**3GPP TSG-RAN** **WG2 Meeting #110-e R2-200xxxx**

**Electronic, June 1 – 12, 2020**

**Source: Qualcomm Incorporated**

**Title: Summary of email discussion [Post109bis-e][064][NR15] XDD FRX differentiation (Qualcomm)**

**Document for: Decision**

**Agenda Item: 5.4.3**

# Introduction

This document provides a summary of the following email discussion.

* [Post109bis-e][064][NR15] XDD FRX differentiation (Qualcomm)

      Scope: First priority, clarify the behaviour of the current UE capability signalling for xDD FRx differentiation, including identification of the problematic case that the current signalling does not allow the UE to signal. Second priority, if progress is good/fast, can discuss which actions should be taken, ways forward.
Intended outcome: Report.
Deadline: Next meeting

# Discussion

## UE setting of xDD FRx split capabilities

Three possible interpretations for the UE setting of xDD FRx split capabilities were identified so far. This section summarizes the setting of UE capability signalling in the following interpretations.

**Interpretation 1-a** (e.g. [R2-2002573](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_109bis-e/Docs/R2-2002573.zip), Qualcomm)

**Interpretation 1-b** (e.g. [R2-2003454](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_109bis-e/Docs/R2-2003454.zip), Huawei)

**Interpretation 2** (e.g. [R2-2003269](http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_109bis-e/Docs/R2-2003269.zip), Ericsson)

NOTE:

* “**Unable to signal**” indicates that the set of UE capabilities is allowed according to the UE capability differentiation rules in the standard, i.e. ‘yes’ or ‘no’ indications in the “FDD-TDD DIFF” and “FR1-FR2 DIFF” in TS38.306. But the UE capability signalling is not capable of expressing the set of UE capabilities.
* “**Not allowed**” indicates the set of UE capabilities is NOT allowed according to the UE capability differentiation rules in the standard, i.e. ‘yes’ or ‘no’ indications in the “FDD-TDD DIFF” and “FR1-FR2 DIFF” in TS38.306.

In both cases, the UE can choose to fallback to an allowed UE capability setting.

## UE capabilities with both xDD and FRx differentiations

**Interpretation 1-a**

|  |  |
| --- | --- |
| Support for the feature | UE capability containers |
| xDD-Diff in common | FRX-diff in common | fdd-Add | tdd-Add | fr1-Add | fr2-Add |
| **Case 1** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘supported
 | Supported | Supported | Not included | Not included | Not included | Not included |
| **Case 2** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘not supported
 | Not supported | Not supported | Not included | Not included | Not included | Not included |
| **Case 3** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘supported
 | Not supported | Supported | Not included | Supported | Not included | Not included |
| **Case 4** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘supported
 | Not supported | Not supported | Not included | Supported | Not included | Supported |
| **Case 5** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘not supported
 | Not supported | Not supported | Not included | Supported | Supported | Not included |
| **Case 6** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘supported
 | Unable to signal |
| **Case 7** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘not supported
 | Not supported | Not supported | Supported | Not included | Supported | Not included |
| **Case 8** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘not supported
 | Supported | Not supported | Not included | Not included | Supported | Not included |

**Interpretation 1-b**

|  |  |
| --- | --- |
| Support for the feature | UE capability containers |
| xDD-Diff in common | FRX-diff in common | fdd-Add | tdd-Add | fr1-Add | fr2-Add |
| **Case 1** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘supported
 | Supported | Supported | Not included | Not included | Not included | Not included |
| **Case 2** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘not supported
 | Not supported | Not supported | Not included | Not included | Not included | Not included |
| **Case 3** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘supported
 | Not supported | Not supported | Not included | Supported | Not included | Not included |
| **Case 4** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘supported
 | Not supported | Not supported | Not included | Supported | Not included | Supported |
| **Case 5** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘not supported
 | Not supported | Not supported | Not included | Supported | Supported | Not included |
| **Case 6** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘supported
 | Unable to signal |
| **Case 7** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘not supported
 | Not supported | Not supported | Supported | Not included | Supported | Not included |
| **Case 8** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘not supported
 | Not supported | Not supported | Not included | Not included | Supported | Not included |

**Interpretation 2**

Label

1 UE supports the feature for the given FRX/XDD mode

0 UE does not support the feature for the given FRX/XDD

x UE does not support the given FRX/XDD mode

fdd UE includes the feature in fdd-Add-UE-NR/MRDC-Capabilities

tdd UE includes the feature in tdd-Add-UE-NR/MRDC-Capabilities

fr1 UE includes the feature in fr1-Add-UE-NR/MRDC-Capabilities

fr2 UE includes the feature in fr2-Add-UE-NR/MRDC-Capabilities

common UE includes the feature in the common branch (xDD-diff and FRx-diff) for features that do not require FR1/FR2 or FDD/TDD differentiation

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | FR1 only |  |  |  |  |  |  |
|   | FDD | TDD |  |   | FDD | TDD |  |   | FDD | TDD |
| FR1 | 1 | 0 |  | FR1 | 0 | 1 |  | FR1 | 1 | 1 |
| FR2 | x | x |  | FR2 | x | x |  | FR2 | x | x |
| fdd |  | tdd |  | common |
|  |  |  |  |  |  |  |  |  |  |  |
|   | FDD | TDD |  |   | FDD | TDD |  |  |  |  |
| FR1 | 1 | x |  | FR1 | x | 1 |  |  |  |  |
| FR2 | x | x |  | FR2 | x | x |  |  |  |  |
| common |  | common |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | TDD only  |  |  |  |  |  |  |
|   | FDD | TDD |  |   | FDD | TDD |  |   | FDD | TDD |
| FR1 | x | 1 |  | FR1 | x | x |  | FR1 | x | 1 |
| FR2 | x | 1 |  | FR2 | x | 1 |  | FR2 | x | 0 |
| common |  | common |  | fr1 |
|  |  |  |  |  |  |  |  |  |  |  |
|   | FDD | TDD |  |  |  |  |  |  |  |  |
| FR1 | x | 0 |  |  |  |  |  |  |  |  |
| FR2 | x | 1 |  |  |  |  |  |  |  |  |
| fr2 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | FR1+FR2  |  |  |  |  |  |  |
|   | FDD | TDD |  |   | FDD | TDD |  |   | FDD | TDD |
| FR1 | 1 | 0 |  | FR1 | 1 | x |  | FR1 | 0 | 0 |
| FR2 | x | 0 |  | FR2 | x | 0 |  | FR2 | x | 1 |
| fdd |  | fr1+fdd |  | fr1+fdd |
|  |  |  |  |  |  |  |  |  |  |  |
|   | FDD | TDD |  |   | FDD | TDD |  |   | FDD | TDD |
| FR1 | 1 | 1 |  | FR1 | 0 | 1 |  | FR1 | 1 | 0 |
| FR2 | x | 0 |  | FR2 | x | 1 |  | FR2 | x | 1 |
| fr1+fdd |  | fr2+tdd |  | fr2+fdd |
|  |  |  |  |  |  |  |  |  |  |  |
|   | FDD | TDD |  |   | FDD | TDD |  |   | FDD | TDD |
| FR1 | 1 | 1 |  | FR1 | 1 | x |  | FR1 | 0 | x |
| FR2 | x | 1 |  | FR2 | x | 1 |  | FR2 | x | 1 |
| common |  | common |  | fr2+tdd |
|  |  |  |  |  |  |  |  |  |  |  |
|   | FDD | TDD |  |  |  |  |  |  |  |  |
| FR1 | 1 | x |  |  |  |  |  |  |  |  |
| FR2 | x | 0 |  |  |  |  |  |  |  |  |
| fr1+fdd |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |

## UE capabilities with xDD differentiation only

Rapproteur’s note: It is rapporteur’s understanding that there is no difference in UE capability bit setting among different interpretations.

**Interpretation 1-a, 1-b and 2**

|  |  |
| --- | --- |
| Support for the feature | UE capability containers |
| xDD-Diff in common | FRX-diff in common | fdd-Add | tdd-Add | fr1-Add | fr2-Add |
| **Case 1** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘supported
 | Supported | N/A | Not included | Not included | N/A | N/A |
| **Case 2** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘not supported
 | Not supported | N/A | Not included | Not included | N/A | N/A |
| **Case 3** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘supported
 | Not supported | N/A | Not included | Supported | N/A | N/A |
| **Case 4** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘supported
 | Not allowed |
| **Case 5** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘not supported
 | Not allowed |
| **Case 6** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘supported
 | Not allowed |
| **Case 7** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘not supported
 | Not supported | N/A | Supported | Not included | N/A | N/A |
| **Case 8** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘not supported
 | Not allowed |

## UE capabilities with FRx differentiation only

Rapproteur’s note: It is rapporteur’s understanding that there is no difference in UE capability bit setting among different interpretations.

**Interpretation 1-a, 1-b and 2**

|  |  |
| --- | --- |
| Support for the feature | UE capability containers |
| xDD-Diff in common | FRX-diff in common | fdd-Add | tdd-Add | fr1-Add | fr2-Add |
| **Case 1** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘supported
 | N/A | Supported | N/A | N/A | Not included | Not included |
| **Case 2** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘not supported
 | N/A | Not supported | N/A | N/A | Not included | Not included |
| **Case 3** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘supported
 | Not allowed |
| **Case 4** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘supported
 | N/A | Not supported | N/A | N/A | Not included | Supported |
| **Case 5** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘not supported
 | Not allowed |
| **Case 6** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘supported
 | Not allowed |
| **Case 7** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘not supported
 | Not allowed |
| **Case 8** | * FR1 FDD: ‘supported’
* FR1 TDD: ‘supported’
* FR2 TDD: ‘not supported
 | N/A | Not supported | N/A | N/A | Supported | Not included |

**Q1: Companies are requested to indicate which interpretation they support.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Interpretation 1-a/1-b/2** | **Comment** |
| Nokia | 1-a/1-b | We are aligned to 1-a table (offline we understood that proponent of 1-b is also aligned to 1-a but chose a different way to represent the information). |
|  |  |  |
|  |  |  |

## The specification text in TS38.306

The current procedural text in TS38.306 is as follows. According to the company inputs during RAN2#109bis-e meeting, the parts highlighted are subject to discussion.

|  |
| --- |
| The UE may support different functionalities between FDD and TDD, and/or between FR1 and FR2. The UE shall indicate the UE capabilities as follows. […]1> set all fields of UE-NR/MRDC-Capability except fdd-Add-UE-NR/MRDC-Capabilities, tdd-Add-UE-NR/MRDC-Capabilities, fr1-Add-UE-NR/MRDC-Capabilities and fr2-Add-UE-NR/MRDC-Capabilities, to include the values applicable for all duplex mode(s) and frequency range(s) that the UE supports;1> if UE supports both FDD and TDD and if (some of) the UE capability fields have a different value for FDD and TDD2> if for FDD, the UE supports additional functionality compared to what is indicated by the previous fields of UE-NR/MRDC-Capability:3> include field fdd-Add-UE-NR/MRDC-Capabilities and set it to include fields reflecting the additional functionality applicable for FDD;2> if for TDD, the UE supports additional functionality compared to what is indicated by the previous fields of UE-NR/MRDC-Capability:3> include field tdd-Add-UE-NR/MRDC-Capabilities and set it to include fields reflecting the additional functionality applicable for TDD;1> if UE supports both FR1 and FR2 and if (some of) the UE capability fields have a different value for FR1 and FR2:2> if for FR1, the UE supports additional functionality compared to what is indicated by the previous fields of UE-NR/MRDC-Capability:3> include field fr1-Add-UE-NR/MRDC-Capabilities and set it to include fields reflecting the additional functionality applicable for FR1;2> if for FR2, the UE supports additional functionality compared to what is indicated by the previous fields of UE-NR/MRDC-Capability:3> include field fr2-Add-UE-NR/MRDC-Capabilities and set it to include fields reflecting the additional functionality applicable for FR2; |

## Discussion point 1: “include the values applicable for all duplex mode(s) and frequency range(s)”

There seems to be different interpretations regarding this sentence.

**Interpretation 1-a** assumes that “XDD-diff” and “FRX-diff” in common branch can be set separately and included when the UE supports the feature for all duplex mode(s) and all frequency ranges, respectively, i.e. “XDD-diff” and “FRX-diff” can include different values.

**Interpretation 1-b** and **interpretation 2** assumes that the “XDD-diff” and “FRX-diff” in common branch is included when the UE supports the feature for all duplex mode(s) and all frequency ranges, i.e. “XDD-diff” and “FRX-diff” cannot include different values.

**Q2: Companies are requested to provide their comment on the observation above, if any.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Comment on interpretation 1-a/1-b/2** | **Comment** |
| Nokia | 1-a | Our understanding is that irrespective of the UE supporting FR1/FR2 or both or FDD/TDD or both, the common bit has to be set. However, if the UE supports both FR1+FR2 and FDD+TDD and it has different capabilities for a given feature in FR1/FR2 and FDD/TDD it will use the specific parts. |
|  |  |  |
|  |  |  |

## Discussion point 2: “the UE supports”

The current specification text assumes that the UE includes the xDD FRx split capabilities based on the duplex mode(s) and frequency range(s) the UE supports. For interpretation 1-a and 1-b, it is not clarified in the tables of section 2.1 how the UE would change the UE capability setting when the UE does not support a given combination of duplex mode + frequency range. For example, in the case 4 below, the UE capability setting should be different when the UE does not support an FR2-TDD band.

|  |  |
| --- | --- |
| Support for the feature | UE capability containers |
| xDD-Diff in common | FRX-diff in common | fdd-Add | tdd-Add | fr1-Add | fr2-Add |
| **Case 4** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘supported’
 | Not supported | Not supported | Not included | Supported | Not included | Supported |

**Interpretation 2** is indeed based on the assumption that the UE includes the xDD FRx split capabilities based on the duplex mode(s) and frequency range(s) the UE supports. Therefore the case where the UE does not support the feature for a given combination of duplex mode + frequency range, and the case where the UE does not support a given combination of duplex mode + frequency range are clearly distinguished, as in the example below.

|  |  |  |
| --- | --- | --- |
| UE does not support the feature in FR1 TDD |  | UE does not support FR1 TDD band |
|   | FDD | TDD |  |   | FDD | TDD |
| FR1 | 1 | **0** |  | FR1 | 1 | **x** |
| FR2 | x | 0 |  | FR2 | x | 0 |
| fdd |  | fr1+fdd |

It should be noted however that the true UE capability for duplex mode and frequency range may not be fully visible from the network point of view, due to the UE capability filter. This poses the question whether the UE is required to include the xDD FRx split capabilities based on the duplex mode(s) and frequency range(s) the UE “reports”, as opposed what the UE “supports”.

**Q3: Companies are requested to confirm that the UE to include the xDD FRx split capabilities based on the duplex mode(s) and frequency range(s) the UE supports.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes / No** | **Comment on interpretation 1-a/1-b/2** | **Comment** |
| Nokia | Yes | -  | Taking the Case 4 example here: As the xADD fields were set to (0,1) and (0,1) for xDD and FRx respectively this implies the UE supports both FR1 and FR2 as well as FDD and TDD but just wants to indicate that it supports a given feature only on TDD and FR2. |
|  |  |  |  |

**Q4: Is the UE required to include the xDD FRx split capabilities based on the duplex mode(s) and frequency range(s) the UE reports?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes / No** | **Comment on interpretation 1-a/1-b/2** | **Comment** |
| Nokia | No | - | Based on Q3 that was the idea of differentiation across xDD and FRx from the beginning. In our understanding, the common part is used ONLYwhen the UE supports the given feature for both FR1+FR2/FDD+TDD or it supports the feature for FR1/FR2 AND it is capable of only FR1/FR2 and so on. |
|  |  |  |  |

## Discussion point 3: “the additional functionality applicable for FDD/TDD/FR1/FR2”

It was clarified for the **interpretation 2** that “the additional functionality applicable for TDD” means additional functionality that applies for TDD in all the FR modes the UE supports, and this applies similarly to other cases. So the corresponding specification text needs to be read as follows when the UE supports FR1 FDD, FR1 TDD and FR2 TDD.

3> include field fdd-Add-UE-NR/MRDC-Capabilities and set it to include fields reflecting the additional functionality applicable for FDD FR1;

3> include field fdd-Add-UE-NR/MRDC-Capabilities and set it to include fields reflecting the additional functionality applicable for TDD FR1 and TDD FR2;

3> include field fdd-Add-UE-NR/MRDC-Capabilities and set it to include fields reflecting the additional functionality applicable for FR1 FDD and FR1 TDD;

3> include field fdd-Add-UE-NR/MRDC-Capabilities and set it to include fields reflecting the additional functionality applicable for FR2 TDD;

**Interpretation 1-a** and **Interpretation 1-b** however do not follow such interpretation, e.g. in case 4.

|  |  |
| --- | --- |
| Support for the feature | UE capability containers |
| xDD-Diff in common | FRX-diff in common | fdd-Add | tdd-Add | fr1-Add | fr2-Add |
| **Case 4** | * FR1 FDD: ‘not supported’
* FR1 TDD: ‘not supported’
* FR2 TDD: ‘supported’
 | Not supported | Not supported | Not included | Supported | Not included | Supported |

**Q5: Companies are requested to provide their comment on the observation above, if any.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Comment on interpretation 1-a/1-b/2** | **Comment** |
| Nokia | 1-a/1-b | Taking the Case 4 example here: As the xADD fields were set to (0,1) and (0,1) for xDD and FRx respectively this implies the UE supports both FR1 and FR2 as well as FDD and TDD but just wants to indicate that it supports a given feature only on TDD and FR2.In fact, for interpretation 2 example from section 2.1.1 1-a table the corresponding case is Case 1 where xADD fields are not required to be used. |
|  |  |  |
|  |  |  |

# Summary

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# Conclusion

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