**3GPP TSG RAN WG1 Meeting #100bis-E R1-200xxxx**

**e-Meeting, April 20th – 30th, 2020**

**Source: Moderator (Intel Corporation)**

**Title: Email Discussion #3 [100b-e-NR-5G\_V2X\_NRSL-Mode-2-03]**

**Agenda item: 7.2.4.2.2**

**Document for:** **Discussion and Decision**

Introduction

This document provides discussion on issues in the third email discussion on V2X Mode-2 during RAN1#100bis-e.

[100b-e-NR-5G\_V2X\_NRSL-Mode-2-03] Email discussion/approval w.r.t. step2 including aspects:

* Whether to support HARQ retransmissions on unreserved resources
* Early in time initial resource selection
* Relation of selected number of resources and signalled number of resources, including number of outstanding reservations

till 4/27, with potential TPs till 4/30 (Intel, Sergey)

Discussion

The first aspect “Whether to support HARQ retransmissions on unreserved resources” has been touched in the last meeting in the context of maximum timing restriction between selected resources. There was no conclusion. This time, a more general question is asked first, and the solution to it, if needed, is expected to be decided right after a consensus.

From the contributions, the following options with respect to reserved/unreserved HARQ retransmissions are discussed:

* Allow unreserved HARQ retransmissions and do not introduce any condition/restriction to do that. Some companies think this is undesirable, and confirm it by evaluation results [13][27].
* Allow unreserved HARQ retransmissions if resource selection does not provide resources which can be signalled in one SCI, without changes to resource selection procedure. Some companies think this is undesirable, and confirm it by evaluation results [13][27].
  + When reservation of HARQ retransmission resources is not possible, there are two options:
    - Stop HARQ retransmissions
    - Continue HARQ retransmissions on unreserved resources. [8] shows that continuation is better than dropping in this case.
* Do not allow unreserved HARQ retransmissions, but introduce exceptions due to events external to the resource selection procedure, i.e. dropping due to prioritization after Uu-SL competition or congestion control
  + If this option is formulated using resource selection terms, then the dropping due to prioritization after Uu-SL competition or congestion control is automatically accounted. The pre-emption event may need to be discussed separately, subject to the outcome of Mode2-02 discussion.
  + If this option is formulated using signalling/reservation terms, then the dropping due to prioritization after Uu-SL competition or congestion control should be explicitly listed as an exception. The pre-emption event may need to be discussed separately, subject to the outcome of Mode2-02 discussion.

**Q1: Which of the following options related to HARQ retransmission resource reservation is preferred? General support can be expressed, while the detailed proposal can be worked out in the second phase.**

* Option 1: Support/allow unreserved HARQ retransmissions
  + Option 1a: Completely up to UE implementation to do that.
  + Option 1b: Only when resource selection does not provide resources which can be signalled in one SCI (without changes to the resource selection procedure)
* Option 2: Do not allow unreserved HARQ retransmissions
  + Option 2a: capture this in terms of Step 2 resource selection restriction as a maximum allowed logical slot distance, so that at least two resources can be signalled in one SCI
  + Option 2b: capture this as a signalling restriction, without direct impact on resource selection. At least Uu-SL competition and congestion control are exceptions to this
* Option 3: Configure between allowed / not allowed
  + One option was proposed in the last meeting

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| Source | Option | Comment |  |
| Ericsson | See comments | None of the alternatives is good.  We think that a UE should make use of reservations whenever the signalling allows for it (e.g., 32 slots) and always make use of reserved resources (except if HARQ-ACK is received). However, preventing “unreserved HARQ retransmissions” altogether does not sound reasonable. There are many cases in which the UE may need to transmit on unreserved resources. Capturing the exceptions in a list may be hard. The following proposal is a way of capturing these points.  **Proposal**:   * The UE indicates max(Nselected, Nmax) resources when setting the values of frequency resource assignment and time resource assignment in SCI format 0\_1, where Nselected is the number of outstanding resources selected by MAC within 32 slots (including the current one). * The UE does not transmit a TB on unreserved resources if it has one or more reservations for transmission for that TB.   We do not think that this issue can be solved with a restriction on the slot distance (2a). |  |
| Intel | Option 2a | In case of re-evaluation in order to meet signalling window constraints (chain integrity):   1. UE can check if there are appropriate resources in candidate set and pick one 2. UE can ignore re-evaluation result and transmit if there is no available candidate resource satisfying chain integrity condition |  |
| Panasonic | Similar to Option 2a | (Re-)transmission of a TB should be reserved by a prior SCI unless some exceptions (pre-emption, Uu-SL priority competition, congestion control, etc.).  For option 2a, just to limit logical slot distance would not be sufficient in order not to allow unreserved HARQ retransmissions as frequency domain also needs to be restricted |  |
| NTT DOCOMO | Option 2a | Support Option 2. Capturing appropriate exceptions may be hard in 2b. |  |
| vivo | Option 2a-like | Agree with Panasonic. | vivo |
| Xiaomi | Option 1 | Can add constraints that only allow when UE does not have reserved resource to transmit. |  |
| NEC | Option 2a | Option 2a could reserve at least 2 resources in one SCI for retransmission. |  |
| TCL | Option 1 | Restricted to cases without other reserved resource to transmit (not necessarily for the same TB) |  |
| Qualcomm | Option 2 | The reservation mechanism reduces resource collisions in the system. Allowing a UE to transmit on unreserved resources degrades the performance of other UEs in the system and should be avoided. |  |
| Huawei/HiSilicon | Option 1a | There can be many cases that the UE needs to perform unreserved HARQ retransmissions. If this is not allowed, then many packets may have to be dropped.  And considering HARQ retransmission happens with small probability, allowing unreserved HARQ retransmission is beneficial in terms of congestion avoidance since the UE may need to retransmit only when NACK is received in feedback-based transmission.  Option 1a is most flexible and offers the above benefits, and thus preferred.  For Option 2a, it might be possible that UE can not find such resources.  For Option 2b, we think it might be hard to capture all the exceptions. |  |
| CATT | Option 2a | The maximum allowed logical slot distance should be restricted for the resource selection scheme. If the transmissions on the unreserved resources is allowed, the resource collisions will be increased to degrade the system performance.  Though the chain may be broken with pre-emption, UL-SL-pre-emption, and congestion control, the HARQ retransmission resources should be transmitted on the reserved resources as much as possible if the chain integrity can be recovered. |  |
| ZTE, Sanechips | Option 1b | Prohibiting unreserved HARQ retransmissions means that subsequent retransmissions of a TB are interrupted when resource selection does not provide resources which can be signalled in one SCI. In our SLS simulation (TDoc 1896), this will degrade PRR performance. |  |

The second aspect is related to the first one, and intends to cover UE behaviour to signal resources in SCI depending on configured Nmax, the number of intended retransmissions M, etc. The following points have been identified from contributions:

* What is UE signalling behaviour for resources t0, t1, …tM-1 for a given configured Nmax value
  + For example, if Nmax = 2, whether UE signals first {t0, t1}, then {t1, t2}, then {t2, t3}, …, {tM-2, tM-1}, and finally {tM-1}, subject to the aspects of reserved/unreserved HARQ retransmissions in Q1
  + For example, if Nmax = 3, whether UE signals first {t0, t1, t2}, then {t1, t2, t3}, then {t2, t3, t4}, …, {tM-3, tM-2, tM-1}, then {tM-2, tM-1}, and finally {tM-1} etc., subject to the aspects of reserved/unreserved HARQ retransmissions in Q1
  + Whether a UE maximizes the number of signalled resources subject to configured Nmax
* How many unused resources can be allowed for FB-based retransmissions?
  + E.g. even if Nmax=3, whether a UE only reserves N=2, so that only one resource is at most left unreserved
* Number of outstanding reservations
  + Similar to the first bullet, current specification may allow reservation in the following un-ordered manner: {t0, t1, t2}, {t1, t3, t4}, {t3, t5, t6} etc. Whether it needs to be disallowed or not. In FL understanding, if the firs bullet aspect is resolved, this aspect is also automatically resolved

**Q2: Whether to support maximization of signaled number of resources in one SCI subject to configured Nmax value. General support can be expressed, while the detailed proposal can be worked out in the second phase.**

* Option 1: Support maximization of signaled number of resources in one SCI subject to configured Nmax value and logical slot distance between resources after the resource selection
  + Subject to fulfilled logical distance condition of 32 slots, the sequence of SCI signaling in different time instances for resources t0, t1, …tM-1 where M is the number of intended (re-)transmissions, can look like
    - N = 2: {t0, t1}, {t1, t2}, {t2, t3}, … {tM-2, tM-1}, {tM-1}
    - N = 3: {t0, t1, t2}, {t1, t2}, {t2, t3, t4}, …, {tM-3, tM-2, tM-1}, {tM-2, tM-1}, {tM-1}
      * here t1 and t3 are not within 32 slots, and thus {t1, t2} signals two resources
* Option 2: Leave the number of signalled resources up to UE implementation w/o any restriction

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| Source | Option | Comment |  |
| Ericsson | 1 |  |  |
| Intel | Option 1 | We think the following UE behavior should be supported   * Case 1: Two resources dynamically signalled by SCI (NMAX ≤ 3):   + If any given SCI reserves one future resource - R1, the next SCI transmission, associated with the same resource selection process, should occur in the reserved resource - R1, subject to congestion control, in-device coexistence, HARQ feedback conditions * Case 2: Three resources dynamically signalled by SCI (NMAX = 3):   + If any given SCI reserves two future resources R1 and R2, the next SCI transmission, associated with the same resource selection process, should occur in the first in time reserved resource - R1, indicate the second reserved resource – R2 and possibly new resource reservation - R3 following the second reserved resource – R2, subject to congestion control, in-device coexistence, HARQ feedback conditions   Number of resources signaled by each SCI is up to UE implementation, subject to Nmax configuration |  |
| Panasonic | Option 1 | To maximize the benefit of the reservation of Nmax resources |  |
| NTT DOCOMO | Option 1 | Agree with Panasonic. |  |
| vivo | Option 1 |  |  |
| Xiaomi | Option 1 | If N=3, it is not clear whether it is allowed to signal resources which is not the nearest in time domain. For example, {t0, t1, t2}, {t1, t3, t4}, …, assuming that t1 and t4 are within 32 slots. Earlier signaling may be helpful for resource reservation purpose. |  |
| NEC | Option 2, option 1 is also acceptable | We slightly also want:  N = 3: {t0, t1}, {t1, t2}, {t2, t3}, … {tM-2, tM-1}, {tM-1}, even t1 and t3 are within 32 slots |  |
| TCL | Option 1 | Maximizing the number of signaled resource at once is of course important: if N=3 and there are 3 resources selected within 32slots (including currently transmitted), the SCI must signal the 3 reservation.  Agree with Xiaomi: need to decide whether to support only consecutive signaling or outstanding reservations is also possible. |  |
| Qualcomm | Option 1 | Option 1 allows indication of reservations as early as possible to other UEs in the system. |  |
| Huawei/HiSilicon | Option 2 | The number of signalled resource can be up to UE implementation.  Option 1 seems to be too optimistic that the UE can always find resources as shown in the pattern in Option 1. For example, if the UE only signals 1 or 2 resources, as Option 1 does, then it is possible that later on the resources are reserved by many other UEs and the UE fails to find resources, thus causing dropping of the packet.  Option 2 gives UE flexibility of signalling resources. For example, UE can decide the number of the signalled resource by the maximum number of the transmission allowed by one TB. If currently the resources are only reserved by a few UEs, the UE can choose to signal more resources to guarantee the successful delivery of the packet, and avoid the “cannot find resource later on” issue as explained above. |  |
| CATT | Slightly prefer Option 2 | From our understanding, N should be respect the configuration of Nmax. For example, N= min{Ntx, Nmax}, where Ntx is the number of retransmission for a TB. The timing restriction of W (32 slots) should be maintained within N transmissions. The flexibility of N = 2 or 3 for N=Nmax is unnecessary.  Otherwise, we think it could be left for UE implementation. |  |
| ZTE, Sanechips | Option 1 | Support maximization of signaled number of resources in one SCI, and un-ordered reservation is not supported. |  |

The third aspect relates to so called “Early in time initial resource selection”. Companies, discussing this issue, argue that the initial resource should be selected as close as possible to the resource (re-)selection trigger. This may allow lower latency access to channel, earlier reservation announcement, and in some cases more HARQ retransmissions. Some companies show SLS results of latency and/or PRR benefits [13][27].

**Q3: Whether the initial resource can be selected in random non-uniform manner by prioritization of earlier candidate resources? General support can be expressed, while the detailed proposal can be worked out in the second phase.**

* Option 1
  + Do not support modifications to Step 2 resource selection that provide earlier in time initial resource selection
* Option 2
  + Support a modification to Step 2 resource selection that provides earlier in time initial resource selection
    - Option 2a: by picking the earliest identified resource after Step 1
    - Option 2b: by picking one resource from M\_earliest identified resources after Step 1. M\_earliest can be a 1/M part of the total identified resource set, where M is the intended number of retransmissions
    - Option 2c: by introducing a separate resource selection window for the initial resource with reduced maximum length

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| Source | Option | Comment |  |
| Ericsson | Option 2c | Feature and window size can be configurable. |  |
| Intel | Option 2 | Prefer Option 2b for implementation. Evaluation results have shown stable and improved system performance with reduced latency. |  |
| Panasonic | Similar to Option 2b | We support that the earlier resources should be more prioritized. We think more weightage should be given to the earlier resources with randomization considered, instead of limiting to single resource (as in Option 2a).  We also think that the later resource should able be selected with lower weightage (as a modified Option 2b). |  |
| NTT DOCOMO | 2a | Support Option 2. In 2c, a resource with bad condition can be selected as candidate resource set due to narrower resource selection window. |  |
| vivo | Option 1 | We are not sure about the benefit of the so-called early in time selection in current situation. Since UE will select all resource for potential retransmission of a TB in one resource selection procedure, UE can decide the exact timing of each selected resource, this is totally up to UE implementation.  In our understanding, early in time selection maybe helpful if HARQ feedback can trigger resource selection. Then, for a given TB multiple resource selection process can be triggered, of course, the initial transmission is better at beginning of the PDB. |  |
| Xiaomi | Option 1 | The first selected resource may not be the first resource transmitted in time domain. Do not see the benefit of the modification |  |
| NEC | Option 1 | Latency requirement has already been taken into consideration in the selection window determination and we are not sure whether there will be collision/ congestion issue when all the UE want to do transmission as early as possible. |  |
| TCL | Option 1/2c | Too much restriction on the first transmission, which is unannounced, will increase collisions and missed initial reservation chains. |  |
| Qualcomm | Option 2 | We prefer Option 2c or Option 2a, but any of the proposals in Option 2 will achieve the goal of reducing system latency. We also observed performance gains. |  |
| Huawei/HiSilicon | Option 1 | Random selection is a good way to avoid collision among different UEs.  Option 2a/2b/2c narrows the selection set, i.e., different UEs will select resource in a smaller set, and will cause more collision. |  |
| CATT | Option 2c | In step2, the resource selection window can be divided into several sub-windows in time domain with equal size according to the number of resources (N) selected for one TB. The initial transmission can **randomly select the candidate resources in the first sub-window [T1, T1+(T2-T1)/N]** shown below, where the yellow blocks represent candidate resources.  We suggest to modify 2c as follows:  *Option 2c: by picking one resource randomly from the candidate resources in the sub-window [T1, T1+(T2-T1)/N], where N refers to the total number of resources selected for one TB.*  Regarding option 2a, selecting the earliest resource has not sufficient randomness.  The performance of option 2b in reducing latency would degrade when most candidate resources distribute in the rear part of the selection window. For example, when the selection window size > 32, many candidate resources would drop into the rear sub-window [31, T2], which is discussed in reference [3] [15] [27].  Option 2c provides more randomness than option 2a, and selects the early resource in time domain irrespective of distribution of the candidate resources comparing to 2b. |  |
| ZTE, Sanechips | Option 1 | It is suggested that only randomized resource selection is supported. How to realize random resource selection is up to UE implementation.  We also concern about the wording in Option 1, which seems to say that, without any modification, the step2 procedure currently already provides earlier in time initial resource selection. |  |

Summary of proposals on the relevant issues

Although Step 2 was discussed last meeting, there are still remaining issues identified as follows:

1. Whether to support HARQ retransmissions on unreserved resources
   * Allowed w/o conditions: [19]
   * Allowed if chain is broken: [8][16]
     + Note: [8] shows results that HARQ process dropping is worse than unreserved retransmissions
   * Not allowed with exceptions
     + Formulated using HARQ retransmissions: [4][10][24][27]
     + Formulated using resource selection: [5][6][13][15][21]
     + Note: [13] and [27] show results in support if it
2. Early in time initial resource selection
   * [3][13][15][24][27]
     + Note: [13] and [27] show results in support if it
3. Relation of selected number of resources and signalled number of resources, including number of outstanding reservations
   * [6][13][17][21][23]

References

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