**3GPP TSG RAN WG1 #105-e R1-2106030**

**e-Meeting, May 10 –27, 2021**

**Source: Moderator (OPPO)**

**Title: FL summary for AI 8.11.1.1 – resource allocation for power saving (before 1st check point)**

**Agenda item: 8.11.1.1**

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

Introduction

In the latest version of Rel-17 WID for NR sidelink enhancement [1], the objective for enhancing RA to reduce UE power consumption in mode 2 is captured as followed.

|  |
| --- |
| 2. Resource allocation enhancement:* Specify resource allocation to reduce power consumption of the UEs [RAN1, RAN2]
	+ Baseline is to introduce the principle of Rel-14 LTE sidelink random resource selection and partial sensing to Rel-16 NR sidelink resource allocation mode 2.
	+ Note: Taking Rel-14 as the baseline does not preclude introducing a new solution to reduce power consumption for the cases where the baseline cannot work properly.
	+ This work should consider the impact of sidelink DRX, if any.
 |

This contribution provides a summary of the submitted contributions, email discussion topics and outcomes during RAN1#105-e meeting. Note that, all past outcomes including agreements, conclusions and working assumptions reached during this WI are captured in Section 5 (5 Appendix) of this summary document.

Collection of agreements / conclusion in RAN1#105-e

To be collected once agreement is reached.

Topics for email discussion

[105-e-NR-R17-Sidelink-01] Email discussion regarding resource allocation for power saving – Kevin (OPPO)

* 1st check point: 5/21
* 2nd check point: 5/25
* Final check: 5/27

## Topic #1: Periodic-based partial sensing – Preserve, k value and sensing occasions to be monitored

**Background**: In RAN1#104b-e, it was agreed to do down-selection of alternatives during this meeting to decide the set of *P*reserve values and the k value for the periodic-based partial sensing according to the following.

|  |
| --- |
| **Agreements:*** In periodic-based partial sensing,
* For the set of *P*reserve values, down-select to one of the following in RAN1#105-e
	+ - Alt.1: *P*reserve corresponds to all values from the configured set *sl-ResourceReservePeriodList*
		- Alt.2: A set of *P*reserve values is (pre-)configured and includes up to the full set of values from the configured set *sl-ResourceReservePeriodList*
			* FFS if support multiple sets of *P*reserve values based on one or more metrics
			* FFS whether/how to restrict the set of values
* For the k value, down-selection to one of the following in RAN1#105-e (further refinement of each of the alternatives is possible)
	+ - * + Alt 1: Option 1 as in RAN1#104-e
				+ Alt 2: A modified Option 5 as in RAN1#104-e, where the modification is such that it also includes option 1

FFS how to (pre-)configure (e.g. including bitmap), whether a maximum number of k values is needed, and whether it can be up to UE implementation to select a k value based on the (pre-)configuration* + - * + FFS details, e.g., sensing before the resource (re)selection trigger or the first slot of the set of Y candidate slots subject to processing time restriction, etc.
			* Note: companies are encouraged to provide more evaluations
 |

Based on reviewing of Tdocs submitted in this meeting:

* + For the set of *P*reserve values, the main reason for Alt. 1 (full set of *sl-ResourceReservePeriodList*) is to ensure high reliability is maintained by avoiding Tx collision in reserved resources with periodicities that were not monitored by the Tx UE. On the other hand, the main reason for Alt. 2 (a subset of *sl-ResourceReservePeriodList* or multiple sets of *P*reserve values) is to achieve better power saving and provide flexibility at the same time. Some expressed usage of Alt. 2 include:
		- Alt. 2.1: A full set of *sl-ResourceReservePeriodList* is used for high priority transmissions or RP with high measured CBR; A subset/smaller set is used for others;
		- Alt. 2.2: A subset or a common divisor (e.g., 100ms) is used for configured reservation periodicities [100…1000], and combined with a bitmap for k values. Another subset for configured periodicities within [1…99];
		- Alt. 2.3: Only one subset is configured with reservation periodicities that is larger than a threshold (e.g., FFS the threshold periodicity value). For sensing occasions that are smaller than the threshold can be monitored/covered by using contiguous partial sensing.
		- Alt. 2.4: Only one subset is configured containing the mostly used/expected to use reservation periodicities.

Based on submitted simulation results in this meeting, it was shown that additional power saving from monitoring a subset of periodicities is about 10%. The communication range improvement from monitoring the full set is about 16 meters at PRR = 99%. It was also shown that when multiple subsets are configured, the power consumption is comparable to the single/full set case. On the other hand, one company showed that the power saving even with additional power consumption of HARQ re-Tx from monitoring only a subset due to collisions, is 28% less than monitoring the full set.

FL comments:

* + - There is no clear majority of company preference between Alt. 1 and Alt. 2 (16 vs. 20).
		- For schemes such as Alt. 2.2 and 2.3, the power saving UE eventually monitors all reservation periodicities configured in *sl-ResourceReservePeriodList*. Effectively, there is no power saving gain. For Alt. 2.1, when the Tx priority or the CBR is low, there always exists some cases of Tx collision due to non-monitored periodicities, e.g., for UEs with priority less than a threshold and monitor only a subset of periodicities and causing collision/interference to high priority transmissions. For Alt. 2.4, it is unclear how to determine the most commonly used / expected periodicities to be used. If a periodicity is not expected to be used, then likely it won’t be configured in *sl-ResourceReservePeriodList*.
		- Overall, based on submitted simulation results, it is clear some performance degradation can be expected when a subset of periodicities is monitored by the UE, while the power saving gain depends on the amount of periodicity reduction in the subset.
		- **Therefore, Alt. 1 is recommended for the down-selection in Proposal 1-1 below.**
	+ For the k value, the main reasons for supporting Alt. 1 (only the most recent sensing occasion for a given reservation periodicity) are due to it offers most power saving gain, missed detection of SCI is low and almost no PRR difference to the full sensing. On the other hand, the main reasons for supporting Alt. 2 (k is (pre-)configured with multiple values including the most recent sensing occasion as in option 1 from RAN1#104-e) are due to network flexibility of configuring the UE to monitor additional sensing occasions other than the most recent one and better reliability from additional sensing in case of SCI missed detection.

Based on submitted simulation results, better PRR performance is observed from using multiple k values per reservation periodicity by two companies, while one company showed no performance gain from doing so, and one company showed PRR is very close to the full sensing result from monitoring just the most recent sensing occasion per periodicity. In terms of power saving, one company showed it costs 10% more power from sensing one additional k value and another company showed 50% more. The difference in these power saving results may came from how much overlapping between the sensing occasions and the size of the selected Y candidate slots.

FL comments:

* + - There is no clear majority of company preference between Alt. 1 and Alt. 2 for the k value (17 vs. 16).
		- Although it is claimed that Alt.2 offers flexibility of configuring the exact sensing occasions to be monitored by the UE, it is still unclear why such flexibility is needed since the older the sensing occasions are the less relevant the information they contain.
		- According to simulation results, monitoring more sensing occasions will generally offer better PRR performance, but at a cost of higher power consumption for the UE.
		- **Since Alt. 2 is a superset of Alt. 1, it is recommended to down-select to Alt. 2 with up to UE implementation to decide how many k values per reservation periodicity to monitor.**
	+ For the sensing occasions to be monitored by the UE before the resource (re)selection triggering slot n or before the first slot of the set of Y candidate slots subject to processing time restriction for the identification of candidate resource set, it was left to be further studied from the last meeting. From the reviewing the Tdocs submitted to this meeting, the only reason to monitor sensing occasions only before the resource (re)selection trigger slot n was to match with R14 and R16 behaviour, where resource is selected at triggering slot n. This view was supported by two companies. On the other hand, majority of companies (13) expressed that the UE should monitor sensing occasions all the way just before the first slot of the set of Y candidate slots to obtain the latest resource reservation information from the most recent sensing occasions and that all corresponding periodic sensing occasions are taken into account for the initial resource selection to minimize collision probability.

FL comments: In LTE-V2X, the smallest reservation periodicity and PDB were always to be 100ms for P2X traffic. In this case, no matter where the Y candidate subframes are selected within the PDB, the most recent sensing occasions are always before the resource (re)selection trigger slot n. In NR sidelink, however, the most recent sensing occasions could very well fall between the triggering slot n and the set of Y candidate slots since much smaller reservation periodicities are supported. This is particularly true when the SL-DRX ON duration of the receiver UE starts far away from the triggering slot n of the Tx UE such that there is a large gap between the triggering slot and the set of Y slots. In addition, if this gap is larger than 31 slots, which should be the duration for the contiguous partial sensing, then there could be sensing occasions between the triggering slot and the Y slots are not monitored by the contiguous partial sensing. Therefore, it is recommended to go with majority that the UE is to monitor sensing occasions before the first slot of the set of Y candidate slots in periodic-based partial sensing for the identification and reporting of candidate resources to the MAC layer.

### Proposals before 1st check point

**Proposal 1-1:**

* For the set of *P*reserve values in periodic-based partial sensing,
	+ Alt. 1 from RAN1#104b-e is selected, where *P*reserve corresponds to all values from the configured set *sl-ResourceReservePeriodList*.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| NTT DOCOMO | Support.Alt 2 leads to performance degradation, which is against to direction of NR-SL where high reliability is supported. At least one occasion per periodicity should be monitored. |
| Panasonic | We support FL’s proposal.  |
| Intel | In our view, Alt. 2 should be supported as it covers Alt. 1 and does not bring additional complexity to the UE. At the same time, it provides additional power saving benefits w/o noticeable impact on reliability especially for the cases when transmissions with certain periodicity are dominant in the system. Therefore, we think the configured subset of Preserve values should be supported per sidelink resource pool and can be properly configured during system profiling stage. |
| OPPO | Support. |
| Sharp | Support. |
| CMCC | We think that Alt. 2 provides configuration flexibility, which takes both power saving and sensing performance into consideration. Note that Alt. 2 includes Alt. 1which supports up to the full set of values from the configured reservation periods, therefore, we prefer Alt. 2.  |

**Proposal 1-2:**

* For the k value in periodic-based partial sensing,
	+ Alt. 2 from RAN1#104b-e is selected, where k is (pre-)configured, including multiple values and the most recent sensing occasion for a given reservation periodicity
		- It is up to UE implementation to decide one or multiple k values per reservation periodicity and at least the most recent sensing occasion for a given reservation periodicity shall be monitored.
		- Note that the most recent sensing occasion for a given reservation periodicity before the resource (re)selection trigger slot n or the first slot of the set of Y candidate slots subject to processing time restriction may correspond to a k value other than k=1.
		- When the k value corresponds to the most recent sensing occasion for a given reservation periodicity is not k=1, the UE does not monitor a (pre-)configured k value that is smaller than it for that given reservation periodicity.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| NTT DOCOMO | ‘Up to UE implementation’ is not OK.Just configurability (+ most recent occasion) should be fine and UEs shall follow the K value, where regulator can decide which should be prioritized between very high reliability performance and good power saving performance.If the configurability is unacceptable by companies, we are OK with Alt 1 as well.Our preference is:- 1st: Alt 2 (not up to UE implementation)- 2nd: Alt 1 |
| Panasonic | We are ok with alt 2. Further, we wish FL could clarify the “given reservation periodicity” is one period or entire period series, and whether a UE could implement different k values for different periods within a series of periods. For the 1st sub-bullet, we share similar view with DCM that not up to implementation would be better.  |
| Intel | In our opinion defining Alt. 2 in this way is essentially leads to Alt. 1 in practical implementation. In our view periodic-based partial sensing should provide partial sensing and complexity reduction. UEs operating in full sensing mode do not consider multiple preceding occasions for a given transmission period and thus it should not be required for periodic-partial sensing. We see the following drawbacks in supporting multiple k values: 1) increase of UE complexity, 2) increase of UE power consumption 3) implies more specification efforts 4) is not aligned with baseline sensing operation principle. Considering above drawbacks, it is sufficient to support k = 1 only.We support Alt.1 due to reasons provided above.  |
| OPPO | Not support the proposal. In our view, alt.1 is preferred.It is necessary to clarify that the main design target for partial sensing is to reduce power consumption. Alt.2 will result in higher power consumption compared to alt. 1. And from our simulation results, it shows that the PRR performance of Alt1 is almost the same as full sensing. Although some results show better PRR performance for alt 2, it is at the cost of higher power consumption which conflicts with the design target for power saving mechanism. Therefore, we prefer Alt 1 which has similar performance as full sensing and can reduce more power than Alt 2.On the other hand, if partial sensing with alt 2 can provide better PRR performance and less power consumption compared to full sensing, do we need to do similar optimization for full sensing, such as UE needs to monitor more periodicities for full sensing to improve PRR performance further. Otherwise, that will confuse the producer or chip vendor why full sensing is needed if partial sensing has better PRR and power consumption benefit?Furthermore, when we discuss period-based partial sensing, UE needs to sense the slots $t\_{y-k\*P\_{reserve}}$, the assumption is that the triggering slot n is predicable, such as based on the periodicity of the data packet. While there are some other conditions defined in RAN2 (section 5.22.1.2 in TS38.321) which can trigger L1 to perform resource (re)selection. The triggering timing of most of trigger conditions is not predicable. In that case, it is hardly for the UE to pre-select Y slots and performs period-based partial sensing in advance. Therefore, we suggest to add a note as follows:* Note: this is applied to the case when slot n is predicable

FFS when slot n is not predicable. |
| Sharp | Regarding 2nd sub-bullet, we don’t think it is necessary, if proposal 1-3 is going to be agreed. For 3rd sub-bullet, we propose a similar method as LTE partial sensing, i.e. a bitmap, only with the clarification that UE monitors $t\_{y-(k\_{0}+k-1)×P\_{reserve}}^{SL}$ if the k-th bit is set to 1 and $t\_{y-k\_{0}×P\_{reserve}}^{SL}$ denotes the most recent occasion before the first slot of the Y candidate slots. |
| CMCC | We are fine with the main bullet. Regarding the 1st sub-bullet, we don’t think it should be left to UE implementation. |

**Proposal 1-3:**

* In periodic-based partial sensing, the UE shall monitor in periodic sensing occasion(s) for a given reservation periodicity before the first slot of the selected Y candidate slots subject to processing time restriction for the identification of candidate resources.
	+ The processing time restriction includes $T\_{proc,0}^{SL} $ and $T\_{proc,1}^{SL}$.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| NTT DOCOMO | OK |
| Panasonic | We are supportive with FL’s proposal. |
| Intel | We would like to clarify the main point of this proposal. Is that to define periodic based partial sensing behaviour or determine the last sensing occasion according to candidate slots Y?  |
| OPPO | OK |
| Sharp | Agree. |
| CMCC | Support |

### Proposals before 2nd check point

FL observations and comments based on inputs received in Sec. 3.1.1:

* TBD

## Topic #2: Contiguous partial sensing – triggering conditions, TA and TB value range, and definition for selection and candidate resource set

**Background**: In RAN1#104-e, it was agreed to further study the condition(s) in which contiguous partial sensing is performed by UE. During the RAN1#104b-e meeting, a set of conditions was defined for the periodic-based partial sensing. Following the same principal and based on Tdoc review in this meeting, a similar set of conditions can be defined for the contiguous partial sensing as well. The only difference is that UE performing contiguous partial sensing is not conditioned by whether the mode 2 resource pool is (pre-)configured with periodic reservation for another TB (sl-MultiReserveResource) enabled. That is, the intention is to support contiguous partial sensing regardless of the triggering traffic type. **The corresponding proposal is in Proposal 2-1.**

Furthermore, in RAN1#104-e, it was also agreed to further study the range of *TA* and *TB* values, including the possibility of equal to zero, positive or negative. Based on Tdoc review in this meeting, many companies expressed the following operating scenarios for the *TA* and *TB* values.

* + - * + *TA*, *TB* being zero: When aperiodic transmission is triggered and the remaining PDB is short, there may not be sufficient time for the UE to perform contiguous partial sensing. In this case, L1 may report a full set of candidate resources (similar to random selection) or perform resource exclusion based on periodic-based partial sensing results only, if available.
				+ *TA*, *TB* being positive: When aperiodic transmission is triggered and the remaining PDB is sufficient for the UE to perform contiguous partial sensing to detect aperiodic reservations from other UEs. In another scenario where the selected Y candidate slots from periodic-based partial sensing is not immediately after the triggering slot n such that the UE should continue to perform contiguous partial sensing just before the first slot of the set of Y candidate slots.
				+ *TA*, *TB* being negative: When the resource (re)selection triggering slot n is predictable (e.g. for periodic traffic), the UE would be able to perform contiguous partial sensing in advance / prior to the triggering slot n. In another scenario, if contiguous partial sensing is supported for resource re-evaluation and pre-emption checking, the contiguous partial sensing would be performed before the triggering slot m-T3.

Based on the above expressed views, it is proposed to conclude that *TA* and *TB* values can be zero, positive or negative depending on operating scenarios. However, the expressed values or range for *TA* and *TB* are still quite wide spread among the companies. This is mainly due to some details in periodic-based partial sensing are still not yet finalized. **Therefore, a corresponding proposal for this aspect is made in Proposal 2-2.**

From the Tdoc review in this meeting, it is also clear as expressed by many companies that at least when the resource (re)selection procedure is triggered for periodic transmission, both periodic-based and contiguous partial sensing processes would be performed by the UE in order to exclude from the candidate resource set (*SA*) both periodic and aperiodic reserved resources from other UEs. And the same candidate resource set (*SA*) is used in both partial sensing mechanisms. However, there are less and divergent views expressed for the case when the resource (re)selection procedure is triggered for aperiodic transmission. **Therefore, a corresponding proposal for this aspect is made in Proposal 2-3.**

### Proposals before 1st check point

**Proposal 2-1:** Condition(s) in which contiguous partial sensing is performed by UE, at least all of the followings are met:

* L1 is triggered to perform resource (re)selection procedure in a mode 2 Tx resource pool
* The resource pool is (pre-)configured to enable partial sensing
* Partial sensing configured by higher layer in the UE

|  |  |
| --- | --- |
| **Company** | **Comments** |
| NTT DOCOMO | OK |
| Panasonic | We are generally ok with it. We’d like to know if the 2nd bullet applies pool enabled with mixed full/partial sensing, and whether any restriction for Rx pool. |
| Intel | OK. We have one question. Should we clarify that it is applicable to both dynamic and semi-persistent sidelink transmissions with partial sensing? |
| OPPO | For the 1st sub-bullet, does it exclude the case TA and TB can be negative? According to the wording, it seems only C-PS can be performed when L1 is triggered to perform resource selection. It that will cause confusing, better to remove it.  |
| Sharp | We don’t agree with the 1st condition which reveals contiguous partial sensing is performed after slot n on which L1 is triggered. For the rest of 2 conditions, we agree. |
| CMCC | For the 1st bullet, we have similar concerns as commented by other companies. We think that the contiguous partial sensing can be performed on top of the periodic based partial sensing to take the aperiodic reservations into account. In such a case, the T\_A and T\_B would be negative, and the contiguous partial sensing occasion can be in advance to the triggering slot n. However, the 1st bullet seems to say that the contiguous partial sensing occasion can only occur after the triggering slot n. |

**Proposal 2-2:** In contiguous partial sensing, *TA* and *TB* values can be zero, positive or negative

* When *TA* and *TB* are not zero, they can’t be equal
* FFS whether *TA* and *TB* values or range should be further restricted base on different operating scenarios or conditions (e.g., periodic/aperiodic traffic, predictability of triggering slot n, remaining PDB, re-evaluation/pre-emption checking, etc)
* FFS: whether and details of how periodic-based partial sensing and contiguous partial sensing can be supported for re-evaluation and pre-emption checking. Including how to reduce UE’s power consumption (caused by additional sensing operation of re-evaluation/pre-emption) after its resource selection.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| NTT DOCOMO | Generally OK.One question: why ‘When T\_A + T\_B are not zero’ is needed? I think just ’T\_A and T\_B cannot be equal’ will be OK. |
| Panasonic | Ok |
| Intel | We are not clear how TB can be negative. Suggest adding TB > TA. Except these aspects we are OK, but we prefer to debate/converge further this meeting.  |
| OPPO | OK  |
| Sharp | Not agree. The 1st sub-bullet was already agreed in RAN1#104e. |
| CMCC | Support. |

**Proposal 2-3:** When a resource (re)selection procedure is triggered for periodic transmission in a mode 2 Tx pool with reservation for another TB (when carried in SCI) enabled, the same resource selection window [n+T1, n+T2] and the same set of Y candidate slots from periodic-based partial sensing shall be used in contiguous partial sensing.

* Only one candidate resource set (*SA*) is to be initialized based on the Y candidate slots from the periodic-based partial sensing
* Note, this does not cover the case when the re-evaluation and pre-emption checking is triggered.
* FFS the RSW definition and the initialization of candidate resource set (*SA*) for the case when resource (re)selection procedure is triggered for aperiodic transmission
	+ In a mode 2 Tx pool with reservation for another TB (when carried in SCI) enabled
	+ In a mode 2 Tx pool with reservation for another TB (when carried in SCI) disabled

|  |  |
| --- | --- |
| **Company** | **Comments** |
| NTT DOCOMO | OKSmall comment: ‘RSW’ would be resource selection window. The abbreviation should be avoided or corresponding definition should be added so that misunderstanding does not happen. |
| Panasonic | We are ok with FL’s proposal. |
| Intel | Our interpretation of this proposal is that resource selection window size and set Y is the same for periodic-based and contiguous partial sensing. If it is the intention, we are OK with the proposal. |
| OPPO | OK |
| Sharp | Not agree. Once partial sensing is configured by higher layers, UE would determine the RSW and the Y candidate slots, which are not separated for periodic-based partial sensing and contiguous partial sensing. Thus, we are not sure what the main bullet is about. |
| CMCC | As per the FL’s explanation in the background part, we understand that the intention of this proposal is to make consensus that when the contiguous partial sensing is performed on top of the periodic based partial sensing to further exclude the aperiodic reservations by other UEs in the RP, the same RSW and candidate resource set should be used. And we agree with the intention.However, as what we discussed several times during previous meetings, we don’t think the condition should be limited to periodic transmissions. In other words, for a RP that allows both periodic and aperiodic transmissions, both partial sensing schemes can be performed by a UE no matter what the traffic type is. Even when an actual aperiodic transmission comes, as long as the Y candidate slots meet the requirement of the remaining PDB, the above rule works.In addition, for the FFS bullet, we also don’t think it should be a case for the aperiodic transmission. In our view, the RSW definition and the initialization of candidate resource set (*SA*) should be considered for the following cases: 1) when a RP allows both periodic and aperiodic traffic, but the resource selection triggered in slot n with an urgent remaining PDB where the Y candidate slots cannot meet the requirement; 2) when a RP with reservation for another TB (when carried in SCI) disabled. |

### Proposals before 2nd check point

FL observations and comments based on inputs received in Sec. 3.2.1:

* TBD

## Topic #3: Random resource selection – timing restrictions and low priority transmissions in a mixed RA pool

**Background**: From the Tdoc review, it has been proposed again by some companies that the two timing restrictions for resource (re)selection (i.e. max distance separation of 32 slots and min HARQ feedback time gap) with sensing from R16 should be adopted for random resource selection in R17. These were discussed in the last meeting without conclusion due to these timing restriction rules would automatically apply in R17 since they are already adopted in R16. However, based on further checking of MAC and RRC specs, these rules currently apply only in the case when sensing/resource exclusion is performed in L1. Random resource selection procedure, at least in FL’s understanding, is never described in either MAC or RRC specs. Since RA based on random resource selection is supported in a resource pool with mixed RA scheme (partial sensing and full sensing), therefore, these timing restrictions should be also supported for randomly selected resources.

Additionally, the issue of random resource selection for low priority transmissions by a UE which does not perform sensing / re-evaluation and pre-emption checking in a resource pool with mixed RA schemes received a lot of interests during the Tdoc review. While there are simulation results showing this is an issue that need to be resolved and many different solutions were proposed, there was also an opposite view that no special indication or treatment is needed. Since there is a strong interest, it is worthwhile to investigate this further. **Therefore, a corresponding proposal for these aspects related to random resource selection is made in Proposal 3.**

From the FL, it is recommended for others to double check the MAC and RRC spec on the random resource selection in R16.

### Proposals before 1st check point

**Proposal 3:**

* For random resource selection,
	+ Reuse the maximum distance separation of 32 logical slots for a HARQ retransmission resource reserved by a prior SCI, which was defined in R16 for full sensing operation.
	+ The minimum HARQ feedback time gap (Z) shall be respected between any two randomly selected resources of a TB where a HARQ feedback for the first of these resources is expected
* FFS the impact when random resource selection is performed for low priority transmissions by a UE which does not perform sensing / re-evaluation and pre-emption checking in a resource pool with mixed RA schemes
	+ Including study potential solution(s) if the impact is not negligible

|  |  |
| --- | --- |
| **Company** | **Comments** |
| NTT DOCOMO | OK |
| Panasonic | We are ok with the proposal.  |
| Intel | We agree with the FL about the aspects of the first bullet and its sub-bullets that R16 signalling and timing requirements should be preserved due to backward compatibility. |
| OPPO | OK |
| CMCC | Support |

### Proposals before 2nd check point

FL observations and comments based on inputs received in Sec. 3.3.1:

* TBD

Contribution summary for power saving RA

## Periodic-based partial sensing

* Set of reservation periods, *P*reserve, to determine periodic sensing occasions
	+ Alt. 1: *P*reserve corresponds to all values from the configured set *sl-ResourceReservePeriodList*
		- Reasons: Better reliability
		- [2/Nokia, NSB], [3/FW], [4/HW, HiSi], [10/QC], [13/OPPO], [14/Lenovo, MotM], [20/LGE], [22/NEC], [27/ZTE, Sanechips], [32/DCM], [33/ASUSTeK], [35/E///] **16**
	+ Alt. 2: $ P\_{reserve}$A set of *P*reserve values is (pre-)configured and includes up to the full set of values from the configured set *sl-ResourceReservePeriodList*. FFS if support multiple sets of *P*reserve values based on one or more metrics and whether/how to restrict the set of values
		- Reasons: Alt. 2 is a superset of Alt. 1. Better power saving, flexibility based on priority or CBR when more than 1 set is configured, a common divisor can be used in some cases combined with a bitmap for k, and sensing occasions with small periodicities can be covered by contiguous partial sensing.
		- [5/vivo], [6/Spreadtrum], [7/CATT, GOHIGH], [8/Fraunhofer], [9/CMCC], [11/Zhejiang Lab], [15/Intel], [16/Fujitsu], [18/Apple], [19/Sony], [21/ETRI], [23/Samsung], [24/MTK], [25/Xiaomi], [28/ Hyundai], [29/Sharp], [30/ITL], [31/IDC], [34/BOSCH] **20**
* Selection of k
	+ Alt. 1: Option 1 as in RAN1#104-e (Only the most recent sensing occasion for a given reservation periodicity before the resource (re)selection trigger or the set of Y candidate slots subject to processing time restriction)
		- Reasons: provides negligible difference to full sensing performance; better power saving; aligning to R16 resource reservation principle; missed detection of the most recent SCI is low
		- [2/Nokia, NSB], [7/CATT, GOHIGH], [11/Zhejiang Lab], [13/OPPO], [14/Lenovo, MotM], [15/Intel], [16/Fujitsu], [20/LGE], [21/ETRI], [22/NEC], [23/Samsung], [24/MTK], [31/IDC], [35/E///] **17**
	+ Alt. 2: A modified Option 5 as in RAN1#104-e, where the modification is such that it also includes option 1 (FFS how to (pre-)configure (e.g., including bitmap), whether a maximum number of k values is needed, and whether it can be up to UE implementation to select a k value based on the (pre-)configuration)
		- Reasons: better flexibility and reliability;
		- [3/FW], [4/HW, HiSi], [5/vivo], [6/Spreadtrum], [8/Fraunhofer], [9/CMCC], [12/CAICT], [18/Apple], [19/Sony], [25/Xiaomi], [27/ZTE, Sanechips], [28/ Hyundai], [29/Sharp], [32/DCM] **16**
* Simulation results for finalizing *P*reserve and k values
	+ [4/HW, HiSi]:
		- For *Preserve* set, it is observed that, the power reduction ratio compared to the Rel-16 baseline for full set case is around 47%, and this will be added around 10% further power reduction for subset case, as shown in Figure 1. From PRR perspective, it is observed that full set case increase communication range by around 16 m over subset case at PRR = 99%, as shown in Figure 2, due to consistent ignorance of periodic reservations (half of the total periodic values are not detected) from other UEs in subset case.
		- For k value, the observed power reduction ratio by around 46% is achieved when k = {1,2}. The additional reduction of sensing slots when k = {1} adds around 10% further power reduction. On the other hand, it is observed k = {1,2} outperforms k = {1} with an increase by around 20m commination range at PRR = 99%.
	+ [5/vivo]: The average PRR with multiple Pstep configuration is better than that of single Pstep when multiple periods packets were configured in the resource pool, while the power consumption is comparable under these two configurations.
	+ [7/CATT, GOHIGH]: No performance gain can be observed when two sensing occasions are supported.
	+ [13/OPPO]: Fig. 2, PRR performance of k=1 is very close to full sensing with negligible loss. Not necessary to optimize PRR performance further by considering other periodic sensing occasions. When more k values are monitored, the power saving gain is degraded. The power reduction ratio for k=1 and k=2 is 0.96 and 0.94, respectively. It costs 50% more power consumption when k=2 compared to k=1.
	+ [23/Samsung]: PRR degradation of monitoring only a subset is acceptable compared with the full set. The power saving from monitoring a subset, even with additional power consumption of HARQ re-Tx, is 28% less than monitoring the full set.
* Remaining details: Sensing for identification of candidate resources
	+ Option 1: Sensing until the resource (re)selection trigger slot n subject to processing time restriction
		- Reasons for support:
			* Align with R16 and LTE design of reporting to higher layer and resource selection timing
		- Reasons for against:
			* Sensing occasions between the triggering slot n and Y candidate slots are not monitored for the initial resource selection
		- Supporting company: [18/Apple] (if resource is selected at triggering slot n), [25/Xiaomi] **2**
	+ Option 2: Sensing until the first slot of Y candidate slots sub. to processing time restriction
		- Reasons for support:
			* All corresponding periodic sensing occasions are taken into account during the initial resource selection to minimize collision probability
			* The most recent periodic sensing occasions are monitored, containing the most accurate/reliable reservation information.
		- Reasons for against:
			* Periodic sensing occasions between the triggering slot n and the first Y candidate slots can still be monitored during the re-evaluation/pre-emption checking before the SL transmission
		- Supporting company: [2/Nokia, NSB], [4/HW, HiSi], [6/Spreadtrum], [7/CATT, GOHIGH], [9/CMCC], [13/OPPO], [16/Fujitsu], [18/Apple] (if contiguous sensing ends before Y candidate slots), [22/NEC], [31/IDC] **13**
* Identification / selection of Y candidate slots (within resource selection window)
	+ The minimum number of candidate slots Y for partial sensing is
		- Selected from the (pre-)configured set based on the configured X% and a measured available resource ratio X’; Specify a new list of X for partial sensing or set new rules for partial sensing on X with the existing list sl-TxPercentageList [3/FW]
		- (Pre)-configured based on CBR value [7/CATT, GH], [16/Fujitsu], [20/LGE]
			* CBR can be measured by UE in M periodic sensing occasions, where M could be a subset of the total sensing occasions.
		- (Pre)-configured per priority level [15/Intel], [16/Fujitsu], [20/LGE], [31/IDC]
	+ [10/QC]: Define a set of periodic partial sensing resource sets partitioning a resource pool. UE performs partial sensing over a single or multiple resource sets. reservation of a resource in a given set can only be signalled from another slot associated with the same resource set. The resource selection window is determined within a set of resources formed by the intersection of resources in a given resource set for partial sensing and those in-between n+T1 and when the remaining PDB of a packet expires.



* + If SL-DRX configuration of the target Rx UE is known, the selection of Y slots within resource selection window should include the slots within Rx UE’s DRX ON duration as much as possible. [13/OPPO]
	+ If a monitored resource by periodic-based partial sensing associated to the transmission of a TB (e.g. (n+1)-th TB) later than n-th TB in periodic transmission conflicts with other UE’s reserved resource, before resource reselection for n-th TB transmission, the monitored resource is excluded from the idle set of resources for n-th TB transmission. [20/LGE]
	+ When PSFCH is configured, the impact of the HARQ RTT related timing restriction should also be considered when UE determines the “Y” candidate slots. [16/Fujitsu]
		- RAN1 needs to discuss whether UE should decide partial sensing/candidate slots for all possible HARQ (re)transmissions of the same TB.
	+ Minimum number of Y candidate slots is (pre)configured per the number of PSCCH/PSSCH resources to be selected. [18/Apple]
	+ The determination of the Y slots should be pre-defined patterns instead of up to UE implementation. The pattern timing could be with reference to t=n or absolute slot number. [17/Pana]
	+ Support multiple range sets of Y values in high layer. E.g., each set per priority/SCS and a minimum value for Y is (pre-)configured from a proper set. [22/NEC]
	+ Slots hypothetically reserved by non-monitored slots due to SL transmissions are excluded from Y candidate slots. Selected Y candidate slots are not overlapped with off-durations of the RX UE(s). [22/NEC]

## Contiguous partial sensing

* Conditions to perform contiguous partial sensing
	+ All traffic types: periodic and aperiodic (without periodic reservation) transmissions
		- [2/Nokia, NSB], [3/FW], [4/HW, HiSi], [13/OPPO], [15/Intel], [20/LGE], [21/ETRI], [23/Samsung], [24/MTK], [31/IDC], [33/ASUSTeK]
	+ Conditions/cases in which a UE performs contiguous partial sensing: [20/LGE]
		- When the priority value of a packet is above a threshold (e.g. pre-emption priority value)
		- When the congestion/interference level in a resource pool is above a threshold
		- When the required reliability level of a packet transmission is above a threshold
		- When the number of retransmissions of a packet is below a threshold
		- When aperiodic transmission is triggered
		- When periodic transmission is triggered, and the number of periodic-based partial sensing slots is below a threshold
	+ After receiving a NACK that the previous transmission was not successful. [35/E///]
* Sensing window [n+*TA*, n+*TB*] (values for *TA* and *TB*)
	+ *TA* and *TB* values can be zero, positive and negative: [2/Nokia, NSB], [3/FW], [6/Spreadtrum], [13/OPPO], [9/CMCC], [20/LGE], [21/ETRI], [23/Samsung], [32/DCM], [31/IDC]
		- Depending on periodic or aperiodic traffic: [3/Nokia, NSB], [32/DCM]
		- Up to UE implementation: [13/OPPO]
		- Positive values if priority < threshold and PDB > threshold: [23/Samsung]
	+ For periodic transmissions,
		- [3/FW]: *n*+*T*A ≤ $t\_{y0}^{SL}-31$and *n*+*T*B = *n*+[*T*B,min *T*B,max], where *T*B,min = $t\_{y0}^{SL}-T\_{proc,1}^{SL}$ and *T*B,max = -n+ max($t\_{y0}^{SL}-T\_{proc,1}^{SL}$, $t\_{y0}^{SL}-Y-1-T\_{proc,1}^{SL}- $T′CPS,offset)
		- [4/HW, HiSi]: *n*+*T*A = $t\_{y0}^{SL}-31$and *n*+*T*B = $t\_{y0}^{SL}-T\_{proc,0}^{SL}-T\_{1}$
		- [13/OPPO]: *n*+*T*A ≥ $t\_{y0}^{SL}-31$ and *n*+*T*B ≤ $t\_{y0}^{SL}- T\_{proc,0}^{SL}-T\_{proc,1}^{SL}$
		- [24/MTK]: *n*+*T*A = $t\_{y}^{SL}-31$ and *n*+*T*B = *n-T*2 *-T*3
		- [16/Fujitsu]: $n+T\_{A}=t\_{y0}^{SL}-31$ and$n+T\_{B}=n-T\_{proc,0}^{SL}$
		- [25/Xiaomi]: $ n+T\_{A}=m-31$ and$n+T\_{B}=n-T\_{proc,0}^{SL}$, where m is slot of a candidate resource
		- [15/Intel]:
			* TA within a range: -max(tn-32, resource selection window size) ≤ TA ≤ 1 slot, or
			* TA within a range: –max((∆A + tn-32), resource selection window size) ≤ TA ≤ 1 slot
		- [18/Apple]: $T\_{A}=t\_{y}-31$and$T\_{B}=max⁡\{T\_{A},t\_{y}-T\_{proc,0}-T\_{proc,1}\}$
		- [23/Samsung]: $n+T\_{A}=t\_{y0}^{SL}-31$ and $n+T\_{B}=n-T\_{proc,0}^{SL}$
		- [20/LGE]: *n+TA ≤* $t\_{y\_{0}}$*-31* and *n+TB ≤* $t\_{y\_{0}}$*-* $T\_{proc,0}-T\_{proc,1}$
		- [29/Sharp]: $T\_{A}=-P\_{reserve}$ (subject to processing time) and $T\_{B}=-P\_{reserve}+31$
		- [22/NEC]: [yk -31, yk – T1 – Tproc,0]
		- [32/DCM]: $n+T\_{A}=t\_{y\_{1}}-31$ and $n+T\_{B}=\left(n+T\_{C}\right)-\left(T\_{proc,0}^{SL}+1\right)$, where $n+T\_{C}\geq t\_{y\_{1}}-T\_{proc,1}^{SL}$ is the resource selection timing
		- [27/ZTE, Sanechips]: [*n*1+*T*proc, *n*2-*T*proc], where n1 and n2 are respectively the triggering times for the start and end of the contiguous partial sensing window
	+ For aperiodic transmissions,
		- [3/FW]: $T\_{A}=1$and$T\_{B}\leq 31-T\_{proc,1}^{SL}$
		- [4/HW, HiSi]: *n*+*T*A = $max\left(n,t\_{y0}^{SL}-31\right)$and *n*+*T*B = $t\_{y0}^{SL}-T\_{proc,0}^{SL}-T\_{1}$
		- [24/MTK]: *n*+*T*A = $n+1$ and *n*+*T*B = *n-T*2 *-T*3
		- [13/OPPO, 16/Fujitsu]: $T\_{A}$ and$T\_{B}$are zero or positive integers and$T\_{B}-T\_{A}\leq 31$
		- [18/Apple]: $T\_{A}=1$and$T\_{B}= 32-T\_{proc,0}$
		- [23/Samsung]: $n+T\_{A}=n'-31$ and $n+T\_{B}=n-T\_{proc,0}^{SL}$, where n’ is n or n+T1
		- [32/DCM]: $n+T\_{A}=n+T\_{proc,2}^{SL}$ and $n+T\_{B}=\left(n+T\_{C}\right)-\left(T\_{proc,0}^{SL}+1\right)$, where $T\_{proc,2}^{SL}=[1]$ and $n+T\_{C}\geq t\_{y\_{1}}-T\_{proc,1}^{SL}$ is the resource selection timing
		- [15/Intel]:
			* ∆A is the max time for UE to switch from a sleeping state to monitoring state needs to be considered. ∆A = 1 meaning that the monitoring window starts at slot ‘n+1’
			* TB = ∆B – T3 ≤ PDB, where the value ∆B is determined by slot corresponding to the last retransmission of a given TB or HARQ feedback, T3 is processing delay in slots
		- [35/E///]:
			* The values TA and TB are adaptive and based on the received HARQ feedback by the UE performing the sensing operation. The minimum duration of partial sensing window is (pre-)configured (which can be zero slot) and is used initially. If NACK is received, the sensing window is increased up to a maximum predetermined value (i.e., min (32, PDB)).
	+ Continuous sensing window should be defined as [max(n, n+T1-32), n+T2-T3] [5/vivo]
	+ Define n + TB as the resource selection time for contiguous partial sensing based resource selection. [7/CATT, GH]
		- If there are sufficient available sensing results when packet arrives, resource selection time is n where TB is equal to 0.
		- If there are no sufficient available sensing results when packet arrives, resource selection time is n + L– M, where L is the (pre-)configured contiguous partial sensing (minimum) duration and M = |TA| + 1.
			* TA depends on the actual sensing starting time, and |TA |+1 means that the UE has performed a contiguous sensing until slot n.
			* If there are no available sensing results, contiguous partial starts at the next logical slot, i.e., TA = 1.
		- Introduce a higher layer parameter to indicate the minimum contiguous partial sensing duration before resource selection.
	+ Sensing from the past 32 slots that are within the intersection of the sensing window and the same selected/configured resource set [10/QC]



* + Adopt predefined windowing with sensing occasions to detect periodic reservations in the pool when UE is transmitting aperiodic traffic [24/MTK]
	+ The maximum contiguous partial sensing window is 32 slots. The minimum contiguous partial sensing window is (pre-)configured per priority and can be zero. [31/IDC]
	+ Maximum TA and TB values can be (pre-)configured. It is up to UE implementation to select an actual value. [34/BOSCH]
	+ Include alignment to the contiguous partial sensing when coexisting with the periodic-based partial sensing, e.g., window size of the contiguous partial sensing or triggering time (or slot) of the contiguous sensing. [35/E///]
* Definition of resource selection window (RSW)
	+ UE selected Y candidate slots after resource (re)selection trigger slot n, regardless of periodic reservation is enabled/disabled for the resource pool: [4/HW, HiSi], [32/DCM]
		- Y candidate slots is selected with a constraint of $t\_{y\_{1}}\geq n+X\_{y\_{1}}$, where $X\_{y\_{1}}$ is (pre-)configured. [32/DCM]
	+ RSW for aperiodic transmissions is between [n+T1, n+T2]
		- [3/FW], [13/OPPO]
	+ RSW window or a set of slots for selection is confined within a selected/configured resource set. [10/QC]

## Random resource selection

* Identified issue 1: Persistent collision / consecutive packet loss between a random resource selecting UE with other UEs due to same reservation period [2/Nokia, NSB], [3/FW], [4/HW, HiSi], [7/CATT, GH]
	+ Random selecting UE makes resource reservation for a new TB in the next period with a pseudo-random frequency hopping, i.e. reserve the resource R\_(x+A,y+P) where P denotes the reservation period in logical SL slots in the pool converted from the reservation period in milliseconds and A denotes the frequency hopping offset determined pseudo-randomly e.g. by the CRC bits of the associated PSCCH. 1 bit in SCI format 1-A to indicate (ON/OFF) the enhanced resource reservation. [3/Nokia, NSB]
		- Conditions in which the UEs may use random resource selection per a TB or more than one consecutive TBs, CBR conditions, priorities of SL transmissions, uses of SL HARQ Option-2 so that the UEs using random resource selection may reselect resources based on HARQ NACKs when persistent collisions happen.
	+ For random resource selection with periodic traffic, the Tx UE uses two different resources for two consecutive transmissions [3/FW]
	+ Due to contiguous NACK for multiple TBs across consecutive periods, when using random selection, reception of NACK across multiple periods of a periodic reservation is a condition for (re-)selecting resources by using exclusion (to turn on sensing). FFS how many periods are required to trigger (re-)selection. [4/HW, HiSi], [7/CATT, GH]
* Identified issue 2: Low priority randomly selected transmission (with no reception capability and no re-evaluation and pre-emption checking) colliding with high priority transmitted from full/partial sensing UE due to mixed configuration of full/partial/no sensing in a same pool [2/Nokia, NSB], [3/FW], [4/HW, HiSi], [5/vivo], [7/CATT, GH], [9/CMCC], [13/OPPO], [32/DCM]
	+ [10/QC]: Based on simulation results, PRR performance of sensing UEs is not impacted in a mixed pool, but the PRR performance of random selection UEs is degraded. No special indication or treatment is needed for resources chosen using random selection.
	+ Increase the priority of UEs performing random resource selection [2/Nokia, NSB], [3/FW], [5/vivo (sim)], [6/Spreadtrum], [22/NEC], [24/MTK]
		- Use the corresponding priority value in the priority field in the 1st-stage SCI [2/Nokia, NSB], [3/FW], [22/NEC]
		- An extra field is added in SCI for indicating the original priority value associated with QoS requirement [2/Nokia, NSB]
		- A 1-bit field in the SCI indicates that the UE is performing random resource selection. [3/FW], [9/CMCC]
			* The offset of priority increase is applied by receiver [3/FW]
			* Resources reserved by random selection are all excluded without RSRP increment [9/CMCC], [19/Sony], [32/DCM],
		- The priority of random selection resources is increased by a (pre-)configured value [5/vivo]
	+ A priority threshold is configured for a resource pool, at which reduced sensing UEs can select resources in a pool configured for mixed types of RA [2/HW, HiSi (sim)], [22/NEC]
	+ For UEs perform sensing are restricted in its usage of resource pools with random resource selection enabled. [8/Fraunhofer]
	+ When pre-emption is enabled in a resource pool, set priority of UE with random resource selection to lowest priority; Otherwise, set the priority lower than $prio\_{pre}$. [13/OPPO]
	+ Different RSRP thresholds or increased RSRP threshold value is (pre-)configured for different resource selection scheme; [9/CMCC], [18/Apple], [31/IDC] Or UE reports whether one candidate resource overlaps with resources reserved by random resource selection UE to higher layer for further resource selection. [9/CMCC]
	+ For random resource selection, partitioning of SL resources / resource pool
		- For random resource selection selects the resource from a sub-pool [3/FW], [17/Pana]
		- For high priority traffic / assigning a priority threshold [3/FW], [19/Sony], [23/Samsung]
	+ SCI indicates at least one of the following information using the reserved bits. [20/LGE]
		- Type of UE: power-saving UE or vehicle UE [31/IDC]
	+ Random selection UE with high priority reserves the resource by sending reservation indication before data transmission. [27/ZTE, Sanechips]
	+ Prioritization is applied for selection of resource allocation schemes in case the UE is capable of multiple resource allocation schemes enabled in a resource pool. [29/Sharp]
* Conditions on dynamic switching random selection or partial sensing for resource selection should be specified, and it may include RSSI/RSRP measurement results, ACK/NACK and QoS requirement (e.g., priority, PDB). [3/FW], [5/vivo], [24/MTK], [11/Zhejiang Lab], [26/Convida], [31/IDC]
* Assistant information from RSU based on CBR measurement on the selection of resource pool to use can be provided via sidelink signalling to the UEs performing random selection. [6/Spreadtrum]
* The UE capability, requirement on power saving, resource pool configuration, congestion condition (as indicated by CBR etc.) and (pre-)configured minimum contiguous partial sensing duration can be the criteria for random resource selection. [7/CATT, GH]
* For UEs carrying out random resource selection and are not capable of PSFCH reception, we propose to restrict the maximum number of blind retransmissions to be carried out based on the priority of the transmission. [8/Fraunhofer]
* R16 principles of resource (re)selection should be followed for random resource selection is used (e.g., Type A and/or B UEs): [13/OPPO], [15/Intel]
	+ Maximum distance separation in logical slots should be 32 for any two resources indicated in a SCI
	+ HARQ feedback time gap (Z) between PSSCH-to-PSFCH-to-PSSCH is respected (i.e., Type B UE with PSFCH reception)
* The frequency that a UE performs random resource selection should be restricted (e.g., a minimum duration can be defined between two consecutive triggering of random selections) [25/Xiaomi]
* Conditions / criteria to use random resource selection [15/Intel]
	+ UE does not have sidelink RX chain to perform sidelink sensing (i.e., Type A and B UE)
	+ UE is configured to operate in power saving resource allocation mode
	+ Dependent on priority level
* Conditions / cases in which the UE perform random resource selection when it is enabled in a resource pool: [20/LGE]
	+ When resource (re)selection is triggered within a threshold from the start of SL DRX ON duration
	+ When congestion/interference level in a resource pool is below a threshold
	+ When the priority value of a packet is below a threshold (e.g. pre-emption priority value)
	+ When PDB is smaller than a (pre-)configured threshold if periodic transmission is not allowed in a resource pool
* When UE randomly selected a resource for periodic transmission, the resource is reselected based on the NR-V2X SPS resource reservation procedure for the following periodic transmissions, similar to LTE-V2X operation. [20/LGE]
* PSFCH resources associated with the randomly selected resources are separately configured from those with the resources based on partial sensing. [20/LGE]
* A non-sensing UE sharing a resource pool with sensing UEs shall select/reserve resources for consecutive transmissions with a separation/gap large enough so that the sensing UE can react accordingly if a collision happens, i.e., trigger resource re-evaluation/re-selection or pre-emption. [35/E///], [31/IDC]
* For random resource selection, support periodic transmission only for UEs with no sensing capabilities. Aperiodic and periodic transmission can be supported for UEs with PSCCH and/or PSFCH decoding capabilities [34/BOSCH]

## Re-evaluation and pre-emption checks

* No re-evaluation and pre-emption checks for UE performing random resource selection
	+ [3/FW], [4/HW, HiSi], [7/CATT, GH]
* When HARQ-feedback is enabled, detection of a number of NACKs on PSFCH occasions corresponding to a UE’s own PSSCH transmissions can be used to trigger re-evaluation and pre-emption for partial sensing RA.
	+ [2/HW, HiSi]
* For the purpose of pre-emption, whether periodic-based partial sensing should be performed or not depends on pre-emption enable or disable. [7/CATT, GH]
* For the purpose of re-evaluation, there is no need to perform periodic-based partial sensing for packet transmission in the duration that a TB arrives but resource (re)selection is not triggered. [7/CATT, GH]
* Introduce random selection with subsequent re-evaluation in NR sidelink. [10/QC], [11/Zhejiang Lab], [13/OPPO], [18/Apple], [26/Convida], [31/IDC], [32/DCM]
* At least for resource(s) selected by period-based partial sensing, when performing re-evaluation or pre-emption, [25/Xiaomi]
	+ Option 1: reuse the set of candidate slots in resource (re)selection
	+ Option 2: the set of candidate slots only includes the slots of transmission resource for re-evaluation or pre-emption
* For pre-emption check in case of periodic-based partial sensing, support configurability among the following two options [15/Intel]
	+ Option 1: Pre-emption check and periodic-based partial sensing are enabled for every TB transmission
	+ Option 2: Pre-emption check and periodic-based partial sensing are enabled for resource reselection events
* For a UE performs partial sensing, re-evaluation/pre-emption and the corresponding resource re-selection is also based on partial sensing. Partial sensing procedure should be enhanced by the mechanism of either the priority adjustment or signalling, to support re-evaluation / pre-emption checking while maintaining the power saving performance. [16/Fujitsu]
* Support re-evaluation and pre-emption checking based on partial sensing (including both periodic-based partial sensing and contiguous partial sensing) after the resource selection. [18/Apple]
* Both re-evaluation and pre-emption checking with power saving mode(s) can be enabled/disabled by resource pool (pre-)configuration. [23/Samsung]
* The procedure of pre-emption check and re-evaluation check in Rel-16 NR V2X is reused for Rel-17 power saving mode with a fixed sensing window size of W=31 slots 🡺 [m-W, m-T3-Tproc,0). [23/Samsung]
* RAN1 should discuss whether a partial sensing UE can select resources in noncandidate slots defined by periodic-based partial sensing slots. [19/Sony]
* A partial sensing UE should conduct re-evaluation or pre-emption checking in subsequent periods after initial selection of periodic sidelink grant. [19/Sony]
* A partial sensing UE should conduct periodic-based partial sensing for re-evaluation or pre-emption checking in subsequent period after initial selection of periodic sidelink grant. [19/Sony]
* Conditions and cases in which the UE should perform re-evaluation and pre-emption checking: [20/LGE]
	+ When random resource selection is performed before resource (re)selection by UE that is capable of sensing
		- if additional sensing is possible within remaining PDB
		- if there are any sensing results available for transmission of other packets
	+ When the number of the periodic-based partial sensing slots before resource (re)selection is below a threshold
	+ When only the contiguous partial sensing is performed before resource (re)selection in a resource pool where the periodic transmission is enabled
	+ When the priority value of a packet is above a threshold (e.g., pre-emption priority value)
	+ When the congestion/interference level in a resource pool is above a threshold
	+ When the required reliability level of a packet transmission is above a threshold
	+ When the number of retransmissions of a packet is below a threshold
	+ For selected resources for which sensing results more than a threshold in a contiguous partial sensing window are not available (e.g., the resources selected in the latter part of a selection window)
* UE continues periodic-based partial sensing after resource selection by monitoring the slots of the timing below within PDB:$t\_{s\_{y}+m×P\_{reserve}}$ where$s\_{y}$is the most recent monitoring occasion for candidate slot *y* for resource selection, and m is an integer greater than zero. [20/LGE]
* UE performs contiguous partial sensing over the window *[*$t\_{r}-T\_{C}$*,* $t\_{r}-T\_{D}$*]*, where $t\_{r}$is the timing of every selected resource,$T\_{C}\geq W\_{CPS}$*,* $T\_{D}\geq T\_{proc,0}+T\_{proc,1}$and *WCPS* is the length of contiguous partial sensing window (e.g. 31 SL logical slots)*.* [20/LGE]
* In determining the idle resources (SA) or in resource reselection based on resource re-evaluation or pre-emption checking in a resource pool where periodic-based partial sensing is configured, a resource is reselected according to the priority below (lower priority number means higher priority). [20/LGE]
	+ Priority 1. Idle resources in Y candidate slots in the range (RCPS), where the conflict with other UE’s transmission resource can be detected by contiguous partial sensing
	+ Priority 2. Idle resources in Y candidate slots outside the range RCPS
	+ Priority 3. Idle resources except Y candidate slots in the range RCPS
	+ Priority 4. Idle resources except Y candidate slots outside the range RCPS
* The pre-emption priority for power saving UE is separately (pre-)configured from that for vehicle UE. [20/LGE]
* For re-evaluation/pre-emption check of a resource at UE performing periodic-based partial sensing and contiguous partial sensing, [32/DCM]
	+ The UE uses the same set of Y candidate slots as that determined in the corresponding resource selection.
		- Sensing slots for periodic-based partial sensing are the same.
		- Sensing slots for contiguous partial sensing includes additionally slots within$\left(n+T\_{B}, m-T\_{proc,0}^{SL}\right)$
* For re-evaluation/pre-emption check of a resource at UE performing random resource selection [32/DCM]
	+ When a UE selects at slot *n* resource(s) randomly from a window of *[n+T1, n+T2]*, the UE monitors slots of *[n+*$T\_{proc,2}^{SL}$*, m−*$T\_{proc,0}^{SL}$*]* and performs re-evaluation/pre-emption check at slot *m*, where
		- $T\_{proc,2}^{SL}$ *= [1]* and *m+*$T\_{proc,1}^{SL}$ is the slot index of the selected/reserved resource
	+ A set of Y candidate slots within *[m+T1, m+T2]* is determined in the same way as partial sensing.
* For semi-persistent reservation, the UE can skip pre-emption for certain reservation periods. The number of skip periods is (pre-)configured per priority. [31/IDC]
* For random resource selection of UEs with PSCCH reception capabilities, support re-evaluation and pre-emption based on a short sensing period. The short sensing starts shortly after resource selection trigger and stops directly before (re-)transmission. [34/BOSCH]

References

1. [RP-202846](http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Docs/RP-202846.zip) WID revision: NR sidelink enhancement LG Electronics
2. R1-2104176 Sidelink resource allocation for power saving Nokia, Nokia Shanghai Bell
3. [R1-2104192](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2104192.zip) Power consumption reduction for sidelink resource allocation FUTUREWEI
4. [R1-2104236](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2104236.zip) Sidelink resource allocation to reduce power consumption Huawei, HiSilicon
5. [R1-2104385](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2104385.zip) Resource allocation for sidelink power saving vivo
6. [R1-2104440](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2104440.zip) Discussion on sidelink resource allocation for power saving Spreadtrum Communications
7. [R1-2104489](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2104489.zip) Discussion on resource allocation for power saving CATT, GOHIGH
8. [R1-2104560](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2104560.zip) NR Sidelink Resource Allocation for UE Power Saving Fraunhofer HHI, Fraunhofer IIS
9. [R1-2104630](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2104630.zip) Discussion on resource allocation for power saving CMCC
10. [R1-2104693](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2104693.zip) Power Savings for Sidelink Qualcomm Incorporated
11. [R1-2104706](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2104706.zip) Discussion on resource allocation for power saving Zhejiang Lab
12. [R1-2104724](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2104724.zip) Considerations on partial sensing in NR V2X CAICT
13. [R1-2104755](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2104755.zip) Power saving mechanisms in NR sidelink OPPO
14. [R1-2104869](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2104869.zip) Sidelink resource allocation for power saving Lenovo, Motorola Mobility
15. [R1-2104926](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2104926.zip) Sidelink Power Saving Schemes Intel Corporation
16. [R1-2105066](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105066.zip) Considerations on partial sensing and DRX in NR Sidelink Fujitsu
17. [R1-2105070](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105070.zip) Discussion on Sidelink Resource Allocation for Power Saving Panasonic Corporation
18. [R1-2105126](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105126.zip) On Sidelink Resource Allocation for Power Saving Apple
19. [R1-2105177](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105177.zip) Discussion on sidelink resource allocation for power saving Sony
20. [R1-2105204](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105204.zip) Discussion on resource allocation for power saving LG Electronics
21. [R1-2105228](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105228.zip) Discussion on resource allocation for power saving ETRI
22. [R1-2105253](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105253.zip) Discussion on resource allocation for power saving NEC
23. [R1-2105334](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105334.zip) On Resource Allocation for Power Saving Samsung
24. [R1-2105380](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105380.zip) Discussion on sidelink power saving MediaTek Inc.
25. [R1-2105544](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105544.zip) Discussion on sidelink resource allocation enhancement for power saving Xiaomi
26. [R1-2105598](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105598.zip) NR SL Resource Allocation for Power Saving Convida Wireless
27. [R1-2105614](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105614.zip) Discussion on resource allocation for power saving ZTE, Sanechips
28. [R1-2105615](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105615.zip) Discussion on resource allocation for power saving Hyundai Motors
29. [R1-2105645](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105645.zip) Discussion on resource allocation for power saving Sharp
30. [R1-2105651](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105651.zip) Resource allocation for power saving with partial sensing in NR sidelink enhancement ITL
31. [R1-2105674](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105674.zip) Sidelink resource allocation for power saving InterDigital, Inc.
32. [R1-2105718](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105718.zip) Discussion on sidelink resource allocation for power saving NTT DOCOMO, INC.
33. [R1-2105845](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105845.zip) Discussion on partial sensing and SL DRX impact ASUSTeK
34. [R1-2105866](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105866.zip) Further discussion on power saving for sidelink ROBERT BOSCH GmbH
35. [R1-2105893](file:///C%3A%5C3GPP%5CRAN1_Meetings%5CTdocs%5C2021%5CR1-2105893.zip) Resource allocation procedures for power saving Ericsson

Appendix (past meeting outcomes)

## RAN1#103-e (26/Oct – 13/Nov 2020)

**Conclusion**

* SL reception Type A and Type D should be used as the reference for evaluation and designing of SL power saving features in R17.
	+ Type A: UE is not capable of performing reception of any SL signals and channels, FFS with exception of performing PSFCH and S-SSB reception (aim to conclude in RAN1#104-e)
	+ Type D: UE is capable of performing reception of all SL signals and channels defined in R16. It does not preclude UE to perform reception of a subset of SL signals/channels
	+ If there are evaluations with assumptions other than the above reference, the detailed assumptions need to be reported
	+ Note: the types and the associated capability defined here are not intended to be defined as Rel-17 UE features as is.

Agreements:

* Partial sensing based RA is supported as a power saving RA scheme
	+ FFS details
* Random resource selection is supported as a power saving RA scheme
	+ FFS any changes or enhancement
	+ FFS on conditions to apply random resource selection

Agreements:

* In R17, a SL Mode 2 Tx resource pool can be (pre-)configured to enable full sensing only, partial sensing only, random resource selection only, or any combination(s) thereof
	+ FFS details, including usage, potential restrictions, whether/how any enhancement or condition is needed for the coexistence of full sensing and power saving RA scheme(s) in a same resource pool, etc.

Agreements:

* Re-evaluation and pre-emption checking are not supported by UEs that do not perform any sensing (i.e. PSCCH reception)
* Re-evaluation and pre-emption checking are supported by UEs that perform sensing
	+ FFS details and any conditions(s) in which re-evaluation and pre-emption can be performed
* FFS whether/how re-evaluation and pre-emption can be supported by UEs performing random resource selection that do perform sensing
* Note: details about sensing in this context, including when it is performed, are not decided yet.

Agreements:

* Further study congestion control based on CBR and CR for power saving RA schemes
	+ Identify necessary changes from R16 CBR/CR (if any), including transmission resource selection and transmission parameters that can be adjusted and applicable to power savings RA schemes
	+ Note: this is not intended to require all UEs to perform sensing for the purpose of CBR measurement

## RAN1#104-e (25/Jan – 05/Feb 2021)

Agreements**:**

* Random resource selection is applicable to both periodic and aperiodic transmissions
	+ FFS conditions for random resource selection

**Conclusion:**

* PSFCH reception is not included for Type A UE
* S-SSB reception is not included for Type A UE
* SL reception Type B is additionally added
	+ Type B: Same as Type A with an exception of performing PSFCH and S-SSB reception
* Note: the same conditions as in RAN1#103-e regarding the context of the discussion of Type A and Type D still apply (also applicable to type B)

Agreements**:** In a resource pool (pre-)configured with at least partial sensing, if UE performs periodic-based partial sensing, at least when the reservation for another TB (when carried in SCI) is enabled for the resource pool and resource selection/reselection is triggered at slot n, it is up to UE implementation to determine a set of Y candidate slots within a resource selection window, where

* FFS condition(s) and timing(s) for which periodic-based partial sensing is performed by UE
* The resource selection window is [n+T1, n+T2]
	+ As a baseline, T1 and T2 are defined in the same way as in R16 NR-V2X according to step 1 [TS 38.214 Sec. 8.1.4]
	+ Further discuss whether or not to introduce a threshold to re-define T1 and T2 such that
		- T1≥ 0 (subject to processing time constraint Tproc, 1), and T2 ≤ remaining PDB
		- T2-T1 *≤* (pre-)configured threshold
* A minimum value for Y is (pre-)configured from a range of values, FFS details
* FFS any restriction to determine Y candidate slots (including its relationship with SL-DRX)
* FFS whether the resource selection window [n+T1, n+T2] should be confined within a set of periodic set of resources and its relationship with SL-DRX
* Note: The terminology “periodic-based partial sensing” is based on the “partial sensing” used in LTE-V and it is intended to be used for the design and discussion of partial sensing in Rel-17.

Agreements**:** In a resource pool (pre-)configured with at least partial sensing, if UE performs periodic-based partial sensing, at least when the reservation for another TB (when carried in SCI) is enabled for the resource pool and resource selection/reselection is triggered at slot n, the UE monitors slots of at least one ~~a set of~~ periodic sensing occasion~~s~~, where a periodic sensing occasion is a set of slots according to 

if tvSL is included in the set of Y candidate slots.

* *P*reserve is a periodicity value from the configured set of possible resource reservation periods allowed in the resource pool (*sl-ResourceReservePeriodList*). Down select to one:
	+ Option 1: *P*reserve corresponds to all values from the configured set *sl-ResourceReservePeriodList*
	+ Option 2: $ P\_{reserve}$ *P*reserve corresponds to a subset of values from the configured set *sl-ResourceReservePeriodList*
		- FFS how to determine the subset (e.g., by (pre-)configuration, UE determination)
	+ Option 3: $P\_{reserve}$ *P*reserve is a common divisor among values in the configured set *sl-ResourceReservePeriodList*
	+ Option 4: FFS others
* k ~~equals to~~is selected according to (down select to one)
	+ Option 1: Only the most recent sensing occasion ~~within sensing window~~ for a given reservation periodicity before the resource (re)selection trigger or the set of Y candidate slots subject to processing time restriction
	+ Option 2: The two most recent sensing occasions ~~within sensing window~~ for a given reservation periodicity before the resource (re)selection trigger or the set of Y candidate slots subject to processing time restriction
	+ Option 3: All possible sensing occasions after $n –T\_{0}$
	+ Option 4: Only one periodic sensing occasion for one reservation period. The k value is up to UE implementation. Max value for k is (pre-)configured.
	+ Option 5: k is (pre-)configured, including multiple values
	+ Option 6: (pre-)configuration of a bitmap, same as in LTE-V
	+ Option 7: FFS others
* FFS relationship between periodic sensing occasions and SL-DRX
* FFS condition(s) and timing(s) for which periodic-based partial sensing is performed by UE
* Note: companies are encouraged to show performance data for the down selections

Agreements:

* In a resource pool (pre-)configured with at least partial sensing, if UE performs contiguous partial sensing and resource (re-)selection is triggered in slot n, support the following option:
	+ Option 1: For the purpose of resource (re-)selection, the UE monitors slots between [*n*+*T*A, *n*+*T*B] and performs identification of candidate resources, in or after slot *n*+*T*B, based on all available sensing results, including periodic-based partial sensing results (if applicable).
		- FFS *T*A, *T*B (including the possibility of equal to zero, positive or negative) and remaining details (in particular, whether there should be exclusion of slots, changes in TA/TB values for different purposes, etc.)
		- FFS whether n can be replaced by e.g., index of some of Y candidate slots
	+ FFS condition(s) in which contiguous partial sensing is performed by UE
	+ FFS interaction with SL-DRX, if any
	+ FFS interaction with periodic-based partial sensing, if any
	+ Other options are not precluded
	+ Note: This option is not to replace random resource selection only without sensing or re-evaluation and pre-emption checking

## RAN1#104b-e (12 – 20 April 2021)

**Conclusion:**

* In periodic-based partial sensing,
	+ It is not necessary to further discuss whether or not to introduce a threshold to re-define T1 and T2.

**Agreements:**

* In periodic-based partial sensing,
* For the set of *P*reserve values, down-select to one of the following in RAN1#105-e
	+ - Alt.1: *P*reserve corresponds to all values from the configured set *sl-ResourceReservePeriodList*
		- Alt.2: A set of *P*reserve values is (pre-)configured and includes up to the full set of values from the configured set *sl-ResourceReservePeriodList*
			* FFS if support multiple sets of *P*reserve values based on one or more metrics
			* FFS whether/how to restrict the set of values
* For the k value, down-selection to one of the following in RAN1#105-e (further refinement of each of the alternatives is possible)
	+ - * + Alt 1: Option 1 as in RAN1#104-e
				+ Alt 2: A modified Option 5 as in RAN1#104-e, where the modification is such that it also includes option 1

FFS how to (pre-)configure (e.g. including bitmap), whether a maximum number of k values is needed, and whether it can be up to UE implementation to select a k value based on the (pre-)configuration

* + - * + FFS details, e.g., sensing before the resource (re)selection trigger or the first slot of the set of Y candidate slots subject to processing time restriction, etc.
			* Note: companies are encouraged to provide more evaluations

**Agreement:**

* When periodic-based partial sensing is potentially performed by UE in a mode 2 Tx resource pool provided by higher layer, at least all of the followings are met:
	+ Periodic reservation for another TB (sl-MultiReserveResource) is enabled for the resource pool
	+ The resource pool is (pre-)configured to enable partial sensing
	+ Partial sensing configured by higher layer in the UE