/TR 22.827]
Up to 5 Mbps/link
250 us transfer interval
750 us E2E latency/6-nines reliability

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Further Enhanced IIoT/URLLC: Objectives

- Enhancements to facilitate FR1 and FR2 CA/DC operation for 'high-throughput URLLC' [RAN1, RAN2, RAN4, RAN3* (*mainly due to DC)]
- SPS/CG Enhancements for both FR1 and FR2 [RAN1, RAN2] including:
  - FR2-oriented enhancements, e.g. to deal with analog-beamforming operation
  - Supporting traffic with periodicity not aligned with 5G numerology
  - More efficient handling of persistent CG/SPS collisions
- Definition of URLLC UE "Classes" or "Profiles" [RAN]
- Mobility enhancements to reduce handover interruption time, especially for FR2 (ideally in a separate mobility-focused WI) [RAN2, RAN3]
- Potential Rel-17 leftovers

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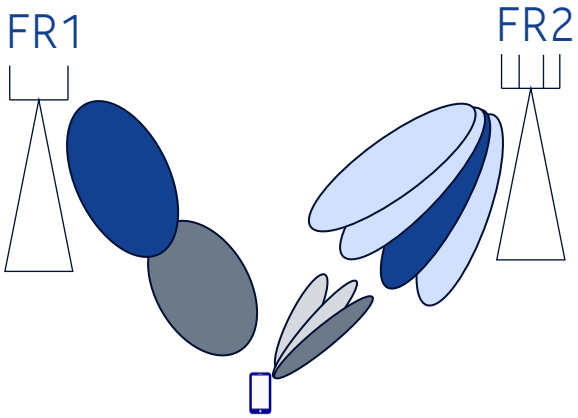
Enhancements to facilitate FR1 and FR2 CA/DC operation for ‘high-throughput URLLC’

Goal is to achieve ‘best of both worlds’: reliable coverage/propagation from FR1, and high spectrum availability from FR2, e.g.:

- Improved FR2 PDSCH/PUSCH/PDCCH/PUCCH reliability using FR1 as ‘anchor carrier’
  - FR1-FR2 CA/DC to circumvent/avoid scheduling unavailability due to e.g. measurement gaps.
- Improvements leveraging multi-panel (FR2) UEs, e.g. leveraging simultaneous Tx/Rx capabilities to avoid unnecessary cancellation/dropping of deprioritized signals



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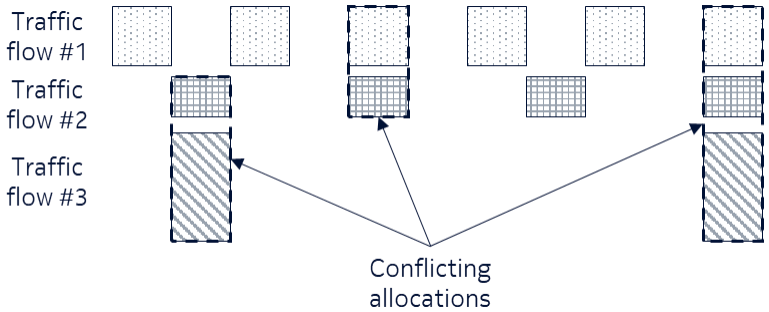
SPS/CG Enhancements for both FR1 and FR2

- FR2-oriented enhancements in general, e.g. for analog-beamforming operation where gNB transmits/receives on only one beam at a time
- Efficient handling of persistent CG/SPS collisions
  - Up to Rel-17, in case of overlapping SPS/CG P(D,U)SCH, only 1 resource used (SPS: PDSCH with lowest config. index, CG: up to UE implementation).
  - Improve SPS/CG operation efficiency to serve a UE with multiple periodic flows of different periodicities
- Non-integer SPS/CG periodicities
  - Spectral-efficient solutions to support traffic with periodicity not aligned with the 5G numerology, e.g. 30, 60, .. 1200 Hz. Needed also for XR applications, in addition to IIoT.



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Definition of URLLC UE “Classes”/”Profiles’”

- RAN-level activity as not introducing new features for specification.
- Focusing on R15, and potentially R16 UE capabilities.
  - For example, mini-slot, UE processing capability 2, CQI table 3.
- A few different categories, e.g. low-latency UE, high-reliability UE, or both.

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Mobility enhancements to reduce interruption time in FR2

- Dual-Active Protocol Stack (DAPS) handover has been specified in Rel. 16 to reduce the interruption time for FR1-FR1, FR1-FR2, FR2-FR1 scenarios but not for intra-frequency FR2-FR2.
  - Close to 0ms interruption time during handover in both DL and UL allows to deploy services with high reliability requirements in 1) FR2 localized deployments such as IIoT services in factory/or high speed train or 2) DC deployments with FR2 as PCell.
  - There is inherent end-2-end UL latency (of at least 2 Xn signalling messages, > 10 ms) in DAPS handover as the target node cannot forward the packets to UPF before receiving the final SN Status Transfer message from source gNB.

- Ideally this topic should be handled in a separate mobility-focused WI

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Background

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Bandwidth requirements for Audio Studio use case with 5Mbps/link

Profile	# of active UEs	UE Speed	Service Area	E2E latency	Transfer interval	Packet error rate	Data rate UL	Data rate DL
Audio Studio	30	-	10 m x 10 m	750 µs	250 µs	10^{-6}	5 Mbit/s	-

Required # of PRBs for 1 cell; indoor deployment, full load SINR			
	Single UE	30 UEs evenly distributed in time	30 UEs; simultaneous transmission
~1%-ile cell edge (MCS 7)	114 PRBs (**46 MHz**)	**775 MHz**	**1370 MHz**
~50%-ile cell center (MCS 17)	21 PRBs (**8.5 MHz**)	**143 MHz**	**252 MHz**

Assumptions:

- Payload size: 1250 bits (resulting from 5 Mbit/s with 250 µs transfer interval)
- TTI duration: 4 OFDM symbol (1 OFDM symbol overhead)
- 30 kHz subcarrier spacing
- ITU-like methodology based on link level results and SINR distribution in R1-1812165 and R1-1812166

Average throughput >5 Mbps with URLLC-constraints is difficult to achieve in FR1 even for single UE.

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