3GPP TSG-RAN WG1 Meeting #100bis-e R1-20xxxxx

e-Meeting, April 20th – 30th, 2020

Agenda Item: 6.2.1.3

Source: Moderator (Ericsson)

Title: Feature lead summary #2 for Multi-TB scheduling for LTE-MTC

Document for: Discussion, Decision

# Introduction

In the Rel-16 work item on “Additional MTC enhancements for LTE” [1], one of the objectives is to specify support for scheduling of multiple DL/UL transport blocks.

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| The objective is to specify the following set of improvements for machine-type communications for BL/CE UEs.  [...]  **Scheduling enhancement:**   * Specify scheduling multiple DL/UL transport blocks with single DCI for SC-PTM and unicast [RAN1, RAN2] |

RAN1 agreements made until RAN1#99 are summarized in [2] and RAN1 agreements made in RAN1#100e are listed below. RAN2 agreements are summarized in [3]. The endorsed L1 configuration parameter list can be found in [4], the initial RAN1 UE feature list in [5], and the endorsed RAN1 CRs in [6] – [16].

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| [**R1-2001056**](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_100_e/Docs/R1-2001056.zip) Feature lead summary for Multi-TB scheduling for LTE-MTC Ericsson  [**R1-2001185**](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_100_e/Docs/R1-2001185.zip) Feature lead summary#2 for Multi-TB scheduling for LTE-MTC Ericsson  [**R1-2001220**](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_100_e/Docs/R1-2001220.zip) Feature lead summary#3 for Multi-TB scheduling for LTE-MTC Ericsson  [100e-LTE-eMTC5-Multi-TB-01] – Johan (Ericsson)  Email discussion/approval onHARQ/NDI/RV/FH encoding for both FDD and TDDby 2/27; if there is a spec impact, followed by endorsing the corresponding TP by 3/2  **Conclusion**  For FDD case:   * For 36.212, use Futurewei’s TP in [R1-2001086](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_100_e/Docs/R1-2001086.zip) as a basis, possibly with the clarification “From MSB to LSB” in each section. * For 36.211 and 36.213, take the provided comments and proposals into account in contributions to the next meeting.   For TDD case:   * There is no consensus in RAN1#100e for optimization (or elimination) of the TDD HARQ process grouping. The 36.212 seems adequate and potential corresponding 36.213 text can be added in the next meeting.   As per email decision posted on Mar. 4th, two companies prefer not to add “From MSB to LSB”, so:  Agreement: The text proposal in [R1-2001086](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_100_e/Docs/R1-2001086.zip) is endorsed for inclusion into TS36.212 editor’s CR.  [100e-LTE-eMTC5-Multi-TB-02] – Johan (Ericsson)  Email discussion/approval onHARQ-ACK bundling for both FDD and TDDby 2/27; if there is a spec impact, followed by endorsing the corresponding TP by 3/2  As per email decision posted on Mar. 5th,:  Agreement: The TP provided in [R1-2001214](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_100_e/Docs/R1-2001214.zip) for TS36.213 section 10.2 is endorsed. To be included as part of the editor’s CR for TS36.213.  [100e-LTE-eMTC5-Multi-TB-03] – Johan (Ericsson)  Email discussion/approval onscheduling gaps for both unicast and multicastby 2/27; if there is a spec impact, followed by endorsing the corresponding TP by 3/2  **Conclusion**  For the unicast case   * There is no consensus in RAN1#100e for the proposal to specify explicit unicast scheduling gaps. * Since unicast scheduling gaps are included in the draft RAN1 UE feature list, there may be a need to update the feature list, and this is something that can be brought up in the email discussion for the feature list.   For the multicast case   * There is no consensus in RAN1#100e for the proposal to insert the scheduling gaps before each TB instead of after each TB. |

This document provides a prioritized list of issues and proposals based on the contributions in [17] – [23].

# Issue #5: TDD HARQ-ACK bundling mechanism

ZTE’s contribution [18] proposes that the TDD HARQ-ACK bundling should be based on legacy TDD bundling mechanism, whereas Qualcomm’s contribution [20] proposes to disallow bundling spanning different multi-TB PDSCHs (see Section 2.3.3 in ZTE’s contribution and Issue #3 in Qualcomm’s contribution for further discussion).

Proposal 5-1: Discuss and decide on potential changes to allow TDD HARQ-ACK bundling.

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| **Company** | **Comments on Proposal 5-1** |
| Qualcomm | In the TP that was agreed in RAN1 100-e (and endorsed in clause 10.2 of the latest version of the specification -g10), **HARQ-ACK bundling „within the TBs of a multi-TB transmission“ was enabled for TDD**—in a similar manner to the FDD agreements.  However, the „TDD-specific“ bundling (what exist today when number of repetitions is 1) is more complex for this setup—e.g., interpreting DAI fields, etc. There were no agreements made on how to address this type of bundling for multi-TB scheduling in RAN1 100-e.  Since with the current „within one multi-TB transmission“ bundling, we are already recovering the throughput loss vis-a-vis not doing „any bundling“, we propose to **disable TDD-specific bundling—much like what is done for legacy single-TB scheduling when the number of repetitions is greater than 1**.  Our **TPs in Section 3 of** [**R1-2002174**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2002174.zip) **implement such a disabling**—by essentially constraining valid scheduling to the case that **in any given ACK-ing opportunity, the UE shall not expect multiple multi-TB transmissions corresponding to which it must send an ACK**. Such scheduling **eliminates bundling „across different multi-TB transmissions“**, while still retaining the throughput benefits from bundling via the „within one multi-TB transmission“ bundling.  As a result, we propose to **endorse the** **TPs 5, 6 and 7 in Section 3 of [R1-2002174](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2002174.zip).**  ***Response to ZTE’s comment on our approved TP in RAN1 100-e:***  *We are not sure we fully understand the concern. The way the approved TP is written, there is never the scope for one bundle’s ACKs starting before the previous bundle’s ACKs have completely finished. Since the maximum bundle size is 4, we do not see how more than 4 TBs can get ACK-ed in any given subframe.*  *Please note that* ***the TP doesn’t have any correspondence to the „legacy k-table“*** *with regards to deciding which subframes need to be ACK-ed at subframe n. As a result****, there is no mention of „k“ for multi-TB TDD timeline determination****. By removing the dependence on „k“, the timeline for ACKs essentially becomes* *sequential—i.e., bundle-by-bundle, at the earliest transmission opportunity* ***when the last bundle’s ACKs (max bundlesize 4) have completely finished and the current bundle is ready for ACK-ing****.*  *Please let us know if we are missing something.* |
| Ericsson | We are fine with Qualcomm’s approach in principle. If the approach can be agreed in principle, we will in the next step take a closer look at the TPs in Section 3 in Qualcomm’s contribution [R1-2002174](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2002174.zip). |
| ZTE,Sanechips | First of all, we think we should not change the legacy TDD HARQ timing. The legacy HARQ-ACK timing is carefully chosen for each UL DL configuration so for bundled/multiplexed TBs are evenly distributed to each UL feedback resource. It's no longer the case with the new change.  To reuse legacy TDD bundling/multiplexing (if supported) mechanism, the only changes required is "the UE is not expected to receive more than one set of multiple PDSCH transmissions scheduled by a single DCI, or one or more set of multiple PDSCHs scheduled by a single DCI and an MPDCCH indicating downlink SPS releases"  The above bundling/multiplexing mechanism should be supported with legacy TDD timing (before the TP change last meeting). |
| Ericsson 2 | It would be good to hear some future comments from Qualcomm on e.g. the uneven distribution to UL subframes that ZTE claims we have with the TDD timing agreed in RAN1#100e. |
| Qualcomm 2 | 1. First, we would like to re-iterate that for legacy single-TB scheduling, for eMTC, TDD bundling **is only enabled for the single-repetition case**. So the only „potential suboptimality“ with respect to legacy TDD behavior is only relevant for the single-repetition case 2. Second, we must keep in mind the **„starting point“** of this discussion in RAN1#100e, when before the throughput issue was raised, the opinion was going towards not supporting „any“ bundling for TDD (ZTE’s inputs pasted below). We provided a TP with a simple solution such that severe throughput losses are not incurred, and it was agreed, and subsequently adopted in the specification.   **TDD case:**  Ericsson’s contribution [R1-2001055](https://can01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fprotect2.fireeye.com%2Fv1%2Furl%3Fk%3D2de1ecf6-7135e007-2de1ac6d-864685b2085c-f2b5a911b542215d%26q%3D1%26e%3D46fc0a41-68e3-4044-9e71-2e022412242f%26u%3Dhttps%253A%252F%252Fnam11.safelinks.protection.outlook.com%252F%253Furl%253Dhttp%25253A%25252F%25252Fwww.3gpp.org%25252Fftp%25252FTSG_RAN%25252FWG1_RL1%25252FTSGR1_100_e%25252FDocs%25252FR1-2001055.zip%2526data%253D02%25257C01%25257Cbrian.classon%252540FUTUREWEI.COM%25257Cbf6dde1e6c744ef6222008d7bb7ae71d%25257C0fee8ff2a3b240189c753a1d5591fedc%25257C1%25257C1%25257C637184008877586967%2526sdata%253D%25252B2IdNWTHMhv2P5vZXIC1z0eZjfLTBvTjlHMleOKgCZk%25253D%2526reserved%253D0&data=02%7C01%7Cgvos%40SIERRAWIRELESS.COM%7C28cf22efbec84d79fe4008d7bba651d4%7C08059a4c248643dd89e33a747e0dcbe8%7C1%7C0%7C637184195335846194&sdata=Y6CAdZDhS0YqqDSjKlKP8lBGSpEAlqQgwve5oqE9NcU%3D&reserved=0) notes that the HARQ-ACK timing is missing for both the bundling and non-bundling case and proposes to not support bundling in TDD. Before a TP for HARQ-ACK timing in TDD is produced, it is good to clarify whether bundling needs to be supported in TDD.   |  |  | | --- | --- | | **Company** | **Comments** | | ZTE/Sanechips | We agree NOT to support bundling in TDD (very complex, no evident benefit) |  1. Third, in many ways, the TP (we should really refer to it as specs) actually provides a **significant advantage to multi-TB scheduling when the number of repetitions is greater than 1**. With legacy procedures, we could not do bundling when the number of repetitions is greater than 1; with the current specs, „within“ a multi-TB block, we can do bundling irrespective of the number of repetitions. 2. **(Trying to address ZTE’s „current“ concern):** The only „limitation“ for the single repetition case with multi-TB scheduling may potentially be due to the maximum bundle size.    1. „Fundamentally“, most (if not all) the legacy TDD configurations for the single-repetition case can be realized with the appropriate „bundling sizes“ for the TBs in a multi-TB block. We are not sure of how much (if any) real-world benefit will result from allowing (only for TDD configs where this issue may be relevant) a larger bundlesize than 4. 3. **(Concerns with „legacy behavior“):** We don’t think it is straightforward to just say „legacy behavior“ is followed for multi-TB TDD. For instance, unlike legacy single-TB scheduling, how to interpret the DAI field, is entirely non-trivial. As you will see in our solutions, this complication is avoided, by restricting bundling „across sets“, and essentially setting the DAI field to „reserved“.    1. Perhaps, such issues were what originally motivated people to not support any bundling for TDD at all, at the cost of suffering a complete loss of throughput from bundling. 4. We have to keep in mind that what ZTE is proposing now would require reverting an endorsed specification. In RAN1#100e, as well as now, we don’t see an alternate solution that solves all the issues that may arise—e.g., issues related to the DAI field. 5. We always remain open to further inputs from all companies. |
| LG | We have similar view with Ericsson. Qualcomm’s proposal seems fine in principle, and TP in Qualcomm’s contribution can be a starting point of discussion. |
| Moderator (Ericsson) | Based on the comments provided above, perhaps the following can be considered:   * Use the TPs in Section 3 in Qualcomm’s contribution [R1-2002174](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2002174.zip) as the starting point for 36.212/36.213 TPs addressing this issue. |
| ZTE,Sanechips 2 | First of all, for the TDD timing TP(R1-2001214) approved last meeting, there could be problem when bundling is disabled. For example, the UE configured with multiple TB, but receives DCIs for scheduling of single TB, if bundling is not enabled, there will be uplink feedback collision issue.  For the TP in R1-2002174, there are two potential problem:  **1. :**    -    if the UE is configured with multi-TB-DL-config, and multiple TBs are scheduled by a single DCI  -    the UE is not expected to receive more than one set of multiple PDSCH transmissions scheduled by a single DCI, or one or more set of multiple PDSCHs scheduled by a single DCI and an MPDCCH indicating downlink SPS releases, corresponding to which the UE shall report HARQ-ACK in the same BL/CE UL subframe(s) according to subclause 10.2.  ....  For UE falls into the above "if" category, if the UE receives one DCI schedules multiples TBs and one DCI schedule one TB, there will be a problem, as shown in the figure below (showing UE receive one DCI schedule 2TB and one DCI schedule 1 TB):    At least we need to make the following change "-    the UE is not expected to receive more than one set of multiple PDSCH transmission(s) "  2. For UE falls into the 'else if'' category below:   else if, the UE is configured with csi-NumRepetitionCE equal to 1 and mPDCCH-NumRepetition equal to 1,  If the UE is configured with multiple TB, but schedule with one DCI for signle TB, it will fall into this 'else if' branch. However, if these UEs are not configured with bundling, feedback collision problem will happen. |
| Qualcomm 3 | Many thanks for the comments on the TDD case. Let me try to address some of these inline below.  For the TP in R1-2002174, there are two potential problem:  **1. :**    -    if the UE is configured with multi-TB-DL-config, and multiple TBs are scheduled by a single DCI  -    the UE is not expected to receive more than one set of multiple PDSCH transmissions scheduled by a single DCI, or one or more set of multiple PDSCHs scheduled by a single DCI and an MPDCCH indicating downlink SPS releases, corresponding to which the UE shall report HARQ-ACK in the same BL/CE UL subframe(s) according to subclause 10.2.  ....  For UE falls into the above "if" category, if the UE receives one DCI schedules multiples TBs and one DCI schedule one TB, there will be a problem, as shown in the figure below (showing UE receive one DCI schedule 2TB and one DCI schedule 1 TB):    At least we need to make the following change  "-    the UE is not expected to receive more than one set of multiple PDSCH transmission(s) "  [Qualcomm:] Many thanks for pointing out this case. This case can be clarified better. The phrase “more than one set of multiple PDSCH transmissions scheduled by a single DCI” can be replaced by “more than one set of PDSCH transmission(s) scheduled by a single DCI” to cover cases wherein, anytime we are dealing with a block of multiple TBs scheduled by a DCI (anchor of the “if clause”), it should not have ACK collisions with “any other PDSCH”.  2. For UE falls into the 'else if'' category below:   else if, the UE is configured with csi-NumRepetitionCE equal to 1 and mPDCCH-NumRepetition equal to 1,  If the UE is configured with multiple TB, but schedule with one DCI for signle TB, it will fall into this 'else if' branch. However, if these UEs are not configured with bundling, feedback collision problem will happen.  [Qualcomm:] We are not quite sure what you mean by “if these UEs are not configured with bundling”. For this case, legacy TDD behavior will hold (i.e., TDD-specific bundling). As long as there is no collision with a “multi-TB DCI that schedules multiple TBs”—which should be taken care of by the “if” branch above—there should be no issue. |
| ZTE,Sanechips 3 | Based on the timing TP last meeting , these UE will follow legacy TDD behavior. However, because these are also multi-TB scheduling UE, their bundling still follow the Rel-16 parameter, if the bundling is disabled, then it's not clear for us how to decide the ul feedback subframe.Note we are talking about "else if" brach, which is parallel to the "if" branch. Any restriction added in the "if " branch will not function here. |
| Qualcomm 4 | The „else if“ branch only concerns those cases of multi-TB DCI where the number of TBs scheduled by the multi-TB DCI is 1 (the „if“ branch deals with the case when multiple TBs are scheduled by the multi-TB DCI). As a result, the „within multi-TB block“ bundling that was agreed in the last meeting is not relevant in this branch. Such „within multi-TB block“ bundling (per last meeting’s TP) is only relevant when the multi-TB DCI schedules multiple (more than 1) TBs.  Also, to avoid any confusion, we wish to re-iterate that the TP for TDD timing from last meeting only applies when multiple TBs are scheduled by a multi-TB DCI:  „For TDD, if a BL/CE UE is configured with higher layer parameter *multi-TB-DL-config* and multiple TBs are scheduled in the corresponding DCI, the BL/CE UE shall upon detection of a PDSCH intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response using the same  derived according to Subclause 10.1.3.1 in subframe(s) *+ki* with , *i =0,1, …, N-1*, where...“  So, for the „else-if“ part, the timeline equation in last meeting’s TP for the timeline does not apply. |
| ZTE,Sanchips | Thanks for the clarificaiton.  Now I see in your proposal the new rel-16 UE configured for mulitple-TB but with DCI only schedule single TB , will follow legacy timing.  But the question I have is : For rel-16 UE with multi-TB enabled, we will have mixed single TB and multi-TB scheduling, for example first DCI schedules 1TB, second DCI schedules 2TB, 3rd DCI schdules. Then you have two timing schemes interlacing together. This is not a problem for the new timing , but for the legacy timing, there could be problems, since the legacy feedback subframe maybe occupied by the new timing feedback already. Can you please clarify this ? Thanks |
| Qualcomm 5 | Thanks for the above question. Let us try to clarify below:  The case you raise is what the „if part“ aims to protect against (modified, with inputs from you). Since the „if part“ deals with „every“ „greater than 1 TB“ scheduling instance that will be encountered, the base station scheduling shall make sure that „none“ of these „greater than 1 TB“-scheudling DCIs have an ACK collision with „any other PDSCH“—including a single-TB PDSCH that follows legacy timing.  To make things clearer, let me try to rephrase the „if condition“ a bit differently below. Here, I try to make an explicit reference to „the“ multiple TBs scheduled by a single DCI within the if condition—which, since it applies to „every“ such occurence, prevents these ACKs from colliding with „any other ACK“, including legacy timing-based PDSCH.  Let me know if this resolves any remaining confusion.  (Others are also encouraged to verify this)  **<TP5\_updated, 36.213, 7.3.2>**  **<unchanged parts omitted>**  For TDD and a BL/CE UE,  - if the UE is configured with *multi-TB-DL-config*, and multiple TBs are scheduled by a single DCI  - the UE is not expected to receive any other PDSCH transmission(s) or MPDCCH indicating downlink SPS releases, corresponding to which the UE shall report HARQ-ACK in any BL/CE UL subframe(s) in which HARQ-ACKs are reported for the multiple TBs scheduled by the single DCI, according to subclause 10.2  **<rest is same as before>**  **</TP5\_updated, 36.213, 7.3.2>** |
| ZTE,Sanechips | Thanks a lot for the clarification.  We have another comment regarding the bundling: The proposal seems to indicate for Rel-16 configured with multiple TB, if the DCI schedules multiple TBs then the UE follows the new precedure; if the DCI schedules singel TB, it follows legacy behavior, including bundling. It seems that the latter need more considerations.  Note these are new rel-16 UEs, they are configured with the rel16 bundling parameter. If you want them to follow bundling behavior that legacy parameter indicates, I think we need new paramters for this (legacy bundling), and some text in the specification to describe this behavior.  Note for legacy UE the bundling could be disabled and multiplexing is enabled, but in rel-16 we just conclude that multiplexing is not support, so we also need text to describe how to handle this .  In term of complexity all these involve, is it better to let these type of UE(configured with multi-TB but DCI schedules singel TB) also go into the 'if' branch? thanks |
| Qualcomm 6 | We believe that when single-TB is scheduled, legacy behavior can be followed without any issue. This includes TDD-specific bundling/multiplexing, which is dictated by a separate TDD-specific higher layer parameter (*tdd-AckNackFeedbackMode*)—none of which have been changed/repurposed. We don’t think any new parameters are required.  We don’t think it is a good idea to restrict the single-TB case to the if-branch: this is because, this may lead to single-TB scheduled by a legacy DCI have a different (marginally better for some TDD configurations) performance than a single TB scheduled by a multi-TB DCI.  As far as we can tell, with the latest TP, there is no issue or no other configurations/specifications needed.  Everyone: please let me know if I am missing something—e.g., some specific parameter, a specific configuration/IE, etc. |

# References

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2. [R1-2001427](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_100_e/Docs/R1-2001427.zip), Corrections for 36.211
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