3GPP TSG-RAN WG1 Meeting #104bis-e Tdoc R1-21xxxxx

e-Meeting, 12th – 20th April, 2021

**Agenda Item: 8.6.1.3**

**Title: FL summary #2 on duplex operation for RedCap**

**Source: Moderator (Qualcomm Inc.)**

**Document for: Discussion, Decision**

# Introduction

This feature lead summary concerns the Rel-17 work item for support of reduced capability (RedCap) NR devices [1]. Earlier RAN1 agreements for this work item are summarized in [2].

This document summarizes contributions [3] – [29] and captures the following email discussion for the RedCap WI [29].

|  |
| --- |
| [104b-e-NR-RedCap-03] Email discussion on aspects related to duplex operation – Chao (Qualcomm)* 1st check point: 4/15
* 2nd check point: 4/19
* 3rd check point: 4/20
 |

The issues in this document are tagged and color coded like this:

1. High Priority
2. Medium Priority

# HD-FDD switching time

RAN1#104e made the following agreements related to switching time:

|  |
| --- |
| Agreements:* (Working assumption) For HD-FDD switching time, reuse existing switching times for UE not capable of full duplex in TS 38.211, Table 4.3.2-3.
	+ FFS: whether to define the guard times in symbol units
	+ FFS: the switching positions
* Sending an LS to RAN4 to inform the above working assumption, and to ask for feedback if any
	+ The LS will not include the two FFS bullets

Draft LS in [R1-2102094](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2102094.zip) is approved. Final LS to be uploaded/updated depending on whether or not there are additional agreements for RedCap related to RAN4. Final LS in [R1-2102146](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2102146.zip) |

On the switching time, two contributions [8, 22] propose to confirm the working assumption on the HD-FDD switching time and one contribution [21] indicates the working assumption can be automatically confirmed upon positive feedback from RAN4.

One contribution [18] observes that a relaxed switching time (e.g. 65 usec) is beneficial for UE power saving. Also, it is discussed that the actual switching time required by HD-FDD should take into account both RF retuning gap and RTT required by the timing advance procedure.

One contribution [10] instead highlight that the description of UE behaviour in clause 4.3.2 in TS 38.211 is from a UE perspective and thus the timing of the UL symbols has included the timing advance. In [4, 27] it is suggested that gNB scheduler is responsible for creating sufficient gap to cover TA and transition time.

**High Priority Question 2-1: Should RTT required by the timing advance procedure be accounted in the HD-FDD operation of RedCap UE? What, if any, other potential RAN1 specification impacts are needed to address the possible TA misalignment between gNB and UE?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Y, and we do not see any new aspects needed to be addressed | The RTT and timing advance need to be accounted for in the HD-FDD operation of RedCap UE, and they have been accounted for in TS 38.211 (subclause 4.3) for UE not capable of full-duplex communication and not supporting simultaneous transmission and reception. We do not see any new aspects needed to be addressed.Relaxed switching time (e.g. 65 usec) for UE power saving is a separate aspect. The issue is whether the working assumption needs to be dropped due to UE power saving consideration. |
| Nokia, NSB |  | We agree with Ericsson that they have already been accounted for and no new aspect needs to be addressed.  |
| vivo |  | Regarding RTT and TA, we agree with Ericsson and Nokia that they have been accounted by the current specification already. Regarding more relaxed switching time, we think it should be discussed in RAN4 first. |
| Qualcomm | Y | In the FDD bands supporting HD-FDD operation, the actual switching time required by HD-FDD should take into account both RF retuning gap and the RTT required by timing advance procedure.  |
| China Telecom | Y | In our understanding, RTT required by TA procedure should be considered in HD-FDD operation of RedCap UE. Potential RAN1 specification impacts are FFS and need further study. |
| DOCOMO | Y | We agree with Ericsson and Nokia that RTT and TA have already been accounted for in current specification. |
| Apple  |  | The switching gap for HD-FDD should account for the RTT, the RF retuning time and TA value, which is the same as existing TDD operation.  |
| FUTUREWEI | Y | As with any duplexing, RTT is accounted for in any uplink transmission. With HD-FDD, the uplink transmission behavior is similar to TDD operation.  |
| Samsung | Y | RTT required by the timing advance procedure has been taken into account in the TS38.211for non full-duplex case. Similarly, it can be used for HD-FDD of RedCap UE as well. We don’t see further specification impacts. |
| Spreadtrum |  | We also agree with Ericsson, no other RAN1 specification impacts are needed. |
| Sharp | Y | TA should be considered for HD-FDD operation of RedCap UE and spec impact need future study |
| CATT | Y | We also think the RTT and TA have already been accounted for in the HD-FDD operation. |
| Xiaomi | Y | We agree that the timing advance should be taken into account in HD-FDD UE operation.  |

## Open issue: whether to define the guard times in symbol units

This issue is discussed in the contributions [3, 4, 5, 6, 8, 10, 11, 12, 13, 18, 21, 22, 23, 28, 29].

* 8 contributions [3, 4, 6, 8, 10, 12, 22, 23] prefer not to specify guard time in symbol units
* 7 contributions [5, 11, 13, 18, 21, 28, 29] propose to use the symbol level switching time instead of the absolute time

Contribution [3] observes no clear benefits to define the guard time in symbol units.

Contribution [10] mentions that the timing offset between DL and UL frames $T\_{TA}$ has granularity finer than symbol duration and defining the guard time in symbol units is therefore not needed as the end of guard time cannot be guaranteed to align with the symbol boundary.

The justifications for the symbol level switching time are

* [11]: Support of the guard period in symbol units is beneficial for lower latency
* [18]: Guard symbols can be configured for DL to UL switching to accommodate TA and RF retuning gap.
* [21]: Definition the guard time in symbol units simplifies the descriptions on the collision handling cases for HD-FDD type A in the spec
* [28, 29]: The switching time of 13 usec can be covered by 1 OFDM symbol duration (including extended CP) for 15, 30, 60 kHz SCSs in FR1

**High Priority Proposal 2-2:**

**For HD-FDD switching time, a guard period of N symbols can be configured for UE Rx-to-Tx switching. FFS the value of N.**

**High Priority Question 2-2: Can Proposal 2-2 be agreed? If not, please explain why?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | N | We do not see any benefit. We do not see defining the guard times in symbol units has any latency benefit. First, the transition time (NRx-Tx and NTx-Rx) needs to be rounded up to symbol units. Then, the UE needs to wait additional time to wait for the start of the next symbol period as the symbols between DL and UL frames are not aligned. This would end up causing an extra delay. |
| Nokia, NSB | N | We also do not see any benefit to define guard times in symbol units. |
| vivo | N | Current specification can already handle the switching time, there is no need to additionally introduce symbol level guard time.  |
| Qualcomm | Y | It is up to network to configure different N value for different frequency bands and/or SCS, where N can be 0,1 or 2.For all NR TDD slot formats supported by a non-RedCap UE (Table 11.1.1-1 of TS 38.213), at least one flexible symbol is configured if there is a switching from DL to UL. The flexible symbol(s) serve as guard symbols of non-RedCap UEs incapable of full-duplex operation, which can accommodate the RTT for timing advance as well as the RF retuning gap. Compared with non-RedCap UE, the latency and throughput requirements of RedCap UE are more relaxed, but coverage (lower frequency bands) and power saving become more crucial. For a RedCap UE deployed in larger cells at FDD bands, longer RTT and more relaxed TX/RX switching gap should be considered and accommodated by a configurable number of guard symbols.  |
| China Telecom | N | We think there is no need and benefit to define new guard period of N symbols. |
| DOCOMO | N | We agree with Ericsson, Nokia, and vivo that there is no need to introduce guard time in symbol units in addition to the switching time. |
| Apple |  | We do not see the dependency between switching gap duration and symbol or absolute time granularity. If long duration is justified, it can be achieved even with absolute timing as it in current specification. On the other hand, we are open to discuss whether there is benefit to change it to symbol granularity.  |
| FUTUREWEI | N | The procedures for TDD should be considered as a baseline for the timing and reused as much as possible. |
| Samsung | N | The benefit is unclear. Don’t see a need to introduce the guard period in symbol level. |
| Spreadtrum | Y | We slightly prefer Yes. A guard period of N symbols simplifies the spec descriptions. Regarding the issue that “the end of guard time cannot be guaranteed to align with the symbol boundary”, we think this problem is still exist even the guard time is based on absolute time. |
| Sharp | N | We agree with Ericsson, the UE can find the symbols border for transmission and satifsy the switching requirement with a guard in any unit |
| CATT | N | We do not see the benefit to define switching gap in a symbol unit. We prefer to reuse current definition to keep specification simple and clear.  |
| Xiaomi | Y (partially) | We agree that defining guard period for Tx/Rx switching can simplify UE behavior. But we think it is only useful if DL/UL slot/symbols are configured to HD-FDD Redcap UE. |

## Open issue: switching position

The other issue is whether/how to define the guard time positions. Some contributions [5, 6, 8, 10, 11, 12, 18, 20, 29] have expressed views on the switching position for HD-FDD.

* [5, 8] supports reusing the LTE definition for Type A HD-FDD, i.e. “not receiving the last part of a downlink subframe immediately preceding an uplink subframe from the same UE”
* [12, 29] express their views that the switching position for Rx-to-Tx is after the end of the last received downlink symbol and the switching position for Tx-to-Rx is after the end of the last transmitted uplink symobl.
* [6, 10] indicate that there is no need to explictly specify the DL/UL switching position as the collision handling principles determine whether DL or UL symbols are prioritized in various cases.
* [11] suggests specifying the switching position based on a defined rule, e.g. the starting symbol based on the BWP with the largest SCS, the smallest SCS or the reference BWP
* [18] proposes the switching position configuration can be left to NW, in a hybrid way similar to TDD. NW can explicitly configure the switching positions by SI or RRC (e.g. guard symbols in a semi-static slot format). Or, NW does not configure the swithcing positions and UE determines the switching position based on the DCI and semi-static scheduling on DL/UL (SPS, CG, SSB, PRACH, etc.)
* [20] suggests applying the switching position based on the channel priority, e.g. the switching gap is applied in the channel with the lower priority. If the two channels have the same L1 priority, it is preferable to share the switching portion between the two channels.

**High Priority Proposal 2-3:**

**For HD-FDD, for the case UL/DL slot pattern (if any) not configured, the switching position is not explicitly specified. It is up to UE to determine the DL/UL switching position based on the prioritized channels/signals.**

**High Priority Question 2-3: Can Proposal 2-3 be agreed? If not, please explain why?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Y |  |
| Nokia, NSB | N | We prefer to have predefined switching position so that any impairment can be properly handled by the gNB. For example, if LTE Type-A switching position is used, the gNB can adjust the MCS accordingly in the last DL subframe before UL. It also provides clear and consistent understanding to the gNB how the transition will be handled. Finally, we prefer to remove “**for the case UL/DL slot pattern (if any) not configured**” since we do not see clear benefit to operate FD-FDD system this way. |
| vivo |  | There seems to be different interpretations regarding the existing specification, as copied below. Since it says UE is not expected to xxx, our understanding is that UE is not required to handle the case where the scheduled transmission/reception falls into the switching gap, gNB scheduler should avoid such case. So there is no need to specify new UE behavior for determining switching position, we would like to rephrase proposal 2-3 as the followingProposal 2-3(update)**For HD-FDD, no additional UE behavior for switching position determination compared to existing specification is specified.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| TS 38.211 sub-clause 4.3.2[…]A UE not capable of full-duplex communication is not expected to transmit in the uplink earlier than $N\_{Rx-Tx}T\_{c}$ after the end of the last received downlink symbol in the same cell where $N\_{Rx-Tx}$ is given by Table 4.3.2-3. A UE not capable of full-duplex communication is not expected to receive in the downlink earlier than $N\_{Tx-Rx}T\_{c}$ after the end of the last transmitted uplink symbol in the same cell where $N\_{Tx-Rx}$ is given by Table 4.3.2-3.**Table 4.3.2-3: Transition time** $N\_{Rx-Tx}$ **and** $N\_{Tx-Rx}$

|  |  |  |
| --- | --- | --- |
| **Transition time** | **FR1** | **FR2** |
| $$N\_{Tx-Rx}$$ | 25600 | 13792 |
| $$N\_{Rx-Tx}$$ | 25600 | 13792 |

[…] |

 |
| Qualcomm | Partially Y | gNB should avoid the ambiguity/collision in DL/UL switching that cannot be resolved by the priority rules specified for R17 RedCap UE |
| DOCOMO | Y | We are also fine with the update from vivo |
| Apple  |  | We shared views of Vivo and Qualcomm. On high-level, UE does not expect to transmit/receive during the switching gap. The simultaneous Tx/Rx within switching gap is feasible only where collision handling rules were defined for it.  |
| Samsung | Y | But we'd like to delete “**for the case UL/DL slot pattern (if any) not configured**”. This is not clear on the pattern for RRC configured (which is not supported for FDD) or the pattern indicated by SFI. Alternatively, we'd like to further confirm that SFI based indication of slot format can be reused, same as current FDD, if configured.  |
| CATT |  | We have similar understanding with vivo.  |
| Xiaomi | Y |   |

# Collision Handling

RAN1#104e made the following agreements related to collision handling for HD-FDD:

|  |
| --- |
| Agreements:* For HD-FDD, for cases (if any) where collision handling needs to be specified, then the existing collision handling principles in Rel-15/16 NR for operation on a single carrier /single cell in unpaired spectrum are used as a starting point if deemed applicable.

Agreements:* For HD-FDD operation for RedCap UEs, collisions may be addressed or alleviated with proper scheduling. The following cases of potential collisions can be further studied to see if any change to the current specs is necessary:
	+ Case 1: Dynamically scheduled DL reception vs. semi-statically configured UL transmission
		- e.g., dynamic PDSCH or CSI-RS collides with configured SRS, PUCCH, or CG PUSCH
	+ Case 2: Semi-statically configured DL reception vs. dynamically scheduled UL transmission
		- e.g., PDCCH or SPS PDSCH collides with dynamic PUSCH or PUCCH
	+ Case 3: Semi-statically configured DL reception vs. semi-statically configured UL transmission
	+ Case 4: Dynamically scheduled DL reception vs. dynamic scheduled UL transmission
	+ Case 5: Configured SSB vs. dynamically scheduled or configured UL transmission
		- e.g., PUSCH, PUCCH, PRACH, SRS
	+ Case 8: Dynamic or semi-static DL vs. valid RO
	+ Case 9: Collision due to direction switching
 |

Many contributions [3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29] express views on how UE should handle the seven potential collision cases identified in the last RAN1 meeting.

Many contributions noted that although in general collision may be avoided by the scheduler, DL/UL collision may not be avoidable in some scenarios and would be handled by UE.

Contribution [11] suggests a general method to handle the collision. For example, three options are proposed including scheduling restriction, defining a prioritization rule, and providing a TDD-like configuration.

Contribution [20] proposes to define a set of priority rules between different types of DL and UL channels and the channel collision can be solved through comparing different L1 priorities of two channels.

## Case 1: Dynamically scheduled DL reception vs. semi-statically configured UL transmission

Many contributions [5, 6, 7, 8, 9, 10, 12, 14, 15, 16, 17, 18, 19, 21, 22, 24, 25, 26, 28, 29] express views that the dynamic scheduled DL should be prioritized over the semi-statically configured UL transmission.

Contributions [5, 6, 7, 10, 14, 16, 17, 18, 19, 26, 28, 29] propose to reuse the existing rule of Rel-15/16 for Case 1, i.e. configured UL is (partially) cancelled if timeline allows. In the contribution [14] it was proposed to further study whether the timeline can be extended by including the Tx/Rx switching time.

Contributions [16, 21] indicate that it should be treated as error case if the first symbol of UL transmission occurs within Tproc,2 relative to a last symbol of the PDCCH.

Contribution [24] proposes to further study the case of DL scheduling collision UL CG resources.

Contribution [3] highlights that the dynamic scheduling is flexible to avoid collision with semi-static UL transmission.

**High Priority Proposal 3-1:**

**For Case 1 (dynamically scheduled DL reception vs. semi-statically configured UL transmission), reuse the existing collision handling principles in Rel-15/16 NR for operation on a single carrier /single cell in unpaired spectrum.**

* **FFS whether the timeline is extended to include the RX/TX switching time for HD-FDD**

**High Priority Question 3-1: Can Proposal 3-1 be agreed? If not, please explain why?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Y | We can accept the proposal, although we don’t think the FFS is needed. The gNB scheduler can take care of the RX/TX switching time when it schedules the DL. |
| Nokia, NSB | Y | We are fine with the main proposal but we do not think the FFS is needed. |
| vivo | Y if the FFS is removed | Agree with Ericsson and Nokia that the FFS is not needed.  |
| Qualcomm | Y | We think the FFS needs to be kept. |
| China Telecom | Y | We are fine to support FL proposal. Reuse the existing collision handling principles in Rel-15/16 NR as a starting point. And we suggest to delete FFS. |
| DOCOMO | Y |  |
| Apple  | Y | We think FFS should be kept because it may impact on possibility that UE performs switching from UL to DL.  |
| TCL | Y | We are fine with the proposal. |
| Samsung | Y | OK with the proposal. In our view, on top of the current time line, the RX/TX switching time can be further considered to determine whether or not the semi-statically configured UL is (partially) cancelled. |
| Spreadtrum | Y | We also think the FFS is unnecessary. |
| Sharp | Y |  |
| CATT | Y | We are fine with the proposal. Regarding to the FFS part, we see some different views. It seems good to keep it for further discussion. To us, it is unclear whether the DL-UL switching time of the switcher is already considered in current spec, and thus the timeline may or may not be extended.  |
| Xiaomi | Y | We also do not see the need of FFS. |

## Case 2: Semi-statically configured DL reception vs. dynamically scheduled UL transmission

Many contributions [5, 6, 7, 8, 10, 12, 14, 15, 16, 17, 18, 19, 21, 22, 25, 26, 28, 29] express views that the dynamic scheduled UL should be prioritized over the semi-statically configured DL reception. The existing collision handling principles in Rel-15/16 NR for operation on a single carrier/single cell in unpaired spectrum can be reused for case 2.

Contribution [3, 9, 24] mentioned that the collision between semi-statically configured DL reception and dynamically configured UL transmission is avoidable via proper gNB scheduler implementation.

Moreover, it was clarified in the contributions [6, 16] that the semi-statically configured DL reception may include also a CSI-RS and a DL PRS; the dynamically scheduled UL transmission may include also SRS or PRACH preamble transmission triggered by PDCCH order.

Based on above, the following proposal can be considered.

**High Priority Proposal 3-2:**

**For Case 2 (semi-statically configured DL reception vs. dynamically scheduled UL transmission), reuse the existing collision handling principles in Rel-15/16 NR for operation on a single carrier/single cell in unpaired spectrum**

* **The semi-statically configured DL reception may include PDCCH, SPS PDSCH, CSI-RS or PRS**
* **The dynamically scheduled UL transmission may include PUSCH, PUCCH, SRS or PRACH triggered by PDCCH order**

**High Priority Question 3-2: Can Proposal 3-2 be agreed? If not, please explain why?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |
| vivo | Y |  |
| Qualcomm | Y |  |
| China Telecom | Y |  |
| DOCOMO | Y |  |
| Apple  | Y |  |
| TCL | Y |  |
| Samsung  | Y |  |
| Spreadtrum | Y |  |
| Sharp | Y |  |
| CATT | Y |  |
| Xiaomi | Y |  |

## Case 3: Semi-statically configured DL reception vs. semi-statically configured UL transmission

Many contributions [5, 7, 8, 9, 10, 12, 14, 15, 16, 17, 18, 19, 22, 24, 25, 26] express views that the overlapped semi-static DL reception and semi-static UL transmission can be avoided by gNB scheduler, however, contributions [3, 6] mention it may not be avoidable in some scenarios.

In the contribution [6], it was discussed that the semi-static configuration should be further separated as semi-static configuration with cell-specific higher layer parameters and semi-static configuration with dedicated parameters. Since FD-FDD and HD-FDD UEs may co-exist in the same cell, there is a big impact for FD-FDD UE when relying on NW’s configuration to avoid the collision between semi-static DL reception and UL transmission configured by cell-specific higher layer parameters.

In the contribution [21], it was proposed to further discuss and down select between the following two alternatives

* Alt.1 (LTE approach): No DL reception during the guard period (=Tsw) before the start of the first UL transmission
* Alt.2 (NR approach): No UL transmission during the guard period (=Tsw) after the end of the last DL reception

Similarly, contribution [29] proposed that a UE behavior should be defined in this case for which channel/signal should take precedence over the other channel/signal.

**High Priority Question 3-3: For Case 3, is it sufficient to assume the collision is avoidable via proper gNB implementation and UE does not expect to be configured with overlapped semi-static DL reception and semi-static UL transmission occasions? What, if any, needs to be specified?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Y | No need to specify anything additionally. |
| Nokia, NSB | Y |  |
| vivo | N | There are four potential sub-cases under case 3* Case 3-1: cell-specifically configured DL reception vs. cell-specifically configured UL transmission
* Case 3-2: cell-specifically configured DL reception vs. UE-dedicated configured UL transmission
* Case 3-3: UE-specifically configured DL reception vs. cell-specifically configured UL transmission
* Case 3-4: UE-specifically configured DL reception vs. UE-specifically configured UL transmission

For case 3-2/3-3/3-4, it should be fine to rely on gNB implementation to avoid the collision between the DL reception and UL transmission as at least one UE specific configured DL or UL is involved. Case 3-1 is a bit different. Due to the existence of both FD-FDD and HD-FDD UEs, if we again rely on the gNB configuration to avoid the collision between DL and UL signals, it would cause degraded performance for FD-FDD UEs. For example, gNB has to configure the RACH occasions such that they do not overlap with the broadcast DL channels, e.g. SSB, CORESET#0, Paging occasions, SI occasions, etc, which would mean restricted configuration flexibility for RACH occasions resulting potentially increased initial access latency. Therefore, we would like to define the collision handling rule for cell-specific DL and cell-specific UL so that the performance of FD-FDD UEs including legacy UEs are not impacted.  |
| Qualcomm | Partially Y | Case 3-1 in Vivo’s comments can be further discussed |
| China Telecom | Y |  |
| DOCOMO | Partially Y | We are fine to further discuss Case 3-1 in vivo’s comments |
| Apple  | Partially Y | Case 3-1 raised by Vivo can be FFS.  |
| TCL | Partially Y | Further discuss Case 3-1 in vivo’s comments |
| Samsung | N | If SFI is configured, the overlap is handled by SFI.If SFI is not configured, we'd like to have some further discussion, including the cases raised by vivo.  |
| Spreadtrum | Y |  |
| Sharp | Partially Y | Case 3-1 in Vivo’s comments should be considered including static DL vs PO |
| CATT | Y, partially | It is reasonable to further study the difference of cell-specific and UE-dedicated configuration as raised by vivo. BTW, we think Case 3-2 and Case 3-3 may also be worth to consider. |
| Xiaomi | Y | We are also fine if case 3-1 is FFS. |

## Case 4: Dynamically scheduled DL reception vs. dynamic scheduled UL transmission

Many contributions [3, 5, 6, 7, 8, 10, 12, 14, 15, 16, 17, 18, 19, 22, 24, 25, 26, 27, 28, 29] express views that gNB should be able to handle the case of dynamic scheduled DL reception collides with dynamic scheduled UL transmission, and UE will not expect the collision.

Contribution [9] mentioned that when dynamically scheduled UL/DL transmission collide, the earlier scheduled transmission should take effect and the latter should be dropped.

In the contribution [21], it was proposed to further discuss and down select between the following two alternatives

* Alt.1 (LTE approach): No DL reception during the guard period (=Tsw) before the start of the first UL transmission
* Alt.2 (NR approach): No UL transmission during the guard period (=Tsw) after the end of the last DL reception

**High Priority Question 3-4: For Case 4, is it sufficient to assume the collision is avoidable via proper gNB implementation and UE does not expect to be dynamically scheduled with overlapped DL reception and UL transmission occasions? What, if any, needs to be specified?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Y | No need to specify anything additionally. |
| Nokia, NSB | Y |  |
| vivo | Y |  |
| Qualcomm | Y |  |
| China Telecom | Y |  |
| Apple  | Y |  |
| TCL | Y |  |
| Samsung | Y |  |
| CATT | Y |  |
| Xiaomi | Y |  |

**High Priority Proposal 3-4:**

**For Case 4: dynamically scheduled DL reception vs. dynamic scheduled UL transmission**

* **It is considered as error case if a dynamically scheduled DL reception overlaps with a dynamically scheduled UL transmission**

**Modified High Priority Question 3-4: Can Proposal 3-4 be agreed? If not, please explain why?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Y |  |
| vivo | Y |  |
| Qualcomm | Y |  |
| China Telecom | Y |  |
| DOCOMO | Y |  |
| Apple  | Y |  |
| TCL | Y |  |
| Samsung | Y |  |
| Spreadtrum | Y |  |
| Sharp | Y |  |
| CATT | Y |  |
| Xiaomi | Y |  |

## Case 5: Configured SSB vs. dynamically scheduled or configured UL transmission

Many contributions [5, 6, 9, 10, 12, 15, 17, 18, 21, 22, 24, 26, 27] express views that the existing TDD rule can be reused so that dynamically scheduled or configured UL transmission should be cancelled when colliding with SSB. Also, contribution [10] indicated that the existing rule may be extended to address the direction switching case by including overlapping with the time intervals that are used for DL-to-UL or UL-to-DL switching.

Contribution [8] mentioned that it is up to gNB implementation to avoid collision.

Contribution [7, 14, 19] discussed that if UE does not need to receive SSB then dynamically scheduled or configured UL transmission may not be cancelled since gNB can transmit and receive simultaneously on paired spectrum.

In the contribution [16], it was noted that UE-autonomous prioritization between SSB reception and UL transmission increases detection complexity at the gNB receiver and therefore as a baseline it can be considered as an error case.

Contribution [25] suggested to come back to this issue after the handling for case 2 and 3. Basically, two possibilities can be considered.

* Alt.1: Follow the handling of case 2 and 3 by considering SSB to be semi-statically configured DL reception
* Alt.2: Folow the principle of Rel-15/16

Contribution [29] noted that it should not be an issue for the dynamically scheduled UL transmission since it is fully controlled by gNB, but whether to transmit semi-statically configured UL transmission need further study.

**High Priority Proposal 3-5:**

**For Case 5, down-select between the following two options:**

* **Option 1: Follow the handling of case 2 and 3 by considering SSB to be semi-statically configured DL reception**
* **Option 2: Reuse the existing collision handling principles in Rel-15/16 NR for operation on a single carrier /single cell in unpaired spectrum**

**High Priority Question 3-5: Can Proposal 3-5 be agreed? If not, please explain why?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Y, with modification | For option 2, we would suggest adding the FFS below.FFS: how to account for Tx/Rx switching time before and after the set of SSB symbols |
| Nokia, NSB | Y |  |
| vivo | Y | OK for now. The further down-selection will depend on the discussion outcome of case 3, especially how to handle the cell-specific DL reception and cell-specific UL transmission.  |
| Qualcomm | Y |  |
| China Telecom | Y | We are fine to support FL proposal and prefer to align with case 2 and case 3. |
| DOCOMO | Y |  |
| Apple  | Y |  |
| TCL | Y |  |
| Samsung | Y with modifications | We are fine with Ericsson's suggestion for option 2And we'd like to add option 3: *-* Whether SS/PBCH is received or a UL is transmitted is up to UE implementationThe reason is because for FDD case, gNB has no issue to receive and transmit at the same time in different frequency range. From UE perspective, it may not need to receive SSB in connected mode. Therefore, UE might be able to transmit UL, especially dynamic scheduled UL.  |
| Spreadtrum | Y |  |
| CATT | Y, mostly. | Samsung’s example seems aligned with the handling of Case 2 (dynamic UL v.s. semi-static DL), where dynamic UL is prioritized (at least partially). To us, Samsung would like to find a combination way between Option 1 and Option 2, i.e. UL transmission is not always dropped, but may be different from Case 2/3. Not sure it is a good idea if the transmission is up to UE implementation, which may lead to gNB’s blind decoding. Anyway, a totally new handling rule is not preferred. If an Option 3 is added, we suggest the following version:**Option 3: Combination of Option 1 and Option 2. FFS details, e.g. up to UE implementation, or controlled by gNB.** |
| Xiaomi |  | If it is not the right time for downselection, we would rather keep it as FFS. We can discuss this issue after solutions of case 2 and 3 are clarified. |

## Case 8: Dynamic or semi-static DL vs. valid RO

Many contributions [5, 10, 12, 15, 18, 21, 24, 26, 29] express views that the existing TDD rule can be reused so that the UE will not receive any DL symbols overlapping with the set of symbols corresponding to a valid RO plus Ngap symbols before the valid RO. Also, contribution [10] indicates that the existing rule may be extended to address the direction switching case by including overlapping with the time intervals that are used for DL-to-UL or UL-to-DL switching.

Contribution [6, vivo] highlights that for Case 8 of dynamic or semi-static DL vs. valid RO, there are contradictions among the existing collision handling principles of Rel-15/16, and proposes to come back to this issue after a common understanding is made.

Contribution [7, 14] mentioned that UE may be allowed to receive the DL signals/signals when colliding with valid RO, for example, when RedCap UE is not in initial access procedure. Similarly, in the contribution [19] it was discussed that prioritization of valid RO over DL reception may result in no DL slots that can be scheduled for RedCap UE when PRACH is configured in all the subframes. Three approaches are thus proposed for further study.

Contribution [16] proposed to consider it as error case if a dynamically scheduled or configured DL reception overlaps with a valid RO since gNB has full control on the scheduling.

Contribution [9, MTK] proposed that dynamic or semi-static DL vs. valid RO could be treated as Case 3 despite R15, while in the contribution [17] it was proposed to follow Case 1 by considering valid PRACH occasion to be semi-statically configured UL transmission.

Contribution [25] suggested to come back to this issue after the handling for case 1 and 3. Basically, two possibilities can be considered.

* Alt.1: Follow the handling of case 1 and 3 by considering RO to be semi-statically configured UL transmission
* Alt.2: Folow the principle of Rel-15/16

**High Priority Proposal 3-6:**

**For Case 8, down-select between the following two options:**

* **Option 1: Follow the handling of case 1 and 3 by considering valid RO to be semi-statically configured UL transmission**
* **Option 2: Reuse the existing collision handling principles (valid RO prioritized over dynamic or semi-static DL) in Rel-15/16 NR for operation on a single carrier /single cell in unpaired spectrum**

**High Priority Question 3-6: Can Proposal 3-6 be agreed? If not, please explain why?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Y, with modification | For option 2, we would suggest adding the FFS below.FFS: how to account for Tx/Rx switching time |
| Nokia, NSB | Y |  |
| vivo | Y | OK for now. The further down-selection will depend on 1. The discussion outcome of case 3, especially how to handle the cell-specific DL reception and cell-specific UL transmission.
2. The outcome of email thread [104b-e-NR-7.1CRs-03] about how to interpret the current specification regarding collision between dynamic scheduled DL and RACH transmission.
 |
| Qualcomm | Y |  |
| China Telecom | Y | Same view with Question 3-5. We are fine to support FL proposal and prefer to align with case 1 and case 3. |
| DOCOMO | Y | We agree with vivo that the down-selection will depend on the outcome of [104b-e-NR-7.1CRs-03] |
| Apple  | Y |  |
| TCL | Y |  |
| Samsung | N | For option 1, if we follow case 1 like “valid RO is (partially) cancelled if timeline allows”, it may impact on the existing RO validity rule. With this reason, we don't support to follow the handling of Case 1.For case 3 in option 1, we suggest directly written as “UE does not expect to be scheduled as DL on the symbols of valid RO and *Ngap.*”, instead of referring to other cases. For option 2, we are fine to considering the outcome of mail thread [104b-e-NR-7.1CRs-03]Beside, we'd like to add following options:Option 3: Follow DL scheduling (FFS dynamic and/or semi-static) and do not transmit PRACH if at least one symbol of RO is collided with scheduled DL reception considering Ngap. Option 4: Leave it up to UE implementation (i.e., UE can transmit PRACH)The reasons for option 3 and 4 are, gNB is capable of receive UL and transmit DL at the same time. For UE, most of the time, there is no need to transmit PRACH. Even UE choose to transmit PRACH, UE can just simply sent NACK for the corresponding PDSCH. Besides, in the principle of LTE FDD, we don’t think there is any predefined rule on how to handle it. We don’t think it is a good choice to follow TDD-like principle of NR. E.g., for option 1, it may put too much restriction on gNB configuration. At this stage, we’d like to list all the potential solutions.  |
| Spreadtrum | Y |  |
| Sharp | Y |  |
| CATT | Y, mostly. | Similar case with proposal 3-5. For the same reason, the following option 3 can be considered:**Option 3: Combination of Option 1 and Option 2. FFS details, e.g. up to UE implementation, or controlled by gNB.** |
| Xiaomi |  | If it is not the right time for downselection, we would rather keep it as FFS. We can discuss this issue after solutions of case 2 and 3 are clarified. |

## Case 9: Collision due to direction switching

Many contributions [5, 6, 7, 8, 9, 10, 12, 14, 15, 16, 18, 19, 25, 26, 29] express their views on the collision due to direction switching (i.e. Case 9).

Several contributions [5, 8] mention it is up to gNB implementation and no issue is identified for Case 9.

Contributions [9, 16] note that any such collision should be treated as part of previous cases and a separate rule is not needed for Case 9.

Contribution [10] observes that if this case concerns the back-to-back UL/DL scenario (without gap or with a gap shorter than the Tx/Rx switching time) then it can be avoided for cases 1, 2, 3 and 4 through proper gNB implementation but not for case 5 and 8.

Contribution [6] proposes to FFS collision handling due to direction switching b/w cell specific configured DL reception and cell specific configured UL transmission and observes that other cases can be handled by gNB implementation.

Several contributions [7, 12, 14, 18, 25, 26] propose to have explicit specification for UE behaviour, e.g. a HD-FDD UE is not required to perform transmission or reception during the switching time.

In the contributions [15, 19] it was discussed that the direction switching time should occur in the duration of operation with lower priority and switching gap(s) need to be created before and/or after the high priority direction.

**High Priority Question 3-7: What, if any, other potential RAN1 specification impacts (beyond possible specification for other cases) do you expect for handling collision due to direction switching (i.e. Case 9)?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson |  | See our comments for 3-5 and 3-6 regarding accounting for Tx/Rx switching time due to direction switching. |
| Nokia, NSB |  | We do not see collision with direction switching |
| vivo |  | This will depend on the outcome of case 3 especially regarding how to handle the cell-specific DL reception and cell-specific UL transmission. For other cases, no additional specification is needed.  |
| Qualcomm |  | A HD-FDD UE is not required to transmit/receive during the interval of direction switching  |
| DOCOMO |  | A HD-FDD UE is not required to transmit/receive during the direction switching time |
| Apple  |  | Share Qualcomm’s view.  |
| Samsung |  | Switching gap due to direction switching can be taken into account for other cases (e.g., 3-1, 3-5, 3-6) |
| Spreadtrum |  | No other RAN1 specification impacts |
| CATT |  | The UE is not required to perform neither transmission nor reception during the switching time. |

## Other potential case

In [12] it was proposed that the rule for handling the collision between L1-RSRP measurement and dynamic or semi-static UL transmission should be addressed. For example, L1-RSRP measurement can be prioritized and UE is not required to perform UL transmission during the window of L1-RSRP measurement.

**Medium Priority Question 3-8: Companies are welcome to provide views for this potential collision case, e.g., whether it has been covered by the identified 7 cases or not.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| TCL | Y | A potential collision may happen when BWP switching (e.g. trigged by the bwpInactivityTimer or by the MAC entity upon initiation of Random Access procedure) and HD-FDD D-U switching performed successively but the time gap is not sufficient to complete the previous switching. |
|  |  |  |
|  |  |  |

# Semi-static UL/DL configuration

Contributions [15, 16, 18, 24] propose to support semi-static TDD-like slot configuration for HD-FDD Type-A UE; while contributions [21, 27, 28] propose not to configure the semi-static TDD-like slot formats for HD-FDD.

In the contributions [16, 18], it was mentioned that with the semi-static configuration of UL/DL pattern UE power consumption can be reduced. Also, [16] mentioned that the semi-static UL/DL configuration can be used to reduce the overhead of Type1 HARQ-ACK codebook size and simplify the collision handling procedures.

Based on above, the following proposal can be considered.

**High Priority Proposal 4-1:**

**FFS the need for NW to optionally configure semi-static TDD-like slot formats for HD-FDD UE.**

**High Priority Question 4-1: Can Proposal 4-1 be agreed? If not, please explain why?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | N | We do not see the need for such an FFS. |
| Nokia, NSB | N | We do not see meaningful benefit from semi-static UL/DL configuration. On the other hand, it introduces considerable complexity in gNB implementation with respect to resource utilization. |
| Qualcomm | Y | It is up to NW to configure or not configure a TDD-like slot format. This option should not be precluded. |
| DOCOMO | Y | We are open to further discuss the necessity of the configuration |
| TCL | Y |  |
| Samsung | N |  |
| Spreadtrum | N |  |
| CATT | N |  |
| Xiaomi | Y | The option is very helpful to avoid most UL/DL collision cases. Also it can help to resolve cell-specific semi-static DL/UL collisions, i.e. semi-static DL is prioritized in DL slots, and semi-static UL is prioritized in UL slots. NW has full flexibility on the configuration, including not configuring it.  |

# Other aspects (for information)

**UE capability signalling**

A few contributions [3, 4, 17] express views on the UE capability of HD-FDD.

* Contributions [3, 17] note that no specification impact in initial access/random access procedure is expected from HD-FDD Type-A UE and the UE capability signaling of HD-FDD can be reported to the network after initial access through UE capability framework
* Contribution [4] mentions that it is required for the network to know the UE capability signaling of HD-FDD in the earlier stage of initial access, e.g. to avoid zero gap between HARQ-ACK and the previous DL transmission

**FD-FDD fallback to HD-FDD**

A few contributions [17, 18] express views on enabling FD-FDD fall back operation to HD-FDD

* [17]: Support a signaling mechanism to enable HD-FDD operation for a FD-FDD capable RedCap UE
* [18]: A RedCap UE capable of full-duplex operation can fall back to Type-A HD-FDD for power saving in RRC connected state subject to the performance requirements for latency and throughput

**HARQ-ACK bundling support**

Contribution [8] proposes that HARQ-ACK bundling is not considered for HD-FDD in Rel-17

**Medium Priority Question 5-1: Companies are welcome to provide views for the above issues. If there is any new issue to be addressed for half duplex FDD operation, please also indicate here.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y | Whether or not to specify different power control parameters for HD-FDD based on the insertion loss and receive sensitivity differences w.r.t. FD-FDD |
|  |  |  |
|  |  |  |

# References

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | [RP-210918](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_91e/Docs/RP-210918.zip) | Revised WID on support of reduced capability NR devices | Nokia, Ericsson |
| [2] | [R1-2102220](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2102220.zip) | RAN1 agreements for Rel-17 NR RedCap | Rapporteur (Ericsson) |
| [3] | [R1-2102356](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102356.zip) | Discussion on duplex operation for RedCap | Huawei, HiSilicon |
| [4] | [R1-2102404](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102404.zip) | On half-duplex operation | OPPO |
| [5] | [R1-2102462](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102462.zip) | Discussion on aspects related to duplex operation | Spreadtrum Communications |
| [6] | [R1-2102531](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102531.zip) | Discussion on RedCap half-duplex operation | vivo, Guangdong Genius |
| [7] | [R1-2102640](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102640.zip) | Discussion on HD-FDD operation | CATT |
| [8] | [R1-2102651](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102651.zip) | UE complexity reduction aspects related to duplex operation | Nokia, Nokia Shanghai Bell |
| [9] | [R1-2102701](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102701.zip) | On half duplex operation for RedCap UEs | MediaTek Inc. |
| [10] | [R1-2102724](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102724.zip) | Duplex operation for RedCap | Ericsson |
| [11] | [R1-2102735](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102735.zip) | Discussion on aspects related to duplex operation | Asia Pacific Telecom, FGI |
| [12] | [R1-2102856](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102856.zip) | HD-FDD for reduced capability NR devices | ZTE |
| [13] | [R1-2102874](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102874.zip) | Discussion on aspects related to duplex operation | Potevio Company Limited |
| [14] | [R1-2102891](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102891.zip) | Discussion on collision handling of HD-FDD operation | CMCC |
| [15] | [R1-2102990](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102990.zip) | Discussion on Half-duplex FDD operation of Redcap UE | Xiaomi |
| [16] | [R1-2103040](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103040.zip) | On HD-FDD support for RedCap devices | Intel Corporation |
| [17] | [R1-2103114](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103114.zip) | On aspects related to half-duplex operation | Apple |
| [18] | [R1-2103176](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103176.zip) | Type-A HD-FDD for RedCap UE | Qualcomm Incorporated |
| [19] | [R1-2103248](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103248.zip) | HD-FDD Operation for RedCap UEs | Samsung |
| [20] | [R1-2103309](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103309.zip) | Half-duplex FDD operation for Redcap UEs | Sony |
| [21] | [R1-2103354](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103354.zip) | Aspects related to the duplex operation of RedCap | LG Electronics |
| [22] | [R1-2103423](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103423.zip) | Duplex operation for RedCap UEs | InterDigital, Inc. |
| [23] | [R1-2103478](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103478.zip) | Discussion on the duplex operation of redcap UEs | Sharp |
| [24] | [R1-2103536](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103536.zip) | Half duplex operation for RedCap | Lenovo, Motorola Mobility |
| [25] | [R1-2103542](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103542.zip) | Aspects related to duplex operation | Panasonic Corporation |
| [26] | [R1-2103585](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103585.zip) | Discussion on duplex operation for RedCap | NTT DOCOMO, INC. |
| [27] | [R1-2103652](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103652.zip) | On aspects related to duplex operation | Nordic Semiconductor ASA |
| [28] | [R1-2103666](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103666.zip) | Discussion on aspects related to duplex operation | ASUSTeK |
| [29] | [R1-2103699](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103699.zip) | Discussion on duplex operation for RedCap UE | WILUS Inc. |