3GPP TSG-RAN RANP Meeting #83 **RP-190535**
March 18th-21st, 2019
Shenzhen, China

Views on normative work for I-IOT

Source: Qualcomm

Overview

- The topic **intra-UE prioritization/multiplexing** was studied as part of IIoT SI (FS_NR_IIOT)
- The study on the topic has been split between RAN2 and RAN1
- Output of the study on the topic indicates that **related WI work is more suited to be driven by RAN1**

Background (FS_NR_IIOT SID)

- Objective of FS_NR_IIOT SID (RP-182090) included the following on intra-UE prioritization/multiplexing

> b) UL/DL intra-UE prioritization/multiplexing, i.e. prioritization (for example dropping, delaying or puncturing lower priority service) between different categories of traffic in the UE, including both data and control channels and considering (RAN2/RAN1):
> i) different latency and reliability requirements
> ii) Different types of resource allocation for example grant-free and grant-based allocations
>
> Note: RAN2 to start the work, RAN1 to take action based on RAN2 progress.

- Related work was split between RAN2 and RAN1

Intra-UE multiplexing: Status summary and proposals

Intra-UE multiplexing scenarios identified in SI stage	RAN2 agreement on leading WG	Comments and References
1. DL Prioritization	RAN1	LS R2-1818795
2. UL Configured vs Dynamic	?	RAN2 discussed solutions with PHY impact. RAN1 discussed a bigger set of solutions. Scenario 2 with UCI multiplexing falls under scenario 5.
3. UL Dynamic vs Dynamic	?	RAN1 has agreed this issues needs to be addressed. RAN2 considered a solution to let L1 handle conflicting transmissions with MAC involvement. Scenario 3 with UCI multiplexing falls under scenario 5.
4. UL Control vs Control	RAN1	LS R2-1818795 recommended to be mainly studied by RAN1, and RAN2 only identified need for RAN2-involvement in cases involving SR colliding with PUSCH
5. UL Control vs Data	RAN1	
6. CA scenarios	RAN1	LS R2-1818795 identified only RAN1 impacts
7. Power control scenarios	RAN1	

Proposal-A: Intra-UE Prioritization for Work Item stage should be led by RAN WG1 with RAN WG2 as secondary
Proposal-B: Work in WG1 can be part of eURLLC WI, or IIoT sub-task that is RAN1 led

SI Progress: Seven scenarios

- RAN2 studied intra-UE prioritization/multiplexing by identifying **seven scenarios** via email discussion in R2-1817579
- Following email discussion, LS R2-1818795 was sent by **RAN2 to RAN1** informing RAN1 about 7 scenarios
  - LS R2-1818795 excerpt related to scenarios 1-5

> RAN2 has discussed and identified a few targeted Intra-UE prioritization/multiplexing scenarios for further study. It is RAN2 understanding that RAN1 should be involved in the study of all these scenarios, since the mechanisms such as pre-emption and the relevant UE behavior should be examined by RAN1.

  - LS R2-1818795 excerpt related to scenarios 6 and 7

> In RAN2's understanding, both of these two additional scenarios have only impacts to RAN1.

- **Observation: RAN2 indicated that all seven scenarios need RAN1 involvement and two scenarios were left completely to RAN1**
- Further progress at Athens in RAN1#96 and RAN2#105, and it is captured in TPs for TR 38.825 (see sections 5 and 7) and RAN1 LS (R1-1903819)

Scenario 1 status

- Scenario 1: Intra-UE DL Prioritization
  - Ie, UE receives two DL assignments with overlapping radio resources in time
- In LS R2-1818795 (Spokane, Nov 2018), RAN2 provided following input to RAN1

> - Scenario 1: Intra-UE DL Prioritization
>
> This scenario considers a case where a UE has sequentially received two DL assignments with overlapping radio resources in time. RAN2 assumes that by the later DL assignment has priority over the earlier DL assignment, considering that in principle the gNB will only give an assignment that overlaps with previous assignment for higher priority traffic. Based on such assumption, RAN1 should study solutions for prioritizing later received DL assignments.

- RAN1#96 (Athens, 2019) provided related TP (for TR 38.825) via LS R1-1903819 with excerpt below

> RAN1 has discussed the downlink intra-UE prioritization/multiplexing in scenario 1. RAN1 recommends to support the handling of scenario 1.

- **Observation: RAN1 and RAN2 agree that RAN1 should address this scenario**

Scenario 2 status (UL dynamic vs configured grant)

- RAN1#96 (Athens, 2019) provided related TP (for TR 38.825) via LS R1-1903819 with excerpt below

> For scenario 2, in case the collision between configured grant and dynamic grant occurs in physical layer, options to determine the prioritization between configured grant and dynamic grant include at least:
>
> - Priority at PHY is determined by MAC layer for the purpose of PHY prioritization.
> - Note: this may or may not have any RAN1 impact
> - Priority at PHY is determined via PHY channel(s)/signal(s)/parameters for the purpose of PHY prioritization.
> - It is configurable as part of the configured grant configuration whether it should have higher priority than dynamic grant in case of conflict.
> - Other options are not precluded.
>
> RAN1 recommends to allow the prioritization of configured grant over dynamic grant under some conditions in case of collision in scenario 2.

- For this scenario, relevant RAN2#105 (Athens) agreements are captured below:

> UE prioritization of a grant when there is at most one dynamic grant in the set of conflicting grants (scenario 2 and configured/configured grant collisions) shall be addressed. MAC specifies currently the UE prioritization of such cases, and modifications to MAC would be required.

> For cases when MAC prioritizes a grant, MAC prioritizes the grant on which data of the highest priority can be transmitted according to LCP restrictions and priority configured for each logical channel.

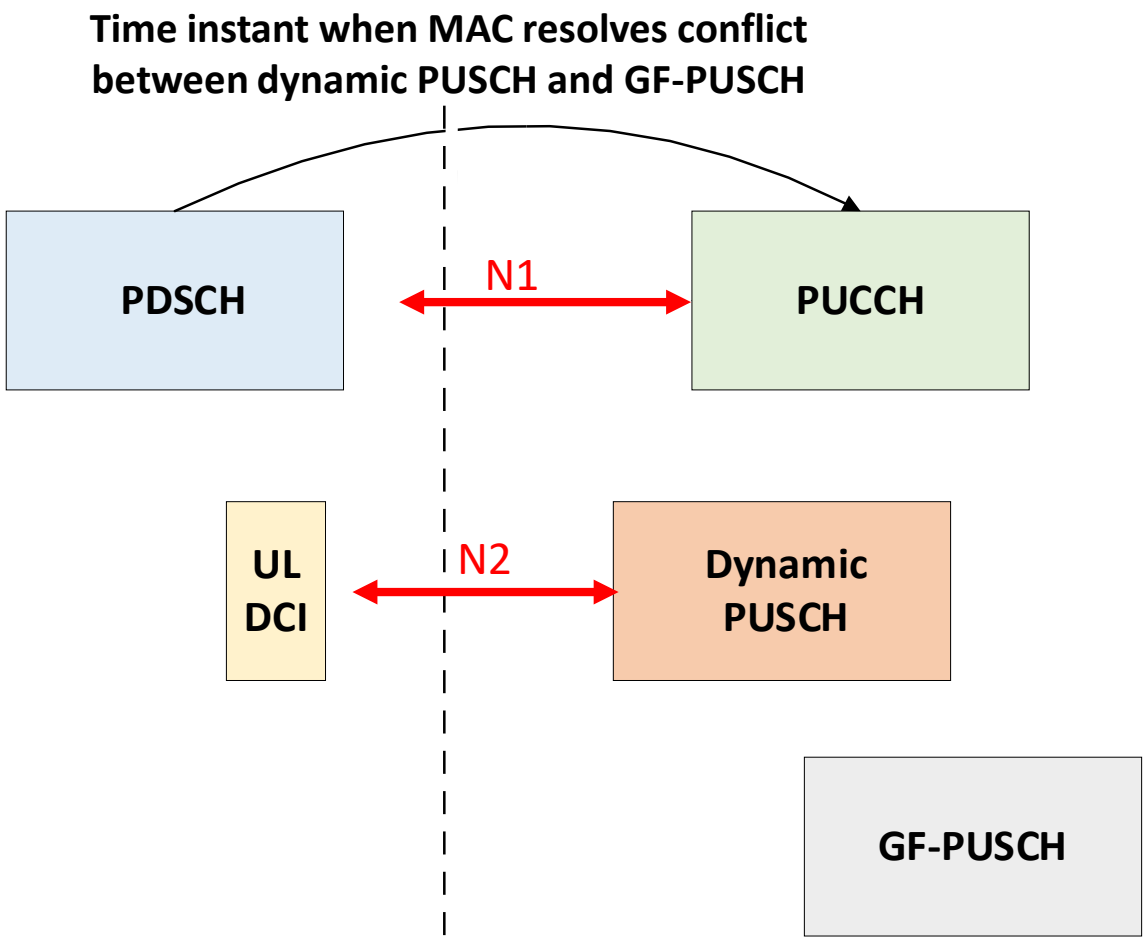
- **Observation: During SI, RAN1 considered options including those being considered in RAN2**

Scenario 2 status (contd)

- For Scenario 2,
  - RAN2 informed RAN1 that this scenario should be studied jointly.
  - We believe solutions involving MAC prioritization will impact PHY timelines
    - e.g., N2 timeline in the figure

- **Scenario 2 realizations with UCI multiplexing fall under Scenario 5**
  - RAN2 informed RAN1 that scenario 5 should be "mainly studied by RAN1"
  - In such realizations, we believe there are clear impacts on RAN1 timelines (e.g., see N1 timeline in the figure)

- **Observation: Significant RAN1 involvement is needed for addressing scenario 2**



Scenario 3 status (Conflict between Dynamic Grants)

- RAN1#96 (Athens, 2019) provided related TP (for TR 38.825) via LS R1-1903819 with excerpt below

> For scenario 3, RAN1 recommends to support the handling of scenario 3.

- RAN2 cannot progress in this scenario without RAN1 evaluation of PHY impacts and this is reflected in RAN2#105 agreements below

> ⇒ **RAN2 assumes that the later dynamic grant may always be prioritized over and earlier dynamic grant (scenario 3). One way to realize this is that MAC generate a PDU for each grant and let L1 handle conflicting transmissions. To be confirmed following progress in RAN1. Other solutions are not precluded**

- Remarks:
  - RAN2 informed RAN1 that "Both RAN1 and RAN2 should further study this topic".
  - RAN2 cannot progress in this scenario without RAN1 evaluation of PHY impacts.
  - (Similar to Scenario 2) Scenario 3 realizations with UCI multiplexing fall under scenario 5. RAN2 informed RAN1 that scenario 5 should be "mainly studied by RAN1"
- **Observation: Significant RAN1 involvement is needed for addressing scenario 3**

Scenario 4 status

- Scenario 4 (Intra-UE UL Prioritization – Resource Conflict between Control Channel and Control Channel)
  - Ie, resources of uplink control transmission overlaps in time with other uplink control transmission relating to another, higher priority traffic
- In LS R2-1818795, RAN2 informed RAN1 about the following related to Scenario 4

> - Scenario 4: Intra-UE UL Prioritization – Resource Conflict between Control Channel and Control Channel
>
> This scenario considers a case where the resources of uplink control transmission overlaps in time with other uplink control transmission relating to another, higher priority traffic. It is RAN2 understanding that this scenario should be mainly studied by RAN1, but RAN2 should be involved for analyzing the cases relating to uplink control transmission relating to SR.

- RAN1#96 (Athens, 2019) provided related TP (for TR 38.825) via LS R1-1903819 with excerpt below

> For scenarios 4 and 5, RAN1 recommends to support enhancements for scenario 4 and 5. RAN1 recommends considering the prioritization and/or multiplexing behaviour among URLLC/eMBB HARQ-ACK/SR/CSI and URLLC/eMBB PUSCH, including the cases with UCI on PUCCH and UCI on PUSCH. Note that RAN1 has not concluded whether to support prioritization, or multiplexing, or both.

- **Observation: RAN1 and RAN2 agree that RAN1 should lead addressing this scenario**

Scenario 5 status

- Scenario 5: Intra-UE UL Prioritization – Resource Conflict between Control Channel and Data Channel
  - uplink control transmission resources overlap in time with uplink data transmission
- In LS R2-1818795, RAN2 informed RAN1 about the following related to Scenario 5

> - Scenario 5: Intra-UE UL Prioritization – Resource Conflict between Control Channel and Data Channel
>
> This scenario considers a case where the resources of uplink control transmission overlaps in time with uplink data transmission relating to another traffic with either higher or lower priority. It is RAN2 understanding that this scenario should be mainly studied by RAN1, but RAN2 should be involved for analyzing the cases relating to uplink control transmission relating to SR.

- RAN1#96 (Athens, 2019) provided related TP (for TR 38.825) via LS R1-1903819 with excerpt below

> For scenarios 4 and 5, RAN1 recommends to support enhancements for scenario 4 and 5. RAN1 recommends considering the prioritization and/or multiplexing behaviour among URLLC/eMBB HARQ-ACK/SR/CSI and URLLC/eMBB PUSCH, including the cases with UCI on PUCCH and UCI on PUSCH. Note that RAN1 has not concluded whether to support prioritization, or multiplexing, or both.

- **Observation: RAN1 and RAN2 agree that RAN1 should lead addressing this scenario**

Status: Scenarios 6 and 7

- Scenario descriptions from LS R2-1818795

- Scenario 6: Intra-UE UL Prioritization – CA-based Concurrent Transmission with Power Limitation

  In cases wherein mixed traffic with different priorities / reliability requirements are exchanged between the UE and gNB and corresponding data or control transmissions simultaneously occur on different serving cells, prioritization may have to occur due to transmit power limitation.

- Scenario 7: Intra-UE UL Prioritization – Power Control for Traffics with Different Priorities

  The UE may need to dynamically change its power control loop to ensure the transmission related to high priority data.

- In LS R2-1818795, RAN2 informed RAN1 about the following related to Scenario 1

  In RAN2's understanding, both of these two additional scenarios have only impacts to RAN1.

  In addition, RAN1 may also consider studying the following scenarios:

  - Scenario 6: Intra-UE UL Prioritization – CA-based Concurrent Transmission with Power Limitation
  - Scenario 7: Intra-UE UL Prioritization – Power Control for Traffics with Different Priorities

- RAN1 has not reached any agreements related to these two scenarios
- **Observation: RAN2 agrees that this scenario only has RAN1 impacts**

Another scenario: configured/configured grant collisions

- RAN2#105 (Athens, Feb 2019) also agreed to address configured/configured grant collisions
  - This is NOT among 7 scenarios included in RAN2 LS R2-1818795 to RAN1 from Spokane (Nov, 2018)

- This conflict can be addressed under TSN (or TSC) related enhancements of IIoT WI
  - TSN related enhancements agreed during RAN2#105 include **supporting multiple configured grants**
  - This type of conflict is different from previous scenarios
    - conflicts are predictable
    - MAC can address it with limited PHY impacts

Annex

Comparison with views in Nokia's draft WID

- IIoT rapporteur (Nokia) shared draft WID for NR Industrial IoT
  - In an email on Mar 8 (PDT) via 3GPP_TSG_RAN_DRAFTS@LIST.ETSI.ORG
- This slide is a comparison of views presented in previous slides and those in the draft WID
- **Observation: The draft WID only proposes scenario 2 to be RAN2-driven**
  - See next slide

Scenario	Description	RAN2 requested RAN1 to be involved?	Already agreed as RAN1-led?	Views in Nokia's draft WID: whether RAN1-driven?
Scenario 1	DL Prioritization	Yes	Yes	Yes
Scenario 2	UL Configured vs Dynamic	Yes		No
Scenario 3	UL Dynamic vs Dynamic	Yes		Yes
Scenario 4	UL Control vs Control	Yes	Yes	Yes
Scenario 5	UL Control vs Data	Yes	Yes	Yes
Scenario 6	CA scenarios	Yes	Yes	N/A
Scenario 7	Power control scenarios	Yes	Yes	N/A

Excerpt from draft WID on intra-UE prioritization/multiplexing

2. The detailed objectives for intra-UE prioritization/multiplexing are:

- Address DL data/data resource conflict [RAN1].
- Specify enhancements to address resource conflicts between dynamic grant (DG) and configured grant (CG) PUSCH and conflicts involving multiple CGs [RAN2, RAN1].
  - Address PUSCH grant prioritization based on LCH priorities and LCP restrictions for the cases where MAC prioritizes the grant [RAN2].
- Specify enhancements to address conflicts between DG and DG PUSCHs under the assumption that the later dynamic grant should always be prioritized over an earlier dynamic grant [RAN1, RAN2].
- Address UL data/control and control/control resource collision, by specifying prioritization and/or multiplexing behaviour among HARQ-ACK/SR/CSI and PUSCH for traffic with different priorities, including the cases with UCI on PUCCH and UCI on PUSCH [RAN1, RAN2].
  - Address resource collision between SR associating to high-priority traffic and uplink data of lower-priority traffic for the cases where MAC determines the prioritization [RAN2].

- Notes
  - Sub-bullet 1 addresses scenario 1
  - Sub-bullet 2 addresses scenario 2
  - Sub-bullet 3 addresses scenario 3
  - Sub-bullet 4 addresses scenario 4 and scenario 5

Three updates (highlighted) for draft WID based on proposals in this contribution

2. The detailed objectives for intra-UE prioritization/multiplexing are [RAN1, RAN2]:

- Address DL data/data resource conflict [RAN1].
- Specify enhancements to address resource conflicts between dynamic grant (DG) and configured grant (CG) PUSCH and conflicts involving multiple CGs [RAN1, RAN2].
  - Address PUSCH grant prioritization based on LCH priorities and LCP restrictions for the cases where MAC prioritizes the grant [RAN2].
- Specify enhancements to address conflicts between DG and DG PUSCHs under the assumption that the later dynamic grant should always be prioritized over an earlier dynamic grant [RAN1, RAN2].
- Address UL data/control and control/control resource collision, by specifying prioritization and/or multiplexing behaviour among HARQ-ACK/SR/CSI and PUSCH for traffic with different priorities, including the cases with UCI on PUCCH and UCI on PUSCH [RAN1, RAN2].
  - Address resource collision between SR associating to high-priority traffic and uplink data of lower-priority traffic for the cases where MAC determines the prioritization [RAN1, RAN2].

- Notes
  - Sub-bullet 1 addresses scenario 1
  - Sub-bullet 2 addresses scenario 2
  - Sub-bullet 3 addresses scenario 3
  - Sub-bullet 4 addresses scenario 4 and scenario 5

Annex (contd)

Scenario 2: overview and LS excerpt

- Scenario 2: Intra-UE UL Prioritization – Resource Conflict between Configured and Dynamic Grant
  - UL radio resource of a configured grant overlaps with a dynamic grant in time

- In LS R2-1818795 (Spokane, Nov 2018), RAN2 provided following input to RAN1
  - Scenario 2: Intra-UE UL Prioritization – Resource Conflict between Configured and Dynamic Grant

    This scenario considers a case where the UL radio resource associated to a configured grant overlaps with a dynamic grant in time. A joint RAN2/RAN1 study should be initiated to handle such issue. In particular, RAN2 should consider LCP and grant handling priority (i.e. if a configured grant can override a dynamic grant), while RAN1 should study the details of related mechanisms for prioritizing configured grant PUSCH over dynamic grant PUSCH.

Scenario 3: overview and LS excerpt

- Scenario 3: Intra-UE UL Prioritization – Resource Conflict between Dynamic Grants
  - Ie, UL radio resource associated to a dynamic grant overlaps with another dynamic grant in time

- In LS R2-1818795, RAN2 informed RAN1 the following

> - Scenario 3: Intra-UE UL Prioritization – Resource Conflict between Dynamic Grants
>
> This scenario considers a case where the UL radio resource associated to a dynamic grant overlaps with another dynamic grant in time. It is RAN2 understanding that traffics with different priorities could be distinguished by for example explicit L1 signaling of priority level per grant, or by other prioritization rule (for example, allowing a later grant to override the previous grant). Both RAN1 and RAN2 should further study this topic.