3GPP TSG RAN Meeting #102

RP-233215

Edinburgh, Scotland, December 11-15, 2023

Agenda Item: 9.1.2.2

Views on Rel-19 XR Enhancements

Qualcomm Incorporated

Enhancements for XR WI

RAN Chairman Summary: RP-232745

- References: RWS-230488, RP-231540, RP-232619

Potential objectives:

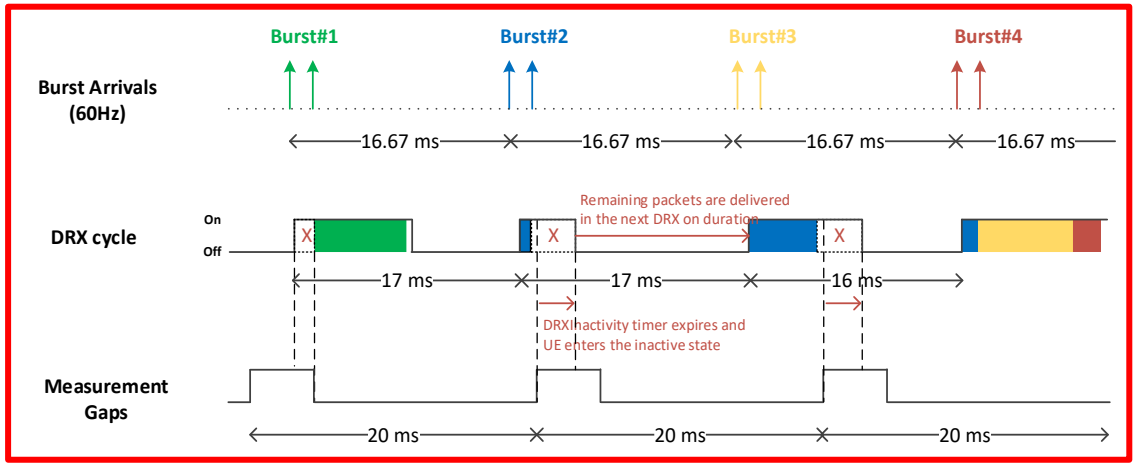
Study and if justified, specify aspects related to multi-modality(intra-UE)/multi-QoS flow (intra-UE) (with coordination with SA2/SA4), and other aspects requiring coordination w/ SA initiated work as necessary (e.g., SA2/SA4 task list which may potential have RAN impact)

Check in RAN#105

Measurement Gaps / Scheduling restrictions: Specify enhancements for reducing the impact to capacity and impact to individual UEs with respect to scheduling restrictions for FR1 and FR2 inter-frequency RRM measurements with measurement gaps and FR2 intra-frequency measurements w/o measurement gaps. [RAN1, RAN2, RAN4].

- **UTO-UCI**: support multiple CG config
- CQI/CSI link adaption enhancement
  - FFS exact scope: PDSCH reception based, Traffic related, Soft-HARQ
  - FFS CBG enh.
- Delay aware / Delay adaptive (remaining time) scheduling
- ~~PDCP Discard enhancements for PDU set discard enhancements for inter-PDU Set dependencies~~
  - ~~Coordination with SA2~~
- ~~Power saving, DRX and PDCCH skip (excluding power saving for Multi-modal)~~

Measurement Gap Enhancements for XR



Issue:

- Frequent MGs can add latency to XR traffic
- XR traffic serving is delayed until end of MG
- With DRX, timers can expire, traffic is further delayed to next DRX cycle

Enhancements:

- Dynamic activation/deactivation of MG using fast indication ex: DCI/MAC-CE
- Configurable priority to prioritize XR data over MG
- Aperiodic/semi-persistent MG triggered outside CDRX active time

Proposal:

- Specify enhancements for dynamic activation/deactivation of MG , Configurable priority to prioritize XR data over MG and Aperiodic/semi-persistent MG triggered outside CDRX active time

Issue:

- Relaxing scheduling restriction may come at cost of reduced RRM measurements
- Inconsistent measurement gaps may impact RRM
- For UEs with high mobility, measurements gaps should not be comprised

Enhancement:

- Extension/scaling of the related measurement gaps procedures can be compensated by introducing a XR specific K factor
- Prioritization/relaxation/deactivation/activation takes into account the UE state UE's RSRP/RSRQ measurement on the current serving cell is above a configured threshold and/or meeting a low-mobility criterion

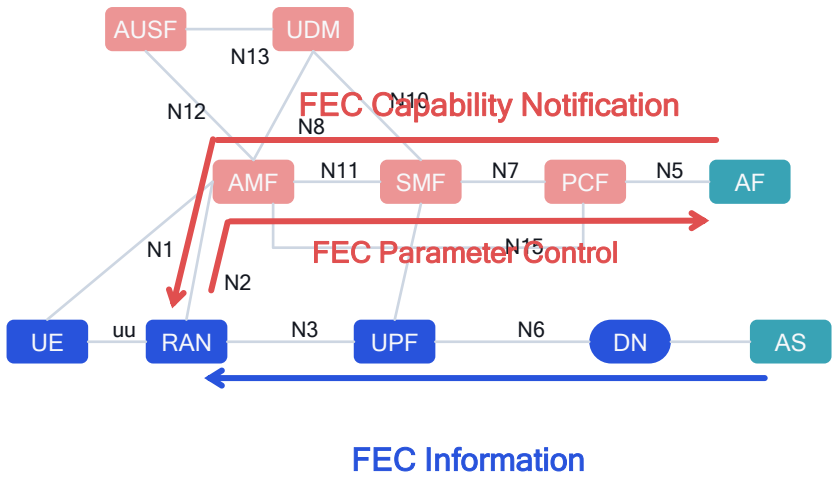
Proposal:

- Specify enhancements for scaling of the related measurement gaps procedures and prioritization/relaxation/(de)activation takes into account the UE's radio channel measurements on the current serving cell.

XR Awareness of Application Level FEC in RAN

Issue:

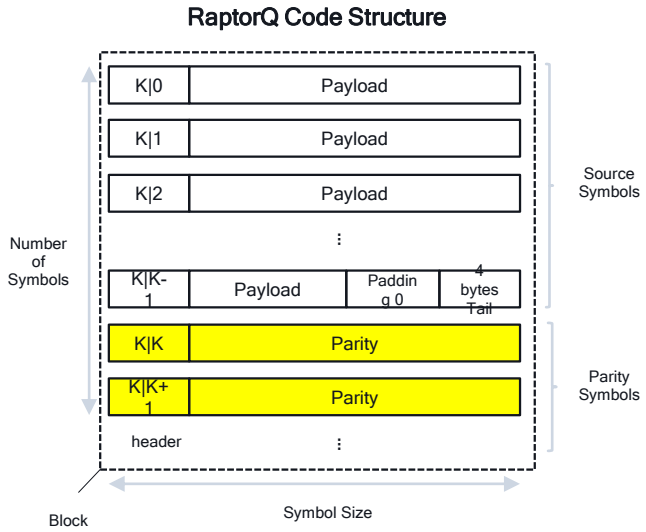
- XR and Cloud Gaming Applications implement FEC for reliability
  - 5G link can be unreliable
  - Non-3gpp access (e.g., WiFi) can be unreliable
  - FEC overhead is set statically without link-awareness
  - Set for worse case (e.g., Can be as high as 30%)
  - Cannot be adapted to radio conditions
  - Consumes 5G capacity when required overhead is much smaller



Enhancement:

- Introduce XR awareness of application-level FEC in RAN
  - Server indicates capability of application-level FEC to RAN (AF → RAN)
    - Supported FEC types and parameters
  - RAN shares feedback on FEC parameters (RAN → AF)
    - FEC enable or disable, Recommended redundancy of parity symbols (%), Recommended symbol size (T)
  - Additional metadata in PDU set for FEC information (AS → RAN)
    - FEC Encoding Type (e.g. RaptorQ, RS), Number of source symbols (K), Encoding Symbol Index (ESI)

- RAN stops the transmission when UE receives sufficient packets



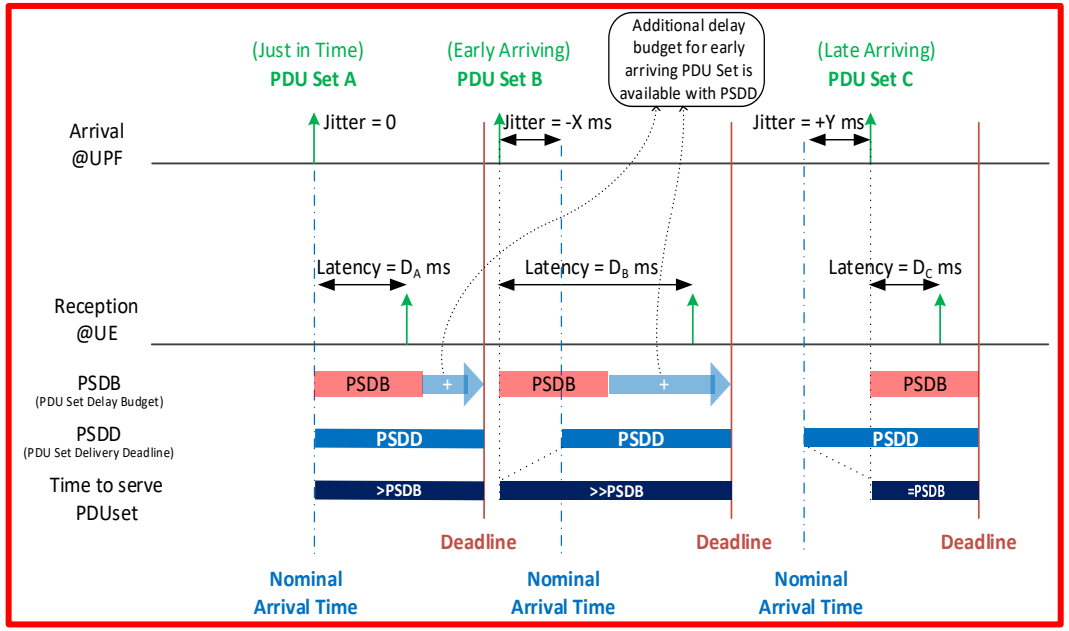
SA2 Rel-19 XRM, WT#1.1 *Study whether and how to enhance PDU Set related (e.g. new standardized 5QI, enhancements to Alternative QoS profiles, FEC) and PDU Set information (including Control Plane and/or User plane information provided by the AF/AS) and the corresponding PDU Set QoS handling enhancement.*

Proposal : Specify necessary control plane and user plane enhancements between RAN and 5GC to enable RAN XR-awareness of application level FEC

Deadline as Latency QoS Metric

Issue:

- XR Traffic arrivals can be quasi-periodic
  - Arrivals can be early or late with respect to a nominal arrival time
- XR receiver starts packet processing for display at regular intervals
  - XR video traffic held in a buffer until time (deadline) when processing must start
- XR performance only requires that packets are delivered before deadline
  - Fixed packet delay budget (PDB) from arrival time is less useful



Enhancement:

- Introduce PDU-set delivery deadline (PSDD) as latency metric
  - Additional time to serve PDU-sets improves XR capacity

SA2 Rel-19 XRM, WT#1.1 *Study whether and how to enhance PDU Set related (e.g. new standardized 5QI, enhancements to Alternative QoS profiles, FEC) and PDU Set information (including Control Plane and/or User plane information provided by the AF/AS) and the corresponding PDU Set QoS handling enhancement.*

Proposal : Specify enhancements to introduce PSDD as new PDU Set QoS Parameter.

Enhanced adaptation between NW and UE for XR services

- Motivation
  - Aspect #1: UE assistance for network's adaptation
    - In Rel-19, SA2 is studying how to support dynamic change in traffic (WT #2.2). Similar issues exist in RAN as well
    - Enhancements to UE indication (e.g. more dynamic) on changes in UL traffic parameters and data volume (e.g. new BSR triggers) can help network react faster and better to those changes
  - Aspect #2: Network assistance for UE's adaptation
    - Many XR devices can adapt their codec in response to variations in the quality of its connections.
    - But such adaptations are usually based on e2e measurements by application/UE itself.
    - Assistance from network can help UE's adaptation be responsive and accurate

SA2 Rel-19 XRM, WT#2.2

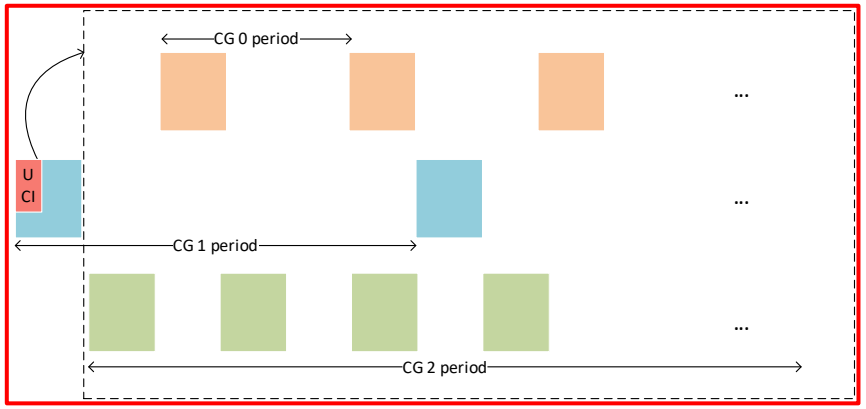
Study whether and how to support dynamic change (via user plane) in traffic characteristics (e.g. burst related parameters), provided by the application in the DN

- Proposal:
  - Specify enhancements that enable UE and RAN to better adapt to traffic and link quality
    - Specify signaling enhancement(s) that enable UE to dynamically switch between a set of pre-configured radio configurations, e.g. based on changes in its traffic
    - Specify signaling enhancements for network to provide link quality info (e.g. available rate vs loss) to UE/application, e.g. to help UE more efficiently adapt its FEC
    - Specify signaling enhancements for UE to indicate its preferred bit rates and QoS parameters to RAN/CN
  - Specify enhancements to UL traffic reporting, e.g.
    - Specify additional information that can be included in UL traffic report, e.g. data rates and burst sizes
    - Specify new BSR trigger(s) for indicating dynamic change in UE's data volume

CG Enhancements

UTO-UCI to indicate multiple CG configurations

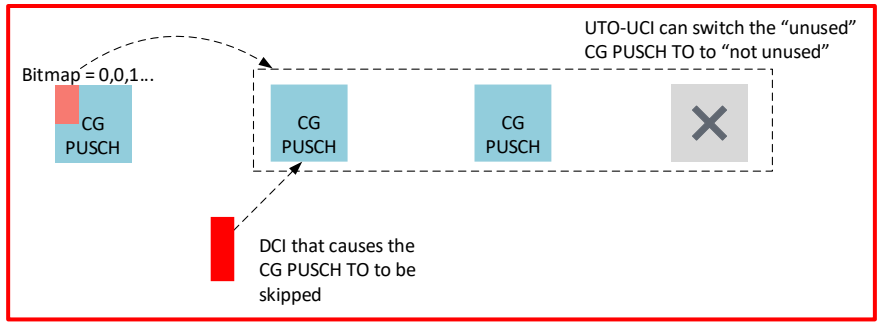
- UTO-UCI indicating multiple CG configurations allows the network to know used/unused state of CG PUSCH transmission occasion (TO) earlier.
- Use cases at least include
  - Indication for multiple active CG configurations associated with different types of traffic.
  - UTO-UCI indicates which CG PUSCH TO of multiple overlapping ones is used.
  - Reliable UTO-UCI transmission in FR1 carrier indicating CG PUSCH TOs in FR2 carrier.
- Proposal: Specify enhancements for UTO-UCI enhancements enable UE to indicate CG PUSCH TOs for multiple active CG configurations.



UTO-UCI indicates unused CG PUSCH occasions of multiple CG configurations

UTO-UCI to switch from “unused” to “not unused”

- “Not unused” CG PUSCH TOs provide insufficient resources for remaining UL data if
  - CG is re-activated with lower MCS or less time and frequency resources in each TO
  - “Not unused” TOs are cancelled by SFI, UL cancellation indication or a dynamically scheduled PDSCH or PUSCH.
- Proposal: Specify enhancements to allow UTO-UCI to switch CG PUSCH TOs from “unused” to “not unused” for the UE to have enough resources to completely transmit the UL data packet in a cycle.



Switching from “unused” to “not unused” after an early “not unused” TO is cancelled

Repetition and TBoMS for multi-PUSCH CG

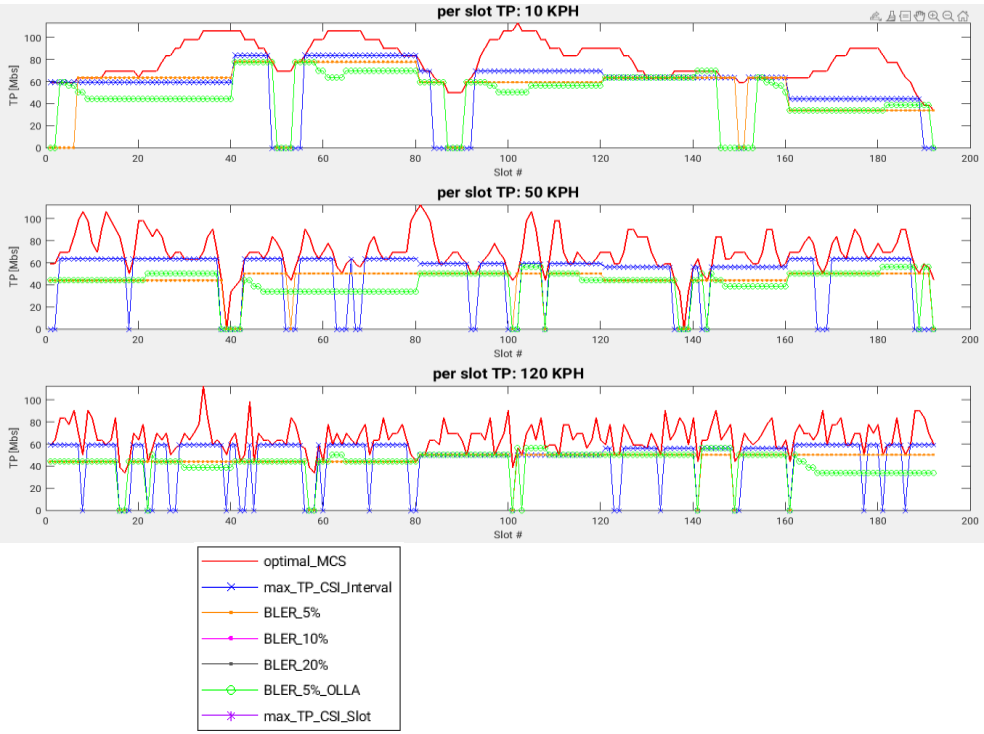
- Coverage enhancements are crucial for AR UL video transfer in the cell edge area.
- Proposal: Specify enhancements to support CG PUSCH repetition and TBoMS, each UTO-UCI bit refers to all repetitions or TBoMS bundle of a CG (or CGs).

Soft-HARQ: principle and motivation

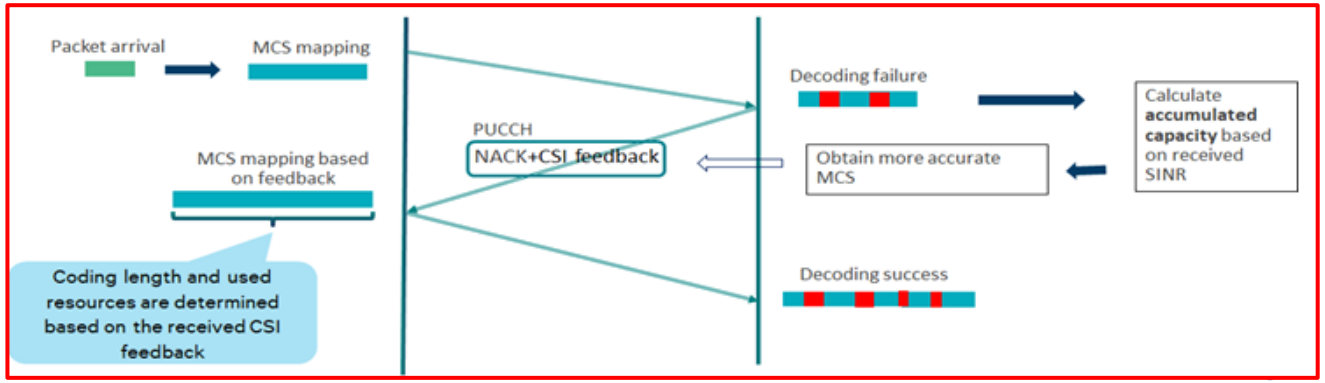
- **Main idea**
  - Schemes based on CSI-RS + OLLA can't track channel variations and are often too optimistic or pessimistic
  - Remedy can be provided by providing CSI feedback based on PDSCH decoding statistics and enhancing HARQ feedback

- **Use cases/examples**
  - Use case 1: Derive OLLA more accurately with CSI feedback
    - Based on NACK/ACK ratio combined with more frequent CSI feedbacks
    - Turbo-HARQ allows OLLA operating based on ratio of low_margin_ACK + NACK/high_margin_ACK

  - Use case 2: Adapt to correct MCS with re-Tx using soft-NACK feedback
    - Based on SINR or on Mutual Information
    - Reference for MI based: RWS-230183 NR MIMO Enhanced LA Coding rate adaptation



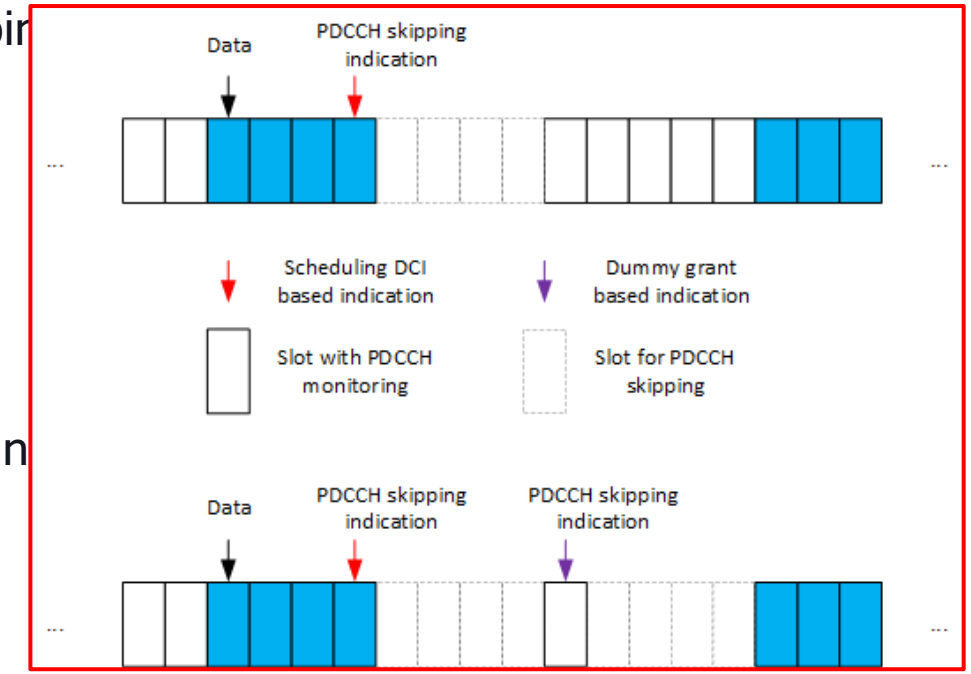
Proposal: specify soft HARQ based capacity enhancement, both for NACK and ACK



PDCCH Skipping by Dummy Grant

Issue

- Rel-17 PDCCH skipping only supports scheduling DCI based skippir indication.
- To avoid latency impact to delay sensitive traffic, network may not indicate long PDCCH skipping duration
  - Power saving performance is compromised if UE only skips PDCCH monitoring for short periods of time.
- Non-scheduling DCI allows UE to go back to PDCCH skipping again for prolonged skipping duration.
- A dummy grant DCI with invalid FDRA or other invalid scheduling information can serve as a non-scheduling DCI
  - This approach has minimal spec impact.



Proposal : Clarify that a dummy grant without data scheduling can be used to indicate PDCCH skipping.

- PDCCH skipping by dummy grant prolongs overall UE PDCCH skipping duration without latency penalty.

Others

On the Potential objectives from the Chairman summary RP-232745

- Study and if justified, specify aspects related to multi-modality(intra-UE)/multi-QoS flow (with close coordination with SA2/SA4), and other aspects requiring coordination w/ SA initiated work as necessary (e.g., SA2/SA4 task list which may potential have RAN impact)
  - Check in RAN#105

Observation: Some aspects related to PDU set enhancements are not specific to multi-modality. Consider decoupling multi-modality enhancements from other aspects requiring coordination with SA for a more general alignment between RAN and SA

Proposal: Consider the following modifications for Potential Objective

Study and if justified, specify aspects related to multi-modality(intra-UE)/multi-QoS flow (with close coordination with SA2/SA4),

- Check in RAN#105

Study and specify aspects requiring coordination w/ SA initiated work as necessary (e.g., SA2/SA4 task list which may potential have RAN impact)

- Check in RAN#105

Summary of Proposals: (1 of 2)

Measurement Gap Related: Specify enhancements

- for dynamic activation/deactivation of MG , Configurable priority to prioritize XR data over MG and Aperiodic/semi-persistent MG triggered outside CDRX active time
- for scaling of the measurement gaps related procedures and prioritization/relaxation/(de)activation takes into account the UE's radio channel measurements on the current serving cell.

SA2 alignment proposals: Specify enhancements to

- control plane and user plane enhancements between RAN and 5GC to enable RAN XR-awareness of application level FEC
- Introduce PSDD as new PDU Set QoS Parameter.
- Enable UE indication for dynamic changes in traffic, re-configuration of radio resources for faster UE adaptation and enhanced UL reporting

UTO-CGI Enhancements: Specify enhancements to

- UTO-UCI enhancements enable UE to indicate CG PUSCH TOs for multiple active CG configurations.
- Allow UTO-UCI to switch CG PUSCH TOs from "unused" to "not unused" for the UE to have enough resources to completely transmit the UL data packet in a cycle.
- Support CG PUSCH repetition and TBoMS, and use one bit in UTO-UCI to indicate all repetitions or TBoMS bundle.

Summary of Proposals: (2 of 2)

Enhanced adaptation between NW and UE for XR services :

- Specify enhancements that enable UE and RAN to better adapt to traffic and link quality
  - Specify signaling enhancement(s) that enable UE to dynamically switch between a set of pre-configured radio configurations, e.g. based on changes in its traffic
  - Specify signaling enhancements for network to provide link quality info (e.g. available rate vs loss) to UE/application, e.g. to help UE more efficiently adapt its FEC
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- Specify enhancements to UL traffic reporting, e.g.
  - Specify additional information that can be included in UL traffic report, e.g. data rates and burst sizes
  - Specify new BSR trigger(s) for indicating dynamic change in UE's data volume

Soft HARQ:

- Specify soft HARQ based capacity enhancement, both for NACK and ACK

PDCCH Skipping Enhancement:

- Clarify that a dummy grant without data scheduling can be used to indicate PDCCH skipping.

Consider the following modifications for Potential Objective

- Study and if justified, specify aspects related to multi-modality(intra-UE)/multi-QoS flow (with close coordination with SA2/SA4)
  - Check in RAN#105
- Study and specify aspects requiring coordination w/ SA initiated work as necessary (e.g., SA2/SA4 task list which may potential have RAN impact)
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