3GPP TSG RAN WG1 Meeting #102-e R1-200xxxx

17th Aug– 28th August 2020

Agenda Item: 8.10.2

Source: Moderator (Qualcomm Incorporated)

Title: Summary of [102-e-NR-eIAB-02]

Document for: Discussion and decision

### 1 – Introduction

This contribution provides a summary of the following email discussion:

[102-e-NR-eIAB-02] Email discussion on other enhancements for simultaneous operation of IAB-node’s child and parent links by 8/28– Luca (Qualcomm)

* Prioritize topics to be resolved in RAN1#102-e by 8/19

### 2 – Summary of discussion on prioritization of discussion topics

Based on the discussion on prioritization in the [102-e-NR-eIAB-02] email thread, it was generally agree to discuss the following topics according to the specified priority:

|  |
| --- |
| **Timing modes:**1. Discussion on which additional timing modes besides Case 1 (prioritizing Case 6 and Case 7 timing and leveraging the discussion that has already taken place in SI/Rel-16 on the same) are needed / useful for which duplexing scenario under which conditions. **HIGH PRIORITY**
2. Discussion on prioritization / focus in Rel-17 for additional timing modes –**MEDIUM PRIORITY**and conditional on agreement on high priority portion of proposed Topic 1 and Topic 2 of email thread [102-e-NR-eIAB-01]

**Interference mitigation:**1. Discussion on which interference scenarios apply to which duplexing scenario under which conditions. **HIGH PRIORITY**
2. Discussion on available solutions (e.g. Rel-16 CLI framework) and/or need and prioritization for Rel-17 IAB specific enhancements for handling the identified interference scenarios –**MEDIUM PRIORITY**and conditional on agreement on high priority portion of proposed Topic 1 and Topic 2 of email thread [102-e-NR-eIAB-01]

 **Power control:**1. Discussion on the need for power control for which duplexing scenario under which conditions –**HIGH PRIORITY**
2. Discussion on prioritization / focus in Rel-17 for power control enhancements –**MEDIUM PRIORITY**and conditional on agreement on high priority portion of proposed Topic 1 and Topic 2 of email thread [102-e-NR-eIAB-01]

 In the above, “conditions” is defined as the key attributes of the scenario which are relevant for RAN1 e.g. FR1 vs. FR2, in-band/out-of-band, TDD spectrum considerations such as RAN4 Scenarios 1/2, high-level antenna designs/RF architectures, deployment considerations etc.), as defined in the [102-e-NR-eIAB-01] email thread. |

### 3 – Discussion on timing modes

**Topic 3.1**

This topic relates to the discussion on which additional timing modes besides Case 1 (prioritizing Case 6 and Case 7 timing and leveraging the discussion that has already taken place in SI/Rel-16 on the same) are needed / useful for which duplexing scenario under which conditions.

Related input from contributions:

|  |  |
| --- | --- |
| Huawei, HiSiliconR1-2005261 | ***Observation 3****: Case #6 timing mode can achieve transmission timing alignment, which facilitates joint transmission of child and parent links of IAB node and mitigates the interference between MT and DU.****Observation 5****: Case #7 timing mode can achieve symbol-level timing alignment, which facilitates joint reception of child and parent links of IAB node.****Proposal 1:*** *Case #6 timing should be supported to mitigate interference in MT Tx/DU Tx scenario*.***Proposal 2:*** *Case #7 timing need to be supported for IAB to enabling better interference mitigation for simultaneous reception.****Proposal 3:*** *A Case #7-like timing mode can be adopted to enhance self-interference cancelation in UL full-duplex.* |
| VivoR1-2005400 | ***Proposal 1: To maintain simultaneous transmission between MT and DU, IAB node should support the Case #6 timing mode as defined in TR 38.874.******Proposal 2: To maintain simultaneous reception between MT and DU, IAB node should support the Case #7 timing mode as defined in TR 38.874.*** |
| AT&TR1-2005952 | **Proposal 4: New timing alignment mechanisms beyond Case 1 timing should be considered in Rel-17 for SDM/MPTR scenarios in resources which are orthogonal from those used by access or TDM-only backhaul links.** |
| LG ElectronicsR1-2006383 | ***Proposal 1:*** * Timing alignment mechanism for ‘case #6 (MT Tx / DU Tx)’ and ‘case #7 (MT Rx / DU Rx)’ of the IAB timing mode are considered as a starting point for specification work
* New cases of IAB timing mode for the other simultaneous scenarios (i.e., MT Tx / DU Rx and MT Rx / DU Tx) are identified.
	+ Case #8: Case#1 + The UL transmission timing of an IAB-node can be aligned with the IAB-node's UL reception timing.
	+ Case #9: Case#1 + The DL reception timing of an IAB-node can be aligned with the IAB-node's DL transmission timing.

***Proposal 2:*** * Simultaneous IAB-MT Tx and IAB-DU Tx can be operated by network configuration. Also, IAB timing mode case#6 can be operated by network configuration.
	+ When simultaneous IAB-MT Tx and IAB-DU Tx is configured, IAB timing mode case #6 (MT UL Tx time is aligned with DU DL Tx time) can be applied according to network configuration.
* When IAB timing mode case#6 is allowed, MT may apply timing advance value determined by DU DL Tx time.
* If network allows both TDM and simultaneous MT Tx/DU Tx, and IAB timing mode case#6 is allowed, MT may apply one of two timing advance values depending on IAB resource multiplexing.
 |
| NTT DOCOMOR1-2006745 | **Proposal 2: Case #6 and #7 timing modes should be considered for IAB node which has single transceiver/antenna panel.** |
| QualcommR1-2006826 | **Observation 3:****The benefits of Case 6 and Case 7 timing modes may be limited in a multi-panel implementation aimed at enhanced duplexing capabilities between the IAB-MT and the IAB-DU. Case 7 timing may have a higher benefit than Case 6 timing.** |
| EricssonR1-2006904 | **Observation 2 Simultaneous transmission and reception on child and parent links can be enabled by supporting Case-6 and Case-7 timing alignment configurations.****Proposal 3 Case-6 OTA timing alignment should be supported, if simultaneous transmission on parent and child links is supported for Rel-17 IAB.****Proposal 4 Case-7 OTA timing alignment should be supported, if simultaneous reception on parent and child links is supported for Rel-17 IAB.** |

There is a majority view that Case 6 and Case 7 timing modes can provide some benefit in at least some scenarios, e.g. SDM with single panel implementation.

For reference, the four main multiplexing scenarios from the Rel-17 WID are:

Case 1: Simultaneous MT-Tx/DU-Tx

Case 2: Simultaneous MT-Rx/DU-Rx

Case 3: Simultaneous MT-Rx/DU-Tx

Case 4: Simultaneous MT-Tx/DU-Rx

In reference to the above multiplexing scenarios the following conclusion is proposed:

**FL Conclusion 3.1:**

**The applicability of Case 6 and Case 7 timing to the defined multiplexing scenarios is summarized in the following table as a function of single panel vs. dual panel implementation:**

|  |  |
| --- | --- |
| **Applicability / Benefit of Case 6 and Case 7 timing**  | **IAB-Node implementation** |
| **Single Panel** | **Dual Panel** |
| **Multiplexing scenario** | **Case 1: Simultaneous MT-Tx/DU-Tx** | Case 6 | N/A |
| **Case 2: Simultaneous MT-Rx/DU-Rx** | Case 7 | N/A |
| **Case 3: Simultaneous MT-Rx/DU-Tx** | N/A | N/A |
| **Case 4: Simultaneous MT-Tx/DU-Rx** | N/A | N/A |

|  |  |  |
| --- | --- | --- |
| **Company** | **Do you agree with FL Conclusion 1?** | **Comments** |
| Qualcomm | Yes | None |
| LG Electronics | For Case 1 and Case2, Yes.But, For Case 3 and Case 4, No | For case 1 and case2 of multiplexing scenario, case 6 and case 7 can be considered. In addition, new timing alignment cases should be defined for case 3 and case 4 of multiplexing scenario if single panel based operation is assumed for the scenarios. |
| CMCC | Yes, for Case 1/2; No, for Case 3/4 | Regarding Case 4, with single panel, we believe that case 7 should be considered so that it is beneficial to self interference cancellation; regarding case 3, it seems that only case 1 can be supported for single panel. |
| NTT DOCOMO | Yes |  |
| ZTE, Sanechips | Yes | For case-3: if the target of timing alignment is to satisfying both of following conditions:* DL Tx of the IAB node and DL-Tx of its parent are time-aligned; 🡨 this is case-1 timing requirement which seems to be the basis for any inter-node resource coordination.
* DL-Tx of the IAB node and DL Rx of the same IAB node are time-aligned. 🡨 this is what simultaneous MT-Rx/DU-Tx targets.

Then the combination of above two leads to alignment between DL-Tx of the parent and the DL-Rx of the IAB node, which means the one-way propagation delay is zero --- infeasible to implement unless giving up case-1 timing. For case-4, I copy our comment from [eIAB-01] to here:In case 4, “timing alignment possible with parent timing advance” looks ok in theory but can have serious problem in practice: Any (controlled or autonomous) adjustment of UL-Tx timing of an IAB node on i-th hop may lead to adjustments of UL-Tx timing in IAB nodes that are on all follow-up hops. The worse is that these adjustments inside IAB nodes may not be able to well sync-up with each other and it is hard for IAB node and its parent to know when the sync-up is well-done. In addition, the case-4 timing requires the UL-Rx timing (or UL Tx timing) are strictly advanced to earlier time as IAB node’s hopping number increases, which could be a new restriction to deployment planning.  |
| Vivo | Yes |  |
| Huawei | No | Case #6 and Case #7 timing are also applicable for dual panel when there is not sufficient isolation between MT and DU. In this case, timing alignment is still benefitial to mitigate the interference. In addition, we don't think the assumption on single/dual panel really matters here as long as the specification impact is same. For Case 4, Case #7 timing can be considered to mitigate the self-interference by adjust the UL Rx timing for IAB-DU. Note that there is no fundamental different from signalling point of view comparing with the Case #7 timing for Case 2.  |
| Ericsson | Yes for single panel Case 1 and Case 2, no for Case 3 and Case 4 | For Case 1 ad Case 2, dual panel can be viewed as an enhancement of the single panel case. For that reason, Case 6 timing and Case 7 timing can be used also for these if needed at all.Case 3 and Case 4 and multi-panel would need to take Case 1 timing requirements into consideration.We think that the multi-panel configuration should be defined so we share a common understanding of the capabilities of such nodes, e.g., w.r.t.* Antenna/RF isolation
* Interference cancellation
* Baseband timing
 |
| Intel | Yes | We also agree with Ericsson that multi-panel configuration should be defined as a common understanding.  |
| Lenovo, Motorola Mobility | Yes, but with comments for clarification | Since we have “Applicability / Benefit” in the description, we could distinguish between the cases where timing alignment Case 6 and Case 7 are not applicable (i.e., Case 3 and Case 4) versus where they may not seem immediately beneficial (i.e., Case 1 and Case 2 with multiple panels). This way:* We don’t rule out the applicability of Case 6 and Case 7 if the spec/implementation chooses to allow them for Case 1/2 with multiple panels.
* We keep open the possibility of introducing timing alignment beneficial for Case 3/4 at a later time.

Hence, for calrification, we suggest using an entry other than “N/A” for Case 1/2 with multiple panels.Side note: It would be helpful to call the scenarios something other than Case 1/2/3/4 so as to avoid confusion with timing alignment cases. |
| CEWiT | No | For case 3 and 4, timing alignment may or may not be required based on implementation. Besides that, isolation may not be enough even in multi panel case to avoid SI cancellation. Therefore timing alignment should be also studied in simultaneous MT-Rx/DU-Tx and simultaneous MT-Tx/DU-Rx cases.In general, there is no need to categorise timing alignment solutions for different cases based on single/dual panel. A timing alignment solution for any case should be applicable to both single or dual panel scenarios in the same way. |
| Nokia | Yes, for single panel. No for dual panel.  | To limit CLI in FDM, timing alignment will still be necessary in dual-panel implementation as well. Both case #6 and #7 may be still applicable for dual panel cases as highlighted by HW. Agree with Ericsson on case 3 and 4 where DL TX alignment may still need Case #1 timing. Case 3 and 4 cannot get any benefit out of timing modes mentioned as in the FL conclusion.  |
| AT&T | Not really | This categorization may be too simplistic. As some companies point out, there may be a need/benefit for Case 6/7 timing even with multi-panel operation in multiplexing Case 1/Case 2 and some form of timing alignment enhancements may also be beneficial for multiplexing Case 3 / 4. So this conclusion could be seen as a prioritization (e.g. identifying the limiting cases), but shouldn’t restrict implementation/specification impact. |
| Samsung | No | We do not see a need to classify timing alignment solutions based on single/dual panel, as commented by other companies. For case 3 and 4, timing alignment should not be mandatory requirement. But, we are open to consider enhancement for the timing alignment as it may have potential benefits for interference handling. |

From the further discussion some companies point out that Case 6 and Case 7 timing may also have some benefit in a dual panel implementation, which is a fair observation. There doesn’t seem to be consensus on the applicability of Case 6 and Case 7 timing to multiplexing scenarios Case 3 and Case 4. As a result, considering we had agreed to prioritize the discussion on Case 6 and Case 7 timing and that multiplexing scenarios Case 3 and Case 4 are still being debated in [102-e-NR-eIAB-01] we can limit the conclusion to multiplexing scenarios Case 1 and Case 2.

In regard to the suggestion from Motorola about renaming the multiplexing scenarios to avoid confusion with the timing cases, it certainly makes sense, however it will need to be coordinated with the discussion in the [102-e-NR-eIAB-01] discussion, from where the current notation was borrowed.

In regard to the suggestion from Ericsson about defining the single-panel and multi-panel configurations, it certainly makes sense and should also be folded into the [102-e-NR-eIAB-01] discussion where the same configurations are referenced in the context of the discussion on the enhanced duplexing scenarios.

For the purpose of this discussion, what seems relevant is the fact that in general it is expected that in multi-panel there would be in general less severe mutual interference between the IAB-MT and the IAB-DU.

**FL Conclusion 3.1b:**

**The applicability of Case 6 and Case 7 timing to the SDM multiplexing scenarios (Case 1 and Case 2) is summarized in the following table as a function of single panel vs. dual panel IAB-node implementation:**

|  |  |
| --- | --- |
| **Applicability / Benefit of Case 6 and Case 7 timing**  | **IAB-Node implementation** |
| **Single Panel** | **Dual Panel** |
| **Multiplexing scenario** | **Case 1: Simultaneous MT-Tx/DU-Tx** | Case 6 applies and it provides benefit | Case 6 applies and it may provide benefit depending on implementation |
| **Case 2: Simultaneous MT-Rx/DU-Rx** | Case 7 applies and it provides benefit | Case 7 applies and it may provide benefit depending on implementation |

|  |  |  |
| --- | --- | --- |
| **Company** | **Do you agree with FL Conclusion 3.1b?** | **Comments** |
| Qualcomm | Yes | None |
| ZTE, Sanechips | Ok to case 7. Not sure on case 6 | According to Rel-16 SI, Case 6 may need to partition all slots on child links into individual ones dedicated to each child node and likely separated for access link as well. This is not a good resource utilization according to queuing theory and could generate traffic jitter if the child nodes do not have balance traffic. We understand case-6 allows simultaneous Tx, which is a winning point, but the overall benefit is less convincing.  |
| Huawei | Yes | We are fine with the existing table. In addition, we would like to point out For Case 4, Case #7 timing can also be considered to mitigate the self-interference by adjust the UL Rx timing for IAB-DU. There is no fundamental different from signalling point of view comparing with the Case #7 timing for Case 2. |
| Intel | Not sure about Dual Panel Case | We think some clarification may be needed about dual panel: whether it means dual antenna panel with single baseband or dual antenna panel with dual baseband. For dual panel with dual baseband, advanced joint receiver for interference cancellation cannot be fulfilled, hence Case 6/Case 7 time alignment is not needed.  |
| LG Electronics |  | Multiplexing Scenario Case 3 and Case 4 should be included in the table. |
| CMCC | OK with single panel | We are fine with the single panel part of this table. We tend to agree with Intel that futher clarifications should be made before we make consensus on the dual panel part.One more thing, I’m not sure if I missed something. Why the main sentence of the FL conclusion 3.1b specifically said that “**Case 6 and Case 7 timing to the SDM multiplexing scenarios**”?  |
| NTT DOCOMO | Yes for single panel | We just wonder necessity of the Case6 and 7 timing alignment for the dual panel. They are for simultanouse Tx or Rx for MT and DU, so we may not have interference between them. |

**Topic 3.2:**

This topic relates to the discussion on prioritization / focus in Rel-17 for additional timing modes.

Related input from contributions:

|  |  |
| --- | --- |
| ZTE, SanechipsR1-2005468 | Observation 1: To support case-6 timing in Rel-17 may cause following concerns.* Misalignment of UL-Rx timing at parent for child nodes and access UEs, for which all existing solutions (TDM-based, non-TDM-based) have deficiencies.
* RAN1 may need to revise or even re-design Rel-16 case-1 timing.
* It is unclear whether RAN4 should re-define the UL-Tx timing requirement once the UL-Tx timing is decoupled from TA process and aligned with DL-Tx timing, and, if yes, how complicated it is.

Proposal 1: To de-prioritize case-6 timing in Rel-17. |
| Lenovo, Motorola MobilityR1- 2005928 | **Proposal 1:** Support both transmission timing alignment (Case-6) and reception timing alignment (Case-7) for IAB Rel-17. |
| SamsungR1-2006166 | ***Proposal 1: Case #6 and Case #7 timing in the TR38.874 can be a starting point for timing discussion in Rel-17 IAB.*** |
| CMCCR1-2006229 | **Proposal 1:****The case #6 and case #7 could be a starting point for the discussion for the IAB timing mode under the simultaneous operation of IAB nodes. Case#7 is slightly preferred than case#6 to ensure both network synchronization, and symbol-level alignment.** |
| QualcommR1-2006826 | **Observation 1:****Operation in Case 6 timing mode of an IAB-node may cause uplink interference at the IAB-DU receiver of its parent node and/or may require special handling in the uplink scheduler of its parent node to TDM users to avoid such interference.****Observation 2:****Operation in Case 7 timing mode may require changes to the Rel-15 UL timing control for IAB nodes, which in turn may also impact the OTA timing mechanism defined in Rel-16 for IAB.****Proposal 1:****Downselect one of the following:*** **Alt 1: adopt Case 1 as the only timing mode.**
* **Alt 2: quantify the benefits of Case 7 timing mode to determine whether such benefits are sufficient to justify the additional complexity.**
* **Alt 3: quantify the benefits of Case 6 and Case 7 timing modes to determine whether such benefits are sufficient to justify the additional complexity.**
 |
| FujitsuR1-2005544 | **Proposal 1: Consider effective negative TA for supporting simultaneous operation of MT Rx/DU Rx in Rel-17.****Proposal 2: Further investigate the required control of the parent or the network for supporting simultaneous operation of MT Tx/Du Tx.** |

There are different views on the prioritization of Case 6 and Case 7 timing modes. However, there seems to be a preference of Case 7 timing vs. Case 6 timing. As a resul, the following is proposed:

**FL Proposal 3.1:**

**Case 7 timing is supported in Rel-17 for IAB-nodes operating in multiplexing scenario Case 2 (simultaneous MT-Rx/DU-Rx).**

**Case 6 timing is deprioritized in Rel-17 until the solutions for Case 7 timing are specified.**

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| --- | --- | --- |
| **Company** | **Do you agree with FL Proposal 1?** | **Comments** |
| Qualcomm | Yes | None |
| Fujitsu |  | We agree with that case-7 can have higher priority than case-6. But we are open to discuss them in parallel. |
| LG Electronics |  | It is good to discuss them in parallel. |
| CMCC | Need further discussion | We generally agree with the first sentence; for the second sentence, case 6 also has its suitable scenarios, which we think is somehow dependent on the discussion in 8.10.1.  |
| NTT DOCOMO | Yes for the 1st sentence | We prefer to define both case #6 and #7 at the same time. If IAB has a single panel, both case #6 and #7 are necessary for the simultanouse MT and DU operation as in FL conclusion 1. Thus, if we agree to discuss the multiplexing scenarios of case1 and case2, both case #6 and #7 are necessary. |
| ZTE, Sanechips | Yes | The Rel-16 SI already showed some issues within case-6 timing (e.g., “require maintenance of separate Rx timings at the parent node for Case 6 UL transmissions from different child nodes”). In addition, we also concern about following issues: * The back-and-forth change of UL-Tx timing between aligning to DL-Tx (when in case-6 timing mode) and aligning to DL-Rx less TA (when in legacy TA mode) may cause RAN1 to revisit case-1 timing mechanism, such as adding time-stamp information to TA and/or T\_delta. This could be time consuming.
* It is also uncertain how RAN4 can handle the requirement for case-6 timing: Among the two aligned timings, DL-Tx timing has no IAB-specific accuracy requirement, and UL-Tx timing has a quite loose accuracy requirement including even the autonomous adjustment component, which results in the timing drift that is larger than what DL-Tx timing usually endures, especially in multi-hop scenario. It could be also time-consuming in RAN4 if RAN4 needs to generate another set of spec for UL-Tx timing under case-6 timing condition.

Given the performance concern upon case-6 timing, we just do not feel it deserves the expected efforts.[update on Aug 25]We are not convinced by Huawei’s comment that “Case 1 timing has nothing to do with Case 6 timing since they are essentially DL Tx timing for DU and UL Tx timing for IAB-MT respectively”. Case-6 timing needs to control, by its definition, the UL-Tx timing in a different way from case-1 timing. The different UL-Tx timing leads to different T\_delta. In the current spec, there is no mechanism on how to pair the TA and T\_delta (RAN1 even agrees this is implementation issue by allowing T\_delta filtering). To support case-6, the paring between TA and T\_delta has to be defined, or RAN1 needs to disable T\_delta when case-6 timing slot is in use, which seems another form to time-stamp a “disabling label” in case-1 timing. This “disabling T\_delta” also makes the definition of case-6 timing a bit different, because the original case-6 timing is defined as case-1 timing plus alignment of DU-Tx/MT-Tx, not the alignment of DU-Tx/MT-Tx at the moment without controllability of DL-Tx timing. Regarding to complexity in RAN4 to support case-6, 38.133 uses several sections to describe the timing requirements for UE’s UL-Tx. Two possibilities for IAB MT: * RAN4 does not specify anything additional for IAB (we see this reason for RAN4 not to include T\_delta value range and not to define new requirement for DL-Tx timing in RAN4 spec), i.e., there is no RAN4 timing requirement for case-6.
* RAN4 will generate another set of spec on UL-Tx adjustment under case-6 timing condition. The new requirement would depend on not only the UE hardware limitation (which is used as the basis to derive current RAN4 requirements for UL-Tx) but also the performance requirements coming from simultaneous Tx scheme. It does not seem an easy work for RAN4.
 |
| vivo | First bullet OK | It is beneficial to identify the enhancement aspects for both case 6 and case 7, it is too early to preclude either case. If the reason for deprioritization is large spec. effort, we can make decision few meetings later. |
| Huawei | Partially | Case #6 and Case #7 target different scenarios. There is no need to prioritize one over the other. Maybe one practical way is first agree on Case #7 timing. However, it should be noted that the feasibility of case #6 has already been proven and different detailed solutions on how to achive Tx timing alignment have already been capured in the Rel-16 TR. Case 1 timing has nothing to do with Case 6 timing since they are essentialy DL Tx timing for DU and UL Tx timing for IAB-MT repectively. The concern on RAN4 performance requirement is not valid since the RAN4 requirement is to define how accurate the UE shall set its UL Tx timing. Similar requirement can be defined once case #6 timing is agreed. |
| Ericsson | Yes for Case 7 timingNo for Case 6 timing if DL Tx | One should not be excluded over the other since a parent node may use Case 6 timing while a child node use Case 7 timing. Any concerns of UL Rx timing would be irrelevant if Case 6 timing is only applied in DL slots. |
| Intel | Not sure | We think this conclusion depends on the results of previous topic. If we have common understanding to operate on multi-pannel, then neither Case 6 nor Case 7 must be supported. It seems too soon to jump to the conclusion to support Case7.  |
| Lenovo, Motorola Mobility | Yes, but no need to deprioritize Case 6 | Case 6 timing alignment is expected to require less specification work in RAN1 than Case 7. We don’t think there is a need for deprioritizing Case 6. RAN1 can introduce Case 6 and Case 7 and introduce spec to deteremine when/where/how each one is applied. This way, the works on the two cases will be independent and can be done in parallel. |
| CEWiT | Yes, for first part Need further discussion for second point | Prioritization of Case 6 timing in Rel-17 depends on the discussion in 8.10.1 |
| Nokia | Partly, agree for case#7 timing, disagree for case#6 timing | A similar view as HW. Both timing modes plays essential roles when supporting MT RX/DU RX and MT TX/DU TX scenarios. It is not fully clear why there should be only Case #7, not Case #6. Also, please note that the agreement was reached during SI to support case#6 and case#7, and there is no clear motivation to support one case over the other, since both are relevant as agreed in FL conclusion 1. |
| AT&T | No | No need to deprioritize Case 6. The more important thing is to decide if there is a need to differentiate single-panel vs. multi-panel operation and whether the use of Case 6/7 timing is restricted to certain time resources (e.g. only backhaul resources or DL slots as proposed by Ericsson)  |
| Samsung | Further discussion | We think the timing alignment options should be further discussed in order to address interference issues from simultaneous operations between DU and MT. We think it is too premature to preclude some option(s) in this stage. |

As a clarification, the intent of FL Proposal 3.1 was not to exclude Case 6 timing, but only to allow a focused discussion on the details of Case 7 timing.

Nevertheless, based on the further discussion there is a majority preference to not deprioritize Case 6 timing. As a result I have modified the proposal accordingly.

As an additional clarification, in response to Nokia’s comments, according to the SI agreements, Case 6 and Case 7 timing modes were not agreed to be supported.

**FL Proposal 3.1b:**

**Case 7 timing is supported in Rel-17 for IAB-nodes operating in multiplexing scenario Case 2 (simultaneous MT-Rx/DU-Rx).**

**Further study Case 6 timing, including:**

* **Impact to parent node.**
* **Implications, if any, to Case 1 timing.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Do you agree with FL Proposal 3.1b?** | **Comments** |
| Qualcomm | Yes | None |
| ZTE, Sanechips | Yes |  |
| Samsung | Yes |  |
| Huawei | Mostly | Not sure about the second bullet “Implications, if any, to Case 1 timing.” Our understanding is the applicability of Case 6 timing should be under the control the parent node as clearly captured in the TR. The IAB-MT known exactly what UL Tx timing is used for a certain transmission. For Case 1 timing, nothing has changed including the signalling of T\_delta and the timing advance it shall use for the DL Tx timing. |
| Intel | Partially Yes | We still have concern about whether Case 6/Case 7 is needed for dual panel (with dual baseband) case. But if most companies agree with the FL, we can agree with it.  |
| LG Electronics |  | Case 7 timing can be applied for at least multiplexing scenario Case 2. In addition, the Case 7 timing can be used for multiplexing scenario Case 4. Case 6 timing can be applied for multiplexing scenario Case 1 if gNB allows. In my understaning there is no implication to Case 1 timing.For multiplexin scenario Case 3, one condition (i.e., time difference between DU Tx timing and MT Rx timing is within CP length?) can be considered for operating self interference cancellation efficiently. |
| CMCC | Mostly | For the first bullet, as what we commented in FL conclusion 3.1, we believe case 7 timing can also be used for case 4. |

### 4 – Discussion on interference mitigation

**Topic 4.1**

This topic relates to the discussion on which interference scenarios apply to which duplexing scenario under which conditions.

Related input from contributions:

|  |  |
| --- | --- |
| Huawei, HiSiliconR1-2005261 | ***Observation 1:*** *There are several different types of interferences resulted from MT Tx/DU Tx:** *Interference between MT and DU*
* *Inter-UE interference*
* *Interference from MT to UE*
* *Interference from MT to UE*

***Observation 2:*** *Inter-UE interferences can be avoided in the following scenarios:** + *Implement simultaneous TX/RX at 2nd hop*
	+ *Implement simultaneous MT TX/DU TX between parent BH link and child BH link for IAB-node*

***Observation 7:*** *For full-duplex uplink transmission at IAB node, IAB MT uplink transmission may cause self-interference at IAB DU uplink reception.* ***Observation 8:*** *Full duplex operation may require timing adjustment to allow interference cancellation and decrease implementation complexity.****Observation 9:*** *For uplink full-duplex, IAB node may not be able to cancel the self-interference if the power gap between the interference and desired signals is too large, and the power gap can be reduced power control of MT.****Observation 10:*** *The interference from IAB DU downlink transmission to IAB MT downlink reception may cause performance degradation on the backhaul link.****Observation 11:*** *For downlink full-duplex, IAB node may not be able to cancel the self-interference if the power gap between the interference and desired signals is too large, and the power gap can be reduced by decreasing DU transmission power which is an implementation issue.****Observation 12:*** *Different from conventional CLI scenarios including BS-BS and UE-UE interference, the interference from IAB backhaul link is relative stable and can be well managed.* |
| AT&TR1-2005952 | **Proposal 2: Specify, if needed, enhancements to UE-UE Rel. 16 CLI measurement framework.** |
| CEWiT, Tejas Networks, Reliance Jio, IITM, Saankhya Labs, IITHR1-2006347 | **Observation 1:** The donor node can collect CLI information and take appropriate measures to mitigate it.**Observation 2:** IAB node MT might need time-frequency resources for SI measurement, which are free from backhaul reception and transmission. This requires cooperation with the parent.**Observation 3:** Severe interference at an IAB node will not allow it to operate in simultaneous Tx and/or Rx mode efficiently. |
| QualcommR1-2006826 | **Observation 5:****The interference components in case of simultaneous operation of the IAB-MT and the IAB-DU are:*** **Inter Cell Interference (ICI)**
* **Cross Link Interference (CLI)**
* **Self-interference (SI)**

**ICI effects are deemed less severe and can be handled anyway with legacy solutions.****CLI is expected to be mitigated by the Rel-16 CLI framework, with some potential enhancements as needed.****SI may require further study to determine need for specific measurements to be introduced in the specification.** |
| EricssonR1-2006904 | **Observation 11   In Scenario 1 UL/DL transmission configuration, even RAN nodes outside the IAB-network can be severely interfered by IAB-nodes transmitting or receiving simultaneously on parent and child links.****Observation 12   In Scenario 2 UL/DL transmission configuration, interference by IAB-nodes, which transmit or receive simultaneously on parent and child links, to RAN nodes outside the IAB-network is not increased.** |

There are different interference scenarios identified by the companies that in general involve any pair of MT, UE, and DU entities. The complete list is as follows:

Scenario 1: DU-to-DU

Scenario 2: MT-to-MT

Scenario 3: DU-to-MT

Scenario 4: MT-to-DU

Scenario 5: MT-to-UE

Scenario 6: UE-to-MT

Scenario 7: UE-to-UE

Scenario 8: DU-to-UE

Scenario 9: UE-to-DU

**FL Conclusion 4.1:**

**The following table summarizes the interference scenarios relevant each multiplexing scenario:**

|  |  |
| --- | --- |
| **Applicability of interference scenarios to multiplexing scenarios** | **Multiplexing scenario** |
| **Case 1****MT-Tx/DU-Tx** | **Case 2****MT-Rx/DU-Rx** | **Case 3****MT-Rx/DU-Tx** | **Case 4****MT-Tx/DU-Rx** |
| **Interference scenario** | **Scenario 1:** **DU-to-DU** | IAB-DU to parent-DU | Parent-DU to IAB-DU | N/A | N/A |
| **Scenario 2:** **MT-to-MT** | IAB-MT to child-MT | Child-MT to IAB-MT | N/A | N/A |
| **Scenario 3:** **DU-to-MT** | N/A | N/A | IAB-DU to IAB-MT (self-interf.), Parent-DU to child-MT | N/A |
| **Scenario 4:** **MT-to-DU** | N/A | N/A | N/A | IAB-MT to IAB-DU (self-interf.),Child-MT to parent-DU |
| **Scenario 5:** **MT-to-UE** | IAB-MT to child-UE | N/A | N/A | N/A |
| **Scenario 6:** **UE-to-MT** | N/A | Child-UE to IAB-MT | N/A | N/A |
| **Scenario 7:** **UE-to-UE** | N/A | N/A | N/A | N/A |
| **Scenario 8:** **DU-to-UE** | N/A | N/A | Parent-DU to child-UE | N/A |
| **Scenario 9:** **UE-to-DU** | N/A | N/A | N/A | Child-UE to parent-DU |

|  |  |  |
| --- | --- | --- |
| **Company** | **Do you agree with FL Conclusion 4.1?** | **Comments** |
| Qualcomm | Yes | None |
| ZTE, Sanechips | The fields without “N/A” could be right.  | Given the 9 scenarios are defined per “any pair of MT, UE, and DU entities” (ref previous page), we are not sure what “N/A” means, given the interference may happen beyong among IAB node, its parent and its children nodes. The corresponding interference could happen between, for example, from DU on i-th hop under donor A to MT on j-th hop under donor B, whenever i and j as well as A and B are applicable.  |
| Samsung | Yes |  |
| Huawei | Patially | The CLI interference between IAB nodes seems missing… |
| Intel | Yes |  |
| LG Electronics | Patially | Same view with Huawei |
| NTT DOCOMO | Yes |  |
| vivo | Yes  |  |

**Topic 4.2**

This topic relates to the discussion on available solutions (e.g. Rel-16 CLI framework) and/or need and prioritization for Rel-17 IAB specific enhancements for handling the identified interference scenarios.

Related input from contributions:

|  |  |
| --- | --- |
| Huawei, HiSiliconR1-2005261 | ***Proposal 5****: Enhancements on CLI to support the simultaneous operation of IAB MT and DU including inter-multiplexing chain scenarios, at least should consider* * *Interference measurement*
* *Interference coordination/management*

***Proposal 6:*** *To handle various types of interference, regardless of interference source is MT or DU, a unified CLI measurement and management framework can be adopted in IAB.* |
| VivoR1-2005400 | ***Observation 1: DU implementation can handle the interference measurement regarding DU Rx interference.******Proposal 8: In case simultaneous MT Rx/DU Rx or MT Rx/DU Tx is enabled, support measurement and report of collocated DU-to-MT self-interference.*** |
| ZTE, SanechipsR1-2005468 | ***Proposal 4: The existing TCI scheme can be a starting point in support of intra-IAB-node CLI mitigation.*** |
| Nokia, , Nokia Shanghai BellR1-2005536 | **Proposal 3**: **An IAB node can be configured to be made aware of the semi-static DU resource configuration (D/U/F/H/S/NA) of its parent IAB node(s) and neighboring nodes.**  |
| Lenovo, Motorola MobilityR1- 2005928 | **Proposal 5**: Consider enhancements for improving resource management and timing adjustment for CLI measurements in IAB systems. |
| AT&TR1-2005952 | **Proposal 1: DU-DU and MT-MT CLI measurements such as short-term (L1/L2) and long term (L3) measurements, multiple antenna and beamforming based measurements should be studied to enable CLI mitigation in IAB.****Proposal 2: Specify, if needed, enhancements to UE-UE Rel. 16 CLI measurement framework.****Proposal 3: Specify DU-DU CLI measurements techniques to enable CLI mitigation for IAB.** |
| SamsungR1-2006166 | ***Proposal 3****:* ***Discuss further CLI mitigation in Rel-17 IAB.*** |
| CMCCR1-2006229 | **Proposal 3:****The measurement to prevent the self-impulse interference in simultaneous transmission and reception of IAB should be discussed and introduced.** |
| CEWiT, Tejas Networks, Reliance Jio, IITM, Saankhya Labs, IITHR1-2006347 | **Proposal 1:** SI measurement occasions are required at an IAB node operating in DUTx-MTRx and DURx-MTTx modes.**Proposal 2:** IAB nodes should be able to request parent and donor node to fall back to TDM mode of operation from simultaneous Tx and/or Rx mode.* **Proposal 3:** There should be a feedback mechanism regarding the interference at an IAB node from MT to the parent to ensure efficient working in simultaneous Tx and Rx mode.
 |
| LG ElectronicsR1-2006383 | ***Proposal 9:*** * For the Case 1 (Victim IAB-node is receiving in DL via its MT, interfering IAB-node is transmitting in UL via its MT of inter IAB-node interference scenario, Rel-16 CLI measurement and handling mechanism can be applied.

Considering on IAB specific TDD configuration (i.e., U-F-D), measurement resource configuration and/or signalling for network coordination (i.e., intended UL/DL configuration) can be modified. |
| NTT DOCOMOR1-2006745 | **Proposal 11: No additional mechanism is necessary for cross link interference for IAB.** |
| QualcommR1-2006826 | **Observation 6:****The Rel-16 CLI framework has some limitations. Specifically:*** **There is no specified inter-CU (Xn) signaling to indicate the SRS configurations for UEs/MTs’ CLI measurements. This is a general, non-IAB-specific, issue.**
* **No specified inter-DU interference measurements and reporting.**
* **Rel-16 CLI signaling (intended TDD configuration) does not support IAB-specific resource configurations.**

**Proposal 2:****Specify enhancements to Rel-16 CLI to guarantee inter-operability and efficiency. Details are FFS.****Proposal 3:****Determine whether specific SI measurements are needed.** |
| EricssonR1-2006904 | **Proposal 7           Consult with RAN whether to pursue IAB specific CLI and interference measurement specification or to work on a scope outside IAB (that includes IAB specific needs).** |

The majority view is to specify enhancements to the available solutions for the IAB-specific scenarios (i.e. interference scenarios 1 to 4). Some companies also explicitly suggested to further discuss the self-interference scenarios showing up in the multiplexing cases 3 and 4.

**FL Proposal 4.1:**

**Interference management solutions for the following IAB interference scenarios should be considered:**

* **MT-to-MT, and DU-to-DU.**
* **MT-to-DU, and DU-to-MT.**
	+ **including self-interference scenarios between a collocated DU and MT.**

**FL Proposal 4.2:**

**The already defined interference management solutions (e.g. Rel-16 CLI framework) are the starting point for the interference management solutions for the identified IAB interference scenarios.**

* **For each interference scenario, it should be further discussed if any enhancement is beneficial/required, or the interference can be managed using the available solutions and/or in an implementation-specific way.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Do you agree with FL Proposal 4.1?****/****Do you agree with FL Proposal 4.2?** | **Comments** |
| Qualcomm | Yes / Yes | None |
| ZTE/Sanechips | No/Yes | We are not quite sure for now that the interference management solution should cover self-interference between collocated DU and MT. Most, if not all, of interfenrce management solutions in people’s mind are baseband methods in digital domain. However, there are at least two issues (listed below) that the digital domain processing may not be able to handle at all if the super strong Tx signal gets looped back into collocated receiver end along with a much weaker signal transmitted by a remote transmitter: * The AGC would make the received signal effectively digitized by limited number of ADC bits, and therefore introduce certain form of distortion of the received signal.
* The strong signal could generate non-negligible inter-modulation (IMD) effect to the received signal, before everything entering baseband. Such IMD effect is normally a hardware-dependent non-linear transform of the original transmitted signal.

It seems difficult to find interference management solutions that could recover the received signal if above two issues happen. |
| Samsung | Yes / Yes |  |
| Huawei | Yes (some clarification)/No | We assume MT-to-MT, and DU-to-DU interference also include the CLI between IAB nodes.In general, the interference types are quite different, there is no need to take the Rel-16 CLI framework as the starting point. |
| Intel | Not sure / Yes | We kind of agree with ZTE about the self-interference case.  |
| LG Electronics | Partially Yes / Partially Yes | In Rel-16 RIM/CLI WI, UE2UE CLI measurement and reporting mechanim were specified. So, in Rel-17 eIAB WI, the framework can be considered for the discussion of MT2MT CLI handling.In addition, it is necessiry to clarify whether DU2DU CLI handling is included in Rel-17 eIAB work scope. (In RAN1 spec, UE behaviour for RS reception and measurement is described. But, there is no description for gNB behaviour.)In this agend (interference mitigation), at least interference measurement (i.e., CLI, Self-Interference) can be discussed and specified.  |
| NTT DOCOMO | No/Yes | We prefer to prioritize Case 1 and 2 (of course it depends on the outcom of 8.10.1.), and in that case, we may consider MT-MT and DU-DU cases. |
| vivo | Partially/Yes  | In this agenda, we think the discussion will be interference measurement and reporting. The interference to MT reception can be focused in IAB agenda, interference to DU reception can be left to implementation, especially for MT-2-DU interference. We wonder whether we can preclude MT-2-DU or DU-2-DU interference at this stage.  |

### 5 – Discussion on power control

**Topic 5.1**

This topic relates to the discussion on the need for power control for which duplexing scenario under which conditions.

Related input from contributions:

|  |  |
| --- | --- |
| Huawei, HiSiliconR1-2005261 | ***Observation 4：****Transmission power gap may degrade the quality of the weaker signal, and this may be mitigated by uplink power control of MT or the downlink power control of DU.****Observation 6:*** *Reception power gap may lead to performance deterioration of the link with lower reception power, and the gap can be reduced by power control.****Observation 9:*** *For uplink full-duplex, IAB node may not be able to cancel the self-interference if the power gap between the interference and desired signals is too large, and the power gap can be reduced power control of MT.****Observation 11:*** *For downlink full-duplex, IAB node may not be able to cancel the self-interference if the power gap between the interference and desired signals is too large, and the power gap can be reduced by decreasing DU transmission power which is an implementation issue.* |
| ZTE, SanechipsR1-2005468 | ***Observation 3:*** *It needs to be determined how to handle Tx power from specification perspective – a Tx parameter controlled by IAB node and/or its parent vs. a fourth resource dimension managed by CU.****Proposal 3: One of the following power control schemes should be supported for FDM/SDM.*** * ***The indication from IAB node to the parent for the expected received power on parent link DL of the IAB node.***
* ***The indication from parent node to the IAB node for the planned transmission power on parent link DL of the IAB node.***
 |
| IntelR1-2005894 | **Proposal 1:** To fulfil simultaneous operation of IAB-node’s child and parent links, IAB backhaul DL power control mechanisms should be supported.  |
| Lenovo, Motorola MobilityR1- 2005928 | **Proposal 4:** Support early power control signaling for simultaneous Tx/Rx operations to avoid prohibitive power imbalance. |
| AT&TR1-2005952 | **Proposal 5: Consider DL and UL power control enhancements to allow for inter- and intra-panel SDM/MPTR of backhaul and access links.** |
| SamsungR1-2006166 | ***Proposal 2: Discuss reception power imbalance and transmission power splitting issues in Rel-17 IAB.*** |
| CMCCR1-2006229 | **Proposal 2:** **The power control should be enhanced for both uplink and downlink considering the issue of transmit power imbalance, signal blockage due to AGC and interference of simultaneous transmission and reception.** |
| CEWiTR1-2006347 | **Observation 4: In case of simultaneous Tx and/or Rx, the high transmit power at MT, as controlled by the parent, can hamper performance at DU.** |
| NTT DOCOMOR1-2006745 | **Proposal 3: Power adjustment between DU DL and MT UL should be considered.** |
| QualcommR1-2006826 | **Observation 4:****Power control handling for enhanced duplexing capabilities may be handled by implementation.** |
| EricssonR1-2006904 | **Proposal 8           Any implementation of power control in IAB nodes should take into account existing base station design principles for which power control typically does not exist.** |

Based on the contributions, there is general consensus that power control mechanisms may be helpful to address the following issues for each of the multiplexing scenarios under consideration:

* Case1 simultaneous TX (MT-TX/DU-TX),
	+ TX power imbalance.
* Case2 simultaneous RX (MT-RX/DU-RX),
	+ RX power imbalance.
* Case3 full duplex (MT-RX/DU-TX)
	+ Self-interference.
* Case4 full duplex (MT-TX/DU-RX)
	+ Self-interference.

**FL Conclusion 5.1:**

**The following table summarizes the applicability of power control to the multiplexing scenarios under consideration:**

|  |  |
| --- | --- |
|  | **Power control may be helpful for mitigating:** |
| **Multiplexing scenario** | **Case 1: Simultaneous MT-Tx/DU-Tx** | Tx power imbalance |
| **Case 2: Simultaneous MT-Rx/DU-Rx** | Rx power imbalance |
| **Case 3: Simultaneous MT-Rx/DU-Tx** | Self-interference |
| **Case 4: Simultaneous MT-Tx/DU-Rx** | Self-interference |

|  |  |  |
| --- | --- | --- |
| **Company** | **Do you agree with FL Conclusion 5.1?** | **Comments** |
| Qualcomm | Yes | None |
| ZTE, Sanechips | Yes for case 1 and case 2; No for case 3 and case 4 | For the self-interference in case 3 and case 4, the power control range could be too small for the power difference between Tx signal and Rx signal, because there could be a lower bound for Tx power to ensure the Tx signal can reach the remote receiver end, while this lower bound could be still quite larger comparing to the locally received signal strength.  |
| Samsung |  | We think power control is also beneficial to mitigate CLI to other nodes. As another comment, power control may be helpful to handle some interference issues but it may impact coverage due to reduced transmit power. So, we need to consider these aspects when discussing power control for interference handling. |
| Huawei | Yes for Case 1/2/4 | Not sure how power control can help for Case 3.  |
| Intel | Yes | None |
| LG Electronics | Yes |  |
| NTT DOCOMO | Yes | Self-interference may be managed by implementation. |
| vivo | Yes  |  |

**Topic 5.2**

This topic relates to the discussion on prioritization / focus in Rel-17 for power control enhancements.

Related input from contributions:

|  |  |
| --- | --- |
| Huawei, HiSiliconR1-2005261 | ***Proposal 4:*** *Enhancements on power control should focus on IAB MT.* |
| VivoR1-2005400 | ***Proposal 4: Support closed loop DL power control for backhaul link.***Proposal 5: Support both semi-static and dynamic power sharing between DU and MT in the case of simultaneous DU Tx and MT TxProposal 6: RAN1 strives for a power setting mechanism to control the PSD imbalance in the case of simultaneous DU Tx and MT Tx via shared RF chain.Proposal 7: Specify power sharing mechanism among DU, MCG and SCG in case of DC. |
| IntelR1-2005894 | **Proposal 2:** At least closed-loop mechanism can be considered for IAB backhaul DL power control. |
| LG ElectronicsR1-2006383 | ***Proposal 6:***For power control for simultaneous reception of IAB-MT and IAB-DU, DL power control mechanism based on IAB-MT request should be adopted. ***Proposal 7:*** The maximum output power allowed for an IAB supporting simultaneous transmission of IAB-MT and IAB-DU should be discussed.***Proposal 8:*** It is necessary to discuss the priority rule or the selection rule for IAB-MT and IAB-DU capable of power sharing and supporting simultaneous transmission considering them together, not separately. |
| CEWiTR1-2006347 | **Proposal 3: There should be a feedback mechanism regarding the interference at an IAB node from MT to the parent to ensure efficient working in simultaneous Tx and Rx mode** |
| SharpR1-2006581 | **Proposal 1:**The scope of the power control enhancements should be limited.  In the WID, the limitation is mentioned between parent-child links, and so the *control* should take place between these links, but also CLI *measurements* should be limited to minimize signaling.**Proposal 2:**Specification of power control for IAB nodes should appropriate as much as is feasible from the existing power control framework of NR.**Proposal 3:**The scope of the power control enhancements should consider MT/DU power transmit requirements and capabilities dependent on the RF parameters involved, duplex capability, etc. |
| NTT DOCOMOR1-2006745 | **Proposal 10: Assistant information for DL power of parent node can be semi-statically and/or dynamically reported by IAB-node for simultaneous MT and DU reception.** |
| QualcommR1-2006826 | **Observation 4:****Power control handling for enhanced duplexing capabilities may be handled by implementation.** |
| EricssonR1-2006904 | **Proposal 8           Any implementation of power control in IAB nodes should take into account existing base station design principles for which power control typically does not exist.** |

Most companies proposed to introduce enhancements to power control. A few companies suggested that power control may be handled by implementation within the existing power control framework. One company raised potential implementation impact on IAB nodes when DL power control is required for IAB-DU.

**FL Proposal 5.1:**

**The following power control mechanisms should be considered:**

* **Open-loop DL power control**
* **Closed-loop DL power control with feedback information from child MT**
* **Closed-loop UL power control with assistance information from child MT**

**Any DL power control mechanism should take into account existing base station design principles related to transmission power.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Do you agree with FL Proposal 5.1?** | **Comments** |
| Qualcomm | Yes | None |
| ZTE, Sanechips | Partially OK to the list. Please see comments. | The 1st PC mechanism (**Open-loop DL power control**) seems to be an implementation issue if it involves no signalling support. The UL TPC in IAB node may also use information coming from the parent to balance the Rx powers in simultaneous DU-Rx/MT-Rx. So we prefer to add:* **Closed-loop UL power control with assistance information from parent DU.**
 |
| Samsung | Yes | We are fine to further discuss power control issues taking into account the FL’s proposal. |
| Huawei | Mostly | Overall, we are a bit sceptical on DL power control, the impact on DL coverage could become an issue. |
| Intel  | Yes | We support the FL proposal.  |
| LG Electronics | Yes |  |
| NTT DOCOMO | Yes |  |
| vivo | Yes |  |